Fruit Growing Research, Vol. XXXVII, 2021 DOI 10.33045/fgr.v37.2021.01
https://publications.icdp.ro/index.php

SOIURI DE PRUN UTILIZATE CA GENITORI ÎN PROGRAMUL DE AMELIORARE DIN ROMÂNIA

PLUM CULTIVARS USED AS PARENTS IN ROMANIAN BREEDING PROGRAM

Butac Mădălina
Research Institute for Fruit Growing Pitesti, Romania

Abstract

There are about three thousand varieties belonging to *Prunus domestica* available at present worldwide that can be used as genitors in plum breeding activity. An analysis of the pedigrees of plum cvs. developed in Romanian breeding programs shows that the most are descended from 'Tuleu gras', 'Renclod Althan', 'Anna Späth', 'Stanley' and 'Early Rivers', called 'ancestors'. That means the majority of plum cvs. have at least one of the ancestors as parent or grandparent. For those 40 plum cvs. registered in Romania in 60 years an increased number of crosses with these 'ancestors' has led to what we call 'inbreeding'. According to data presented in this paper, 'Tuleu gras' cv. was the most frequently used parent in the cross combinations, giving origin to 23 cvs. Among the other frequently used genitors were: 'Renclod Althan' (7 cvs.), 'Anna Späth' (3 cvs.) and 'Stanley' (1 cv.). Many of the cultivars – 32 altogether (80%) have originated from hybridization, whereas 4 cvs. have originated from open pollination, others 3 cvs. from mutagenesis and 1 cv. from clonal selection. The goal of this work is to measure genetic diversity presently use in Romanian plum breeding. Pedigrees of each cv. were used to study the genetic contributions of ancestor. Of the 40 cvs. analyzed, 33 had an inbreeding coefficient other than zero. The overall mean inbreeding coefficient was 0.419 for all cvs., where their parentages were known. For cvs. with unknown parentage (nonrelated with known parentage) the inbreeding coefficient is zero. The mean coefficient of coancestry of 40 plum cvs. are 0.081 with 'Tuleu gras' cv., 0.019 with 'Renclod Althan' and 'Anna Späth' cvs., 0.017 with 'Early Rivers' cv., 0.014 with 'd'Agen' and 'Renclod Violet' cvs. and 0.005 with Stanley cv. In conclusion, plum breeders have worked with populations of greatly reduced genetic diversity and this strategy becomes a problem because it leads to genetic impoverishment, and, also, the loss of the genetic resistance to different diseases.

Cuvinte cheie: prun, ameliorare, consangvinizare, strămoși, diversitate genetică.
Key words: plum, breeding, inbreeding, ancestors, genetic diversity.

1. Introduction

European plum (*Prunus domestica* L.) is one of the most widespread species in the temperate regions, after the apple, pear and peach (Butac, 2020). The origin place of this species is Caucasus Mountains near the Caspian Sea (Milosevič and Milosevič, 2018). This species grown in cooler areas can be divided in several groups considering the fruit characters: plumes, prunes, greengages (Reineclaudes) and mirabelles (Butac, 2020, Hartmann and Neumüller, 2009). Many researchers suggested that *Prunus domestica* (2n = 6x = 48, genome formula CCSSSS) is genetically a hybrid between diploid cherry plum (*Prunus cerasifera* Ehrh. 2n =2x = 16, genome formula CC) and tetraploid sloe or blackthorn (*Prunus spinosa* L., 2n = 4x = 32, genome formula SSSS) based on the fact that these species grow together in the Caucasian forests and can naturally hybridize with each other (Butac et al., 2019; Butac, 2020; Crane and Lawrence, 1934; Milosevič and Milosevič, 2018; Neumüller, 2011). The origin of *Prunus domestica* remains somehow mysterious. There are three subspecies within *Prunus domestica*: ssp. *insititia* (mirabelles and so called "Spilinge"), ssp. *oeconomica* (prunes) and ssp. *italica* (plums, Reineclaudes and all other kinds of plum fruits) (Butac, 2010; Neumüller, 2011).

