CONTRIBUTION OF BREEDING PROGRAMS TO THE IMPROVEMENT OF THE ROMANIAN FRUIT TREES AND BERRIES ASSORTMENT

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Abstract. *To answer to the demands and challenges of modern fruit growing is the assortment, respectively the varieties available to growers and consumers. Romania carries out extensive breeding programs for all fruit trees and berries species. The Romanian genetic resources fund includes 5,705 accessions, of which 2,900 (50.8%) are local varieties and biotypes. The main breeding objectives are: high productivity, resistance to major diseases and pests, improving adaptability to diverse climatic and soil conditions, fruit quality. Specific breeding objectives focus on late flowering and tolerance to late spring frosts, increased resistance to winter frost, extension of the fruit ripening period, self-fertility, and reduced tree vigor. Over the last 15 years, breeding activities have involved approximately 5,000 hybrid combinations, 10,000,000 pollinated flowers, and the production of about 1,500,000 hybrid seeds or stones, resulting in 500,000 hybrid seedlings. From these, around 1,500 promising selections were obtained at ICDP Pitesti, leading to the release of 40 new cultivars.*

Keywords: assortment, breeding, objectives, fruit trees, berries.

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1. Introduction

To answer to the demands and challenges of modern fruit growing is the assortment, respectively the varieties available to growers and consumers. Replacing old varieties, which are less adapted to current demands, with new ones that are superior, more productive, and more resistant to diseases and pests is a continuous and necessary process that society cannot give up [4, 3].

This replacement carry out through the introduction of new varieties from other countries, the creation of new autochthonous varieties, and the selection of the best clones, both from introduced varieties and from local ones.

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The most difficult problems in fruit growing sector are the susceptibility of existing varieties to the specific diseases and pests, the need for costly phytosanitary treatments with negative effects on the environment and human health, as well as those caused by climate change.
There are two major difficulties in the breeding process of fruit trees and berries: the long ontogenetic development of fruit crops and the impossibility of simultaneously improving multiple traits and characteristics (productivity + resistance + sensory quality + long storage life, etc.). This is why, worldwide, there have been and continue to be breeding programs led by multinational and multidisciplinary teams (for example: Fruit Breedomics, which involving countries such as France, Belgium, Italy, Israel, Spain, Czech Republic, Netherlands and the United Kingdom; Shar-Co, involving researchers from France, Bulgaria, Czech Republic, Serbia, Italy, Slovakia, Spain, Romania, Turkey and Germany; Berry GenRes, involving France, Finland, Germany, Italy, Norway, Spain, Turkey and the United Kingdom) [4, 1, 6, 3].

Romania, through its specialized institutes, research stations, and universities, carries out extensive breeding programs for all fruit trees and berries species. A fundamental prerequisite for the successful development of new cultivars is the availability of a rich and diverse germplasm collection. Romania holds one of the most valuable fruit germplasm resources, comprising biological material from 11 genres and species of fruit trees, 11 genres of berry, as well as strawberry. The Romanian genetic resources fund includes 5,705 accessions, of which 2,900 (50.8%) are local varieties and biotypes.Local varieties represent an essential resource for breeders and biotechnologists, as they provide valuable genetic material for the development of new cultivars with improved resistance to biotic and abiotic stresses and enhanced productivity [2, 5].

The aim of this study was to present the objectives, research methods and the results of the breeding program for fruit growing in Romania.

2. Materials and Methods

The biological material used in the breeding work was represented by a rich genetic fund, consisting of *Malus, Pyrus*, *Prunus, Fragaria* × *ananassa*, *Vaccinium spp.*, *Ribes spp., Rubus idaeus*, *Rubus fruticosus*, *Ribes uva-crispa* species, native and foreign varieties, clonal selections, interspecific and intraspecific hybrids.
The basic method used in creating the genetic variability necessary for the selection and creation of new varieties was artificial hybridization between the best available potential parents. To improve fruit quality, intraspecific hybridizations were performed, using quality parents in "best-of-best" cross systems. For resistance to diseases and pests, the interspecific hybridization

method was used, according to the scheme of valuable variety x resistant species, continued with backcrossing until obtaining valuable successors.

