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EFFECT OF HARVESTING DATES AND POTASSIUM FERTILIZATION LEVELS ON VEGETATIVE GROWTH, TUBER YIELD AND QUALITY OF JERUSALEM ARTICHOKE

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ABSTRACT

The effects of three harvesting dates; 120 150 and 180 days after planting (DAP) and four potassium fertilizer levels; 0, 48, 72 and 96 Kg K_2O fed^{-1}, on vegetative growth characteristics, tuber yield potential and quality of Jerusalem artichoke (cv. Balady) were studied. Two field experiments were conducted during the two successive summer seasons of 2001 and 2002 at the Experimental station Farm, at Abeis, Faculty of Agriculture, Alexandria University. The results revealed that delaying harvesting date up to 180 days after planting was accompanied with significant increases in plant height, leaf's dry matter content (%), number of main stems and canopy fresh mass per plant. Moreover, yield potential; i.e. tuber yield / plant, total tuber yield / m^2 and average tuber weight; were positively and significantly increased by the late harvest (180 DAP). It was also noticed that the late harvesting date lowered the leaf's N content, but raised the leaf's K content. However, leaf's P content was not significantly affected by harvesting dates. The harvested tubers at 180 days age were characterized with high contents of total soluble solids, total carbohydrates, inulin, protein and K; indicating that the late was the harvest

date the higher was the nutritional quality of Jerusalem artichoke tubers.

The results showed also that the application of K fertilizer up to 96 Kg K_2O fed^{-1}, significantly, increased the plant height, number of main stems, canopy fresh mass, leaf's area plant^{-1}, dry matter content, leaf's K content and yield potential; i.e. tuber yield plant^{-1}, total tuber yield / m^2 and average tuber weight as well as improved tuber contents of total soluble solids, total carbohydrate, inulin and K. On the other side, the different potassium rates decreased significantly tuber's protein content.

Delaying harvesting date up to 180 DAP combined with the application of 96 Kg K_2O fed^{-1}, appeared to be the most efficient treatment combination which gave a vigorous vegetative growth to be used as forage in summer season, and a higher yield potential as well as higher chemical contents in the harvested tubers of Jerusalem artichoke.

INTRODUCTION

Jerusalem artichoke (*Helianthus tuberosus L.*) is familiar to many as a perennial herb which is often cultivated as an annual, with tubers produced on the ends of underground stems. It is considered one of the important nontraditional vegetable crops that is newly introduced, to Egypt. However, the cultivation of this crop is still limited in small plantations.

The tubers which are rich in carbohydrates (8 – 18 %), inulin (11 – 15.5 %) and protein (9 – 10 %) can be eaten fresh or cooked in appetizing ways similar to potatoes especially, in diabetic diets (Khereba, 1979; El-Sharkawy, 1998; Mansour *et. al.*, 2001). Jerusalem artichoke tubers resemble potatoes except the carbohydrates composing 75 to 80 % of the tuber are in the form of inulin rather than

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starch (Cosgrove *et. al.* 1991). On the other hand, the stems and leaves are used for making good forage and silage with a high value for animals. Optimal forage quality can be obtained by harvesting tops early when protein levels are at their maximum. The potential advantage of the crop for forage may arise from the fact that it adapts well to a wide variety of soils and habitats. (Cosgrove *et. al.*, 1991). Jerusalem artichoke, also, was commercially employed as a flour and source of fructose or alcohol beside its benefits in medical treatments against rheumatism and diabetes (Duke and Wain, 1982; Spitters, 1987; Cosgrove *et. al.* 1991).

Fertilization, in general, and with potassium, in particular, plays a major role in stepping up productivity of tuberous crops. It involves in many physiological and biochemical processes; as cell division and elongation, enzyme activation, synthesis of simple sugars and starch, and translocation of carbohydrates (Nelson, 1970; Marschner, 1986; Beringer *et. al.* 1990). Potassium is one of the important macronutrients that promotes vegetative growth of Jerusalem artichoke (Mansour *et. al.*, 2001), improves tuber yield and quality (Tawfik *et. al.*, 2003; Ahamed, 2004) and influences tuber chemical composition (El-Sharkawy, 1998). More recently, Feleafel (2004) found that growth, yield and tuber characters of Jerusalem artichoke responded positively with increasing the applied levels of potassium.