Today, more than 6,000 cvs. have been reported, but in commercial plantations around the world are spread only a few varieties, namely 'Stanley', 'Anna Späth', 'Renclod Althan', 'Early Rivers', and 'd'Agen'.

Recently, the genetic diversity of fruit trees and therefore a European plum has decreased, due to its sensitivity to *Plum Pox* virus on the one hand and due to the use in breeding works of a small number of parents on the other hand (Lansari et al., 1994).

In Romania, during 60 years of breeding work, over 2,000,000 plum flowers were pollinated, thousand hybrids were obtained and finally 40 new plum cvs. were registered. The objectives of plum breeding programs have mainly focused on: improvement of old cvs. 'Tuleu gras', 'Grase românești', 'Vinete românești', fruit quality, resistance or tolerance to PPV, ripening season extension, productivity and self fertility (Butac et al., 2010; Butac et al., 2013; Butac, 2020). Almost the cvs. created in Romania

are descended from 'Tuleu gras', 'Renclod Althan', 'Anna Späth', 'Stanley' and 'Early Rivers', called 'ancestors'. That means the majority of plum cvs. have at least one of the ancestors as parent or grandparent. For those 40 plum cvs. registered in Romania in 60 years an increased number of crosses with these 'ancestors' has led to what we call 'inbreeding'.

The consequences of inbreeding for *Prunus domestica* are difficult to predict, as it has several characteristics that may mitigate inbreeding depression, including the capacity for both cross pollination and self fertility. Generally, self fertility species have lower levels of inbreeding depression than cross pollination species (DeBuse et al., 2005).

The goal of this work is to measure genetic diversity presently use in Romanian plum breeding. Pedigrees of each cultivar were used to study the genetic contributions of ancestors for those 40 plum cvs. registered.

2. Material and methods

Pedigrees of 40 plum cvs. registered in Romania were collected from breeding records and published sources (Braniste et al., 2007; Butac, 2010, 2013, 2019, 2020; Ștefan et al., 2018) (Tables 3, 4, 5, 6).

The inbreeding coefficient (F) was calculated according to the following formula (Wright, 1922):

$F = \Sigma [(1/2)^{n_1+n_2+1}(1 + F_A)]$

Where:

n_1 = number of generations from one parent back to the common ancestor;

n_2 = number of generations from other parent back to the common ancestor;

F_A = inbreeding coefficient of the common ancestor

The inbreeding coefficient (F) is defined as the probability that two genes at any locus in an individual are replicates of one and the same gene in a previous generation. These genes are said to be „identical by descent" (Wright, 1922).

Considering that the most plum cvs. are forced to cross-pollinate due to self-sterility or male-sterility, all parents of unknown origin were assumed non-inbred and unrelated.

All cvs. obtained by open pollination were assumed to be non-inbred and unrelated to the pollen of parents.

The coancestry coefficient of perspective progeny of two individuals is equal to one half the covariance of the parents. Common coancestry coefficient are 0.500 for self-pollination, 0.250 for parent – offspring and full sib-matings, 0.125 for half-sib matings and 0.063 for first-cousin matings (Alspach, 1976; DeBuse et al., 2005; Lansari et al., 1994; Noiton and Alspach, 1996).

The degree of relationship of those cvs. with the seven 'ancestor' ('Tuleu gras', 'Stanley', 'Renclod Althan', 'Anna Späth', 'Early Rivers', 'd'Agen', 'Renclod Violet') was investigated by calculation of the individual coefficient of coancestry of each of them with the 40 Romanian cvs.

3. Results and discussions

Coancestry coefficient

The mean coefficient of coancestry of 40 plum cvs. are 0.081 with 'Tuleu gras' cv., 0.019 with 'Renclod Althan' and 'Anna Späth' cvs., 0.017 with 'Early Rivers' cv., 0.014 with 'd'Agen' and 'Renclod Violet' cvs. and 0.005 with Stanley cv. (Table 1).

