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Comparative Study on the Behavior of Some Old Apple Varieties before and after Their Grafting, with Potential for Use in Urban Horticulture

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Abstract: Urban horticulture has to respond to several challenges, including reducing the growth vigor of the scion/rootstock combination, adapting the cultivated species/variety to the pedoclimatic conditions—more varied in recent years, and increasing tolerance to diseases and pests that cause extensive qualitative and quantitative damage to fruit production. For this experiment, 15 old apple varieties were chosen, all known and cultivated in the Banat area, which were grafted on the MM106 rootstock. Several parameters were analyzed that can be used for a relevant classification for planting them in limited spaces, such as in a private garden. Our research started 10 years ago and has already resulted in a doctoral thesis that extensively presents the data taken from the initial biological material and the first two years after grafting the trees; the research continued and is still ongoing in the experimental orchard. From the multitude of aspects studied, we have chosen to present some results related to the vigor of the scion/rootstock combination, the quality of the fruits, their content in acidity as well as the behavior with respect to diseases and pests—results that can be useful to those who want to grow old apple varieties in their own garden. Growth vigor was reduced in most varieties, but the highest influence of the rootstock on growth was observed in the 'Bănățenesc' variety, followed by 'Jonathan de Munte' and 'Caslere'. Grafting and agrotechniques had a positive influence on the fruit mass in all cultivars, except 'Crețesc', with an experimental average of 163.35 g, namely 60.56 g higher on average than that of the original biological material. After grafting, the SSC was between 10.05 °Brix in the 'Curcubătoase' variety and 18.48 °Brix in 'Parmen Auriu', with an experimental average of 14.96 °Brix. The fruit acidity oscillated between 0.13 g/100 g in 'Florănești' and 'Pătul' varieties and 0.46 g/100 g in 'Domnesc', with an experimental average of 0.25 g/100 g.

Keywords: *Malus domestica*; grafting; vigor; fruit quality

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1. Introduction

Urban gardening with tree species with a certain habitus or performance allows for greening that is either horizontal or vertical, permanent or temporary, stationary or mobile, and that influences the climate, adaptation to and mitigation of climate change, human involvement, socialization, food supply, damage reduction and environmental conservation. Although gardens as socialization spaces have been known since antiquity, urban gardening experienced its greatest growth in the 19th century, during the Industrial Revolution, which is known for the massive migration of villagers to cities. At the start of the 20th century, some utopian initiatives and ideas emerged as a result of this. One of

the first to promulgate urban gardening was Howard Ebenezer who, in his major work "Garden cities of tomorrow" (first published in 1898), proposed the establishment of garden cities as a new type of settlement that should combine the benefits of rural and urban life, and provide a solution to the issues caused by accelerated urbanization [1].

Research looks at numerous nature-based solutions that enable safe, successful and sustainable urban fruit production, through careful selection of species and cultivars with naturally inherited resistance/tolerance to a particular disease/pathogen and pest, along with the use of biopesticides that can be applied on the outside.

North et al. [2] considered that human health is related to environmental health and that trees are important organisms that contribute to urban environments. Some of the benefits provided by trees include: improved air quality, carbon sequestration, reduced energy use, increased property values, and reduced stormwater discharge [3–5]. Some researchers consider that urban trees have a positive cultural impact by improving the quality of life of those who live near trees, and another researcher argues that in areas covered with mature trees, crime can be reduced [6,7].

Among fresh fruits, apples are the most frequently consumed, being recognized as a rich source of carbohydrates, vitamins, minerals, fibers, pectins and different classes of polyphenols, all of which contribute to improving the health of the human body [8–11]. The relative content of different chemical compounds in a fruit, and the fruit's nutritional value, depends on its genotype, the structure of the tissues, the ripening of the fruit, the pedoclimatic conditions and the culture technology applied, but also on the conditions of harvesting and storing it [12–19]. Old varieties and local populations come with a series of deficiencies regarding character variability, high growth vigor, and sometimes in fruit appearance or sensitivity to particular diseases or pests. However, many researchers consider that these deficiencies can be mitigated, and this is why the existing apple germplasm deserves renewed attention and to be thoroughly studied [20–23].

2. Materials and Methods

2.1. Plant Material and Growth Conditions

The present work was intended to be a comparative study carried out on 15 old apple varieties collected from the Banat area, regarding their behavior in situ and after their grafting in the orchard.

In order to achieve the proposed objectives, important old apple varieties from the most representative areas of Banat were studied regarding their traditional cultivation: in Timiș county Berini locality (45°39′7″ N/21°25′44″ E); in Hunedoara county, localities: Zeicani (42°28′42″ N/22°44′48″ E), Peștenita (45°34′44″ N/22°48′20″ E) and Ohaba Ponor (45°30′54″ N/23°05′33″ E); in Caraș Severin county, the localities: Vârciorova (45°19′37″ N/22°21′7″ E) and Mehadica (44°57′09″ N/22°23′03″ E).

The old apple varieties studied according to the area of origin were: 'Măr Dulce Amar' (Berini), 'Bănățenesc', 'Pătul', 'Parmen Auriu' (Zeicani), 'Domnesc', 'Curcubătoase', 'Vițate', 'Botu Oii' (Peștenița), 'Poinic', 'Mustoase', 'Florănești' (Ohaba Ponor), 'Caslere', 'Aore', 'Crețesc' (Vârciorova) and 'Jonathan de Munte' (Mehadica).

The trees from which the biological material was collected for propagation are 30–50 years old and either come from seed or were propagated by grafting, usually on generative, vigorous rootstocks.

The observations regarding the initial biological material took place during three consecutive years, with the consent of the citizens who granted us access to their own yards and who gave us details about the varieties studied.

In 2015, the experiment was established in the Lugoj fruit-tree nursery (45°42′22.1″ N 21°51′36.1″E), a nursery belonging to the University of Life Sciences "King Mihai I" from Timisoara. The grafting of the biological material taken from the apple germplasm was performed in the fall of 2015, using the method of T-budding. MM106 was used as rootstock for the apple species, this being the main rootstock used in Romania notably for the production of saplings intended for commercialization. The rootstock MM106 has a

semi-medium vigor, allows a good induction of cropping for many varieties, and has high productivity and a good anchoring in the soil, which is why it does not require a support system [24,25]. It also behaves well on heavier soils, but the fruits remain somewhat smaller than in the case of grafting on M 9.

For each variety, 10 saplings were grafted, and in the fall of 2016, the grafted trees were planted in their assigned permanent location, forming an experimental plot where the study of apple germplasm from Banat was begun. From this starting point, the ongoing study ensures the conservation, tracking and retention for propagation of the most valuable specimens.

The planting distances in the experimental orchard were 4 m × 2 m and the maintenance technology was the internationally adopted standard one, with the mention that phytosanitary treatments in the period 2020–2022 were much reduced, namely: two winter treatments with Bordeaux mixture—active substances: 20% copper and 80% neutralized copper sulfate—at 2 kg/100 L + Ovipron Top—paraffin oil 96.5 g/kg—at 2.5L/100L; and upon warning, three treatments with biological control products. For the treatments carried out upon warning, the following products were used, in different combinations: Champ (active substances: 500 g/kg metallic copper in the form of copper hydroxide); Antario (active substances: bacillus thuringiensis and abamectin); Thiopron (active substances: 825 g/L sulfur), calcium-polysulfide (active substances: sulfur 18%, calcium hydroxide 10%), Laser (active substance: spinosad 240 g/L) and Ovipron Top (paraffin oil 96.5 g/kg) which can be used against pests during the vegetation period (in smaller doses).

In the present paper, we will present a comparative study of the initial biological material and the one resulting from grafting, through the prism of several parameters, as follows: (a) growth vigor of the tree; (b) external and internal morphological characterization of fruits; (c) soluble solid content and fruit acidity.

We will also present an analysis from the point of view of disease and pest resistance of the grafted varieties, carried out in the period 2020–2022.

The data collected for the initial biological material are expressed as the average of the years 2015–2017, and those of the grafted, planted and cultivated material in the experimental orchard as the average of the years 2020–2022, respectively the year 2023 for the growth vigor of the trees.

2.2. The Vigor of the Tree Material

Vigor is a characteristic expressed by the height, trunk and crown diameter and the intensity of their formation in the first years after planting. Varieties are usually grafted onto different rootstocks so that the vigor of the trees represents the combined action of the two partners (symbionts).

