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EVALUATION OF THE MAIN PHENOTYPIC AND PHYSICO-CHEMICAL CHARACTERISTICS IN THE NEW GENOTYPES OF JERUSALEM ARTICHOKE (*HELIANTHUS TUBEROSUS*) OBTAINED AT V.R.D.S. BUZĂU

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Abstract

Long ago, the Jerusalem artichoke was grown on large areas and almost all households had areas allocated to this crop. Over time, it was gradually removed ending up endangered. The Jerusalem artichoke was called turnip by the Romanian peasants, a mistake later rectified by Romanian specialists demonstrating that it belongs to the Asteraceae family, while the turnip belongs to the Brassicaceae family. The Breeding and Biodiversity Laboratory included the Jerusalem artichoke in its research in 1996, achieving a rich collection of genotypes, three of which have been approved and have distinct phenotypic characteristics: L1 (Olimp) shows white tubers, rich foliage mass composed of stems taller than 3 m; L2 (Rareș) has brown pink tubers, rich foliage mass and heights over 3 m; L3 (Dacic) has pink tubers, reduced foliage mass and stems shorter than 80 cm. During the vegetation period, phenological and biometric determinations were performed. Genotypes L1, L2 and L3 were physical-chemically analysed in the laboratory: the protein content was 1.1% in L1, 1.34% in L2 and 1.42% in L3 and cellulose content ranged from 0.9% in L1 to 0.98% in L3 and 0.99% in L2.

Key words*: biodiversity, breeding, genotype, germplasm, natural sweetener.*

INTRODUCTION

The Jerusalem artichoke belongs to the *Asteraceae* family and it is known botanically as *Helianthus tuberosus* L. It has several names among the folk such as "earth apple, bulbous chervil, rape, winter potato, earth potato, earth turnip, Jerusalem artichoke"; however, the most used name is that of "turnip". Unfortunately, this name was mistakenly embraced by the folk because the Jerusalem artichoke belongs to the *Asteraceae* family and the turnip belongs to the *Brassiceae* family. In Romania, the species is very little known as Jerusalem artichoke.

The plant has its origin in North America, being cultivated since ancient times by a tribe of Indians named topinambas. European explorers introduced it to Europe, where it spread rapidly, both as food for humans and animals (Rebora C., 2008). We have relevant data on its use as food from France, where it received the name of Jerusalem artichoke, gradually expanding throughout Europe, globally registered and known in all botanical nomenclatures under the name of Jerusalem artichoke (Luchian et al., 2017).

The Jerusalem artichoke is a perennial grassy plant with branched stems and can reach up to 2-3 m tall. Leaves are located towards the top of the stalk, flowers are small, bright yellow (Gupta D., Chaturvedi N., 2020).

In the soil it develops a system of rhizomes unequal in size, elongated and varying from nodes to round clusters in the form of small, fleshy tubers, similar to potatoes. The color of the tubers varies from pale brown to pink, red and purple, depending on the climate conditions (Gupta D., Chaturvedi N., 2020).

The plant was introduced in Romania in the 19th century, as a turnip though. There were also hypotheses released by the scientific world that, the species had been in Romania long before the 19th century, arguing that both in spontaneous flora and in households, there was a variety of dwarfed artichoke, called "Dacic". The species adapted very well to the pedoclimatic conditions of our country, even considered as invasive, being encountered in

the spontaneous flora and in the domestic system, almost throughout the entire territory of our country (Gherman N., 2013).
Vegetable Research Development Station (V.R.D.S.) Buzău has been intensively studying this species since 1996. The researches were channeled towards the breeding of the species in order to obtain genotypes with distinct phenotypic expressiveness suitable for several uses: consumption of fresh tubers, industrialization and processing, use of both, the flowering stems and the aerial stems, in the feeding of animals, use of the flowering stems as an energy plant, and the production of pellets. The researches were also extended for the use of the plant for medicinal, melliferous and ornamental purposes. Also, due to the woody stalk and tall height of 2-3m, the Jerusalem artichoke can be used successfully as a protective crop for the more sensitive crops to cold winds or to prevent the evaporation of humidity from the soil (Ciuciuc et al., 2019; Barcanu et al., 2019).
Therefore, the Jerusalem artichoke is a plant with great potential, both in the food industry and as industrial and fuel product.
Tuber production has a high yield, grows better in poor soils than most crops and has a high resistance to diseases and pests, as well as to low temperatures (Rebora, 2008; Drăghici, 2018). This paper aims to evaluate the phenotypic expressivity and biological production potential of three new genotypes of Jerusalem artichoke obtained at Vegetable Research Development Station (V.R.D.S.) Buzău.

