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RESEARCH ARTICLE

The Effect of Organic and Potassium Fertilization on the Chemical Content and Quality of Fruits in Carrots

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ABSTRACT

A field experiment was carried out at the research station affiliated with the College of Agriculture/Al-Bu'itha Village/Anbar Governorate, to study the effect of organic and potassium fertilization on the chemical content and quality of fruits in carrots. The study was carried out by distributing factorial experiments in a completely randomized block design (RCBD) with three replicates. The first factor included organic poultry fertilizer in four concentrations (0-, 10-, 15-, and 20-tons ha-1), and the second factor is potassium fertilizer, also at four concentrations (0, 150, 200 and 250 kg K2O ha-1). The results of the statistical analysis showed that organic fertilization at the level: 20 tons ha-1 of poultry waste gave a significant increase in nitrogen index, total sugars, total yield, and marketable yield, where their value was: 3.05%, 8.43%, 125.07 tons ha-1 and 110.00 tons ha-1 respectively, compared to with the comparison treatment given 1.54%, 5, 525.52%-, 79.25 tons ha-1 and 99.97 tons ha-1 for the same qualities. Potassium fertilization had a significant effect as the treatment was superiorK3 which means level 250 kg K2O ha-1 in nitrogen index, total sugars, total yield and marketable yield its value was: 2.51%, 7.01%, 112.25 tons ha-1 and117.90 tons ha-1 Respectively. The interaction between the two study factors gave a significant effect, as the treatment was superior C3K3, which means: 20 tons ha-1 of poultry waste + 250 kg K2O ha-1 it gave the best results nitrogen index, total sugars, total yield and marketable yield and I reached: 3.50%, 8.73%, 126.85 tons ha-1 and 124.31 tons ha-1 respectively.

INTRODUCTION

Carrots, whose scientific name is Daucus carota L. as it belongs to the Apiaceae family, carrots are grown locally as an annual crop to produce roots and as a bi-annual crop to produce seeds. In the first season, its plants give vegetative growth and juicy, colorful storage roots, and in the second season they give vegetative growth and flowers in the form of tentacle inflorescences containing seeds. (Hassan, 2015). Carrot roots contain several types of sugars (the main ones that contribute to their sweet taste and nutritional value), which are: sucrose, which is the dominant sugar in carrots, and represents 30-50% of the total sugar content, which provides the distinctive sweet taste of carrots and its source of energy, and glucose, which represents 20-30% of total sugar, which is a simple sugar that can be used directly by the body for energy, and fructose, which constitutes 10-20% of the total sugars found in carrots (Sharma *et al.*, 2012; Tian *et al.*, 2024).

In relatively heavy soils, root crops suffer from poor yield quality due to poor soil structure and hardening, which does not allow the roots to penetrate and grow normally. This increases the percentage of unmarketable roots as a result of abnormal growth of the roots, increased branching and cracks in the roots, and other undesirable characteristics. Therefore, producers resort to use organic fertilizers for the purpose of improving the properties of the soil and increasing its fragility and the extent of its moisture retention, which reduces deformities, improves the quality characteristics of the roots, and facilitates the process of uprooting the roots, which is one of the economically expensive operations, as well as encouraging the growth of beneficial microorganisms that work to increase the efficiency of the roots' absorption of nutrients (Brackin *et al*., 2015, Musleh and Al-Mohammedi, 2022; Al-Mohammedi and Kokaz, 2021) In root crops, a regular balance must be provided between the shoot and the root system by providing soil improvers such as organic fertilizers that prepare and provide the plant with nutrients and make the soil more loose, porous and with a higher ability to retain moisture, which It reflects positively on growth and yield and improves the quality of the fruits produced (Shayaa and Hussein 2019). Organic fertilizers play a major role in improving the quality characteristics of carrot roots, especially their total sugar content. Using organic fertilizers alone or with chemical fertilizers can enhance the roots' total dissolved solids content as well as increase the water content of the roots, which reflects positively on the fragility of the root tissues and improving other nutritional aspects of carrots, which contributes to increasing marketable yield and further improving fruit quality (Hailu *et al*., 2008).

Potassium is necessary to increase the growth and development of carrot plants, due to its effective role in transporting sugars and carbohydrates in general from where they are manufactured in the leaves to where they are stored in the roots. Potassium also stimulates root growth, provides resistance to pests and diseases, and contributes to resistance to biotic and biotic stresses such as drought and frost. Potassium is a highly mobile element in plants and has a specific phenomenon called luxuriant consumption (luxury consumption) is a process in which the plant absorbs more potassium than it needs for normal growth and development. This excess potassium is stored in the plant's tissues and can be used when the plant suffers from a nutritional imbalance or when the plant is experiencing rapid growth (Rodrigues *et al*., 2021).