The height of the trees was determined with the topographic electronic leveling rod (NEDO GmbH model, Dornstetten, Germany), the tree height being measured from the ground level to the apex of the highest branch. The collected data were expressed in meters.

Trunk diameter (mm) was determined by measurement; for the initial biological material, the circumference of the trunk was measured and the diameter was calculated with the help of the L = 2ΠIr formula, while for the young trees, the diameter was determined with the help of the digital caliper. The measurements were made 20 cm above the ground.

The diameter of the crown was determined on the basis of the average radius at the base of the crown, measured with the electronic leveling rod of German production. The collected data were expressed in meters.

2.3. External and Internal Characteristics of Fruits

The morphological characterization of the apple fruits involved the determination of their size and mass, of the soluble solid content (SSC) and of fruit acidity.

In order to analyze the specific parameters, 15 fruit samples from each variety were taken from both initial biological material and grafted material, and an average value

for each was determined. The fruits had been collected for examination at their optimal ripening stage.

The measurable elements were determined with the digital caliper (Insize-1108, Loganville, GA, USA) and the mass of the fruits was determined using the analytical balance (Kern PES620-3M, Balingen, Germany).

SSC (%Brix) was determined using the Atago Pal 3870 (Tokyo, Japan), portable refractometer on samples of about 0.3 mL of fresh juice from the analyzed fruits.

Fruit acidity was determined using the volumetric method, by titration of the aqueous extract of a fruit sample with sodium hydroxide solution in the presence of phenolphthalein (as an indicator). The reagents used were of analytical purity (MERCK degree). The results were expressed as g/100 g malic acid.

2.4. The Taste and Commercial Appearance

The taste and commercial appearance of the fruits, before and after grafting, was assessed according to a Tasting sheet by three qualified fruit growers. For the determination of these aspects, the following fruit parameters were evaluated: shape, skin color, pulp color, taste, consistency and aspect.

The taste was appraised through 5 graduations: acidic, slightly acidic, sweet and sour, light sweet and sour, and sweet and bitter; the consistency of the pulp was evaluated according to 7 graduations: crispy, medium crispy, crunchy, medium crunchy slightly crunchy, fondant and soft; and the commercial aspect of the fruit rated as one of three graduations: unattractive, attractive and very attractive.

2.5. Disease and Pest Resistance/Tolerance

Disease and pest resistance/tolerance was monitored over three growing seasons in 2020, 2021 and 2022 on the basis of the main apple tree disease-causing agents and pests. During the experiment, the following disease and pest evaluations were made: apple scab caused by *Venturia inaequalis*, powdery mildew caused by *Podosphaera leucotricha*, monilia caused by *Monilinia fructigena*, codling moth (*Cydia pomonella*), green apple aphid (*Aphis pomi*) and rosy leaf-curling aphid (*Dysaphis devecta*).

Disease and pest resistance/tolerance was monitored in three different phenological growth stages: BBCH 71–72, BBCH 75–77 and BBCH 81–85 [26]. The observations were assessed on individual trees (4 trees/variety) in the Lugoj farm experimental field (45°42′22.1″N 21°51′36.1″E).

In the first investigation period (BBCH 71–72), ten branches of similar maturity were randomly selected from the northern part of the first tree, southern part of the second tree, eastern part of the third tree and western part of the fourth tree (a total of 40 branches for each cultivar), and the infestation level of leaves and fruits was assessed. At the second and third investigation, the branches were selected from different parts than in the previous round. Fruits were harvested after every evaluation.

The detailed 5-point scoring system for each class was as follows:

1—Highly susceptible (HS): Infected/attacked leaf/fruit area is 76–100%;

2—Susceptible (S): Infected/attacked leaf/fruit area is 51–75%;

3—Moderately resistant (MR): Infected/attacked leaf/fruit area is 26–50%;

4—Resistant (R): Infected/attacked leaf/fruit area is 6–25%;

5—Highly resistant (HR): Infected/attacked leaf/fruit area is 1–5%.

Overall scores on the 1–5 scale were awarded based on the complete results, and also separately for every disease and pest investigated for each variety.

2.6. Data Analysis

All the data were analyzed using SPSS 16.0, ANOVA and t-Test (two sample assuming equal variances at confidence level of 95%, $\alpha = 0.05$), on Microsoft Excel.

3. Results

3.1. Trees' Vigor

Vigor is a characteristic expressed by the height, trunk and crown diameter of the trees, and by the intensity of their formation in the first years after planting.

For the initial biological material, we presented the average of the measurements taken in three consecutive years (2015–2017), and for the grafted trees we opted for the measurements from 2023 (8th year after planting).

The values of the trunk diameter (Table 1) of the initial biological material varied between 254.77 mm in the 'Aore' and 'Măr Dulce Amar' varieties and 700.63 mm in the 'Curcubătoase' variety, with an experimental average of 438.63 mm. Eight of the varieties studied had values below the experimental average, while seven varieties were above the average value [27].

Table 1. Trunk diameter differences before and after grafting. Trunk prediction for the grafted material.

Variety	* TD (OBM) 30–50 Year Old Trees mm	TD (after Grafting) 8 Year Old Trees mm	Average Diameter Growth/Year 8 Year Old Trees mm	TD Prediction 30 Year Old Trees mm	TD Prediction Compared to OBM (%)
'Bănățenesc'	445.85	81.75	10.22	306.6	−31.23
'Domnesc'	350.31	91.88	11.49	344.7	−1.60
'Parmen Auriu'	452.22	63.50	7.94	238.2	−47.33
'Curcubătoase'	700.63	90.68	11.34	340.2	−51.44
'Poinic'	541.40	90.75	11.34	340.2	−37.16
'Mustoase'	388.53	98.23	12.28	368.4	−5.18
'Florănești'	668.78	97.31	12.16	364.8	−45.45
'Pătul'	509.55	79.15	9.89	296.7	−41.77
'Vițate'	541.40	69.26	8.66	259.8	−52.01
'Jonathan de Munte'	350.31	77.11	9.64	289.2	−17.44
'Măr Dulce Amar'	254.77	77.01	9.63	288.9	+13.40
'Caslere'	404.45	65.42	8.18	245.4	−39.33
'Aore'	254.77	89.43	11.18	335.4	+31.65
'Crețesc'	366.24	81.20	10.15	304.5	−16.86
'Botu Oii'	350.31	73.83	9.23	276.9	−20.96
Average	438.63	81.77	10.22	306.7	

* Trunk diameter prediction is based on the average growth/year; TD—Trunk diameter; OBM—original biological material.

The trees grafted and planted in the experimental orchard had a trunk diameter between 63.5 mm in the 'Parmen Auriu' variety and 98.23 mm in the 'Mustoase' variety, with an average diameter of 81.77 mm. After grafting, a uniformity of diameter growth can be observed, which is due both to the fact that the trees are of the same age, and to genetics.

Since the diameter of the trunk is a characteristic that is not strongly influenced by the agrotechniques applied, as is the diameter of the crown and the height of the tree, we made a prediction of the evolution of this parameter until the grafted trees in the experiment reach the age of 30 years. It can be observed (Table 1) that for 13 of the 15 varieties studied, a decrease in trunk diameter is predicted, the only two varieties that could have a trunk diameter greater than that of the initial biological material being 'Măr Dulce Amar' and 'Aore', although these varieties in fact show a lower growth vigor compared to the rest of the studied varieties. Interestingly, a reduction in trunk vigor is a feature in varieties that genetically have high vigor ('Curcubătoase', 'Florănești' and 'Vițate').

The height of the trees (Table 2) from which the biological material for grafting was taken varied between 3.8 m in the 'Aore' variety and 12.0 m in the 'Curcubătoase' variety, with an experimental average of 8.36 m. As is the case for the diameter of the crown, this indicator is not greatly relevant because, as mentioned for the biological material, the trees were chosen from different locations, both from people's yards, but also found on public ground, which is why the same agrotechniques were not applied to them, especially pruning. The trees identified in people's yards were subjected to minimal pruning, in particular the removal of dry branches and less extensive fruit-bearing pruning, thus

preserving a form of growth as natural as possible. The trees found on public ground were allowed to grow in their natural form, no maintenance being undertaken.

Table 2. Differences between tree height before and after grafting.