MATERIALS AND METHODS

Vegetable Research Development Station (V.R.D.S.) Buzău has a valuable germplasm base of this species, out of which three genotypes were selected, which received code names L1, L2 and L3 and were approved under the names of L1 - Olimp, L2 - Rareș and L3 - Dacic.
The breeding method used to obtain the genotypes was clonal selection.
The crop technology applied was the one specific to Jerusalem artichoke, being very similar to the one specific to potatoes. The land was prepared in the fall and the establishment of the crop was carried out for all three varieties, after the fall of haze, starting with November 10th.
Planting was done on hilling, with a distance of 70 cm between rows and 20-30 cm between plants/row.
The care work consisted of mechanical and manual hoeing for rebuilding the hills, in the spring. Starting with June, three irrigations have been made to fill the water supply required by the plant.
Starting from June 15, mechanical and manual hoeing could no longer be realized, as the flowering stems would have been broken.
During the vegetation period and after the harvest, phenological and biometric observations, as well as sensorial and laboratory analyzes were made.

RESULTS AND DISCUSSIONS

Bellows, it will present the results obtained in the study performed on the three genotypes obtained at Vegetable Research Development Station (V.R.D.S.) Buzău: L1 Olimp (Figure 1), L2 Rareș (Figure 2) and L3 Dacic (Figure 3). These are measurements that have highlighted the main phenotypic characteristics and sensory and physico-chemical analyzes of fresh Jerusalem artichoke tubers.

Figure 1. Olimp variety, with yellow-white tubers

Figure 2. Rareș variety, with pink-brown tubers

Figure 3. Dacic variety, with pink colour tubers and small height

The three genotypes selected for research have distinct characteristics. The first three phenotypic characteristics studied in the Table 1, below are: plant height (m), where first place was occupied by L2 genotype (Rareș) with 2.8 m, while the last place, at plant height characteristic was occupied by L3, Dacic, with only 0.8 m. The next indicator studied was number of stems/plant, where L3, Dacic has the highest value (10 stems/plant), and the smallest value was L1, Olimp with 6 stems/plant (Table 1). The last column from Table 1 is reserved for the distance between the leaves, where the first place is occupied by L1 (6 cm) and the last place by L3 (1.2 cm).

Table 1. The Jerusalem artichoke main characteristics I

Feature	Plant height (cm)			Stems no./ plant			Leaf distance (cm)		
	Limit of variability		Average value	Limit of variability		Average Value	Limit of variability		Average Value
	lowest	highest		lowest	highest		lowest	highest	
Genotype L1 OLIMP	240	260	121	5	7	6	4,00	8,00	6,00
Genotype L2 RAREȘ	260	300	280	6	10	8	4,00	6,00	5,00
Genotype L3 DACIC	60	80	70	8	12	10	0,70	1,70	1,20

In the Table 2 below, were considered for study the following three characteristics as follows: length of the leaf (cm), width of the leaf (cm) and the length of the peduncle (cm). Regarding the length of the leaf, the highest value was registered at L1, Olimp (22 cm), and the lowest value at L3, Dacic (10 cm). The next phenotypical characteristic studied was the width of the leaf, where the highest value was measured at L1, Olimp (16 cm), and the lowest value measured was at L3, Dacic (4 cm).

The last studied characteristics was the length of the peduncle, where the first position was occupied by L1, Olimp with 10 cm, and the last position was occupied by L3, Dacic, with a length of the peduncle of only 1 cm.

Table 2. The Jerusalem artichoke main characteristics II

Feature	Leaf length (cm)			Leaf width (cm)			Peduncle length (cm)		
	Limit of variability		Average value	Limit of variability		Average value	Limit of variability		Average value
	lowest	highest		lowest	highest		lowest	highest	
Genotype L1 OLIMP	20	24	22	12	16	14	8	12	10
Genotype L2 RAREȘ	16	20	18	10	14	12	6	10	8
Genotype L3 DACIC	8	12	10	2	6	4	1	2	1

Continuing, for the three genotypes that were studied, Olimp, Rareș and Dacic, the tubers were subjected to multiple measurements.

First of all, were selected several tubers coming from each and every genotype. Therefore at the Olimp, L1 genotype, the tubers were numbered, weighted and the average weight of the tubers was calculated.

The same method was repeated for the Rareș, L2 genotype tubers, identical measurements were made also to the Dacic, L3, tubers. According to the Table 3, at the genotype Rareș, L2, were obtained the highest values, that is, the biggest tubers, with an average weight of 192 g.

