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Effects of Various Organic Fertilizer Sources and External Applications of Potassium Fulvate and Potassium Citrate on the Yield and Quality of Two Barley Varieties Grown under Salt Affected Soil

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ABSTRACT

The expansion of barley cultivation in Egypt is essential due to its strategic importance, particularly under saline conditions where the studied soil has an electrical conductivity (EC) value of 7.3 dSm^{-1}.To investigate optimal cultivation practices, a field experiment was conducted to evaluate the performance of two barley varieties (Giza 123 and Giza 132) and the impact of different organic fertilizers (chicken manure (ChM), farmyard manure (FYM), and compost) along with foliar applications of potassium fulvate and potassium citrate. Various growth and yield parameters were measured, including plant height, fresh and dry weights, leaf area, chlorophyll content, carotene content, grain yield, straw yield, biological yield, and grain nutrient content (N, P, K). Results demonstrated that the Giza 123 variety outperformed Giza 132 in all measured parameters. Among the organic fertilizers, compost proved to be the most effective, followed by ChM and FYM. Foliar application of potassium fulvate resulted in the highest values for all studied parameters, with potassium citrate being the next most effective, surpassing the control (tap water). The combination of sowing Giza 123, fertilizing with compost, and spraying with potassium fulvate yielded the best overall results. The future outlook suggests focusing on the Giza 123 variety and enhancing organic fertilization practices with compost and potassium fulvate application to improve barley yield and quality under salinity stress. Recommendations include further research into optimizing fertilizer combinations and application methods to sustain and increase barley production in saline environments.

***Keywords**:* Chicken manure,Farmyard manure, Compost

INTRODUCTION

The selection of crop varieties that can withstand environmental stresses such as soil salinity is crucial for the development of sustainable agricultural strategies (Chikha *et al.* 2016). Salinity poses a significant threat to crop productivity, particularly in arid and semi-arid regions such as Egypt where irrigation practices and soil characteristics often lead to salt accumulation (Jamshidi and Javanmard, 2018). Barley (*Hordeum vulgare* L.), a staple cereal crop with considerable economic and nutritional value, is relatively salt-tolerant compared to other cereals, making it an ideal candidate for cultivation in saline environments (Abo El-Ezz *et al.* 2020). The identification and utilization of barley varieties that exhibit enhanced resistance to salinity is vital for ensuring food security and maintaining agricultural productivity in affected areas (El-Hadidi *et al.* 2020; El-Shamy *et al.* 2022; Soudy *et al.* 2024).

Organic fertilization plays a fundamental role in enhancing plant resilience to salinity. Organic fertilizers improve soil structure, enhance microbial activity, and increase the availability of essential nutrients, thereby promoting better plant growth and yield under stress conditions. Among organic fertilizers, farmyard manure (FYM), compost, and chicken manure (ChM) are commonly used due to their nutrient-rich composition and beneficial effects on soil health (Seadh *et al.* 2021; Ghazi *et al.* 2022).

Farmyard manure (FYM), composed of decomposed livestock manure and bedding, enriches the soil with organic matter and nutrients, improving water retention and soil aeration. Compost, derived from the aerobic decomposition of organic waste, is an excellent soil conditioner that supplies a balanced mix of macro- and micronutrients, enhances soil microbial activity, and improves soil structure. Chicken manure (ChM) is particularly high in nitrogen, phosphorus, and potassium, making it a potent fertilizer that boosts plant growth and productivity (El-Sherpiny and Faiyad, 2023; Elsherpiny *et al.* 2023).

In addition to organic fertilization, the foliar application of potassium (K) has shown promising results in mitigating the adverse effects of salinity on plants. Potassium is an essential macronutrient that plays a critical role in osmotic regulation, enzyme activation, and the synthesis of proteins and starch. Foliar spraying with potassium compounds, such as potassium fulvate and potassium citrate, can enhance nutrient uptake, improve water use efficiency, and strengthen the plant's defense mechanisms against salinity stress. Potassium fulvate, a bioactive compound derived from humic substances, enhances nutrient absorption and stimulates plant growth by improving cell permeability and metabolic processes. Its application has been associated with increased chlorophyll content, better root development, and higher overall plant vigor. Potassium citrate, a water-soluble form of potassium, facilitates rapid absorption and utilization by plants, leading to improved physiological functions and stress tolerance (El-Sherpiny *et al.* 2022; Soliman *et al.* 2022; EL-Metwally *et al.* 2023).

Given the importance of barley as a crop, the objective of this study is to evaluate the performance of two barley varieties under saline conditions and to assess the impact of different organic fertilizers and foliar applications

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of various potassium sources on growth, yield, and nutrient content. The findings aim to identify optimal cultivation practices that can enhance barley productivity and resilience in saline environments, contributing to sustainable agricultural development in Egypt and similar regions.

