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Evaluate Different Sources of Potassium on Carrot Plant Yield and Chemical Ingredients Grown On Sandy Soil Under Salt Stress

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ABSTRACT

Potassium (K) is an essential element, important for plant growth. A field experiment was carried out in the newly reclaimed desert area of Wadi El-Notron station, Beheira Governorate, Egypt (Longitude 28◦54′ E, Latitude 28◦20′ N, and Altitude 130 m). Carrot plants (*Daucus Carota* L.) It was grown in winter season 2022 and 2023. Potassium nanoparticels (K-NPs) were prepared through sub-atomic synthetic methodology technique under tension 1.5 Mpa., They were examined using a transmission electron microscope (TEM) to measure the sizes of potassium molecules. Three potassium sources, potassium 20% (K 20%) from traditional fertilizer as control treatment, potassium sulfate (K_2SO_4) and K-NPs were applied on carrot plants. This study aims to, evaluate the different sources of potassium (K) on carrot yield parameters (morphological and physiological) under salt stress conditions. Data showed that carrot yield and quality improved significantly with the use of K-NPs.

Keywords: Potassium nanoparticles, potassium sulphate, NPK fertilizers, carrot plant, foliar application, physiological and biochemical components and salt stress.

1. Introduction

1.1. Overview of Carrot Cultivation

Carrot (*Daucus carota* L.) is a one of the Umbelliferae family (Ismail *et al.,* 2023) and it is an important root vegetables are widely used in food of human whether raw or cooked. It is the ideal source of beta-carotene and is a precursor to vitamin A (Zeb and Mahmood, 2004), it is high in Riboflavin B2, Vitamin C, and Thiamin B1 (Mbatha *et al.,* 2014). Moreover, carrot also contains abundant amounts of nutrients and minerals (Handelman, 2001). Different parts of carrot plant can be used for various medical purposes, such as treating kidney diseases, in dropsy, nervine tonic and improve vision (Krinsky and Johnson, 2005).

Carrot cultivation can be a preferred option for most small-scale farmers who lack resources. Since carrots are a short-duration crop, it allows for a higher yield per unit area, making it a profitable option (Ahmad *et al.,* 2005). But in most developing countries, carrot production per unit area is still below the recommended global average. One of the main reasons for this low production is the lack of skills in using technical methods of production (Muendo and Tschirley, 2004). To obtain a high-quality crop of carrots, the soil must have good soil fertility and the roots must continue to grow continuously to facilitate the production and transfer of carbohydrates from the leaves to the roots.

1.2. Importance of Potassium (K) in Agriculture

Potassium (K) considers is a vital macronutrient essential for plant growth, development, and overall productivity, playing crucial roles in enzyme activation, osmo-regulation, and the production of carbohydrates and proteins (Kushwah *et al.,* 2019). In agriculture, potassium is recognized for its pivotal role in improving crop yield, quality, and stress tolerance. Potassium deficiency can result in reduced crop yields, poor root development, and increased susceptibility to biotic and abiotic stresses, highlighting the necessary of adequate potassium nutrition in agricultural systems (Ismail *et al.,* 2023).

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1.2. Potassium Sources

The choice of potassium source can significantly impact of carrot yield parameters, including root biomass, size distribution, and marketable yield. Potassium chloride (KCl), potassium sulfate (K2SO4), and potassium nitrate (KNO3) are commonly used potassium fertilizers in agriculture, each possessing distinct chemical properties and agronomic effects. Understanding the comparative effects of these potassium sources is essential for optimizing potassium management practices in carrot cultivation. Potassium chloride (KCl) is a widely used potassium fertilizer known for its high potassium content and rapid solubility. However, excessive chloride content in KCl may negatively affect soil health and plant growth, particularly in sensitive crops like carrots (Zhao *et al.,* 2022). Potassium sulfate (K_2SO_4) is a potassium fertilizer containing sulfur, making it suitable for soils deficient in both potassium and sulfur. It provides a readily available source of potassium without the risk of chloride toxicity, making it an attractive option for carrot cultivation (Kausar *et al.,* 2016). Potassium nitrate (KNO_3) is a compound fertilizer containing potassium and nitrogen, essential nutrients for plant growth (Ahmad *et al.,* 2022). KNO_3 promotes balanced nutrient uptake and enhances crop vigor, making it beneficial for improving carrot yield and quality (Asante *et al.,* 2019).

