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'SAROM' ȘI 'IREAL', SOIURI NOI DE CĂPȘUN
'SAROM' AND 'IREAL', NEW STRAWBERRY CULTIVARS

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Abstract

Since 1980, the strawberry breeding program developed at the Research Institute for Fruit Growing Pitesti, Romania has released seven short-day cultivars of interest for temperate climate environments. The latest released cultivars, 'Sarom' and 'Ireal' are late cropping season ones (second decade of June) with large fruit size (more than 25 g) and total yield per plant of over 600 g. Fruits are firm flesh and excellent flavour. Plants have compact habit with high vigour, and fruits are well presented on long braces providing increased picking efficiency. They are characterized with high plant resilience to diseases and high fruit quality.

Cuvinte cheie: program de ameliorare, rezistență la boli și calitate ridicată a fructelor.
Key words: breeding programme, disease resilience and high fruit quality.

1. Introduction

Since 1980, the strawberry (*Fragaria x ananassa*) breeding program developed at the Research Institute for Fruit Growing (RIFG) Pitesti, Romania has as result the registration in the Official Catalogue of the crop plants cultivars in Romania of 7 cultivars suitable for the temperate climate with one fruiting per year, in spring (Sturzeanu et al., 2018). For strawberry, there are very functional breeding programs that have as main objective, related in particular to extending the ripening period, improving fruit quality and resistance to the main strawberry-specific diseases. The strawberry is easily adaptable to various climatic conditions, due to the great diversity of cultivars that have been created. Traits of practical and economic interest are similar worldwide, but the importance given to each differs from one program to another, depending on the area for which the cultivars have been released (Mezzetti et al., 2021).

In the last decades, strawberry breeding programs are focused to release new cultivars adapted to different climatic conditions and cultivation systems, with high yield, fruit size and firmness, resistance to pathogens and transport damages, and with longer shelf life. Besides the agronomic performance of the plant, the sensorial traits of the fruits have now gained an increasing priority in many breeding programs. In fact, consumer quality acceptance is generally related to specific perceived organoleptic traits such as fruit color, shape, acidity and sweetness, combined with flavor and aroma determined by volatile compounds (Lucia Di Vittori et al., 2017, Mezzetti et al., 2021). The overall objective of the breeding program is to select valuable genotypes with high productivity, different ripening times, and superior fruit quality. The focus on fruit quality is global, with the same parameters being targeted in breeding programs around the world. However, the specific tastes of people from different countries or areas are also taken into consideration. In recent years, quality objectives have also been correlated to ensure the health of the population (Olbricht et al., 2021).

The strawberry breeding programme developed at the RIFG Pitesti has as main goal the obtainment of new cultivars with highly resilient plants to low input cultivation systems and high adaptability to future climate conditions, and to be able to bear high yields of organoleptic and nutritional quality fruits. Additionally, the fruit size and shape, flesh firmness, skin resistance, flesh and skin color, taste and aroma, and vitamin and mineral content are also important factors in the breeding program.

Adaptability to the climate and soil conditions of our country is, also, a key factor in the breeding program. The objective of this study is to present the high quality fruit properties recorded by the cultivars recently introduced in the Official Catalogue of cultivars of crop plants in Romania, 'Sarom' and 'Ireal'.

2. Material and methods

The research was conducted between 2019 and 2023 at the Research Institute for Fruit Growing Pitesti. The experiment followed a specific scheme, with two factors: 'cultivar' and 'year of experiment'. The 'cultivar' factor had three graduations: 'Sarom', 'Ireal', and 'Mira'. The 'year of experiment' factor had four options: 2019, 2020, 2021, and 2022. The experiment was designed as a split-plot, randomized complete block design with three replications, each replication consisting of ten plants. The study focused on recently registered cultivars, namely 'Sarom' (registered in 2018) and 'Ireal' (registered in 2019), as well as the maternal cultivar of both cultivars, 'Mira' (registered in 2000). 'Mira' was used as a control cultivar and is commonly grown by farmers.

The phenological data included the development of inflorescences, the start of flowering, the onset of fruiting, and the onset of harvest. The traits studied were recorded at the optimal time for fruit harvesting, using a sample of 20 fruits. Fruit production per plant was determined by weighing ripe fruits at each harvest and combining the weights to give a cumulative yield. The average fruit weight was determined by weighing each fruit using a digital balance. The length and diameter of the fruit were determined by measurement using a digital caliper. The shape index of the fruit was calculated as the ratio of these two dimensions. Short-conic strawberries have a length/width ratio of about 0.9-1.1, while long-conic fruits have a ratio of 1.2-1.4. The fruit firmness was determined for each sample using the non-destructive penetrometer Bareiss HPE II-FFF, with a measuring surface of 0.50 cm^2.

The biochemical characteristics of the fruit were determined in a sample of approximately 200 g per repetition. The total soluble solids content (TSS) was determined using a digital refractometer Haana Instruments 96801. The total dry matter was determined by measuring the loss of water when heated to 105°C. The content of organic acids, expressed as % citric acid, was analysed using the titrimetric method with 0.1 N sodium hydroxide. The total sugar content (TSC) was determined using the Fehling-Soxlet method (1964). This method involves boiling the fruits in distilled water, inverting the sugar, and titrating the Fehling reagent with the resulting sugar solution. Vitamin C content, expressed in mg/100 g of fresh weight, was determined by the titrimetric method after extraction with 2% hydrochloric acid. The content of total polyphenols, expressed as mg GAE/kg FW, was determined spectro-photo-colorimetrically using a Pg Instruments T70 spectrophotometer. The method involves measuring the optical density of the extract obtained using methanol (70%) as a solvent. Determination of total anthocyanins was done by the spectrophotometric method (Fuleki and Francis, 1968), which measures the absorbance and expresses the concentration by interpolation on a calibration curve. The results were expressed in mg anthocyanins/100 g fresh fruit.

