RESEARCH ON THE INFLUENCE OF PLANTING DENSITY ON BIOMASS PRODUCTION IN JERUSALEM ARTICHOKE GROWN ON SANDY SOILS

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ABSTRACT

Jerusalem artichoke is a species with high production potential, resistance to diseases and pests, with good tolerance to variations in climatic factors. Research conducted showed that the highest production of above-ground biomass of 64779 kg / ha was obtained at a planting distance of 40 cm between plants in a row. Analyzing the interaction between the studied factors (planting density x fertilization doses) on the production of fresh tubers, it is found that the distance of 40 cm between plants / row and the level of fertilization of $N_{120}P_{120}K_{80}$ ensured the highest production of 41671 kg / ha fresh tubers / ha, not statistically insured.

INTRODUCTION

Jerusalem artichoke is a species with high production potential, with potential and extensive use (Sawicka, 1998, 2009), with high tolerance to climatic conditions (Baldini, et al. 2006, Lingyun, et al. 2007). The above-ground part of Jerusalem artichoke can be used for biomethane production, for the manufacture of briquettes and pellets (Sawicka, 2009). In addition to the yield of above-ground biomass, Jerusalem artichoke also produces a high yield of tubers (Sawicka, 1998, Góral, 2000) that can have various uses. Jerusalem artichoke tubers are characterized by a high content of inulin, dietary fiber, protein, ash and phenolic compounds (Kays, 2008) and can be used in the beer industry or the pharmaceutical industry (Sawicka,1999). Jerusalem artichoke is appreciated for its characteristic sweet taste, rich in minerals (Ca, Mg, K, P), vitamins (β-carotene, thiamine, lactoflavin, niacin, biotin, ascorbic acid), amino acids (lysine, arginine, histidine ,cystine, tryptophan, aspartic acid), specific amino acids (choline, betaine, saponin, quercitrin) and enzymes (inulinase, proteinase, invertase, phosphorylase and phenolase).

Jerusalem artichoke tubers contain 80% water (Fineli, 2004). They can play an important role in human nutrition as sources of protein (1-2%), carbohydrates (15%), vitamins, inulin (up to 20%) and minerals, especially iron (0.4 to 3.7 mg 100 g), calcium (14 to 37 mg / 100 g) and potassium (420-657 mg /100 g) (Whitney &Rolfes, 1999, Kocsis, et al., 2008). They contain very little or no starch, are virtually fat-free and have a relatively low calorie level (Chaimala, et al., 2020). In the small amount of fat found 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). Due to the high inulin content (Cieślik,1998), tubers are recommended in the diabetic diet (Barta, et al. 1993, Sawicka, et al. 2009). They could also be used in the production of bioethanol or biogas (Denoroy, 1996). Jerusalem artichoke biogas production is much higher compared to other energy crops (Emmerling, 2007).

From an agronomic point of view, Jerusalem artichoke is considered a drought-resistant species and can be grown in non-irrigated conditions, by capitalizing on poor soils (Monti et al., 2005). It has a very high adaptability to the extremes of unfavorable factors, resistance to extremely high temperatures (35-45 ° C plants and - 30 - 45 ° C in the case of tubers), resistance to high concentrations of salts, heavy metals, nitrates. 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 diversity in plant breeding, new crop management and practices, new methods and technologies in agriculture and food research and production (Paraschivu, M., Cotuna, O., 2021)

Despite the great interest in this Jerusalem artichoke crop, there are few studies showing the spread of this species in the crop. Plant density is an important agronomic factor that affects crop growth, development and yield. Within certain limits, increasing plant density leads to decreased plant yield. Planting density has been little studied and there is no important research for the regions of southern Europe. In fact, in the literature, planting density varies from case to case in a range between 2 plants / m2 and 7 plants / m2 (Liu,Z. X., et al., 2015, Monti, A. et al., 2005) . Fertilization is the most important factor influencing the quantity and quality of Jerusalem artichoke production, but the research conducted by Negro, et al., 2016, shows that soil, climatic conditions, genotype and cultivation technology contribute to the increase in Jerusalem artichoke production. 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 (Partal, E., Paraschivu, M., 2020).