Potassium improves the sugar content of carrot roots, increases the flavor of the roots, increases the speed of their maturation, and improves the physical and chemical properties of carrot roots (Haque *et al*., 2019 and Thapa *et al*., 2023). Fertilizing with high levels of potassium increases the productivity and quality of carrot roots and improves the quality of the roots produced (Ayer *et al*., 2019). Potassium plays a crucial role in regulating the osmotic pressure of plant cells, which enhances the content of root cells of elements and total dissolved solids and increases the activity of metabolic processes in plant cells. Potassium also works to regulate the opening and closing of stomata, which reflects positively on the efficiency of the carbon assimilation process and increases the accumulation of dry matter in plant cells, potassium deficiency leads to a defect in the process of opening and closing stomata and thus a defect in the process of photosynthesis (Hasanuzzaman *et al*., 2018). From the above, the study aimed to know the effect of adding organic and potassium fertilizer on the chemical indicators of carrot plants, and to determine the best combination of organic and potassium fertilizer that gives the best yield and the best quality characteristics of the roots.

MATERIAL AND METHODS

To achieve the objectives of the study, a field experiment was carried out at the research station affiliated with the College of Agriculture, Al-Bu'itha village, Anbar Governorate, (longitude 43.30 and latitude 33.410). The experiment included two factors, the first being different concentrations of organic fertilization (decomposing poultry waste) with four concentrations (0, 10, 15, and 20 tons ha^{-1}), which are coded C0, C1, C2, and C3, respectively (Kumar *et al*., 2017). The second factor, potassium fertilizer (K_2O), was added during soil preparation at four levels (0, 150, 200, and 250 kg K_2O ha^{-1}), which are respectively designated as K0, K1, K2, and K3 (Papree, 2008). The treatments were randomly distributed as a factorial experiment within a completely randomized block design with three replications. The experiment included sixteen treatments as a result of the interaction between the levels of the two study factors. It was repeated in three replications, so that the number of experimental units reached 48. The soil preparation operations for agriculture were carried out, including plowing and smoothing, and it was divided into terraces with a length of 2 m and a width of 1 m. The drip irrigation method was adopted using T-tape drip tubes, with two tubes for each area. Seeds of the approved variety Nantes were used. The seeds were spread in two lines on both sides of each drip tube, with a distance of 20 cm between one line and another, so that the number of lines became four lines per platform. Planting took place on September 15, 2023, according to the approved date in the central region of Iraq, and after germination was completed, the Thin the plants so that the distance between one plant and another was approximately 5 cm, at a rate of 160 plants per experimental unit. The plants were uprooted after the roots reached maturity. Samples were collected within a month to estimate indicators of chemical content and fruit quality in carrots, as follows:

1. Nitrogen percentage (N) in leaves (%): It was estimated using the Microkjeldal device as mentioned in Jackson (1958).
2. Phosphorus ratio (P) in leaves (%): It was determined using a spectrophotometer at a wavelength of 882 nm (Sommers and Olsen, 1982).
3. Potassium percentage (K) in leaves (%): It was estimated using a flame photometer (Al-Sahhaf, 1989).
4. Ratio of xylem to phloem (%) in roots: calculated after leaving1 cm of the crown area of the carrot and my agencies: xylem/phloem ratio (%) = (xylem diameter/phloem diameter) × 100
5. Percentage of total sugars (%) in the roots: according to the method Joslyn (1970) on the determination of total sugars.
6. Percentage of beta-carotene (%): By method which was described before Negat and Yamashita (1992).
7. Total yield (tons ha^{-1}): The total result in H = the result of the experimental unit×10000/2.
8. Marketable yield (tons ha^{-1}): It was calculated according to the following equation:

   Marketable yield = total yield – non-marketable yield.

Statistical analysis:

After sorting the data, it was analyzed according to the statistical program Genstat, and the arithmetic means were compared using the least significant difference (LSD) test at the probability level of 0.05 (Al-Mohammadi and Al-Mohammadi, 2012).

RESULTS

The effect of organic fertilization on the chemical content and quality of fruits in carrots:

Organic fertilization treatment was superiorC3 achieved the highest percentages of nitrogen, phosphorus, and potassium in the leaves, and achieved the highest ratio of wood to bark, the highest content of total sugars, the content of beta-carotene, the total yield, and the marketable yield (3.05%, 1.46%, 3.79%, 29.32%, 8.43%, 2.29%, 125.07 tons ha^{-1} and 110.00 tons ha^{-1}), for the characteristics mentioned respectively, compared with the lowest results achieved by plants that were not fertilized with organic fertilizer, which gave:1.54%, 0.79%, 2.64%, 38.46%, 5.52%, 1.42%, 79.25 tons ha^{-1} and 99.97 tons ha^{-1} for the same characteristics Respectively (Table1).