Nano potassium particles, due to their small size, may have increased mobility and accessibility in the soil, facilitating better uptake by carrot roots, leading to improved potassium absorption, enhanced growth, and yield.

1.4. Interactions between Potassium and Other Nutrients

Potassium interacts synergistically with other nutrients in carrot plants, influencing nutrient uptake, assimilation, and metabolism. Understanding these interactions is essential for optimizing fertilizer formulations and nutrient management practices in carrot cultivation.

Nitrogen is a primary macro-nutrient essential for plant growth, development and protein synthesis. Potassium enhances nitrogen uptake and assimilation in carrot plants, promoting vegetative growth, root development, and overall productivity. Phosphorus (P) is a key component of nucleic acids, phospholipids, and energy-rich compounds in plants. Potassium facilitates phosphorus uptake and translocation in carrot plants, enhancing root development, flowering, and fruit set. Calcium is a structural component of cell walls and membranes in plants, playing a crucial role in cell division, elongation, and signaling. Potassium improves calcium uptake and utilization in carrot plants, decreasing the incidence of physiological disorders such as internal browning and tip burn. Magnesium (Mg) is a central component of chlorophyll molecules, essential for photosynthesis and carbohydrate metabolism. Potassium enhances magnesium uptake and translocation in carrot plants, optimizing chlorophyll synthesis, carbon fixation, and biomass production. By considering these nutrient interactions, growers can develop balanced fertilizer formulations and nutrient management strategies to optimize carrot yield, quality, and overall nutritional value (Çalişkan and Çalişkan, 2018).

1.5. Environmental Considerations and Sustainability of Potassium nutrition

The environmental considerations and sustainability of potassium nutrition in carrot production are paramount, given the growing concerns regarding soil health, water quality, and ecosystem integrity. Sustainable nutrient management practices are essential for minimizing environmental impacts and promoting long-term agricultural resilience.

Soil Health and Fertility: Potassium fertilization can influence soil pH, nutrient cycling, and microbial activity, affecting soil health and fertility. Sustainable potassium management practices, such as balanced fertilization, organic amendments, and cover cropping, can enhance soil structure, nutrient availability, and biological diversity, promoting sustainable soil management and resilience.

Water quality and nutrient runoff: Excessive potassium fertilization can lead to nutrient runoff and water pollution, which poses risks to aquatic ecosystems and human health. Best management practices, such as precision agriculture, controlled-release fertilizers, and irrigation management, can mitigate nutrient losses and safeguard water quality, ensuring the environmental sustainability of potassium fertilization in carrot production.

Long-Term Effects on Ecosystems: Potassium fertilization may have long-term effects on ecosystem dynamics, including soil carbon sequestration, biodiversity conservation, and climate resilience. Sustainable agricultural practices as agro-forestry, regular tillage, and integrated nutrient management, can enhance ecosystem services and promote ecological sustainability, balancing agricultural productivity with environmental stewardship (Rawat *et al.,* 2016).

Salt stress is the main menace to yield productivity round the world, especially in arid and semi-arid regions (Moghaddam *et al.,* 2019). Salt stress Include of combination of stresses as ionic imbalance osmotic stress, Nutritional deficiency leads to poor plant growth and mainly leads to a decrease in yield (Assaha *et al.,* 2017). Salt stress conditions inhibit the efficiency of potassium (K+) absorption in plants affected by the stress (Arif *et al.,* 2020). Also, Salinity stress has a negative impact on the physiological traits of plants, such as photosynthesis, respiratory activity, chlorophyll content in leaves, seed germination rate, and other growth-related traits. (Bistgani *et al.,* 2019).

1.6. Nanotechnology

Nanotechnology, which relies on manipulating matter at the atomic or molecular level, holds tremendous promise across diverse fields. By engineering Materials and devices manufactured at the nanoscale, which typically range from 1 to 100 nanometers, provide advanced application possibilities in various fields, researchers can unlock novel properties and functionalities not present at larger scales. In agriculture, nanotechnology offers innovative solutions to address challenges such as enhancing crop productivity, improving nutrient management, and mitigating environmental impacts. For example, nano-based formulations of fertilizers and pesticides can improve nutrient uptake efficiency, reduce chemical leaching, and minimize environmental contamination. Furthermore, nanosensors and smart delivery systems enable precise monitoring and targeted delivery of agricultural inputs, optimizing resource utilization and minimizing waste. As nanotechnology continues to advance, its applications are poised to revolutionize various aspects of agriculture, paving the way for more sustainable and efficient farming practices (Qibin *et al.,* 2023).