The skin fruit color was determined on both sides of the fruit using a colorimeter (Konica Minolta CR 400). The colorimeter measured the shade of red (a* - positive values indicate red color, negative values indicate green color), yellow (b* - positive values indicate yellow color, negative values indicate blue color), and brightness (L* - maximum value of 100 represents white color, minimum value of 0 represents black color). Chroma index was calculated using the formula $C^* = [(a^{*2} + b^{*2})]^{1/2}$. The hue angle was of the formula hº = arctangent (b*/a*), where 0º = red-purple, 90º = yellow, 180º = bluish-green, and 270º = blue. Low values of the color indicators L*, a*, b*, hº, C* generally indicate darker fruit color.

Statistical analysis was performed using the IBM SPSS 14 program. All results were evaluated using analysis of variance (ANOVA), and differences between cultivars were determined using Duncan's multiple range test (P≤0.005). Graphical representations were created using Microsoft Office 2007.3.

Breeding methods and strategy

The breeding strawberry programme at RIFG used a standard breeding method with following steps:

1. Crossing of parental lines for short-day (about 25 crosses/year);
2. Selection of superior plants based on the progeny performance (about 1-2% selection rate from a population size of 5,000 hybrids/year), following a subjective evaluation of fruit quality, potential yield, fruit size, plant habit and vigor and pest and disease resistance;
3. Initial evaluation of selected lines (about 50-100 lines/year) in experimental plots at RIFG Pitesti consisted of replicated plots of ten plants per selection, grown in open field, with objective measurements of yield, fruit size, fruit quality characteristics (appearance, firmness, flavor) and shelf-life;
4. First selection of advanced lines (about 8 -12 lines/year) for testing the yield in a split-plot, randomized complete block design with three replications, each replication consisting of ten plants;
5. Second selection of advanced lines (about 10 -12 lines/year) are compared with a control cultivar for testing the yield in a split-plot, randomized complete block design with three replications, each replication consisting of ten plants; now quality test and data processing was done based on analysis of variance; the selections that exceed the control were registered at the State Institute for Testing and Registration of Varieties (ISTIS) for promotion as a new variety and introducing in commercial trials in different geographic regions (Sturzeanu et al.,2022).

3. Results and discussions

Climate data

During study period, the average air temperature was 11.5°C, which is 1.5°C higher than the normal average. Additionally, the average annual precipitation amount was 618.8 mm, which is approximately 59 mm less than the long-term average. As shown in figure 1, there was a rainfall deficit of 376 mm during the vegetation period, although there was a temporary interruption with rainfall in June. This deficit becomes more pronounced in July and lasted until mid-September. Under these circumstances, the necessity for irrigation systems becomes evident.

Phenological data

Flowering time, ripening, and fruit size in strawberries are traits that are controlled by heritable quantitative factors. Analysing the stages of growth and fruiting can provide insight into the intensity of physiological processes that determine plant growth. This is particularly important in understanding how it affects fruiting and fruit production. It is crucial to achieve a perfect balance between growth and fruiting in order to consistently achieve large and high-quality yields.

In the four-year study, the inflorescence (flower cluster) development began between April 15th and 18th for the 'Sarom' and 'Mira' cultivars, and between April 15th and 19th for the 'Ireal' cv. For all three genotypes, flowering started between April 22nd till May 2nd for the 'Sarom' cv., April 20th till May 1st for the 'Ireal' cv., and April 20th till April 31st for the 'Mira' cv. The onset of fruiting occurred between April 27th and May 2nd for the 'Sarom' cv., April 27th and May 8th for the 'Ireal' cv., and April 28th and May 7th for the 'Mira' cv. Harvesting began between May 19th and 25th for the 'Sarom' cv., April 27th and May 8th for the 'Ireal' cv., and April 28th and May 7th for the 'Mira' cv. (Table 1).

Biometric data

From an agronomic point of view, a competitive strawberry cultivar can be characterized by several important features: plant yield (over 600 g), medium or large fruit (over 20 g), uniform shape and color, taste and aroma, highlights a consistency of complete and complex biochemical composition, good behaviour during the transport and handling of fruits designed for fresh consumption (Temocico et al., 2017; Sturzeanu and Temocico, 2018).

In our study, we found statistically significant differences in yield between the years 2019-2022 for the studied cultivars. The highest average yield was recorded by the 'Ireal' cv., with a value of 653.16 grams. The lowest yields were recorded in 2020, with 476.00 grams for the 'Sarom' cv. and 625.33 grams for the 'Ireal' cv., compared to the control which registered 427.00 grams. The year 2019 did not show significant differences in yield among all the cultivars. However, there were statistically significant differences in yield between the years 2021 and 2022 for the different cultivars. The 'Sarom' cv. was the most productive, with a yield of 674.00 grams in 2022, followed by the 'Ireal' cv. with a yield of 658.33 grams in 2022. In comparison, the control recorded yields of 392.00 grams in 2021 and 362 grams in 2022.

The average fruit weight recorded in our study was over 25 grams for all the studied cultivars. The 'Ireal' cv. had the highest average fruit weight, specifically 30.42 grams. In 2019, the lowest fruit weight was recorded by the 'Sarom' cv., with a value of 23.33 grams. For the other three years of the study, there were no significant differences in fruit weight between the two cultivars. The highest fruit weight was recorded by the 'Sarom' cv., with a value of 32.10 grams. The control showed statistically significant differences in fruit weight between the years (Table 2).

