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EVALUAREA SOIURILOR DE MĂR PENTRU CIDRU ÎN ECOSISTEMUL POMICOL MĂRĂCINENI

EVALUATION OF CIDER APPLE CULTIVARS GROWN IN FRUIT GROWING ECOSYSTEM MĂRĂCINENI

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Abstract

Cider apple fruit growing is a special branch of horticulture considering that the varieties for cider are different from other apple varieties by the fruit chemical composition (high polyphenol content), and also by the specific agronomic characters (type of growth, vigor, alternate fruit bearing). Nowadays, at Research Institute for Fruit Growing Pitesti, Romania researches are carried out, in order to identify some cider varieties adapted to the pedoclimatic conditions, varieties that can be extended in commercial plantations. This paper presents the results registered during 2020-2022 regarding vigor, precocity, fruit attributes and behavior of specific disease (scab, powdery mildew, fire blight) for 22 cultivars, with different origin ('Marie Ménard', 'DouceMoën', 'Kermerrien', 'Juliana', 'Judor', 'Jurella', 'Judeline', 'Judaine' from France; 'Dabinett', 'Ellis Bitter', 'Harry Masters Jersey', 'Major' from England; 'Cortland', 'Golden Russet', 'Grimes Golden', 'Gravestein Rouge', 'Norther Spy', 'Liberty' and 'Virginia Crab' from USA; 'Mc Intosh', 'Red Mc Intosh' and 'Geneva' from Canada)grafted on two rootstocks (MM106 and M9). In the first three years after planting, 'Judeline', 'DouceMoën' and 'Golden Russet' cvs.grafted on M9, show a low vigor. The total solid soluble content ranged between 12.6% at 'Harry Masters Jersey' cv. and 18.9% at 'Judaine' cv. The highest value of fruit firmness was recorded at 'Judaine' cv. (8.21kgf/cm^2), 'Virginia Crab' (7.98 kgf/cm^2), 'Jurella' (7.97 kgf/cm^2), and 'Dabinett' (7.84kgf/cm^2), and the lowest value was recorded for 'Cortland' cv. (6.12kgf/cm^2) and 'Judor' (6.55 kgf/cm^2). 'NortherSpy' cv. show a high sensitivity to apple scab, 'Cortland', 'Grimes Golden' and 'Liberty' cvs. to powdery mildew, 'Harry Master Jersey' and 'Dabinett' cvs. to fire blight.

Cuvinte cheie: *Malus*, cidru, fenotip.
Key words: *Malus*, cider, phenotype.

1. Introduction

Apples (*Malus x domestica* Borkh.) are one of the most important horticultural species grown in temperate areas and most commonly consumed fruits in the world (Ferree and Warrington, 2003).Although primarily are sold for fresh consumption, apples are also used for processing into juice or apple sauce. Apple juice can be fermented into cider, called 'hard cider' in the United States, a beverage that humans have been enjoying for over 2000 years (McGoven, 2009).

Cider is an alcoholic beverage obtained only by the complete or partial fermentation of the juice of fresh apples or the reconstituted juice of concentrate made from the juice of apple, or the mixture of juice of fresh apples of reconstituted juice of concentrate made from the apple juice. It is becoming more popular among people who drink alcoholic beverages, because it doesn't have gluten and can be sweeter and more refreshing than beer. In the late 1980's modern ciders were born: ciders containing juice and flavors began to be produced, alongside traditional ciders. The industry calls these 'flavored ciders', and they can contain, in addition to the apple base, ingredients such as juice of other fruits, extracts, flavorings. Another innovation is the so-called 'cider de glace' or 'ice cider', which is a cider made only from the fermentation of frozen juice or frozen apples (European Cider Trends, 2021).

Cider and its different varieties are the most common alcoholic drink especially in UK, Spain, France, Germany, Poland, Republic of Ireland, Ukraine, Finland, Russia, Czech Republic and Sweden. In Romania, the annual cider consumer is 165,000 hectoliters, which means more than 2 bottles of 0.33 l/capita/year. In the last 5 years, Romanian cider market grown with 14.87%.

