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VARIATION OF TUBER YIELDS AND QUALITY AT SOME JERUSALEM ARTICHOKE GENOTYPES IN PEDOCLIMATIC CONDITIONS FROM CENTER OF MOLDOVA AND THE PLAIN OF OLTENIA, ROMANIA

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ABSTRACT

Existing information in the literature on the variation in tuber yield and their inulin content, depending on the variety and soil and climatic conditions of *Helianthus tuberosus* L., is limited. For this reason, in the pedoclimatic conditions from ARDS Secuieni (Center of Moldova) and from ARDS Caracal (Oltenia Plain) was conducted a study regarding this aspects. This study was conducted between 2018-2020, within an experiance with four genotype of Jerusalem artichoke and specifically: Dacic dwarf, Rareș, Olimpic and Dăbuleni population. The results obtained showed major differences between the cultivated genotypes and between the two agricultural areas, both in terms of tuber yield and tuber quality. Jerusalem artichoke is a species that has resistance to drought and high temperatures, achieving average yields of 21.3 to ha^{-1} in Secuieni and 24.0 to ha^{-1} in Caracal. The Oltenia Plain offered more favorable conditions for the growth and development of Jerusalem artichoke, but the species also successfully succeeded in Central of Moldova. Inulin was present in the tubers in a percentage between 48.35% and 58.38%, which confirms the high functional potential of the species and recommends the species as a "*source of fiber*". Also, due to the high mineral content identified in the tubers, the mention of "*iron source*" and "*magnesium source*" may be issued.

Keywords: climate, genotype, inulin, production, soil, tuber.

INTRODUCTION

Topinambur or Jerusalem artichoke is a fascinating species with an exceptional history (Kays and Nottingham, 2007).

The species belongs to the *Helianthus* L. genus, *Asteraceae* family, *Asterales* order and has the scientific name of *Helianthus tuberosus* L. (Salaman, 1940).

The second popular name of the species, very often used, the Artichoke of Jerusalem, has nothing to do with the artichoke, this being part of the genus *Cynara* nor with Jerusalem, appeared due to the description made by Samuel de Champlain, the first European to describe the Jerusalem artichoke from the New World (Massachusetts in 1605), who compared the flavor to that of artichoke in a description of his visit to the homes of the natives with Seigneur De Monts, the leader of the expedition (Bourne, 1906).

Over the last 300 years, interest in this species has varied from area to area. Currently, the latest studies highlight the increased interest in Jerusalem artichoke due to its benefits when included in human and

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animal diets and due to its increased potential to be used for biofuel production (Rakhimov et al., 2003).

The Jerusalem artichoke tubers have in their composition 80% water, 15% carbohydrates and 1-2% protein (Fineli, 2004). Data on its composition are relatively scarce compared to other species, however, they reveal significant variations between certain parameters. They contain very little or no starch, are practically fat-free and have a relatively low calorie level (Chaimala et al., 2020). From the small amount of fat in the tubers, unsaturated fatty acids were identified and no saturated fatty acids were determined (Whitney and Rolfes, 1999). Tubers are a good source of dietary fiber, due to the presence of inulin, which is the main storage carbohydrate (Somda et al., 1999). Inulin from tubers varies from 7 to 30% by fresh weight and about 50% by dry weight (Van Loo et al., 1995).

Jerusalem artichoke, native to the north-central part of the USA, is a perennial species that is cultivated as an annual species. It is a temperate zone culture, with a high ecological plasticity, it is cultivated between 40° and 55° north and south latitude (Kays and Nottingham, 2007).

Jerusalem artichoke can be grown on all types of soil, even the poorest in terms of nutrition with minimal cultivation technology. It is considered to be a species with relatively high tolerance to water stress and very high adaptability to unfavorable factors - drought resistance, at extremely high temperatures (Ciuciuc et al., 2019). However, crop productivity is considerably influenced by applied agronomic practices, namely: variety selection, planting date, effective weed control, fertilization, irrigation and harvesting procedures (Slimestad et al., 2010). Most studies suggest planting Jerusalem artichoke in early spring at a depth of 10-15 cm, at a distance between rows between 45-120 cm and at a distance between tubers in a row of 30-60 cm. The optimum soil temperature for planting is between 6 and 7°C (Duke, 1983).

