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THE ROLE OF ORGANIC FERTILIZATION IN IMPROVING THE YIELD AND QUALITY CHARACTERISTICS OF QUINOA UNDER NORTH SINAI CONDITIONS

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ABSTRACT

The effects of replacing organic fertilizers with chemical ones on quinoa plants (*Chenopodium quinoa Willd*.) were investigated throughout two winter seasons in 2021–2022 and 2022–2023, at the Environmental Agricultural Sciences Faculty Experimental Farm at Arish University in the El-Arish area, North Sinai (31^0 08' 40.3 N, 33^0 49` 37.2 E). The objective of this study was to assess the impact of partial replacement chemical fertilizers with organic fertilizers on both the yield and quality of quinoa. Seeds of "Danish KVL3704" *cv*. of quinoa were sown on October 26th for both seasons. Five distinct treatments of chemically recommended fertilizers (CRF) and organically recommended fertilizers (ORF) were utilized in the study, along with the replacement of CRF with part of organic fertilizer. The treatment of using 25% CRF + ORF + 75% CRF as organic fertilizer (T4) recorded the highest value for plant height, number of leaves and branches, fresh and dry weight of leaves and shoot, weight of 1000 grains, and leaves content of phosphorus and potassium, while the treatment of 50% CRF + ORF + 50% CRF (T3) recorded the highest grain yield (ton fed^{-1}), and the highest leaves content of nitrogen and protein after 90 days of sowing, while the trend was different with the leaves content after 60 days of sowing, where, the treatment of 0.0% CRF + ORF at 100% (T5) recorded the highest value. As for the grains content of nitrogen and protein, the highest values were with the treatment of 75% CRF + (ORF) + 25% CRF (T2) as an organic fertilizer, and the treatment of 0.0% CRF + ORF 100% of CRF (T5) as organic fertilizers for phosphorus and potassium content in grains.

INTRODUCTION

Quinoa (*Chenopodium quinoa* Willd.) is a pseudo-cereal from India that has been planted in the area for at least 5000 years **(El-Kasheif *et al*., 2019)**. Drawing attention for its rich nutritional quality, robust growth ability, and abundant supply of vital amino acids, minerals, phenolic compounds, vitamins, and micronutrients **(Mobeena *et al*., 2023)**. Also, **Castillo *et al*. (2022)** showed that quinoa has a variety of beneficial microbes that can enhance plant development without chemicals. This reduces environmental harm and preserves quinoa's natural quality. **Geren (2015)** demonstrated that quinoa exhibited a strong response to nitrogen fertilization. It is a crop that can grow in various environments and withstand harsh environmental and climatic conditions. It can tolerate drought stress **(Eisa *et al*., 2012)**. High amounts of chemical pesticides and fertilizers are used today to boost the yields of various field crops, as reported by **Roba (2018)**, inorganic fertilizers deliver nutrients rapidly and directly, yet their prolonged application results in soil degradation and environmental

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pollution. Therefore, employing a combination of organic and inorganic fertilizers enhances soil quality without compromising environmental integrity.

Reddy *et al*. (2000) stated that organic manure supplies plant nutrients in addition to replenishing the organic matter content of the soil. In this regard, research supporting the importance of soil organic matter for crop yield and long-term soil fertility was presented by **Moral *et al.* (2005). Chen (2006)** stated that the soil contains an existing supply of nutrients. Sustaining rich soil is essential for increased agricultural output and long-term sustainable crop productivity, in this context, According to **Cayuela *et al*. (2008)**, organic manures contain a substantial amount of organic matter, nitrogen, and other plant nutrients, making them appropriate for use as fertilizers. Particularly when prepared from animal dung, organic fertilizer contains significant amounts of minerals, organic materials, and a variety of micronutrients. It is better for the preservation of the environment and the soil quality to use organic manure rather than just chemical fertilizers.