MATERIAL AND METHOD

The research was conducted at Research Development Station for Plant Culture on Sands Dabuleni, in the period 2018-2020, in the conditions of a sandy soil with a low nitrogen content, normal phosphorus, low potassium and organic matter, and the soil reaction was weakly acidic. The experience was bifactorial, placed according to the method of subdivided plots, in three repetitions.

FACTOR A: Fertilization system

a1 - Unfertilized

a2 - $N_{40}P_{40}K_{40}$

a3 - $N_{80}P_{80}K_{80}$

a4 - $N_{120}P_{120}K_{80}$

a5 - $N_{160}P_{160}K_{80}$

FACTOR B: The distance between plants in a row

b1 - 40 cm

b2 - 50 cm

The biological material used for planting was the Rustic variety. The preparation of the land was done by plowing at a depth of 28-30 cm, fertilization with complex fertilizer 15-15-15 at the level of N, P, K established for the variants studied, discussed + worked with milling cutter.

Planting was done manually on April 3 in 2018, on March 20 in 2019 and on March 13 in 2020, at a distance of 70 cm between rows and 40 cm, respectively 50 cm between tubers per row.

The maintenance works of the culture consisted of:

- two manual plows;
- herbicide with Fusilade Forte 1 l / ha;
- sprinkler irrigated

During the vegetation period, observations and determinations were made regarding: plant height, average number of shoots / plant, average number of leaves / plant, leaf area. At the beginning of flowering, because the initiation of flowers is a signal of accumulation of assimilates in tubers (Curt,M.D. et al., 2006) the number of tubers / plant, the weight of tubers / plant, the production of aerial and underground biomass were determined. Biomass production (stems and tubers) was expressed in kg / ha. The calculation and interpretation of the results was performed using the method of analysis of variance.

In order to determine the nutrient supply status of the soil from the Jerusalem artichoke culture, soil samples were collected at a depth of 0-40 cm. The samples were recorded and conditioned in the laboratory, from which the following determinations were made:

-total nitrogen - Kjeldahl method;
-extractable phosphorus (P-AL) - Egner method - Riem Domingo, by which phosphates are extracted from the soil sample with a solution of acetate - ammonium lactate at pH - 5.75, and the extracted phosphate anion is determined colorimetrically as - blue of molybdenum;
- exchangeable potassium (K-AL) - Egner - Riem Domingo method by which the hydrogen and ammonium ions of the extraction solution replace by exchange the exchangeable potassium ions in the soil sample which are thus passed into the solution. Potassium dosing in the solution thus obtained is done by flame emission photometry.
-organic carbon - the method of wet oxidation and titrimetric dosing (after Walkley - Blak in the Donut modification);
-PH- of the soil, potentiometric method.
In this experiment, determinations were made on the physiological behavior of Jerusalem artichoke plants in the flowering phenophase, observations and experimental determinations regarding: physiological processes of photosynthesis and perspiration in correlation with environmental factors, determined with the portable device LC PRO +.

RESULTS AND DISCUSSIONS

Biometric determinations performed on the height of Jerusalem artichoke plants show an average plant height with values between 205.2 cm in the non-fertilized version and cultivated at 40 cm between plants / row that can reach up to 271.3 cm in the version fertilized with the dose of $N_{80}P_{80}K_{80}$, where the distance between plants in a row was 50 cm (Table 1).

Table 1

Biometric determinations in Jerusalem artichoke during the vegetation period(2018-2020)

Agrofound	Planting density	The average height of the plant (cm)	Average number of stems / plant	Average number of shoots / pl
a_1- Unfertilized	b_1-40 cm	205.2	5.9	4.9
	b_2- 50 cm	216.5	4.6	2.5
a_2 - $N_{40}P_{40}K_{40}$	b_1-40 cm	215.8	4.1	2.8
	b_2- 50 cm	231.3	3.0	2.6
a_3 -$N_{80}P_{80}K_{80}$	b_1-40 cm	250.3	3.9	2.8
	b_2- 50 cm	271.3	2.5	3.6
a_4 -$N_{120}P_{120}K_{80}$	b_1-40 cm	224.3	1.4	3.0
	b_2- 50 cm	255.2	2.8	3.4
a_5- $N_{160}P_{160}K_{80}$	b_1-40 cm	240.3	3.3	4.5
	b_2- 50 cm	227.3	3.9	5.0