MATERIALS AND METHODS

1. Experimental Site

The trial was conducted during the agricultural seasons of 2022/23 and 2023/24 at a private farm located in Met Antar village, Talkha district, El-Dakahlia Governorate, Egypt to evaluate the performance of two barley varieties and the impact of different organic fertilizers and foliar potassium applications under saline conditions.

2.Experimental Treatments

Barley varieties:

a) Giza 123
b) Giza 132

Organic fertilizers:

a) Chicken Manure (ChM) at rate of 15 m^3 fed^{-1} (it was added at month before sowing).
b) Farmyard Manure (FYM) at rate of 15 m^3 fed^{-1} (it was added at month before sowing).
c) Compost (plant resedues such as rice straw and wheat straw) at rate of 15 m^3 fed^{-1} (it was added at month before sowing).

Foliar potassium applications:

a) Control (without)
b) Potassium fulvate (at rate of $3gL^{-1}$), it was applied as a foliar spray three times at 10-day intervals. The first application was made 40 days after sowing, with a total spray volume of 400 L fed^{-1}.
c) 3.Potassium citrate (at rate of $3gL^{-1}$), it was applied as a foliar spray three times at 10-day intervals. The first application was made 40 days after sowing, with a total spray volume of 400 L fed^{-1}.

3. Soil and Fertilizer Properties

The soil at the experimental site was characterized by an electrical conductivity (EC) of 7.3 dSm^{-1}, indicating saline conditions. The chemical properties of the soil and organic fertilizers used in the study are as follows using the standard methods described by Dane and Topp (2020) and Sparks *et al.* (2020):

Soil characteristics:

It have EC value of 7.3 dSm^{-1},pH value of 7.8, Organic matter value of 1.35%, available N value of 45 mg kg^{-1}, available P value of 9.0 mg kg^{-1} and available K value of 210 mg kg^{-1}.

Chicken manure (ChM) characteristics:

It have total N of 3.1%, total P value of 1.5%, total K value of 1.2% and organic matter value of 60%.

Farmyard Manure (FYM):

It have total N of 0.06 %, total P value of 0.3%, total K value of 0.5% and organic matter value of 45%.

Compost:

It have total N of 2.9 %, total P value of 1.6 %, total K value of 1.85% and organic matter value of 50 %.

4. Experimental Procedure

The field experiment was laid out in a split-splite-plot design with three replications. The main plots were assigned to the two barley varieties, while the sub-plots received the organic fertilizer treatments and the sub sub main factor was the foliar potassium applications. Planting date was November 29 for both seasons. Irrigation was performed seven times throughout the growing period. Each sub sub plot measured 3 × 2 meters. Mineral fertilizers (nitrogen, phosphorus, and potassium) were applied, and other agricultural practices, such as weed, insect, and fungal disease control, were carried out according to the guidelines of the Ministry of Agriculture and Soil Reclamation in Egypt. Harvesting took place on May 20 of each season.

5. Growth and Yield Measurements

Various growth and yield parameters were measured at different growth stages:

At 70 days from sowing:

Plant height (cm), fresh weight (g/plant),dry weight (g/plant),leaf area (cm²/plant) and chlorophyll content (SPAD) were measured. Additinaly, carotene content (mg/g) was determinded according to the method described by Dere *et al.* (1996). Leaf nutrient content, including N (%), P (%), K (%) following the method outlined by Walinga *et al.* (2013).

At harvest:

Spike length (cm),spike weight (g),weight of 1000 grains (g), number of grains per spike,grain yield (ton/hectare),straw yield (ton/hectare),biological yield (ton/hectare) and harvest index (%) were measured. Also, grain quality parameters ,including N (%), P (%), K (%), carbohydrates (%), protein (%) according to AOAC (2000).

6.Statistical Analysis

The collected data were subjected to analysis of variance (ANOVA) following the methodology described by Gomez and Gomez (1984). The statistical analysis was performed using the CoStat computer software package (Version 6.303, CoHort, USA, 1998–2004). The significance of differences between means was determined using the least significant difference (LSD) test at a 5% probability level.

RESULTS AND DISCUSSIONS

1. Performance at a Period of 70 Days from Sowing

Table 1 details the effects of different organic fertilizers [farmyard manure (FYM), Chicken Manure (ChM) and Compost] and potassium sources [control, potassium fulvate, and potassium citrate] on the growth performance of two barley varieties (Giza 123 and Giza 132) at 70 days after sowing during the 2022/23 and 2023/24 seasons. The growth parameters measured include plant height, fresh weight, dry weight, and leaf area. Giza 123 significantly outperformed Giza 132 in all growth parameters across both seasons. Compost resulted in the highest values for plant height, fresh weight, dry weight, and leaf area, followed by ChM, with FYM being the least effective. Potassium fulvate led to the highest growth parameters, followed closely by Potassium Citrate, with the control treatment showing the lowest values. The combination of Giza 123, compost, and potassium fulvate achieved the best growth performance, indicating a synergistic effect.