1.7 Advantages and Disadvantages of Commercial Fertilization (Chemical fertilizers) Commercial fertilizers often referred to as chemical fertilizers, offer several advantages and disadvantages in agricultural production:

1.7.1. Advantages

Chemical fertilizers provide readily available nutrients to plants, ensuring rapid growth and increased yields. Their Formulas can be designed to meet the specific nutritional needs of different crops and soil types, allowing for precise nutrient management. Additionally, chemical fertilizers are easy to handle, store, and apply, making them a convenient option for large-scale agricultural operations. They deliver nutrients directly to plants, resulting in quick responses and visible improvements in growth and productivity. Furthermore, in some cases, chemical fertilizers can be more cost-effective than organic alternatives, especially when considering yield gains and labor savings (Alnaass, 2021).

1.7.2. Disadvantages

While chemical fertilizers offer immediate benefits in terms of nutrient availability and crop productivity, their overuse can lead to several disadvantages. Over reliance on chemical fertilizers can result in nutrient imbalances in the soil, causing deficiencies or toxicities that negatively impact plant health. Continuous use this can deteriorate soil quality due to disruption of microbial communities in the soil, reducing organic matter content, and increasing soil acidity. Additionally, excess elements from chemical fertilizers can lead to their leakage into groundwater or runoff into surface water bodies, causing eutrophication and harmful algal blooms. Many chemical fertilizers are derived from non-renewable resources, such as fossil fuels; contribute to the depletion of natural resources and environmental degradation. Although they may provide short-term productivity gains, chemical fertilizers can compromise long-term soil fertility and agricultural sustainability if not managed carefully. Balancing these advantages and disadvantages requires adopting sustainable nutrient management practices that aim to enhance benefits while minimizing harmful impacts on soil, water, and ecosystems (Alnaass, 2021).

1.8. Objective

This research aims to assess the comparative effects of potassium nanoparticels, potassium sulfate (K_2SO_4) and potassium from commercial fertilizers (N 20% P 20% K 20%) on carrot yield parameters (morphological and physiological) under salt stress conditions.

2. Material and Methods

The current study was conducted over two winter seasons (2022 and 2023) in an open field at the recently reclaimed desert area of Wadi El-Notron station, Beheira Governorate, Egypt (Longitude 28◦54′ E, Latitude 28◦20′ N, and Altitude 130 m). Before planting, physical and chemical analyses (Table 1) of the reclaimed soil were performed at the Soil, Water, and Environment Research Institute, Agriculture Research Centre (A.R.C.), Egypt, according to Richards (1954) and Jackson (1967).

Table 1: Some physical and chemical properties of experimental soil

Soil characteristics		Value	Soil characteristics		Value
Particles size distribution%:			**Soluble cations(cmole kg^{-1} soil)**		
Sand		89.60	Ca^{2+}		14.60
Clay		3.30	Na^{+}		9.20
Texture		Sandy	K^{+}		6.10
Soil chemical properties:			**Soluble anions(cmole kg^{-1} soil)**		
pH(1:2.5) soil: water suspension		7.80	CO_2^{2-}		0.00
EC ($dS.m^{-1}$)		4.30	HCO_3^-		18.2
Calcium carbonates(%)		4.14	Cl^-		10.8
Organic matter (%)		0.28	SO_4^{2-}		12.30
Available macro and micronutrients(mg kg^{-1})					
N	**P**	**K**	**Fe**	**Mn**	**B**
14.70	7.01	4620	10.60	1.60	0.22

2.1. Treatments for carrot plant

Utilizing nitrogen (N 20%), phosphorus (P 20%), and potassium (K 20%) from commercial fertilizers (compound fertilizer) as a control treatment, the study compared the effects of potassium sulfate, Nano potassium oxide, and natural composts added to all treatments at 10 t fed^{-1}. Table 2 shows the physical and chemical analysis of compost.