It is observed that depending on the planting density, the height of the plants had higher values in the variants where the distance between plants in a row was 50 cm (Fig.1)

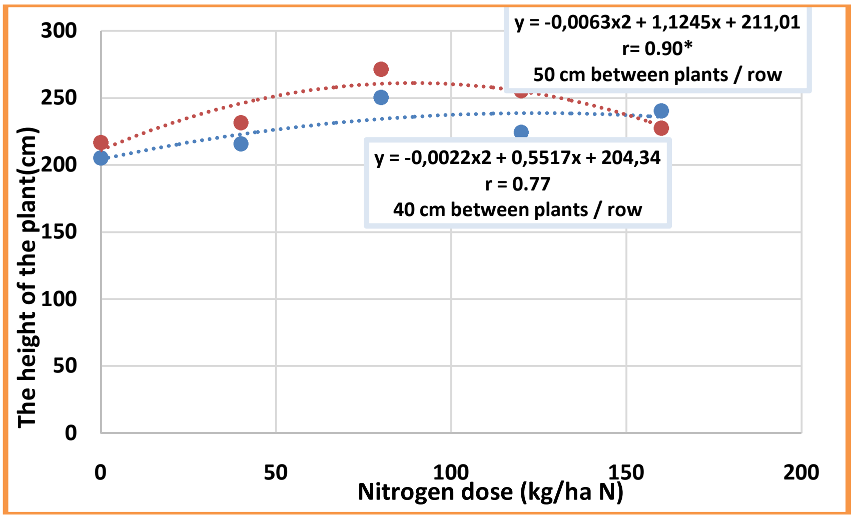

Fig. 1. Influence of planting density depending on the dose of nitrogen on the height of the plant

Table 2

Biometric determinations in Jerusalem artichoke during the vegetation period (2018-2020)

Agrofound	Planting density	Number of leaves /plant	Foliar surface (m^2/ha)	Above ground biomass weight (stems + leaves) (kg/ha)
a_1- Nefertilizat	b_1-40 cm	444	103594.3	34250
	b_2- 50 cm	426	78933	34050
a_2 - $N_{40}P_{40}K_{40}$	b_1-40 cm	470.3	119015.3	42502
	b_2- 50 cm	454.3	96696	36589
a_3 - $N_{80}P_{80}K_{80}$	b_1-40 cm	517.3	115530.7	57487
	b_2- 50 cm	660.3	143960	46166
a_4- $N_{120}P_{120}K_{80}$	b_1-40 cm	486.6	124030	52173
	b_2- 50 cm	649.6	147810.7	54080
a_5 - $N_{160}P_{160}K_{80}$	b_1-40 cm	651.3	163860	64779
	b_2- 50 cm	512.6	105468.7	45881
LSD 5%=			67369	20960
LSD 1%=			95766	29800
LSD 0,1%=			138665	43150

The leaf area was determined using the Area Metter AM 300. This physiological indicator is directly related to the amount of light that can be intercepted by plants. Knowledge of the leaf area is of particular importance. Knowing this parameter we can approximate the primary photosynthetic production, evapotranspiration and can be used as a reference tool for crop growth, having an essential role in the ecology of theoretical production. The optimal planting density allows the interception of more than 95% of photosynthetically active radiation to obtain the highest yield.

Karsli,M.A. et al. (2009) concluded that the higher density facilitated the maximum interception of light which ultimately contributed to the increase in production and total dry matter content.

The accumulation of total dry matter of a crop depends on the efficiency of using radiant energy for the net assimilation of CO2.

The leaf area / ha increased with increasing number of plants / ha by reducing the planting distance to 40 cm between plants / row leading to the interception of a larger amount of photosynthetically active radiation due to the higher number of plants / ha (Fig.2) .