Climate change in Romania forces us to introduce new species in culture, from the perspective, one of them being Jerusalem artichoke. In this species it is necessary to identify and use well-adapted varieties in order to make a faster introduction into production (Khristich et al., 2021) and later in human nutrition. In this sense, in the pedoclimatic conditions from ARDS Secuieni and from ARDS Caracal, in the period 2018-2020, research was conducted on the adaptability of some native varieties/genotypes of Jerusalem artichoke to zonal conditions and on the quality of tubers harvested from experimental fields.

MATERIAL AND METHODS

In order to elucidate the proposed aspects, in the period 2018-2020, a single-factor experiments were organized whose follow-up factor was the genus of Jerusalem artichoke.

The experiments were carried out in the experimental fields of the Secuieni and Caracal Agricultural Research-Development Stations, according to the method of the Latin rectangle, in three repetitions.

The soil

At ARDS Caracal, the location of the experiments was made on an argic chernozem, in which the particle size composition showed that the soil falls into the group of fine textures, the soil being clay - medium clay, and at ARDS Secuieni on a typical phaeozem (chernozem) cambic soil type, with medium texture. In Caracal the soil is characterized as weakly alkaline, well to very well supplied with potassium, weak to medium fertile and poorly supplied with nitrogen, and in Secuieni, as weakly acidic, well to very well supplied with mobile phosphorus and potassium, poorly supplied with nitrogen and poorly fertile (Table 1).

Table 1. Characterization of the type of soil on which the experiments were located

Soil characteristics	ARDS Caracal		ARDS Secuieni	
	Argic chernozem		Phaeozem (chernozem) cambic	
	Value	Interpretation	Value	Interpretation
Humus content	3.2%	weak to medium fertile	2.3%	weak fertile
Total nitrogen content	0.130%	poorly supplied with nitrogen	0.134%	poorly supplied with nitrogen
Affordable phosphorus content	44 ppm	medium to well supplied with phosphorus	74 ppm	well to very well supplied with mobile phosphorus
Affordable potassium content	234 mg/kg	good to very well supplied with potassium	221 mg/kg	good to very well supplied with potassium
pH	7.6	weak alkaline	6.1	weak acid

From a climatic point of view, the period 2018-2020 was characterized as warm in both study areas, dry in the Secuieni area and normal to rainy in the Caracal area. Comparing the two agricultural areas, the Oltenia Plain was warmer and richer in precipitation compared to the Center of Moldova (Figure 1).