Table1: The effect of organic fertilization on the chemical content and quality of fruits in carrots

Organic fertilizer (C)	Nitrogen in leaves (%)	Phosphorus in leaves (%)	Potassium in leaves (%)	Wood to bark (%)	Total sugars (%)	Beta carotene (%)	Total yield (tons $^{-1}$)	Marketable yield (kg)
C0	1.54	0.79	2.64	38.46	5.52	1.42	79.25	99.97
C1	1.97	0.98	3.02	38.70	6.11	1.51	107.22	101.49
C2	2.53	1.27	3.44	34.92	7.00	1.84	122.46	108.56
C3	3.05	1.46	3.79	29.32	8.43	2.29	125.07	110.00
LSD .05	0.117	0.053	0.052	0.661	0.128	0.151	1.123	5.086

The effect of potassium fertilization on the chemical content and quality of fruits in carrots:

The results show the superiority of the fertilization treatment K3 significantly increased by giving it the highest percentages of nitrogen, phosphorus and potassium in the leaves, as well as the best ratio of wood to bark and the highest content of total sugars and beta-carotene. It achieved the highest total yield and the highest marketable yield of 2.51%, 1.19%, 3.40%, 37.45%, 7.01%, 1.83%, 112.25 tons ha^{-1} 117.90 tons ha^{-1} for the characteristics mentioned Respectively, compared to plants that were not fertilized with potassium, which gave the lowest values of: 2.10% and 1.05%, 3.11%, 39.51%, 6.26%, 1.67%,103.00 tons ha^{-1} 77.26 tons ha^{-1} for the same characteristics in sequence (Table 2).

Table 2: The effect of potassium fertilization on the chemical content and quality of fruits in carrots

K_2O (K)	Nitrogen in leaves (%)	Phosphorus in leaves (%)	Potassium in leaves (%)	Wood to bark (%)	Total sugars (%)	Beta carotene (%)	Total yield (tons $^{-1}$)	Marketable yield (kg)
k0	2.10	1.11	3.11	39.51	6.26	1.67	103.00	77.26
k1	2.17	1.05	3.16	31.27	6.90	1.73	107.97	105.15
k2	2.31	1.15	3.21	33.17	6.89	1.84	110.78	119.71
k3	2.51	1.19	3.40	37.45	7.01	1.83	112.25	117.90
LSD .05	0.117	0.053	0.052	0.128	0.128	0.151	1.123	5.086

The effect of the interaction between organic and potassium fertilization on the chemical content and quality of fruits in carrots:

The results showed (Table 3) there are significant differences between the interaction treatments between organic fertilizer and potassium in the characteristics of the chemical content of carrots, as the C3K3 treatment achieved the highest percentage of nitrogen, phosphorus and potassium in the leaves, and the best ratio of wood to bark in the roots. The same treatment also achieved the highest content of total sugars and beta-carotene and achieved the highest total and highest marketable result reached 3.50%, 1.53%, 3.92%, 26.57% and 8.73%, 2.65%, 126.85 tons ha^{-1} and124.31 tons ha^{-1} for the characteristics mentioned Respectively, compared to the lowest values achieved by plants that were not fertilized with organic and potassium fertilizers, which achieved:1.53%, 0.78%, 2.55%, 47.23%, 5.10%, 1.34%, 78.53 tons ha^{-1} and 76.17 tons ha^{-1}**,** for the same qualities Respectively.

Table 3: Effect of the interaction between organic and potassium fertilization on the chemical content and quality of fruits in carrots