A comparative trial with 22 apple cultivars was planted at Research Institute for Fruit Growing (RIFG) Pitesti in order to determine whether cider cultivars can be grown successfully in Romania.

2. Material and methods

The experiment consisted in 22 apple cultivars ('Marie Ménard', 'DouceMoën', 'Kermerrien', 'Juliana', 'Judor', 'Jurella', 'Judeline', 'Judaine', 'Dabinett', 'Ellis Bitter', 'Harry Master Jersey', 'Major', 'Geneva', 'Mc

Intosh', 'Red Mc Intosh', 'Cortland', 'Golden Russet', 'Grimes Golden', 'Gravestein Rouge', 'Norther Spy', 'Liberty' and 'Virginia Crab') grafted on two rootstocks (M9 and MM106), was carried out in the Central-Southern part of Romania, at the Research Institute for Fruit Growing Pitesti (table 1).The trees were planted in autumn 2019in a completely randomized single-factor experiment with two trees, in three repetitions for each of 22 cultivars. Trees grafted on MM106 were spaced 2 m within and 3.5 m between rows, and 1m within and 3.5 m between rows for trees grafted on M9. At planting, the trees were headed and trained to a wire trellis in a vertical axis system and they received regular treatment according integrated pests and disease management.

The growth vigor expressed by the diameter of the trunk (Φ mm), measured 20 cm above the grafting point and the calculation of the surface of the cross trunk section expressed in cm^2.

In 2020, 2021 and/or 2022, 10 fruits from 12 cider cultivars were picked at commercial harvest time established based on iodine starch test, values 4-5 on a 10point scale, from late of September till middle of October for chemical analyses. Soluble solids content (SSC) was measured in %Brix using the Hanna HI 96801 portable refractometer. For pH, the apples juice was extracted using a domestic juice extractor, filtered through a cotton cloth and measured using Hanna HI 84532 minititrator. The firmness of the apple was measured using a non-destructible penetrometer (Bareiss Qualitest HPE-II-FFF, Germany), equipped with 5 mm diameter cylindrical probe, at two distant places, near the equator on each side of the apple, and average values were calculated and reported.

Water content, expressed in %, was determined by gravimetric method described by Gergen (2004).

Total acidity was determined by titrimetric method, using NaOH 0.1N solution. Results were expressed as % of malic acid, according with AOAC (2007).

Tannins content was measure using Löwenthal permanganate titration (Löwenthal, 1877), following the method described by Miles and King (2014). The principle of the methods based on their action of potassium permanganate with tannoid substances in an acidic environment in the presence of indigo-carmine.

In our experience field, macroscopic observations of the symptoms expression were made for apple scab (*Venturia inaequalis*), fire blight (*Erwinia amylowora*) and powdery mildew (*Podosphaera leuchotriha*) according to ECPGR descriptors, using a scale from 1 (no visible symptom) to 9 (maximum infection, tree completely affected, nearly dead; maximum infection, tree completely affected, nearly all organs with symptoms).

Data were analyzed by Duncan multiple range test. The level of significance was defined as $P \leq 0.05$.

3. Results and discussions

Tree vigor

In the first three years after planting, 'Judeline', 'Judor' and 'Golden Russet' cvs., grafted on M9, show a low vigor. The highest value of the average years, in the case of varieties grafted on the M9 rootstock, in terms of growth vigor was recorded for 'Marie Ménard' cv. (trunk diameter = 34.37 mm, TCSA = 10.40 cm^2), and the smaller for 'Judeline' cv. (trunk diameter = 20.13 mm, TCSA = 3.22 cm^2).From all 22 apple studied cultivars, in the first three years after planting, 3 varieties were noted by small growth vigor: 'Judeline', 'Golden Russet', 'Douce Moèn'.Making a comparison between years, the measurements made in 2021 and those performed in 2022, it is observed that the smallest growth increase was registered for 'Judeline', 'Jurella', 'Judor' cvs. (under 2 cm^2), and the one the greater growth increase was recorded for 'Marie Menard', 'Red Mc Intosh' 'Harry Master Jersey', 'Ellis Bitter' and 'Mc Intosh' cvs. (over 6 cm^2) (Figure 1, Table 2).

