GROWTH AND PRODUCTIVITY STUDIES ON JERUSALÉM ARTICHOKE (Helianthus tuberosus L.) IN NORTHEAST BRAZIL.

F. A.G. ALMEIDA *
L.L. TIESZEN **
F. C. G. ALMEIDA ***

CRESCIMENTO E PRODUTIVIDADE DA ALCACHOFRA DE JERUSALÉM (**HELIANTHUS TUBEROSUS** L.) NO NORDESTE DO BRASIL

RESUMO

O objetivo deste estudo foi investigar a possibilidade de crescimento da Alcachofra de Jerusalém em condições tropicais de baixa latitude, comparar a produção de duas variedades, MFW e Columbia e identificar qualquer problema agronômico ou considerações especiais para o Brasil.

Duas variedades de *Helianthus tuberosus* L., Columbia e "Mamoth French White" (MFW), foram estudadas na zona litorânea do Estado do Ceará, Brasil. A variedade foi irrigada à mão, pelos sistemas de jato pulsante e aspersão, e a variedade Columbia irrigada somente à mão.

Precipitação, temperatura, radiação e insolação foram medidas durante o experimento. Também, as características físicas e químicas do solo da área experimental foram estudadas.

A altura média das plantas, em ambas variedades, atingiu um "plateau" dez semanas após o plantio, quando submetidas aos diversos tipos de irrigação. A floração iniciou-se sete semanas após o plantio. As partes florais começaram a senescer quando as plantas estavam com dez semanas de idade e a maioria das folhas mostraram-se mortas com quatorze semanas.

A alocação de nutrientes na parte aérea estabelece uma alocação de substância na porção subterrânea da planta. A produção de tubérculos aumentou rapidamente durante o período de crescimento das plantas, atingindo 31,8 t por hectare (peso fresco) para a variedade MFW, após dezesseis semanas de vida, e 31,1 t por hectare para a variedade Columbia, após doze semanas de vida. A produtividade com o sistema de jato pulsante foi duas vezes maior.

Foi observado algum ataque da *Spodoptera frugiperda* na folhagem e do *Sclerotium rolfsii* nos tubérculos.

PALAVRAS-CHAVE: Jerusalem Artichoke, Growth, Productivity, Northeast Brazil, Phenology, Biomass Production.

SUMMARY

The proposal of this study was to establish the feasibility of grouth of Jerusa-

* Professor do Departamento de Biologia do Centro de Ciências da Universidade Federal do Ceará.
** Professor do Departamento de Biologia do Colégio de Augustana, Estados Unidos da América.
*** Professor do Departamento de Fitotecnia do Centro de Ciências Agrárias da Universidade Federal do Ceará.

lem Artichoke in low latitude tropcs, to compare the production of two varities, MFW and Columbia, and to identify any special agronomic problems or considerations for Brazil.

Two varieties of **Helianthus tuberosus L.**
White (MFW), were studied in the litoral zone in Ceara State, Brazil. The variety MFW was irrigated by hand and jet pulse system, and by spray irrigation system; the Columbia one only by hand.

Precipitation, temperature, radiation, and insolation were measured during the experiment. Also, physical and chemical characteristcs of the soil on the experimental plot were determined.

Mean plant height attained a plateau after ten weeks of growth in both varieties under various types of irrigation. They initiated flowers seven weeks after planting. Floral parts dehisced after ten weeks and most leaves were dead after fourtenn weeks.

Allocation to aerial components preceded substantial allocation to belowground compartments. Tuber production increased rapidly for the duration of the growth period attaining 31.8 t/ha (fresh weight) in NFW after sixteen weeks and 31.1 t/ha (fresh weight) in Columbia after twelve weeks. Productivities with jet pulse irrigation were even two times greater.

It was observed some attach of **Spodoptera frugiperda** on the foliage and **Sclerotium rolfsii** on the tubers.

INTRODUCTION

The biological synthesis of reduced organic matter provides an immense resource for the production of mobile fuels as well as feedstocks for chemical industries. This resource, however, is often difuse, and intensive investigation during the last ten years have attempted to identify highly productive species. Agricultural crops represent the most readily available source of this biomass. The high cost of these feedstocks, more than 50% of production,' has stimulated continuing searches for additional carbohydrate rich crops. The Jerusalem artichoke (**Helianthus tuberosus** L.) is often identified as one of the species containing potential for high carbohydrate productivity (STAUFFER & INGALLS[8]).

