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# EFFECT OF TUBER CUTTING, PHOSPHORUS LEVELS AND MICRO-ELEMENTS ON JERUSOLEM ARTICHOKE YIELD AND QUALITY UNDER DRIP-IRRIGATION ON SANDY SOIL

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## ABSTRACT

**Jerusalem artichoke is one of the comparatively new and non-traditional vegetable crop introduced in the Egyptian agriculture.**

**In a field experiment, two cultivars of Jerusalem artichoke (*Helianthus tuberosus* L.,)i.e., cv. Local and cv. Fuseau were subjected to different supplies of phosphorus levels (7.5, 15 and 22.5 Kg $P_2O_5$ / Fed) with or without microelements (Zn, Fe, and Mn) and two planting materials i.e. whole seed tuber and cut tubers under drip-irrigated sandy soil during 2005 and 2006 seasons. Results indicated that Fuseau and Local cultivars growth parameters responded positively with whole seed tuber in the two seasons. Fuseau cultivar had higher stem length, No. of branches, fresh weight of branches/plant, leaf chlorophyll content, tuber fresh weight plant per total yield and dry matter percentage. Meanwhile, the Local cultivar had higher No. of main stems.**

**Increasing the rate of application of $P_2O_5$ fertilization level up to 22.5 Kg $P_2O_5$ /Fed had a significant effect on plant height, branches fresh weight, No. of main stems, leaf chlorophyll content, tuber fresh weight per plant, total yield, dry matter percentage and inulin.**

**Results demonstrated that spraying plants with microelements (Zn, Fe and Mn) appeared to be the most effective treatment in increasing the growth rate and yield of Jerusalem artichoke plants.**

## INTRODUCTION

Jerusalem artichoke, is sometimes called sunchokes, is the tuberous root of a sunflower-like plant. Jerusalem artichoke is an agricultural crop with a great potential for high sugar yield per hectare (9-13 t/ha,) Klaushofer 1986).

Jerusalem artichoke plant tubers is similar to that of potatoes. Planting whole or cut pieces of the tubers contains one or two eyes under optimum conditions, the yield obtained from cut sets of J. artichoke may produce equal or nearly equal that obtained from whole seed potatoes. Nevertheless, there is a risk that serious reductions in yields may be caused by mistakes in the cutting, storage and planting of the seed-pieces, by climatic conditions unfovaurable to the healing of cut tubers, or by the incidence of diseases which attack the cut surfaces (Bolye and Baukwill, 1955).

Klug-Andersen (1992), reported that in Jerusalem artichoke, different planting materiel sizes (25-200 g/tubers) did not affect the tuber characters investigated. Jerusalem artichoke (*Helianthus tuberous* L., cv. topianka and cv. violet de Rennes) subjected to different supplies of N, P and K; nitrogen supply increased tuber yield more than the productivity of aerial parts. While, nutrient regimes without P or K addition but including N to some extent depressed the yield of tubers by 8-23% (Soja *et al*, 1994).

Results from fertilizer experiments frequently are inconsistent as the preexisting soil fertility plays an important role in the apparent nutrient requirement. Dorrell and Chubey (1977) found moderate or no yield increases due to increasing nutrient supply. In spite of the huge additions of chemical P fertilizers to the cultivated soil in Egypt, the available P level for plants is usually low, since it is rapidly converted to an unavailable form by its reaction with other soil constituents thus, becomes inaccessible by plants (El-Dahtory *et al.*, 1989). Phosphate is important for good root development in the plant.

This is only a half truth, where adequate phosphate is necessary for the normal growth of the whole plant, in addition to that phosphate is an essential part of the chromosome which controls the growth of each plant cell. Moreover, phosphate is also essential for energy transfer which is a characteristic of living cells.

Several investigators indicated that soil inoculation with P-soluablizing microorganism improved soil fertility and plant productivity by releasing P-element from rock or tricalcium-P (Forster and Ferter, 1988 and Hauka *et al.*, 1990).

Reust and Dutoit., (1992) found in the *H.tuberosus* trials that a basal fertilizer application of 80 Kg $P_2O_5$ + 240 Kg $K_2O$/ha supplemented by up to 40 Kg N mineral or organic fertilizer at planting, produced tuber yields which ranged from 25.0 to 47.52 t/ha, DM content from 19 to 24%, tuber sugar contents from 11 to 19% and shoot and leaf FW ranged from 5.0 to 48.0 t/ha.

Although microelements are needed in relatively very small quantities for good plant growth, their deficiencies cause great disorders in the physiological and metabolic processes of the plants (Kanwer and Dhingra, 1962). Fe, Mn and Zn were reported to stimulate the growth of various plants due to their enhancement effect on most metabolic processes such as carbohydrate, protein, phosphate, RNA and ribosome formation (Bidwell, 1980) in addition to chlorophyll formation and nucleic acid metabolism (Mohr and Schopfer, 1995). Iron plays a role in the syntheses of ribonuclein acid and the reduction of nitrate to ammonia (Russel, 1989). Also, the most important function of manganese is related to the oxidation reduction processes (Mengel and Kirkby, 1982).

The basic function of zinc in plant is related to its role in the metabolism of carbohydrates, proteins and phosphate (Price *et al.*, 1972). It is also important for RNA and protein synthesis. (Vallee and Wacker, 1976).

Little work could be traced in the literature concerning the effects of different mineral-P-levels alone or in combination with microelements on the growth, yield and tuber chemical composition of Jerusalem artichoke cultivars local and Fuseau with their seeds being

whole or cut under drip-irrigated sandy soil. Therefore, this was the aim of this study.

## MATERIALS AND METHODES

This study was conducted on sandy soil at South Tahrir Horticultural Research Station., Agricultural Research Center, during 2005 and 2006 seasons. Tubers of local and fuseau cultivars of Jerusalen artichoke (*Helianthus tuberosus* L.) were used. The mechanical and chemical characteristics of the experimental soil are given in Table 1.