In the case of varieties grafted on the MM106 rootstock, the smallest growth vigor was recorded for 'Geneva' cv. (trunk diameter = 19.93 mm), and the highest growth vigor had 'Marie Menard' cv. (trunk diameter = 30.88 mm).

For all experiment, the mean of growth vigor, in the case of the varieties grafted on the MM106 rootstock, was smaller than in the case of the varieties grafted on the M9 rootstock (trunk diameter = 25.74 mm; TCSA = 6.0 cm^2 in the case of MM 106; the diametertrunk = 26.32 mm; TCSA = 5.99 cm^2 in the case of the rootstock M9).The growth increase was higher in the varieties grafted on MM106 (7.28 cm^2) than those grafted on the M9 rootstock (4.65 cm^2).

Physico-chemical analyses

Cider characteristics, like %Brix and pH, vary depending on the apple growing location and apple varieties used (Chikthimmah et al., 2006).Based on acidity and tannins of the juice, according classification system developed at the Long Ashton Research Station, cider cultivars are classified as: sweet (acid <0.45%, tannin <0.2%), bittersweet(acid <0.45%, tannin >0.2%), sharp(acid >0.45%, tannin <0.2%)or bittersharp (acid >0.45%, tannin >0.2%).

In the climatic conditions of the Research Institute for Fruit Growing Pitesti, Romania, the studied varieties had the fruit average weight between 60.44 g for 'Harry Master Jersey' cv. and 198 g for 'Northern

Spy' cv. (Table 2).Regarding the soluble solids content, the studied varieties were noted by a high content, ranging between 12.6% Brix for 'Harry Master Jersey' cv. and 18.9% Brix for 'Judaine' cv. Also, the pH value varied between 4.06 at 'Judor' cv. and 5.22 for 'Dabinett' cv.

The highest value of fruit firmness was recorded at 'Judaine' cv. (8.21 kgf/cm^2), 'Virginia Crab' (7.98 kgf/cm^2), 'Jurella' (7.97 kgf/cm^2), and 'Dabinett' (7.84 kgf/cm^2), and the lowest value was recorded for 'Cortland' cv. (6.12 kgf/cm^2) and 'Judor' (6.55 kgf/cm^2). (Table 4).

The water content is of particular importance on the freshness of the fruit, the yield of juice obtained in the first steps of cider making (Guillermin et al., 2006).This quality parameter cannot be evaluated based on visual appearance. According to the results obtained, the water level in the analyzed apple fruits is determined by the genetic background. As shown in Table 4, the differences between cultivars are significant regarding the mean values of fruit water content. Among the cider apple cultivars analyzed in the present study: 'Liberty', 'Norther Spy', 'Judaine' and 'Jurella' stood out with a water content higher than 80.8% in the period 2020-2022. Minimum values of the water level in the fruits were found in 'Douce Moën' and 'Judor' cvs. (68.18% and 70.89%, respectively), significantly lower compared to the other cultivars. Literature data also show large variations in water content between cultivated apple varieties (Câmpeanu et al., 2009; Henríquez et al., 2010).

Tannins present in horticultural products, or their derivatives, can influence their visual appearance (Cheynier et al., 2006), texture (McRae et al., 2011) and flavor (Harbertson et al., 2006; Symoneaux et al., 2014a).Those from cider contain mostly epicatechins and some terminal catechins with an impact on perceived bitterness and astringency (Sanoner et al., 1999; Symoneaux et al., 2014b).Astringencyismainlyduetopolymericprocyanidins.Bitternessiscausedbylower molecular weight procyanidins (Heikefelt, 2011). For the production of high-quality cider, the categories of sweet-bitter apples are used (Miles et al., 2017).Thus, the concentration of tannins in apples intended for cider must be considerably higher (Somer et al., 2022) compared to those recommended for dessert. In bittersweet apples, the content of tannins is higher than 0.2%, sweet ones generally have a lower content of tannins (Heikefelt, 2011).In the present study, the average value of the tannin level for the 12 apple varieties was 0.149% (Table 4).In the 'Marie Ménard' and 'Juliana' cvs., the tannin content was significantly higher (0.361% and 0.321%, respectively) compared to the other varieties. With exception of the 'Dabinett' cv. (0.236% tannins), the other 9 analyzed varieties had a tannin content lower than 0.2%.