Harvesting date was found to affect growth and development of Jerusalem artichoke tubers. It was reported as an important factor for yield and tuber composition. Hang and Gilliland (1982) and El-sharkawy (1998) reported that the top fresh weight of Jerusalem artichoke increased rapidly after emergence, reaching a maximum around 120 days, when tuber initiation was observed. Similarly, Kiehn and Chubey (1993) and Abdel-Hak (2005) reported that plant height and fresh weight were increased by delaying the harvesting date. The effect of harvesting date on tubers yield production was discussed by Kiehn and Chubey (1985), Soja *et. al*, (1990) and El-sharkawy (1998), who indicated that the highest yield

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was obtained after 180 days of planting. Tuber chemical contents were positively affected by harvesting date (Graham and Aman, 1986; Soja *et. al.,* 1990; El-Sharkawy, 1998; Tawfik *et. al.*, 2003). The total inulin content in tuber is considered one of the most important contents of Jerusalem artichoke for human nutrition particularly for those suffering from diabetes. The late harvest was accompanied by an increased in inulin content (Khereba, 1979; Chubey and Dorrel, 1982; El-Sharkawy, 1998); Abdel-Hak, 2005).

Therefore, the objective of the present study was to find out the best harvesting date and the suitable level of potassium fertilization for good vegetative growth, high tuber yield and quality characters of Jerusalem artichoke.

MATERIALS AND METHODS

The goal of the current study is to assess the influence of three different (digging) harvesting dates (120, 150 and 180 days after planting and four varying potassium levels fertilization (0, 48, 72 and 96 Kg K_2O fed^{-1}) on vegetative growth, chemical constituents of leaves and tubers as well as yield and its components of Jerusalem artichoke. To achieve the goal of the present study, two field experiment were conducted at the Experimental Station Fram at Abis, Faculty of Agriculture, Alexandria University during the summer seasons of 2001 and 2002.Perior the initiation of each experiment soil samples of 25 cm depth were collected and analysed for some important physical and chemical properties according to the methods described by Page *et. al.* (1982). Results of the analyses are given in in Table (1).

Table 1. The physical and chemical properties of the experimental sites in 2001 and 2002 summer seasons

Season	Physical properties				Chemical properties			
	Clay%	Silt%	Sand%	Texture	pH	N%	P%	K%
2001	45.50	14.70	39.80	Silty loam	7.5	0.14	0.062	0.073
2002	42.10	14.34	43.56	Silty loam	7.4	0.12	0.068	0.079

The experimental layout was a split-plots system in a randomized complete blocks design, with three replications. Harvesting dates were arranged as the main plots, while the potassium fertilization rates were randomly distributed in the sub-plots.

Tubers of the Balady cultivar of Jerusalem artichoke were planted in rows of 1 m width and 4 m length at 0.5 m plant distances on May 6, 2001 and April 28, 2002. The area of the smallest experimental unit was 16 m^2 comprised of 4 rows. Two guard rows were left between each two adjacent main plots and one guard row was left between each two adjacent sub-plots to protect against side effects. All experimental units received identical levels of nitrogen and phosphorus fertilizers. Calcium super phosphate (15.5% P_2 O_5) was base dressed before planting at the rate of 200 Kg fed^{-1}. Ammonium sulphate (20.5% N) was used as a nitrogen source at the rate of 400 Kg fed^{-1}. These amounts were equally divided and side dressed at 30, 60, 75 and 90 days after planting. Potassium fertilizer rates, used in this study, were applied as potassium sulphate (48% K_2O). Each potassium rate was equally divided and side dressed at 30, 60, 75 and 90 days after planting. All other agricultural practices were adopted whenever it was necessary and as commonly recommended for the commercial production of Jerusalem artichoke.

At each harvesting time, data on vegetative characteristics, leaf mineral contents, yield and its components and chemical composition of tubers were recorded as follows:

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a) Vegetative growth characters; in terms of plant height (cm); number of main stems plant^{-1}, canopy fresh mass (Kg plant^{-1}) and leaves dry matter percentage were recorded using three plants randomly selected from the outer two rows of each sub-plot.

b) Leaf's mineral contents; random samples from the upper fourth leaves were collected, washed an dried at 70^{o}C to determine the percentages of N, P and K contents according to the methods described in A.O.A.C. (1992).

c) Tuber's yield and its components; at each harvesting date, tubers from the inner two rows of each plot were harvested and weighed to calculate tuber yield(Kg) / plant, total tuber yield (Kg)/ square meter and average tuber weight (g).

d) Tuber's chemical contents; tuber samples from each sub plot were taken, washed and dried to 70^{o}C to a constant weight, then ground to determine total protein, according to pregl (1945), total carbohydrate, as described by Montgomery (1961), concentration of inulin, according to Whistler *et. al*, (1962), and contents of K, as described by A. O. A. C. (1992). Fresh samples were also saved to determine tuber's total soluble solids, using a hand refractmeter.

