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Effect of Different Nitrogen and Potassium Fertilization Levels on Carrot Productivity

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تأثير مستويات التسميد المختلفة بالنيتروجين والبوتاسيوم على إنتاجية الجزر

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Abstract
Two field experiments were conducted in a sandy soil at Al-Kufra City, Libya, during the two successive winter seasons of 2021and 2022, to study the effects of varying nitrogen and potassium fertilization levels, as well as their interaction, on yield and its components, chemical composition, and overall quality of carrot (Nantaise Amelioree) variety. Data cleared that that nitrogen fertilizer levels treatments have significant effect on yield and its components i.e., total yield, root weight and xylem/phloem, chemical composition i.e., N, K and chlorophylls content in the plant and quality parameters i.e., root dry weight and total soluble sugar percentages, in both seasons. The highest significant values for these traits were recorded as a result of increasing nitrogen fertilizer levels from 0 to 210 kg/ha regularly in both seasons. In relation to the impact of potassium fertilizer levels treatments, reveal significant effects on yield and its components, chemical composition and quality parameters, in the two seasons. It is evident that the highest values were achieved as a result of increasing the potassium fertilization levels from 0 to 180 kg/ha regularly in both seasons, with the exception of root weight in the first growing season. Plants fertilized at a rate of (60-120 kg/ha) outperformed those fertilized at a rate of (180 kg/ha). As for the interaction among nitrogen and potassium fertilizer levels treatments have significant effects for all studied qualities, in both seasons. The most effective combined treatment, which resulted in the highest significant increase, was achieved by applying the highest nitrogen rate (210 kg/ha) along with the highest potassium rate (180 kg/ha).

Keywords: Carrot, nitrogen, potassium.

الملخص

يهدف هذا البحث إلى استكشاف التحديات التي يواجهها الطلاب عند ترجمة التعابير الاصطلاحية، كما يحقق في الاستراتيجيات التي يستخدمها الطلاب للتغلب على هذه التحديات. ولجمع البيانات، اعتمدت الدراسة على منهج البحث المختلط من خلال استبيان وُزّع على 20 طالبًا في كلية التربية بجامعة مصراتة، بالإضافة إلى مقابلة شبه منظمة مع اثنين من الأساتذة الذين يدرّسون الترجمة في قسم اللغة الإنجليزية بالكلية. شملت عينة الدراسة 20 طالبًا يدرسون اللغة الإنجليزية في كلية التربية، إلى جانب اثنين من أساتذة مساقات الترجمة. أظهرت النتائج محدودية معرفة الطلاب بالتعابير الاصطلاحية، واعتمادهم على الترجمة الحرفية، ونقص الوعي الثقافي لديهم. وخلصت الدراسة إلى أن الترجمة الفعالة للتعابير الاصطلاحية تحتاج إلى خلفية ثقافية جيدة، واستراتيجيات مرنة، وقدرة على الاستدلال السياقي. كما أبرزت الدراسة أهمية تدريب الطلاب على استراتيجيات مثل إعادة الصياغة، وإيجاد المكافئات المناسبة، وتنمية الوعي الثقافي. إن تضمين هذه العناصر ضمن المقررات الدراسية يمكن أن يعزز بشكل كبير كفاءة الطلاب في الترجمة وفعاليتهم في التواصل الثقافي.

الكلمات المفتاحية: الجزر، النيتروجين، البوتاسيوم.

Introduction

Carrot (*Daucus carota* L.), a member of the Apiaceae family, is a widely cultivated root vegetable known for its high nutritional and economic value. It is a rich source of beta-carotene an important precursor of vitamin A as well as essential nutrients including dietary fiber, sugars, vitamins, and minerals. Owing to its health benefits and versatility in culinary and industrial applications, carrot cultivation has gained importance in many regions around the world.

Carrot productivity and quality are influenced by several environmental and agronomic factors, among which nutrient management plays a pivotal role. Nitrogen (N) and potassium (K) are two essential macronutrients required for optimal plant growth and root development.