**Table 1: Mechanical and chemical characteristics of the experimental soil.**

| Soil properties | Value |
|---|---|
| Coarse sand % | 9.0 |
| Fine sand % | 64.2 |
| Silt % | 12.5 |
| Clay % | 11.4 |
| Soil type | Sandy soil |
| Available K (ppm) | 73 |
| Total nitrogen (ppm) | 135 |
| Iron (ppm) | 3.6 |
| Zinc (ppm) | 0.83 |
| Manganese (ppm) | 2.75 |
| EC (m mhos/cm) | 2.21 |
| pH | 8.3 |

Drip-irrigation system with nozzles 50 cm apart were used for irrigation. Tubers were planted on 0.5m within rows of 1.0m wide and 20m long. The planting date was 19$^{th}$ and 21$^{st}$ of April 2005 and 2006 seasons, respectively. The area of the experimental unit was 20m$^2$ and consisted of 40 hills. Phosphorus levels (7.5,15 and 22.5 Kg $P_2O_5$ Fed) were provided as mono-super-phosphate (15% $P_2O_5$) form and were hand dressed on rows during soil preparation, before planting, while nitrogen fertilizer was used at the rate of 40 Kg/Fed in the form of ammonium sulphate (20.6% N) and sulphate of potash (48% $K_2O$) was used as K source at the rate of 96 Kg $K_2O$/Fed. Nitrogen and

potassium fertilizers were applied on weekly equal doses through the drip-irrigation system where the first dose was started at thee third week after planting and was continued till flowering stage (14 weeks from planting). Plants were sprayed with an aqueous solution of micro-nutrients (Iron, Manganese and Zinc) three times during the growing season starting 60 days after planting with a 30 days interval between each two sprays at rate of 0.15% to give a concentration of 57 mg/L of each element.

The experimental design was a split-split plot with three replicates in both years. The local and Fuseau cultivars were located in the main plots, whereas, tuber seed treatments (whole or cut tubers) were distributed at random in the sub plots. Meanwhile, phosphorus levels were distributed randomly in the sub-sub plots. Each sub-sub plots was divided into two parts, one part was sprayed with microelements (Iron, manganese and zinc)., while the other part was not sprayed.

At 120 days after planting (flowering time), five plants from each treatment were taken at random to determine stem length (m), number of stems per plant, number of branches per plant, foliage fresh weight (FW) and leaf chlorophyll content.

At harvest time (180 days after planting) five plants from each treatment were taken to determine tuber fresh weight (Kg/plant), tuber fresh weight (Kg/plot) and dry matter percentage (DM%). Tuber samples were selected from each treatment and washed with distilled water, weighed and oven dried at 105°C to a constant weight to determine the dry matter content.

In 2005 and 2006 seasons, tuber inulin content was determined following oven-dry at (65-70°C for 48 h in an air-forced ventilated oven according to Winton and Winton (1958).

**Statistical analysis:-**

Mean separation was done according to Waller and Duncan (1969).

## RESULTS AND DISCUSSION

**Stem length (m):**

Data of stem length shown in Table 2 indicate that cultivars had a significant effect on stem length in the two seasons of study. Fuseau cultivar gave higher stem length than the local cultivar. It is also clear from the same table that planting whole tubers produced higher stem length than that produced from cut tubers in both seasons.

Regardless of planting material, increase in stem length was positively influenced by increasing the rate of phosphorus application (Table 2). Spraying Jerusalem artichoke plants with micro-elements significantly increased the efficiency of fertilization with phosphorus. However, the increase in the stem length due to using microelements was not significant within the same P level in most cases. In 2006 season there was no significant differences between 15 and 22.5 Kg $P_2O_5$/Feddan with microelements spraying.

The interaction between planting materials and cultivar was significant in both seasons. Local cv. with the intact whole complete tubers gave the highest stem length while Fuseau cv. produced the lowest stem length, when planted with cutting tubers (Table 2).

Data in Table 2 also, indicate, that the interaction between cultivar and phosphorus levels was significant in both seasons. Moreover, Local cv. with phosphorus levels and microelements spraying significantly increased the stem length.

The interaction between cultivar, cutting tubers and phosphorus with or without microelements spraying was significant. Planting whole tubers of local cv. and applying phosphorus fertilizer at rate of 22.5 Kg $P_2O_5$/Fed. with microelement spraying gave the highest stem length.

**Number of stems per plant:**

Concerning number of stems/plant, data in Table 3 indicate that the grown cultivar had a significant effect on this character in the second season., where Local cv. gave the higher No. of stems, than the other tested cultivar.

Seed tubers affected No. of stems/plant, since planting whole tubers gave higher No. of stems than cut tubers, in both seasons. Regardless of cultivars and tuber cutting, it is also evident that number

**Table 2: Interaction effect of cultivars, planting materials, phosphorus fertilizer and microelements on Stem length (m), 2005 and 2006.**

| Treatments Cultivars | Whole | | | | | | | Cutting | | | | | | | Average | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean |
| | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | |
| 2005 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 1.94 | 1.80 | 2.31 | 2.21 | 2.54 | 2.44 | 2.21 | 1.71 | 1.58 | 1.80 | 1.70 | 2.29 | 2.16 | 1.87 | 1.82 | 1.69 | 2.05 | 1.95 | 2.42 | 2.30 | 2.04 |
| Local | 2.30 | 2.22 | 2.40 | 2.49 | 2.71 | 2.52 | 2.44 | 1.97 | 1.80 | 2.14 | 1.89 | 2.34 | 2.20 | 2.06 | 2.13 | 2.01 | 2.27 | 2.19 | 2.52 | 2.35 | 2.25 |
| Mean | 2.12 | 2.01 | 2.36 | 2.35 | 2.63 | 2.84 | 2.33 | 1.84 | 1.69 | 1.97 | 1.79 | 2.32 | 2.18 | 1.97 | 1.97 | 1.85 | 2.16 | 2.07 | 2.47 | 2.33 | 2.14 |
| 2006 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 1.82 | 1.75 | 1.91 | 1.78 | 1.87 | 1.93 | 1.84 | 1.63 | 1.57 | 1.71 | 1.61 | 1.71 | 1.79 | 1.67 | 1.73 | 1.66 | 1.81 | 1.69 | 1.79 | 1.86 | 1.76 |
| Local | 1.99 | 2.11 | 2.28 | 2.29 | 2.37 | 2.34 | 2.23 | 2.14 | 2.08 | 2.23 | 2.18 | 2.29 | 2.18 | 2.19 | 2.06 | 2.09 | 2.26 | 2.24 | 2.33 | 2.26 | 2.21 |
| Mean | 1.91 | 1.93 | 2.1 | 2.04 | 2.12 | 2.13 | 2.04 | 1.89 | 1.83 | 1.97 | 1.90 | 2.00 | 1.98 | 1.93 | 1.89 | 1.88 | 2.03 | 1.97 | 2.06 | 2.06 | 1.98 |