The superior performance of Giza 123 over Giza 132 can be attributed to its genetic potential for better growth under saline conditions. Previous studies have shown that certain barley varieties have enhanced tolerance to salinity, which translates into better growth and yield parameters

(Chikha *et al.* 2016; Jamshidi and Javanmard, 2018). The effectiveness of compost in improving growth parameters is likely due to its higher nutrient content and better improvement of soil structure compared to FYM and ChM. Compost is known to enhance soil organic matter and microbial activity, leading to improved nutrient availability and uptake (Seadh *et al.* 2021; Ghazi *et al.* 2022).

Potassium fulvate's superior performance could be attributed to its role in improving nutrient uptake and stress tolerance. Fulvic acids in potassium fulvate enhance the absorption of nutrients and improve plant resilience under stress conditions, including salinity. Potassium citrate also provided significant benefits, likely due to its role in osmotic adjustment and ion balance in plants under salinity stress (El-Sherpiny *et al.* 2022; Soliman *et al.* 2022; EL-Metwally *et al.* 2023).

Table 2 outlines the effects of the same treatments as in Table 1 on photosynthetic pigments (chlorophyll and carotene) and chemical constituents (nitrogen, phosphorus, and potassium content) in the leaves of the two barley varieties at 70 days after sowing. Giza 123 consistently showed higher values for chlorophyll, carotene, and nutrient content (N, P, K) compared to Giza 132. Compost again led to the highest levels of photosynthetic pigments and nutrient content, followed by ChM and FYM. Potassium fulvate resulted in the highest levels of chlorophyll, carotene and nutrient content, with Potassium citrate also showing significant improvements over the control. The combination of Giza 123, compost, and potassium fulvate achieved the highest values for photosynthetic pigments and nutrient content.

Higher chlorophyll and carotene content in Giza 123 suggests its better photosynthetic efficiency and stress tolerance under saline conditions. Enhanced photosynthetic pigments are crucial for maintaining plant growth and productivity under stress (Jamshidi and Javanmard, 2018). The superior performance of compost in enhancing photosynthetic pigments and leaf nutrient content aligns with its high nutrient availability and soil conditioning properties, which improve overall plant health and nutrient uptake(El-Sherpiny and Faiyad, 2023; Elsherpiny *et al.* 2023). Potassium fulvate's role in enhancing photosynthetic pigments and nutrient content can be linked to its ability to improve nutrient solubility and uptake, thus supporting better plant metabolic functions. The observed benefits of potassium citrate can be attributed to its role in improving osmotic regulation and ion homeostasis in plants, essential for maintaining metabolic activities under saline stress (Soliman *et al.* 2022; EL-Metwally *et al.* 2023).

Table 1. Effect of organic fertilizers and different potassium sources on growth performance of two barley varieties grown under salt affected soil at 70 days after sowing during the season of 2022/23 and 2023/24

Treatments			Plant height cm		Fresh weight g/plant		Dry weight g/plant		Leaf area cm^2/plant	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd
Main										
Giza 132			89.23b	91.94b	46.15b	47.10b	14.07b	14.34b	136.49b	138.94b
Giza 123			108.06a	110.98a	54.98a	55.37a	17.71a	17.98a	159.22a	161.09a
LSD at 5%			1.02	1.88	0.84	1.24	0.62	0.55	3.77	4.24
Sub										
FYM			93.18c	96.19c	46.80c	47.72c	14.34c	14.64c	139.64c	141.88c
ChM			98.15b	101.19b	50.43b	51.48b	16.08b	16.40b	148.77b	151.32b
Compost			104.61a	107.00a	54.46a	54.52a	17.24a	17.44a	155.17a	156.85a
LSD at 5%			0.81	0.48	0.26	0.36	0.27	0.13	1.13	1.30
Sub sub										
Control			96.55c	99.48b	48.99c	49.93c	15.49b	15.77c	144.56c	146.81c
Potassium citrate			99.30b	102.07a	50.71b	51.16b	15.94a	16.21b	148.43b	150.83b
Potassium fulvate			100.08a	102.83a	52.00a	52.62a	16.22a	16.50a	150.59a	152.42a
LSD at 5%			0.71	0.89	0.46	0.42	0.29	0.14	1.48	1.13
Interaction										
Giza 132	FYM	Control	81.02	83.94	40.26	41.09	11.36	11.61	123.51	125.20
		Potassium citrate	84.22	86.84	41.29	42.10	11.88	12.09	124.81	127.03
		Potassium fulvate	86.05	88.58	43.99	44.72	12.38	12.66	126.54	128.56
	ChM	Control	86.68	89.24	44.06	44.98	13.71	13.99	127.80	129.91
		Potassium citrate	87.92	90.47	47.52	48.37	14.41	14.65	141.26	143.96
		Potassium fulvate	88.00	90.64	49.04	50.11	14.92	15.25	143.91	146.71
	Compost	Control	95.71	98.78	49.08	50.08	15.72	16.02	145.39	148.24
		Potassium citrate	96.74	99.49	49.68	50.84	16.10	16.41	146.66	149.36
		Potassium fulvate	96.74	99.44	50.39	51.62	16.12	16.39	148.57	151.50
Giza 123	FYM	Control	97.76	100.71	51.19	52.11	16.21	16.52	150.41	152.57
		Potassium citrate	104.53	107.86	52.00	53.10	17.03	17.37	155.34	158.08
		Potassium fulvate	105.49	109.23	52.08	53.17	17.19	17.61	157.21	159.86
	ChM	Control	106.49	109.56	52.30	53.50	17.67	18.06	158.13	161.11
		Potassium citrate	109.39	113.11	53.44	54.52	17.81	18.16	159.82	162.59
		Potassium fulvate	110.39	114.12	56.24	57.38	17.93	18.27	161.71	163.63
	Compost	Control	111.63	114.68	57.05	57.83	18.30	18.43	162.11	163.81
		Potassium citrate	113.01	114.64	60.31	58.01	18.41	18.59	162.68	163.92
		Potassium fulvate	113.82	114.96	60.26	58.71	18.80	18.79	165.60	164.26
LSD at 5%			1.74	2.19	1.12	1.03	0.73	0.34	3.65	2.76