Regarding fruit firmness, statistically significant differences were found between cultivars, and it is a trait that directly affects the quality of strawberries. The average fruit firmness ranged from 15.09 N ('Mira' cv.) to 32.32 N ('Ireal' cv.). The highest firmness value was recorded in 2019 by the 'Sarom' cv., with a value of 46.90 N, compared to the control which recorded 17.60 N. In 2020, the 'Sarom' cv. also had the highest firmness value, with 38.30 N. Statistically significant differences in fruit firmness were observed between cultivars in all years of the study. The year 2022 stood out with the 'Ireal' cv., which had a firmness value of 40.30 N, compared to the control with a value of 21.77 N.

The 'Ireal' cv. registered the highest average shape index for strawberry fruits, with a value of 0.90. Throughout the four years of the study, the 'Ireal' cv. did not show significant differences in shape index. The lowest shape index value was 0.72 in 2022 for the 'Mira' cv

Biochemical data

Regarding the contents of the analysed biochemical indicators, the studied strawberry cultivars fall within the normal limits of variation of these indicators.

Total dry matter content

On average, strawberries contain 86-91.0% water, with the rest being dry matter (Gherghi et al., 1973). The dry matter consists of carbohydrates, proteins, lipids, minerals, organic acids, vitamins, and phenolic compounds (Kader, 2002). Essentially, the total dry substances reflect the quality of the fruits at harvest, with the most relevant components being starch and soluble dry substances (Travers, 2013). Among the analysed varieties, the average total dry matter content, as seen in Table 4, recorded the lowest value in the 'Sarom' cv. fruits in 2021 (8.30%) and the highest value in the 'Ireal' cv. fruits in 2022 (10.95%). Across the three cultivars, the highest value of total dry matter was recorded in the 'Ireal' cv. fruits (10.33%), significantly higher than the total dry matter value of the 'Sarom' cv. fruits (9.97%), both significantly higher than the 'Mira' cv. fruits (9.70%). The fruit's total dry matter content was significantly influenced by the genetic characteristics of the cultivar, with a percentage of only 14.4% according to the analysis of variance (ANOVA) test. The environmental conditions also had a very significant effect on this biochemical indicator (47.4%).

Soluble solids content

Along with other phytochemical compounds, the content of soluble solids contributes to the aroma of fruits. The total of soluble substances consisting of soluble carbohydrates and other non-carbohydrate compounds influences the refractive index of the aqueous extract obtained from a horticultural product (Diaconu, 2006). This is a genetic characteristic specific to each cultivar as shown in Table 4. Except for the year 2021, when the average value of the total soluble solids from 'Sarom' and 'Mira' cvs. was 6.87° Brix and 6.50° Brix soluble solids, the tested cultivars exceeded the recommended values for an acceptable aroma, corresponding to a minimum of 7° Brix soluble solids (Mitchell et al., 1996; Namesny, 1999; cited by Antunes et al., 2010). The result of the analysis of variance (ANOVA) shows a very significant variation of 39.0% in the content of soluble solids in strawberries among the three analysed cultivars, determined by genetic background. Thus, 'Sarom' cv. had the highest average content of soluble solids in fruits (9.02° Brix), while 'Mira' cv. recorded the lowest value (7.98° Brix); the differences between cultivars were statistically assured by the Duncan multiple comparisons test. According to Chitarra and Chitarra (2005 cited by Antunes et al., 2010), the content of soluble solids substances varies depending on species, cultivar, fruit ripening stage, and climatic conditions, with a range between 2 - 25%, and average values ranging from 8° Brix to 14° Brix. In the present study, the effect of climatic conditions resulting from the ANOVA analysis was also very significant on this biochemical indicator (71.7%). The average content of soluble solids between the years 2019-2022 recorded values ranging from 6.87° Brix ('Sarom' cv., 2021) to 10.00° Brix ('Sarom' cv., 2022), and the differences between years were very significant according to the test.

Total fruit acidity expressed as citric acid

According to previous studies, the content of organic acids in fruits can be influenced by growing conditions and the environment (Gündoğdu, 2019), genotypic differences, and post-harvest handling procedures (Lee and Kader, 2000). In this study, 'Ireal' and 'Sarom' cvs. recorded the richest content of organic acids, with the total titratable acidity expressed as citric acid being significantly higher (1.10% and 1.03% respectively) compared to the 'Mira' cv. (0.94%). The level of organic acids in strawberries was significantly lower in 2020 for all cultivars. The 'Mira' cv. also had low titratable acidity values in 2021. The ANOVA variance analysis data show that the level of organic acids in strawberries can be determined by the genomic differences characteristic of each cultivar. The genetic background influence was very significant, at only 14.0%. The meteorological conditions from 2019-2022 also had a significant effect on the content of organic acids in fruits, with a percentage of 15.9%. It is known that during periods of abundant precipitation or in cooler areas, the values of titratable acidity become higher (Gherghi, 1973).

Vitamin C content

According to Lee and Kader (2000), among the pre-harvest factors influencing the increase in vitamin C content in fruits, light intensity and temperature play a very important role. Therefore, in horticultural crops, higher light intensity and lower environmental temperature have a beneficial effect on the biosynthesis of ascorbic acid. However, very low temperatures have the opposite effect. In 2020, the studied strawberry cultivars had the lowest vitamin C content. According to the two-way analysis of variance (ANOVA), the biosynthesis of ascorbic acid in fruits was very significantly influenced by the climatic conditions during the period 2019-2022, with a percentage of 98.5%.

The study of cultivars shows a high level of vitamin C in the analyzed fruits. The influence of genetic characteristics on the ascorbic acid content is significant, with three homogeneous value classes appearing across the cultivars based on the Duncan test ($p \leq 0.05$). The highest level of ascorbic acid was obtained in 'Ireal' cv. The two-way analysis of variance (ANOVA) indicates a significant genetic background variation in the vitamin C content of the three studied cultivars, with an effect of 94.6%.