Along with polyphenol content, titratable acidity has traditionally been used to classify apple varieties based on flavor. A sweet or bittersweet apple has an acidity below 0.45 g malic acid/100 ml, while sharp and bittersharp apples have a content above this level (Heikefelt, 2011). The need to have high levels of organic acids is due to maintaining microbial and chemical stability during and after fermentation (Somer et al., 2022). The average value of the content of organic acids in the 12 apple varieties analyzed in this study was 0.84% malic acid. With the exception of the 'Marie Ménard' and 'Douce Moën' cvs. (0.38% and 0.44% malic acid, respectively), all the other 10 apple varieties have titratable acidity >0.45%. Amongthese, 'Jurella', 'Juliana', 'Judor' and 'Judeline' cvs. stood out with an organic acids content higher than 1% (table 4).Titratable acidity is variable from year to year and must therefore be measured every year. Of the 12 apple varieties analyzed, only 'Douce Moën' cider cultivar was classified as sweet (acid - 0.44%, tannin - 0.093%). As a bitter sweet cider cultivar, the 'Marie Ménard' cv. (acid -0.38%, tannin -0.361%), and as sharp the cultivars: 'Jurella' (acid - 1.43%, tannin - 0.058%), 'Judor' (acid - 1.13%, tannin - 0.103%), 'Harry Masters Jersey' (acid - 0.50%, tannin - 0.057%), 'Norther Spy' (acid - 0.46%, tannin - 0,081%), 'Liberty' (acid - 0.99%, tannin <0.081%), 'Cortland' (acid - 0.61%, tannin - 0.059%) and 'Virginia Crab' (acid - 0.93%, tannin - 0.189%). As a bittersharp cider cultivar, 'Juliana' cv. (acid - 1.38%, tannin - 0.321%) was identified.

Only a few varieties of cider apples have sufficiently complex characteristics of sweetness, acidity, flavor and tannins to be used successfully in monovarietal ciders (Proulx and Nichols, 2003 cited by Heikefelt, 2011). Producers tend to make a mixture based on sea juice with the right sweetness that will result in an effective alcoholic fermentation. Aromatic and astringent apples are then added to the sweet base after pressing. Since titratable acidity has a linear scale of values, the organic acid content can be adjusted to achieve the optimal pH range (generally 3.3-3.8) (Valois et al., 2006).

Diseases susceptibility

A proper choice of cultivars is of critical importance in the planning of new orchards. Apart from productivity and the technological and organoleptic features of the apple, resistance to pests and diseases should be a key point in the choice of cultivars for a sustainable production of apple for cider (Cross, 2002; Mc. Carthy, 1994; Avilla and Riedl, 2003; Prokopy, 2003; Weibel and Haseli, 2003).

Regarding the behavior to diseases, the most affected varieties on apple scab (*Venturiainaequalis*) were 'Jurella' cv. grafted on M9 (note 5) and 'Norther Spy' cv. grafted onMM106 (note 7).The most affected cider apple cultivars by fire blight (*Erwinia amylowora*) were 'Harry Master Jersey' and 'Dabinett' cvs. graftedM9 (note 7).The lowest resistance to powdery mildew (*Podosphaera leucotricha*) has 'Cortland', 'Grimes Golden' and 'Liberty' cvs., noted with 7, grafted on M9 (Figure 3 and 4).

4. Conclusions

In the fruit growing ecosystem Mărăcineni, Romania, in the first three years after planting, 'Judeline', 'DouceMoën' and 'Golden Russet' cvs., grafted on M9, show a low vigor.

The total soluble solid content ranged between 12.6% Brix at 'Harry Masters Jersey' cv. and 18.9% at 'Judaine' cv. The highest value of fruit firmness was recorded at 'Judaine' cv. (8.21 kgf/cm^2), 'Virginia Crab' (7.98 kgf/cm^2), 'Jurella' (7.97 kgf/cm^2), and 'Dabinett' (7.84 kgf/cm^2), and the lowest value was recorded for 'Cortland' cv. (6.12 kgf/cm^2) and 'Judor' (6.55 kgf/cm^2).