All obtained data were statistically analysed using Costat Software (1985) and the Revised L. S. D. test was used to compare the differences among the means as illustrated by El-Rawy and Khalf-Allah (1980).

RESULTS AND DISCUSSION

Vegetative growth characters

Data presented in Table (2) showed that plant height, number of main stems plant^{-1}, canopy fresh mass plant^{-1} and leaves dry matter percentage were significantly affected by harvesting dates. Harvesting Jerusalem artichoke at 180 days after planting (DAP), significantly, resulted in the highest mean values of plant height, number of main stems plant^{-1}, canopy fresh mass plant^{-1} and leaves dry matter percent, in both seasons. The lowest mean values were obtained from the early harvesting date (120 DAP). Such positive effects of the late harvesting date could be related to the excessive rates of photosynthesizes and to the accumulation of stored food in the canopy of Jerusalem artichoke. Expanding the duration of harvesting over 120 DAP probably devoted a longer period for the foliage to grow more resulting in better vegetative growth. The obtained vigorous vegetative growth as a result of delaying harvesting date up to 180 DAP means that the fresh mass of Jerusalem artichoke plants can be used for making good forage and silage for animals in the summer season. These results appeared to be in a close agreement with the previous findings recorded on Jerusalem artichoke by Kiehn and chubey (1993), who mentioned that plant height was shorter with the early mature than either the mid season or late maturing. Abdel-Hak (2005) mentioned that plant height and fresh weight of Jerusalem artichoke plants were considerably and consistently increased till they reached the maximum values at the age of 180 days after planting. Unlikely, the obtained results did not agree with those reported by Hang and Gilliland (1982) and El-Sharkawy (1998), who concluded that each of plant height, number of main stems, fresh weight plant^{-1} and leaves dry matter percent of Jerusalem artichoke reached its maximum at 120 DAP then decreased till the time of harvesting.

Data arranged in Table (2) indicated that the application of K fertilizer at 48, 72 and 96 Kg K_2O fed^{-1}, significantly, increased plant height, number of main stems plant^{-1}, canopy fresh mass plant^{-1} and leaves dry matter percent relative to the control, in both seasons. Application of 96 Kg K_2O fed^{-1}, in general, recorded the highest mean values for all studied traits. However, the differences among 48, 72 and 96 Kg K_2O fed^{-1} in terms of plant height, number of main stems plant^{-1} and canopy fresh mass plant^{-1}, in the first season, were found insignificant. Moreover, the differences between 72 and 96 Kg K_2O fed^{-1} for number of main stems and between 48 and 72 Kg K_2O fed^{-1}

for canopy fresh mass plant^{-1} were not significant, in the second season. The positive results of k effects could be related to its vital contribution to several biochemical processes in the plant related to growth (Marschner, 1986) and to the important role of K in activation and stabilization of some enzymes, protein and starch synthesis and membrane transport. These results are in general accordance with the findings of Mansour *et. al.* (2001), working on Jerusalem artichoke, found that plant height, number of branches plant^{-1} and foliage fresh weight plant^{-1} were enhanced as the rate of K application increased to 96 Kg K_2O fed^{-1}. Similar conclusions were reported by Tawfik *et. al.* (2003), Ahamed (2004) and Feleafel (2004).

The interaction effects between harvesting date and K fertilizer levels on plant height, number of main stems, canopy fresh weight plant^{-1} and leaves dry matter percent were found significant, in both seasons(Table,2). The exception was in the first season, where number of main stems was not significantly affected. The highest values for plant height and average number of main stems as well as the heaviest significant fresh canopy and dry matter content were attained from the treatment combination of late harvesting (180 DAP) and 96 Kg K_2O fed^{-1}, in both seasons. The positive effect of harvesting date at 180 DAP and K level at 96 Kg K_2O fed^{-1} seemed to be coupled together and reflected eventual increases on vegetative growth characters.

