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RESEARCHES ON THE BEHAVIOR OF JERUSALEM ARTICHOKE VARIETIES GROWN ON SANDY SOILS IN TERMS OF NUTRITIONAL QUALITY OF TUBERS

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Abstract

The aim of this study was to evaluate the quality of Jerusalem artichoke tubers in genotypes grown on sandy soils in Southern Oltenia. The area of sandy soils in southern Oltenia offers favorable conditions for the growth and development of Jerusalem artichoke plants. The average productions obtained for this species in the pedoclimatic conditions from SCDCPN Dăbuleni showed the resistance of the species to the high temperatures in this area. Inulin was present in tubers in a percentage of 12.08 % in the local population of Dăbuleni and 13.39 % in the Dacic variety, with an average of 12.93 % which confirms the functional potential of the species and recommends the species as a "source of fiber".

Key words: *quality, artichoke genotypes, sandy soils, Romania*

INTRODUCTION

The Jerusalem artichoke is a species that belongs to the genus *Helianthus L.*, Asteracea family, Asterales category and has the *Helianthus tuberosus L.* scientific name [28].
The Jerusalem artichoke, native to the north of the United States, is a perennial species that can be grown as an annual species. It is a temperate zone to culture it , with a high ecological plasticity, it is cultivated between 40-55 Celsius degrees, from north to south latitude [12]. It grows well in semi-arid tropical areas [18]. Today it is widely grown in France, Norway, Russia, Great Britain, Germany, Spain, Italy, Asia, America or Australia.
For over 300 years, the interest in this species has varied from area to area. Currently, the latest studies highlighted an increased interest in the Jerusalem artichoke culture due to its benefits in human and animal diets and due to its increased potential to be used for biofuel production [23] [25].
The researches made in Romania by [33], led to the hypothesis that the plant is much older in our country, being almost non-existent when researches began on this plant in Romania.
The Jerusalem artichoke tubers are composed of 80 % water, 15 % carbohydrates and 1-2 % protein [10]. Data on its composition are relatively small compared to other species, however, they reveal significant variations between certain parameters. They contain very little or no starch, are virtually fat-free and have a relatively low calorie level [5]. In the small amount of fat found in the tubers, unsaturated fatty acids were identified and no saturated fatty acids were determined [34]. Tubers are a good source of dietary fiber, due to the presence of inulin, which is the main storage carbohydrate [30]. Inulin in tubers ranges from 7 to 30 % by fresh weight and about 50 % by dry weight [31].
The chemical composition of the tubers clearly highlights their nutritional value. The average values recorded show that they have a high dry matter content, over 22 %, protein 1.6 %, fat 0.2 %, cellulose 1.1 %, mineral salts 0.95 %, non-nitrogenous extractive

substances in the form of inulin , sucrose and starch 18.43 %.

Comparing to other plants studied so far, it has been found that inulin in Jerusalem artichoke that has the lowest percentage of glucose and sucrose, thus helping patients with diabetes, contributing to the normalization of blood sugar [32].

The researches undertaken on Jerusalem artichoke highlighted the role of the variety studied together with the other elements of technology: fertilization, density, planting season, and so on.

Due to the rapid growth rate of plants, weed competition is low [29].

The variety is one of the main factors of the technology, the cultivation of a variety must be done only after a prior test regarding its adaptability to natural environmental factors.

Plant pathogens, pests and weeds are one of the most important drivers of the diversity in plant breeding, new crop management and practices, new methods and technologies in agriculture and food research and production [19].

The researches conducted by [36] highlighted a relationship between genotypes and the geographical origin of the Jerusalem artichoke variety. The production of tubers, the number of tubers per plant and the size of tubers in Jerusalem artichoke are influenced by the interaction between genotype and environmental conditions [4].

The higher the size of the tubers, the lower the number of them as proved by the negative correlation between these indicators [21].

The research mentioned by [11] showed the production of fresh tubers that varied from 40 to 100 t/ha. [17] obtained productions between 20 and 60 t/ha for different Jerusalem artichoke clones in the semi-arid region of China. [14] and [1] proved that high temperatures increased the sugar content. In addition, high temperatures registered at some planting dates generally determined a late maturity. Other research results proved that a late harvesting could improve Jerusalem artichoke inulin [2], [27] and a late harvesting prolongs the accumulation of inulin in Jerusalem artichoke tubers and results in a large amount of inulin.

However, the inulin content depends mainly on the used varieties [3],[2]. The differential responses of Jerusalem artichoke varieties to planting seasons for total dry weight, inulin content, also indicated the importance of selection for certain varieties adapted to the most appropriate growing areas that differ in temperature values.