| | | Cultivar (cv.) | Planting materials (P.M) | Cv. x P.M | $P_2O_5$ | $P_2O_5$ x Cv. | $P_2O_5$ x P.M. | Cv. x P.M. x $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|
| L.S.D. 5% | 2005 | 0.07 | 0.02 | 0.02 | 0.04 | 0.06 | 0.06 | 0.09 |
| | 2006 | 0.01 | 0.02 | 0.03 | 0.05 | 0.07 | 0.06 | 0.09 |

M° = Microelements
W* = Without microelements

**Table 3: Interaction effect of cultivars, planting materials, phosphorus fertilizer and microelements on Stem No., 2005 and 2006.**

| Treatments Cultivars | Whole | | | | | | | Cutting | | | | | | | Average | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean |
| | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | |
| 2005 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 8.00 | 7.43 | 9.19 | 8.77 | 9.35 | 9.26 | 8.66 | 6.57 | 6.54 | 7.81 | 8.12 | 8.76 | 8.50 | 7.71 | 7.28 | 6.98 | 8.50 | 8.44 | 9.06 | 8.88 | 8.19 |
| Local | 8.34 | 9.22 | 9.63 | 9.54 | 9.84 | 9.71 | 9.38 | 6.12 | 5.64 | 6.91 | 7.67 | 8.88 | 8.60 | 7.30 | 7.23 | 7.43 | 8.27 | 8.61 | 9.36 | 9.16 | 8.34 |
| Mean | 8.17 | 8.33 | 9.41 | 9.15 | 9.60 | 9.48 | 9.02 | 6.34 | 6.09 | 7.36 | 7.90 | 8.82 | 8.55 | 7.51 | 7.26 | 7.21 | 8.38 | 8.52 | 9.21 | 9.02 | |
| 2006 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 5.52 | 5.33 | 5.81 | 5.82 | 9.69 | 6.40 | 5.93 | 5.55 | 2.17 | 2.71 | 5.30 | 6.34 | 6.08 | 4.69 | 5.54 | 3.75 | 4.26 | 5.56 | 6.51 | 6.24 | 5.31 |
| Local | 7.53 | 7.03 | 8.07 | 8.03 | 8.40 | 8.02 | 7.85 | 6.82 | 6.54 | 7.40 | 7.22 | 7.47 | 7.30 | 7.13 | 7.18 | 6.79 | 7.73 | 7.63 | 7.93 | 7.66 | 7.49 |
| Mean | 6.52 | 6.18 | 6.94 | 6.93 | 7.55 | 7.21 | 6.89 | 6.19 | 4.36 | 5.06 | 6.26 | 6.90 | 6.69 | 5.91 | 6.36 | 5.27 | 5.10 | 6.60 | 7.22 | 6.95 | |

| | | Cultivar (cv.) | Planting materials (P.M) | Cv. x P.M | $P_2O_5$ | $P_2O_5$ x Cv. | $P_2O_5$ x P.M. | Cv. x P.M. x $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|
| L.S.D. 5% | 2005 | N.S. | 0.26 | 0.37 | 0.30 | 0.43 | 0.42 | 0.61 |
| | 2006 | 0.15 | 0.09 | 0.13 | 0.08 | 0.11 | 0.12 | 0.16 |

M° = Microelements
W* = Without microelements

of stems/plant was increased with increasing phosphorus level. These differences were significant when the phosphorus at the highest rate (22.5 Kg $P_2O_5$/Fed) was applied with the microelements spraying in the second season. While, in the first season, application of 22.5 Kg $P_2O_5$/Fed. with or without microelements significantly increased number of stems., comparing with the lowest phosphorus level (Table 3).

The interaction between cultivar and tuber cutting was significant in both seasons of study, so it is clear that whole tubers of local cultivar (without cutting) gave the highest number of stems per plant in both seasons.

The maximum No. of stems/plant was obtained when the local cultivar was planted and fertilized with 22.5 Kg $P_2O_5$/plant with or without microelements application. Fuseau cultivar when fertilized with 22.5 Kg $P_2O_5$/Fed and sprayed with microelements gave the highest number of stems/plant during the 2005 and 2006 seasons.

The interaction between planting material and phosphorus level was significant in both seasons. Whole tubers with 22.5 Kg $P_2O_5$/Fed. And spraying with micro-elements produced the highest number of stems/plant in both seasons.

The greatest No. of stems/plant was achieved by local cv. when complete tubers were planted and fertilized with 22.5 Kg $P_2O_5$/Fed. with micro-elements in the second season, while, in the first season, differences between 15 and 22.5 Kg $P_2O_5$/Fed. with or without micro-elements were not significant with Fuseau or local cultivar.

**Number of branches/plant:**

Regardless of planting material and phosphorus effects, results did not reflect any significant differences between the two cultivars (Table 4). Planting tubers gave higher No. of branches/plant than that of cut-tubers in both seasons.

Concerning the effect of phosphorus levels and micro-elements on No. of branches, data revealed that increasing the phosphorus level caused paralleled enhancement in No. of branches/plant. Moreover, No. of branches were raised in each P level by spraying plants with the used micro-elements (Table 4).