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

Table 2. Effect of organic fertilizers and different potassium sources on photosynthetic pigments and leaves chemical constituents of two barley varieties grown under salt affected soil at 70 days after sowing during the season of 2022/23 and 2023/24

Treatments			Chlorophyll SPAD		Carotene $mg.g^{-1}$		N %		P %		K %	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Main												
Giza 132			37.02b	37.73b	0.286b	0.297b	2.83b	2.98b	0.326b	0.339b	2.71b	2.77b
Giza 123			40.06a	40.85a	0.339a	0.349a	3.37a	3.54a	0.377a	0.397a	3.31a	3.35a
LSD at 5%			0.29	0.93	0.008	0.004	0.09	0.05	0.002	0.002	0.01	0.05
Sub												
FYM			37.44c	38.20c	0.292c	0.304c	2.94c	3.09c	0.335c	0.347c	2.80c	2.85c
ChM			38.60b	39.34b	0.311b	0.323b	3.11b	3.26b	0.353b	0.368b	3.02b	3.09b
Compost			39.59a	40.32a	0.334a	0.342a	3.27a	3.44a	0.368a	0.389a	3.22a	3.24a
LSD at 5%			0.38	0.31	0.004	0.004	0.02	0.02	0.006	0.005	0.02	0.02
Sub Sub												
Control			38.17b	38.92b	0.307c	0.317c	3.06c	3.21c	0.347c	0.361c	2.94c	2.99c
Potassium citrate			38.53b	39.21b	0.313b	0.324b	3.10b	3.26b	0.351b	0.366b	3.01b	3.05b
Potassium fulvate			38.93a	39.73a	0.317a	0.329a	3.16a	3.32a	0.358a	0.376a	3.09a	3.14a
LSD at 5%			0.37	0.40	0.002	0.003	0.03	0.03	0.002	0.003	0.03	0.03
Interaction												
Giza 132	FYM	Control	35.13	35.84	0.261	0.271	2.63	2.78	0.304	0.313	2.40	2.45
		Potassium citrate	35.77	36.44	0.268	0.278	2.66	2.79	0.307	0.315	2.54	2.58
		Potassium fulvate	36.19	36.96	0.272	0.283	2.70	2.83	0.314	0.323	2.57	2.62
	ChM	Control	36.29	36.99	0.279	0.290	2.77	2.91	0.318	0.333	2.67	2.73
		Potassium citrate	36.96	37.55	0.287	0.298	2.81	2.95	0.328	0.340	2.74	2.79
		Potassium fulvate	37.86	38.62	0.293	0.305	2.91	3.06	0.334	0.349	2.81	2.87
	Compost	Control	38.15	38.91	0.300	0.313	2.94	3.08	0.339	0.353	2.84	2.90
		Potassium citrate	38.25	38.95	0.304	0.317	3.02	3.19	0.340	0.357	2.88	2.94
		Potassium fulvate	38.62	39.29	0.308	0.321	3.07	3.23	0.355	0.368	2.98	3.03
Giza 123	FYM	Control	38.87	39.64	0.314	0.327	3.15	3.31	0.358	0.372	3.02	3.08
		Potassium citrate	39.30	40.00	0.318	0.332	3.23	3.38	0.361	0.377	3.07	3.13
		Potassium fulvate	39.39	40.33	0.322	0.336	3.26	3.43	0.365	0.380	3.19	3.26
	ChM	Control	39.97	40.81	0.328	0.341	3.34	3.51	0.375	0.390	3.25	3.32
		Potassium citrate	40.09	40.89	0.337	0.351	3.35	3.50	0.377	0.394	3.29	3.36
		Potassium fulvate	40.45	41.19	0.342	0.355	3.46	3.62	0.385	0.402	3.38	3.44
	Compost	Control	40.60	41.34	0.360	0.361	3.50	3.65	0.387	0.409	3.47	3.47
		Potassium citrate	40.83	41.44	0.362	0.366	3.51	3.72	0.391	0.416	3.53	3.51
		Potassium fulvate	41.07	41.99	0.368	0.375	3.57	3.78	0.396	0.433	3.62	3.60
LSD at 5%			0.92	0.97	0.005	0.007	0.07	0.07	0.005	0.007	0.07	0.07