The chemical analyses for 12 apple cultivars, show that only 'DouceMoën cv. was classified as sweet, 'Marie Ménard' cv. as a bitter sweet cider cultivar, and 'Jurella', 'Judor', 'Harry Masters Jersey', 'Norther Spy', 'Liberty', 'Cortland' and 'Virginia Crab' as sharp cultivars.

As a bitter sharp cider cultivar, 'Juliana' cv. was identified. 'Jurella' and 'NortherSpy' cvs. show a high sensitivity to apple scab, 'Cortland', 'Grimes Golden' and 'Liberty' cvs. to powdery mildew, 'Harry Master Jersey' and 'Dabinett' cvs. to fire blight.

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Tables and Figures

Table 1. Origin of cider apple cultivars

Cultivar	Synonym	Origin	Parentage/information
Juliana		France, INRA Angers	DouceMoën (open pollination)
Judaine		France, INRA Angers	Reinette de Mons x Prima
Jurella		France, INRA Angers	von ZuccalmagliosRenette (open pollination)
Judeline		France, INRA Angers	Golden Delicious x Prima
Judor		France, INRA Angers	DouceMoën (open pollination)
Major		England, Long Ashton Research Station	Triploid cultivar
Marie Ménard		France, Côtesd'Armor	Seedling, 1910
DouceMoèn		France, Finistère	
Kermerrien		France, Finistère	1896
Harry Masters Jersey	Port Wine	England, Somerset, Yarlington	
Ellis Bitter	Ellis's Bitter Sweet	England, Devon	
Dabinett		England, Somerset, Royaume-Uni	
Gravestein Rouge	Red Gravestein	USA, Washington	Natural mutation of Gravestein, triploid cultivar
Golden Russet		USA	
Norther Spy	Spy, King	USA, New York	
Liberty		USA, Geneva	Complex hybridization (*M. floribunda* 821, Rome Beauty, McIntosh, Jersey Black, Wealthy, Macoun)
Grimes Golden		USA, West Virginia	
Cortland		USA, State Agricultural Experiment Station Geneva	McIntosh x Ben Davis
Mc Intosh	Mac Intosh	Canada, Ontario	Fameuse (open pollination)
Red Mc Intosh		Canada	Natural mutation of Mc Intosh
Virginia Crab	Cider crab, Hewes Crab, Hugh's Crab, Hughes Crab	USA, Virginia	
Geneva		Canada	Hybrid from *M. pumilaniedzwetzkyana*

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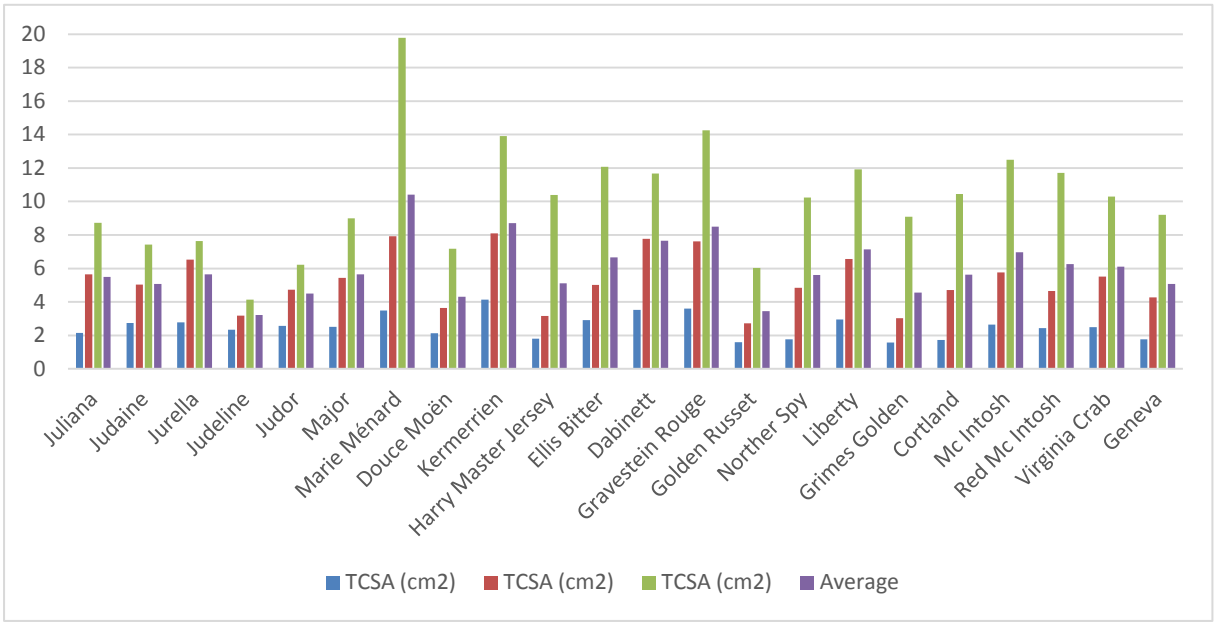