Leaf's mineral contents

Data recorded in Table (3) showed that delaying harvesting date up to 180 DAP, significantly, decreased leaf's N content relative to the early one, in both seasons. It was also noticed that, in 2001 season, the difference between the early (120 DAP) and mid harvesting dates (150 DAP) was insignificant. Leaf's P content, on the other side, did not reflect any significant response, indicating that leaf's P content was stable throughout the growing season. The results showed that expanding the duration of harvesting to 150 DAP produced leaves with a higher K content, in the two studied seasons, than that obtained from

Table 2. Vegetative growth characters of Jerusalem artichoke plants as affected by harvesting dates and K rates in the summer seasons of 2001 and 2002

Treatments		2001 season				2002 season			
Harvesting dates (DAP*)	K rates (Kg K_2 fed^{-1})	Plant height (cm)	No. of main stems	Canopy fresh mass Plant^{-1} (Kg)	Dry matter content (%)	Plant height (cm)	No. of main stems	Canopy fresh mass Plant^{-1} (Kg)	Dry matter content (%)
120		61.9C**	4.6C	1.86C	18.27C	70.9C	4.8C	1.83C	18.33C
150		140.7B	5.0B	2.70B	19.62B	155.7B	5.2B	2.59B	19.87B
180		172.6A	5.5A	3.15A	20.25A	180.4A	5.7A	3.04A	20.47A
	0	109.7D	4.7B	2.39B	18.49C	115.9D	4.8C	2.21C	18.77D
	48	117.8C	5.0A	2.57A	19.06B	130.8C	5.2B	2.41B	19.21C
	72	128.5B	5.2A	2.63A	19.49B	141.0B	5.4A	2.58B	19.72B
	96	144.3A	5.3A	2.69A	20.48A	155.1A	5.5A	2.74A	20.53A
120	0	45.7j	4.3a	1.79e	17.25h	57.4i	4.3f	1.73g	17.57f
	48	55.4j	4.6a	1.88e	17.86g	66.4h	4.8e	1.77g	17.93e
	72	67.8h	4.8a	1.88e	18.31f	78.6g	4.9d	1.90g	18.36d
	96	78.8g	4.8a	1.91e	19.64cd	81.3g	5.2dc	1.92g	19.47c
150	0	119.7f	4.6a	2.52d	18.71e	132.6f	4.8d	2.26ef	19.36c
	48	135.3e	4.9a	2.64cd	19.63cd	147.3e	5.3c	2.52de	19.33c
	72	145.1d	5.2a	2.81cd	19.87c	156.9d	5.5c	2.65cd	20.25b
	96	162.6c	5.3a	2.84cd	20.30b	186.2b	5.3c	2.93bc	20.55b
180	0	163.6c	5.2a	2.87bc	19.51d	157.6d	5.4c	2.63cd	19.38c
	48	162.7c	5.5a	3.20ab	19.69cd	178.8c	5.4c	2.95bc	20.39b
	72	172.6b	5.7a	3.21ab	20.83b	187.5b	5.8ab	3.19ab	20.56b
	96	191.6a	5.7a	3.33a	21.50a	197.8a	6.1a	3.38a	21.56a

* DAP: Days after planting
** Values marked with the same alphabetical letter (s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.

Table 3. Leaf's mineral contents of Jerusalem artichoke plants as affected by harvesting dates and K rates in the summer seasons of 2001 and 2002

Treatments		2001 season			2002 season		
Harvesting dates (DAP*)	**K rates (Kg K_2O fed^{-1})**	**N (%)**	**P (%)**	**K (%)**	**N (%)**	**P (%)**	**K (%)**
120		1.872A **	0.605A	1.290B	1.888A	0.609A	1.305B
150		1.827B	0.611A	1.300A	1.862A	0.626A	1.317A
180		1.799C	0.622A	1.304A	1.816B	0.630A	1.321A
	0	1.869A	0.586A	1.236D	1.872A	0.600A	1.255D
	48	1.839B	0.613A	1.306C	1.851B	0.618A	1.322C
	72	1.821C	0.633A	1.320B	1.839C	0.629A	1.336B
	96	1.801D	0.630A	1.329A	1.832C	0.638A	1.344A
120	0	1.890a	0.557a	1.239e	1.881a	0.590a	1.248a
	48	1.879ab	0.610a	1.290d	1.870ab	0.600a	1.301a
	72	1.868ab	0.623a	1.310c	1.862ab	0.613a	1.330a
	96	1.849c	0.630a	1.319bc	1.859ab	0.633a	10341a
150	0	1.860bc	0.580a	1.239e	1.876a	0.600a	1.258a
	48	1.848c	0.600a	1.309c	1.865ab	0.630a	1.329a
	72	1.816d	0.630a	1.322abc	1.859ab	0.635a	1.338a
	96	1.784e	0.633a	1.330ab	1.848b	0.637a	1.342a
180	0	1.856bc	0.612a	1.229e	1.860ab	0.610a	1.258a
	48	1.791e	0.618a	1.318bc	1.818c	0.623a	1.336a
	72	1.778e	0.624a	1.329ab	1.797cd	0.640a	1.340a
	96	1.768e	0.631a	1.338a	1.788d	0.645a	1.350a

