EFFECT OF NITROGEN AND POTASSIUM FERTILIZATION AND THEIR INTERACTIONS ON GROWTH, YIELD AND QUALITY OF JERUSALEM ARTICHOKE

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ABSTRACT

The effects of four varying N rates (0, 60, 90 and 120 kg N fed$^{-1}$) and four K levels (0, 48, 72 and 96 kg K$_2$O fed$^{-1}$) and their interactions on vegetative growth characters, tuber yield and quality of jerusalem artichoke (cv. Local) were studied. Two field experiments were conducted during the summer seasons of 2001 and 2002, at the Agricultural Experimental Station Farm, Faculty of Agriculture, Alexandria University. The results, generally, indicated that increasing applied N rate was accompanied with significant increases on plant height, foliage fresh weight, tuber carbohydrate content and tuber yield characters, i.e., tuber yield per plant and feddan and average tuber weight. On the contrary, leaf dry matter percentage decreased significantly with increasing the N fertilization rate. The results showed also that fertilizing jerusalem artichoke plants with the highest N level (120 Kg N fed$^{-1}$) gave significantly the highest tuber protein and N contents, leaf N and K percentages, and the lowest tuber T.S.S percentage. On the other hand, the number of main stems, and leaf P and tuber K percentages showed insignificant differences with increasing N rates. Increasing the amount of applied K up to 96 Kg fed$^{-1}$, significantly increased the plant height, foliage fresh weight, leaf dry matter and K percentages, and all tuber yield characters as well as tuber T.S.S and carbohydrate percentages. On the other side, the different potassium rates did not significantly affect number of main stems, leaf N and P percentages, and tuber’s protein, N and
K contents. Generally, the vigorous growth, tubers-yield and quality of jerusalem artichoke could be improved through the combined fertilization with N and K at the rates of 120 and 96 kg of N and K$_2$O fed$^{-1}$, respectively.

INTRODUCTION

Jerusalem artichoke (Helianthus tuberosus L.) is may be considered one of the new non-traditional tuberous vegetable crops, which is recently introduced in the Egyptian Agriculture. It has high nutritional and medicinal values for human health due to its high tubers contents of fructose and inulin (Dorrell and Chubey, 1977; Chubey and Dorrell, 1982 and Spitters, 1987). Its tubers contain 8-18% carbohydrates (Khereba, 1979) and about 9-10% proteins (El-Sharkawy, 1998 and Mansour et al., 2001) of fresh weight. Inulin is a polysaccharide which breaks down to fructose and is considered a better sugar for most diabetics (Nonnecke, 1989). The crop produces also a large top growth, having a high protein content, that can be used in animal feeding.

Fertilizer requirements of jerusalem artichoke are quite high due to its high top growth and yield potential per unit area. In Egypt, the research work on jerusalem artichoke and its fertilization requirements are still limited. However, the favorable effects of N fertilizer on vegetative growth, tuber yield and tuber chemical constituent characters of jerusalem artichoke were reported by some investigators such as Burton (1989), El-Sharkawy (1998), Schittenhelm (1999) and El-Araby (2004). Schittenhelm (1999) found that jerusalem artichoke tended to have its maximum yields at the highest used N level (120 Kg N ha$^{-1}$). Similarly, El-Araby (2004) stated that the gradual additions of N applications, up to 120 Kg fed$^{-1}$, were accompanied with significant increases on growth, yield characters and chemical constituents of jerusalem artichoke tuber.

Potassium plays a major role in many physiological and biochemical processes; as cell -division and -elongation, enzyme activation, synthesis of simple sugars and starch as well as accelerated translocation of carbohydrate, necessary for tubers formation and development (Nelson, 1970; Marschner, 1986 and Beringer et al.,
1990). Potassium fertilization has been shown to improve foliage growth, tubers-yield and quality of the Jerusalem artichoke. Under Egyptian conditions, the results showed that fertilization jerusalem artichoke plants with K fertilizer, up to 48 kg $K_2O$ fed$^{-1}$, increased plant height and tubers-yield (Mansour et al., 2001). Meanwhile, Tawfik et al. (2003) found that growth parameters, yield and tubers chemical constituents of the Jerusalem artichoke responded positively with the increased levels of K application up to 72 Kg $K_2O$ fed$^{-1}$.