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

2.Yield and Grain Quality

Data presented in Tables 3, 4, and 5 illustrate the impact of different treatments on the yield components, overall yield, and grain quality of two barley varieties (Giza 132 and Giza 123) grown in salt-affected soil over the 2022/23 and 2023/24 seasons.

The yield components measured include spike length, spike weight, weight of 1000 grains, and the number of grains per spike (Table 3). Giza 123 consistently outperformed Giza 132 in all measured yield components across both seasons. Compost showed the highest values for all yield components compared to Farmyard Manure (FYM) and Chicken Manure (ChM).Potassium fulvate resulted in the highest values for spike length, spike weight, and 1000 grain weight, while the control had the lowest values.Previous studies have shown that barley varieties exhibit different tolerances to saline conditions, influencing their yield components. Giza 123's superior performance can be attributed to its genetic traits that confer better salt tolerance. Organic fertilizers like compost improve soil structure and nutrient availability, enhancing plant growth and yield. Potassium fulvate, known for its high bioavailability, improves nutrient uptake and stress resistance in plants**.**

Table 4 presents data on the grain yield, straw yield, biological yield, and harvest index of two barley varieties treated with various treatments of organic fertilizers and potassium sources. Giza 123 exhibited notably higher grain yield, straw yield, biological yield, and harvest index compared to Giza 132. Among the organic fertilizers, compost yielded the highest results, followed by ChM and FYM. Similarly, potassium fulvate treatments yielded the highest values for both yield and harvest index followed by potassium citrate, while the control treatments demonstrated the lowest performance. The superior performance of Giza 123 in terms of yield components aligns with its overall higher productivity under saline conditions. Organic fertilizers, particularly compost, play a pivotal role in enhancing soil fertility and water retention, essential factors in saline environments. Additionally, potassium fulvate enhances plant metabolism and stress tolerance, thereby contributing to increased yields**.**

Table 5 shows the effects of the treatments on grain quality parameters, including nitrogen (N), phosphorus (P), potassium (K) content, carbohydrate content, and protein content of the barley varieties. Giza 123 had higher N, P, K, carbohydrate, and protein contents compared to Giza 132. Compost led to the highest nutrient and protein content, followed by ChM and FYM. Potassium fulvate improved nutrient and protein content the most, with control treatments having the lowest values.

Table 3. Effect of organic fertilizers and different potassium sources on yield components of two barley varieties grown under salt affected soil at harvest stage during the season of 2022/23 and 2023/24