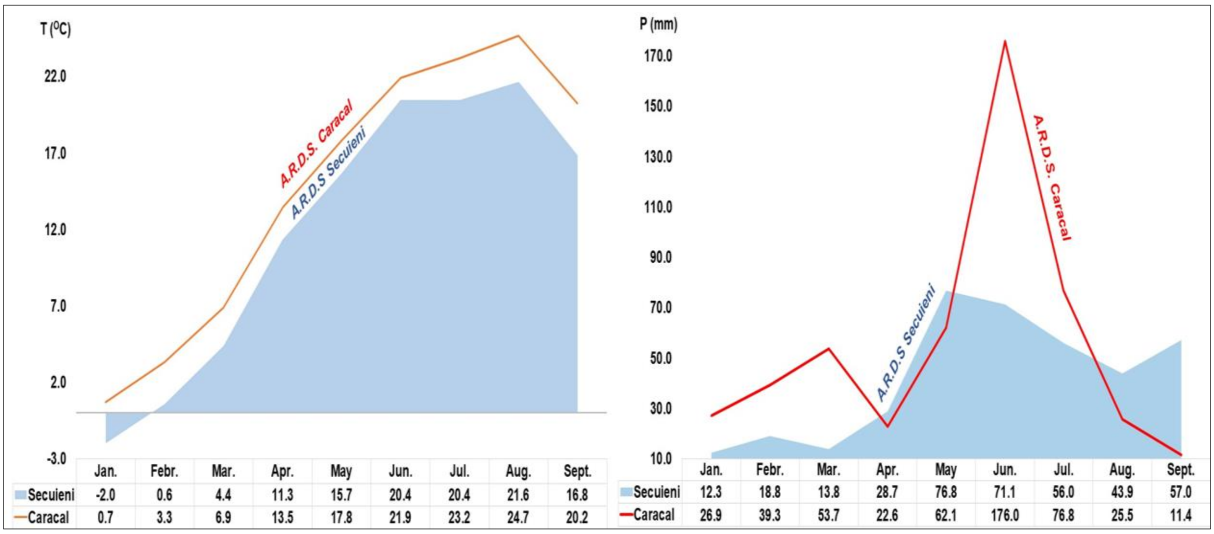

Figure 1. Climatic conditions registered in the experimental areas, 2018-2020

The biological material used in the experiment was provided by Vegetable Research and Development Station Buzău and Research and Development Station for Agricultural Plants on Sands Dăbuleni, represented by the varieties Rareş, Olimpic, Dacic dwarf and the Dăbuleni local population.

The Jerusalem artichoke was planted in the field in the spring, the third decade of March - the first decade of April, at a distance of 70 cm between rows and 50 cm between tubers/row. The sowing depth was 10 cm, and the previous plant was soybeans. The tubers were harvested in late October - early November.

In the, within the, The physico-chemical and nutritional characterization of these varieties was performed at laboratory of the National Research-Development Institute for Food Bioresources Bucharest. This unit using modern methods of analysis, apparatus and equipment for analysis, measurement and processing specific to raw materials and products (https://erris.gov.ro/Food-Chemistry-Laboratory; https://erris.gov.ro/Microbiology-ELISA-Laboratory; https://erris.gov.ro/Food-Packaging-Laboratory).

RESULTS AND DISCUSSION

Following the research carried out in the three agricultural years, it was observed that both the genotype experienced and the pedoclimatic conditions had influences on both the yield and the quality of the Jerusalem artichoke tubers.

Compared to the average experience (control), the Rareș and Olimpic varieties achieved statistically assured yield increases in each of the three years of experimentation and in each location. These were interpreted as being very significant for the Olympic variety every year in both locations and for the Rareș variety in the first and second year of vegetation in Secuieni and in the first year in Caracal. The Dacic dwarf varieties and the population of Dăbuleni achieved significant negative yield differences in both locations (Table 2).

Thus, from Table 2 it can be seen that the best conditions for the growth and development of Jerusalem artichoke were those of the third year of experimentation in Caracal (2020), when an average tuber yield of 36.6 to ha^{-1} was obtained. In this pedoclimatic area, the second year of experimentation was extremely unfavorable to the crop, obtaining an average production of 10.3 to ha^{-1}.

In Secuieni, the average yield obtained in the first two years of experimentation were similar, these having values of 24.7 to ha^{-1} (2018) and 24.1 to ha^{-1} (2019), respectively. The third year of experimentation offered extremely unfavorable conditions for the growth and development of Jerusalem artichoke, the average yield being only 15.0 to ha^{-1} (Table 2).

Regardless of the pedoclimatic conditions, the Olympic variety stood out as superior to the other varieties, being productively ranked first in each year of experimentation in both locations, with an average yield of 37.6 to ha^{-1}, respectively 32.0 to ha^{-1} in year I, of 36.6 to ha^{-1}, respectively 14.6 to ha^{-1} in second year and of 20.6 to ha^{-1}, respectively 47.1 to ha^{-1} in the third year. This was followed by yield close to the Rareș variety (Table 2).