Thus, the scope of the present study was to investigate the effect of varying nitrogen and potassium rates and their interactions on growth characters, tubers-yield and quality of Jerusalem artichoke.

MATERIALS AND METHODS

Two field experiments were executed at the Agricultural Experimental Station Farm (at Abis), of the Faculty of Agriculture, Alexandria University, during the two successive summer seasons of 2001 and 2002. Preceding the conduction of each experiment, soil samples to 30 cm. depth were collected and analysed according to the published procedures by Page et al. (1982). The physical analysis indicated that the soil texture of the two experimental sites was clay loam; containing 45.50 and 42.10 % clay, 14.70 and 14.34 % silt, 39.80 and 43.56% sand, in 2001 and 2002, respectively. The chemical analysis resulted in a pH of 7.5 and 7.4, total N (%) of 0.14 and 0.12, P (%) of 0.061 and 0.067 and K (%) of 0.073 and 0.079, in the first and second seasons, respectively.

The experiments included 16 treatment combinations, which were the all possible combinations of the four nitrogen levels (0, 60, 90 and 120 Kg N fed$^{-1}$) and the four different levels of potassium (0, 48, 72 and 96 Kg $K_2O$ fed$^{-1}$). The two experiments were carried out in a split-plot system in a randomized complete blocks design with three replications. The main plots were assigned to the four nitrogen levels, whereas, the four potassium levels were randomly distributed within each of the main plots and were considered as the sub-plots. Each sub-plot consisted of 4 rows, 4 m long and 1m width, comprising an area of 16m$^2$. Tubers of jerusalem artichoke (local cv.) were planted on May 6, 2001 and April 28, 2002, at a 50 cm intrarow spacing.
Each two adjacent sub-plot were separated by a guard row.

Nitrogen fertilizer, in the form ammonium nitrate (33.3% N), and potassium fertilizer, in the form potassium sulphate (48% K$_2$O), were applied at three equal applications; after 30, 45 and 60 days from planting. A seasonal total of 72 Kg P$_2$O$_5$ fed$^{-1}$, as calcium super phosphate (15.5% P$_2$O$_5$), was broadcasted during soil preparation.

The normal cultural practices; such as cultivation, irrigation, and disease and pest control; were carried out whenever they were found necessary and as usually, practiced in the commercial production of jerusalem artichoke.

**Data Recorded:**

**Vegetative growth Characters:**

At 120 days after planting, three plants were randomly taken, from the outer two rows of each sub-plot, to determine the number of main stems plant$^{-1}$, plant height (cm) and foliage fresh weight (kg plant$^{-1}$).

**Dry matter and Mineral contents of leaves:**

After 120 days of planting, random samples, from the upper leaves of the previous plants, were collected, washed and dried out at 70°C, to determine the percentages of leaves dry matter, and N, P and K contents; according to the methods described by A.O.A.C. (1992).

**Tubers Yield:**

At harvest (180 days after planting), tubers of the inner two rows of each sub-plot were harvested and weighed to calculate tubers yield (kg) plant$^{-1}$, average of tuber weight (g) and total tuber yield (ton) fed$^{-1}$.

**Tubers Chemical components:**

Tuber samples were taken, washed and dried out at 70°C to a constant weight, to determine the dry matter content (%), then ground to determine the total tubers protein, according to the methods described by Pregl (1945), and the contents of N and K, according to the methods described by A.O.A.C. (1992). Fresh samples were also saved to determine tubers total soluble solids, using a hand
refractometer, and total carbohydrates, as outlined by Malik and Singh (1980).

Data of the two experiments were subjected to the statistical analysis using Costat software (1985). The comparisons among the means of the different treatments were carried out, using the Revised L.S.D test, as illustrated by Al-Rawi and Khalf-Allah (1980).

RESULTS AND DISCUSSION

Vegetative Growth Traits:

Table (1) shows that the application of N at 60, 90 or 120 Kg N fed⁻¹ significantly increased plant height and foliage fresh weight than the control treatment in both years. These results matched well with those obtained on jerusalem artichoke by El-Sharkawy (1998), Mansour et al. (2001) and El-Araby (2004) and on potato by Ghoneim and Abd El-Razik (1999). However, the number of main stems did not significantly respond to N applied rates. This result agreed with the findings of El-Gamal (1985), who reported that N fertilization had no effect on the number of main stems of potato plant. The enhancing effect of N on plant height and foliage fresh weight of jerusalem artichoke plants can be explained on the basis of the physiological fact that N plays a major role on protein and nucleic acids synthesis, and protoplasm formation. Moreover, it stimulates the meristemic activity which, in turn, results in more new organs (Russel, 1973 and Yagodin, 1984).

