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The Effect of Mineral and Biological Nitrogen Fertilization, Foliar Spraying with Amino Acids + Zinc, Algae Extract, and Potassium Silicate, and Their Effect on the Productivity and Quality of Strawberry Plants.

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Abstract

During the winter, 2 field experiments were conducted in both seasons (2022/2023 and 2023/2024). We investigated the effects of mineral and biological nitrogen fertilizers, growth stimulants applied as foliar sprays, on vegetative growth, leaf chemical composition, strawberry yield, and fruit quality. This experiment included 16 treatments, with a total of four nitrogen fertilization treatments in four foliar sprays, as follows: F1: 100% of the recommended dose of mineral nitrogen fertilizer per acre (NRD), F2: 75% of NRD + bio-nitrogen, F3: 50% of NRD+ bio-nitrogen, F4: 25%of NRD + bio-nitrogen ,The dose of biofertilizer (Nitropin) was 20 liters/acre. In addition to the foliar spray, we used Kelp grow set (seaweed extract) at a concentration of 2.5 ml/L, Growmin (amino acid + zinc) at a concentration of 5 ml/L, and Cesar K (potassium silicate) at a concentration of 5 ml/L, in addition to the control treatment. The results showed that adding the recommended dose of mineral nitrogen fertilizer (150 kg N/acre) was equivalent to adding 450 kg ammonium nitrate at a concentration of 33% N/acre, which is 75% of NRD + bio-nitrogen plus seaweed extract group achieved the highest values in all measured growth parameters, leaf chemical components (total nitrogen, phosphorus, potassium, and carbohydrates), fruit productivity and its components (exportable yield, marketable yield, and total fruit yield per plant and feddan), as well as chemical fruit quality (total soluble solids, total acidity, vitamin C, total sugars, and anthocyanin content) of strawberry plants during both study seasons.

Keywords: Strawberry, Minerals, Bio-Nitrogen Fertilizers, Growth Stimulants, Fruit Yield.

Introduction

Strawberry (*Fragaria x Ananassa*) ranks among the most significant plant species in Egypt for fresh consumption, processing, and export. Various agricultural practices throughout the growing season influence the growth, yield, and quality of strawberry fruits. Strawberries exhibit heightened sensitivity to nitrogen fertilization; however, if the nitrogen value exceeds the recommended levels, it results in a reduction in fruit size and yield. Nitrogen is a crucial nutrient for the growth and development of plants, being utilized more than any other element **(Treder et al., 2014)**. It plays a vital role in transpiration and regulates the opening and closing of stomata, enhancing water use efficiency, particularly during periods of water scarcity. Potassium participates in numerous transport and accumulation processes within the plant system, including the translocation of nitrates and the activation of various enzymes. Biofertilizers consist of microbial agents formed from live cells of bacteria, algae, or fungi, either individually or in combination, which contribute to increased productivity in plant harvests **(Karlidag et al., 2010).**

Biofertilizers have a direct effect on growth through the production of plant hormones that stimulate and improve plant growth. These hormones include gibberellins, cytokines, and indole acetic acid. They also have an indirect effect through nitrogen fixation and the production of biocontrol agents against soil borne plant pathogens. This increases the formation of metabolites that promote plant vegetative growth and increases the activity of meristematic cells in tissues **(Tripathi et al., 2017).**

Kumar et al. (2020) highlighted the role of biofertilizers in strawberry cultivation. They found that the use of biofertilizers significantly affected strawberry quality, with this effect appearing in the sugar-to-acidity ratio of the fruit as well as the soluble fiber content. The use of biofertilizers also significantly affected vitamin C content. These fertilizers are among the most suitable alternatives to chemical fertilizers, and they have an impact on plant growth and productivity, as we have explained, which was examined in this study. Many producers also use growth promoters, either as soil additives or foliar sprays, to improve the growth, productivity, and quality of the produced fruits. Using growth promoters as sprays is more environmentally friendly

than applying them to the soil **(Al-Shall and Al-Ramadi, 2017).**

The study aims to investigate the effect of biological and mineral nitrogen fertilizers as a soil additive, spraying some algae extracts, amino acids and potassium silicate on plant growth, productivity and quality of Fortuna strawberry fruits.