One of the biggest advantages of Jerusalem artichoke culture is its adaptability to different environmental conditions and productive regions [24]. It adapts to an annual amount of annual rainfall from 310 to 2,800 mm [7]. In addition, it can be grown on soils with a pH from 4.4 to 8.6 [15], although its production is favored by slightly alkaline soils, its performance may decrease in heavy soils [6].

The climate changes in Romania require to introduce new species in culture capable of capitalizing on the climatic conditions on sandy soils, one of them being Jerusalem artichoke. In this species it is necessary to identify and use well-adapted varieties to make a faster introduction into production [13] and later in human nutrition. In this sense, in the pedoclimatic conditions at Research Development Station for Plant Culture on Sandy soils Dabuleni in the period 2018 – 2020, research was conducted on the adaptability of some genotypes of Jerusalem artichoke on sandy soils and the determination of the nutritional quality of tubers.

MATERIALS AND METHODS

Between 2018 – 2020, at Research and Development Station for Plant Culture on Sandy Soils (SCDCPN) Dăbuleni were studied four genotypes of Jerusalem artichoke, which were followed by the processes of growth and development of plants and the nutritional quality of tubers at harvest.

The studied varieties were: Dacic, Olimp, Rustic and a local population of Dăbuleni. To determine the quality of Jerusalem artichoke tubers, samples were taken at technological maturity, and the following determinations were performed in the laboratory:

(1) water and total dry matter (TDM) (%) using the gravimetric method;

(2) soluble dry matter (SDM) (%), using the

refractometric method;
(3) C vitamin (mg/100 g f.s.) using the iodometric method;
(4) inulin (%) by means of the gravimetric method;
(5) soluble carbohydrates (%) using Fehling-Soxlet method;
(6) production per variant (kg / ha) - by weighing with DESSIS type balance, with three decimals (error + / - 5 /10 g).

RESULTS AND DISCUSSIONS

The experiment was located on a sandy soil with a nitrogen content between 0.05 – 0.08 %, values that indicate a low state of soil supply in nitrogen. The phosphorus content was between 45 ppm and 62 pmm, so the soil was well supplied with extractable phosphorus, and the values of exchangeable potassium (23 – 29 ppm) indicate a low supply of potassium. The non-uniformity of the soil could be observed from the results obtained from organic carbon (0.19 – 0.50 %). The pH of the soil showed values between 5.34 – 5.56, so a weakly acid reaction.

The results obtained regarding to the nutritional quality of Jerusalem artichoke tubers according to the studied variety are presented in Table 1.

The quality and level of production are the result of the interaction between the stability of the soil nutrition regime, the technological measures applied and the variation of the environmental factors [20].

The studied genotypes accumulated in the tubers a total amount of dry matter between 21.77 % in the Olimp variety and 27.91 % in the local population of Dăbuleni, with an average of 24.46 %. The highest total dry matter content was determined in the local population of Dăbuleni (27.91 %) and in the Dacic variety (25.03 %).

[35] showed that Jerusalem artichoke contains a quantity of dry matter between 19.26 % and 23.21 %, so values similar to those obtained on sandy soils in southern Oltenia. [8] obtained similar data (an average of about 22.0 %). The amount of water from Jerusalem artichoke tubers was between 72.09 % in the local population of Dăbuleni and 78.23 % in the Olimp variety, with an average of 75.54 %.

A higher amount of water in the tubers (82.4 %) was reported by [26]. Using the refractometrical method, the amount of soluble dry matter varied between 20.13 % for the Olimp and 22.93 % for the Dacic variety, meaning 21.68 % in average. Variety Dacic (22.93 %) and the local population (22.70 %) registered higher values than the average value of the other varieties.

The carbohydrate content of Jerusalem artichoke tubers had high values, accounting for 17.10 % for the Olimp variety and 19.47 % for the Dacic variety, with an average of 18.44 %. Also, the Dacian varieties and the local population had a higher carbohydrate content compared to the average of the varieties.

[22] determined in carbohydrate tubers a carbohydrate content of 15 %, and [12], in a study conducted in Canada determined in different groups of varieties a carbohydrate content between 8.2 % and 20.7 %. Inulin is a form of carbohydrate stored in Jerusalem artichoke tubers as opposed to starch which is stored in most tuber crops and in roots [12], [27].

Inulin is a kind of polysaccharide handled in a different way by the body compared to other types of starch. The Inulin has the ability to strengthen the defense mechanisms against infections and to neutralize viruses and bacteria that cause colds and flu in the winter season. Inulin helps the body maintain stable blood sugar and therefore diabetics, people with a predisposition to gain weight or who are struggling with obesity should consume as many foods rich in inulin as possible. The inulin content was between 12.08 % in the local population of Dăbuleni and 13.39 % in the Dacic variety, with an average of 12.93 %.