Fertilizing jerusalem artichoke plants with K at 96 kg K₂O fed⁻¹, significantly, increased plant height and foliage fresh weight in comparison with the control treatment, in both years, (Table,1). However, potassium rates did not significantly affect the number of main stems. These results are in a general accordance with the findings of Mansour et al. (2001), who found that plant height of jerusalem artichoke was enhanced as the rate of K application was increased.

The results in Table (1) reflected some significant interaction effects between nitrogen and potassium levels on the vegetative growth characters of jerusalem artichoke plants. The different comparisons, generally, indicated that the highest mean values of plant height and foliage fresh weight, in the two studied seasons, were obtained from the fertilized plants with 120 Kg N fed⁻¹ and 96 K₂O.
fed¹. On the contrary, the detected differences for the interactions effects between varying N and K rates on the number of main stems of jerusalem artichoke plants, appeared insignificant.
Dry Matter and Mineral Contents of Leaves

Concerning the effects of N fertilization on the leaves dry matter and mineral contents of Jerusalem artichoke, the results in Table (2) illustrated that dry matter percentage reflected significant decreases with each increase in the applied N rate, in both years. On the contrary, leaves N and K percentages increased significantly and successively as a result of raising the nitrogen fertilization level up to 60 kg fed⁻¹ and up to 90 kg fed⁻¹, orderly. However, Leaf P percentage did not reflect any significant response due to using different rates of nitrogen fertilization. The obtained results seemed to confirm those reported by El-Araby (2004) on Jerusalem artichoke and by Ghoneim and Abd El-Razik (1999) on potato.

Results of Table (2) indicated that fertilization of Jerusalem artichoke with potassium up to 96 K₂O fed⁻¹ was accompanied with corresponding increments of leaves dry matter percentage, in both years. In the case of leaf K content, the results, also, showed that significant increases were detected when the used potassium rate was raised from 48 to 72 K₂O fed⁻¹. On the other hand, the percentages of N and P contents showed insignificant differences with increasing potassium rates. These results are in accordance with the findings of Midan et al. (1987), who found that leaves dry weight of sweet potato was increased with increasing applied K level up to 100 kg K₂O fed⁻¹.

The interaction effects between N and K fertilizers rates on dry matter and mineral contents of leaves are listed in Table (2). In both years, the results showed that the interaction of 0-72 and 0-96 Kg N – K₂O fed⁻¹ resulted in the highest values for dry matter percentage. However, the interaction effects between N and K rates were not found significant on the mineral contents of leaves.

Tubers yield

The results of Table (3) showed clearly that the successive increases in the nitrogen fertilization were always associated with corresponding and significant increments in the tubers yield plant⁻¹, total tubers yield fed⁻¹ and average tuber weight of Jerusalem artichoke, in both years. The stimulatory effects of N on Jerusalem artichoke yield might be related to the effect of N on plant growth (Table,1) which, in turn, enhanced the production of more photosynthates required for tuber formation and development. These results agreed to a great extent with those reported by Schittenhelm
El-Araby (2004) found that a maximal jerusalem artichoke yield was achieved when the plants were fertilized with N at the rate of 90 kg fed⁻¹. Reversal results were reported by Mansour et al. (2001), who used 20 Kg N fed⁻¹ and obtained a higher tuber yield than that of 40 kg N fed⁻¹, in drip-irrigated sandy soils.