Materials and Methods

The 2 experiments were conducted during the winter seasons of 2022/2023 and 2023/2024 to study the effect of mineral and nitrogenous biofertilizers, in addition to foliar spraying with some growth promoters, on vegetative growth, leaf chemical composition, and fruit yield and quality of strawberry plants (Fragaria X ananassa Duch) of the Fortuna cultivar. Seedlings were immersed in a 300 ml/L PREVICUR solution for 20 minutes before planting. The soil was sandy in texture, with a pH of 7.3. Table A shows the comprehensive chemical and mechanical analyses of the soil used.

Table A. Mechanical and Chemical Analyses of the Soil Used.

Mechanical analysis		**Chemical analysis**			
		Cations meq/l		Anions meq/l	
Coarse sand	18.2%	Ca^{++}	8.9	CO_3^{--}	Zero
Fine sand	36.2%	Mg^{++}	3.15	HCO_3^-	4.5
Silt	27.3%	Na^+	4.20	Cl^-	6.35
Clay	18.3%	K^+	1.18	SO_4^{--}	8.10
Texture class sandy					
Soil pH	7.3	Available N		23.9mg/kg	
E.C, dS/m	1.87	Available P		12.6mg/kg	
Organic matter	2.6%	Available K		18.3mg/kg	

The plot area used was 12 square meters, including a basin measuring 8 meters in length and 1.50 meters in width. Within the basin, there were four rows, and seedlings were planted 25 cm apart. The planting date was September 15 during both study seasons. Sprinkler and drip irrigation were used for the first month after planting. Thereafter, the basins were covered with a 40-micron white plastic sheet. Drip irrigation was used only after covering until the end of the growing season. This experiment included 16 treatments, four nitrogen fertilizer treatments resulting in four foliar spray treatments, as follows:

A. Nitrogen fertilizer treatments:

1. 100% of the recommended dose of mineral nitrogen fertilizer (200 kg nitrogen/acre) NRD.
2- 75% of the recommended dose of mineral nitrogen fertilizers 150kg N/fed + Bio nitrogen fertilizer Nitropin
3- 50% of the recommended dose of mineral nitrogen fertilizers 100kg N/fed + Bio nitrogen fertilizer Nitropin
4- 25% of the recommended dose of mineral nitrogen fertilizers 50kg N/fed equal + Bio nitrogen fertilizer Nitropin

b. Foliar spray treatments

1- Kelp growers set as a source of seaweed extract at 2.5 ml/L
2- Growmin as a source of amino acid + zinc at 5ml/l.
3- Cesar K as a source potassium silicate at 5ml/l.
4- The control treatment (spray with water).

Foliar spraying was applied to strawberry plants 30 days after planting and continued throughout the planting season every 15 days.

Kelp grow set: A commercial product containing Macrocystis integrifolia algae, 5.6%, magnesium 4.6%, sulfur, 2.5% boron, and 0.025% molybdenum.

Growmin: A commercial product contains 10% amino acids (proline), 5% zinc, and 2.5% sulfur.

Cesar K: A commercial product contains 22% silicon and 11% potassium.

The distribution of mineral and biological nitrogen fertilization treatments was in three replicates in the main plots, and the spray treatments were randomly placed in the sub-plots. In this regard, the separate plots design was used.

3. Studied Traits:

1. Vegetative growth characteristics.

After 130 days of planting, 5 plants were collected as a representative sample from each experimental plot of the experiment in February to record the following data:

a- Plant height (cm):
b- Fresh weight per plant (g)
c- Dry we. per plant (g):
d- Number of crowns/plant.
e- Number of leaves/plant.

2. Chemical composition of plant foliage:

1- Total Nitrogen%: was determined according to **Pregl (1945).**
2. The Phosphorus content: was determined by method described by **John (1970).**
3. The Potassium %: was determined by method described by **Brown and Lilleland (1946).**

4 -Total carbohydrates: determined calorimetrically according to **James (1995)**

3. Fruit yield and its components:

1. Early fruit yield (t/fed):
2. Exportable yield (t/fed):
3. Total Fruit yield/plant (g/plant):
4. Total fruit yield/fed (t/fed):

4. Chemical fruit quality:

1. Total soluble solids (T.S.S.):
2. Total titratable acidity (T.T.A): according to **A. O. A.C. (1990).**
3. Ascorbic acid "Vitamin C": the method mentioned in **A. O. A. C. (1990).**
4. Total sugars: according the method described by **Somogyi (1952)** and **Nelson (1974).**
5. Anthocyanin: according to **A. O. A.C. (1990).**

Statistical analysis:

Even the smallest difference was considered significant when possible, and all data collected were subjected to statistical analysis according to Sndecor and Cochran (1991).