The Jerusalem artichoke is native to North America (WISE & WILFAHRT[9]), however, it has became grown widely throughout the coaler part of the northern hemisphere following its introduction to Europe by Chanplain early in the 17th. century. Estimates of the magnitude of cultivation are uncertain; however, in France, between 117 and 164,000 hectares were cultivated from 1930. This cultivation diminished to around 8000 hectares by 1980. In addition to its use as a food by native americans, it has been cultivated and marketted as a specialty food in the United States. SCHROEDER[7] reported an agronomic study in Uruguay early in the 20th. century and, furthermore, reported that DRAGENDORFF (1898), WEHMER (1911), and LOFGREN (1917) indicated the existence of Jerusalem artichokes in Brazil. Although it is reported to be seen occasionally in markets in southern Brazil, we have been unable to confirm its presence. It is reported very little cultivation of Jerusalem artichokes in South America. It is known that only Argentina and Uruguay have sporadic plantations. South America literature indicated that the species was not being cultivated and studied in any other country.

Numerous "varieties" of varying genetic purity exist. These have been maintained and developed mainly in two laboratories: Station d'Amelioration des Plantes, INRA-Le Rheu by Le Cochec and in Canada at the Marden Research Station (CHUBEY & DORRELL[2]). The following varieties are generally available in the United States: Mammoth French White, Oregon White, and a recent variety from Canada, Columbia.

The Jerusalem artichoke is of special interest because it has shown excellent potencial as high yilding and carbohydrate rich crop. STAUFFER & INGALLS[8], in Canada, showed forage yields as high as 31.8 metric tons per hectare with protein contents between 9.5 and 17.3%. Similar yields were reported by SACHS et alii[6], at Davis, California. In a phenological study in France, CHABBERT et alii[1], showed a maximum biomass of stems in September around 51.4 t/ha and a production of leaves which preceded this around 10 to 15 t/ha. As the plants matures this dry matter is stored in tubers with variable yields depending upon the variety, location, and cultural conditions. CHUBEY & DORRELL[3] working with Columbia plants at the Agriculture Canada Research Station, report that their tuber yields have ranged from 38.1 t/ha in 1980, under drought conditions, to 76.2 t/ha in 1972, under ideal growing conditions. In others years, the yields have ranged from 46 to 60 t/ha. CHABBERT et alii[1] report that Jerusalem artichoke can yield up to 90 t of tubers per hectare. Working with the cultivar "Violet Commun" in Montpellier, France they obtained 54.4 t/ha. In north central United States, it is reported that realistic tuber yields are approximately 33 t/ha.

The tuber represents a high quality source of organic material. This is in the form of inulin, or polyfructan, which in temperate zones, makes up 13.2 to 27.7% of the tuber. The composition of this material has been revived by FLEMING & GROOTWASSINK[4] and consists of a homologous series of molecules of varying polymerization. This material can be readily hidrolyzed to free sugar, yelding up 8 metric tons of fructose per hectare (PILNIK & VERVELDE[5]). These potential yields of fructose and/or ethanol in a plant that has has been subjected to a little genetic improvement and which grows well in a wide range of environmental and soil conditions are impressive and necessitate further study as our search for energy and chemical feedstocks continues.

The main objectives of the research reported in this paper were: to establish the feasibility of growth of Jerusalem Artichoke in low latitude tropics, to compare the productivity of two varieties, MFW and Columbia, and to identify any special agronomic problems or considerations for Brazil.

MATERIALS AND METHODS

Two varieties of **Helianthus tuberosus** L., Columbia and Mammoth French White (MFW), were studied in experimental plots located in the litoral zones, Caucaia (12 km North of Fortaleza), Ceara, Northeast Brazil. The site elevation is at sea level and at a latitude of gers from 21.8 to 31.7.° C with a mean of 26.5°C. The area shows two defined seasons, one rainy season, from January to July, with peaks of precipitation in March and April, and one dry season. The mean annual precipitation is 1085 mm.

The tubers were planted in black plastic bags, 30 cm long and 15 cm wide, on March 25, 1983. The soil substrade was a mixture of one part of sand, one part of clay, and part of cattle manure.

Sixty MFW and sixty Columbia plants, in bags, were transplanted to the field two weeks later and hand irrigated. At the same time, 46 MFW plants were transplanted to an experimental jet pulse irrigation area. Three weeks later, 120 MFW were transplanted to another plot under spray irrigation utilizing 55,000 liters of water a day/ha.