Variety	* TH 30–50 Year Old Trees (OBM) m	TH 8 Year Old Trees (After Grafting) m	TH-Reduction Maintained by Pruning (%)
'Bănățenesc'	11.00	2.20	−80.00
'Domnesc'	8.20	2.03	−75.24
'Parmen Auriu'	10.30	1.92	−81.36
'Curcubătoase'	12.00	2.46	−79.50
'Poinic'	10.30	2.36	−77.09
'Mustoase'	8.00	2.35	−70.63
'Florănești'	10.50	2.20	−79.05
'Pătul'	9.10	2.20	−75.82
'Vițate'	9.70	2.09	−78.45
'Jonathan de Munte'	8.00	2.40	−70.00
'Măr Dulce Amar'	5.95	2.10	−64.71
'Caslere'	6.93	2.15	−68.98
'Aore'	3.80	2.46	−35.26
'Crețesc'	7.50	2.47	−67.07
'Botu Oii'	4.20	2.08	−50.48
Average	8.36	2.23	

* TH—Tree height.

It has been observed that the height of the grafted trees is the one that can give clear indications regarding the vigor of the scion/rootstock combination, because in the experiment, the trees have been properly pruned. We observe that the value of the height of the grafted trees varies between 1.92 m in the 'Parmen Auriu' variety and 2.47 m in the 'Crețesc' variety, the average of the experiment being 2.23 m. By undertaking appropriate pruning, the height of the grafted trees can be maintained between these limits, and thus result in a decrease in height compared to the biological material, with percentages between 35.26% in the 'Aore' variety and 81.36% in the 'Parmen Auriu' variety.

Under the condition of the initial biological material, the crown diameter (Table 3) varied between 3.1 m in the 'Aore' variety and 10.0 m in the 'Curcubătoase' and 'Poinic' varieties, with an experimental average of 7.2 m.

Table 3. Differences between crown diameter before and after grafting.

Variety	* CD 30–50 Year Old Trees (OBM) m	CD 8 Year Old Trees (After Grafting) m	CD Reduction Maintained by Pruning (%)
'Bănățenesc'	7.50	1.77	−76.40
'Domnesc'	9.60	2.18	−77.29
'Parmen Auriu'	7.10	1.29	−81.83
'Curcubătoase'	10.10	2.06	−79.60
'Poinic'	10.00	2.14	−78.60
'Mustoase'	7.00	2.41	−65.57
'Florănești'	8.10	2.74	−66.17
'Pătul'	6.90	2.39	−65.36
'Vițate'	8.50	1.77	−79.18
'Jonathan de Munte'	8.00	1.68	−79.00
'Măr Dulce Amar'	5.10	1.33	−73.92
'Caslere'	6.20	1.66	−73.23
'Aore'	3.10	2.11	−31.94
'Crețesc'	7.40	1.49	−79.86
'Botu Oii'	3.40	1.28	−62.35
Average	7.20	1.89	

* CD—Crown diameter.

After grafting and applying the same agricultural technique to the fruit trees in the experiment, the crown diameter varied between 1.28 m in varieties such as 'Botu Oii' and 'Măr Dulce Amar' and 2.74 m in the 'Florănești' variety, the average diameter being 1.89 m; moreover, the values recorded in the entire experiment showed little difference. Proper pruning can maintain a crown diameter between the limits mentioned above, thus making it possible to grow these varieties in limited spaces, in a private garden.

Regarding the genetic influence of the variety on the vigor characteristic in the original biological material, the studied apple varieties can be divided into three groups (Figure 1): vigorous—'Curcubătoase', 'Florănești', 'Poinic' and 'Vițate'; with medium-high vigor—'Bănățenesc' 'Caslere', 'Crețesc', Jonathan de Munte, 'Mustoase', 'Pătul', 'Domnesc' and 'Parmen Auriu'; and with low vigor—'Botu Oii', 'Aore' and 'Măr Dulce Amar'.

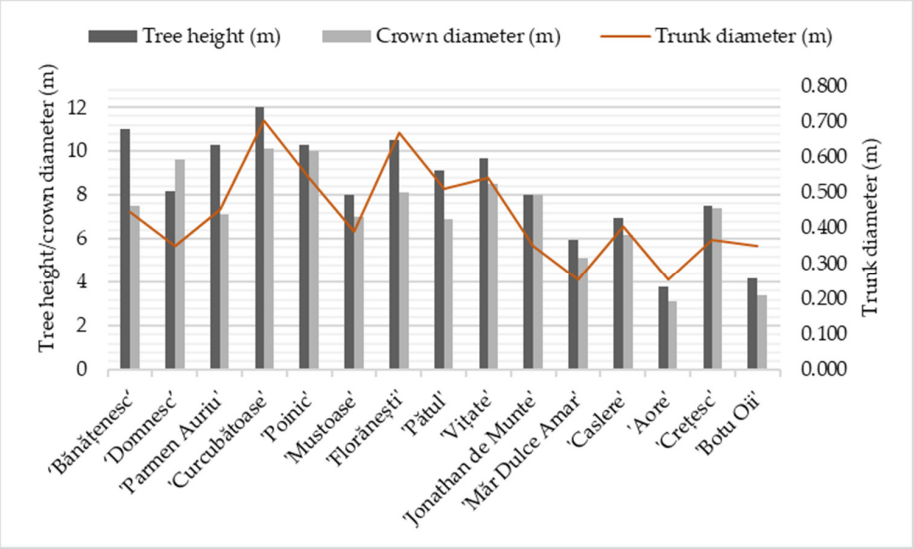


Figure 1. Growth vigor of the investigated apple varieties before grafting.

After their grafting and cultivation in the orchard, the same varieties can be divided as follows (Figure 2): vigorous—'Curcubătoase', 'Poinic', 'Mustoase', 'Florănești' and 'Aore'; with medium vigor—'Domnesc', 'Pătul', 'Bănățenesc', 'Crețesc' and 'Jonathan de Munte'; and with low vigor—'Botu Oii', 'Caslere' 'Vițate', 'Măr Dulce Amar' and 'Parmen Auriu'.

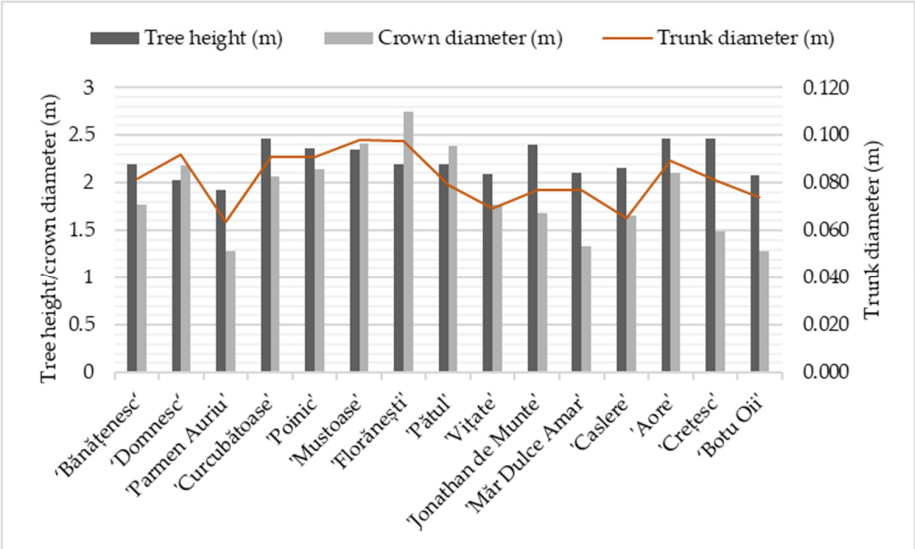


Figure 2. Growth vigor of the investigated grafted apple varieties.

3.2. External and Internal Characteristics of Fruits

The values determined for the analyzed parameters (large diameter, fruit mass, sugar content and acidity), both for the original biological material and after grafting of the 15 investigated apple varieties, are presented in Tables 4 and 5, as means ± standard deviation (SD). Between the variants with the same letters, there are significant differences at a confidence level of 95% ($\alpha = 0.05$).

Table 4. The characteristics of the apple varieties before grafting.