Results and Discussions

1. Vegetative growth characteristics.

Table 1 shows the effects of using mineral and biological nitrogen fertilizers, and foliar spray treatments, on the vegetative growth characteristics of Fortuna strawberry plants in both the 2022/2023 and 2023/2024 seasons.

a. The effectiveness of nitrogen fertilizers on plant growth characteristics:

Adding different levels of mineral fertilizer (100% NRD, 75%, 50% and 25%) with bio-nitrogen significantly affected the vegetative growth characteristics of Fortuna strawberry. Plant height (cm) increased significantly at the(75% NRD+BIO) level compared to all other treatments and the control, reaching 18.77 cm, followed by 100% NRD, 50% NRD+BIO, and 25% NRD+BIO (17.23 cm, 16.02 cm, and 14.13 cm, respectively). All characteristics improved in the second season compared to the first season. The superiority of the "75% N + Nitrobein" treatment in vegetative growth characteristics was observed. This may be due to the mixing of a large amount of free mineral nitrogen fertilizer with the nitrogen-fixing biofertilizer, which releases some growth regulators around the plant roots, such as gibberellic acid and cytokinins **(Amrit et al.(2023);Kumari et al.(2018); Morais et al.(2019).** The plant rhizosphere is also rich in trace elements, as well as microorganisms, antibiotics, hormones such as auxins and cytokinins, and other nutrients including nitrogen, phosphorus, and potassium **(Himanshi et al. (2023);Abu Al-Saud et al.(2013).** The stimulation of plant hormones, which specifically affect plants due to microorganisms, can increase the availability of non-available minerals in the soil, promote non-symbiotic nitrogen fixation, and activate disease resistance mechanisms. These are examples of direct effects **(Youssef and Issa.(2014); Kudoyarova et al.(2019).** The higher concentration of (75% NRD+ Nitropin) may be attributed to its increased ability to convert nitrogen to ammonia, thus making it available to plants. Nitropin can affect soil pH by secreting organic acids such as acetic, propionic, fumaric, and succinic acids, which maintain soil properties such as aeration and moisture retention, making it suitable for the absorption of other elements. This ultimately leads to improved vegetative growth, chemical composition, and increased yield **(Awis and Othman.(2013). (Svanbäck et al.(2019); Abu al-Fadl et al.(2024); Hijab.(2024); Marai and Al-Masry, (2024).**

B: The effect of growth promoters on plant growth characteristics:

Table 1 shows distinct data indicating that spraying strawberry plants with growth promoters (Kelp Grow Set, Growmin, and Cesar K) significantly increased plant vegetative growth. Based on these data, it became clear that spraying plants with growth promoters yielded significantly higher values for all vegetative characteristics measured in both treatments. The highest values were obtained with the Kelp Grow Set treatment, followed by Growmin and Cesar K, respectively. The superiority of the algae extract in increasing vegetative growth may be due to its content of natural plant hormones, various natural nutrients, vitamins, carbohydrates such as alginic acid, polysaccharides, and trace minerals. Plant hormones and growth regulators include cytokinins, auxins, gibberellins, abscisic acid, and brassinosteroids **(Mohamed et al. (2022).;Renuka.(2018).** This superiority is also due to the abundance of phenolic compounds, **Sterk et al. (2020)**. In addition, **Al-Juthari et al. (2020)** indicated that these extracts improve the enzymatic and non-enzymatic systems of plants, which helps them tolerate abiotic stress, **EL. Bukhari et al. (2020).** These results are consistent with those reported by **Panda et al. (2012).**

Table 1. The effects of using mineral and biological nitrogen fertilization, foliar spraying, and the reaction product on the vegetative growth characteristics of strawberry variety Fortuna during the two study seasons.