Total sugar content

Regarding the sugar level, it is normal for strawberries. The normal limits of total sugar content in strawberry fruits are 3.45-8.90% according to Gherghi et al. (1973). The results obtained highlighted significant differences between cultivars. The 'Sarom' and 'Ireal' cvs. had a higher average sugar content (7.21% and 7.47%, respectively) during the period 2019-2022. The 'Mira' cv. recorded a significantly lower average level (5.86%). The sugar content values of the analysed varieties ranged from 4.80% (in 2021 - 'Mira' cv.) to 8.64% (in 2019 - 'Sarom' cv.). After analysing the influence of the study year on the total sugar content of the fruits, very significant differences were found between years. The genetic baggage effect of the cultivar was stronger on the sugar content with a variation of 73.2%. In the four years of the study, climatic factors significantly influenced the sugar level in fruits by 47.7% ($p = 0.000$). The cumulative effect of these two experimental factors was 69.9%.

Total polyphenol content

Phenolic compounds from fruits or vegetables are powerful antioxidants according to previous research (Rice-Evans et al., 1995). The primary role in slowing tissue degradation caused by oxidative breakdown is played by polyphenols (Connor et al., 2002). In strawberry fruits, the level of these flavonoids varies depending on the cultivar (Aaby et al., 2005; Khanizadeh et al., 2009). In the specialized literature, the variation limits of these biochemically active substances in fruits are quite wide for the strawberry species, showing values ranging from 1262.91 mg GAE/kg (Trebichalsky et al., 2015) to 8000 mg GAE/kg FW (Fredes et al., 2014). The major factors influencing the level of strawberry polyphenols pre-harvest and at harvest include genetic background, climatic conditions, and fruit ripeness stage (Josuttis et al., 2012). In the present study, the analysis of mean values indicated a variation in the total polyphenol content in fruits ranging from a minimum of 3686.91 mg GAE/kg fresh fruit ('Ireal' cv. - in 2020) to a maximum of 6493.28 mg GAE/kg fresh fruit ('Sarom' cv. - in 2019). The 'Sarom' cv. was richer in polyphenols, and the difference in polyphenol content between this cultivar and the other two cultivars analyzed was significant according to the Duncan test with a 5% error probability. The ANOVA test results indicate a variation in the total polyphenol content in fruits determined by the genetic background of 96.2%. The study year also had a significant influence on the total polyphenol content in strawberry fruits. The year 2019 marked the highest polyphenol threshold in the analysed fruits. The variance analysis shows a very significant variation in the level of total polyphenols determined by the study year with an effect of 94.5%.

Total anthocyanin content

Anthocyanin pigments are part of the flavonoid class and are responsible for the blue, violet, and red colours of fruits depending on the pH. According to Wu et al. (2006), the dominant anthocyanins in the exocarp and mesocarp of strawberries give them their red colour. Strawberries are distinguished by a high content of anthocyanins: pelargonidin 3-glucoside (Moor et al., 2005). Delaying the harvest time has a positive effect on the level of anthocyanins (Josuttis et al., 2012). In the present study, the analysis of variance (ANOVA) test revealed that the genetic background was the determining factor for the anthocyanin content in the fruits. The obtained results showed a very significant impact of genetic characteristics on the total anthocyanin level in strawberries (81.2%). The content of anthocyanin flavonoids is significantly lower in 'Mira' and 'Ireal' cvs. (387.26 mg pelargonidin 3-glucoside/kg FW and 399.62 mg pelargonidin 3-glucoside/kg FW, respectively) compared to 'Sarom' cv. (426.70 mg pelargonidin 3-glucoside/kg FW). Although in 'Sarom' cv., the maximum average value of anthocyanin pigments was noted in 2020 (509.86 mg pelargonidin 3-glucoside/kg FW), in 'Ireal' and 'Mira' cvs., the maximum anthocyanin flavonoid levels were obtained in 2022 (532.34 mg pelargonidin 3-glucoside/kg FW and 477.44 mg pelargonidin 3-glucoside/kg FW, respectively).

Soluble solid/titratable acidity ratio

The solid soluble substance/titratable acidity ratio is one of the most commonly used methods for evaluating the flavour of fruits (Antunes et al., 2010). The statistical test grouped the cultivars into three classes of homogeneous values, with 'Sarom' cv. showing the highest values for this variable, and the 'Ireal' cv. presenting the lowest solid soluble substance/titratable acidity ratio in the group, due to low levels of solid soluble substance and high acidity.

Colorimetric data

Color is one of the most important traits influencing the choice of fruits by consumers, bright red-light fruits being preferred (Tiwari et al., 2009). Fruit color, the CIE L*a*b* color gamut is a uniform color scale, so the differences between the graphically represented points in the color space correspond to the visual differences between the graphically represented colors (Sturzeanu et al., 2015, Sturzeanu et al. , 2016).

The color analysis of strawberry fruits using the CIE L* a* b* color range showed positive values for all genotypes. However, there were no statistically significant differences found between the genotypes in terms of color parameters. The L* value, which represents luminosity or brightness, ranged from 27.44 ('Ireal' cv.) to 30.64 ('Mira' cv.), with the highest luminosity value recorded as 32.79 ('Mira' cv.). The fruit color index (C*) ranged from 23.90 ('Ireal' cv.) to 29.83 ('Sarom' cv.), with the highest value of 32.99 observed in 2022 for 'Mira' cv. The lowest C* value was 16.96 in 2019 for 'Ireal' cv. The fruit color angle index (h°) varied between 23.85 units ('Mira' cv.) and 24.74 units ('Sarom' cv.). Throughout the four years of the study, no statistically significant differences were found. The lowest h° value was recorded as 22.60 in 2020 ('Mira' cv.), while the highest was 26.20 in 2021 ('Sarom' cv.). Generally, lower values of the color indicators L*, C*, and h° indicate a darker fruit color (Zorrilla-Fontanesi et al., 2011).