On the other side, the smallest values were occupied by Olimp, L1, with an average weight of 98 g. In the Table 3, were presented, also, the length (cm) and the diameter (cm) of Jerusalem artichoke tubercles, it was highlighted the fact that the genotype Dacic, L3, show the highest value of tuber length (10.2 cm), and the genotype Olimp, L1, show the lowest value in table, regarding the tuber length (7.7 cm). Measures that were made further revealed that the biggest diameter was measured at the genotype Dacic L3, with 5.4 cm, and the smallest diameter was measured at the genotype Olimp L1, with 4.2 cm.

Table 3. Quantitative characteristics at Jerusalem artichoke tubers

Feature	Tuber weight (g)			Tuber length (cm)			Tuber diameter (cm)		
	Limit of variability		Average	Limit of variability		Average	Limit of variability		Average
	lowest	highest	value	lowest	highest	Value	lowest	highest	Value
Genotype L1 OLIMP	54	143	98	5,2	10,3	7,7	3,8	4,5	4,2
Genotype L2 RAREȘ	46	338	192	6,0	13,4	9,7	4,2	6,4	5,3
Genotype L3 DACIC	34	166	100	7,8	12,7	10,2	4,1	6,7	5,4

Accordingly, transposed in a graphic, the first characteristics determined in Table 3, that is, The Average weight of artichoke tubercles is represented in Figure 4.

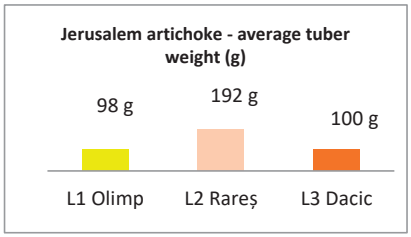

Figure 4. The Average weight Jerusalem artichoke tubers representation

The following step of the study was the sensorial analyses for fresh tubers, that was done for all three genotypes L1 Olimp, L2 Rareş and L3 Dacic. All the measured values are presented in the Table 4.

Table 4. The sensorial analyses of the fresh Jerusalem artichoke tubers

Jerusalem artichoke Variety	INDICATOR					
	Appearance before washing	Appearance after washing	Color	Texture	Taste	Smell
L1 Olimp	tubers of irregular shape and different sizes, with the surface covered by wet dust	tubers of irregular shape (oval, fusiform) of different sizes, 5-10 cm length, and 4-5 cm diameter	specific yellow - white	freshness crispy, juicy	moderately sweetness, characteristic pleasant taste	distinctive
L2 Rareș	tubers of irregular shape and different sizes, with the surface covered by wet dust	tubers of irregular shape (oval, fusiform) of different sizes, 6-13 cm length and 4-6 cm diameter	specific pink-brown	freshness crispy, juicy	weakly sweetness, characteristic pleasant taste	distinctive
L3 Dacic	tubers of irregular shape and different sizes, with the surface covered by wet dust	tubers of irregular shape (oval, fusiform) of different sizes, 8-13 cm length and 4-7 cm diameter	specific pink	freshness crispy, juicy	strongly sweetness, characteristic pleasant taste	distinctive

Therefore, the following indicators were followed: the aspect of the tubers before washing, the aspect after washing, colour of the tubers, the texture, the taste and the smell.

For the first indicator, the aspect of the tubers before washing, the observations made revealed that all three genotypes of Jerusalem artichoke, that is: L1- Olimp, L2- Rareş and L3-Dacic, presents tubers with an irregular forma, sizes and dimensions and the surface of the tubers was covered with wet dust.

The second indicator that was studied, the aspect of the tubers after washing, was analysed after the procedure of cleaning the wet dust and revealed the fact that the tubercle presents different irregularities on the surface of the tubers, of different shapes and forms: oval, spindly, and different lengths and diameters as well, as follows: at genotype L3, Dacic (Figure 5) were obtained the highest values in regards of the length of the tubers that is between 8-13 cm, and at the measurement of the diameters, at the same genotype, L3, Dacic, were measured diameters between 4-7 cm.

Figure 5. Genotype Dacic, longitudinal section

The smallest values were registered measuring the tubers for the genotype L1, Olimp (Figure 6), that is lengths covered in the interval 5-10 cm, and regarding the diameters, the measured values were found between 4-5 cm.

Figure 6. Genotype Olimp, longitudinal section

At the Jerusalem artichoke genotype L2, Rareş (Figure 7), the tubers length measured value is included in the interval 6-13 cm, and the diameter values that were measured, is included in the interval 4-6 cm.