The mean coancestry coefficient of the most cvs. used as genitors in Romanian breeding program was 0.007, ranged from 0.000 to 0.125 (Table 2). The mean coancestry was low compared with other coancestry reported in plums by Byrne in 1989 (0.069 to 0.080), in peaches by Scorza et al. in 1985 (0.023 to 0.208; 0.034 to 0.330), in sweet cherry for self-compatible cultivars by Choi and Kappel in 2004 (0.102 to 0.256), in apple by Noiton and Alspach in 1996 (average 0.051, range 0.017 to 0.088) and by Militaru et al. in 2019 (0.003 to 0.105).

Inbreeding coefficients (F)

The inbreeding problem and potential genetic limitation have been raised for numerous other fruit species (apple, sweet cherry, peach and almond) (Choi and Kappel, 2004; Lansari et al., 1994; Noiton and Alspach, 1996; Scorza et al., 1988).

Of the 40 cvs. analyzed, 33 cvs. had an inbreeding coefficient other than zero (Tables 3, 4, 5, 6). The overall mean inbreeding coefficient was 0.419 for all cvs., where their parentages were known. For cvs. with unknown parentage (nonrelated with known parentage) the inbreeding coefficient is zero.

The inbreeding coefficient of cvs. for case I (one ancestor 'Tuleu gras' or his progeny) was 0.387, ranged from 0.000 (for 'Albatros', 'Tita' and 'Alina' cvs.) to 0.500 (for most cvs.) (Table 2).

For cases II (one ancestor 'Grase românești') and III (one ancestor 'Vinete românești') the inbreeding coefficient was 0.500 (Tables 3 and 4).

Inbreeding coefficient of cvs. for case IV (different ancestors) was 0.290, ranged from 0.000 (for 'Record', 'Andreea', 'Agent' and 'Matilda' cvs.) to 0.500 (for most cvs.) (Table 5).

An analysis of the pedigrees of plum cvs. developed in Romanian breeding program shows that the most are descended from 'Tuleu gras', 'Renclod Althan', 'Anna Späth', 'Stanley' and 'Early Rivers', called 'ancestors'. That means they have at least one of these plums in their family, as a parent, grandparent, brother or cousin.

For example, 'Piteștean' cv. (registered by Research Institute for Fruit Growing Pitești) has as ancestors in its family 'Tuleu gras', 'Peche', 'Tuleu timpuriu' and 'Early Rivers' (Fig. 1). 'Geta' cv. (registered by Research Station for Fruit Growing Bistrița) has as ancestors in its family 'Tuleu gras', 'Renclod Althan', 'Centenar', 'Ialomița' (once) and 'Early Rivers' (twice) (Fig. 2)., 'Romanța' cv. (registered by Research Institute for Fruit Growing Pitești) has as ancestors in its family 'd'Agen', 'Grand Duke', 'Stanley', 'Wilhelmina Späth', 'Vâlcean' (once), 'Renclod Althan' and 'Early Rivers' (twice) (Fig. 3).

For those 40 plum cvs registered in Romania in the 60 years of breeding an increased number of crosses with these ancestors has led to what we call 'inbreeding'.

According to the data presented in this paper, 'Tuleu gras' cv. and its descendents were the most frequently used parents in the cross combinations, giving origin to 23 cvs.

Other genitors frequently used in breeding were: 'Renclod Althan' (7 cvs.), 'Anna Späth' (3 cvs) and 'Stanley' (1 cv.).

Regarding other ancestors in origin of the cvs., we can see that a significant share has the following cvs.: 'Early Rivers', 'd'Agen', 'Wilhelmina Späth' and 'Renclod violet'.

Many of the cvs. – 32 altogether (80%) have originated from hybridization, whereas 4 cvs. have originated from open pollination, others 3 cvs. from mutagenesis and 1 cv. from clonal selection.