K×C	Nitrogen in leaves (%)	Phosphorus in leaves (%)	Potassium in leaves (%)	Wood to bark (%)	Total sugars (%)	Beta carotene (%)	Total yield (tons $^{-1}$)	Marketable yield (kg)
C0K0	1.53	0.78	2.55	47.23	5.10	1.34	78.53	76.17
C0K1	1.47	0.74	2.54	32.10	5.15	1.34	78.67	86.71
C0K2	1.59	0.84	2.58	34.94	5.78	1.57	79.33	116.81
C0K3	1.56	0.79	2.87	39.58	6.04	1.44	80.45	120.20
C1K0	1.84	0.91	2.83	41.60	5.39	1.72	89.12	76.30
C1K1	1.78	0.91	2.95	33.36	6.56	1.53	106.61	105.43
C1K2	2.05	1.01	3.03	39.40	6.11	1.47	115.57	119.43
C1K3	2.19	1.10	3.27	40.42	6.39	1.34	117.57	104.78
C2K0	2.21	1.30	3.39	36.30	6.69	1.35	120.43	77.74
C2K1	2.55	1.17	3.43	29.94	7.34	1.93	121.87	113.27
C2K2	2.59	1.29	3.40	30.21	7.11	2.20	123.41	120.94
C2K3	2.78	1.34	3.56	43.23	6.87	1.90	124.13	122.30
C3K0	2.81	1.44	3.67	32.90	7.87	2.26	123.92	78.84
C3K1	2.90	1.40	3.71	29.68	8.57	2.14	124.72	115.21
C3K2	3.01	1.47	3.86	28.12	8.55	2.12	124.80	121.64

C3K3	3.50	1.53	3.92	26.57	8.73	2.65	126.85	124.31
LSD .05	0.235	0.107	0.105	1.322	0.256	0.303	2.246	10.171

DISCUSSION

The results presented in the Tables (1) the effective and moral role that organic fertilization plays in improving indicators of chemical content, yield characteristics, and fruit quality. The results showed a steady increase in these characteristics with increasing levels of organic fertilization, reaching the highest results given by plants fertilized with 20 tons ha^{-1} (C3), The reason for the increase may be due to the use of organic fertilizers supplying the soil with some macro- and micro-nutrients, which increases the efficiency of the plant's photosynthesis process and increases the accumulation of dry matter and the products of other metabolic processes, which reflects positively on the roots' content of sugars and beta-carotene. Fertilizers also tend to organic fertilizers also because a steady and slow release of nutrients, providing nutrients at a more balanced rate to the plant throughout the plant's growth (Sah *et al*., 2024).

The reason for the increase in the quality characteristics of fruits, especially the marketable yield, can be attributed to the role of organic matter in improving the physical structure of the soil and increasing its porosity, which gives the roots freedom to grow and penetrate the soil and reduces distortions caused by heavy soils, in addition to the role of organic fertilizer in increasing the soil's ability to retain water. Which may also positively affect the plant's ability to absorb nutrients and water, which ultimately affects the sugar and beta-carotene content in carrots (Nikmatullah *et al*., 2021), similar results were obtained by (Al-Amri and Al-Abdaly, 2020) on onions.

The results indicated there was a significant increase in the chemical content and quality characteristics of fruits as a result of potassium fertilization, and that this increase was proportional and increased with the increase in the level of potassium fertilization used. Plants fertilized with the highest concentration of 250 kg K_2O ha-1 achieved the best results. The reason for the moral superiority can be attributed to the role of potassium in increasing the availability of elements in the soil, which provides a suitable opportunity for fertilized plants to absorb them and utilize them in metabolic processes and accumulation of photosynthesis products. In addition to the role of potassium in transporting photosynthesis products from the manufacturing sites in the leaves to the storage sites in the roots, this is the reason for a clear increase in the root content of sugars and beta-carotene, which are among the most important characteristics of fruit quality in carrots (Rodrigues *et al*. 2021). Similar results were obtained by (Rodrigues *et al*. 2021). Zaily and Al-Abdaly (2022); Al-Mohammady and Al-Abdaly, (2023) on garlic crop. It is pointed out here that the role of potassium in regulating osmotic pressure in plant cells was reflected positively in the increased absorption of nutrients by the roots, and this was reflected positively in their content of sugars and beta-carotene (Hasanuzzaman *et al*., 2018).

As for the effect of the interaction between the two factors of the study, the results can be explained by the superiority of the interaction treatment C3K3 in most indicators of chemical content and fruit quality characteristics indicates the combined role of both organic fertilizer and potassium fertilizer in improving the composition of the soil and supplying it with elements, as well as the role of potassium in stimulating many enzymes and facilitating the transfer of carbon metabolites from the leaves to storage places in the roots, which helped improve growth. And the quality characteristics of carrot fruits. Similar results were obtained by (Haque *et al*., 2019; Vikram *et al*., 2022).

CONCLUSIONS

Based on the results we obtained from this study, we can conclude the following:

Increasing the levels of organic and potassium fertilization, independently or through bilateral interaction, led to a clear improvement in the chemical content, yield, and quality characteristics of the fruits, which was significantly reflected in an increase in the total yield and the marketable yield. This calls for testing higher levels of these two fertilizers, taking into account the critical economic limit of fertilization.

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