**Table 4: Interaction effect of cultivars, planting materials, phosphorus fertilizer and microelements on No. of branches/plant, 2005 and 2006.**

| Treatments / Cultivars | Whole | | | | | | | Cutting | | | | | | | Average | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean |
| | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | |
| 2005 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 38.83 | 36.79 | 44.85 | 45.00 | 48.39 | 46.00 | 43.31 | 35.98 | 34.94 | 41.33 | 41.20 | 44.89 | 42.09 | 40.07 | 37.41 | 35.87 | 43.09 | 43.10 | 46.64 | 44.04 | 41.69 |
| Local | 40.16 | 38.06 | 48.34 | 46.86 | 50.89 | 47.60 | 45.32 | 28.94 | 27.42 | 44.36 | 41.76 | 46.82 | 47.22 | 39.42 | 34.55 | 32.74 | 46.35 | 44.31 | 48.85 | 47.41 | 42.37 |
| Mean | 39.50 | 37.43 | 46.59 | 45.93 | 49.64 | 46.80 | 44.31 | 32.46 | 31.18 | 42.85 | 41.48 | 45.85 | 44.65 | 39.75 | 35.98 | 34.30 | 44.72 | 43.70 | 47.75 | 45.73 | |
| 2006 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 37.94 | 36.18 | 43.95 | 42.28 | 45.89 | 43.35 | 41.60 | 23.38 | 22.12 | 27.13 | 25.71 | 28.83 | 26.72 | 25.65 | 30.66 | 29.15 | 35.54 | 34.00 | 37.36 | 35.04 | 33.63 |
| Local | 40.55 | 40.16 | 45.64 | 44.22 | 47.42 | 45.71 | 43.95 | 23.78 | 21.83 | 24.89 | 23.70 | 25.56 | 38.72 | 26.41 | 32.17 | 31.00 | 35.27 | 33.96 | 36.49 | 32.72 | 35.18 |
| Mean | 39.25 | 38.17 | 44.80 | 43.25 | 46.65 | 44.53 | 42.78 | 23.58 | 21.98 | 26.01 | 24.70 | 27.19 | 32.72 | 26.03 | 31.41 | 30.08 | 35.40 | 33.98 | 36.92 | 42.22 | |

| | | Cultivar (cv.) | Planting materials (P.M) | Cv. x P.M | $P_2O_5$ | $P_2O_5$ x Cv. | $P_2O_5$ x P.M. | Cv. x P.M. x $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|
| L.S.D. 5% | 2005 | N.S. | 0.76 | 1.07 | 0.58 | 0.82 | 0.82 | 1.17 |
| | 2006 | N.S. | 1.67 | 2.36 | 0.07 | 2.92 | 2.94 | 4.15 |

M° = Microelements
W* = Without microelements

Fuseau and local cultivars produced the maximum number of branches by applying 22.5 Kg $P_2O_5$/Fed and spraying micro-elements by using whole tubers in the second season. On the other hand, No. of branches of local cultivar increased significantly by 15 and 22.5 Kg $P_2O_5$/Fed levels with or without spraying micro-elements.

**Fresh weight of branches/plant:**

Table 5, clearly shows that Fuseau cv. produced the highest whole branches fresh weight per plant which was higher by about 22.7 and 14.8% than local one, during 2005 and 2006 seasons, respectively.

Planting material affected also plant fresh weight since planting whole tuber gave higher plant fresh weight than that of cut tubers in both seasons. With regard to the effect of spraying micro-elements + P fertilizer at 22.5 Kg $P_2O_5$/Fed level, a significant increase was found in the fresh weight of branches compared to the same levels without micro-elements.

Concerning the interaction effect, results showed that the foliage fresh weight was higher when planting was by whole tuber of the two studied cultivars in 2005 and 2006 seasons.

The interaction between cultivars and phosphorus levels with and without micro-elements indicated that foliage fresh weight increased when phosphorus (22.5 Kg $P_2O_5$/Fed) combined with micro-elements was used to Fuseau cv. However, no significant differences between 15 and 22.5 Kg $P_2O_5$/Fed + micro-elements in 2006. The interaction between "cultivar x tuber cutting x phosphorus levels" was significant, only Fuseau cv. with whole tuber and phosphorus (22.5 Kg $P_2O_5$/Fed) with micro-elements produced the highest branches fresh weight Also, 22.5 Kg $P_2O_5$/Fed with or without micro-elements produced the highest branches fresh weight/plant in the first season.

**Leaf chlorophyll content:**

Fuseau cultivar leaf chlorophyll content was higher by about 6.70 and 5.09% than local one, during 2005 and 2006 seasons, respectively (Table 6) and these differences were significant.

Table 6 indicates that tuber seeds significantly affected the chlorophyll content, best results were obtained by using whole tubers in propagation.

**Table 5: Interaction effect of cultivars, planting materials, phosphorus fertilizer and microelements on Fresh weight of branches/plant, 2005 and 2006.**

| Treatments / Cultivars | Whole | | | | | | | Cutting | | | | | | | Average | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean |
| | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | |
| 2005 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 1.27 | 1.09 | 1.62 | 1.61 | 1.73 | 1.66 | 1.50 | 1.26 | 1.19 | 1.42 | 1.29 | 1.53 | 1.27 | 1.33 | 1.26 | 1.14 | 1.52 | 1.45 | 1.63 | 1.47 | 1.41 |
| Local | 1.15 | 1.15 | 1.31 | 12.9 | 1.50 | 1.32 | 1.29 | 0.83 | 0.69 | 0.92 | 0.81 | 1.13 | 0.98 | 0.90 | 0.99 | 0.92 | 1.11 | 1.05 | 1.32 | 1.15 | 1.09 |
| Mean | 1.21 | 1.12 | 1.46 | 1.45 | 1.61 | 1.49 | 1.39 | 1.05 | 0.94 | 1.17 | 1.05 | 1.33 | 1.13 | 1.11 | 1.13 | 1.03 | 1.32 | 1.25 | 1.47 | 1.31 | |
| 2006 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 1.38 | 1.30 | 1.43 | 1.31 | 1.52 | 1.42 | 1.40 | 1.29 | 1.21 | 1.38 | 1.28 | 1.28 | 1.17 | 1.27 | 1.34 | 1.26 | 1.41 | 1.30 | 1.40 | 1.30 | 1.33 |
| Local | 1.29 | 1.24 | 1.34 | 1.30 | 1.44 | 1.39 | 1.33 | 0.78 | 0.68 | 1.03 | 0.92 | 1.17 | 1.10 | 0.95 | 1.04 | 0.96 | 1.19 | 1.11 | 1.31 | 1.25 | 1.14 |
| Mean | 1.34 | 1.27 | 1.38 | 1.31 | 1.48 | 1.41 | 1.36 | 1.04 | 0.95 | 1.21 | 1.10 | 1.23 | 1.14 | 1.11 | 1.19 | 1.11 | 1.30 | 1.20 | 1.35 | 1.27 | |

| | | Cultivar (cv.) | Planting materials (P.M) | Cv. x P.M | $P_2O_5$ | $P_2O_5$ x Cv. | $P_2O_5$ x P.M. | Cv. x P.M. x $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|
| L.S.D. 5% | 2005 | 0.04 | 0.04 | 0.06 | 0.03 | 0.05 | 0.05 | 0.07 |
| | 2006 | 0.08 | 0.05 | 0.07 | 0.02 | 0.03 | 0.03 | 0.05 |