An integrated strategy for optimum nutrient utilization that incorporates both inorganic and organic fertilizers increases the efficiency of chemical fertilizers while lowering nutrient losses **(Schoebitz and Vidal, 2016).** A study by **Loss *et al*. (2019)** found that application of animal manure resulted in an increased in the total organic carbon (TOC) in the soil, which enhanced the soil's cation exchange capacity and nutrient uptake. Consequently, increased yield of grain crops, in terms of environmental protection, this is more profitable than relying solely on chemical fertilizers. When manure is applied, soil organic matter is increased and soil aeration is improved, which promotes biological activity and is more environmentally friendly than relying solely on chemical fertilizers. Additionally**, Abou-Amer and Kamel (2011)** stated that the application of split doses of mineral and organic fertilizer increased the yield and quality of quinoa. When combined organic manure and inorganic fertilizers are applied as a complete basal dressing, the release of nutrients is balanced and nitrogen loss is reduced **(Liu *et al*., 2008).** According to **Abdrabou *et al*. (2022)**, application of organic fertilizers in sandy soils enhances quinoa plants' resilience to saline irrigation water, facilitating the use of lower-grade water for irrigation. Thus, the goal of this study was to find out if using organic fertilizers instead of chemical ones had an impact on the yield and quality of quinoa in North Sinai.

MATERIALS AND METHODS

This study was conducted in the Experimental Farm of Environmental Agricultural Sciences at Arish University during 2021-2022 and 2022-2023. The goal of this study was to find out how quinoa plants (*Chenopodium quinoa*) yield and quality would change with applying totally or partially replacing of chemical fertilizers with organic fertilizers under North Sinai conditions. The soil used in the experiment had a sandy loam texture, a pH of 8.11, EC of 1.04 dSm^{-1} (in 1:5 water extract), soluble ions (in 1:5 soil water extract, meq. l^{-1}) of Ca^{++} (3.90), Mg^{++} (3.42), Na^{+} (2.54), K^{+} (0.34), CaCaO3 19.78 %, and an organic matter content of 0.156%. Irrigation water was obtained from underground well in the experimental farm with EC of 5.93 dSm^{-1} which is high saline water. Chicken manure was taken (fully decomposed) from The Chicken Farm of Environmental Agricultural Sciences Faculty and utilized as organic fertilizer. Chicken manure contains 4.0% N, 0.87% P, 2.12% K., and 0.61% Mg. Replaced organic manure was estimated on basis of its content of N% (4%). Quinoa seeds of the hybrid ""Danish KVL3704" " were sown on 26^{th} October for two successive seasons. Drip irrigation system was used; each plot had one dripper line, and one row of plants. Plants in the same row were separated by 20 cm between each other and by 0.7 m between dripper lines. The experimental unit area was 14 m^2 (20 m length and 0.7 m width). Seven plants per meter square were planted. Along with the soil preparation, organic fertilizer was added.

Treatments and Experimental Designing

Data Collected

Growth parameters of plants

After 60 and 90 days of sowing, five plants at random from each experimental unit were picked, and the following traits were recorded:

Plant height (cm)

The measurement of plant height was from the plant's base at the lowest point to the highest point.

Number of leaves and branches per plant

Plant leaf area (dm^2)

Leaf surface area per plant was calculated according to the method described by **Ackley (1964)**.

Leaves chlorophyll content

SPAD chlorophyll meter was used to assess the total chlorophyll of the photosynthetic pigments, following the method of **(Hoel and Solhaug 1998).**

Fresh and dry weight of stem, leaves, and total fresh weight of shoot (g)

Quinoa plant samples were oven dried at 70°C until their weight remained constant to determine the dry weight of stem, leaves, and dry weight of shoot was calculated.

Yield and yield components

At harvest date (120 days from sowing) the following yield components were estimated:

Grain yield (ton fed ^{1})

It was determined from the average grain weight per square meter.

Weight of 1000-grain (g)

It was determined as the average weight of 1000 grains.