Regarding the effects of K fertilizer, it was generally noticed that the soil application of K fertilizer at varying rates, significantly, increased tuber yield (kg) plant⁻¹, tubers yield (ton) fed⁻¹ and average tuber weight (g), compared to the control treatment in both years. However, raising the applied potassium level from 72 to 96 kg K₂O fed⁻¹ did not show any significant response on the tubers yield plant⁻¹, in the second year, and average tuber weight, in the first year. The favorable effect of K application could be related to the basic and a major role of K in many physiological and biochemical processes, on cell division and elongation, enzyme activation, synthesis of simple sugars and starch, and acceleration of carbohydrate translocation necessary for tuber formation and development (Marschner, 1986). These results appeared to be in a close agreement with those obtained by Mansour et al. (2001) and Tawfik et al. (2003), who found that the local cultivar tubers yield increased successively as the K level was raised from 24 to 48 and 72 kg K₂O fed⁻¹. Also, Bourk (1985) reported that K application increased the proportion of dry matter diverted from the foliage to the underground plant organs of sweet potato. Likely, Gowda et al. (1990) and Mukhopadhyay and Jana (1990) concluded a positive correlation between the addition of K and the tubers yield of sweet potato.

Concerning the interactions between the different applied N and K fertilizers rates (Table, 3), the comparisons among the mean of various treatment combinations, clearly, indicated that jerusalem artichoke plants which received high N and K fertilizers rates (120-96 Kg N- K₂O fed⁻¹) resulted in the highest significant mean values for all the studied yield parameters, in both years. Mansour et al. (2001) reported that fertilizing jerusalem artichoke plants with 20 kg N fed⁻¹, combined with 24 or 48 kg K₂O fed⁻¹ rates, reflected the optimum rates to maximize tubers yield in drip-irrigated sandy soil.
Data presented in Table (4) showed that tuber’s carbohydrate percentages reflected some significant increments with each increase in the applied nitrogen level, in both seasons. Similar findings were recorded by El-Araby (2004) on jerusalem artichoke and Abd El-Razik and Gabr (1999) on sweet potato. Tuber’s T.S.S percentage decreased significantly as a result of raising the nitrogen fertilization rate from 90 to 120 kg fed\(^{-1}\). Such a result is in a general agreement with those of Constantin et al. (1984). Tuber’s total protein and N percentage showed also significant increases when the applied N level was increased to 60 kg fed\(^{-1}\). However, raising the nitrogen applied rate up to 90 or 120 kg fed\(^{-1}\) did not reflect any significant response on tuber’s total protein and N percentage, in the two growing seasons. Concerning, tuber’s total K percentage the results showed insignificant differences with increasing the N rates.

Regarding the effects of potassium fertilization, the results of Table (4) illustrated that the application of K in varying rates, significantly, increased tuber’s T.S.S and total carbohydrate percentages compared to the control treatment, in both years. However, the differences between the three K levels on the above mentioned traits were not high enough to be significant. The detected positive effects of potassium fertilizer on the biochemical constituents might be related to the well known role of K on improving photosynthesis process and on enhancing the translocation of carbohydrates towards storage organs (Bidwell, 1979). Nevertheless, tuber’s total protein, N and K percentages did not respond positively respond to the increased the applied K levels, in both years.

The comparisons presented in Table (4) illustrated the presence of some interaction effects, between the different N and K fertilizer levels, on tuber’s T.S.S and total carbohydrate contents, in both seasons. The comparisons among the sixteen treatment combinations, generally, indicated that the combinations of O–96 kg N- K\(_2\)O fed\(^{-1}\) and 120–96 kg N- K\(_2\)O fed\(^{-1}\) were the most beneficial treatments which gave significantly the highest means values for tuber’s T.S.S and total carbohydrate contents, orderly, in both years. However, tuber’s total protein, N and K percentages were not affected.

In view of the previous results, vigorous growth, tuber yield and quality of jerusalem artichoke could be improved through the
fertilization with N and K at the rates of 120 and 96 kg N–K₂O fed⁻¹, respectively.

REFERENCES


تأثر التسميد النيتروجيني والبوتاسيوم والتفاعل بينهما على مواصلات النمو والمحصول وجوهدة الطرطوفة

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تمت دراسة تأثير أربعة معدلات لكل من التسميد النيتروجيني (صفر، 0.6، 1.2، 2.6 كجم ن/فدان) والتمديد البوتاسيوم (صفر، 0.8، 2.2، 4.0 كجم بو/فدان) في مداخلة في مواصلات النمو الخضري ومحصول الطرطوفة، وبدون تداخلات الأسمدة الكيميائية للطرطوفة، وذلك من خلال تجربتين حقيقيتين أجريتا خلال الموسم productId=7198838628133193218