4. Conclusions

In Romania, plum breeders have worked with populations of greatly reduced genetic diversity and this strategy becomes a problem because it leads to genetic impoverishment, and, also, the loss of the genetic resistance to different diseases, especially to *Plum Pox* virus.

The results suggest that the repeated use of the same ancestors have narrowed the genetic base of plum breeding. As the gene pool gets narrower the genetic gain becomes also narrow.

Redundant use of the same parents and their progeny can greatly limit long-term progress in plum breeding programs.

For continued improvement of commercial traits of plum the genetic diversity should be maximized because it enhances the genetic gain. Possible methods to accomplish this include using more diverse parents in crossing.

So, these results indicate that pedigrees should be carefully examined before selecting the parents for future cross combinations.

Acknowledgments

This work was supported by the Romanian Ministry of Agriculture and Rural Development, project ADER 7.2.2/2019.

References

1. Alspach P.A., 1976. Computation of inbreeding coefficients from stored pedigree data using Malecot's method. MS thesis, Univ. of York, England.
2. Branişte N., Budan S., Butac Mădălina, Militaru Mădălina, 2007. Soiuri de pomi, arbuşti fructiferi şi căpşuni create în România (in Romanian). Ed. Paralela 45, Piteşti; ISBN 978-973-47-0177-3, 476 pp.
3. Butac M., 2010. Ameliorarea prunului (in Romanian). Ed. Univeristatii din Pitesti. 101 pp.
4. Butac, M., Zagrai, I., Botu, M., 2010. Breeding of new plum cultivars in Romania. Acta Hortic. 874: 51-58.
5. Butac M., Bozhkova V., Zhivondov A., Milosevic N., Bellini E., Nencetti V., Blazek J., Balsemin E., Lafarque B., Kaufmane E., Gravite I., Vasiljeva M., Pintea M., Juraveli A., Webster T., Hjalmarsson I., Trajkovski V., Hjeltnes S.H., Lakatos T., 2013. Overview of plum breeding in Europe. Acta Hortic. 981: 91-98.
6. Butac M., Botu M., Militaru M., Mazilu Cr., Duțu I., Nicolae S., 2019. Plum Germplasm and Breeding in Romania. Proceedings of the Latvian Academy of Sciences Section B., Vol. 73 (2019), No. 3 (720): 214-219.
7. Butac M., 2020. Plum breeding. In: *Prunus*. Intech Open, London, United Kingdom (Open Access books); Indexed in Web of Science Core Collection.

8. Byrne D.H., 1989. Inbreeding, coancestry and founding clones of Japanese-type plums of California and the Southeastern United States. J. Amer. Soc. Hort. Sci. 114: 699-705.
9. Choi C. and Kappel F., 2004. Inbreeding, coancestry and founding clones of sweet cherries from North America. J. Amer. Soc. Hort. Sci 129 (4): 535-543.
10. Crane, M.B. and Lawrence, W.J.C., 1934. The genetics of garden plants. MacMillan and Co., Ltd., London, UK.
11. DeBuse C., Shaw D., DeJong T., 2005. Response to inbreeding of seedling traits in a *Prunus domestica* L. breeding population. J. Amer. Soc. Hort. Sci. 130 (6): 904-911.
12. Hartmann W. and Neumüller M., 2009. Plum Breeding. In "Breeding Plantation Tree Crops: Temperate Species. Edited by Jain S.M., Priyadaeshan P.M., Ed. Springer: 161-231.
13. Lansari A., Kester D., Iezzoni A., 1994. Inbreeding, coancestry and founding clones of almonds of California, Mediterranean Shores, and Russia. J. Amer. Soc. Hort. Sci. 119 (6): 1279-1285.
14. Militaru M., Sestraș A., Călinescu M., Mareși E., Mihăiescu C., 2019. Genetic diversity of Romanian apple cultivars released in the last 20 years. Fruit Growing Research, vol XXXV: 6-12.
15. Milosevič T. and Milosevič N., 2018. Plum (*Prunus* spp.) breeding. Chapter 5. In: Advances in Plant Breeding Strategies: Fruits. Springer International Publishing AG, part of Springer Nature 2018: 165-215.
16. Neumüller M., 2011. Fundamental and applied aspects of plum (*Prunus domestica*) Breeding. In: Fruit, Vegetable and Cereal Science and Biotechnology. Global Science Books: 139-156.
17. Noiton D.A.M. and Alspach P.A., 1996. Founding clones, inbreeding, coancestry and status number of modern apple cultivars. J. Amer. Soc. Hort. Sci. 121 (5): 773-782.
18. Scorza R., Mehlenbacher S.A., Lightner G.W., 1985. Inbreeding and coancestry of freestone peach cultivars of the Eastern United States and implications for peach germplasm improvement. J. Amer. Soc. Hort. Sci. 110: 547-552.
19. Ștefan N., Glăman Gh., Braniște N., Stănică F., Duțu I., Coman M., ……., Butac M., 2018. Pomologia României. Vol. IX – Soiuri noi de măr, păr, gutui, cireș, vișin, prun și cais create în România (in Romanian). Ed. Ceres, București, 1043 pp.
20. Wright S., 1922. Coefficients of inbreeding and relationship. Amer. Natl. 56: 330 – 338.