* DAP: Days after planting

** Values marked with the same alphabetical letter (s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.

the early harvesting date (120 DAP). Delaying harvesting date from 150 to 180 DAP, however, did not show any significant improvement on leaf's K content, in both growing seasons. It was evident that the late was the harvesting date, the lower was the leaf's N content. Such a result supported the findings obtained by soja *et. al.* (1993) and El-Sharkawy (1998), who noticed a reduction in N content as well as an increase in K content as the harvesting date was delayed up to 180 DAP.

Results of Table (3) indicated that fertilizing Jerusalem artichoke plants with K up to 96 Kg K_2O fed^{-1}. was accompanied with corresponding reductions of leaf's N content as well as with successive increments in leaf's K content relative to the unfertilized (control) plants, in both seasons. However, leaf's P content showed insignificant differences with increasing potassium rates. This antagonistic effect between K applied and leaf's N content might by related to the unbalance occurred between ratios of K^+ and ammonium (NH_4^+) cations during mineral absorption (Marschner, 1986). These results are in accordance with those reported by Feleafel (2004), who found that increasing the amount of applied K up to 96 Kg K_2O fed^{-1} increased significantly leaf's K content and had no effect on leaf's P content.

The interaction effects between harvesting dates and K fertilizer rates on leaf's mineral contents are illustrated in Table (3). The results showed that treatment combination of early harvesting without potassium fertilization resulted in the highest mean values for leaf's N content, in both years. However, the highest leaf's K content was recorded for the late harvesting date when plants were fertilized with the highest K level (96 Kg K_2O fed^{-1}), but in the first season only. Leaf's P content, in the other side, exhibited insignificant effects for the interaction between harvesting dates and K levels, in both seasons.

Tuber's yield and its components

Data in Table (4) exhibited that the highest tuber yield / plant, total tuber yield / m^2 and average tuber weight was obtained from harvesting Jerusalem artichoke 180 days after planting, in both seasons, indicating that the late was the harvest date, the higher was the yield potential of Jerusalem artichoke. On the other hand, the lowest tuber yield was recorded for the earliest harvest date (120 DAP). Such a result might be expected on the basis that the plants require more time to redistribute their reserves of carbohydrates in vegetative organs to the tubers. The translocation of the reserves from stems and leaves to tubers still continued from 120 to 180 days resulting in increasing tuber yield $plant^{-1}$, total yield per m^2, and average tuber weight. The results agreed to a great extent with those reported by El-Sharkawy (1998), who found that fresh weight of tubers $plant^{-1}$ increased with increasing the age of plants and reached the maximum at 180 days after planting. Recently, Abdel-Hak (2005) reported that the tuber fresh weight increased slowly till 155 DAP then the increase turned to be moderate up to 170 DAP ,after which a quick jump took place to 200 DAP.

The results of Table (4) showed that K application at the rate of 96 Kg K_2O fed^{-1} was superior and resulted significantly in higher means values of tuber yield / plant, total tuber yield / m^2 and average tuber weight than the lower K levels, in both seasons. The only exception was found in the 1^{st} season where the difference between 72 and 96 Kg K_2O fed^{-1}, for average tuber weight was not significant. The favorable effect of K application might be attributed to that the soil analysis showed a low available K concentration (Table, 1). Therefore, soil application with K, probably, increased soil exchangeable K (Beringer *et. al.* 1990) and, consequently, enhanced the translocation of K to the plants. So, the basic and major role of K on many physiological and biochemical processes; such as on cell division and elongation, enzyme activation, synthesis of simple sugars and starch, and acceleration of carbohydrates translocation, which are necessary for tuber formation and development (Marshner, 1986); were ideally performed, resulting in a higher yield potential. These findings appeared to be in a close agreement with those obtained by Mansour *et. al.* (2001), Tawfik *et. al.* (2003) and Feleafel (2004); who found that the application of K, significantly, increased tubers yield plant^{-1} and fed^{-1}, and the average tuber weight of Jerusalem artichoke.