Chemical analysis

N, P, K and content of protein in leaves and grains

Samples of leaves and grains were dried in an oven at 70ºC and then pulverized in a stainless-steel mill. A digestion process was done by taking 0.2 g from each sample, which was subjected to a solution of perchloric acid and sulphuric acid in a 1:3 (*V/V*) ratio according to **Piper (1947)** until a clear solution was obtained. After transferring the solution to a 50 ml flask with a precise volume mark, deionized water was added until it reached that point. This extraction was used for determination of nitrogen, phosphorus, and potassium as follows:

- **Nitrogen content (%):** It was calculated following the procedure by **Bremner and Mulvaney (1982)**
- **Phosphorus content (%):** It was quantified calorimetrically with the Spectrophotometer **(Model 6300 & 6100 Jenway Co.)** described by **Olsen and Sommers (1982).**
- **Potassium content:** It was measured by flame photometry, following the method of **Brown and Lilleland (1946)**
- **Content of protein:** Protein quantity was calculated from the nitrogen concentration of the grains and leaves using a conversion factor (usually 6.25 which is equivalent to 0.16 g nitrogen per gram of protein).

Statistical Analysis

The data collection was followed by a statistical analysis using the variance analysis method by **Snedecor and Cochran (1980)**, and **Duncan's procedures (1955)** were used to separate the means at the 0.05 level.

Table 1. The five treatments of replacing chemical fertilization with organic fertilization included in the experiment

Treatments	Description
T1	100% of recommended chemical fertilizer CRF (80kg N of ammonium sulphate fertilizer, 75kg P_2O_5 of agricultural phosphoric acid 70%, and 50kg K_2O of potassium sulphate fertilizer) + recommended organic fertilizer ORF (15m^3 of chicken manure fertilizer)
T2	75% of recommended chemical fertilizer CRF + recommended organic fertilizer ORF plus 25% recommended chemical fertilizer (equivalent for 25% of chemical fertilizer as organic fertilizer)
T3	50% of recommended chemical fertilizer CRF+ recommended organic fertilizer ORF plus 50% of recommended (equivalent for 50% of chemical fertilizer as organic fertilizer)
T4	25% of the recommended chemical fertilizer CRF plus recommended chicken manure with 75% of recommended chemical fertilizer (equivalent for 75%% of chemical fertilizer as organic fertilizer)
T5	0.0% of the recommended chemical fertilizer CRF plus recommended organic manure ORF plus 100% of the recommended chemical fertilizer (equivalent for 100% of chemical fertilizer as organic fertilizer.

With preparing soil organic fertilizers in addition to chemical fertilizers were added directly to the soil (20 kg N, 45 kg P_2O_5, 10 kg K_2O), The rest portion of chemical fertilizers was added twice a week as fertigation with irrigation (60 kg N, 30 kg P_2O_5, and 40 kg K_2O) during plant growth.
The treatments were arranged using a complete randomized block design with three replicates. The usual agricultural methods for North Sinai were followed.

RESULTS

Effects of Using Chicken Manure Instead of Chemical Fertilizers

Vegetative growth

Replacing chemical fertilization with organic fertilization had significant effects on all vegetative growth traits (plant height, number of leaves, and number of branches) in both seasons, except plant height after 60 days of sowing in the first season, and the number of branches after 60 days of sowing. However, total chlorophyll content showed no significant effects in both seasons (Table 2). The fourth treatment (T4) recorded the highest significant values, including a 22% increase in plant height after 90 days of sowing, a 13% increase in the number of leaves after 60 days of sowing, and a 10% increase in the number of branches after 90 days of sowing, in both seasons. Leaf area showed significant improvements after 60 and 90 days of sowing, with increases of 21% and 24% in the first season, and 25% and 22% in the second season, respectively, compared to the control (T1). However, the number of leaves after 90 days from sowing, recorded the highest value with (T1). Plant height did not differ significantly from the fifth treatment (T5) after 60 days after sowing in both seasons, and leaf area did not differ significantly from the second treatment (T2) after 90 days from sowing in the first season.