Tables and Figures

Table 1. Coancestry coefficients with 'Tuleu gras', 'Renclod Althan', 'Early Rivers', 'Anna Späth', 'Stanley', 'd'Agen' and 'Renclod violet' of 40 cvs. released from Romanian breeding programs

No.	Cultivar	Coefficient of coancestry with						
		Tuleu gras	Renclod Althan	Early Rivers	Anna Späth	Stanley	d'Ágen	Renclod Violet
1	Tuleu timpuriu	0.063	0.000	0.000	0.000	0.000	0.000	0.000
2	Superb	0.063	0.000	0.000	0.000	0.000	0.000	0.000
3	Tuleu dulce	0.063	0.000	0.000	0.000	0.000	0.063	0.000
4	Centenar	0.063	0.000	0.063	0.000	0.000	0.000	0.000
5	Albatros	0.500	0.000	0.000	0.000	0.000	0.000	0.000
6	Dambovița	0.063	0.000	0.000	0.063	0.000	0.000	0.000
7	Piteștean	0.250	0.000	0.063	0.000	0.000	0.000	0.000
8	Carpatin	0.063	0.000	0.063	0.000	0.000	0.000	0.000
9	Minerva	0.250	0.000	0.063	0.000	0.000	0.000	0.000
10	Flora	0.063	0.000	0.000	0.000	0.000	0.000	0.063
11	Sarmatic	0.250	0.000	0.063	0.000	0.000	0.000	0.000
12	Bărăgan 17	0.063	0.000	0.063	0.000	0.000	0.000	0.000
13	Tita	0.500	0.000	0.000	0.000	0.000	0.000	0.000
14	Alina	0.500	0.000	0.000	0.000	0.000	0.000	0.000
15	Iulia	0.063	0.063	0.000	0.000	0.000	0.000	0.000
16	Ivan	0.063	0.000	0.000	0.000	0.000	0.000	0.000
17	Jubileu 50	0.063	0.000	0.000	0.000	0.000	0.000	0.000
18	Roman	0.063	0.000	0.063	0.000	0.000	0.000	0.000
19	Dani	0.063	0.000	0.000	0.000	0.000	0.000	0.000
20	Geta	0.063	0.063	0.063	0.000	0.000	0.000	0.000
21	Romaner	0.063	0.063	0.000	0.000	0.000	0.000	0.000
22	Elena	0.063	0.000	0.000	0.000	0.063	0.000	0.000
23	Topval	0.063	0.000	0.000	0.000	0.063	0.000	0.000
24	Gras ameliorat	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	Vinete românești 300	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26	Silvia	0.000	0.063	0.063	0.000	0.000	0.000	0.000
27	Pescaruș	0.000	0.063	0.000	0.000	0.000	0.000	0.000
28	Ialomița	0.000	0.063	0.063	0.000	0.000	0.000	0.000
29	Diana	0.000	0.063	0.063	0.000	0.000	0.000	0.000
30	Record	0.000	0.000	0.000	0.000	0.000	0.000	0.500
31	Vâlcean							
32	Renclod de Caransebeș	0.000	0.063	0.000	0.000	0.000	0.000	0.000
33	Andreea	0.000	0.000	0.000	0.000	0.000	0.000	0.000
34	Delia	0.000	0.000	0.000	0.063	0.000	0.000	0.000
35	Agent	0.000	0.000	0.000	0.000	0.000	0.000	0.000
36	Doina	0.000	0.063	0.000	0.063	0.000	0.000	0.000
37	Matilda	0.000	0.000	0.000	0.500	0.000	0.500	0.000
38	Zamfira	0.000	0.063	0.000	0.063	0.000	0.000	0.000
39	Alutus	0.000	0.125	0.000	0.000	0.000	0.000	0.000
40	Romanța	0.000	0.000	0.000	0.000	0.063	0.000	0.000
	Average	**0.081**	**0.019**	**0.017**	**0.019**	**0.005**	**0.014**	**0.014**