Variety	Large Diameter (mm)	Fruit Mass (g)	SSC (°Brix)	Acidity (g/100 g Malic Acid)
'Bănățenesc'	65.83 ± 11.52 ^{a}	99.00 ± 16.95 ^{a}	15.20 ± 0.53 ^{a}	0.50 ± 0.020 ^{a}
'Domnesc'	69.39 ± 3.54 ^{b}	116.00 ± 20.18 ^{b}	17.43 ± 2.00 ^{b}	0.96 ± 0.058 ^{b}
'Parmen Auriu'	49.66 ± 11.21 ^{bc}	126.55 ± 47.4	14.53 ± 0.37 ^{c}	0.52 ± 0.040 ^{bc}
'Curcubătoase'	69.80 ± 9.66 ^{d}	134.77 ± 17.15 ^{c}	15.60 ± 0.48 ^{cd}	0.52 ± 0.010 ^{bd}
'Poinic'	63.47 ± 0.41 ^{be}	90.33 ± 2.60 ^{cd}	14.52 ± 0.60 ^{e}	0.47 ± 0.020 ^{bde}
'Mustoase'	80.38 ± 3.00 ^{bcef}	76.33 ± 2.67 ^{bcde}	15.8 ± 0.90 ^{f}	0.58 ± 0.020 ^{abdef}
'Florănești'	86.83 ± 2.00 ^{bcdefg}	172.10 ± 9.85 ^{abcdefg}	14.7 ± 0.65 ^{g}	0.57 ± 0.020 ^{abdeg}
'Pătul'	97.43 ± 11.73 ^{abcdeh}	115.67 ± 30.83 ^{fgh}	16.50 ± 1.58 ^{h}	0.51 ± 0.010 ^{befgh}
'Vițate'	61.86 ± 11.18 ^{ghi}	82.00 ± 29.76 ^{fgh}	15.52 ± 2.20 ^{i}	0.56 ± 0.020 ^{abdehi}
'Jonathande Munte'	87.24 ± 1.90 ^{abcdefij}	93.65 ± 17.88 ^{cfgi}	14.9 ± 0.95 ^{j}	0.54 ± 0.010 ^{abefhj}
'Măr Dulce Amar'	56.43 ± 2.12 ^{befghjk}	54.83 ± 5.00 ^{abcdefghij}	17.73 ± 0.50 ^{acdefgk}	0.48 ± 0.020 ^{bdfgijk}
'Caslere'	71.90 ± 3.41 ^{cefghjkl}	137.33 ± 40.94	16.20 ± 1.53 ^{l}	0.52 ± 0.040 ^{bl}
'Aore'	90.763 ± 0.49 ^{abcdefgijklm}	93.22 ± 26.85 ^{fg}	21.9 ± 0.18 ^{abcdefghijm}	0.55 ± 0.020 ^{abehkm}
'Crețesc'	64.06 ± 3.00 ^{fghjklmn}	97.43 ± 1.34 ^{cdefgik}	16.7 ± 0.15 ^{acdegjkm}	0.53 ± 0.020 ^{befk}
'Botu Oii'	47.33 ± 3.51 ^{bdefghjklmn}	52.67 ± 3.62 ^{abcdefgk}	14.36 ± 1.15 ^{km}	0.23 ± 0.020 ^{abcdefghijklmn}

Between the variants with the same letters, there are significant differences at a confidence level of 95% ($\alpha = 0.05$).

Table 5. The characteristics of the apple varieties after grafting.

Variety	Large Diameter (mm)	Fruit Mass (g)	SSC (°Brix)	Acidity (g/100 g Malic Acid)
'Bănățenesc'	64.9 ± 18.25	145.56 ± 31.46 ^{a}	13.72 ± 1.04 ^{a}	0.23 ± 0.02 ^{a}
'Domnesc'	61.69 ± 3.54 ^{a}	120.68 ± 25.86 ^{b}	15.1 ± 3.70	0.46 ± 0.02 ^{ab}
'Parmen Auriu'	67.02 ± 18.79	164.53 ± 64.53 ^{c}	18.48 ± 0.56 ^{ab}	0.29 ± 0.01 ^{abc}
'Curcubătoase'	71.77 ± 12.75 ^{b}	294.76 ± 42.39 ^{abcd}	10.05 ± 0.13 ^{abc}	0.38 ± 0.02 ^{abcd}
'Poinic'	59.61 ± 1.27 ^{c}	155.73 ± 8.82 ^{de}	13.73 ± 1.62 ^{bc}	0.22 ± 0.02 ^{bcde}
'Mustoase'	71.00 ± 4.58 ^{acd}	87.61 ± 2.67 ^{adef}	15.26 ± 0.95 ^{bcd}	0.21 ± 0.01 ^{bcdf}
'Florănești'	70.00 ± 2.00 ^{ace}	251.56 ± 17.40 ^{abefg}	15.26 ± 0.93 ^{bce}	0.13 ± 0.02 ^{abcdefg}
'Pătul'	78.71 ± 11.96 ^{f}	256.94 ± 41.11 ^{abefh}	14.37 ± 1.61 ^{bc}	0.13 ± 0.01 ^{abcdefh}
'Vițate'	69.12 ± 12.28 ^{g}	179.09 ± 42.37 ^{dhi}	18.4 ± 2.60 ^{acf}	0.19 ± 0.02 ^{bcdghi}
'Jonathan de Munte'	75.65 ± 3.11 ^{ach}	193.58 ± 18.14 ^{bdefgj}	16.63 ± 1.66 ^{cg}	0.23 ± 0.03 ^{bcdghj}
'Măr Dulce Amar'	57.41 ± 2.18 ^{defhi}	60.00 ± 5.00 ^{abcdefghijk}	15.86 ± 0.90 ^{bc}	0.24 ± 0.01 ^{bcdfghik}
'Caslere'	67.17 ± 4.55 ^{dij}	162.76 ± 72.22	16.77 ± 2.75 ^{ci}	0.17 ± 0.02 ^{abcdefhjkl}
'Aore'	75.33 ± 2.08 ^{aceijk}	182.75 ± 43.56 ^{dfkl}	11.65 ± 0.19 ^{abcdefghi}	0.28 ± 0.02 ^{abdefghiklm}
'Crețesc'	45.00 ± 3.00 ^{bcefghijkl}	62.39 ± 1.34 ^{abdefghijlm}	12.96 ± 0.15 ^{bcdefghjk}	0.32 ± 0.04 ^{abefghijkln}
'Botu Oii'	67.00 ± 5.56 ^{il}	132.68 ± 10.45 ^{defghkm}	16.1 ± 1.39 ^{cjk}	0.2 ± 0.01 ^{bcdghkmn}

Between the variants with the same letters, there are significant differences at a confidence level of 95% ($\alpha = 0.05$).

In the case of the fruits collected from the apple varieties before grafting, the lowest value of the fruit large diameter was recorded in the varieties 'Botu Oii' (47.33 ± 3.51 mm) and 'Parmen Auriu' (49.66 ± 11.21 mm), while the fruits with the largest diameter were obtained in the varieties 'Pătul' (97.43 ± 11.73 mm) and 'Aore' (90.763 ± 0.49 mm) (Table 4).

It can be seen that most apple varieties have large diameter with values below 70.00 mm and only six of them exceed this value.

After grafting, the average of the large diameter of the fruit (period 2020–2022) was between 45.00 ± 3.00 mm in the 'Crețesc' variety and 78.71 ± 11.96 mm in the 'Pătul' variety (Table 5), thus slightly smaller than for the varieties used as initial propagation biological material. The lowest values were recorded in 'Crețesc', 'Măr Dulce Amar' (57.41 ± 2.18 mm) and 'Poinic' varieties (59.61 ± 1.27 mm), these differing significantly compared to the rest of the varieties. By contrast, the largest fruit diameters were recorded in 'Pătul', 'Jonathan de Munte' (75.65 ± 3.11 mm) and 'Aore' (75.33 ± 2.08 mm) varieties. A visible increase in the large diameter of the fruit, in comparison with the varieties before grafting, was recorded in

'Parmen Auriu', 'Vițate' and 'Botu Oii' varieties. Slightly smaller fruits were recorded in the varieties 'Poinic', 'Mustoase', 'Florănești', 'Pătul', 'Aore' and 'Crețesc'. The other cultivars showed similar values.