The interaction effects between harvesting date and K fertilization level on tubers yield and its components appeared significant in both years (Table, 4). The combined treatment of late harvesting date (180 DAP) and 96 Kg K_2O fed^{-1} was the best for all studied yield potential characters. Such favorable effects of late harvesting date and high K rate on yield potential of Jerusalem artichoke might be explained through the linkage between hormones, induced throughout tuber development stages, and the nutrient attracting ability of K in the storage organs(Pantastico, 1975).Similar findings were recoded by El-Sharkawy (1998).

Tuber's chemical contents

Table (5) shows that tuber's chemical contents as expressed by TSS, total carbohydrate, inulin, protein and K contents increased significantly as harvest was delayed to 180 DAP, in both growing seasons. However, the differences between 150 and 180 DAP for tuber's protein content, and between 120 and 150 DAP for K content were not significant. It might be said that the late harvest date, the raised the tuber contents and nutritional quality of Jerusalem artichoke. Harvesting date seemed to be an important factor not only for yield potential but also for tuber quality (Dorrel and Chubey,1977; Soja *et. al.,* (1990); Seiler, 1990; El-Sharkawy ,1998; Tawfik *et. al.,* 2003). The noticeable gradual increases in tuber's chemical contents by delaying the harvesting might be due to the direct transfer of carbohydrates including inulin and the accumulated protein and nutrients from the aging leaves to the tubers of plant. Meijer and Mathijssen (1991), reported that during the vegetative growth of Jerusalem artichoke much larger amount of sugars are stored in the stem then translocated to the tubers during tuber initiation. The increase in protein content with the proceed of plant age was discussed earlier by

Seiler (1990), who showed that nitrogen concentration, which is the essential compound in protein constitution, increased by the proceed of tuber age due to the increase in dry weight and the decrease in moisture content during tuber growth, beside the translocation of nitrogen from stem and leaves to the tubers in this period. These obtained results are in a general accordance with the findings of El-Sharkawy (1998); Tawfik *et. al.,* (2003) and Abdel-Hak (2005), who reported that total carbohydrate, total sugar; inulin, protein and dry weight of Jerusalem artichoke tubers exhibited a gradual increase till the age of 185 or 200 days after planting.

Fertilizing Jerusalem artichoke plants with K up to 96 Kg K_2O fed^{-1} led to significant increments in tuber contents of TSS, total carbohydrate, and K, relative to the unfertilized control, in both years (Table, 4). However, the differences among the three K levels (48, 72 and 96 Kg K_2O fed^{-1}) for tuber's K content were not high enough to be significant, in first season. The application of 96 Kg K_2O fed^{-1}, was the most efficient treatment which recorded the highest mean values for most tuber's chemical contents. Tuber's protein content, on the other side, exhibited a decrement with increasing K levels. Such a result concerning the effect of K rates on tuber protein content seemed to suggest the presence of an antagonistic effect between the level of applied K and N concentration (Marschner, 1986). The detected positive effects of K fertilizer on most biochemical constituents of Jerusalem artichoke tubers might be related to the well known role of K on improving photosynthesis process and on enhancing the translation of carbohydrates towards storage organs (Marschner, 1986). Similar potassium promoting effects on Jerusalem artichoke tuber contents were previously reported by Soia *et. al.,* (1990); Mansour *et. al.,* (2001); Tawfick *et. al.,* (2003) and Feleafel (2004); who mentioned that increasing of applied K up to 96 Kg K_2O fed^{-1}increased significantly total tuber's soluble solids and carbohydrate percentages.

The comparisons presented in Table (4) illustrated the presence of significant interaction effects between harvest dates and K rates on tuber's chemical contents, in both seasons. The comparisons among the twelve treatment combinations, generally, indicated that fertilizing

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Table (4):Tuber yield and its components of Jerusalem artichoke plants as affected by harvesting dates and K rates in the summer seasons of 2001 and 2002