Treatments			Spike length cm		Spike weight g		Weight of 1000 grain g		No. grain/spike	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd
Main										
Giza 132			16.44b	16.94b	3.82b	3.99b	47.55b	48.69b	52.52b	53.67b
Giza 123			19.09a	19.71a	5.50a	5.75a	52.87a	54.11a	57.63a	57.85a
LSD at 5%			0.69	0.33	0.22	0.04	1.24	0.03	1.26	1.59
Sub										
FYM			16.92c	17.46	4.14c	4.31c	48.61c	49.71c	53.33c	54.33b
ChM			17.74b	18.28	4.72b	4.92b	50.38b	51.53b	54.83b	55.83a
Compost			18.65a	19.23	5.13a	5.38a	51.65a	52.97a	57.06a	57.11a
LSD at 5%			0.14	0.33	0.08	0.05	0.39	0.76	0.94	1.44
Sub sub										
Control			17.49c	18.02b	4.48c	4.67c	49.64c	50.84c	54.67b	55.22a
Potassium citrate			17.75b	18.30ab	4.66b	4.87b	50.20b	51.37b	55.00ab	55.83a
Potassium fulvate			18.07a	18.65b	4.84a	5.06a	50.80a	52.00a	55.56a	56.22a
LSD at 5%			0.16	0.36	0.09	0.05	0.50	0.39	0.81	n.s
Interaction										
Giza 132	FYM	Control	15.18	15.68	3.04	3.16	45.22	46.28	50.67	51.33
		Potassium citrate	15.58	16.04	3.23	3.37	45.86	46.73	51.00	52.67
		Potassium fulvate	15.77	16.24	3.39	3.55	46.53	47.61	51.33	53.00
	ChM	Control	15.88	16.34	3.60	3.75	46.86	47.82	51.67	53.33
		Potassium citrate	16.17	16.64	3.79	3.94	47.26	48.49	52.00	53.67
		Potassium fulvate	16.88	17.39	4.09	4.29	48.34	49.27	53.33	54.00
	Compost	Control	17.27	17.82	4.26	4.44	48.76	50.21	53.67	54.33
		Potassium citrate	17.49	17.98	4.42	4.61	49.32	50.61	54.33	55.00
		Potassium fulvate	17.79	18.30	4.61	4.79	49.81	51.22	54.67	55.67
Giza 123	FYM	Control	17.98	18.53	4.77	4.95	50.43	51.60	55.33	56.00
		Potassium citrate	18.39	18.99	5.11	5.32	51.47	52.59	55.67	56.33
		Potassium fulvate	18.59	19.25	5.29	5.52	52.16	53.46	56.00	56.67
	ChM	Control	18.91	19.43	5.46	5.68	52.69	54.00	57.00	57.67
		Potassium citrate	19.09	19.72	5.62	5.84	53.31	54.54	57.33	58.00
		Potassium fulvate	19.51	20.14	5.75	6.01	53.80	55.03	57.67	58.33
	Compost	Control	19.70	20.31	5.77	6.06	53.89	55.12	59.67	58.67
		Potassium citrate	19.78	20.43	5.82	6.17	53.97	55.26	59.67	59.33
		Potassium fulvate	19.88	20.56	5.89	6.22	54.14	55.40	60.33	59.67
LSD at 5%			0.39	0.89	0.21	0.12	1.23	0.95	1.99	2.58

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

Table 4. Effect of organic fertilizers and different potassium sources on yield of two barley varieties grown under salt affected soil at harvest stage during the season of 2022/23 and 2023/24

Treatments			Grain yield (ton/hectare)		straw yield (ton/hectare)		Biological yield (ton/hectare)		Harvest index %	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd
Main										
Giza 132			4.27b	4.34b	6.80b	6.85b	11.07b	11.19b	38.50b	38.71b
Giza 123			5.53a	5.58a	7.80a	7.84a	13.34a	13.43a	41.46a	41.57a
LSD at 5%			0.05	0.17	0.11	0.29	0.16	0.46	0.17	0.17
Sub										
FYM			4.55c	4.59c	6.99c	7.05c	11.54c	11.64c	39.23c	39.28c
ChM			4.94b	4.99b	7.33b	7.36b	12.26b	12.34b	40.11b	40.24b
Compost			5.21a	5.30a	7.59a	7.63a	12.81a	12.93a	40.59a	40.89a
LSD at 5%			0.05	0.04	0.05	0.03	0.07	0.04	0.29	0.25
Sub sub										
Control			4.77c	4.82c	7.20c	7.24c	11.97c	12.06c	39.71b	39.83b
Potassium citrate			4.89b	4.97b	7.31b	7.34b	12.20b	12.32b	39.93ab	40.22a
Potassium fulvate			5.03a	5.08a	7.41a	7.46a	12.44a	12.54a	40.29a	40.37a
LSD at 5%			0.05	0.04	0.07	0.05	0.07	0.07	0.39	0.27
Interaction										
Giza 132	FYM	Control	3.82	3.85	6.40	6.43	10.22	10.28	37.37	37.45
		Potassium citrate	3.92	3.99	6.49	6.53	10.41	10.52	37.63	37.92
		Potassium fulvate	4.04	4.04	6.56	6.60	10.60	10.64	38.08	37.96
	ChM	Control	4.15	4.20	6.64	6.69	10.79	10.89	38.48	38.60
		Potassium citrate	4.22	4.23	6.76	6.75	10.97	10.98	38.43	38.53
		Potassium fulvate	4.41	4.45	6.97	7.05	11.38	11.50	38.74	38.69
	Compost	Control	4.50	4.56	7.06	7.11	11.56	11.68	38.90	39.08
		Potassium citrate	4.58	4.79	7.13	7.18	11.72	11.97	39.12	40.04
		Potassium fulvate	4.75	4.90	7.21	7.31	11.97	12.21	39.72	40.14
Giza 123	FYM	Control	4.92	4.96	7.29	7.34	12.21	12.30	40.27	40.34
		Potassium citrate	5.21	5.28	7.55	7.63	12.77	12.91	40.84	40.89
		Potassium fulvate	5.37	5.43	7.66	7.76	13.03	13.19	41.20	41.16
	ChM	Control	5.52	5.57	7.77	7.83	13.29	13.40	41.51	41.56
		Potassium citrate	5.61	5.70	7.86	7.89	13.47	13.60	41.64	41.95
		Potassium fulvate	5.72	5.77	7.94	7.92	13.67	13.69	41.88	42.14
	Compost	Control	5.74	5.79	8.01	8.01	13.75	13.80	41.75	41.97
		Potassium citrate	5.80	5.85	8.04	8.08	13.84	13.93	41.93	41.99
		Potassium fulvate	5.89	5.90	8.11	8.11	14.00	14.01	42.09	42.12
LSD at 5%			0.12	0.10	0.18	0.13	0.18	0.17	0.96	0.67