3. Results and Discussions

3.1.Breeding objectives in fruit trees

The main breeding objectives are: increasing yield potential, enhancing genetic resistance to major diseases and pests, improving adaptability to diverse climatic and soil conditions, and ensuring the continuous improvement of fruit quality.Specific breeding objectives focus on late flowering and tolerance to late spring frosts, increased resistance to winter frost, extension of the fruit ripening period, self-fertility, and reduced tree vigor (Table 1) [3].

Table 1. Breeding objectives in fruit trees

Species	Objectives	
	Current	**Perspective**
Apple	- resistante to scab and powdery mildew; - fruit quality; - spur fructification	- resistance to fire blight and pests; - resistant columnar types; - selection of apple genotypes for resistance to scab by using molecular markers;
Pear	- resistance to fire blight and*Psylla*; - winter cultivars with long storage; - fruit quality	- immunity to diseases and insects; - good affinity with quince; - low vigor; - identification of red-fleshed genotypes
Plum	- tolerance/resistance to*Plum Pox Virus*; - fruit quality	- immunity to Sharka; - low vigor and spur fructification; - fruit quality; - self fertility
Sweet and sourcherry	- fruits size (> 10 g, respectivelly> 30 mm caliber) – for sweet cherry; - self fertility; - resistance to diseases and pests	- low vigor and spur fructification; - fruits size and quality; - late flowering; - suitability for mechanized harvesting – for sour cherry

3.2.Breeding methods used in fruit tree

The main breeding methods include controlled hybridization, open pollination, conservative clonal selection, mutagenesis, embryo culture, and marker-assisted selection.

The most widely used breeding method is controlled hybridization, which has the following stage: selection of the mother tree, isolation of flowers, emasculation of flowers, artificial pollination, control of fruit setting (Photo 1).

Photo 1. The stage of controled hybridization method

Over the last 15 years, breeding activities have involved approximately 5,000 hybrid combinations, 10,000,000 pollinated flowers, and the production of about 1,500,000 hybrid seeds or stones, resulting in 500,000 hybrid seedlings. From these, around 1,500 promising selections were obtained at ICDP Pitești, leading to the release of 40 new cultivars.

3.3.Apple breeding in Romania

The implementation of a breeding program and its successful completion depend largely on the precision of the proposed objectives and the existence of genetic resources. Romania has a rich germplasm fund, a national treasure recognized and appreciated at international level, collected and preserved with permanent effort, according to the goals and objectives agreed in the signed international treaties and conventions. The main objectives of the evaluation of fruit genetic resources are to highlight the morphological polymorphism of accessions, to identify the original accessions and/or the different varieties present in a collection and to study the phenotypic variability (Militaru et al., 2018) [5]. In the apple (*Malus domestica*), there is a diversity of objectives in the breeding program, but only 3 objectives are considered to have an international character: production potential, superior fruit quality and resistance to diseases and pests (Cociu et al., 1999) [4].
To achieve the objectives, suitable genitors were introduced from foreign varieties ('Golden Delicious', 'Starkrimson', 'Jonathan') or *Malus* species (*Malus floribunda* 821, *Malus zumi*), immune to scab or tolerant to powdery mildew.

In Romania, the stability objectives in breeding programs have undergone major changes over the years, depending on the historical stage, interest in a certain objective, available genetic resources, and material possibilities.

Generally, the current objectives of the apple breeding program in Romania are similar to those worldwide, research has been directed towards improving fruit quality and resistance to diseases and pests, especially scab, reducing fruit pollution and finally, environmental protection. The prospective objectives are: fire blight and insect resistance; resistant columnar types and selection of apple genotypes for disease resistance using molecular markers.

In the 1970s-1980s, by introducing new genetic material (′Prima′ - *Vf* cv. and the COOP selections from U.S.A.), Romanian varieties with *Vf* resistance were created in breeding programs.