Treatments		2001 season			2002 season		
Harvesting dates (DAP*)	K rates (Kg K_2O fed^{-1})	Tuber yield $plant^{-1}$ (kg)	Total tuber yield m^{-2} (kg)	Average tuber weight (g)	Tuber yield $plant^{-1}$ (kg)	Total tuber yield m^{-2} (kg)	Average tuber weight (g)
120		0.95C **	4.93C	19.9C	0.97C	4.72C	22.3C
150		1.92B	5.88B	42.6B	1.87B	5.77B	42.3B
180		2.21A	6.49A	47.9A	2.32A	6.46A	52.1A
	0	1.37C	5.44D	32.3C	1.47C	5.28C	33.5D
	48	1.65B	5.66C	35.4B	1.66B	5.56B	36.5C
	72	1.75B	5.89B	39.0A	1.74B	5.62B	41.2B
	96	2.00A	6.08A	40.4A	2.02A	6.14A	44.4A
120	0	0.77d	4.57h	18.3i	0.79g	4.23g	20.2h
	48	0.87cd	4.84gh	18.6i	0.87g	4.59f	20.5h
	72	1.20cd	5.04fg	20.3h	1.00fg	4.69f	23.9g
	96	1.15c	5.28ef	22.3g	1.22f	5.38e	24.4g
150	0	1.68b	5.57de	37.7f	1.63e	5.50de	36.8f
	48	1.80b	5.88cd	40.4e	1.83de	5.73d	41.8e
	72	1.92b	5.96bc	45.4d	1.84de	5.68de	44.0d
	96	2.27a	6.12bc	46.7c	2.18bc	6.17bc	46.8c
180	0	1.65b	6.18bc	40.8e	1.98cd	6.11c	43.5d
	48	2.30a	6.28b	47.3c	2.27bc	6.37bc	47.3c
	72	2.31a	6.67a	51.4b	2.38ab	6.49b	55.6b
	96	2.59a	6.83a	52.3a	2.65a	6.87a	62.0a

* DAP: Days after planting

** Values marked with the same alphabetical letter (s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.

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Table 5. Tuber's chemical contents of Jerusalem artichoke plants as affect by harvesting dates and K rates in the summer seasons of 2001 and 2002

Treatments		2001 season					2002 season				
Harvesting dates (DAP*)	K rates (g K_2O fed^{-1})	T.S.S (%)	Total carbohydrate (g100 g^{-1}d.w.)	Inulin (% d.w.)	Protein (g100g^{-1}d.w.)	K (%)	T.S.S (%)	Total carbohydrate (g100 g^{-1}d.w)	Inulin (% d.w.)	Protein (g100 g^{-1}d.w)	K (%)
120		18.12C	16.47C**	9.98C	8.77B	0.135B	17.80C	16.57C	10.22C	8.84B	0.134B
150		19.39B	16.92B	10.84B	9.58A	0.137B	19.15B	17.14B	11.17B	9.70A	0.138B
180		20.53A	17.54A	11.55A	9.77A	0.139A	20.58A	17.76A	11.96A	9.82A	0.148A
	0	18.58D	16.49B	10.13D	9.83A	0.132C	18.38D	16.78D	10.46D	9.86A	0.133D
	48	19.16C	17.01A	10.57C	9.30B	0.135BC	18.94C	17.03C	10.99C	9.45B	0.139C
	72	19.60B	17.18A	11.09B	9.25BC	0.137B	19.61B	17.23B	11.30B	9.30BC	0.143B
	96	19.99A	17.21A	11.35A	9.10C	0.142A	19.79A	17.58A	11.71A	9.20C	0.149A
120	0	17.37g	16.20f	9.26i	9.83a	0.131a	17.17e	16.23f	9.64k	9.80b	0.132a
	48	18.03f	16.40ef	9.81h	8.50d	0.132a	17.33e	16.30f	10.12k	8.70g	0.134a
	72	18.30f	16.60de	10.28g	8.45d	0.136a	18.23d	16.70e	10.42i	8.50h	0.138a
	96	18.77e	16.67de	10.56f	8.30e	0.139a	18.47d	17.03de	10.68h	9.37i	0.142a
150	0	18.77e	16.50ef	10.26g	9.80a	0.132a	18.57d	16.80e	10.62h	9.85ab	0.133a
	48	19.40d	16.90bcd	10.68e	9.60b	0.136a	19.23c	17.20d	10.96g	9.80bc	0.136a
	72	19.50d	17.07bc	11.08c	9.53b	0.136a	19.27c	17.20d	11.32e	9.62e	0.138a
	96	19.70cd	17.70	11.32b	9.37c	0.143a	19.53c	17.37cd	11.76d	9.51f	0.145a
180	0	19.60d	16.77cde	10.88d	9.87a	0.133a	19.40c	17.30cd	11.12f	9.92a	0.133a
	48	20.03c	17.73a	11.22b	9.81a	0.136a	20.27b	17.60bc	11.88c	9.84ab	0.146a
	72	21.00b	17.87a	11.90a	9.77a	0.139a	21.33a	17.80b	17.16b	9.78cd	0.152a
	96	21.50a	17.77a	12.18a	9.63b	0.144a	21.33a	18.33a	12.68a	9.72de	0.160a