In the case of the initial biological material (Table 4), the apples' mass varied between 52.67 ± 3.62 g in the 'Botu Oii' variety and 172.10 ± 9.85 g in the 'Florănești' variety, with a major variation compared to that of the fruit diameter. The group of varieties that had a reduced fruit mass were, in addition to the variety 'Botu Oii', the varieties 'Măr Dulce Amar' (54.83 ± 5.00 g) and 'Mustoase' (76.33 ± 2.67 g) that are significantly different from the others in the experiment. In contrast as well as in the 'Florănești' variety, high fruit mass values were obtained in 'Caslere' (137.33 ± 40.94 g) and 'Curcubătoase' (134.77 ± 17.15 g) varieties, which were significantly different from the rest studied in the experiment.

In the case of the grafted varieties (Table 5), the fruit mass varied between 60.00 ± 5.00 g in 'Măr Dulce Amar' and 294.76 ± 42.39 g and in 'Curcubătoase', the differences between the values being even higher than in the case of the original biological material. The varieties that recorded low values other than 'Măr Dulce Amar' were 'Crețesc' (62.39 ± 1.34 g) and 'Mustoase' (87.61 ± 2.67 g) which differ significantly from the rest. High fruit mass values, in addition to 'Curcubătoase', were found for 'Pătul' (256.94 ± 41.11 g) and 'Florănești' (251.56 ± 17.40 g) which differ significantly from the others in the experiment.

The measurement of sugar content (SSC), or Brix as it is commonly known, is an essential part of the quality analysis of agricultural products and alcoholic beverages [28].

Before grafting (Table 4), five of the varieties studied had an SSC below 15 °Brix, being significantly negative: 'Botu Oii' and 'Poinic' (14.36 ± 1.15; 14.52 ± 0.60 °Brix), 'Parmen Auriu' (14.53 ± 0.37 °Brix), 'Florănești' (14.7 ± 0.65 °Brix) and 'Jonathan de Munte' (14.9 ± 0.95 °Brix); while three of the varieties studied had a high SSC, being significantly positive: 'Aore' (21.9 ± 0.18 °Brix), 'Măr Dulce Amar' (17.73 ± 0.50 °Brix) and 'Domnesc' (17.43 ± 2.00 °Brix). After grafting (Table 5), the SSC of the studied apple varieties was between 10.05 ± 0.13 °Brix in 'Curcubătoase' and 18.48 ± 0.56 °Brix in 'Parmen Auriu'; the differences between the varieties regarding the accumulation of sugars in the fruit were smaller; and the values were closer to those in the original biological material. After grafting, five of the studied varieties had an SSC below 15 °Brix, lowest values being recorded in 'Curcubătoase', 'Aore' (11.65 ± 0.19 °Brix) and 'Crețesc' (12.96 ± 0.15 °Brix). The varieties 'Parmen Auriu' and 'Vițate' accumulated the highest amounts of sugars in the fruit, both exceeding the value of 18 °Brix.

The fruit acidity of the varieties in the case of the initial biological material (Table 4) oscillated between 0.23 ± 0.020 g/100 g in 'Botu Oii' and 0.96 ± 0.058 g/100 g in 'Domnesc'. Most varieties had acidity values around 0.50 g/100 g.

After grafting (Table 5), the acidity of the fruits oscillated between 0.13 ± 0.01 g/100 g in 'Pătul' and 'Florănești' and 0.46 ± 0.02 g/100 g in 'Domnesc', and the limit of variation is higher than in the case of the original biological material. Low values of fruit acidity were recorded in 'Pătul' and 'Florănești', followed by 'Caslere' (0.17 ± 0.02 g/100 g) and 'Vițate' (0.19 ± 0.02 g/100 g), being significantly different from the rest of the varieties.In addition to 'Domnesc', high acidity levels were recorded in 'Curcubătoase' (0.38 ± 0.02 g/100 g) and 'Crețesc' (0.32 ± 0.04 g/100 g).

From the statistical analysis of the values of the four studied indicators (large fruit diameter, fruit mass, soluble solid content and fruit acidity), it was found that for large diameter and sugar content, there are no significant differences between the original biological material and that after grafting, with the confidence level of 95% ($\alpha = 0.05$). By contrast, for fruit mass and acidity, significant differences between the two types of material was found (Figure 3).

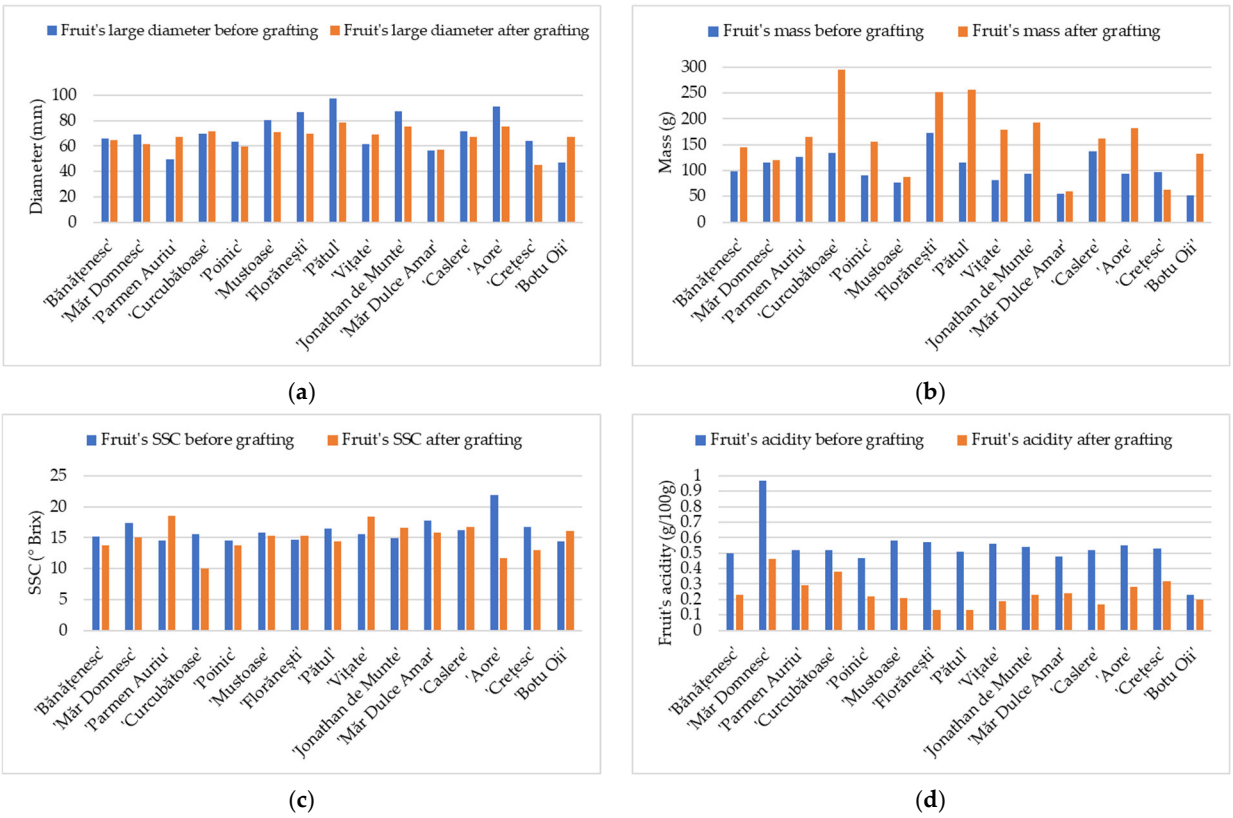


Figure 3. External and internal characteristics of fruits before and after grafting: (**a**) large fruit diameter; (**b**) fruit mass; (**c**) soluble solid content; (**d**) fruit acidity.

3.3. The Taste and Commercial Appearance

The taste and commercial appearance of the fruits are presented in Tables 6 and 7.

Table 6. Fruit taste, consistency and commercial aspect before and after grafting.