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

Table 5. Effect of organic fertilizers and different potassium sources on grain quality of two barley varieties grown under salt affected soil at harvest stage during the season of 2022/23 and 2023/24

Treatments			N %		P %		K %		Carbohydrates %		Protein %	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Main												
Giza 132			1.53	1.60b	0.183b	0.190b	1.88b	1.96b	60.97b	62.83b	8.81b	9.18b
Giza 123			2.19	2.30a	0.249a	0.258a	2.40a	2.51a	70.33a	72.73a	12.61a	13.21a
LSD at 5%			0.02	0.07	0.004	0.003	0.11	0.03	2.60	0.35	0.13	0.42
Sub												
FYM			1.66c	1.74c	0.191c	0.198c	1.92c	2.00c	62.09c	64.09c	9.52c	10.02c
ChM			1.83b	1.90b	0.219b	0.227b	2.15b	2.26b	65.18b	67.22b	10.54b	10.94b
Compost			2.10a	2.20a	0.239a	0.247a	2.35a	2.44a	69.69a	72.03a	12.08a	12.63a
LSD at 5%			0.05	0.03	0.003	0.001	0.03	0.03	0.54	0.20	0.28	0.20
Sub Sub												
Control			1.80b	1.88c	0.206c	0.213c	2.08c	2.16c	64.58b	66.65c	10.32b	10.82c
Potassium citrate			1.85b	1.94b	0.219b	0.226b	2.14b	2.23b	65.17b	67.29b	10.65b	11.16b
Potassium fulvate			1.94a	2.02a	0.224a	0.232a	2.20a	2.30a	67.20a	69.40a	11.17a	11.61a
LSD at 5%			0.06	0.04	0.001	0.002	0.04	0.04	0.59	0.19	0.36	0.20
Interaction												
Giza 132	FYM	Control	1.20	1.25	0.140	0.145	1.51	1.57	54.20	55.96	6.92	7.19
		Potassium citrate	1.23	1.33	0.152	0.158	1.58	1.65	54.77	56.53	7.09	7.63
		Potassium fulvate	1.26	1.37	0.155	0.161	1.67	1.74	55.16	56.85	7.25	7.86
	ChM	Control	1.29	1.40	0.158	0.164	1.79	1.87	55.42	57.08	7.44	8.05
		Potassium citrate	1.41	1.47	0.201	0.209	1.94	2.02	56.95	58.61	8.11	8.45
		Potassium fulvate	1.71	1.68	0.204	0.212	2.04	2.13	67.39	69.53	9.83	9.66
	Compost	Control	1.84	1.90	0.209	0.215	2.11	2.20	67.78	69.97	10.58	10.93
		Potassium citrate	1.87	1.96	0.212	0.220	2.13	2.22	68.32	70.30	10.74	11.25
		Potassium fulvate	1.97	2.02	0.217	0.224	2.17	2.25	68.74	70.67	11.35	11.62
Giza 123	FYM	Control	2.01	2.11	0.225	0.233	2.20	2.28	69.01	71.14	11.56	12.13
		Potassium citrate	2.10	2.19	0.234	0.240	2.26	2.34	69.52	71.80	12.08	12.57
		Potassium fulvate	2.13	2.22	0.239	0.249	2.30	2.43	69.85	72.27	12.25	12.75
	ChM	Control	2.16	2.25	0.244	0.253	2.34	2.46	70.16	72.18	12.44	12.92
		Potassium citrate	2.19	2.27	0.250	0.258	2.38	2.52	70.39	72.72	12.59	13.05
		Potassium fulvate	2.23	2.34	0.256	0.267	2.43	2.58	70.81	73.18	12.81	13.47
	Compost	Control	2.26	2.38	0.261	0.270	2.51	2.60	70.93	73.59	13.00	13.67
		Potassium citrate	2.31	2.44	0.265	0.273	2.55	2.66	71.06	73.78	13.28	14.01
		Potassium fulvate	2.35	2.49	0.271	0.278	2.60	2.70	71.28	73.88	13.51	14.32
LSD at 5%			0.15	0.09	0.003	0.004	0.10	0.11	1.45	0.47	0.88	0.50