The effect of organic manure led to enhancement of the soil's biological, physical, and chemical properties, and mitigating irrigation water salinity, may have contributed to the overall improvement in the vegetative

Table 2. Effect of replacement chemical fertilization by organic fertilizer on vegetative growth traits of quinoa plant after 60 and 90 days of sowing in 2021–2022 and 2022–2023 seasons

Parameters	Plant height (cm)		No. Leaves		No. Branches		Leaf area (dm^2)		Chl. (SPAD)
	Days after Sowing								
Treatments	60	90	60	90	60	90	60	90	60
First season (2021)									
T1	95.1a	126.7b	68.9a-c	66.7a	13.9a	16.4ab	28.88b	32.59b	48.96a
T2	90.8a	137.3b	60.9c	60.4ab	14.6a	15.4b	26.75b	37.97a	50.36a
T3	86.6a	127.7b	72.7ab	62.3ab	15.7a	16.2ab	27.47b	35.93ab	49.21a
T4	94.5a	154.6a	77.8a	56.6bc	17.1a	18.1a	35.05a	40.50a	48.95a
T5	94.8a	137.7b	65.4bc	51.1c	14.9a	16.8ab	30.01ab	36.24ab	47.69a
Second season (2022)									
T1	100.7ab	128.8c	69.6c	67.5a	14.5a	16.9b	30.11b	34.86c	49.39a
T2	95.2b	139.5b	62.4d	61.5b	15.1a	15.7b	28.44b	39.82ab	50.03a
T3	92.3b	130.3c	73.6b	63.7b	16.0a	16.5b	30.69b	38.75a-c	49.43a
T4	107.6a	156.7a	78.7a	55.9c	16.3a	18.7a	37.50a	42.61a	48.22a
T5	105.2a	140.0b	67.3c	52.0d	15.4a	17.1b	31.89b	38.35bc	48.94a

T1) CRF + ORF at 100%
T2) Using 75% CRF + (ORF) + 25% CRF as an organic fertilizer,
T3) Using 50% CRF + ORF + 50% CRF as an organic fertilizer,
T4) Using 25% CRF + ORF + 75% CRF as organic fertilizer,
T5) Using 0.0% CRF + ORF 100% of CRF as organic fertilizers.
Means that shared the same alphabetical letter or letters did not significantly differ from one another, according to Duncan's multiple range test.

growth parameter. **Saha *et al*. (2008**) reported that the combined application of organic manures and inorganic fertilizers led to improvements in soil organic matter (SOM), soil structure, water retention capabilities, and nutrient recycling. Additionally, it helped maintain the soil's nutrient levels, cation exchange capacity (CEC), and microbial activity. Also, the results obtained by **Abou-Amer and Kamel (2011)** indicated that, adding half the amount of mineral fertilization along with organic fertilizer resulted in an increase in plant height and the number of basal branches, compared to adding the same dose of mineral fertilization only. In addition, **Soliman *et al*. (2019)** explained that using chemical and organic fertilization together recorded the highest plant height, it was better than using both alone. **El-Gamal *et al*. (2020)**, found that organic fertilizer enhanced the growth of quinoa in sandy soil. In this direction, the obtained results agreed with that of **Al-Naggar *et al*. (2021)** who explained that organic fertilization promote development in quinoa, resulting in increasing plant height, a greater number of leaves and branches, and leaf area per plant.

Plant fresh and dry weight

Replacing chemical fertilization with organic fertilization had significant effects on fresh and dry weight of quinoa plant; leaves, stem and shoot in both seasons, except dry weight of leaves after 60 days of sowing, in first season and fresh and dry weight of shoot after 60 days of sowing, in the first season. The fourth treatment (T4) recorded the highest value for fresh and dry weight of leaves, and shoot of quinoa plant in both seasons, without significant difference than (T2) after 60 days of sowing in both seasons. First treatment (T1) recorded the highest value for fresh weight of stem after 90 days of sowing, but it was not significantly differ than fourth treatment (T4) in both seasons. It could say that the fourth treatment (T4) recorded the highest value for fresh and dry weight of leaves and shoot of quinoa plant in both seasons (Table 3).