Over time, the apple germplasm fund has been enriched through advances in working methods, through the development of new hybrid selection procedures, through Jiffypot cultivation and artificial infections with pathogen races or populations.
At various stages, the method used in breeding was the classical one, respectively hybridization between the best available potential genitors, supplemented with intraclonal selection of natural or artificially induced somatic mutants. For resistance, the combination of genetic resistance to vertical diseases with horizontal or polygenic disease was sought, by complexing the genome of the new creations using several sources of resistance genes (Branişte et al., 2004) [1].

In the following stages, the germplasm fund being enriched, new objectives were addressed in the genetic breeding program and new modern cultivation systems. A series of varieties that contributed to the modernization of Romanian fruit growing were used as parents, such as: ′Florina′, ′Elstar′, ′Gloster′, ′Jonagold′, ′Gala′, ′Topaz′, ′Opal′, ′Sirius′, ′Luna′, ′Goldrush′, ′Dalinette′, ′Dalinco′, ′Dalinbel′.

1. Colmar; 2. Colonade; 3. Rumina; 4. Rustic

Photo 2. Apple cultivars registered in the last 15 years in Romania

The results of the apple breeding program were materialized by the registration of 71 varieties created between 1967-2025, many of which were affirmed by the quality of the fruit with taste, pleasant appearance, different periods of ripening and consumption, resistance/tolerance to diseases and pests. Among these, the following varieties have been distinguished: ′Generos′, ′Ciprian′, ′Romus 3′, ′Romus 5′, ′Rebra′, ′Rustic′, ′Auriu de Bistrita′, ′Ardelean′, ′Delia′, ′Nicol′.

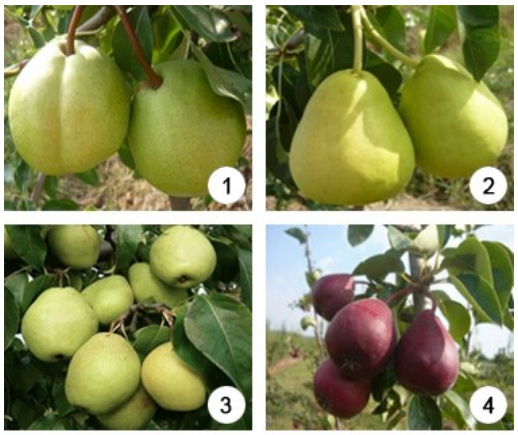
3.4. Pear breeding in Romania

In the case of pear species, the breading objectives were: superior quality, resistance/tolerance to scab and fire blight, winter varieties with high storage capacity. Perspective objectives in pear breeding are: immunity to diseases and pests (*E. amylovora* and *Psylla* sp.); low vigor; good affinity with quince; identification and introduction into the breeding program of some red-fleshed genotypes.

To widen the selection basis there has been introduced genotypes from assortment international, which have diversified the genetic fund obtaining new, qualitatively improved varieties, registered as valuable varieties. Also, to achieve the objectives there have been made intra and inter specific crosses, starting with the local varieties adapted to the local environment conditions to which there have been added quality genes from valuable varieties.

The main genitors used in the Romanian breeding pear program were:′Packham's Triumph′, ′Beurre Hardenpont', 'Conference′ for low vigor and spur-type fruiting; ′Busuioace′, ′Aromata de Bistrita′ for late flowering; ′Beurré Bosc′ ′Beurré Hardy′, ′Williams′, ′Max Red Barlett′, ′Highland′, ′Abate Fetel′, ′Packham's Triumph′, ′General Leclerc′, ′Olivier de Serres′, ′Untoasa de Geoagiu′, ′Daciana′, ′Argessis′, ′Carpica′ for fruit quality and commercial appearance; ′Napoca′, ′Beurré precoce Morettini′, ′Clapp's Favorite′, ′Aromată de Vară′ for early fruit ripening; ′Passe Crassane′, ′Comtesse de Paris', 'Curé', 'President Drouard′, ′Doyenne d'hiver′, ′Madame Levavasseur′, ′Republica′, ′Euras′, ′Beurré Hardenpont', 'Olivier de Serres′ ′Josephine de Malines′, for late ripening and good storage capacity; ′Triomphe de Vienne′, ′Beurré Bosc′, ′Abate Fetel', 'Duchesse d'Angoulême′ for large fruits; *′P. serotina′*, *′P. serotina* x Williams′, ′Kieffer Seedling′ for resistance to fire blight (*Erwinia amylowora*) and scab (*Venturia piryna*); ′Honeysweet′, ′Severianka′, ′Tse Li', ′Chang Pa Li', ′Old Home', 'Sierra', `Imperiale', ′Haydeea′ for tolerance to pests (*Psylla* sp.); ′Packham's Triumph′, ′Napoca′, 'Highland', 'Haydeea′ for productivity; ′Cu Miez Rosu′ for red pulp [6, 2, 5].