* DAP: Days after planting

** Values marked with the same alphabetical letter (s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.

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Jerusalem artichoke plants with 96 Kg K_2O fed^{-1} and delaying the harvesting up to 180 DAP seemed to be the most beneficial treatment which gave significantly the highest mean values for most tubers' chemical contents, in both years.

In view of the previous results better vegetative growth, higher yield potential and good quality of Jerusalem artichoke tubers could be improved through fertilization with K at the rate of 96 Kg K_2O fed^{-1}, and delaying harvesting to 180 days after planting. It could be used the vigorous vegetative growth as a summer crop forage and silage.

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الملخص العربي

تأثير مواعيد الحصاد و معدلات التسميد البوتاسي على النمو الخضري والمحصول وجودة الدرنات في الطرطوفة

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تمت دراسة تأثير ثلاثة مواعيد للحصاد، هي 120 و 150 و 180 يوماً بعد الزراعة وأربعة معدلات للتسميد البوتاسي، هي صفر و 48و72 و 96 كجم بو $_2$أ للفدان على صفات المحصول الخضري والجهد المحصولي وجودة درنات محصول الطرطوفة ، وذلك من خلال تجربتين حقليتين أجريتا خلال الموسم الصيفي لعامي 2001 و 2002 في محطة البحوث الزراعية – كلية الزراعة – جامعة الإسكندرية .

وقد أوضحت النتائج أن تأخير حصاد الطرطوفة حتى 180 يوماً من الزراعة قد صاحبه زيادة معنوية في ارتفاع النبات وعدد السيقان الرئيسة والوزن الطازج للمجموع الخضري والنسبة المئوية لمحتوى الأوراق من المادة الجافة ، كما لوحظ أن الحصاد المتأخر قلل محتوى الأوراق من النتروجين وزاد محتواها من البوتاسيوم في حين لم يكن لمواعيد الحصاد تأثيرً معنوي على محتوى الأوراق من الفسفور. وعلاوة على ذلك، فإن الجهد المحصولي، معبراً عنه بمحصول النبات أو محصول المتر المربع ومتوسط وزن الدرنه ، قد استجاب معنوياً بالزيادة كنتيجة لتأخير ميعاد الحصاد ، ولقد تميزت الدرنات التي تم حصادها عند عمر 180 يوما بارتفاع جودتها، معبراً عنها بالمواد الصلبة الكلية الذائبة والكربوهيدرات الكلية وسكر الانيولين والبروتين والبوتاسيوم، مما يدل على أنه كلما كان الحصاد متأخراً كانت جودة درنات الطرطوفة مرتفعة.

ولقد بينت النتائج أيضاً أن إضافة التسميد البوتاسي حتى 96 كجم بو $_2$ أ للفدان أدى لزيادة معنوية فى كل من ارتفاع النبات وعدد السيقان الرئيسية والوزن الطازج للمجموع الخضري، ومحتوي الأوراق من المادة الجافة والبوتاسيوم، والجهد المحصولي- معبراً عنه بمحصول درنات النبات ومحصول المتر المربع ومتوسط وزن الدرنة. بالإضافة إلي ذلك، فقد أدى التسميد البوتاسى الى تحسين محتويات الدرنات من المواد الصلبة الذائبة الكلية والكربوهيدرات والانيولين والبوتاسيوم . ومن ناحية أخرى، فقد أدت إضافة المستويات المختلفة من البوتاسيوم إلي نقص محتوى الدرنات من البروتين .

ولقد وجد أن تأخير ميعاد الحصاد حتى 180 يوما مع التسميد البوتاسي حتى 96 كجم بو $_2$ أ للفدان كانت أكفأ المعاملات العاملية حيث أعطت أفضل نمو خضري، والذي يمكن استخدامه كعلف في فصل الصيف، وكذلك أعلى جهد محصولي، بالإضافة إلي زيادة المحتويات الكيماوية في درنات الطرطوفة.

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