The results of **Abdrabou *et al*. (2022)** demonstrated that organic fertilization of quinoa increased the dry weight of the shoot by up to twice its weight compared to the control (without organic fertilizer). In this regard, **Rekaby *et al*. (2023)**, explained that application of organic fertilizer increased the fresh weight and dry matter of quinoa by 38.6% and 32.4%, respectively, when compared to the use of chemical fertilizers. This outcome may be attributed to the stimulation of metabolic processes, hastening the production of metabolic substances, which in turn fosters growth and leads to better plant development of quinoa plant **(Zedan *et al.*, 2021)**.

Yield and yield components

Grain weight (g/plant) and 1000-grain weight (g)

When poultry manure fertilizer treatments were used in place of chemical fertilizer, there were significant effects on grain yield and the weight of 1000 grains in both seasons. Third treatment (T3) was the highest in terms of grain yield, the amount of increment was 82 and 80% in first and second season, respectively, compared to (T1), while fourth treatment (T4) was the highest in terms of weight of 1000 grains, the amount of increment was 7% in both seasons compared to (T1) (Table 4).

Replacing a portion of chemical fertilizers with organic fertilizers is gaining acknowledgment as a viable strategy for promoting sustainable agricultural practices. This explanation is in the same direction of **Fawy *et al*. (2017)** who reported that as the application of organic manure to the soil was intensified, yield of quinoa crops showed improvement. Replacing 50% of chemical fertilizers with organic fertilizers increased the productivity of tons per acre by 35.7% and replacing 75% with organic resulted in an increase in the weight of 1000 grains by 7.4%. In this regard, **Parra *et al.* (2019)**, explained that using mineral and organic fertilizers together resulted in a higher yield of quinoa grains. **Al-naggar *et al.* (2021)** found that advantage of organic fertilizer over mineral fertilizer was not only observed in the seed yield per hectare but also in a 94.88% increase in seed yield per plant and a 24.69% gain in the weight of 1000 grains. Also, **Youssef and Farag (2021)** stated that that the use of organic manure played a beneficial role in enhancing both the yield and its components for quinoa crops, along with improving the quality of quinoa seeds.

N, P, K and content of protein

Leaves

The replacement of chemical fertilization by organic fertilizer had significant effects on leaves content of nitrogen, phosphorus, potassium, and protein (Table 5). The percentage of nitrogen and protein content of the leaves after 60 days of sowing in both seasons had the highest values with first treatment (T1), while after 90 days of sowing third treatment (T3) recorded the highest value. As for phosphorus and potassium content of the leaves, fourth

Table 3. Effect of replacement chemical fertilization by manure poultry on fresh and dry weight of quinoa plant after 60 and 90 days of sowing in 2021–2022 and 2022–2023 seasons

Parameters	Leaves (g)		Stem (g)		Shoot (g)		Leaves (g)		Stem (g)		Shoot (g)	
	Sowing after Days											
Treatments	60	90	60	90	60	90	60	90	60	90	60	90
Organic fertilizer replacement	First season (2021)						Second season (2022)					
	Fresh weight											
T1	32.6b	38.7c	42.9b	91.6a	75.5a	130.3a	34.1bc	39.2c	43.7c	91.8a	77.7c	131.0b
T2	32.0b	42.4b	52.4a	60.9c	84.4a	103.3b	33.0c	43.2b	54.0a	61.8c	87.0a	105.1c
T3	32.1b	40.0bc	47.4ab	68.3bc	79.5a	108.3b	33.3c	40.9c	49.6b	68.6bc	82.9b	109.5c
T4	41.6a	48.9a	39.8b	89.1a	81.3a	138.0a	42.3a	50.8a	41.7c	89.1a	84.0ab	140.0a
T5	34.8b	37.6c	45.7ab	74.0b	80.5a	111.6b	36.3b	39.6c	47.6b	74.0b	83.9ab	113.6c
	Dry weight											
T1	4.6a	6.1b	6.5ab	17.8b	11.1a	23.8b	5.1b	6.4b	7.1ab	18.5b	12.2ab	24.8b
T2	5.2a	6.2ab	6.9a	11.2c	12.2a	17.4c	5.8b	6.6ab	7.4a	11.6d	13.2a	18.2d
T3	4.7a	6.3ab	6.5ab	14.2bc	11.2a	20.4bc	5.4b	6.6ab	7.0ab	14.7c	12.4ab	21.3cd
T4	6.0a	7.1a	5.6bc	22.4a	11.6a	29.5a	6.9a	7.5a	6.3bc	21.7a	13.2a	29.2a
T5	4.8a	5.1c	5.2c	17.4b	10.1a	22.5bc	5.6b	5.4c	6.0c	19.1ab	11.5b	24.6bc