A study conducted in Northern China obtained similar results (14-18%) [16]. The vitamin C content of Jerusalem artichoke tubers accounted for 11.44 mg in the Dacic variety and 14.96 mg in the local population of Dăbuleni, with an average of 13.42 mg. The literature indicates in Jerusalem artichoke an average of vitamin C that contents of 4 mg/100 g fresh substance.

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Table 1. Biochemical composition of Jerusalem artichoke tubers depending on the genotype studied in the period 2018-2020

Genotype	Total dry matter (%)	Water (%)	Soluble dry matter (%)	Carbohy drates (%)	Inulin (%)	C vitamin (mg/100g f.s*)	The tubers production (kg/ha)
Dacic	25.03	74.97	22.93	19.47	13.39	10.56	25.20
Olimp	21.77	78.23	20.13	17.10	13.31	11.15	70.77
Rustic	23.12	76.88	20.97	17.83	12.93	13.19	57.16
Local population of Dăbuleni	27.91	72.09	22.70	19.35	12.08	13.49	22.87
Average genotypes	24.46	75.54	21.68	18.44	12.93	12.10	44

f.s* - f.s - fresh substance
Source: Own results.

[9] determined a vitamin C content of 9.7 mg in Jerusalem artichoke tubers under Martinique conditions.
The production of Jerusalem artichoke tubers was between 22.87 t/ha for the local population of Dăbuleni and 70.77 t/ha for the Olimp variety, with an average of 44 t/ha. The highest yields were determined for the Olimp (70.77 t/ha) and Rustic (57.16 t/ha) varieties. According to literature, the yield of the Jerusalem artichoke is highly variable, depending largely on environmental conditions and ranging from 28 to 128 t/ha [15]. The yield of tubers depends not only on climatic conditions, soil type, cultural practices, and harvest period but also on the quality of the plant and especially the choice of cultivars, having high production in fructose, a correct choice of cultivar is the first necessity for the improvement of this crop [12].
Between the amount of total dry matter in the tubers, the carbohydrate content, inulin and vitamin C, polynomial correlations given by second degree equations were established, with significant correlation factors for carbohydrates and insignificant for inulin and vitamin C (Figure 1). The amount of carbohydrates and inulin accumulates in the tubers up to a total dry matter accumulation of 25 %, after which they decrease in percentage, and the amount of vitamin C increases insignificantly, with increasing amount of total dry matter in the tubers.

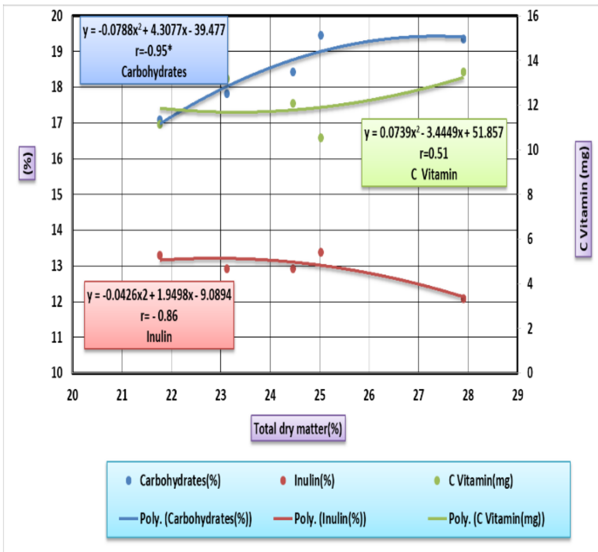

Fig. 1. The correlation between total dry matter in tubers, carbohydrate content, inulin and C vitamin
Source: Own results.

Between the production of tubers and the amount of total dry matter, a polynomial correlation was established given by a second degree equation, with a significant correlation factor (r = 0.92 *) (Figure 2). The total amount of dry matter in the tubers decreases with increasing tuber production. Edaphic factors determined, to a greater extent than genetic factors, the nutritional value of tubers. Assessment of the influence of varietal characteristics, meteorological conditions, and geographic location on the amount of biologically active compounds in Jerusalem artichoke will allow growers and consumers to choose the most suitable cultivars. From a climatic point of view, the three years of study were different.