Table 2. Coancestry coefficients of cvs. used as genitors in plum cross combinations released in Romania

No.	Cultivar	Coancestry coefficient
1	Tuleu gras	0.000
2	Stanley	0.063
3	Anna Späth	0.000
4	Early Rivers	0.000
5	d'Agen	0.000
6	Renclod Althan	0.000
7	Renclod violet	0.000
8	Wilhelmina Späth	0.000
9	Abbaye d'Arton	0.000
10	Peche	0.000
11	Vânăt de Italia	0.000
12	Grase românești	0.000
13	Vinete românești	0.000
14	De Bistrița	0.000
15	Centenar	0.063
16	Tuleu timpuriu	0.063
17	Vâlcean	0.125
	Average	**0.007**

Table 3. Parentage of plum cvs. released in Romania (one ancestor 'Tuleu gras' or descendents of 'Tuleu gras') and inbreeding coefficient – case I

No.	Cultivar	Reported parentage	Year released	Inbreeding coefficient (F)
1	Tuleu timpuriu	Tuleu gras [a] x Peche [a]	1967	0.500
2	Superb	Tuleu gras [a] x Abbaye d'Arton [a]	1968	0.500
3	Tuleu dulce	Tuleu gras [a] x d'Agen [a]	1968	0.500
4	Centenar	Tuleu gras [a] x Early Rivers [a]	1978	0.500
5	Albatros	Tuleu gras o.p	1979	0.000
6	Dambovița	Tuleu gras [a] x Anna Späth [a]	1981	0.500
7	Pitești an	Tuleu timpuriu [b] x Early Rivers [a]	1982	0.375
8	Carpatin	Tuleu gras [a] x Early Rivers [a]	1982	0.500
9	Minerva	Tuleu timpuriu [b] x Early Rivers [a]	1984	0.375
10	Flora	Tuleu gras [a] x Renclod Violet [c]	1989	0.500
11	Sarmatic	Tuleu timpuriu [b] x Early Rivers [a]	1989	0.375
12	Baragan 17	Tuleu gras [a] x Early Rivers [a]	1990	0.500
13	Tita	Tuleu gras [d] – irradiated stones	1991	0.000
14	Alina	Tuleu gras [d] – irradiated stones	1991	0.000
15	Iulia	Tuleu gras [a] x Renclod Althan [a]	2002	0.500
16	Ivan	Tuleu gras [a] x Vânăt de Italia [a]	2003	0.500
17	Jubileu 50	Tuleu gras [a] x De Bistrița [a]	2003	0.500
18	Roman	Tuleu gras [a] x Early Rivers [a]	2004	0.500
19	Dani	Tuleu gras [a] x Grase românești [a]	2004	0.500
20	Geta	Centenar [e] x Ialomița [f]	2004	0.250
21	Romaner	Tuleu gras [a] x Renclod Althan [a]	2005	0.500
22	Elena	Tuleu gras [a] x Stanley [g]	2005	0.266
23	Topval	Tuleu gras [a] x Stanley [g]	2010	0.266
	Average			**0.387**