Nitrogen (N) is one of the three primary macronutrients required by plants in large quantities. It is widely recognized as having a more significant impact on crop productivity than any other essential nutrient. Nitrogen plays a vital role in numerous biochemical and physiological processes within plants. It is a key component of several important organic molecules, including nucleic acids and proteins. Additionally, it is the basis of many enzymes and chlorophyll molecules and serves as a structural element in cell walls. It is also involved in various metabolic pathways that are critical for the process of photosynthesis **(Marschner, 2012).**

Akkamis and Caliskan (2023) found that full irrigation combined with the application of 300 kg N/ha produced the highest potato tuber yield, highlighting the critical role of sufficient water and nitrogen availability in achieving optimal crop performance. Also, on sugar beet **(Seadh *et al.*, 2025)** found that the application of 100 kg N/fed resulted in the highest recorded values for root weight, root length and diameter, potassium and alpha-amino nitrogen percentages, as well as both root and shoot yields per feddan.

Potassium is essential for enhancing the growth and development of carrot plants due to its vital role in the translocation of sugars and carbohydrates from their sites of synthesis in the leaves to their storage organs in the roots. Additionally, potassium promotes root development, strengthens plant resistance against pests and diseases, and improves tolerance to both biotic and abiotic stresses, such as drought and frost. Being a highly mobile element

within plant tissues, potassium exhibits a phenomenon known as luxury consumption—whereby plants absorb potassium in excess of their immediate needs. This surplus is stored in plant tissues and can be mobilized later during periods of nutritional deficiency or rapid growth **(Rodrigues *et al.*, 2021).** Also, application of elevated potassium levels has been reported to enhance both the yield and quality of carrot roots, leading to the production of superior root characteristics **(Ayer *et al.*, 2019)**. Also on carrots, **AL-Dulaimy and AL-Abdaly (2024)** indicated that increasing the levels of both organic and potassium fertilization—whether applied individually or in combination—resulted in notable improvements in the chemical composition, yield, and quality traits of the fruits. These enhancements were significantly reflected in higher total and marketable yields.

This study was conducted to evaluate the effects of varying nitrogen and potassium fertilization levels, as well as their interaction, on yield and its components, chemical composition, and overall quality of carrot "Nantaise Amelioree" variety grown under the ecological conditions of Al-Kufra City, Libya.

Materials And Methods

Analysis of soil:

Before cultivation and prior to soil preparation, a soil sample was randomly collected from the experimental field at a depth of 0–30 cm to assess selected physical and chemical properties, as presented in Table 1. All analyses were conducted according to the methods described by **Buurman *et al.* (1996).**

Table 1: Selected chemical and physical properties of the experimental soil before cultivation during the two study seasons.

K PPM	P PPM	CO^{3--} %	pH	N (%)	E.C M/cm	Organic Matter (%)	Particle Size distribution			season
							Clay (%)	Silt (%)	Sand (%)	
75	82	0.8	7.1	0.23	1.30	0.10	2	3	95	2021
80	93	0.9	7.2	0.21	1.36	0.15	3	3	94	2022

The experimental design and treatments:

These agricultural experiments were conducted using a randomized complete block design with a split-plot design system, including three replicates. Each experiment included 16 treatments. The vertical-plots were allocated to four nitrogen fertilizer treatments (main plots) as follow: (0, 70, 140 and 210 N/kg ha). The calculated amount of nitrogen fertilizer for each level was added in four batches by spreading. The first dose was added 45 days after seeding, while the remaining doses were added approximately 55, 65, and 75 days after the first dose.

The horizontal plots were devoted into four potassium fertilizer treatments (sub plots) as follows: (0, 60, 120 and 180 K/kg ha). Potassium fertilizer levels were added in four equal and simultaneous batches of the first four nitrogen fertilizer batches.

Each experimental unit for this study consisted of an area of one square meter.

Agricultural practices:

Nitrogen fertilizer was added in the form of urea (46% N) and potassium fertilizer was added in the form of potassium sulfate (48% K_2O), while all experimental units were fertilized with single calcium superphosphate (15.5% P_2O_5) at a rate of 400 kg/ha.

A suitable plot of land was selected for the experimental project. All debris, stones, and other waste materials were removed from the designated area. The plot was then plowed and divided into replicates and experimental units. Carrot seeds (Nantaise Amelioree variety) were sown in the first week of November in both 2021 and 2022 at a seeding rate of 10 kg/ha. All recommended agricultural practices for carrot production were followed. Single superphosphate fertilizer was applied during soil preparation prior to cultivation. A drip irrigation system was used throughout the study. Pest and disease control measures were applied as needed, in accordance with recommended guidelines for commercial carrot production.

Studied Characters:

1- Yield and its components:

- Average root weight.
- Xylem / phloem.
- **Total yield:** Was calculated by determining the yield from each individual plot and then converting the values into tons per hectare.