Fig. 1. The dynamics of trunk cross-sectional area (cm^2) on M9 rootstock

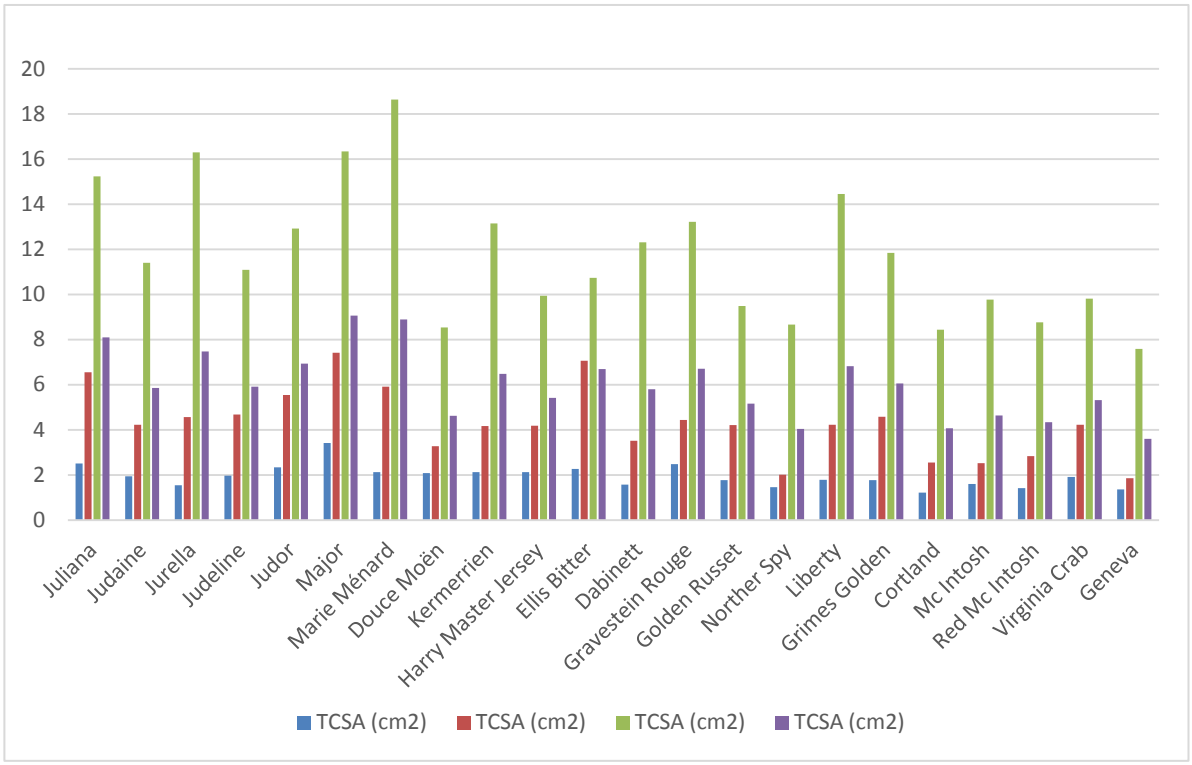

Fig. 2. The dynamics of trunk cross-sectional area (cm^2) on MM106 rootstock

Table 2. Vigor of growing apple varieties studied grafted on rootstock M9 (2020-2022)