وقد أظهرت النتائج أن الزيادات في مستوى التسميد النيتروجيني حتى 120 كجم جرام/فدان قد تسبب في زيادة محسوبة ومعنوية في مواصلات النمو الخضري لنباتات الطرطوفة (ارتفاع الورقة، وزن الورقة)، بالإضافة إلى مواصلات الطلب النيتروجيني (حصص الورقة الحادة) ومحصول الطرطوفة، وذات تداخل مع محتوى النباتات من الكربوهيدرات. بينما أشارت النتائج أن نسب الزيادة في التسميد النيتروجيني تحت 200 كجم جرام/فدان قد تسبب في زيادة محسوبة ومعنوية في مواصلات الحصاد، وذات تداخل مع محتوى النباتات من البروتين، والوزن الحاصل، وزن الورقة، بالإضافة إلى محتوى النباتات من الأحماض الكأسية والكارمونة، والكربوهيدرات.

وتأثر التسميد النيتروجيني، والبوتاسيوم، على مواصلات النمو ومحصول الطرطوفة إلى حد كبير، حيث أظهرت النتائج أن تسميد الطرطوفة بمعدل 96 كجم بو/فدان أدى إلى زيادة محسوبة ومعنوية في مواصلات النبات، وفي زمن الورقة الخضراء، ومحصول الأوراق، وتحتوي الأوراق، وأقل القمي بالنسبة لمحتوى النباتات من المواد الصلبة الانتقائية الكلية، وتحتوي الأوراق من البروتينات، والعديد من النباتات من الفوسفور، وتحتوي الأوراق من البروتينات، والذي أدى إلى زيادة في نسبة الانتقائية الأصلية للنباتات، وتحتوي الأوراق من الفوسفور، وتحتوي الأوراق من البروتينات، والنيتروجين، وتحتوي الأوراق من البروتينات، والذي أدى إلى زيادة في نسبة الانتقائية الأصلية للنباتات، وتحتوي الأوراق من الفوسفور، وتحتوي الأوراق من البروتينات، والذي أدى إلى زيادة في نسبة الانتقائية الأصلية للنباتات، وتحتوي الأوراق من الفوسفور، وتحتوي الأوراق من البروتينات، والذي أدى إلى زيادة في نسبة الانتقائية الأصلية للنباتات، وتحتوي الأوراق من الفوسفور، وتحتوي الأوراق من البروتينات، والذي أدى إلى زيادة في نسبة الانتقائية الأصلية للنباتات، وتحتوي الأوراق من الفوسفور، وتحتوي الأوراق من البروتينات، والذي أدى إلى زيادة في نسبة الانتقائية الأصلية للنباتات، وتحتوي الأوراق من الفوسفور، وتحتوي الأوراق من البروتينات، والذي أدى إلى زيادة في نسبة الانتقائية الأصلية للنباتات، وتحتوي الأوراق من الفوسفور، وتحتوي الأوراق من البروتينات، والذي أدى إلى زيادة في نسبة الانتقائية الأصلية للنباتات، وتحتوي الأوراق من الفوسفور، وتحتوي الأوراق من البروتينات، والذي أدى إلى زيادة في نسبة الانتقائية الأصلية للنباتات، وتحتوي الأوراق من الفوسفور، وتحتوي الأوراق من البروتينات، والذي أدى إلى زيادة في نسبة الانتقائية الأصلية للنباتات، وتحتوي الأوراق من الفوسفور، وتحتوي الأوراق من البروتينات، والذي أدى إلى زيادة في نسبة الانتقائية الأصلية للنباتات، وتحتوي الأوراق من الفوسفور، وتحتوي الأوراق من البروتينات، والذي أدى إلى زيادة في نسبة الانتقائية الأصلية للنباتات، وتحتوي الأوراق من الفوسفور، وتحتوي الأوراق من البروتينات، والذي أدى إلى زيادة في نسبة الانتقائية الأصلية للنباتات، وتحتوي الأوراق من الفوسفور، وتحتوي الأوراق من البروتينات، والذي أدى إلى زيادة في نسبة الانتقائية الأصلية للنباتات، وتحتوي الأوراق من الفوسفور، وتحتوي الأوراق من البروتينات، والذي أدى إلى زيادة في نسبة الانتقائية الأصلية للنباتات، وتحوي