**M° = Microelements**

**W* = Without microelements**

**Table 6: Interaction effect of cultivars, planting materials, phosphorus fertilizer and microelements on Chlorophyll, 2005 and 2006.**

| Treatments / Cultivars | Whole | | | | | | | Cutting | | | | | | | Average | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | 22.5 $P_2O_5$ (Kg) | | | Mean |
| | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | |
| 2005 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 42.83 | 41.10 | 46.47 | 45.07 | 46.73 | 44.60 | 44.47 | 31.83 | 28.77 | 34.40 | 31.37 | 40.83 | 39.50 | 34.45 | 37.33 | 34.93 | 40.43 | 38.22 | 43.78 | 42.05 | 39.46 |
| Local | 35.03 | 37.00 | 40.40 | 39.63 | 44.90 | 41.80 | 39.79 | 31.80 | 31.37 | 34.50 | 33.73 | 36.63 | 35.07 | 33.85 | 33.42 | 34.18 | 37.45 | 36.68 | 40.77 | 38.43 | 36.82 |
| Mean | 38.93 | 39.05 | 43.43 | 42.35 | 45.82 | 43.20 | 42.13 | 31.82 | 30.07 | 34.45 | 32.55 | 38.73 | 37.28 | 34.15 | 35.38 | 34.56 | 38.94 | 37.45 | 42.28 | 40.24 | |
| 2006 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 34.87 | 34.03 | 37.03 | 35.97 | 38.73 | 36.97 | 36.27 | 33.70 | 32.63 | 35.10 | 33.10 | 36.37 | 35.30 | 34.37 | 34.28 | 33.33 | 36.07 | 34.53 | 37.55 | 36.13 | 35.32 |
| Local | 33.37 | 30.87 | 34.00 | 32.57 | 36.60 | 36.33 | 33.96 | 31.43 | 28.67 | 34.30 | 33.07 | 35.70 | 35.37 | 33.09 | 32.40 | 29.77 | 34.15 | 32.82 | 36.15 | 35.85 | 33.52 |
| Mean | 34.12 | 32.45 | 35.52 | 34.27 | 37.67 | 36.65 | 35.11 | 32.57 | 30.65 | 34.70 | 33.08 | 36.03 | 35.33 | 33.73 | 33.34 | 31.55 | 35.11 | 33.67 | 36.85 | 35.99 | |

| | | Cultivar (cv.) | Planting materials (P.M) | Cv. x P.M | $P_2O_5$ | $P_2O_5$ x Cv. | $P_2O_5$ x P.M. | Cv. x P.M. x $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|
| L.S.D. 5% | 2005 | 0.29 | 0.18 | 0.25 | 0.60 | 0.86 | 0.85 | 1.21 |
| | 2006 | 0.07 | 0.09 | 0.13 | 0.41 | 0.58 | 0.58 | 0.82 |

M° = Microelements
W* = Without microelements

It was clear from the data that a significant increase in leaf chlorophyll content, was apparent by using the highest P level (22.5 Kg $P_2O_5$/Fed) with micro-elements. The effect of interaction between the cultivar and seed cutting was significant in both seasons by using whole tuber of Fuseau cultivar.

The interaction between the tuber seeds and P levels indicate that the addition of 22.5 Kg $P_2O_5$/Fed with micro-elements to whole tuber gave the highest leaf chlorophyll content.

The interaction effects between cultivar and P levels with or without micro-elements were significant. The greatest chlorophyll content was achieved by Fuseau cultivar when subjected to 22.5 Kg $P_2O_5$/Fed with micro-elements. In general, the maximum chlorophyll content was obtained when whole tubers of Fuseau cultivar were planted and fertilized with 22.5 Kg $P_2O_5$/Fed and also sprayed with micro-elements.

**Tuber fresh weight/plant:**

At 180 days after planting, Fuseau cultivar produced a yield of 10.30 and 23.41% higher than that of the local one during 2005 and 2006 seasons, respectively (Table 7).

Planting whole seed tubers produced higher fresh weight of tuber/plant than cut seed tubers in both seasons. These results agree with those obtained by Kushwah and Grewal (1992), who showed that, weight of tubers per plant were higher with planting whole tubers compared with cut tubers.

It is also clear from Table 7 that fresh weight of tuber enhanced significantly with 22.5 Kg $P_2O_5$/Fed with micro-elements in both seasons.

The interaction between cultivar and seed tubers was significant in both seasons. The highest tuber fresh weight/plant was produced by Fuseau cv. grown from whole tuber.

Regardless of cultivars, FW of tubers was generally enhanced by combination of 22.5 Kg $P_2O_5$/Fed with micro-elements and planting whole tuber in both seasons.

The interaction of cultivar and planting material differences among Jerusalem artichoke cultivars on tuber fresh weight were also reported by (Khereba. (1979). Similar results were recently reported

by El-Sharkawy. (1998) where plant height of Fuseau cv. surpassed that of the local one under Egyptian conditions.

The differences among phosphorus level with or without micro-elements were significant in both season. The whole tuber of Fuseau cv. fertilized with 22.5 Kg $P_2O_5$/Fed and sprayed with micro-elements gave a significant increase in tuber yield.

**Total yield (Kg/plot):**

Results in Table 8 indicate that total yield/plot was influenced by cultivars. In general, Fuseau cultivar had a higher yield, 10.46 and 22.95% than those of the local one in both seasons, respectively.