Table 2: Composition analysis of utilized compost.

Property	Quantity
Moisture content (%)	25
PH (1:5)	7.60
EC (1: 5 extract) dsm^{-1}	3.11
Organic-C (%)	33.12
Organic matter (%)	70.10
Total-N (%)	1.83
Total-K (%)	1.26
C/N ratio	14:1
Total-P (%)	1.30
Fe (mg kg^{-1})	1018
Mn (mg kg^{-1})	112
Cu (mg kg^{-1})	182
Zn (mg kg^{-1})	281
Total content of Bacteria ($cfu.g^{-1}$)	2.5×10^7
Phosphate dissolving Bacteria ($cfu.g^{-1}$)	2.5×10^6
Weed seeds	0

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All agricultural practices were implemented in accordance with the recommendations of the Egyptian Ministry of Agriculture, but nano-K_2O was applied by 10% of recommended dose. This approach aimed to assess the efficacy and impact of different potassium sources and combinations on crop performance and soil health.

2.2. Data recorded

Five plants were arbitrarily looked over every treatment during vegetative developing season. The accompanying information were recorded and genuinely examined.

2.3. Vegetative development boundaries

Vegetative development boundaries were assessed by measuring various parameters: plant height (cm), root length (cm), root width (cm), plant fresh weight (gm), plant dry weight (gm), photosynthesis rate, stomatal conductance, CO_2 exchange concentration, transpiration rate, and efficient use of water.

2.4. Chemical analysis

The plant herbs were desiccated in an electric oven at seventy degrees for 48 hours, and the unprocessed dry weight was gauged for each treatment herb. The raw dry materials were ground into a fine powder in an electric grinder, thoroughly mixed, and stored it in tightly sealed Pyrex glass containers for subsequent analysis of nutrients and carbohydrates.

2.5. Inorganic component

Analyses for nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), zinc (Zn), and manganese (Mn) content were conducted on fine dry plant material. The wet digestion of 0.2g plant material with sulfuric and perchloric acids was carried out according to Jackson (1973).

2.5.1. Nitrogen

The total nitrogen content of the dried material was determined using the modified micro-Kjeldahl method as described by Chapman and Pratte (1961).

2.5.2. Phosphorus

Phosphorus was resolved calorimetrically by utilizing the chlorostannous molybdophosphoric blue variety technique in sulphuric corrosive as per Jackson (1973).

2.5.3. Potassium

Potassium still up in the air by utilizing the fire photometer device (model, JENWAY PFP7) according to Jackson *et al.* (1973).

2.5.4. Zinc and Manganese

Centralization of Zn and Mn in plant tests were resolved utilizing nuclear retention spectrophotometer with air-acetylene and fuel (model, analyticjenanovAA350) according to AOAC (2012).

2.6. Organic Compounds

2.6.1. Plant pigments

Chlorophyll (A), (B), total chlorophyll and full scale carotenoids were assessed by Spectrophotometer at frequencies 663, 647 and 470 nm, according to Sumanta *et al*. (2014).

2.6.2. Determination of carbohydrates

Total sugars in plant not entirely settled by phosphor molybdic corrosive strategy as per (AOAC, 2012).

2.6.3. Total phenolic

All out phenolic items in natural product extricates were resolved spectrophotometrically as per the Folin-Ciocalteu colorimetric strategy (Singleton and Rossi 1965) in light of the fact that catechin is one of the polyphenol intensifies all out phenolic content of boiling water remove structure cucumber natural product was communicated as microgram catechin counterparts (CE)/gram.

2.6.4. Vitamins

Not entirely settled in plant new weight and assessed per 100 mL new weight. According to Katoch (2011), vitamin B1 (thiamin) was measured using a fluorometer, while vitamin C (ascorbic acid) was measured using a colorimeter.

2.6.5. Fiber

Rough fiber in carrot natural not set in stone as per AOAC (1970).