Means within a row followed by a different letter (s) are statistically different at a 0.05 level

Higher nutrient and protein contents in Giza 123 can be linked to its genetic capacity to efficiently utilize and assimilate nutrients under saline conditions. Organic fertilizers, particularly compost, enhance nutrient availability and uptake by improving soil health and microbial activity. Potassium fulvate's role in enhancing nutrient uptake and stress resilience is well-documented, contributing to improved grain quality. The findings are consistent with the studies conducted by Abo El-Ezz *et al.* (2020); El-Hadidi *et al.* (2020); Seadh *et al.* (2021); Ghazi *et al.* (2022); Soliman *et al.* (2022); EL-Metwally *et al.* (2023).

CONCLUSION

The results underscored the superiority of Giza 123 over Giza 132 across all measured parameters, highlighting its enhanced adaptation and productivity under saline conditions. Among the organic fertilizers tested, compost emerged as the most effective, followed by ChM and FYM, emphasizing the significance of soil fertility management in enhancing barley growth and yield. Additionally, foliar application of potassium fulvate exhibited remarkable efficacy, surpassing potassium citrate and the control treatment (tap water) in promoting plant vigor, yield, and grain quality.

A synergistic approach, combining the cultivation of Giza 123, organic fertilization with compost, and foliar application of potassium fulvate, yielded the most favorable results, indicating the potential for integrated management practices to mitigate the adverse effects of soil salinity on barley production. Looking ahead, the focus should remain on optimizing barley cultivation by variety Giza 123 and enhancing organic fertilization strategies with compost and potassium fulvate application. Recommendations for future research include further exploration of fertilizer combinations and application methods tailored to saline environments to sustain and increase barley production. By prioritizing research and development efforts in this direction, stakeholders can contribute to ensuring food security and agricultural sustainability in regions prone to soil salinity.

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تأثير مصادر مختلفة من الأسمدة العضوية والرش الورقي بفلفات البوتاسيوم وسترات البوتاسيوم على إنتاجية وجودة صنفين من الشعير النامي بتربة متأثرة بالأملاح

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الملخص

يعد التوسع في زراعة الشعير في مصر أمرًا ضروريًا نظرًا لأهميته الاستراتيجية، خاصة تحت ظروف الملوحة حيث تبلغ قيمة التوصيل الكهربائي (EC) للتربة المدروسة ٧,٣ ديسيمنز-١. لاستكشاف الممارسات الزراعية المثلي، تم إجراء تجربة حقلية لتقييم أداء صنفين من الشعير (جيزة ١٢٣ وجيزة ١٣٢) تم معاملتهم بمصادر مختلفة من الأسمدة العضوية [زرق الدواجن (ChM) والسماد البلدي (FYM) والكمبوست] بالإضافة إلى الرش الورقي بفلفات البوتاسيوم وسترات البوتاسيوم. تم قياس مدلولات النمو والمحصول المختلفة، مثل ارتفاع النبات، والأوزان الطازجة والجافة، والمساحة الورقية، ومحتوى الكلوروفيل، ومحتوى الكاروتين، ومحصول الحبوب، ومحصول القش، والمحصول البيولوجي، ومحتوى العناصر الغذائية في الحبوب (النيتروجين والفوسفور والبوتاسيوم). أظهرت النتائج أن صنف جيزة ١٢٣ تفوق على صنف جيزة ١٣٢ في جميع المدلولات التي تم دراستها. من بين المصادر المختلفة للتسميد العضوي، أثبت الكمبوست فعاليته الأعلى، يليه سماد زرق الدواجن ثم السماد البلدي. أدى الرش الورقي بفلفات البوتاسيوم إلى القيم الأعلى لجميع المدلولات المدروسة، بينما سترات البوتاسيوم جاءت في المرتبة الثانية من حيث الفعالية، متفوقة على الكنترول (بدون رش). عموما، زراعة الصنف جيزة ١٢٣، مع التسميد بالكمبوست، والرش بفلفات البوتاسيوم ادي إلى تحقيق أفضل النتائج بشكل عام. وتشير النظرة المستقبلية إلى التركيز على صنف جيزة ١٢٣ وتعزيز ممارسات التسميد العضوي باستخدام الكومبوست وفلفات البوتاسيوم لتحسين إنتاجية الشعير وجودته تحت ظروف الاجهاد الملحي. تتضمن التوصيات إجراء المزيد من الأبحاث حول تحسين التركيبات السمادية وطرق التطبيق للحفاظ على إنتاج الشعير وزيادته تحت الظروف الملحية.