Variety	Taste		Consistency		Commercial Aspect	
	OBM *	AG	OBM	AG	OBM	AG
'Bănățenesc'	Acidic	Slightly acidic	Crunchy	Medium crunchy	Unattractive	Attractive
'Domnesc'	Slightly acidic	Sweet and sour	Medium crispy	Slightly crunchy	Attractive	Very attractive
'Parmen Auriu'	Slightly sweet and sour	Sweet	Crunchy	Slightly crunchy	Unattractive	Attractive
'Curcubătoase'	Acidic	Acidic	Crunchy	Medium crispy	Unattractive	Attractive
'Poinic'	Sweet and sour	Sweet and sour	Fondant	Fondant	Attractive	Attractive
'Mustoase'	Acidic	Sweet	Soft	Soft	Attractive	Very attractive
'Florănești'	Sweet and sour	Sweet	Slightly crunchy	Slightly crunchy	Unattractive	Attractive
'Pătul'	Sweet and sour	Sweet and sour	Slightly crunchy	Slightly crunchy	Attractive	Very attractive
'Vițate'	Acidic	Sweet and sour	Fondant	Fondant	Unattractive	Attractive
'Jonathan de Munte'	Sweet and sour	Sweet and sour	Medium crispy	Slightly crunchy	Attractive	Attractive
'Măr Dulce Amar'	Sweet and bitter	Sweet and bitter	Slightly crunchy	Slightly crunchy	Attractive	Attractive
'Caslere'	Slightly acidic	Sweet and sour	Medium crispy	Slightly crunchy	Attractive	Very attractive
'Aore'	Acidic	Slightly acidic	Crispy	Medium crispy	Attractive	Attractive
'Crețesc'	Acidic	Sweet and sour	Slightly crunchy	Slightly crunchy	Attractive	Attractive
'Botu Oii'	Slightly acidic	Sweet and sour	Fondant	Fondant	Unattractive	Very attractive

* AG—after grafting; OBM—original biological material.

Table 7. Fruit shape, skin and pulp color before and after grafting.

Variety	Fruit Shape		Skin Color		Pulp Color	
	OBM	AG *	OBM	AG	OBM	AG
'Bănățenesc'	Spherical flattened	Spherical flattened	Green covered with streaked red	Green covered with streaked red on S	Greenish white	Greenish white
'Domnesc'	Flat	Spherical flattened	Yellow with red stripes	Greenish yellow with streaked red on S	White	Yellowish white
'Parmen Auriu'	Spherical flattened	Spherical flattened	Greenish yellow with streaked red on S	Greenish yellow with streaked red on S	Yellow	Yellow
'Curcubătoase'	Spherical	Spherical	Green streaked with a little red	Greenish yellow, slightly blown with red on S	White	White
'Poinic'	Spherical flattened	Spherical flattened	Yellow	Yellowish green	White	White
'Mustoase'	Lightly flattened rib	Lightly flattened rib	Yellow with red stripes	Greenish yellow with streaked red on S	Yellowish white	White
'Florănești'	Spherical flattened	Spherical flattened	Yellow with red stripes	Yellow covered with red on S	Greenish white	Yellowish white
'Pătul'	Spherical flattened	Spherical flattened	Yellow–red on S	Yellow–red on S	White	White
'Vițate'	Irregular sphere	Truncated, costal	Green covered with red on S	Green covered with red over almost the entire surface	Greenish white	Greenish white
'Jonathan de Munte'	Spherical flattened	Spherical	Dark green–red	Green covered with red on S	Greenish	Greenish white
'Măr Dulce Amar'	Spherical flattened	Spherical flattened	Yellow–red on S	Yellow–red on S	White	White
'Caslere'	Spherical flattened	Truncated, slightly ribbed	Yellow streaked with red	Yellow streaked with red on S	White	Yellowish white
'Aore'	Flat	Flat	Yellow	Yellow	White	White
'Crețesc'	Spherical flattened	Spherical flattened	Yellow streaked with red	Yellow streaked with red	White	White
'Botu Oii'	Cylindrical	Elongated cylindrical	Yellow with 1/2 streaked red	Yellow with 1/2 streaked red on S	White	White with pink undertones

* AG—after grafting; OBM—original biological material; S—sunny side.

The taste and commercial appearance of the fruits improved substantially after being grafted. Thus, 'Domnesc', 'Poinic', 'Pătul', 'Jonathan de Munte' and 'Botu Oii' improved their taste under the conditions of appropriate agrotechniques, while 'Domnesc', 'Mustoase', 'Pătul', 'Caslere' and 'Botu Oii' varieties acquired a pleasing commercial aspect (Table 6).

Overall, the fruit shape—which represents a stable element for the recognition of varieties as it remains almost constant, regardless of size [22]—has indeed proven to be the most constant among the analyzed characteristics, 13 of the 15 varieties retaining the same shape from that in the initial biological material throughout the years of experimentation after grafting. The two exceptions were the varieties 'Vițate' and 'Botul Oii', in which the fruit shape has changed slightly from cylindrical to elongated cylindrical (Table 7).

The color of the fruit is specific to each variety, but it also differs depending on the cultivation area, training system, and the climatic conditions of the respective year. In terms of the color of the skin, the differences between the fruits of the original biological material and the grafted ones were relatively small, and all varieties maintained their background color and cover color.

3.4. Disease and Pest Tolerance Observations

Regarding the tolerance to diseases and pests (Table 8), considering the overall score on the 1–5 scale, five varieties scored 4 (resistant), nine varieties scored 3 (moderately resistant)

and one variety scored 2 (susceptible). The best results were obtained with three of the varieties studied—namely, 'Pătul', 'Jonathan de Munte' and 'Botu Oii'—which obtained a score of 4 (resistant) for all the diseases and pests analyzed. Resistance (score 4) to apple scab on the leaves (AS-l) was registered in the varieties: 'Parmen Auriu', 'Pătul', 'Crețesc', 'Jonathan de Munte' and 'Botu Oii'. Resistance (score 4) to apple scab on the fruits (AS-f) was recorded in the following varieties: 'Bănățenesc', 'Domnesc', 'Pătul', 'Jonathan de Munte', 'Aore' and 'Botu Oii'. In terms of resistance to powdery mildew (PM), the best results (score 4) were obtained by the varieties: 'Pătul', 'Jonathan de Munte', 'Aore' and 'Botu Oii'. Among the investigated pests, the most problematic was the codling moth (CM) for which was recorded a score of 2 (susceptible) for six of the fifteen analyzed cultivars: 'Parmen Auriu', 'Curcubătoase', 'Mustoase', 'Florănești', 'Vițate' and 'Măr Dulce Amar'. The incidence of green apple aphid (GAA) was also quite problematic, 11 of the varieties registered a score of 3 (moderately resistant), one variety scored 2 ('Vițate') and only three varieties scored 4 (resistant). Rosy leaf-curling aphid (RL-CA) did not cause much damage, and only five varieties obtained the lower score of 3 (moderately resistant) while the others registered a score of 4 (resistant).

Table 8. Post-grafting disease and pest tolerance of the studied traditional apple cultivars, 2020–2022.

Variety	Overall Score for Disease Tolerance 1/5	AS-l * 1/5	AS-f 1/5	PM 1/5	MF 1/5	Overall Score for Pest Tolerance 1/5	CM 1/5	GAA 1/5	RL-CA 1/5
'Bănățenesc'	3	3	4	3	4	3	3	3	4
'Domnesc'	3	3	4	3	3	3	3	3	4
'Parmen Auriu'	3	4	3	3	3	3	2	3	3
'Curcubătoase'	3	3	2	3	3	3	2	3	3
'Poinic'	3	3	3	3	3	3	3	3	4
'Mustoase'	3	3	3	2	2	3	2	3	4
'Florănești'	3	3	3	3	3	3	2	3	3
'Pătul'	4	4	4	4	4	4	4	4	4
'Vițate'	2	2	2	2	2	2	2	2	3
'Jonathan de Munte'	4	4	4	4	4	4	4	4	4
'Măr Dulce Amar'	3	3	3	3	4	3	2	3	3
'Caslere'	3	3	3	2	3	3	3	3	4
'Aore'	4	3	4	4	4	4	4	3	4
'Crețesc'	4	4	3	3	4	4	4	3	4
'Botu Oii'	4	4	4	4	4	4	4	4	4

* AS-l—apple scab in leaf caused by *Venturia inaequalis*; AS-f—apple scab in fruit caused by *Venturia inaequalis*; PM—powdery mildew caused by *Podosphaera leucotrich*; MF—monilia caused by *Monilinia fructigena*; CM—codling moth caused by *Cydia pomonella*; GAA—green apple aphid caused by *Aphis pomi*; RL-CA—rosy leaf-curling aphid caused by *Dysaphis devecta*.