2.6.6. Synthesis of potassium nanoparticles

All indicators were of logical grade from antecedent Potassium per sulfate ($K_2S_2O_8$) and methacrylic corrosive were bought from Aldrich (Germany) and potassium chloride KCl was bought from Sigma Substance Co. St. Louis, USA. The amalgamation of potassium nanoparticles were finished utilizing (through and through sub-atomic synthetic methodology technique under tension 1.5 Mpa.) as KCl and KOH then, at that point, combined as one as molar proportion of 1:1 under energetic mixing for 8 h at 50 °C. The encourage got was sifted and washed completely with ionized water in a blended water/toluene framework utilizing a high velocity stirrer, then, at that point, Sodium hydroxide arrangement and H_2SO_4 (97%) were added gradually in a molar proportion of 1:2 under energetic mixing for 3 h, in this manner washed again with ionized water alone for 3hours, a short time later centrifuged at 1200 rpm for 40 minutes. After being dried for 24 hours in an oven at 100 degrees Celsius, the precipitate was subjected to 1.5 psi of pressure for three consecutive days for five hours per day. After being transferred to buffer solution for five hours at room temperature, the suspension was sonicated for 30 minutes at 0.5 cycles with an amplitude of 80. The size and state of nano-particles were noticed straight by Transmission Electron Microscopy (TEM) utilizing an electron speed increase voltage of 60 kV. The TEM tests were ready by dropping a couple of drops of the arrangement on a carbon-covered copper framework, the work were finished in TEM labs (Histo. Unit) in Fac. of Agric., Cairo College Research Park (FA-CURP). Potassium with grouping of 100 ppm was foliar multiple times with 10 days stretches in the wake of planting.

2.7. Potassium Nanoparticles

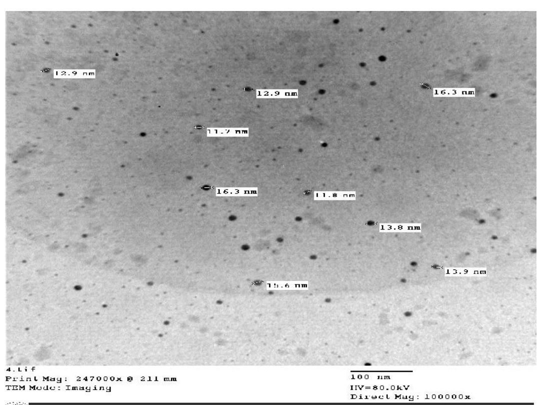

Fig. 1: TEM image of potassium nanoparticles

2.8. Statistical analysis

The exploratory plan was Randomized Finished Blocks Plan (RCBD) with ten reproduces. The information were broke down utilizing ANOVA at 5% importance level; the distinction between medicines, then, at that point, investigated utilizing DMRT (Duncan Different Reach Test) at 5%.

3. Results

3.1. Effect of some potassium sources on vegetative growth parameters

As the obtained results of both successive seasons were not significantly, their average was taken into consideration.

Data in Table (3) affirmed the outcome of all potassium sources under study with foliar method on plant growth parameters of carrot plant (*Daucus Carota* L.).

The inspected vegetative parameters were plant height, root length, root diameter, fresh and dry weight contrasted with control treatment (potassium 20% in commercial NPK fertilizer). The results appeared that the potassium nanoparticles treatment (K-NPs) significantly increased the maximum value of plant height by 24%, root length by 27%, root diameter by 36%, and fresh weight by 11%. It was remarkable that, there were insignificant outcomes recorded between potassium sulphate and control treatments in most vegetative growth parameters.

Table 3: Different sources of potassium treatments and its effects on carrot plant growth parameters

Treatment	Plant height (cm)	Root length (cm)	Root diameter (cm)	Fresh weight of root (g)	Dry weight of root (g)
NPK	33.5b	15.6b	3.3a	50.5b	7.8a
K- sulphate (K_2SO_4)	30.2b	13.8b	2.8b	48.7b	6.2b
Nano-K_2O	41.6a	19.3a	4.5a	56.3a	8.1a

Values sharing the same letter within a column are not significantly distinct as per DMRT at the 5% significance level.