As a result of the breeding program for the pear species, 45 varieties were registered between 1967 and 2025, some of which were also appreciated abroad both as parents in breeding programs and for expansion into commercial plantations ('Isadora′, ′Monica′ and ′Paradise′).



1. Paramis; 2. Paradox; 3. Isadora; 4. Paradise

Photo 3. Pear cultivars registered in the last 15 years in Romania

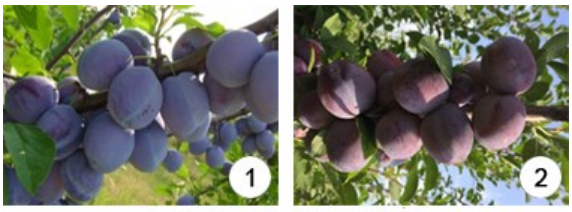
3.5.Plum breeding in Romania

In the case of plum species, the breeding program began in 1950 at the Istrita nursery, the first objectives being to improve the old traditional varieties, such as ′Tuleu gras′, ′Grase româneşti′ and ′Vinete româneşti′.

Later, the breeding objectives targeted fruit quality, resistance and tolerance to Plum Pox Virus, different ripening times, vigor and low self-fertility.

In the breeding work carried out in Romania, the main genitors used in controlled hybridizations were: ′Tuleu gras′, ′Carpatin′, ′Centenar′, ′Tita′, ′Yakima′, ′California Blue′, ′Grand Duke′, ′Ontario′, ′Giant plum′, 'Vision', ′Oneida′, ′Bluefree′, ′Andreea′, ′Agent', 'Romanţa′, ′Record', 'Hanita', 'Haganta'for quality and commercial appearance;'Early Rivers′, ′Ruth Gerstetter′, 'Diana', 'lalomița′, ′Cacanska lepotica', 'Cacanska ranna'for earliness;'Anna Spath', 'Vinete romanesti′, ′Valor′, ′President', `Jojo' for lateness; ′Oneida′, ′Kirke′, ′Grase de Becs′, ′Grase de Peşteana′, ′Agen de Sirăuți′, ′Boambe de Leordeni', 'Ontario', 'Wilhelmina Spath′, ′Kirke′, ′Jojo'for resistance or tolerance to Plum Pox Virus;'Stanley', 'Anna Spath', 'Bluefree', 'lalomita′, ′Diana′, ′Romanţa′, ′Cacanska lepotica'for self-fertility; 'Stanley', 'Bluefree', 'Wilhelmina Spath'for low vigor;′Stanley′, ′Anna Spath', 'Bluefree', 'Standard', 'Grase de Becs′, ′Cacanska lepotica′for good yielding capacity.

As a result, in the period 1967-2025, 43 plum varieties were registered. Although the varietal conveyor is quite wide, the most cultivated Romanian varieties remain 'Centenar′, ′Pescărus′, 'Agent', 'Andreea', 'lulia', 'Silvia' [3].