Every two weeks, after the transplanting date the heights of the plants under irrigation and jet pulse irrigation were measured. Every four weeks, five plants of each variety under hand irrigation were harvested. Flowers, leaves, stems, rhizomes, tubers, and root complex were separated and weighed. These parts were dried in a oven at 80 ° C for 48 hours to determine their dry matter production. The plants under spray and jet pulse irrigation were harvested only at 18 weeks of age to determine their tuber productivity.

Precipitation, temperature, radiation, and insolation were measured during the experiment. Also, physical and chemical characteristics of the soil on the experimental plot were determined.

RESULTS AND DISCUSSIONS

Before to present growth and productivity data, the Tables 1, 2, and 3 show the climate and soil data determined on the experimental plot at the time of the research conduction.

Growth continued immediately upon transplanting into the field gardens. Mean plant height, however, attained a plateau after ten weeks (June 4) in both varieties under various types of irrigation. The varieties differed in height by around 10 cm. The low maximum plant heights, less than 1.0 meter with hand irrigation and 1.37 meter with jet pulse are in contrast to the heights of several meters attained by MFW in the northern hemisphere.

Both varieties initiate flowers on april 30, about five weeks after transplanting and when they were only 50 cm tall. Under normal temperate zone conditions, Columbia initiates flowers 6 weeks before MFW and usually after 12 weeks of growth. The plant height at this time would be greater than 1.0 meter for Columbia and perhaps 2.0 meters for MFW. Floral parts dehisced after 10 weeks and most leaves were dead after 14 weeks, although the stems were still pulpy at this time.

Allocation to aerial components preceded substantial allocation to belowground compartments. Maximum aboveground biomass in each variety was attained on June 4, 10weeks after transplanting. NFW possessed more forage at this time than Columbia, 5.2 and 4.5t of dry matter per hectare, respectively. Aboveground dry matter decreased after this time, concurrent with the visual onset of maturity and senescence. At the termination of the experiment MFW possessed 2.5 and Columbia 0.7 t/ha in the aerial

Table 1

Climate Data During the Experiment

MONTH	TEMPERATURE (o.C)			PRECIPITATION	RADIATION	INSOLATION
	MINIMUM	MAXIMUM	MEAN	(mm)	(cal/cm2)	(hours)
March	25.0	30.3	27.7	348	11,042	170.6
April	24.6	30.8	27.7	112	11,604	219.3
May	24.8	31.0	27.9	95	11,472	249.8
June	24.0	30.0	27.0	90	11,615	282.1
July	23.5	29.3	26.4	25	12.418	293.0
TOTAL				670		

Cien. Agron., Fortaleza, 18 (2): pág. 107 112 Dezembro. 1987

TABLE 2

Physical Characterization of the Soil (Eutrophic Yellow Red Podzolic) Experimental Blot in Caucaia, Ceará, Brazil.

HORIZON		PARTICLE COMPOSITION				NATURAL	TEXTURAL	WATER CONTENT	
SYMBOL	DEPTH	COARSE SAND	FINE SAND	SILT	CLAY	CLAY	CLASSIFICATION	13 Atm	15 Atm
A 11	0 – 18	44,75	47,00	2,30	5,95	0,25	Sandy	3,54	2,08
A 12	18 – 35	49,40	41,20	1,55	7,85	0,85	Sandy	3,82	1,48
A 2	35 – 52	54,15	34,70	5,15	6,00	1,35	Sandy	4,28	2,35
B 1	52 – 74	53,65	33,15	1,70	11,50	2,40	Loamy Sand	4,96	3,17
B 21 Tp 1	74 – 100	43,55	22,85	5,25	28,35	0,95	Sandy clay loam	13,01	3,56
B 22 Tp 2	100 – 120	41,55	24,20	4,00	30,25	0,05	Sandy clay loam	19,52	3,81

TABLE 3

Chemical Characterization of the Soil at the Experimental Plot in Caucaia, Ceará, Brazil.