Regarding the effect of tuber seeds, data in Table 8 indicate that tuber seeds significantly affected the total yield per plot. The best results were obtained by using whole tuber in propagation. Singh (1993) planted whole (50g) or cut (25.0 g) potato seed kufrijyoti. cv at rate of 2,3 or 4 t/ha.; the average total tubers yield was higher from whole tubers (14.3 t/ha) than cut tubers (11.2 t/ha).

Patel and Patel (1994) showed that whole seed tuber gave the highest total tuber yield compared with cut tuber. Moreover, the positive effects of planting material on potato yield were recorded by Coraspe and Cartaya (1995), Abdel-Naby *et al.*, (1996), and Wierzejska-Bujakowska, (1996).

Table 8 also, reveals that total yield per plot increased with increasing P levels with spraying micro-elements.

The interaction effect between cultivar and seed cutting was significant in both seasons. Fuseau cv. ranked first in values of total yield per plot when planted with whole seed tubers (Table 8). The interaction of "cultivar x P levels with micro-elements had significant effect in both seasons Fuseau cultivar gave higher total yield per plot when fertilized by of 22.5 Kg $P_2O_5$/Fed and spraying micro-elements.

Regardless of cultivars, total yield per plot was generally enhanced by a combination of 22.5 Kg $P_2O_5$/Fed with micro-elements when planted with whole tuber. Fuseau cultivar when planted with whole tuber with P fertilizer at 22.5 Kg $P_2O_5$/Fed and sprayed with microelements resulted in a significant increase in tuber yield per plot.

**Table 7: Interaction effect of cultivars, planting materials, phosphorus fertilizer and microelements on Tuber fresh weight (Kg)/plant, 2005 and 2006.**

| Treatments | Whole | | | | | | | Cutting | | | | | | | Average | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean |
| Cultivars | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | |
| 2005 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 2.54 | 2.33 | 2.28 | 3.17 | 4.38 | 3.77 | 3.25 | 2.60 | 2.15 | 2.87 | 2.73 | 3.35 | 2.92 | 2.77 | 2.57 | 2.24 | 3.08 | 2.95 | 3.87 | 3.34 | 3.01 |
| Local | 2.48 | 2.23 | 2.97 | 2.69 | 3.42 | 3.30 | 2.85 | 2.18 | 2.10 | 2.69 | 2.59 | 3.07 | 2.63 | 2.55 | 2.33 | 2.17 | 2.83 | 2.64 | 3.24 | 2.97 | 2.70 |
| Mean | 2.51 | 2.28 | 3.13 | 2.93 | 3.90 | 3.53 | 3.05 | 2.39 | 2.13 | 2.78 | 2.66 | 3.21 | 2.78 | 2.66 | 2.45 | 2.20 | 2.95 | 2.80 | 3.55 | 3.15 | |
| 2006 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 3.10 | 2.90 | 3.39 | 3.23 | 3.74 | 3.80 | 3.36 | 2.58 | 2.33 | 2.68 | 2.62 | 2.85 | 2.69 | 2.63 | 2.84 | 2.62 | 3.04 | 2.93 | 3.30 | 3.24 | 2.99 |
| Local | 2.58 | 2.56 | 2.81 | 2.75 | 3.28 | 3.12 | 2.85 | 1.58 | 1.17 | 1.79 | 1.68 | 2.14 | 1.94 | 1.72 | 2.08 | 1.86 | 2.30 | 2.22 | 2.71 | 2.53 | 2.29 |
| Mean | 2.84 | 2.73 | 3.1 | 2.99 | 3.51 | 3.46 | 3.11 | 2.08 | 1.75 | 2.24 | 2.15 | 2.50 | 2.32 | 2.17 | 2.46 | 2.24 | 2.67 | 2.57 | 3.00 | 2.89 | |

| | | Cultivar (cv.) | Planting materials (P.M) | Cv. x P.M | $P_2O_5$ | $P_2O_5$ x Cv. | $P_2O_5$ x P.M. | Cv. x P.M. x $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|
| L.S.D. 5% | 2005 | 0.09 | 0.05 | 0.06 | 0.10 | 0.14 | 0.15 | 0.20 |
| | 2006 | 0.13 | 0.04 | 0.58 | 0.04 | 0.064 | 0.063 | 0.09 |

M° = Microelements
W* = Without microelements

**Table 8: Interaction effect of cultivars, planting materials, phosphorus fertilizer and microelements on Total yield/plot, 2005 and 2006.**

| Treatments / Cultivars | Whole | | | | | | | Cutting | | | | | | | Average | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | 22.5 $P_2O_5$ (Kg) | | | Mean |
| | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | |
| 2005 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 53.04 | 50.55 | 67.31 | 64.59 | 89.55 | 77.31 | 67.06 | 55.76 | 43.79 | 58.87 | 55.95 | 68.56 | 59.59 | 57.09 | 54.40 | 47.17 | 63.09 | 60.27 | 79.06 | 68.45 | 62.07 |
| Local | 50.66 | 45.56 | 60.72 | 55.44 | 70.04 | 67.10 | 58.25 | 44.76 | 43.06 | 52.90 | 53.47 | 62.77 | 60.44 | 52.90 | 47.71 | 44.31 | 56.81 | 54.46 | 66.40 | 63.77 | 55.58 |
| Mean | 51.85 | 48.06 | 64.01 | 60.02 | 79.79 | 72.20 | 62.66 | 50.26 | 43.42 | 55.89 | 54.71 | 65.67 | 60.01 | 54.99 | 51.06 | 45.74 | 59.95 | 57.36 | 72.73 | 66.11 | |
| 2006 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 63.65 | 60.93 | 67.30 | 66.14 | 78.10 | 77.30 | 68.90 | 52.76 | 47.67 | 55.19 | 53.83 | 58.52 | 55.28 | 53.88 | 58.21 | 54.30 | 61.24 | 59.99 | 68.31 | 66.29 | 61.39 |
| Local | 57.75 | 54.56 | 56.63 | 56.20 | 67.31 | 63.99 | 59.41 | 32.51 | 23.96 | 36.58 | 34.50 | 43.91 | 39.71 | 35.19 | 45.13 | 39.26 | 46.60 | 45.35 | 55.61 | 51.85 | 47.30 |
| Mean | 60.70 | 57.74 | 61.97 | 61.17 | 72.70 | 70.65 | 64.16 | 42.64 | 35.81 | 45.88 | 44.17 | 51.22 | 47.49 | 44.53 | 51.67 | 46.78 | 53.92 | 52.67 | 61.96 | 59.07 | |

| | | Cultivar (cv.) | Planting materials (P.M) | Cv. x P.M | $P_2O_5$ | $P_2O_5$ x Cv. | $P_2O_5$ x P.M. | Cv. x P.M. x $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|
| L.S.D. 5% | 2005 | 2.23 | 1.40 | 1.97 | 1.61 | 2.28 | 2.29 | 3.23 |
| | 2006 | 3.55 | 1.20 | 1.70 | 1.07 | 1.42 | 1.43 | 2.01 |