T1) CRF + ORF at 100%
T2) Using 75% CRF + (ORF) + 25% CRF as an organic fertilizer,
T3) Using 50% CRF + ORF + 50% CRF as an organic fertilizer,
T4) Using 25% CRF + ORF + 75% CRF as organic fertilizer,
T5) Using 0.0% CRF + ORF 100% of CRF as organic fertilizers.
Means that shared the same alphabetical letter or letters did not significantly differ from one another, according to Duncan's multiple range test.

Table 4. Impact of replacement chemical fertilization by organic manure on grain yield and weight of 1000 grain of quinoa in 2021–2022 and 2022–2023 seasons

Parameters	Grain yield (ton fed^{-1})	Weight of 1000 grain (g)	Grain yield (ton fed^{-1})	Weight of 1000 grain (g)
Treatments	First season (2021)		Second season (2022)	
T1	1.19d	3.36ab	1.22c	3.45ab
T2	1.51c	3.19b	1.57b	3.28b
T3	2.16a	3.33ab	2.19a	3.44ab
T4	1.81b	3.61a	1.82b	3.68a
T5	1.27cd	3.46ab	1.29c	3.53ab

T1) CRF + ORF at 100%
T2) Using 75% CRF + (ORF) + 25% CRF as an organic fertilizer,
T3) Using 50% CRF + ORF + 50% CRF as an organic fertilizer,
T4) Using 25% CRF + ORF + 75% CRF as organic fertilizer,
T5) Using 0.0% CRF + ORF 100% of CRF as organic fertilizers.
Means that shared the same alphabetical letter or letters did not significantly differ from one another, according to Duncan's multiple range test.

Table 5. Effect of organic fertilizer replacement for chemical fertilization on leaves content of nitrogen, phosphorus, potassium, and protein in 2021-2022 and 2022–2023 seasons

Parameters	N (%)		P (%)		K (%)		Protein (%)	
	Days after Sowing							
Treatments	60	90	60	90	60	90	60	90
First season (2021)								
T1	3.59a	3.15e	0.62d	0.56c	3.13c	3.03d	22.42a	19.69e
T2	3.06b	3.55b	0.58e	0.51d	2.76e	3.09c	19.15b	22.18b
T3	2.37e	3.75a	0.80c	0.58b	2.98d	3.38b	14.81e	23.40a
T4	2.95d	3.32d	0.97a	0.79a	3.43a	3.46a	18.44d	20.73d
T5	2.99c	3.35c	0.89b	0.52d	3.36b	3.02d	18.71c	20.92c
Second season (2022)								
T1	3.79a	3.25d	0.65d	0.58c	3.25c	3.05d	23.71a	20.32e
T2	3.26b	3.82b	0.60e	0.56c	2.93e	3.31c	20.37b	23.91b
T3	2.60e	3.92a	0.86c	0.60b	3.10d	3.45b	6.27e	24.53a
T4	3.07d	3.47c	1.04a	0.84a	3.62a	3.62a	19.17d	21.72c
T5	3.23c	3.26d	0.97b	0.50d	3.52b	2.88e	20.20c	20.41d