Treatments		2022/2023					2023/2024				
Nitrogen fertilizer	Foliar spray	Plant height (cm)	Fresh weight (g)	Dry weight(g)	Number of Leaves	Number of crowns	Plant height (cm)	Fresh weight (g)	Dry weight(g)	Number of Leaves	Number of crowns
100% NRD		17.23	83.16	19.74	15.56	3.62	21.25	87.55	21.80	18.31	3.75
75%NRD+BIO		18.77	87.33	20.97	18.13	3.93	22.71	91.10	23.05	19.69	3.99
50%NRD+BIO		16.02	75.60	18.20	16.56	3.48	19.67	83.75	19.65	16.25	3.77
25%NRD+BIO		14.13	72.60	16.32	13.06	2.56	17.85	79.92	16.36	12.06	2.91
LSD at 5%		0.32	1.82	0.37	0.62	0.24	0.65	0.84	0.15	0.23	0.18
	Kelp grow set	19.20	86.01	21.04	18.38	4.68	22.14	91.60	22.99	18.38	4.36
	Growmin	18.75	82.58	19.72	16.25	3.58	20.80	88.18	21.80	16.38	3.98
	Cesar K	16.20	81.36	18.11	15.12	3.37	18.02	77.55	19.31	14.94	3.52
	Control	13.56	68.74	16.36	12.67	2.71	16.52	72.36	15.68	12.63	2.89
LSD at 5%		0.29	1.09	0.39	0.54	0.36	0.34	0.88	0.21	0.26	0.15
100% NRD	Kelp grow set	18.90	87.90	21.30	17.75	4.25	21.62	91.90	22.95	18.75	4.56
	Growmin	17.30	84.25	20.90	15.75	3.75	20.10	89.50	21.10	17.50	3.89
	Cesar K	15.80	81.36	19.85	15.50	3.48	18.00	88.70	20.95	16.00	3.52
	Control	14.90	79.12	16.90	13.25	3.05	16.90	80.10	18.20	14.00	2.98
75%NRD+BIO	Kelp grow set	19.80	91.60	23.20	19.75	4.56	23.75	95.60	24.70	19.50	4.75
	Growmin	18.90	87.25	21.10	17.50	4.06	22.60	91.50	22.20	18.00	4.65
	Cesar K	17.10	86.39	19.59	17.00	3.74	20.00	90.90	21.90	16.50	3.94
	Control	16.30	74.10	19.00	15.25	3.25	18.50	86.40	20.40	14.75	3.41
50%NRD+BIO	Kelp grow set	16.50	88.80	19.10	18.50	3.94	19.10	82.50	21.10	18.50	4.49
	Growmin	15.60	86.50	17.80	15.50	3.62	18.30	80.50	18.00	17.75	3.88
	Cesar K	14.90	75.20	17.00	15.00	3.25	17.60	79.70	18.30	15.25	3.61
	Control	13.10	71.90	16.90	14.25	2.75	15.70	72.30	16.85	12.50	2.78
25%NRD+BIO	Kelp grow set	14.60	75.75	16.55	16.50	3.56	17.70	76.40	17.20	13.75	3.48
	Growmin	13.20	72.30	15.09	13.25	2.86	16.20	71.20	15.90	12.25	3.21
	Cesar K	13.00	72.50	14.00	11.25	2.51	15.50	70.90	14.10	11.00	2.98
	Control	11.70	64.85	13.65	9.75	2.01	13.25	61.20	12.25	9.98	2.51
LSD at 5%		0.59	2.12	0.84	1.11	0.51	0.64	1.23	0.43	0.71	0.36

A: The effect of the interaction between nitrogen fertilizer and growth stimulants on plant growth characteristics:

In Table 1, the use of 75% of the recommended nitrogen fertilizer (NRD) plus BIO in addition to the algae extract group showed the highest values in all growth parameters measured during the two study seasons. This treatment was higher than the other treatment groups or the control group. The lowest values were taken into account with the use of 25% (NRD + BIO) in addition to all growth stimulants.

2. Chemical constituents of strawberry leaves:

Macronutrients are affected by different levels of mineral and biological nitrogen fertilizers, as well as foliar sprays from different sources of growth promoters, and their interactions, on the total nitrogen, phosphorus, and potassium content, as well as the total carbohydrate content in plant leaves during two successive growing seasons.

a: Effect of nitrogen bio fertilizer (NRD+BIO) on chemical composition:

There was a significant difference in the results of total nitrogen, phosphorus, potassium, and total carbohydrates due to the amounts of tested mineral fertilizers added with the biofertilizer during both seasons of the study. All values of all traits improved during the second season compared to the first season. The treatment (75% NRD+BIO) led to a significant increase in all traits compared to the other treatments (50% NRD+BIO, 25% NRD+BIO) and the control group (100% NRD + Zero BIO). The values of N, P, K, and total carbohydrates during the first season for the 75% NRD+BIO treatment were 2.89, 0.391, 1.83, and 15.80. The values of N, P, K, and total carbohydrates during the first season for the 75% NRD+BIO treatment were 2.94, 0.396, 1.93, and 16.56. These values were higher than those of the first season. As for the positive effect of nitrogen on leaf chemical content, this may be due to the fact that nitrogen is a major nutrient, comprising approximately 75% of plant dry matter. The presence of sufficient nitrogen promotes the uptake of other nutrients. These results were consistent with those obtained **by Bhagat et al., 2020;Hassan (2015), Mohamed et al. (2021), and Mohamed et al. (2024).** Furthermore, the addition of mineral nitrogen fertilizer may increase its concentration in the soil solution and thus enhance its uptake by the plant. The increase in macronutrients (NPK) may be attributed to the effect of biofertilizers on reducing soil pH and increasing soil microbial biomass, which influences the decomposition and availability of

these nutrients, which in turn increases their uptake by plant roots. Furthermore, **Al-Aziz (2007), Abu Sedera et al. (2009), and Moussalem (2014)** all worked on strawberries and reported similar results.

B: Effect of growth stimulants on chemical composition:

Treatment with seaweed extract resulted in increased measurements of the studied traits compared to the other treatments and the control. The highest values were recorded for nitrogen, phosphorus, potassium, and total carbohydrates (TC), followed by gromin, then cesarki, while the lowest values were recorded using the control. All measurements increased in the second season compared to the first. As for the positive effect of seaweed on the chemical content of strawberry leaves, this increase in the concentration of specific macronutrients may be attributed to the distinct effects of these organic compounds present in the extract on root growth and elongation, in addition to the increased root zone area, which increases the root's ability to absorb and the availability of macronutrients for absorption and accumulation by the plant. The results obtained are consistent with those reported by **Vishal et al. (2022) , Al-Atbani (2015) and Al-Sayed et al. (2015), Ibrahim and Ramadan (2015), and Abu Sedira et al. (2016)**

A: The result of the interaction between mineral and biological nitrogen fertilizers and growth promoters on the chemical composition:

It was confirmed that adding mineral fertilizers at 75% of the recommended dose with biological fertilizer, along with spraying the plants with growth promoters (algae extract), produced the highest values for all chemical components studied, followed by (100 NRD + 0 BIO), then 50% + Bio during the two growing seasons. All differences between the averages were significant for the two consecutive seasons.

3: Fruit yield and its components in strawberry plants:

A: The effect of using mineral and biological nitrogen fertilizers on fruit yield and its components:

In this regard, we show the total yield per acre, the total exportable and marketable yield, early production, and yield per plant. All results were influenced by the use of the recommended dose (75% NRD+BIO) and the replacement of 25% of mineral fertilizers with biofertilizer, which increased the vegetative growth rate (Tables 1 and 2) and the physical parameters of the fruit (Table 4), which in turn affected the total fruit yield. Meanwhile, significant differences were detected between all levels of mineral fertilizers, with and without biofertilizers, used in this study for all fruit yield traits and components per acre during the two study seasons. This may be attributed to ensuring a balanced nitrogen uptake, which resulted in higher yield per plant or acre. The combined treatment of nitrogen fertilization with biofertilizers was also found to be superior in terms of productivity parameters. This may also be due to its positive effect on vegetative growth, which in turn stores a large amount of dry matter, reflecting the quantity and components of the crop. This may lead to improved yield. They confirmed that this result stems from the effect of the tested compounds, along with those mentioned by **Mosalem (2014)**, on strawberries.

Table 2. Effect of biological and mineral nitrogen fertilization, as well as foliar spraying and their interaction on the chemical components of the leaves of the Fortuna strawberry cultivar during the two study seasons.