M° = Microelements
W* = Without microelements

**Dry matter of tuber (%):**

Tubers of the Fuseau cultivar had significantly higher DM percentage than local one during 2005 and 2006 seasons. (Table 9). A similar trend was recorded under the Egyptian conditions (El-Sharkawy, 1998). Cutting of seed tubers gave a significant effect on dry matter at harvest time in both seasons. Planting whole seed resulted in higher DM compared with cut seeds, the increase was 21.74 and 20.47% during 2005 and 2006 seasons, respectively.

Fertilization by 22.5 Kg $P_2O_5$/Fed with spraying micro-elements significantly enhanced tuber DM by 22.33 and 20.79% during the two seasons respectively. Albegov and Ratskevich (1972), found that fertilization of potatoes and tomato plants with N, Fe + Mn or Mn + Cu increased their dry matter content.

Results in table 9 also indicate that tuber DM% was influenced by cultivars and seed tuber. The interaction effect between cultivar and P levels application was significant during 2005 and 2006. The highest tuber Dry matter was obtained with Fusaeu cultivar fertilized by 22.5 Kg $P_2O_5$/Fed and sprayed with micro-elements, in both seasons.

Regardless of cultivars, the highest DM% at harvest time occurred with the combination between whole seed tubers and P levels when 22.5 Kg $P_2O_5$/Fed with micro-elements were used while, in 2006, no significant differences were recorded between application of 22.5 Kg $P_2O_5$/Fed with or without micro-elements.

Concerning interaction effect between cultivar, seed tuber and P levels with or without spraying micro-elements it was noticed from that Fuuseau cultivar contained the largest tuber DM when planted with whole tuber and fertilized by 22.5 Kg $P_2O_5$/Fed with micro-elements in both years.

**Inulin percentage of tubers:**

Regardless other treatments, the present data (Table 10.) indicated that Fuseau cultivar contained 8.55 and 10.60% higher tuber inulin percentage than local one, during 2005 and 2006 respectively. Same trend was reported by El-Sharkawy, (1998).

**Table 9: Interaction effect of cultivars, planting materials, phosphorus fertilizer and microelements on (D.M%), 2005 and 2006.**

| Treatments / Cultivars | Whole | | | | | | | Cutting | | | | | | | Average | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean |
| | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | |
| 2005 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 22.29 | 20.09 | 23.37 | 20.88 | 24.22 | 21.15 | 22.00 | 30.36 | 19.64 | 21.45 | 20.89 | 22.12 | 21.53 | 21.00 | 21.32 | 19.86 | 22.41 | 20.88 | 23.17 | 21.34 | 21.50 |
| Local | 21.31 | 20.09 | 22.45 | 20.96 | 22.67 | 21.36 | 21.47 | 18.72 | 18.38 | 19.85 | 18.61 | 20.31 | 19.42 | 19.21 | 20.02 | 19.23 | 21.15 | 19.78 | 21.49 | 20.39 | 20.34 |
| Mean | 21.80 | 20.09 | 22.91 | 20.92 | 23.44 | 21.26 | 21.74 | 19.54 | 19.01 | 20.65 | 19.75 | 21.12 | 20.48 | 20.11 | 20.67 | 19.55 | 21.78 | 20.33 | 22.33 | 20.87 | |
| 2006 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 19.75 | 19.62 | 20.76 | 20.41 | 21.87 | 21.44 | 20.64 | 18.85 | 18.64 | 19.92 | 19.61 | 20.80 | 20.66 | 19.75 | 19.30 | 19.13 | 20.34 | 20.01 | 21.33 | 21.05 | 20.19 |
| Local | 20.02 | 19.51 | 20.64 | 20.26 | 20.63 | 20.78 | 20.31 | 18.93 | 18.73 | 18.82 | 18.70 | 19.86 | 19.05 | 19.02 | 19.48 | 19.12 | 19.73 | 19.48 | 20.24 | 19.92 | 19.66 |
| Mean | 19.89 | 19.57 | 20.70 | 20.33 | 21.25 | 21.11 | 20.47 | 18.89 | 18.69 | 19.37 | 19.15 | 20.33 | 19.86 | 19.38 | 19.39 | 19.13 | 20.03 | 19.74 | 20.79 | 20.49 | |

| | | Cultivar (cv.) | Planting materials (P.M) | Cv. x P.M | $P_2O_5$ | $P_2O_5$ x Cv. | $P_2O_5$ x P.M. | Cv. x P.M. x $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|
| L.S.D. 5% | 2005 | 0.12 | 0.13 | 0.19 | 0.28 | 0.41 | 0.40 | 0.57 |
| | 2006 | 0.16 | 0.14 | 0.20 | 0.21 | 0.29 | 0.30 | 0.41 |