3.2. Effect of some potassium sources on photosynthetic characteristics

Carrot plants (*Daucus Carota* L.) were examined to determine the effect extent of the different potassium sources under study on the photosynthesis characteristics as shown in Table (4). Indisputably made sense of that the highest level of photosynthesis rate was recorded because of K-NPs treatment application by 46%, 11.5% for stomatal conductance, 68.7% for water use productivity and 5.7% for intercellular CO_2 compared with control treatment (K 20% in commercial NPK fertilizer). On the other hand, the highest rate of transpiration (19.8%) was given from control treatment in contrasted by K-NPs treatment. In the meantime, insignificant distinction was recorded between K-sulphate and control plants in regard to photosynthesis rate, transpiration rate and water use efficiency.

Table 4: Different sources of potassium treatments and its effects on photosynthetic characteristics of carrot plant

Treatment	Photosynthetic rate ($\mu mol\ m^{-2}s^{-1}$)	Stomatal conductance ($mmol\ m^{-2}s^{-1}$)	Transpiration rate ($mmol\ m^{-2}\ s^{-1}$)	Water-use efficiency ($\mu mol\ mmol^{-1}$)	Intercellular CO_2 concentration ($mg\ kg^{-1}$)
NPK	9.38b	95.28b	4.73a	1.98b	109.37b
K- sulphate (K_2SO_4)	8.47b	88.53c	4.90a	1.73b	97.96c
Nano-K_2O	13.70a	106.21a	3.79b	3.34a	115.61a

Values in the same column sharing a letter are not significantly distinguishable based on DMRT at a 5% level of significance.

3.3. Effect of some potassium sources on biochemical ingredients and nutrient concentrations

3.3.1. Total chlorophyll, total phenolic and total carbohydrate

The data in Table (5) appeared that utilization of K-NPs lead to increase of total chlorophyll, total phenolic and total carbohydrates by 52, 20.8 and 23.5% respectively, in compare with control treatment (K 20% in commercial NPK fertilizer). Meanwhile, there was insignificant distinction between potassium sulphate treatment and control treatment in regard to total phenolic, also, the least value measured of total chlorophyll to potassium sulfate treatment in compare with control treatment.

3.3.2. Macro and micro-nutrients

Also, information associated with fixation of supplements as shown in Table (5) explained that, accommodation of K-NPs treatment altogether enrichment the supplements inside plant tissue with 18.7%, 39%, 29% and 38.5% for N, P, K and Mg, respectively. It was remarkable that no significant differences between K-NPs treatment and control treatment in terms of zinc and manganese. In addition, the potassium sulphate treatment leads to a minimum estimated value of zinc and manganese compared to the control treatment, and there were no significant differences between potassium sulphate treatment and control treatment in term of nitrogen and phosphorus.

Table 5: Different sources of potassium sources treatments and its effects on Carrot Plant chemical ingredients

Treatment	Chlorophyll content (mg/g FW)	Total phenolic (mg GAEg^{-1} DW)	Total carbohydrates %	N%	P%	K%	Mg%	Zn (ppm)	Mn (ppm)
NPK	1.30b	51.87b	10.2b	0.75b	0.069b	0.17b	0.026b	1.91a	2.03a
K- sulphate (K_2SO_4)	1.12c	49.95b	9.4c	0.70b	0.062b	0.14c	0.018c	1.86b	1.93b
Nano-K_2O	1.98a	62.66a	12.6a	0.89a	0.096a	0.22a	0.036a	1.96a	2.16a

Means with the same letter in a column are not significantly different by DMRT 5%

3.3.3 Total Carotenoids, Fiber and Ascorbic acid

Table (6) displayed that, the K-PNs treatment had a positive response to formation of total carotenoids content by 25% compared to the control treatment. In the meantime, control treatment gave total carotenoids by 10% compared to potassium sulfate treatment. About fiber content in carrot plants, application of K-NPs treatment to raise fiber content by 14.5% compared to control treatment (suggested portion of NPK), meanwhile, fiber content was irrelevantly higher than potassium sulfate treatment. The same result was found with ascorbic acid where use of K-NPs treatment to raise content of ascorbic acid by 38.6% compared to control treatment, on the other hand control treatment gave higher ascorbic acid content by 59% than potassium sulphate treatment.