2- Chemical constituents in the leaves.

Leaf samples were randomly taken from each experimental treatment 120 days after seeding and completion of all fertilizer treatments. The following were estimated:

- **Chlorophyll content:** The concentration of chlorophyll pigments was assessed using a spectrophotometric technique, following the protocol of **Gavrilenko and Zigalova (2003).**

- **Nitrogen content (N):** Was estimated using the method described by **Jones *et al.* (1991).**

- **Potassium content (K):** Was estimated using the method described by **Peters *et al.* (2003).**

3- Root quality parameters:

- Root dry weight.
- **Total soluble sugars:** Was estimated using the method described by **Sadasivam and Manickam (1996).**

Statistical analysis

Data were analyzed using the "MSTAT-C" software package. Analysis of variance (ANOVA) was conducted based on a randomized complete block design (RCBD) with a split-plot arrangement, following the procedure outlined by **Gomez and Gomez (1984).** To compare treatment means, the least significant difference (LSD) test at the 5% probability level was applied, as described by **Snedecor and Cochran (1980).**

Results And Discussion

Effect of nitrogen fertilizer levels treatments:

Data present in Tables 2 and 5 show that nitrogen fertilizer levels treatments have significant effects on yield and its components *i.e.,* total yield, root weight and xylem/phloem of carrot plants, chemical composition *i.e.,* N, K and chlorophylls content in the plant of carrot and quality parameters *i.e.,* root dry weight and total soluble sugar percentages, in both seasons. The highest significant values for these traits were recorded as a result of increasing nitrogen fertilizer levels from 0 to 210 kg/ha regularly in both seasons. The increase in these

characteristics with increased nitrogen fertilizer levels in both seasons can be attributed to the vital role nitrogen plays in numerous biochemical and physiological processes within plants. It is a key component of several important organic molecules, including nucleic acids and proteins. Additionally, it forms the basis of many enzymes and chlorophyll molecules and serves as a structural element in cell walls. Nitrogen is also involved in various metabolic pathways that are critical for the process of photosynthesis, as mentioned by **(Marschner, 2012)**. These findings are consistent with the conclusions reported earlier by **Akkamis and Caliskan (2023)** on potato and **(Seadh *et al.*, 2025)** on sugar beet.

Effect of potassium fertilizer levels treatments:

In relation to the impact of potassium fertilizer levels treatments, data in the same tables reveal a significant effect on yield and its components, chemical composition and quality parameters, in the two seasons. It is evident that the highest values were achieved as a result of increasing the potassium fertilization levels from 0 to 180 kg/ha regularly in both seasons, with the exception of root weight in the first growing season. Plants fertilized at a rate of (60-120 kg/ha) outperformed those fertilized at a rate of (180 kg/ha). This improvement can be attributed to the essential role of potassium in enhancing the growth and development of carrot plants. Potassium plays a vital role in the translocation of sugars and carbohydrates from their sites of synthesis in the leaves to their storage organs in the roots. Additionally, it promotes root development, strengthens plant resistance against pests and diseases, and improves tolerance to both biotic and abiotic stresses, such as drought and frost. Being a highly mobile element within plant tissues, potassium exhibits a phenomenon known as luxury consumption—whereby plants absorb potassium in excess of their immediate needs. This surplus is stored in plant tissues and can be mobilized later during periods of nutritional deficiency or rapid growth, as mentioned by **(Rodrigues *et al.*, 2021)**. These findings are consistent with the conclusions reported earlier by **(Ayer *et al.*, 2019)**. and **AL-Dulaimy and AL-Abdaly (2024)** on carrots.

Effect of interactions:

The interactions among nitrogen and potassium fertilizer levels treatments have significant effects yield and its components *i.e.,* total yield, root weight and xylem/phloem of carrot plants, chemical composition *i.e.,* N, K and chlorophylls content in the plant of carrot and quality parameters *i.e.,* root dry weight and total soluble sugar percentages, in both seasons are present in Tables 3, 4, 6 and 7. The most effective combined treatment, which resulted in the highest significant increase, was achieved by applying the highest nitrogen rate (210 kg/ha) along with the highest potassium rate (180 kg/ha).

Table 2: the main effects of nitrogen and potassium fertilizer levels on total yield, root weight, root dry weight and xylem/phloem of carrot plants in the two study seasons.