$M^0$ = Microelements

$W^*$ = Without microelements

**Table 10: Interaction effect of cultivars, planting materials, phosphorus fertilizer and microelements on Inulin percentage of tubers 2005 and 2006.**

| Treatments / Cultivars | Whole | | | | | | | Cutting | | | | | | | Average | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean | 7.5 $P_2O_5$ (Kg) | | 15 $P_2O_5$ (Kg) | | 22.5 $P_2O_5$ (Kg) | | Mean |
| | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | | M° | W* | M° | W* | M° | W* | |
| 2005 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 11.97 | 11.47 | 12.47 | 12.27 | 12.43 | 12.02 | 12.13 | 11.50 | 11.27 | 12.07 | 11.77 | 12.10 | 11.67 | 11.73 | 11.73 | 11.37 | 12.27 | 12.02 | 12.27 | 11.93 | 11.93 |
| Local | 11.17 | 11.00 | 11.47 | 11.13 | 11.83 | 11.27 | 11.31 | 10.40 | 9.73 | 11.13 | 10.43 | 10.93 | 10.43 | 10.51 | 10.78 | 10.37 | 11.30 | 10.78 | 11.38 | 10.85 | 10.91 |
| Mean | 11.57 | 11.23 | 11.97 | 11.70 | 12.13 | 11.73 | 11.27 | 10.95 | 10.50 | 11.60 | 11.10 | 11.52 | 11.05 | 11.12 | 11.26 | 10.87 | 11.78 | 11.40 | 11.82 | 11.39 | |
| 2006 | | | | | | | | | | | | | | | | | | | | | |
| Fuseau | 11.30 | 10.57 | 11.57 | 11.20 | 11.97 | 11.37 | 11.33 | 9.50 | 9.23 | 9.87 | 9.50 | 10.07 | 9.53 | 9.62 | 10.40 | 9.90 | 10.72 | 10.35 | 11.02 | 10.45 | 10.47 |
| Local | 9.33 | 8.93 | 9.83 | 9.50 | 10.10 | 10.00 | 9.62 | 8.80 | 8.47 | 9.13 | 8.53 | 10.17 | 9.53 | 9.11 | 9.07 | 8.70 | 9.48 | 9.02 | 10.13 | 9.77 | 9.36 |
| Mean | 10.32 | 9.75 | 10.70 | 10.35 | 10.03 | 10.68 | 10.47 | 9.15 | 8.85 | 9.50 | 9.02 | 10.12 | 9.53 | 9.36 | 9.73 | 9.30 | 10.10 | 9.68 | 10.57 | 10.11 | |

| | | Cultivar (cv.) | Planting materials (P.M) | Cv. x P.M | $P_2O_5$ | $P_2O_5$ x Cv. | $P_2O_5$ x P.M. | Cv. x P.M. x $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|
| L.S.D. 5% | 2005 | 0.10 | 0.068 | 0.09 | 0.13 | 0.18 | 0.19 | 0.26 |
| | 2006 | 0.12 | 0.058 | 0.08 | 0.58 | 0.08 | 0.08 | 0.11 |

M° = Microelements
W* = Without microelements

At harvest using whole seed tuber gave higher inulin percentage than seed tuber cutting at harvest time in both seasons of study (Table 10).

Application of 22.5 $P_2O_5$ Kg/Fed with or without microelements gave a significant increase in inulin tuber percentage. Insulin concentration (g/100g DW) was higher when the plants of the two cultivar were planted with whole tubers. It is clear also that the interaction effect between cultivar and phosphorus levels with micro-elements was significant in both years. Fuseau cultivar gave higher inulin percentage when fertilized by 22.5 Kg $P_2O_5$/Fed with spraying micro-elements.

The interaction effects between the tuber seeds and phosphorus levels indicated that addition of 22.5 Kg $P_2O_5$/Fed with micro-elements to whole tuber gave the highest inulin of tuber. In general, the maximum inulin concentration was obtained when whole tubers of Fuseau cultivar were planted and fertilized with 22.5 Kg $P_2O_5$/Fed with micro-elements (Table 10).

It could be concluded that application of 22.5 Kg $P_2O_5$/Fed with microelements are the optimum fertilization rates to maximize tuber yield and increase tuber DM and inulin of the local and Fuseau cultivars growth when planting whole tuber in drip-irrigated sandy soils.

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## تأثير تجزئة الدرنات ومستوى الفوسفور وبعض العناصر الصغرى على محصول وجودة نبات الطرطوفة تحت نظام الري بالتنقيط في الأراضي الرملية

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الطرطوفة هي أحد محاصيل الخضر غير تقليدية التي أدخلت حديثاً لزراعتها في جمهورية مصر العربية .

- أجريت هذه الدراسة على صنفين من الطرطوفة هما الصنف البلدي والصنف الأجنبي (فيوزا) ، وذلك بهدف دراسة تأثير التسميد بمستويات مختلفة من الفوسفور (٧,٥ ، ١٥ ، ٢٢,٥كجم $P_2O_5$ للفدان مع وبدون العناصر الغذائية الصغرى (حديد) وزنك ، ومنجنيز) هذا بالإضافة إلى استخدام طريقتين للزراعة (زراعة درنات سليمة ودرنات مجزأه) . أجريت هذه التجربة فى أراضى رملية تحت ظروف الري بالتنقيط في عامي ٢٠٠٥ ، ٢٠٠٦ .
- أشارت النتائج إلى أن صنفي الطرطوفة (البلدي والفيوزا) قد أظهرت استجابة موجبة لقياسات النمو عند الزراعة بالدرنات السليمة في كلا الموسمين . كما أكدت أيضاً أن

صنف الفيوزا أعطى أعلى قيم فى كلا من الصفات التالية (طول الساق الرئيسي – عـدد الأفرع – وزن الأفرع الطازج للنبات – محتوى الأوراق من الكلوروفيل – وزن الدرنات الطازج بالنبات – المحصول الكلى – نسبة المادة الجافة بالـدرنات) . بينمـا الـصنف المحلى أعطى أعلى عدد من السيقان الرئيسية .

- زيادة التسميد الفوسفاتي إلي أعلى مستوى (٢٢,٥كجم/فدان $P_2O_5$) أدى إلـى إحـداث تأثير معنوي على كل من ارتفاع النبات ووزن الأفرع الطازج وعدد السيقان الرئيـسية ومحتوى الأوراق من الكلوروفيل ووزن الدرنات الطازج بالنبـات ومحـصول الـدرنات الكلى ونسبة المادة الجافة والأنيولين بالـدرنات . وكـذلك ، أشـارت النتـائج أن رش النباتات بالعناصر الصغرى (الحديد – الزنك – المنجنيز) كان أكثر المعاملات تأثيراً على نمو ومحصول الدرنات بالطرطوفة .