1. Romanța; 2. Milenium

Photo 4. Plum cultivars registered in the last 15 years in Romania

3.6. Sweet and sour cherry breeding in Romania

In the case of sweet and sour species, the main breeding objectives are: low vigor and spur fructification, good yielding capacity, self fertility, late flowering, resistance to diseases and pests,size and quality of fruits (e.g. > 10 g, respectivelly > 30 mm caliber – for sweet cherry), resistance of fruits to cracking, suitability for mechanized harvesting – for sour cherry.

In the breeding work carried out in Romania, the main sweet cherry genitors used in controlled hybridizations were:'Stella', 'Lapins', 'Maria', 'Skeena' for self fertility; 'Van', 'Skeena' for productivity; 'Cerna', 'Van compact', 'Stella compact', 'Lapins compact' for low vigor; 'Viscount', 'Hedelfinger', 'Bigarreau Napoleon' for tolerance to diseases; 'Bigarreau Burlat', 'Spectral', 'Merchant' for earlyness; 'Skeena', 'Kordia', 'George', 'Areko' for lateness; 'Van, 'Superb', 'Vanda', 'Techlovan', 'Kordia' for fruit quality and resistance to cracking.

The main sour cherry genitors used in controlled hybridizations were:'Schattenmorelle', 'Spaniole', 'Oblacinska', 'Nana', 'Ilva' for productivity; 'Erdi Nogygyumolcsu', 'Țarina', 'Eugenia' for up right growing; 'Schattenmorelle', 'Nana', 'Oblacinska' for self fertility; 'Spanka', 'Mari timpurii', 'Northstar' for tolerance to diseases; 'Rival', 'Schattenmorelle', 'Sumadinka' for color and quality of fruits.

As a result, in the period 1967-2025, 62 sweet cherry and 19 sour cherry varieties were registered.

1.Sublim; 2.Spectral; 3.Special; 4.Stelar

Photo 5. Sweet and sour cherry cultivars registered in the last 15 years

3.7. Breeding objectives for strawberry and berries

ICDP Pitești is the main Romanian centre for the breeding, evaluation, and conservation of berries and strawberry cultivars.

Breeding programs for strawberries and berries aim to develop cultivars that are productive, resilient, and of high fruit quality. One of the primary objectives is to improve adaptability to both biotic and abiotic factors, including frost, late spring frosts, drought, and specific diseases and pests. Ensuring that new cultivars can withstand these environmental and biological stresses is essential for sustainable production and reduced dependence on chemical treatments. Another key goal is high productivity, enabling growers to achieve better yields per unit area while maintaining economic viability. Alongside productivity, fruit quality is of paramount importance, encompassing taste, size, color, aroma, and storage potential, which directly affect consumer acceptance and marketability.

Finally, breeding programs focus on developing cultivars with different ripening periods, allowing for a staggered harvest that can meet market demands over an extended season. By addressing these objectives simultaneously, strawberry and berry breeding programs in Romania, particularly through specialized centres such as ICDP Pitești, contribute to the creation of cultivars that are resilient, productive, and commercially valuable, meeting both growers' and consumers' needs.

3.8. The role of parent varieties in the improvement of strawberries and berries

Plant breeding is a vital tool in modern agriculture, aiming to develop new cultivars with improved characteristics**.** For strawberries, blueberries, currants, raspberries, blackberries, and gooseberries, breeders select parent varieties carefully to combine desirable traits such as fruit quality, yield, disease resistance, and adaptability. The choice of parents plays a decisive role in shaping the success of breeding programs.

Strawberries (*Fragaria* × *ananassa*) are among the most widely cultivated berries. Varieties such as 'Sunrise', 'Gorella', 'Earlyglow', 'Cardinal' and'Clery' are used in breeding due to their large, flavorful fruits, early ripening, or uniformity. Some varieties, like 'Gorella'and'Redgauntlet' are valued for their resistance to diseases and high productivity, making them ideal paternal parents. In strawberry breeding, maternal parents are often chosen for fruit quality, aroma, and size, while paternal parents are selected for resistance traits and vigor [7, 8]. This complementarities ensures that the resulting hybrids combine the best features of both parents [9].