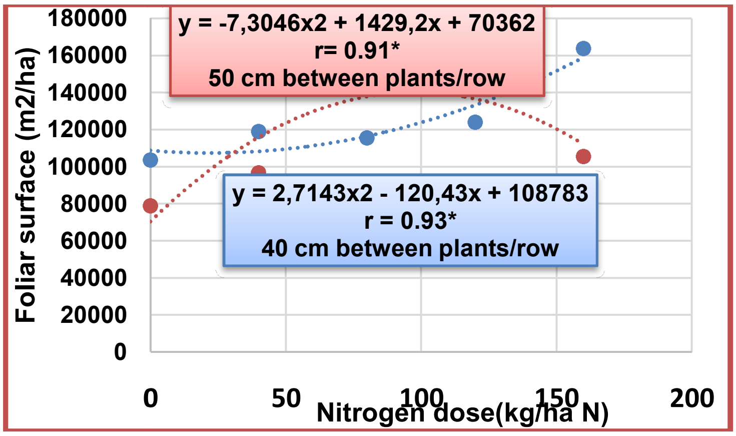

Fig. 2. The influence of planting density depending on the dose of nitrogen on the foliar surface

The amount of solar radiation intercepted in the leaves depends on the arrangement of the plants and the density of the plants.

From our research in the period 2018-2020 it is observed that the highest biomass production of 64779 kg / ha was obtained on the agrofund of $N_{160}P_{160}$ K_{80} and the planting distance of 40 cm between plants in a row. The functional link between the fertilization variant with N_{160} and the density of 40 cm between plants in a row is given by the polynomial function of degree 2 which shows a significant correlation (r = 0.93)*(Fig.3).

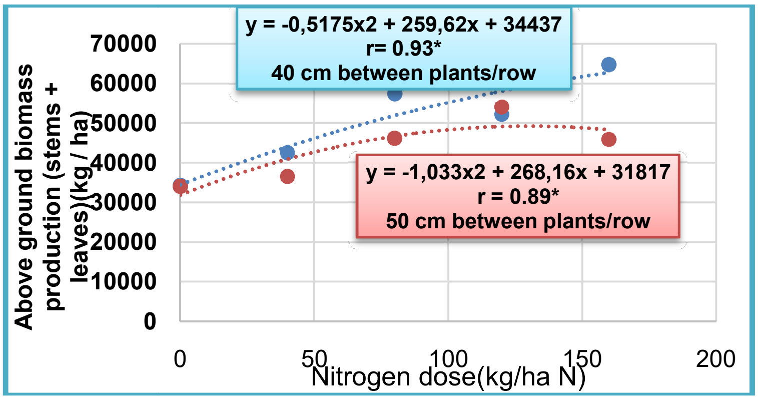

Fig. 3. Influence of planting density and nitrogen dose on above-ground biomass production (stems + leaves)

The physiological processes studied showed value variations, depending on the abiotic factors (temperature, light intensity, relative air humidity, etc.) that are constantly changing, but also depending on the agrotechnical factors studied.

The experimental determinations were made in diurnal variation, at 9, 12, 15, and for the statistical interpretation the daily average values obtained in the three years of study were used.

Regarding the influence of planting density on photosynthesis, no significant differences were obtained between the two analyzed variants, the rate of photosynthesis presenting slightly lower values for Jerusalem artichoke plants in the variant with 35000 plants / ha. By decreasing the planting density by 7000 plants, there was, on average, an increase in the rate of photosynthesis by only 0.37 µmol CO2/m2/s, a statistically insignificant increase (Table 3).

Table 3

The influence of density (factor B) on Jerusalem artichoke photosynthesis (2018-2020)

Factor B	Photosynthesis			
	µmol $CO_2/m^2/s$	Relativ photosynthesis %	The difference from the witness (µmol $CO_2/m^2/s$)	The significance of the difference
b_1-40 cm (Witness)	6.65	Wt. (100)	(Wt.)	
b_2- 50 cm	7.02	105.5	0.37	-

DL 5%= 1.36
DL 1%= 1.93
DL0,1%= 2.79

Foliar transpiration varied and intensified in close connection with the studied agrotechnical factors and climatic conditions.

By using a smaller number of plants per unit area, an insignificant reduction of foliar perspiration was found (Table 4).

In order to determine the production of tubers / ha, the number of tubers / plant, the weight of the tubers / plant were determined at harvest (Table 5).