5. Conclusions

Based on this evaluation of 2 new strawberry cultivars introduced in the Official Catalogue of cultivars, from an agronomic perspective, a competitive strawberry cultivar can be characterized by several important general characteristics: production per plant (over 600 g), fruit weight (over 25 g), aroma and light red color.

In our study, both cultivars: 'Sarom' and 'Ireal', exceeded the control ('Mira' cv.), regarding yield, fruit weight fruit, firmness and in all biochemical indicators, except for the 'Ireal' cv., which recorded a lower content of polyphenols.

Fruit the CIE L* a* b* color range recorded positive values in all genotypes in the case of strawberry fruits. The values obtained indicate a dark red color for the 'Ireal' cv, less glossy than the 'Sarom' and 'Mira' cvs.

References

1. Aaby K., Skrede G. and Wrolstad R.E., 2005. Phenolic composition and antioxidant activities in flesh and achenes of strawberries (*Fragaria x ananassa*). Journal of Agricultural and Food chemistry, 53(10): 4032-4040.
2. Antunes L.E.C., Ristow N.C., Krolow A.C.R., Carpenedo S. and Reisser Júnior C., 2010. Yield and quality of strawberry cultivars. Horticultura Brasileira, 28: 222-226.
3. Balducci F., Marcellini M., Schrey S., Linnemannstöns L., Capocasa F., Mezzetti B. and Mazzoni L., 2021. 'Francesca', 'Lauretta', 'Silvia' and 'Dina': four new strawberry cultivars for Northern and Southern European cultivation conditions from the Marche Polytechnic University breeding programme. In IX International Strawberry Symposium 1309: 205-208.
4. Braniște N., Budan S., Butac M., Militaru M., 2007. Soiuri de pomi, arbuști fructiferi și căpșuni create în România, Ed. Paralela 45 (In Romanian).
5. Connor A.M., Luby J.J., Hancock J.F., Berkheimer S. and Hanson E.J., 2002. Changes in fruit antioxidant activity among blueberry cultivars during cold-temperature storage. Journal of agricultural and food chemistry, 50(4): 893-898.
6. Diaconu C., 2006. Valoarea biologică şi culturală a germoplasmei de căpşun (*Fragaria x ananassa*) şi utilitatea ei în programele de ameliorare genetică. Teză de doctorat, ASAS Bucureşti (In Romanian).
7. Frede C., Montenegro G., Zoffoli J.P., Santander F. and Robert P., 2014. Comparison of the total phenolic content, total anthocyanin content and antioxidant activity of polyphenol-rich fruits grown in Chile. Ciencia e investigación agraria, 41(1): 49-60. www.rcia.uc.cl, DOI: 10.4067/S0718-16202014000100005.
8. Gherghi A., Millim K., Burzo I., 1973. Păstrarea şi valorificarea fructelor şi legumelor, Ed. Ceres Bucureşti, 1973 (In Romanian).
9. Gündoğdu M., 2019. Effect of rootstocks on phytochemical properties of apricot fruit. Turkish Journal of Agriculture and Forestry, 43(1): 1-10.
10. Jamieson A.R., 2017. Strawberry shape: phenotypic variation in length and width. Acta Hortic. 1156: 135-140. DOI 10.17660/ActaHortic.2017.1156.19: 135-140.
11. Josuttis M., Carlen C., Crespo P., Nestby R., Toldam-Andersen T.B., Dietrich H. and Krüger E., 2012. A comparison of bioactive compounds of strawberry fruit from Europe affected by genotype and latitude. Journal of Berry Research, 2(2): 73-95.
12. Khanizadeh S., Tao S., Zhang S., Tsao R., Rekika D., Yang R., Charles M.T., Gauthier L. and Gosselin A., 2009. Profile of antioxidant activities of selected strawberry genotypes. Acta Hortic. 814: 551-556.
13. Lee S.K., Kader A., 2000. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. Elsevier, Postharvest biology and technology 20(3): 207-220.
14. Lester G., Lewers K., Medina M., Saftner R., 2012. Comparative analysis of strawberry total phenolics via Fast Blue BB vs. Folin–Ciocalteu: Assay interference by ascorbic acid. Journal of Food Composition and Analysis, Volume 27, Issue 1: 102-107.
15. Mezzetti B., Mazzoni L., Balducci F., Marcellini M., Schrey S., Linnemannstöns L. and Capocasa F., 2021. 'Francesca', 'Lauretta', 'Silvia' and 'Dina': four new strawberry cultivars for Northern and Southern European cultivation conditions from the Marche Polytechnic University breeding programme. Acta Hortic. 1309: 205-208. https://doi.org/10.17660/ActaHortic.2021.1309.30
16. Moor U., Karp K., Põldma P. and Pae A., 2005. Cultural systems affect content of anthocyanins and vitamin C in strawberry fruits. European Journal of Horticultural Science, 70(4): 195.
17. Olbricht K., Wagner H. and Gerischer U., 2021. 'Rendezvous': portrait of a new European strawberry cultivar. Acta Hortic. 1309: 157-162. https://doi.org/10.17660/ActaHortic.2021.1309.23
18. Pérez-Jiménez J., Neveu V., Vos F., Scalbert A., 2010. Identification of the 100 richest dietary sources of polyphenols: an application of the Phenol-Explorer database. European Journal of Clinical Nutrition, 64: S112–S120.
19. Rice-Evans C.A., Miller N.J., Bolwell P.G., Bramley P.M., Pridham J.B., 1995. The relative antioxidant activities of plant-derived polyphenolic flavonoids. Free radical research, 22(4): 375-383.
20. Sturzeanu M., Ancu I., Chitu E., 2015. The evaluation of fruits quality in some strawberry cultivars (*Fragaria x ananassa* L. Duch.). Fruit Growing Research vol. XXXI: 23-29. http://publications.icdp.ro/publicatii/lucrari%202015/03.Monica%20Sturzeanu.pdf