Table 6: Different sources of potassium treatments and its effects on Carrot Plant Carotenoids, fiber, ascorbic and vitamins

Treatment	Total Carotenoids (mg100g^{-1} F.W)	Fiber (%)	Ascorbic acid (mg g^{-1} F.W)	Vitamin A (mg100g^{-1} F.W)	B1(Thiamine) (mg100g^{-1} F.W)
NPK	11.75b	1.79b	0.057b	361.19b	0.047b
K- sulphate (K_2SO_4)	10.52b	1.78b	0.036c	344.52b	0.043b
Nano-K_2O	14.64a	2.05a	0.079a	405.11a	0.075a

Means with the same letter in a column are not significantly different by DMRT 5%

3.3.4. Vitamins

The carrot plant content of vitamin A and Thiamine B1as displayed in Table (6) revealed that, the most elevated grouping of vitamin A was 12% occurred because of K-NPs treatment more than control treatment and 17.6% contrasted with potassium sulfate treatment, while there is no significant distinction was recorded between potassium sulfate and control treatment. Comparably, result was found with Thiamine B1, that the application of K-NPs treatment gave a value 59.6% compare with control treatment, and there in no significant deference was followed between potassium sulfate treatment and control one.

3.4. Chemical soil conditions with use of compost in carrot plant agriculture

Data in Table (7) showed that addition of compost ameliorates soil chemical characteristics, enrichment of nutrients in agricultural soil, and create the right environment for vegetation. Compost adding to soil in preparing stage, generally, lead to decrease soil pH values compared to chemical properties of experimental soil before planting (as shown in Table 1). This may be refers to acidic functional groups released during the oxidation process of compost can be responsible to decrease the soil pH (Liu and Zhang, 2012).

Concerning electric conductivity (EC), data in the same showed that a change in EC values in planting soil from 4.30 (before planting) to 4.92 dS m^{-1} (after planting) as a result of compost effect (compost EC 3.10 dS m^{-1} as found in Table 2), this agree with Wagida and Seddik (2018).

The data in Table 7 showed that also a significant increase in soil content, under study, of available macronutrients (N, P, K) as a result of addition compost. The available macronutrients content of soil under study takes this trend: N > K > P before planting with values 195 > 62 > 30 mg kg^{-1}, this depending on the soil initial content of these nutrients (Awadalla *et al.,* 2007).

Table 7: Effect of compost on some soil chemical properties after planting

Soil status	pH (1:2.5)	EC dSm^{-1}	Macronutrients availability (mg kg^{-1})		
			N	P	K
Before planting	7.80	4.30	14.70	7.01	46.20
After planting	7.21	4.92	195.00	30.00	62.00

4. Discussion

The present experiment illustrated that the values of vegetative growth measurements, including plant height, root length, root diameter, and fresh and dry weight, were examined in the plants treated with potassium nanoparticles (K-NPs) and potassium sulfate compared to potassium (K 20%) from commercial chemical fertilizer (N 20%, P 20% K 20%) as control treatment, indicating that using K-NPs showed augmentation in all vegetative growth parameters (Al-Saif et al., 2023). This improvement is the result of potassium's significant and effective role in biological and plant processes (Mahari et al., 2024). Potassium is associated with the development of water, supplements, and carbs in plant tissue and is associated with catalyst enactment, influencing protein, starch, and adenosine triphosphate (ATP) creation, which manages the pace of photosynthesis (Oosterhuis *et al.,* 2014). Additionally, it regulates the stomatal's opening and closing, which controls the exchange of water vapor, oxygen, and carbon dioxide. If deficient, it can stunt plant growth and decrease yield (White, 2010). Potassium increments root development, further develops dry spell obstruction, keeps up with turgor, lessens water misfortune and shriveling, supports photosynthesis and food arrangement, diminishes breath forestalling energy misfortunes, improves movement of sugars and starch, produces grain wealthy in starch, increments plant protein content, forms cellulose decreasing housing, and assists impede with trimming sicknesses (Hu *et al.,* 2016).

The formed organic acids of compost create a suitable environment for solubilization of nutrients (Nada, 2011). Application of compost to sandy calcareous soil enrichment of available N, P and K in the soil after planting, while the pH values of lightly decreased (Mohamed *et al.,* 2008). Abdel-Aziz (2010) decided that, the mean values elevated of available N, P and K were due to addition of compost. El-Gamal (2015) stated that application of compost in soil boost Improvement contents of available N, P and K in planting soil. Soils with unsuitable environmental conditions for agriculture, such as sandy, calcareous, and newly reclaimed soils with poor productivity, adding compost to the soil improves its chemical properties.