Table 4

The influence of density (factor B) on Jerusalem artichoke transpiration (2018-2020)

Factor B	Transpiration			
	mmol $H_2O/m^2/s$	Relativ transpiration %	(mmol $H_2O/m^2/s$)	Semnificațiadiferentei
b_1-40 cm	2.50	Mt (100)	(Mt)	
b_2- 50 cm	2.28	91.3	-0.22	

DL 5%= 0.45
DL 1%= 0.64
DL0,1%= 0.93

Table 5

Production of Jerusalem artichoke tubers depending on planting density and level of fertilization (2018-2020)

Agrofound	Planting density	Number of tubers / plant	Weight of tubers / plant(kg)	Tuber production (kg/ha)
a_1-Unfertilized	b_1-40 cm	50.4	0.658	23036
	b_2- 50 cm	45.5	0.848	23756
a_2 - $N_{40}P_{40}K_{40}$	b_1-40 cm	46.8	0.908	31785
	b_2- 50 cm	43.5	0,913	25570
a_3 - $N_{80}P_{80}K_{80}$	b_1-40 cm	40.4	0.839	29376
	b_2- 50 cm	47.6	1,1	31039
a_4 -$N_{120}P_{120}K_{80}$	b_1-40 cm	38.7	1.19	41671**
	b_2- 50 cm	55.7	1,39	39127*
a_5- $N_{160}P_{160}K_{80}$	b_1-40 cm	37.5	1.08	37807*
	b_2- 50 cm	38.0	1.069	29947

DL 5%= 11200
DL1%= 16000
DL0,1%= 23200

Analyzing the interaction between the studied factors (planting density x fertilization doses) on the production of fresh tubers, it is found that the distance of 40 cm between plants / row and the level of fertilization of $N_{120}P_{120}K_{80}$ ensured the highest production of 41671 kg / ha fresh tubers / ha, not statistically insured.

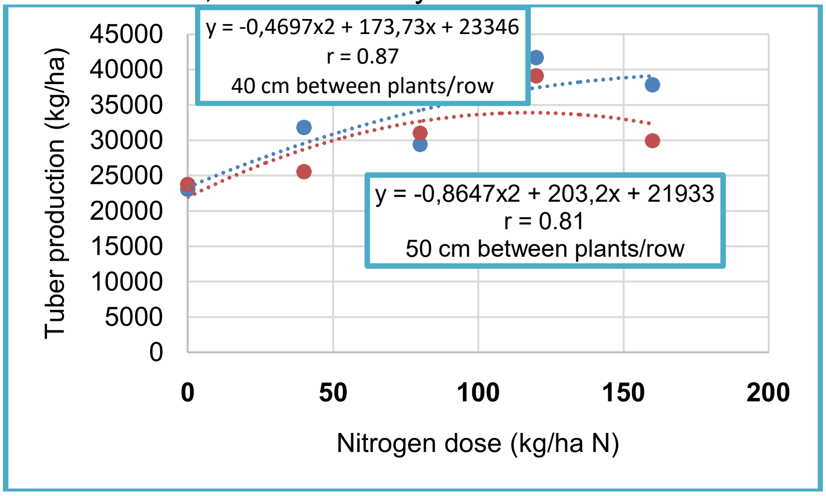

Fig.4. Influence of planting density and nitrogen dose on Jerusalem artichoke tuber production

CONCLUSIONS

Jerusalem artichoke is a species that has performed well in cultivation on sandy soils in climatic conditions from 2018-2020.

From the research conducted in 2018-2020 it is observed that the highest biomass production of 64779 kg / ha was obtained at a planting distance of 40 cm between plants in a row.

Analyzing the interaction between the studied factors (planting density x fertilization doses) on the production of fresh tubers, it is found that the distance of 40 cm between plants / row and the level of fertilization of N120P120K80 ensured the highest production of 41671 kg / ha fresh tubers / ha, not statistically insured.

From a physiological point of view, the analysis of the average values obtained during the entire research period did not reveal any notable differences from a statistical point of view in terms of the influence of planting density on photosynthesis and perspiration processes in Jerusalem artichoke.

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