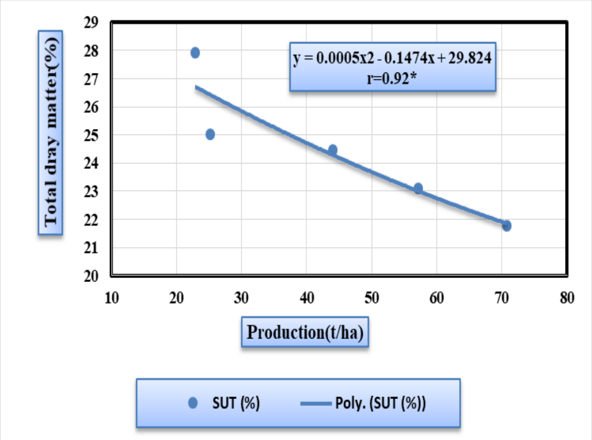

Fig. 2. Correlation between tuber production and total amount of total dry matter in tubers
Source: Own results.

The year 2018 was very warm (20.4 °C average temperature during the vegetation of, Jerusalem artichoke), but also rich in rainfall especially during the period of intense plant growth and tuber initiation (Table 2).

In 2019 and 2020 were warm, but with little precipitation compared to 2018. If in 2019 the amount recorded of precipitation was better represented in the first part of the vegetation period, in 2020 for the entire vegetation period, there were recorded at least 40 mm of precipitation per month.

One of the biggest advantages of Jerusalem artichoke culture is its adaptability to different environmental conditions and productive regions [24].

It adapts to annual rainfall from 310 to 2800 mm [7]. In addition, it can be grown on soils with a pH of 4.4 to 8.6 [15], although its production is favored by slightly alkaline soils, so its performance may decrease in heavy soils [6].

Table 2. The main climatic elements during the vegetation of Jerusalem artichoke (2018 - 2020)

Year/ The climatic element	**2018**	**2019**	**2020**
Average temperature during the vegetation period (^{0}C)	20.4	19.5	19.5
Rainfalls (mm)	518,7	289	276,2
Absolute maximum temperature (^{0}C)	35.7	38.4	37.3

Source: Own results.

The climatic conditions of the three years of study influenced the nutritional quality of Jerusalem artichoke tubers. The results obtained are presented in Table 3. Ensuring moisture in the soil, against the background of high air temperatures (climatic conditions in 2018) led to the accumulation of percentage of total dry matter, soluble dry matter, carbohydrates, inulin and vitamin C in the tubers of Jerusalem artichoke.

Table 3. Biochemical composition of Jerusalem artichoke tubers depending on the year of study

Year/ Quality index	**Total dry matter (%)**	**Soluble dry matter (%)**	**Carbohydrates (%)**	**Inulin (%)**	**C vitamin (mg/100g f.s*)**
2018	24.79	22.95	19.12	13.53	13.42
2019	26.00	22.88	19.64	13.34	11.66
2020	22.58	19.23	16.55	11.92	11.25

f.s- fresh substance
Source: Own results.

In the climatic conditions of 2018, the highest content of inulin (13.53 %) and C vitamin (13.42 mg/100 g f.s) was determined in Jerusalem artichoke tubers. Also, the amount of total dry matter, soluble dry matter and soluble carbohydrates showed higher values in 2018 and 2019. The lowest values of the quality indices were determined in the conditions of 2020, a warm year with lower rainfall during the period of intense accumulation of biochemical components.

The results showed that temperature was important for the production of an increased yield of tubers with a high inulin content during the dry season. According to [3] (Italy), when the plant is fully harvested (vegetative mass and tubers) at preflowering, the best results are obtained both in terms of production and in terms of sugar and inulin yield. In addition to the production of tubers, the inulin content of the tubers is of great importance and they are influenced by the temperatures during the vegetation period. The yield of tubers and the inulin content increase in conditions of high temperatures in temperate areas, while low temperatures have had detrimental effects on growth and inulin content.

CONCLUSIONS

The Jerusalem artichoke is considered to be a species with a relative high tolerance to thermohydric stress and with very high adaptability to unfavourable environmental factors and can be an alternative in the conditions of climate change in Romania.

The area of sandy soils in the southern of Oltenia offers favorurable conditions for the growth and development of Jerusalem artichoke plants. The average productions obtained for this species in the pedoclimatic conditions from RDSPCS Dăbuleni show the resistance of the species to the high temperatures in this area.

The production of Jerusalem artichoke tubers was between 22.87 t/ha for the local population of Dăbuleni and 70.77 t/ha for the Olimp variety, with an average of 44 t/ha. The highest yields were determined for the Olimp (70.77 t/ha) and Rustic (57.16 t/ha) varieties.

The Inulin was presented in tubers in a percentage of 12.08 % in the local population of Dăbuleni and 13.39 % in the Dacic variety, with an average of 12.93 % which confirms the functional potential of the species and recommends the species as a "source of fiber”.

The climatic conditions of the three years of study decisively influenced the quality of Jerusalem artichoke tubers, and the lowest values of quality indices were determined in 2020, a warm year with low rainfall during the period of intense accumulation of biochemical components.

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