T1) CRF + ORF at 100%
T2) Using 75% CRF + (ORF) + 25% CRF as an organic fertilizer,
T3) Using 50% CRF + ORF + 50% CRF as an organic fertilizer,
T4) Using 25% CRF + ORF + 75% CRF as organic fertilizer,
T5) Using 0.0% CRF + ORF 100% of CRF as organic fertilizers.
Means that shared the same alphabetical letter or letters did not significantly differ from one another, according to Duncan's multiple range test.

treatment (T4) recorded the highest value in both seasons. It could say that nitrogen and protein content had highest values with first treatment (T1), while fourth treatment (T4) recorded the highest value of P and K**.**

Abou-Amer and Kamel (2011) explained that using a fertilization dose divided between mineral fertilizers and organic fertilizers had a significant impact on the nitrogen content in quinoa plant tissues, resulting in an increase of about 15% compared to using mineral fertilizers. **Kakabouki *et al*. (2014)** documented that quinoa could serve as a substitute for legumes in protein production for feeding ruminant animals only. According to **Papastylianou *et al*. (2014)**, the use of organic fertilizers resulted in a 17% increase in the protein content of quinoa compared to mineral fertilizers. **Salama *et al*. (2021)** concluded that quinoa silage or hay can serve as suitable substitutes for medium-quality roughages in the feeding of ruminants from a nutritional standpoint. Also, Quinoa leaves can be eaten in salads or cooked as vegetable **(Mohamed *et al*., 2019)**, and had more protein than the grains **(Villacrés *et al*., 2022)**.

Grains

Replacing chemical fertilizers with poultry manure had significant effects on the grains content of nitrogen, phosphorus, potassium, and protein in both seasons. The second treatment (T2) recorded the highest nitrogen and protein content in both seasons. Phosphorus content of grains was highest in the fifth treatment (T5), in the first season and fourth treatment (T4), in the second season, without significant difference than fifth treatment (T5) in the same season. As for the potassium content in grains, the fifth treatment had the highest value and did not differ significantly than third treatment (T3) (Table 6).

Quinoa grains are a superior nutritional choice because they are packed with high-quality protein that includes all vital amino acids, are gluten-free, and are rich in various minerals such as calcium (Ca), magnesium (Mg), and iron (Fe), contributing to their health-enhancing properties **(Zedan *et al*., 2021)**.

On quinoa, the utilization of chemical fertilizers and organic fertilizer resulted in an increase in grain protein compared to the control (no fertilization) by 1.43% and 1.66%, respectively **(Kiyan *et al*., 2022)**. **Soliman *et al*. (2019)** explained that this interaction achieved the highest percentage of grain protein. According to **Abou-Amer and Kamel (2011)**, combining organic fertilizers with mineral fertilizers resulted in higher levels of nitrogen, phosphorus, potassium, and protein in quinoa grains compared to using mineral fertilizers alone, in this direction, In addition, the use of organic fertilizers improved the quality of quinoa seeds, including their protein and oil content and chemical composition **(Youssef and Farag, 2021)**.

Conclusion

It could conclude that the treatment of 50% CRF + ORF + 50% CRF as an organic fertilizer recorded the highest grain yield (ton fed^{-1}), and the highest leaves content of nitrogen and protein after 90 days of sowing. As regard to the grains content of nitrogen and protein, highest values were recorded with the treatment of 75% CRF + ORF + 25% CRF as an organic fertilizer.