Overall, among all the varieties analyzed, the worst results for both disease and pest resistance were recorded in the 'Vițate' variety, which scored 2 (susceptible) for all diseases and pests evaluated, except for tolerance to rosy leaf-curling aphid to which it recorded a score of 3 (moderately resistant).

4. Discussion

4.1. Trees' Vigor

Fruit growing extensively uses grafted trees obtained by using scions on different rootstocks [29]. The grafted trees present a series of advantages conferred both by the rootstock and by the success of the grafting itself, among which we mention: different growth vigor, adaptability to varied climate and soil conditions, early maturity, high productivity, and larger and higher quality fruits [24]. Moreover, the cultivation of trees in an intensive and super-intensive system is dependent on the use of rootstocks of reduced vigor. Only the use of this type of rootstocks ensures optimal conditions for the growth and fruiting of the trees, leading to high and constant yields.

Growth vigor was reduced in most varieties, but the highest influence of the rootstock on growth was observed in the 'Bănățenesc' variety, followed by 'Jonathan de Munte' and 'Caslere'.

Amiri et al. [30] believe that the mechanisms behind the rootstock's influence on seedling vigor and productivity of the cultivar is that the rootstock influences the amounts of minerals taken up and translocated into the scion (thus MM 106 had the highest efficiency

in the absorption of phosphorus), while other researchers believe that, in addition to the influence of the rootstock, the growth rate of the diameter is also greatly influenced by the water level in the soil [31].

Effects of the scion–rootstock combinations were investigated on tree size, vigor and yield of pomegranate. The data indicated that grafting led to higher yield than the own-rooted plants, but grafted trees showed lower vigor and tree size compared with ungrafted trees [32].

Kiprijanovski et al. [33] based their conclusions upon their 10-year research, finding that the distance between the trees in the row had a significant influence on their vegetative growth, bearing and quality of the fruits. The results of other studies suggested that grafting heights of 40 cm and 60 cm have the potential to promote branching and early bearing for apple fruit production in sustainable and organic agricultural systems [34].

Scion growth and vigor is influenced by many factors, one of the most important of which is choice of rootstock or interstock. Most of these factors interact in determining the seasonal vigor of shoot growth and the eventual size of the mature tree [35–37].

4.2. External and Internal Characteristics of Fruits

It is known that the size of the fruits is a characteristic influenced by several factors in addition to the variety, such as: the age of the tree, the position of the fruits in the crown, the climatic conditions and the agricultural techniques applied.

In our country, the classification of fruits according to size, more precisely according to the large diameter and mass of the fruits, was carried out by several researchers [38–40].

Compared to OBM, in our experimental orchard, a variability regarding the size of the fruits was observed, due to genetics, rootstock, applied agrotechniques and pedoclimatic conditions.

Thus, according to the classification criteria mentioned above, the 15 varieties studied as initial biological material had fruits that can fit into the following size groups: five fell into the group with large fruits (over 75 mm)—'Domnesc', 'Curcubătoase', 'Florănești', 'Pătul' and 'Caslere'; seven were in the group with medium fruits—'Bănățenesc', 'Poinic', 'Mustoase', 'Vițate', 'Jonathan de Munte', 'Aore' and 'Crețesc'; and three varieties have small fruits—'Măr Dulce Amar', 'Parmen Auriu' and 'Botu Oii'.

After grafting, we observed some uniformity in fruit size compared to the original biological material, the difference between the smallest and largest fruit in the cultivar group being 33 mm, compared to 50 mm observed before grafting. It was also found that after grafting, the large diameter of the fruits decreased slightly, which led to a redistribution of the varieties, as follows: three varieties belong to the group with large fruits ('Pătul', 'Jonathan de Munte', 'Aore'), 11 varieties obtained medium-sized fruits and only one, the remaining one, fell into the small group ('Crețesc').

In light of classification of the fruits according to their mass, the fruits of the varieties of the original material are mostly in the group with medium fruits, with the exception of the varieties: 'Domnesc', 'Parmen Auriu', 'Curcubătoase', 'Florănești', 'Pătul' and 'Caslere', which registered large fruits. After grafting, 11 of the 15 varieties had large fruits, two varieties had fruits with an average mass ('Domnesc' and 'Mustoase'), and the remaining two varieties had low values for their fruit mass ('Măr Dulce Amar' and 'Crețesc').

The genetics of the variety was expressed by the mass characteristic of the following varieties: 'Curcubătoase', 'Mustoase', 'Florănești', 'Măr Dulce Amar', showing their tendency to produce heavier or lighter fruits, regardless of grafting and differentiated maintenance of the trees. On all the varieties, except Cretesc, the rootstock and agrotechnics had a positive influence on the fruit mass, none of them had a lower mass after grafting than in the case of the original biological material. The highest increase in the fruit mass after grafting was recorded in 'Botu Oii' variety (2.5 times heavier prior to grafting), but also in the 'Curcubătoase' variety (doubled its mass), and in the 'Florănești' and 'Pătul' varieties that have exceeded 250.0 g.

Our results are in accordance with those found in the literature, 11 of the 15 varieties exceeding 166 g, which is more than some commercial varieties. Agnolet et al. [20] studying

old apple varieties from the Tyrol region conclude that exists a great variability in fruit mass, from small fruits (exp. 'Rosa di Seio', 118 g) to large fruits ('Winterkalvill', 281 g), most, however, having a mass below that of the commercial varieties.

The SSC of apples was higher in the initial biological material than after grafting. The cultivars that accumulated the highest SSC from the initial biological material such as 'Domnesc', 'Măr Dulce Amar' but especially the variety 'Aore', recorded a decrease in SSC after grafting, while the cultivars 'Jonathan de Munte' and 'Botu Oii' with a low initial SSC, they accumulated large amounts of SSC after grafting, exceeding the average of the experiment.

The soluble solid content in the fruits after grafting (period 2020–2022) had an average value of 14.96 °Brix, with varieties that exceeded 18.0 °Brix ('Parmen' and 'Vițate') but also many varieties that exceeded 16.0 °Brix like 'Jonathan de Munte', 'Botu Oii', 'Caslere'. The results are in accordance with those in the literature, the varieties showing the capacity to accumulate organic and mineral substances in the fruit, at levels comparable or higher than those accumulated by many of the commercial apple varieties. Boudabous et al. [41], report a SSC with variations from 11.0 °Brix ('Golden', 'Startcrimson', 'Richared' and 'Anna') and 12.4 °Brix ('Douce de Djerba') and Vieira et al. [42] report a SSC between 11.8 ('Fred Hough') and 14.0 °Brix ('Daiane'). Agnolet et al. [20] conducting a complex study on apple quality in 34 old apple varieties grown in Tyrol compared to eight commercial apple varieties showed a range of SSC variation from 10.1 ('Granny Smith') to 16.1 °Brix ('Pananas Renette'). Vieira et al. [42], in his research, recorded a sugar content between 11.54 °Brix ('Imperatriz') and 14.78 °Brix ('Fuji Suprema'). Other researchers studying the chemical content of apples from commercial varieties but also from different hybrids showed a variation in sugar content between 9.53 and 12.34 °Brix; the highest sugar content was registered for H3/73 hybrid [43]. Rop et al. [44] studied the chemical composition of native apple cultivars from central Europe considered that 'Strymka' cultivar also showed a high content of soluble solid content (15.98 °Brix) and more than 14 °Brix of soluble solid content were also observed in the 'Matcino' and 'Starkrimson'cultivars . In Pakistan, Bibi et al. [45] recorded in 'Red Delicious' apple variety a content of SSC (14.29 °Brix), acidity % (0.42), while in 'Amri' variety the result mean interval SSC (14.21 °Brix), Acidity % (0.36).

The acidity of the fruits in the initial biological material had an average value of 0.53 g/100 g, while after grafting, the acidity value of the apples was around the average value of 0.25 g/100 g. The results obtained in our experiment regarding the acidity of apples fall within the limits cited in literature, for example Vieira et al. [42] reported variation limits of acidity between 0.20 g/100 g in the 'Baronesa' variety and 0.36 in the 'Imperatriz' variety, while Boudabous et al. [41] report a variation in acidity between 0.20 g/100g in the cultivar 'Richared' and 0.31 g/100 g in 'Golden'. In the research carried out by Câmpeanu et al. [43] it was observed that the taste and quality of the fruits in apple varieties and hybrids can be improved if the total acidity (%) has a low content (between 0.127 and 0.345%, in their case). In the study carried out by Bărăscu et al. [46] on 'Pinova' apple tree, grafted on different rootstocks, it was discovered that titratable acidity can be influenced by rootstocks, having higher values in apples produced by trees grafted on MM106 and M9/M111.