21. Sturzeanu M., Ancu I., Chitu E., Stanciu C., 2016. Some fruit qualities characteristics of strawberry selection from Queen Elisa x Premial. Fruit Growing Research vol. XXXII: 44-47. 2286-0304 http://publications.icdp.ro/publicatii/lucrari%202016/07.Lucrare%20Sturzeanu%20Monica.pdf
22. Sturzeanu M., Călinescu M., Nicola C., Titirică I., Ciucu M., 2018. Study of new strawberry selections from the Romanian strawberry breeding programme. Fruit Growing Research, Vol. XXXIV: 57-62. DOI 10.33045/fgr.v34.2018.11. http://publications.icdp.ro/index.php
23. Sturzeanu M., Baruzzi G., Sbrighi P. and Calinescu M., 2021. The evaluation of some Italian strawberry genotypes in Romania. In IX International Strawberry Symposium 1309: 431-438.
24. Sturzeanu M., Militaru M., Butac M., Călinescu M., Iancu A., Petre Ghe., Iurea E., Guzu G., 2022. Eficientizarea ameliorării genetice a soiurilor de pomi și arbuști fructiferi. Ed. Invel Multimedia, Bucharest, ISBN 978-606-764-074-8 (In Romanian).
24. Travers S., 2013. Dry matter and fruit quality: manipulation in the field and evaluation with NIR spectroscopy. Department of Food and Technology: 28-35.
25. Tiwari B.K., O'donnell C.P., Muthukumarappan K. and Cullen P.J., 2009. Anthocyanin and colour degradation in ozone treated blackberry juice. Innovative food science & emerging technologies, 10(1): 70-75.
26. Trebichalský P., Molnárová J., Bajčan D., Timoracká M., Musilová J. and Harangozo Ľ., 2015. Total polyphenols content in fruits of selected cultivars of strawberries in relation to concentrations of cadmium and lead in soil. Potravinarstvo Slovak Journal of Food Sciences, 9(1): 480-486.
27. Tudor V, Asanica A, Neagu T., 2014. First results of some day-neutral strawberry cultivars behavior in the Bucharest area conditions. Uni. Agron. Sci. and Veterinary Medicine of Bucharest 58: 101-106.
28. Wu X., Beecher G.R., Holden J.M., Haytowitz D.B., Gebhardt S.E. and Prior R.L., 2006. Concentrations of anthocyanins in common foods in the United States and estimation of normal consumption. Journal of agricultural and food chemistry, 54(11): 4069-4075.
29. Zorilla F.Y., Cabeza A., Domínguez P., Medina J.J., Valpuesta V., Denoyes R.B., Sánchez S.J.F., Amaya I., 2011. Quantitative trait loci and underlying candidate genes controlling agronomical and fruit quality traits in octoploid strawberry (*Fragaria × ananassa*). Theoretical and Applied Genetics 123: 755-778.

Tables and Figures:

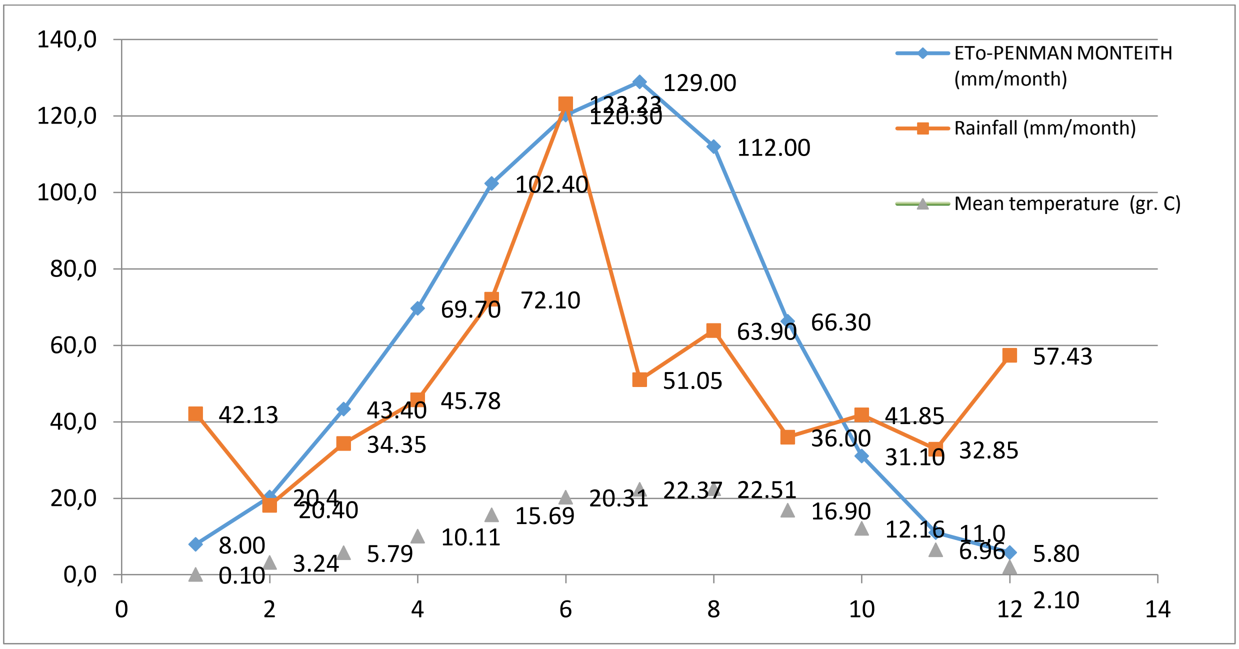

Fig. 1. Meteorological parameters (ETo, rainfall and mean monthly temperature) during January 2019−December 2022