Cultivars	Trunk diameter (mm)				SST (cm^2)				Growth increase (cm^2)
	2020	2021	2022	Mean	2020	2021	2022	Mean	
Juliana	16.53	26.79	33.33	25.55	2.14	5.64	8.72	5.50	3.08
Judaine	18.69	25.25	30.76	24.90	2.74	5.04	7.42	5.07	2.38
Jurella	18.84	28.85	31.22	26.30	2.78	6.53	7.64	5.65	1.11
Judeline	17.27	20.17	22.95	20.13	2.34	3.19	4.13	3.22	0.94
Judor	18.11	24.56	28.15	23.61	2.57	4.73	6.22	4.51	1.49
Major	17.90	26.30	33.85	26.02	2.51	5.43	8.99	5.64	3.56
Marie Ménard	21.09	31.79	50.22	34.37	3.49	7.93	19.79	10.40	11.86
DouceMoën	16.47	21.55	30.23	22.75	2.12	3.64	7.17	4.31	3.53
Kermerrien	22.97	32.12	42.11	32.40	4.14	8.09	13.92	8.72	5.83
Harry Master Jersey	15.17	20.08	36.40	23.88	1.80	3.16	10.40	5.12	7.24
Ellis Bitter	19.26	25.,31	39.24	27.94	2.91	5.02	12.08	6.67	7.06
Dabinett	21.23	31.51	38.58	30.44	3.53	7.78	11.68	7.66	3.90
Gravestein Rouge	21.43	31.16	42.62	31.74	3.60	7.62	14.25	8.49	6.63
Golden Russet	14.28	18.67	27.74	20.23	1.60	2.73	6.04	3.46	3.31
Norther Spy	15.00	24.89	36.10	25.33	1.76	4.85	10.23	5.61	5.38
Liberty	19.41	28.92	39.00	29.11	2.95	6.56	11.93	7.15	5.37
Grimes Golden	14.18	19.66	34.05	22.63	1.57	3.03	9.10	4.57	6.07
Cortland	14.88	24.50	36.47	25.28	1.73	4.71	10.44	5.63	5.73
Mc Intosh	18.35	27.11	39.89	28.45	2.64	5.76	12.49	6.96	6.73
Red Mc Intosh	17.61	24.34	38.63	26.86	2.43	4.65	11.71	6.26	7.06
Virginia Crab	17.87	26.54	36.24	26.88	2.50	5.52	10.30	6.11	4.78
Geneva	15.01	23.32	34.25	24.19	1.76	4.27	9.20	5.08	4.93
Mean of experience	**17.79**	**25.60**	**35.43**	**26.32**	**2.53**	**5.20**	**9.85**	**5.99**	**4.65**

Table 3. Vigor of growing apple varieties studied grafted on rootstock MM 106 (2020-2022)