HORIZON	CONDUCTIVITY (SATURATED)	pH (H_2O)	C (%)	N (%)	C/N	ORGANIC MATTER	AVAILABLE PHOSPHORUS	CATIONS COMPLEX (mE/100 g OF SOIL Ca++	Mg++	K+	Na+	S	H+A13+	A13+	T	100S/T V%
A 11	1,84	7,1	0,22	0,02	11,00	0,38	0,13	0,50	0,70	0,08	0,66	1,94	0,00	0,00	1,94	100
A 12	0,96	5,1	0,10	0,02	5,00	0,17	0,04	0,20	0,60	0,07	0,27	1,14	0,66	0,23	1,80	63
A 2	0,58	5,1	0,10	0,01	10,00	0,17	0,33	0,50	0,70	0,08	0,22	1,50	0,66	0,33	2,16	69
B 1	0,39	5,3	0,11	0,01	11,00	0,19	1,54	0,20	0,50	0,08	0,16	0,94	0,49	0,18	1,43	66
B 21 Tp1	0,41	5,3	0,13	0,01	13,00	0,22	0,17	1,00	1,50	0,24	0,22	2,96	0,99	0,08	3,95	75
B 22 Tp2	0,29	5,2	0,11	0,01	11,00	0,19	0,04	1,00	1,50	0,15	0,18	2,63	1,32	0,38	3,95	66

parts. The seasonal course of leaf biomass differed signicantly from that of the stem. The percent of material decreased with time in leaves from 42% to around 4 to 6% at harvest. Stems illustrated an intermediate peak in biomass. These values for Columbia, however, were significantly lower than for MFW.

In the belowground compartments rhizome biomass was soon surpassed by developing tubers. Tubers were already present on May 23, only 4 weeks after transplanting with Columbia possessing more (10.5 per plant) than MFW (0.5 per plant) at this time. Thus tuber formation occurs very early and is concurrent with, or may even precede flowering. Tuber production increased rapidly for the duration of the growth period, attaining 41.0 t/ha (fresh weight) in MFW after 16 weeks and 42.2 t/ha (fresh weight) in Columbia after 12 weeks. This production corresponded to 1.5 and 9.3 t/ha of dry matter in the respective species. Productivities with jet pulse irrigation were even two times greater and with spray irrigation were 33.3 t/ha, both after 18 weeks.

Large amounts of entire plant biomass are transferred to the harveststalk tuber (harvest index). These values of 85.2% for MFW and 94.9 for Columbia represent high values and efficient conversion. The 28.0% dry matter for tubers is also a high dry matter content.

Three weeks after transplanting, it was observed an insect attach in the foliage caused by **Spodoptera frugiperda.** It was controlled by using a monocrotophos inseticide. Also, tubers were attached by a fungy known as Sclerotiun Rolfsii. It was not used any fungicide to treat them.

LITERATURE CITED

1. CHABBERT, N et alii. Productivity and Fermentability of Jerusalem Artichoke According to Harvesting Date. *Biomass* 3, 209–224. 1983.
2. CHUBEY, B.B. & DORRELL, D. G. Jerusalem Artichoke, a Potential Fructose Crop for the Prairies. *Can. Inst. Food Sci. Technol.* J. 7 (2), 98–100. 1974.
3. Columbia Jerusalem Artichoke. *Can. J. Plant Sci.* 42, 537–539.1982.
4. FLEMING, S.E. & GROOTWASSINK, J. W. D. *Preparation of High Fructose Syrup from the Tubers of the Jerusalem Artichoke (Helianthus tuberosus L.).* CRC Critical Review in Food Sci. and Nutrition. Dep. of Food Sci. Univ. of Manitoba, Winnipeg, Manitoba. Nov., 1979.
5. PILNIK, W. & VERVELDE, G. J. Jerusalem Artichokes (*Helianthus tuberosus* L.) as a Source of Fructose, a Natural Alternative Sweetener. *J. Agron. Crop. Sci.* 142. 153. 1976.
6. SACHS, R.M. et alii. Fuel Alcohol from Jerusalem Artichoke. *Calif. Agric.* 35, 4–6. Sept. – Oct. 1981.
7. SCHROEDER, J. *El Cultivo Experimental y la Composicion Quimica del Topinambur en el Uruguai.* Apartado de la Facultad de Agronomia, N.º 1. Montevideo, Agosto, 1928.
8. WYSE, D. L. & WILFAHRT, L. Today's Weed, Jerusalem Artichoke. *Weeds Today,* 15–16, Early Spring, 1982.
9. STAUFFER, M.D. & INGALLS, J.R. *The potential of Jerusalem Artichoke as a Forage Crop: Comparisons with Corn and Sorghum as Affected by Harvest Date.* Research Station, Agriculture Canada. Morden, Manitoba, Canada.