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Table 1. The phenological data of the strawberry cultivars evaluated compared to the control (2019-2022)

Cultivar	Year	Evolution of inflorescence	Beginning of flowering	Onset of flowering	Onset of fruiting	Onset of harvest
Sarom	2019	18 April	24 April	27 April	19 May	29 May
	2020	15 April	02 May	09 May	19 May	22 May
	2021	17 April	22 April	03 May	25 May	01 June
	2022	16 April	22 April	03 May	23 May	27 May
	Interval	15-18 April	22 April - 02 May	27 April – 09 May	19-25 May	22 May – 01 June
Ireal	2019	19 April	26 April	27 April	20 May	30 May
	2020	16 April	01 May	08 May	18 May	22 May
	2021	16 April	20 April	30 April	26 May	03 June
	2022	15 April	23 April	03 May	25 May	30 May
	Interval	15-19 April	20 April – 01 May	27 April – 08 May	20 – 26 May	22 May – 03 June
Mira	2019	17 April	25 April	01 May	23 May	28 May
	2020	18 April	31 April	07 May	18 May	20 May
	2021	15 April	20 April	28 April	25 May	30 May
	2022	16 April	22 April	01 May	16 May	27 May
	Interval	15-18 April	20 - 31 April	28 April -07 May	16 - 25 May	20-30 May

Table 2. The biometrical traits of the strawberry cultivars evaluated compared to the control (2019-2022)

Cultivar	Year	Yield (g/plant)	Fruit weight (g)	Shape index	Fruit firmness (N)
Sarom	2019	665.00±39.52^{a*}	23.33±2.21^{b}	0.80±0.01^{b}	46.90±0.20^{a}
	2020	476.00±11.00^{b}	27.30±3.13^{a}	0.83±0.01^{a}	38.3±0.75^{a}
	2021	649.67±38.18^{a}	32.10±1.17^{a}	0.83±0.01^{c}	25.68±0.67^{b}
	2022	674.00±36.00^{a}	30.37±1.21^{a}	0.78±0.01^{b}	15.60±3.13^{c}
	Mean	616.33±89.73^{b}	28.27±3.91^{b}	0.81±0.02^{b}	31.62±12.54^{a}
Ireal	2019	684.00±13.00^{a}	31.40±0.70^{a}	0.94±0.01^{a}	36.10±0.70^{b}
	2020	625,33±36,90^{b}	29.40±1.18^{a}	0.88±0.01^{a}	31.40±1.26^{b}
	2021	645.00±22.00^{ab}	30.40±0.20^{a}	0.90±0.01^{a}	21.50±2.13^{b}
	2022	658.33±34.55^{ab}	30.50±1.08^{a}	0.90±0.01^{a}	40.30±0.45^{a}
	Mean	653.16±32.85^{a}	30.42±1.05^{a}	0.90±0.21^{a}	32.32±7.39^{a}
Mira	2019	421.00±14.00^{a}	25.16±1.22^{a}	0.71±0.01^{c}	17.60±0.20^{b}
	2020	427.00±32.00^{a}	22.82±1.09^{b}	0.87±0.01^{a}	11.10±0.35^{c}
	2021	392.00±11.00^{ab}	24.80±1.18^{b}	0.87±0.01^{b}	9.90±0.15^{c}
	2022	362.00±25.00^{b}	24.80±1.18^{b}	0.72±0.01^{c}	21.77±0.70^{a}
	Mean	400.50±32.97^{c}	24.55±1.45^{c}	0.75±0.01^{c}	15.09±5.07^{b}

*The values in the table that do not have common letters differ significantly for a statistical assurance level of 5% ($P \leq 0.05$).

Table 3. The color traits of the strawberry cultivars evaluated compared to the control (2019-2022)

Cultivar	Year	Brightness (L)	Chroma index (C*)	The angle (h*)
Sarom	2019	29.26±2.597[ab*]	30.273±1.47[a]	22.62±1.79[a]
	2020	29.88±3.87[a]	29.36±6.69[a]	24.44±1.18[a]
	2021	30.89±1.71[a]	31.18±0.34[a]	26.20±3.13[a]
	2022	28.84±3.66[a]	28.51±5.06[a]	25.66±1.64[a]
	Mean	2.72±2.75[a]	29.83±3.78[a]	24.74±2.27[a]
Ireal	2019	26.59±0.89[b]	16.96±2.86[a]	24.48±2.72[a]
	2020	27.15±0.85[a]	24.67±3.06[a]	23.82±5.59[a]
	2021	28.43±0.55[a]	27.80±4.44[a]	21.96±3.67[a]
	2022	27.58±0.93[a]	26.17±2.16[a]	22.39±1.28[a]
	Mean	27.44±0.99	23.90±5.15	24.48±2.72
Mira	2019	31.03±0.99[a]	26.70±3.15[a]	24.43±0.19[a]
	2020	29.55±2.20[a]	26.51±3.30[a]	22.60±3.59[a]
	2021	29.20±5.28[a]	25.74±7.29[a]	23.59±5.10[a]
	2022	32.79±3.22[a]	32.99±2.58[a]	24.77±2.84[a]
	Mean	30.64±3.19	27.99±4.89	23.85±3.05

*The values in the table that do not have common letters differ significantly for a statistical assurance level of 5% (P≤0.05).