[a] Unknown parentage;
[b] Tuleu timpuriu = Tuleu gras x Peche;
[c] Renclod violet = Stones of Renclod verte;
[d] Tita and Alina = irradiated stones
[e] Centenar = Tuleu gras x Early Rivers;
[f] Ialomița = Renclod Althan x Early Rivers;
[g] Stanley = d'Agen x Grand Duke;
o.p. = open-pollinated.

Table 4. Parentage of plum cv. released in Romania (one ancestor 'Grase românești') and inbreeding coefficient – case II

No.	Cultivar	Reported parentage	Year released	Inbreeding coefficient (F)
1	Gras ameliorat	Grase românești[a] self pollination	1968	0.500

[a] Unknown parentage.

Table 5. Parentage of plum cv. released in Romania (one ancestor 'Vinete romanesti') and inbreeding coefficient – case III

No.	Cultivar	Reported parentage	Year released	Inbreeding coefficient (F)
1	Vinete românești 300	Vinete românești [a] selection	1970	0.500

[a] Unknown parentage.

Table 6. Parentage of plum cvs. released in Romania (different ancestors) and inbreeding coefficient – case IV

No.	Cultivar	Reported parentage	Year released	Inbreeding coefficient (F)
1	Silvia	Renclod Althan [a] x Early Rivers [a]	1979	0.500
2	Pescaruș	Renclod Althan [a] x Wilhelmina Späth [a]	1979	0.500
3	Ialomița	Renclod Althan [a] x Early Rivers [a]	1981	0.500
4	Diana	Renclod Althan [a] x Early Rivers [a]	1983	0.500
5	Record	Renclod violet o.p.	1983	0.000
6	Vâlcean	H 8/12 (R.C. Althan [a] x Wilhelmina Späth [a]) x H 5/23 (R.C. Althan [a] x Early Rivers [a])	1990	0.133
7	Renclod de Caransebeș	Renclod Althan [a] x Wilhelmina Späth [a]	1991	0.500
8	Andreea	H 27/87 [a] o.p	2000	0.000
9	Delia	Vânăt de Italia [a] x Anna Späth [a]	2002	0.500
10	Agent	Open pollination	2004	0.000
11	Doina	Anna Späth [a] x Renclod Althan [a]	2004	0.500
12	Matilda	Anna Späth [a] x d'Agen [a] – irradiated with Co^{60}	2004	0.000
13	Zamfira	Anna Späth [a] x Renclod Althan [a]	2005	0.500
14	Alutus	(R.C. Althan [a] x Early Rivers [a]) x (R.C. Althan [a] x Wilhelmina Späth [a]) x mixed pollen	2010	0.133
15	Romanța	Stanley [b] x Vâlcean [c]	2012	0.078
	Average			**0.290**

[a] Unknown parentage;
[b] Stanley = d'Agen x Grand Duke;
[c] Vâlcean = H 8/12 (R.C. Althan x Wilhelmina Späth) x H 5/23 (R.C. Althan x Early Rivers);
o.p. = open-pollinated.