Cultivars	Trunk diameter (mm)				SST (cm^2)				Growth increase (cm^2)
	2020	2021	2022	Mean	2020	2021	2022	Mean	
Juliana	17.90	28.93	44.05	30.29	2.51	6.56	15.23	8.10	8.67
Judaine	15.73	23.25	38.12	25.70	1.94	4.23	11.40	5.86	7.17
Jurella	14.08	24.14	45.57	27.93	1.55	4.57	16.30	7.47	11.73
Judeline	15.88	24.42	37.60	25.97	1.97	4.68	11.09	5.91	6.41
Judor	17.28	26.61	40.58	28.16	2.34	5.55	12.92	6.94	7.37
Major	20.88	30.77	45.64	32.43	3.42	7.42	16.35	9.06	8.93
Marie Ménard	16.47	27.45	48.73	30.88	2.12	5.91	18.64	8.89	12.63
DouceMoën	16.31	20.44	33.00	23.25	2.08	3.27	8.54	4.63	5.27
Kermerrien	16.46	24.52	40.94	27.31	2.12	4.17	13.15	6.48	8.98
Harry Master Jersey	16.45	23.12	35.60	25.06	2.12	4.19	9.94	5.42	5.75
Ellis Bitter	17.03	30.02	37.00	28.02	2.27	7.07	10.74	6.69	3.67
Dabinett	14.18	21.18	39.62	24.99	1.57	3.52	12.32	5.80	8.80
Gravestein Rouge	17.78	23.81	41.05	27.55	2.48	4.44	13.22	6.71	8.78
Golden Russet	15.05	23.17	34.77	24.33	1.77	4.21	9.49	5.16	5.28
Norther Spy	13.66	16.04	33.25	20.98	1.46	2.01	8.67	4.05	6.67
Liberty	15.09	23.22	42.93	27.08	1.78	4.23	14.46	6.82	10.23
Grimes Golden	15.02	24.17	38.85	26.01	1.77	4.58	11.84	6.06	7.26
Cortland	12.47	18.05	32.79	21.10	1.22	2.55	8.44	4.07	5.89
Mc Intosh	14.30	17.96	35.30	22.52	1.60	2.53	9.78	4.64	7.25
Red Mc Intosh	13.43	19.11	33.44	21.99	1.41	2.83	8.77	4.34	5.94
Virginia Crab	15.66	23.20	35.37	24.74	1.92	4.22	9.82	5.32	5.60
Geneva	13.20	15.47	31.11	19.93	1.36	1.86	7.59	3.60	5.73
Mean of experience	**15.65**	**23.13**	**38.42**	**25.74**	**1.94**	**4.30**	**11.58**	**6.00**	**7.28**

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Table 4. Physical and chemical analyses of 12 cider apple cultivars grown at RIFG Pitesti

Cultivar	Fruit weight (g)	Water content (%)	Soluble solids (%Brix)	Juice pH	Firmness (kgf/cm^2)	Titratable acidity (% malic acid)	Tannoids (%tannic acid)
Juliana	102.14	74.30^{b,c}	15.7^{b}	4.30^{a}	7.23^{b,c}	1.38^{a}	0.321^{a}
Judaine	159.22^{b}	80.55^{a,b}	18.9^{a}	4.38^{a}	8.21^{a}	1.04^{a,b}	ND
Jurella	110.05	80.47^{a,b}	15.8^{b}	4.34^{a}	7.97^{a,b}	1.43^{a}	0.058^{d,e}
Judor	65.75	70.89^{c}	14.1^{d}	4.06^{a}	6.55^{c}	1.13^{a,b}	0.103^{c}
Marie Ménard	72.63	77.03^{b}	18.4^{a}	4.45^{a}	8.12^{a}	0.38^{d,e}	0.361^{a}
DouceMoèn	68.54	68.18^{c}	15.4^{b,c}	4.11^{a}	7.34^{b,c}	0.44^{d}	0.093^{d}
Harry Masters Jersey	60.44	74.47^{b,c}	12.6^{e}	4.30^{a}	7.52^{b}	0.50^{d}	0.057^{d,e}
Dabinett	107.90	77.15^{b,c}	17.5^{a,b}	5.22^{b}	7.84^{a,b}	0.84^{b,c}	0.236^{b}
Norther Spy	197.51^{a}	82.12^{a}	16.1^{b}	4.35^{a}	7.66^{b}	0.46^{d}	0.081^{d}
Liberty	197.45^{a}	84.64^{a}	15.1^{b,c}	4.26^{a}	7.19^{b,c}	0.99^{b}	0.081^{d}
Cortland	155.31^{b}	78.23^{b}	14.5^{d}	4.72^{a,b}	6.12^{d}	0.61^{c}	0.059^{d,e}
Virginia Crab	43.89	77.73^{b}	15.3^{b,c}	4.42^{a}	7.98^{a,b}	0.93^{b}	0.189^{b,c}
Mean of experience	**111.73**	**77.15**	**15.78**	**4.40**	**7.47**	**0.84**	**0.149**

Identical lowercase superscripts within columns indicate no significant difference (p>0.05).

Fig. 3. Fire blight attack on 'Harry Masters Jersey' cv.

Fig. 4. Powdery mildew symptoms on 'Cortland' cv.