N kg/ ha	K kg/ ha	Total yield (ton/ ha)	Root weight (g)	Root dry weight (g)	xylem / phloem
First season					
0		64.3D*	24.81D	5.80B	8.5A
70		71.9C	33.58C	7.85A	8.60A
140		85.4B	61.62B	7.92A	8.70A
210		94.3A	77.9A	8.10A	8.83A

	0	76.7D	41.92B	7.19A	7.82A
	60	78.3C	46.09A	7.25A	8.60A
	120	79.3B	46.21A	7.42A	9.05A
	180	81.5A	43.58B	7.81A	9.18A
second season					
0		55.6D	26.34C	2.80C	9.65B
70		70.5C	35.21C	3.13C	10.34AB
140		85.7B	56.33B	5.62B	11.86A
210		96.75A	77.8A	7.79A	11.47A
	0	72.6D	42.59C	3.85B	9.66C
	60	75.7C	45.65C	5.03A	10.59BC
	120	79.5B	52.5B	5.03A	11.07AB
	180	80.8A	55.95A	5.45A	12.02A

*Values followed by the same letter (s) of the alphabet, within each group, are means for each trait, and do not differ significantly from each other according to the least significant difference (LSD) method at a significance level of 0.05.

Table 3: Effect of the interaction between nitrogen and potassium fertilizer levels on the characteristics total yield, root weight, root dry weight and xylem/phloem of carrot plants in the first season.

N Kg/ ha	K Kg/ ha	Total yield (ton/ ha)	Root weight (g)	Root dry weight (g)	xylem / phloem
0	0	*62k	8. 53i	5.95cd	6.73f
	60	63.6j	14.33h	5.42d	6.77f
	120	64.6j	17.53gh	5.47d	7.1ef
	180	67i	18.86g	6.36b-d	7.05ef
70	0	60.5h	31.66f	6.86b-d	7.25d-f
	60	71.3h	31.33f	6.12b-d	7.75d-f
	120	71.8h	35ef	6.47b-d	8.21b-f
	180	74g	36.33e	7.68a-c	8.45b-f
140	0	82.4f	59d	7.16b-d	8.55b-f
	60	85.1e	59.66a	7.76a-c	8.68b-f
	120	85.8e	61.5cd	7.95a-c	9a-f
	180	88.2d	66.33ab	8.23ab	9.75a-e
210	0	92.1c	64bc	8.29ab	10.3a-c
	60	93.3c	68.5a	9.45a	10.15a-c
	120	95.1b	69a	9. 48a	10.98ab
	180	96.9a	69.66a	9. 73a	11.9a

*Values followed by the same letter (s) of the alphabet, within each group, are means for each trait, and do not differ significantly from each other according to the least significant difference (LSD) method at a significance level of 0.05.

Table 4: Effect of the interaction between nitrogen and potassium fertilizer levels on the characteristics total yield, root weight, root dry weight and xylem/phloem of carrot plants in the second season.

N/ Kg ha	K/ Kg ha	Total yield (ton/ ha)	Root weight (g)	Root dry weight (g)	xylem / phloem
	0	*53m	10.56 i	1.56h	7.39g
	60	55.4i	21.5i	1.76h	9.1e-g

0	120	56.3ki	34.8g	2.92gh	10.2c-f
	180	57.7kj	38.5g	2.95gh	11.95a-d
70	0	62.6j	27.2h	3.03fgh	8.55fg
	60	64.5i	34g	3.17fgh	10.25c-f
	120	76.5h	35.33g	3.65efg	10.3c-f
	180	78.5g	44.33f	4.63d-f	12.41a-c
140	0	82.4f	51.33e	5.10c-e	9.7d-g
	60	85.7e	50.33e	5.46cd	13.11ab
	120	86.8de	57.66d	5.92cd	12.2a-d
	180	88.2d	66c	6.03cd	12.42a-c
210	0	92.5c	71.33bc	6.05cd	10.57b-f
	60	97.1b	75b	6.72bc	10.75b-f
	120	98.3ab	82. 2a	8.32b	11.27a-e
	180	98.9a	82.66a	10.1a	13.28a

*Values followed by the same letter (s) of the alphabet, within each group, are means for each trait, and do not differ significantly from each other according to the least significant difference (LSD) method at a significance level of 0.05.

Table 5: The main effects of nitrogen and potassium fertilizer levels on N, K, chlorophyall and total sugars roots of carrot leaves and roots in the two study seasons.