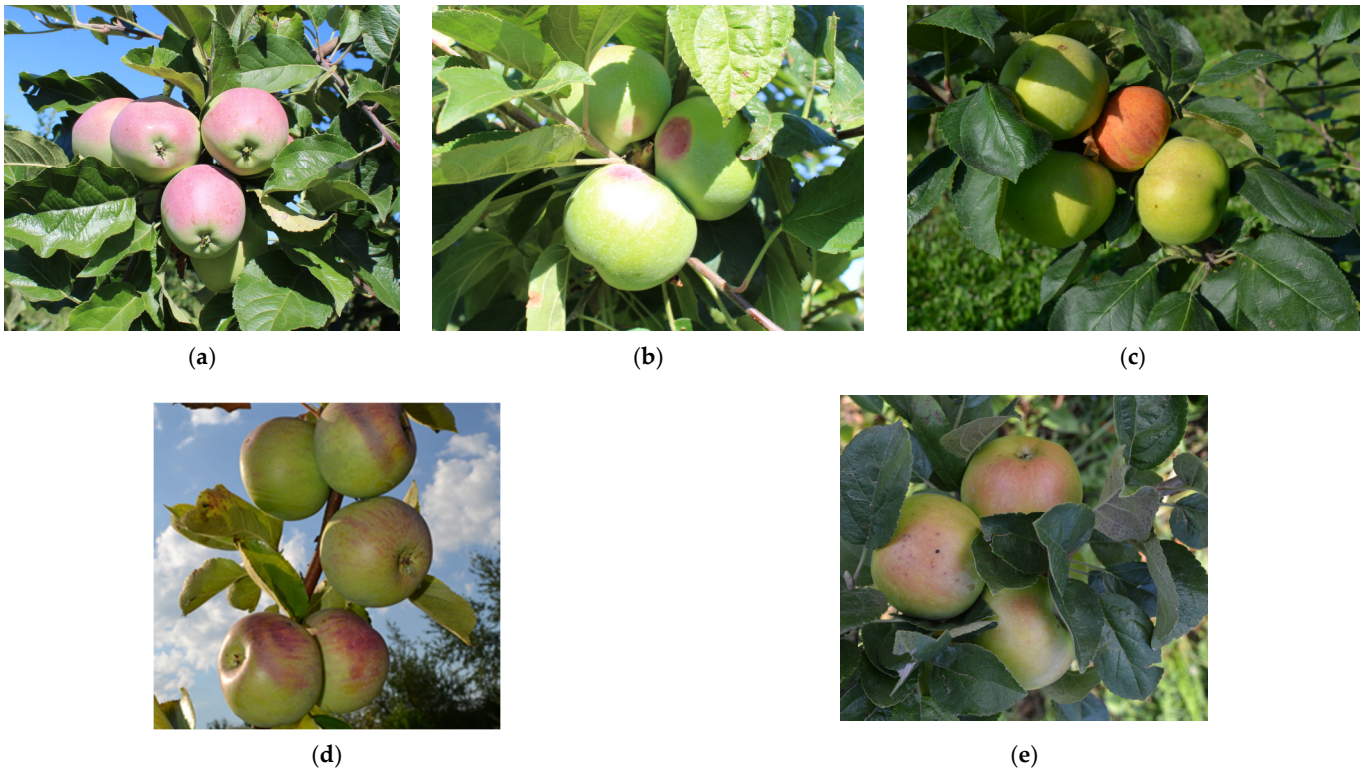
The probable reason for the difference between varieties before and after grafting is due to the presence of rootstock, variety/rootstock compatibility that ensures good absorption of water and mineral salts, adequate photosynthesis. Another reason could be the influence of pedoclimatic conditions, in general, in high temperature conditions, larger, less acidic fruits with a higher sugar content are produced.

4.3. The Taste and Commercial Appearance

After grafting, characteristics such as fruit shape, skin color and pulp color underwent minimal changes, being characteristics that proved to be constant, influenced significantly by the variety and less by other factors.

Fruit taste was the characteristic influenced by rootstock and culture conditions for which the difference between cultivars before and after their grafting was most apparent.

Three of the studied varieties ('Bănățenesc', 'Curcubătoase' and 'Aore') improved their taste from an unbalanced and mediocre one to a good, sweet–sour taste. Five of the varieties ('Domnesc', 'Mustoase', 'Pătul', 'Jonathan de Munte' and 'Botu Oii') improved from a taste rated as good before grafting to a taste rated as very good after grafting. We consider that these varieties (Figure 4) can compete with commercial varieties in terms of the characteristic taste and aroma, as well as the pleasant and very pleasant commercial appearance that they showed.



(**a**) (**b**) (**c**)

(**d**) (**e**)

Figure 4. Commercial appearance of (**a**) 'Botu Oii', (**b**) 'Jonathan de Munte', (**c**) 'Mustoase', (**d**) 'Domnesc' and (**e**) 'Pătul'.

4.4. Disease and Pest Tolerance of the Investigated Old Apple Varieties

Protecting plants against diseases and pests is one of the most important factors to produce them consistently and qualitatively. In an apple orchard, in one season, around 20 phytosanitary treatments are needed. For example, up to 12 fungicide treatments are needed against apple scab [47], 5–7 treatments against apple powdery mildew [48], and up to nine treatments against codling moth [49]. Although the use of pesticides is beneficial for the protection of plants, they have a negative impact on the environment, and their excessive use threatens the survival of many animals, including humans [50–52].

By using varieties resistant to diseases and pests, the use of pesticides is considerably reduced, thus contributing to a better protection of the environment. Among the varieties studied, those most resistant, which could therefore be cultivated with the least possible treatments, are 'Pătul', 'Jonathan de Munte' and 'Botu Oii'; these obtained a score of 4 of 5 (resistant) for all the diseases and pests analyzed. Although the improved variety of 'Jonathan' is known for high susceptibility to apple powdery mildew and its strong tendency to transmit the characteristic to its progeny [53], it is worth noting that the variety 'Jonathan de Munte' taken from the locality of Mehadica (44°57′09″ N 22°23′03″ E) and investigated in this experiment has proven resistance.

5. Conclusions

Significant differences were recorded between the varieties considered regarding most of the parameters analyzed.

Compared to the vigor of the original biological material, the growth vigor was reduced in most of the grafted varieties: the highest influence of the rootstock on growth was observed in 'Bănățenesc' variety, followed by 'Jonathan de Munte' and 'Caslere'. The lowest growth vigor was recorded in the varieties 'Botu Oii', 'Caslere''Vițate', 'Măr Dulce Amar' and 'Parmen Auriu' which can all be used in urban horticulture, on relatively limited spaces, especially when pruned correctly.

Regarding the fruits' mass, after grafting, 11 of the 15 varieties obtained large fruits, 2 varieties obtained fruits with an average mass ('Domnesc' and 'Mustoase'), while the remaining two had low values of fruit mass ('Măr Dulce Amar' and 'Crețesc').

As previously noted, the fruit taste was the characteristic on which the influence of rootstock and growing conditions made the most difference between the cultivars before and after their grafting. Regarding the taste and commercial appearance of the fruits that improved after grafting, we can state that five varieties ('Domnesc', 'Mustoase', 'Pătul', 'Jonathan de Munte' and 'Botu Oii') can compete with the commercial varieties in terms of taste and characteristic aroma, as well as pleasant and very pleasant commercial appearance.

Considering all analyzed parameters, the best results were recorded for the 'Botu Oii' variety. It has a low growth vigor, good resistance to diseases and pests, large fruits with good taste and attractive commercial appearance, which is why we recommend it for urban gardening and beyond. Moreover, worth mentioning are 'Jonathan de Munte' and 'Pătul' varieties, which also showed good results, especially in terms of resistance to diseases and pests, a very important factor that contributes to a better protection of the environment.

We consider that future research is necessary, especially for these three varieties mentioned, and efforts should be made to graft them on the MM106 rootstock with M9 as interstock.

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