Blueberries(*Vaccinium spp.*), including varieties like 'Bluecrop', 'Blueray', 'Spartan' and 'Chandler' are primarily valued for fruit size, anthocyanin content, and resistance to cold and diseases**.** Maternal parents in blueberry breeding are typically those with large, flavourful berries, while paternal parents contribute productivity and resilience. By combining these traits, breeders create new cultivars adapted to different climates and with superior fruit quality [10].

Currants (*Ribes spp.*)**,** such as 'Tsema', 'Kantata 50', 'Rouge de Versailles', and 'Ruben' are selected for fruit color, taste, yield, and disease resistance. Maternal parents contribute to the aroma and visual appeal of berries, while paternal parents improve resistance and productivity, enabling the development of new, robust cultivars suitable for commercial production.

Raspberries (*Rubus idaeus*), including varieties like 'Heritage', 'Cayuga', 'Rubin' and 'Viking' are valued for fruit size, aroma, productivity, and remontant (double-harvest) ability. Maternal parents are chosen for fruit quality and size, while paternal parents contribute resistance to fungal diseases and environmental adaptability. Modern raspberry breeding focuses on creating cultivars with extended harvest periods and superior taste.

Blackberries (*Rubus fruticosus*)**,** such as 'Darrow', are primarily used as maternal parents due to their large, flavorful fruits, which are desirable for breeding new cultivars with improved fruit quality and aroma.

Gooseberries (*Ribes uva-crispa),* including 'Malahit', 'Invicta', 'Hinnomaki'and 'Verda'are used in breeding to combine fruit quality**,** disease resistance**,** and high productivity. Maternal parents are selected for taste and uniformity, while paternal parents strengthen resistance and yield potential**.**

As a result of breeding program, over 30 cultivars were registered, of which 7 strawberry, 9 blueberry, 6 black currant, 5 raspberry and 2 blackberry.