Table 2. The tuber yield for studied varieties of Jerusalem artichoke (*Helianthus tuberosus* L.) in the period 2018-2020

Variety	Tuber yield (to ha^{-1})					
	Year I		Year II		Year III	
	Secuieni	Caracal	Secuieni	Caracal	Secuieni	Caracal
Rareș	32.7***	31.9***	31.9***	11.5*	18.4**	41.7**
Olimpic	37.6***	32.0***	36.6***	14.6***	20.6***	47.1***
Dacic dwarf	17.6^{ooo}	27.1*	18.0^{ooo}	9.4	9.8^{ooo}	27.1^{ooo}
Dăbuleni Pop	10.8^{ooo}	8.9^{ooo}	9.8^{ooo}	5.8^{ooo}	11.0^{ooo}	30.6^{ooo}
Average	24.7^{Mt}	25.0^{Mt}	24.1^{Mt}	10.3^{Mt}	15.0^{Mt}	36.6^{Mt}
LSD 5% (to ha^{-1})	1.7	1.6	2.3	1.1	1.4	1.6
LSD 1% (to ha^{-1})	2.4	2.3	3.1	1.8	2.1	3.4
LSD 0.1% (to ha^{-1})	3.7	3.4	5.8	3.2	3.8	5.8

On average over the three years of experimentation, the tuber yield varied from one variety to another and from one area to another, being between 10.5 to ha^{-1} and 31.6 to ha^{-1} in the conditions from Secuieni and between 15.1 to ha^{-1} and 31.2 to ha^{-1} in the conditions of Caracal. The Olympic variety stood out with superior yields in both experimental areas, these being 31.6 to ha^{-1} and 31.2 to ha^{-1}, respectively.

Compared to the average experience, the control of the experience, statistically assured yield increases were obtained for the Olimpic and Rareș varieties, these being interpreted as being very significant in Secuieni and distinctly and very significant in Caracal. The other genotypes experienced, namely the Dăbuleni population and Dacic dwarf, achieved very significant negative yield differences in Secuieni and distinct negative and very significant in Caracal (Table 3).

The average yield/experience was 21.3 to ha^{-1} in the conditions from Secuieni and 24.0 to ha^{-1} in the conditions from Caracal. This highlights a greater favorability of the pedoclimatic conditions in the Caracal area for the cultivation of Jerusalem artichoke, but nevertheless the species achieved good productions even in the conditions from Secuieni (Table 3).

Table 3. The average of tuber yield for studied varieties of Jerusalem artichoke (*Helianthus tuberosus* L.) in the period 2018-2020

Variety	Yield tubers							
	Secuieni				Caracal			
	to ha^{-1}	%	Diff. from the control	Semn.	to ha^{-1}	%	Diff. from the control	Semn.
Rareş	27.7	130	6.4	***	28.4	118	4.4	**
Olimpic	31.6	148	10.3	***	31.2	130	7.2	***
Dacic dwarf	15.1	71	-6.2	ooo	21.2	88	-2.8	oo
Dăbuleni Pop.	10.5	49	-10.8	ooo	15.1	63	-8.9	ooo
Media (control)	21.3	100	Mt.		24.0	100	Mt.	
LSD (to ha^{-1})	5% = 2.3; 1% = 3.5; 0.1% = 5.5				5% = 1.7; 1% = 2.8; 0.1% = 4.9			

The results obtained from the physico-chemical and nutritional analysis of the tubers showed that Jerusalem artichoke has in its composition substances with functional potential, namely inulin and crude fibers. Of the four genotypes analyzed, the Olympic variety achieved the highest inulin content in both areas, of 55.41 % and 56.15 %, respectively.

Given the high percentages of inulin (prebiotic) identified in Jerusalem artichoke tubers, higher than 50%, the species is considered a „fiber source” [Regulation (EC) No 1924/2006]. The experimental analysis of the chemical composition of Jerusalem artichoke tubers shows that the total constituent substance is represented by the inulin content (48.35% and 56.15%) (Table 4). This high inulin content confirms that Jerusalem artichoke tubers of studied varieties have great functional potential. Numerous studies have shown that inulin is a valuable substance for human health, having a beneficial action from the moment it enters the human body through the stomach and up to the gastrointestinal tract (Rubel et al., 2014; Ramnani et al., 2010).