Although, soils contain a large supply of total potassium, only small amounts are available for plant growth at any time due to most potassium being in the structural component of soil minerals. The amount of potassium supplied by soils varies greatly due to differences in soil parent materials and weathering effects. Three forms of potassium, unavailable, slowly available or fixed, and readily available or exchangeable exist in equilibrium in the soil system, with the majority found in the crystalline-insoluble form (Oosterhuis *et al.,* 2014). Over long periods, these minerals weather and release potassium too slowly to meet field crops' full needs, with fixed potassium being trapped between clay layers. Growing plants cannot use much fixed potassium during a single season, and it is not measured by routine soil-testing procedures but can serve as a reservoir for readily available potassium. The amount of fixed potassium varies with the type of clay in the soil. Potassium is the most abundant inorganic cation, crucial for optimal plant growth, activating important enzymes like those for protein synthesis, sugar transport, and photosynthesis, playing a significant role in yield formation and quality improvement (Sardans and Peñuelas, 2021). Potassium stimulates ATPase in the plasma membrane, triggering cell wall loosening and hydrolase activation, promoting cell growth, and regulating osmotic pressure and cation-anion balance in the cytoplasm (Hu *et al.,* 2016). Studies have shown that potassium affects the absorption and utilization of other nutrients by plants, with interactions between potassium and nitrogen being particularly significant (Tränkner *et al.,* 2018). The highest number of micro-shoots was formed by using K-NPs, with a significant difference compared with the control treatment (Amal *et al.,* 2024). Amino acid and protein synthesis are boosted and carbon metabolism is influenced by adequate potassium intake (Praveen and Singh, 2023). According to Hasanuzzaman *et al.* (2018), the regulation of membrane potential, osmoregulation, sugar transport, stress adaptation, and the maintenance of enzyme activity, photosynthesis, and stomatal control under stress are all dependent on potassium. It maintains chlorophyll, protects plasma membranes, and scavenges reactive oxygen species (ROS) to help plants withstand abiotic stress (Mohamed *et al.,* 2020). Potassium improves plant responses to salt stress by increasing antioxidant activity and competes with sodium to retain water (Kumar *et al.,* 2020). Recently, the application of nanoparticles in soil-plant nutrition has been proposed to achieve sustainable agricultural development with minimal environmental threats (Mahmoud *et al.,* 2020). Nanoparticles, with diameters of 0-100 nm and large surface areas, offer special functions due to the quantum size effect and dielectric confinement, providing new directions for agricultural production and development (Chen and Yada, 2011).

Potassium nanoparticles has been suggested to confer enhanced stress tolerance in plants, potentially resulting in higher yield and quality, while also stimulating root growth and development, leading to increased nutrient uptake, better water absorption and overall improved plant health. Furthermore, potassium nanoparticles may regulate various physiological processes in carrot, such as photosynthesis, enzyme activity, and hormone synthesis, optimizing these processes lead to increase biomass accumulation and yield parameters. Compared to conventional potassium fertilizers, potassium nanoparticles formulations may offer advantages such as reduced leaching and runoff, better utilization by carrot plants, and minimized environmental contamination (Qibin *et al.,* 2023). Use of K-NPs as fertilizer have been successful for better nutrition of crops compared to the commercial fertilizers and use of K-NPs as foliar spray application on plants by 10% of recommended dose lead to reduced losses of available potassium loss through soil (Eman *et al.,* 2021). Application of nanotechnology on crop plants fertilization due to improve plant growth, yield quality and quantity and rationalize of fertilizers using (Eman *et al.,* 2021).

5. Conclusions

Could be concluded that, use of potassium nanoparticals (K-NPs) led to a significant role in enhancing morphological performance, physiological characteristics, nutritional condition and yield productivity on carrot plant (*Daucus Carota* L.). This result is due to different behavior of potassium nanoparticles from traditional sources of potassium fertilizers used in the farm. Therefore, it is recommended to use potassium nanoparticles in reclaimed and old soils to obtain the best quality and yield productivity. Also, the use of potassium nanoparticles leads to mitigate stress conditions on plants, rationalizing the economic cost and reducing the harmful environmental impact on living organisms.

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