N/kg ha	K/ kg ha	N	K	Chloro phyall mg/100g))	Total sugars/ Roots
Based on the dry weight of the leaves %					
First season					
0		1.325D	14.5D	3.356C	3.46D
70		1.5225C	24.2C	3.518C	5.16C
140		1.725B	28.48B	4.14B	5.75B
210		2.30A	32.9A	4.50A	7.20A
	0	1.53C	23.5D	3.8875AB	4.975D
	60	1.64BC	24. 49C	3.946A	5.13C
	120	1.75B	24.996B	3.959A	5.29A
	180	1.95A	27.22A	3.73B	6.19A
second season					
0		1.25C	14.43D	3.26C	3.39D
70		1.40C	24.1775C	3.38C	5.058B
140		1.59B	28.4295B	4.07B	5.58B
210		2.25A	32.83A	4.38A	7A
	0	1.43C	23.43D	3.775A	4.83D
	60	1.53C	24.4205C	3.8625A	5.03C
	120	1.66B	24.93B	3.81A	5.18B
	180	1.875A	27.08A	3.65B	5.98A

*Values followed by the same letter (s) of the alphabet, within each group, are means for each trait, and do not differ significantly from each other according to the least significant difference (LSD) method at a significance level of 0.05.

Table 6: The effect of the interaction between nitrogen and potassium fertilizer levels on N, K, chlorophyall and total sugars roots of carrot leaves and roots for the first agricultural season.

N/ Kg ha	K Kg/ ha	N	K	Total Chlo. (Mg/100g)	Total sugar/ Roots
% Based on the dry weight of the leaves					
0	0	1.16j	13.106m	3.40cd	3.33h
	60	1.33ij	12.88m	3.38cd	3.46h
	120	1.46gh	13. 40l	3.39cd	3.53h
	180	1.33ij	18.82k	3.28d	3.53h
70	0	1.41hi	22.852j	3.30d	4.76g
	60	1.54f-i	23.852i	3.64c	5.16f
	120	1.56 e-g	24.12i	3.58cd	5.3ef
	180	1.56e-g	26.226h	3.53cd	5.4de
140	0	1.66e-g	26.751g	4.33ab	5.5de
	60	1.73d-f	28.814f	4.22b	5.6d
	120	1.76c-f	29.037f	4.36ab	5.63d
	180	1.73d-f	29.33e	3.67c	6.26c
210	0	1.9cd	31.351d	4.50ab	6.3c
	60	1 .96d	32.409c	4.61a	6.3c
	120	2.2b	33.41b	4.49ab	6.7b
	180	3.1a	34.494a	4.43ab	9.53a

*Values followed by the same letter (s) of the alphabet, within each group, are means for each trait, and do not differ significantly from each other according to the least significant difference (LSD) method at a significance level of 0.05.

Table 7: The effect of the interaction between nitrogen and potassium fertilizer levels on N, K, chlorophyall and total sugars roots of carrot leaves and roots for the second season.

N Kg/ ha	K Kg/ ha	N	K	Total Chlo. (Mg/100g)	Total sugar/ Roots
% Based on the dry weight of the leaves					
0	0	1.06h	13.03n	3.23ef	3.3g
	60	1.26h	12.81mn	3.26ef	3.36g
	120	1.43d-g	13.284m	3.32ef	3.46g
	180	1.26gh	18.62i	3.22f	3.43g
70	0	1.33fg	22.74k	3.23ef	4.6f
	60	1.43d-g	23.717j	3.43ef	5.1e
	120	1.46d-g	24.04i	3.40ef	5.1e
	180	1.46d-g	26.20h	3.45e	5.3de
140	0	1.5d-f	26.7g	4.22bc	5.2de
	60	1.6de	28.78f	4.16c	5.4de
	120	1.63cd	29.03ef	4.23bc	5.5d
	180	1.63cd	29.2e	3.69d	6.1c

210	0	1.83c	31.28d	4.40ab	6.1c
	60	1.83c	32.37c	4.58a	6.2c
	120	2.13b	33.37b	4.30bc	6.6b
	180	3.2a	34.30a	4.26bc	9.a

*Values followed by the same letter (s) of the alphabet, within each group, are means for each trait, and do not differ significantly from each other according to the least significant difference (LSD) method at a significance level of 0.05.

Conclusion

Based on the above results, it is recommended to fertilize carrot plants with 210 kg/ha of nitrogen and 180 kg/ha of potassium to achieve the highest yield and superior quality under comparable environmental conditions.

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