The highest protein content, of 19.58%, was identified in the tubers of the Dacian variety (19.58%), under conditions of Caracal location. The high ash content of the Jerusalem artichoke samples indicates that they have a high mineral content (Table 4).

Table 4. The physico-chemical composition of tubers from studied Jerusalem artichoke varieties

Compound	Mineral content							
	Rareş		Olimpic		Dacic dwarf		Dăbuleni Pop.	
	Secuieni	Caracal	Secuieni	Caracal	Secuieni	Caracal	Secuieni	Caracal
Moisture %	7.03	8.65	7.29	9.18	7.53	8.70	6.26	8.78
Ash %	3.73	3.52	3.95	3.13	3.74	3.84	3.35	3.87
Lipids %	0.39	0.39	0.35	0.31	0.28	0.26	0.31	0.24
Proteins %	12.15	12.58	11.52	11.84	11.66	19.58	12.32	13.77
Crude fiber %	3.08	3.36	3.12	3.28	3.56	3.67	3.00	3.00
Inulin %	55.04	54.67	55.41	56.15	55.04	48.35	54.67	55.04

The minerals determined in the Jerusalem artichoke samples collected from the two locations had values of high contents, as follows (mg/100 g s.u.): phosphorus - 260-360; potassium - 2666-3277; calcium - 13.1-21.3; magnesium - 230-240; iron - 15.1-22.3; zinc - 1.74-2.44; copper - 0.44-1.05; manganese - 0.33-0.84 (Table 5).

The iron content identified in the tubers of the population of Dăbuleni exceeds the recommended daily dose, but the one identified in the rest of the varieties is close to the recommended daily dose. Also, the magnesium and potassium content identified in the tubers exceeds half of the recommended daily dose. The copper content of the Dacian variety grown at ARDS Caracal exceeds half of the recommended daily dose (Table 5). Following the results obtained, Jerusalem artichoke should be referred to as „source of iron” and „source of potassium” (Regulation EC no. 1924/2006; Directive 90/496/EEC).

The high mineral content, especially potassium, iron and magnesium, is confirmed by other research in the field (Bach et al., 2013; Somda et al., 1999; Terzic et al., 2012).

Table 5. The mineral composition of tubers from Jerusalem artichoke varieties

The mineral	Mineral content							
	Rareş		Olimpic		Dacic dwarf		Dăbuleni Pop.	
	Secuieni	Caracal	Secuieni	Caracal	Secuieni	Caracal	Secuieni	Caracal
P mg/100g su	260	360	270	290	310	360	260	310
K mg/100g su	3020	2988	2698	2777	3000	2666	3177	3277
Ca mg/100g su	18.9	13.9	14.2	13.1	21.3	17.7	19.7	16.8
Mg mg/100g su	230	240	230	220	230	240	230	230
Fe mg/100g su	15.7	17.3	16.4	15.8	19.3	17.2	22.3	15.1
Zn mg/100g su	1.74	2.30	1.85	1.93	1.98	2.44	1.98	2.27
Cu mg/100g su	0.44	0.66	0.51	0.65	0.84	1.05	0.73	0.88
Mn mg/100g su	0.33	0.70	0.44	0.53	0.49	0.84	0.58	0.62

CONCLUSIONS

The average Jerusalem artichoke yields obtained in Secuieni (21.3 to ha^{-1}) and Caracal (24.0 to ha^{-1}), two localities in Romania with drought and strong heat conditions, demonstrate the drought and heat resistance of the studied varieties. Which suggests that this species may be an alternative in the conditions of climate change in Romania.

Although, the Oltenia Plain offers more favorable conditions for the growth and development of Jerusalem artichoke, the species also succeeds successfully in Central of Moldova.

Inulin was present in the tubers in a percentage between 48.35% and 58.38%, which confirms the high functional potential of the species and recommends the species as a „source of fiber”.

Also, due to the high mineral content identified in the tubers, the mention of „iron source” and „magnesium source” may be issued.

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To carry out this study, all authors made equal efforts, as a result all authors have equal rights.

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