The third studied characteristic, was the colour of the Jerusalem artichoke tubers where the following aspect were revealed: at the genotype L1, Olimp, as presented in Figure 6, the tubers presents a specific white-yellow colour, at the genotype L2, Rareş (Figure 7), the tubers presents a characteristic pink-brown colour, and at the genotype L3, Dacic (Figure 5), tubers have a specific pink colour.

Figure 7. Genotype Rareş, longitudinal section

The forth characteristic that was studied was the texture of the Jerusalem artichoke tubers, where it was revealed that for all the three genotypes, the texture of each one was crunchy and juicy, with the specification that at Rareş, L2, the texture of fresh tubers was a little bit floury, similar to the raw potato. Also, all the Jerusalem artichoke samples generated a pleasant sensation of freshness at the taste buds level.

The fifth characteristics, in regards of the sensitive analyse, is the taste, and it was revealed that the taste is sweet, nice and characteristic to the Jerusalem artichoke tubers, to be mentioned here that the genotype L1, Olimp has a moderate sweet taste, the genotype L2, Rareş is the less sweet and the genotype L3, Dacic is the sweetest one of the three genotypes.

The last studied characteristic was the smell of the Jerusalem artichoke tubers that revealed the fact that all the tubers coming from the three genotypes, that is L1 Olimp, L2 Rareş and L3 Dacic, as well, present a distinctive smell.

In Table 5 are presented the figures that were obtained after the physical and chemical analyse at the Jerusalem artichoke tubers at all three studied genotypes, that is L1, Olimp, L2, Rareş and L3, Dacic. Therefore, there were studied the following indicators, in percentual form: humidity, total ash, proteins and cellulose.

The first indicator studied physically and chemically was humidity, where the lowest value measured was registered at genotype L3, Dacic 73.72%, meantime the highest value measured was at genotype L1, Olimp, 74.10%.

After that, the total ash was analysed, the lowest percentage was measured at genotype L1, Olimp (72%), and the highest percentage was measured at the genotype L3, Dacic 1.16%.

The third indicator that was studied was the protein percentage, where the genotype L3 Dacic generated the highest value measured that is 1.42%, and the genotype L1, Olimp, the lowest value measured 1.10%.

The last indicator that was analysed physical and chemical for the Jerusalem artichoke tubers was to calculate the cellulose percentage. In this case the highest rate was identified for the genotype L1, Olimp, 0.90%, and the highest value was 0.99%, found at genotype L2, Rareş.

Table 5. Physical and chemical analyse for the fresh Jerusalem artichoke tubers

Crt. No.	Physical-Chemical Indicator	Jerusalem artichoke variety		
		L1 Olimp	L2 Rareş	L3 Dacic
1	Humidity (%)	74,1	75,31	73,22
2	Total ash (%)	0,72	1,14	1,16
3	Protein (%)	1,1	1,34	1,42
4	Cellulose (%)	0,9	0,99	0,98

CONCLUSIONS

The researches were finalised achieving three different Jerusalem artichoke varieties, each one having distinct phenotypical expression.

L1 - present white-yellow colour tubers, rich foliage mass and a height over 3m.

L2 - present pink-brown tubers, rich foliage mass, and height beyond 3m.

L3 - present pink colour tubers, slight spherical, low foliage mass and a height of a maximum 80 cm.

L2 was approved and registered in The Official List of Culture Plants from Romania, starting 2018, being named Rareş.

L1 was approved and is registered in The Official List of Culture Plants from Romania from 2019, and L2, is presently in the last year

of tests and trials, and will follow to be approved and registered in The Official List of Culture Plants from Romania, starting 2020.
Biological material (the tubers), offered promotionally to the farmers, helps to increase the areas cultivated with this specie in Romania, increasing the interest of the farmers and of the consumers as well for this plant. During the study, was followed not only the plant, but the preparation of the specific process of farming of the plant, as well, each farmer receiving not only the biological material, but specific information regarding the farming of artichoke.
The interest for Jerusalem artichoke remains of great actuality, if we consider the valorification of tubers for achieving of functional ingredient with high nutritional value. We are speaking here about the powders achieved from Jerusalem artichoke tubers, and can be used to fortify food products (bakery and pastry products, especially), in order to increase the nutritional and their antioxidant potential, but also as sweetening agent for products, for diabetics. (Catană et al., 2018).
Researches will continue through the enrichment of the germplasm base germplasm of this specie and the support and promotion of the production for this specie and the promotion of the production on a large scale of the new genotypes achieved.

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