Table 6. Effect of organic fertilizer replacement for chemical fertilization on grain content of nitrogen, phosphorus, potassium, and protein after 60 and 90 days of sowing in 202١–2022 and 2022–2023 seasons

Parameter / Treatments	N (%)	P (%)	K (%)	Protein (%)	N (%)	P (%)	K (%)	Protein (%)
	first season (2021)				second season (2022)			
T1	3.45b	0.77c	1.68c	21.53b	3.47b	0.78d	1.71b	21.67b
T2	3.48a	0.79bc	1.66d	21.71a	3.49a	0.82c	1.67c	21.79a
T3	3.15c	0.84ab	2.04a	19.67c	2.85e	0.86b	2.07a	17.81e
T4	2.73e	0.84ab	1.71b	17.04e	3.06d	0.91a	1.72b	19.11d
T5	3.12d	0.87a	2.04a	19.46d	3.14c	0.90a	2.08a	19.60c

T1) CRF + ORF at 100%
T2) Using 75% CRF + (ORF) + 25% CRF as an organic fertilizer,
T3) Using 50% CRF + ORF + 50% CRF as an organic fertilizer,
T4) Using 25% CRF + ORF + 75% CRF as organic fertilizer,
T5) Using 0.0% CRF + ORF 100% of CRF as organic fertilizers.
Means that shared the same alphabetical letter or letters did not significantly differ from one another, according to Duncan's multiple range test.

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الملخص العربي

دور التسميد العضوي في تحسين الصفات المحصوليه والجوده للكينوا تحت ظروف شمال سيناء

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تم دراسة استبدال الأسمدة العضوية بدلا من الأسمدة الكيميائية على نباتات الكينوا (*Chenopodium quinoa* Willd.) على مدار موسمين شتويين في ٢٠٢١-٢٠٢٢، و٢٠٢٢-٢٠٢٣، في المزرعة التجريبية لكلية العلوم الزراعية البيئية بجامعة العريش بمنطقة العريش، شمال سيناء. كان الهدف من هذه الدراسة هو تقييم تأثير الاستبدال الجزئي للأسمدة الكيماوية بالأسمدة العضوية على كل من محصول وجودة الكينوا. تم زراعة صنف "Danish KVL3704" من محصول الكينوا في ٢٦ أكتوبر في الموسمين. تم استخدام خمس معاملات للأسمدة الكيميائية الموصي بها مع الأسمدة العضوية الموصي بها في الدراسة، مع استبدال أجزاء من الأسمدة الكيماوية بالسماد العضوي. وقد نتج عن استخدام المعاملة ٢٥% من السماد الكيماوي الموصي به + السماد العضوي الموصي به+ 75% من السماد الكيماوي الموصي به في صورة سماد عضوي أعلى قيمة لارتفاع النبات، وعدد الأوراق، والفروع، والوزن الطازج، والوزن الجاف للأوراق والبراعم، ووزن ١٠٠٠ حبة، ومحتوى الأوراق من الفوسفور، والبوتاسيوم. بينما سجلت المعاملة ٥٠% من السماد الكيماوي الموصي به + السماد العضوي الموصي به + ٥٠% من السماد الكيماوي الموصي به في صورة سماد عضوي أعلى محصول من الحبوب (طن للفدان)، وأعلى محتوى للأوراق من النيتروجين، والبروتين بعد ٩٠ يوم من الزراعة. وكان الاتجاه مختلفا مع محتوى الأوراق من النتروجين والبروتين بعد ٦٠ يوما من الزراعة، حيث سجلت المعاملة ١٠٠% من السماد الكيماوي الموصي به + السماد العضوي الموصي به أعلى القيم. أما بالنسبة لمحتوى الحبوب من النيتروجين والبروتين؛ فكانت أعلى القيم مع المعاملة ٧٥% من السماد الكيماوي الموصي به + السماد العضوي الموصي به + ٢٥% من السماد الكيماوي الموصي به في صورة سماد عضوي، وأعلى محتوى من الفوسفور والبوتاسيوم في الحبوب مع استخدام المعاملة ٠,٠% من السماد الكيماوي الموصي به + السماد العضوي الموصي به + 100% من السماد الكيماوي الموصي به في صورة سماد عضوي.

الكلمات الاسترشادية: الكينوا، الأسمدة العضوية، الأسمدة الكيماوية، المحصول، الجودة.، تفريد البروتين.

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