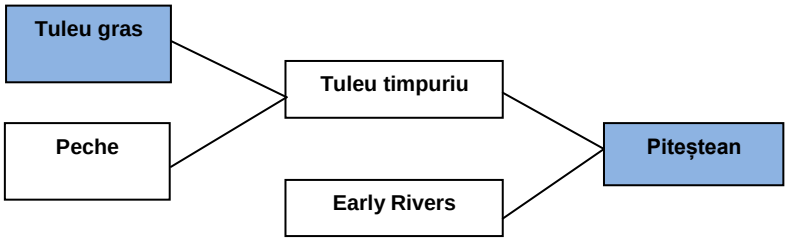

Fig. 1. 'Piteștean' cv. with gene accumulation from four 'ancestors'

 DOI 10.33045/fgr.v37.2021.01

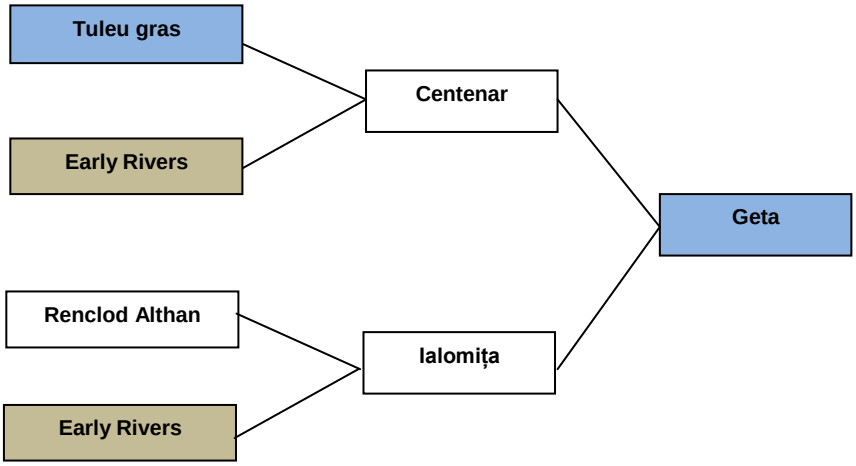

Fig. 2. 'Geta' cv. with gene accumulation from five 'ancestors': once 'Tuleu gras' and 'Renclod Althan', twice 'Early Rivers'

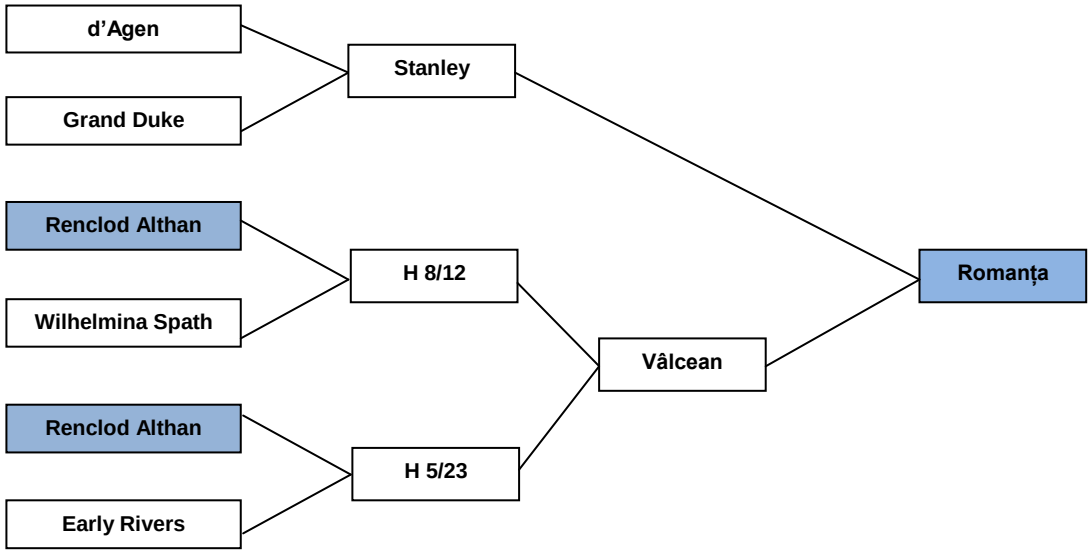

Fig. 3. 'Romanța' cv. with gene accumulation from nine 'ancestors': once 'd'Agen', 'Grand Duke', 'Wilhelmina Späth', 'Early Rivers' and twice 'Renclod Althan'