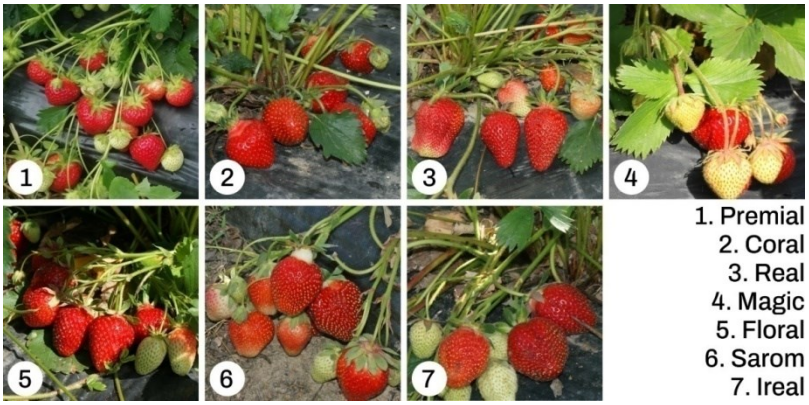


Photo 6. Strawberry cultivars registered

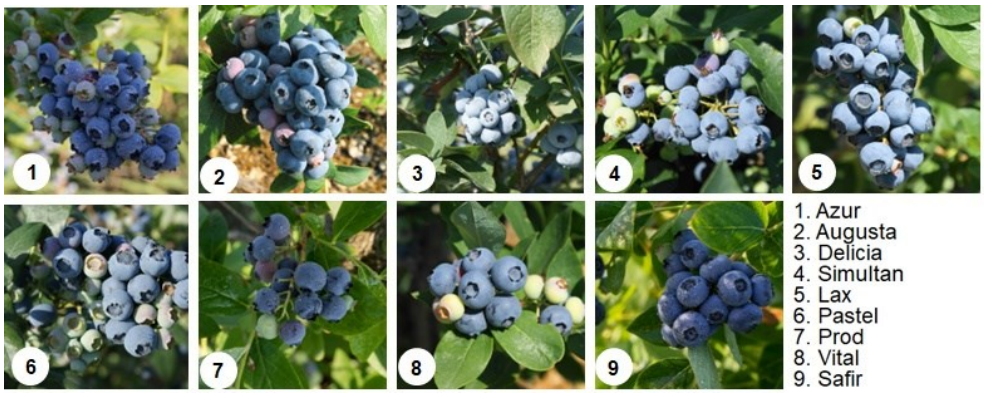


Photo 7. Blueberry cultivars registered

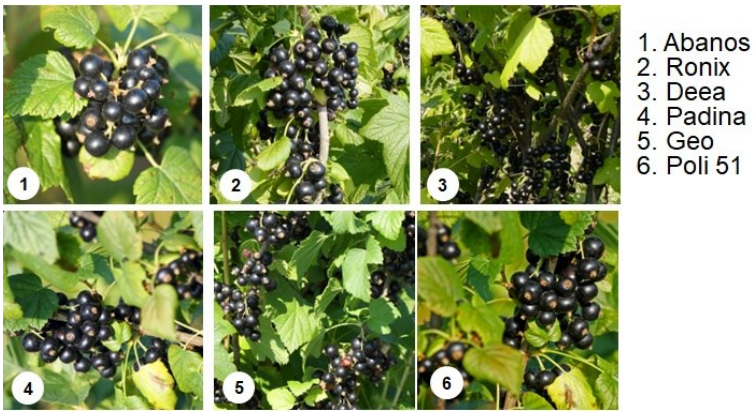


Photo 8. Black currant cultivars registered

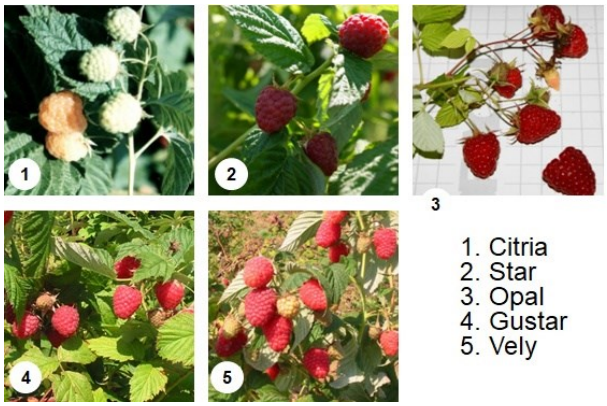
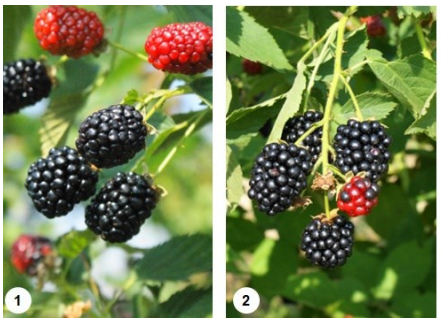


Photo 9. Raspberry cultivars registered



1. Dar 8
2. Dar 24

Photo10. Blackberry cultivars registered

Conclusions

1.Over a period of 15 years, a wide assortment of fruit tree species, berry and strawberries has been developed at the ICDP Pitești, reflecting extensive scientific research. The experimental fields provide a rich genetic material, serving as a foundation for the continued work in fruit breeding and genetic improvement.

2.The thematic plan for the implementation of the ASASStrategy for Research – Development – Innovation in Fruit Growing for the period 2021–2027 ensures the continuation of scientific research through proposed projects and experiments, including: creation of genetic variability and expansion of the selection base by obtaining large and diverse hybrid progenies; improvement of selection technology using molecular markers to accelerate the development of new cultivars; use of molecular techniques to identify resistance genes, enhancing the efficiency of breeding programs.

3.These efforts provide the basis for the development of superior cultivars, combining productivity, fruit quality, and resistance to diseases, while also shortening the time needed to release a new variety. The integration of traditional breeding with molecular tools positions ICDP Pitesti as a leading centre in modern fruit breeding.

4.Selection from the wild flora continues to offer opportunities for identifying and utilizing valuable genotypes that are well adapted both to local soil conditions and to climate change.

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