Table 4. The biochemical compounds of the strawberry cultivars evaluated compared to the control (2019-2022)

Cultivar	Year	Total dry matter content %	TSS (°Brix)	Titratable acidity (citric acid %)	Total sugar content (%)
Sarom	2019	10.86 ± 0.54[a*]	9.80 ± 0.95[a]	1.01 ± 0.36[a]	8.64 ± 1.14[a]
	2020	9.78 ± 0.89[b]	9.40 ± 0.53[b]	0.89 ± 0.20[a]	7.15 ± 0.23[b]
	2021	8.30 ± 0.26[c]	6.87 ± 0.29[c]	1.05 ± 0.20[a]	6.77 ± 0.31[bc]
	2022	10.94 ± 0.32[a]	10.00 ± 0.35[a]	1.08 ± 0.21[a]	6.28 ± 0.26[c]
	Mean	9.97 ± 1.21[b]	9.02 ± 1.41[a]	1.03 ± 0.23[ab]	7.21 ± 1.06[a]
Ireal	2019	10.20 ± 0.33[ab]	9.30 ± 0.55[a]	1.15 ± 0.19[a]	7.31 ± 0.24[a]
	2020	9.68 ± 0.80[b]	8.50 ± 1.08[b]	1.00 ± 0.21[a]	8.03 ± 0.37[a]
	2021	10.47 ± 0.66[ab]	8.20 ± 0.66[bc]	1.19 ± 0.21[a]	7.52 ± 0.58[a]
	2022	10.95 ± 0.80[a]	7.93 ± 0.38[c]	1.08 ± 0.11[a]	7.02 ± 0.26[a]
	Mean	10.33 ± 0.75[a]	8.48 ± 0.82[ab]	1.10 ± 0.17[a]	7.47 ± 0.51[a]
Mira	2019	9.77 ± 0.54[a]	9.43 ± 0.46[a]	1.05 ± 0.06[a]	6.54 ± 0.79[ab]
	2020	9.28 ± 1.72[a]	7.50 ± 0.75[bc]	0.83 ± 0.06[b]	5.08 ± 0.68[ab]
	2021	9.17 ± 0.44[a]	6.50 ± 0.62[c]	0.80 ± 0.11[b]	4.80 ± 0.26[b]
	2022	10.59 ± 0.69[a]	8.50 ± 0.70[ab]	1.07 ± 0.32[a]	7.00 ± 0.12[a]
	Mean	9.70 ± 1.03[c]	7.98 ± 1.27[b]	0.94 ± 0.20[b]	5.86 ± 1.08[b]

*The values in the table that do not have common letters differ significantly for a statistical assurance level of 5% (P≤0.05).

Table 5. The biochemical compounds of the strawberry cultivars evaluated compared to the control (2019-2022)

Cultivar	Year	TPC (mg GAE /kg fresh fruit)	TAC (pelargonidin-3-glucoside mg/kg fresh fruit)	Vitamin C content (mg/100g fresh fruit)	Soluble solids/ titratable acidity
Sarom	2019	6493.28 ± 219.78[a*]	267.39 ± 43.10[c]	52.81 ± 1.05[c]	9.19 ± 2.58[ab]
	2020	5680.04 ± 53.86[b]	472.18 ± 21.05[ab]	44.79 ± 0.85[d]	10.91 ± 2.52[a]
	2021	5126.09 ± 104.60[c]	509.86 ± 9.67[a]	55.79 ± 0.77[b]	6.73 ± 1.70[b]
	2022	4987.00 ± 4.48[d]	457.38 ± 19.47[b]	69.68 ± 0.17[a]	9.36 ± 1.89[ab]
	Mean	5571.60 ± 627.33[a]	426.70 ± 100.65[a]	55.77 ± 9.40[b]	9.05 ± 2.47[a]
Ireal	2019	5082.61 ± 65.57[a]	333.23 ± 11.75[c]	55.72 ± 2.35[c]	8.16 ± 1.02[a]
	2020	3686.91 ± 51.43[c]	364.89 ± 14.04[b]	49.35 ± 0.80[d]	8.74 ± 1.54[a]
	2021	4221.74 ± 64.63[b]	368.02 ± 6.88[b]	73.04 ± 0.72[a]	7.06 ± 1.88[a]
	2022	4462.45 ± 346.42[b]	532.34 ± 80.92[a]	65.37 ± 1.40[b]	7.39 ± 0.96[a]
	Mean	4363.43 ± 545.76[b]	399.62 ± 126.41[b]	60.87 ± 9.54[a]	7.84 ± 1.36[c]
Mira	2019	4982.62 ± 66.62[a]	230.48 ± 10,24[d]	57.31 ± 1.39[b]	9.02 ± 0.10[a]
	2020	5082.61 ± 107.99[a]	388.77 ± 18.31[c]	38.72 ± 0.47[d]	9.02 ± 1.06[a]
	2021	3701.45 ± 18.44[c]	452.36 ± 1.29[b]	52.80 ± 0.29[c]	8.20 ± 0.61[a]
	2022	4044.65 ± 56.72[b]	477.44 ± 31.92[a]	59.52 ± 0.25[a]	7.91 ± 3.51[a]
	Mean	4452.83 ± 621.66[b]	387.26 ± 101.70[b]	52.09 ± 8.47[c]	8.54 ± 1.63[b]

*The values in the table that do not have common letters differ significantly for a statistical assurance level of 5% (P≤0.05).