Treatments		2022/2023				2023/2024			
Soil addition	Foliar spray	N%	P%	K%	Total Carbohydrates (%)	N%	P%	K%	Total Carbohydrates (%)
100% NRD		2.76	0.382	1.78	14.35	2.88	0.387	1.89	15.32
75%NRD+BIO		2.89	0.391	1.83	15.80	2.94	0.396	1.93	16.56
50%NRD+BIO		2.61	0.341	1.52	13.19	2.69	0.354	1.73	13.93
25%NRD+BIO		2.28	0.305	1.47	11.32	2.31	0.310	1.52	11.87
LSD at 5%		0.05	0.03	0.09	0.36	0.06	0.04	0.07	0.41
	Kelp grow set	2.84	0.389	1.71	15.96	2.96	0.398	1.82	16.72
	Growmin	2.62	0.364	1.64	14.37	2.81	0.384	1.80	15.19
	Cesar K	2.41	0.345	1.87	13.26	2.64	0.352	1.95	14.54
	Control	2.29	0.311	1.45	11.45	2.38	0.318	1.61	11.92
LSD at 5%		0.03	0.02	0.08	0.41	0.04	0.03	0.05	0.43
100% NRD	Kelp grow set	2.82	0.388	1.78	14.68	2.93	0.395	1.82	16.41
	Growmin	2.71	0.372	1.73	13.56	2.87	0.382	1.79	15.83
	Cesar K	2.51	0.351	1.89	13.81	2.64	0.351	1.94	14.26
	Control	2.31	0.312	1.55	12.21	2.46	0.324	1.61	12.57

75%NRD+BIO	**Kelp grow set**	**2.89**	**0.392**	**1.71**	**17.28**	**2.99**	**0.399**	**1.89**	16.78
	Growmin	**2.74**	**0.386**	**1.79**	**16.36**	**2.89**	**0.389**	**1.78**	15.23
	Cesar K	**2.68**	**0.372**	**1.87**	**14.28**	**2.81**	**0.376**	**1.94**	14.56
	Control	**2.51**	**0.304**	**1.52**	**11.55**	**2.63**	**0.341**	**1.53**	12.58
50%NRD+BIO	**Kelp grow set**	**2.76**	**0.386**	**1.69**	**14.89**	**2.81**	**0.376**	**1.86**	14.18
	Growmin	**2.58**	**0.371**	**1.75**	**13.41**	**2.64**	**0.362**	**1.73**	13.86
	Cesar K	**2.56**	**0.346**	**1.81**	**12.25**	**2.56**	**0.351**	**1.90**	13.12
	Control	**2.39**	**0.298**	**1.48**	**11.12**	**2.43**	**0.286**	**1.42**	12.74
25%NRD+BIO	**Kelp grow set**	**2.48**	**0.325**	**1.58**	**13.17**	**2.57**	**0.341**	**1.71**	12.97
	Growmin	**2.37**	**0.319**	**1.65**	**12.48**	**2.51**	**0.334**	**1.65**	12.12
	Cesar K	**2.31**	**0.304**	**1.72**	**11.25**	**2.32**	**0.310**	**1.80**	11.76
	Control	**2.18**	**0.279**	**1.39**	**10.36**	**2.11**	**0.284**	**1.41**	10.61
LSD at 5%		0.11	0.05	0.13	0.84	0.12	0.06	0.09	0.76

B: Effect of the Use of Growth Stimulants on Yield and Its Components:

Spraying plants during the growing seasons with seaweed extracts prepared as growth stimulants yielded the highest values in all specified yield parameters (6.89, 4.61, 598.6, and 23.95) for early yield, exportable yield, total yield per plant, and total yield per acre, respectively) compared to other foliar spray treatments during the first season. Furthermore, significant differences were recorded in all studied traits of fruit yield. The increase in total yield and its components resulting from the use of these tested organic compounds is related to their effect on vegetative growth (Table 1) and macronutrient concentrations in the leaves (Table 2). In this regard, the results obtained are consistent with those reported by **El-Sayed et al. (2015), Ibrahim and Ramadan (2015), Kusira et al. (2016), and Shehata et al. (2017).**

Table 3. Results of the use of mineral and nitrogenous biofertilizers, foliar spray treatments, and their interaction on fruit yield and fruit components of the Fortuna strawberry variety during the two study seasons.

Treatments		**2022/2023**				**2023/2024**			
Soil addition	**Foliar spray**	**Early yield (t/ fed.)**	**Exportable yield (t/fed)**	**Total yield (g) /plant**	**Total yield (t/ fed.)**	**Early yield (t/ fed.)**	**Exportable yield (t/fed)**	**Total yield (g) /plant**	Total yield (t/ fed.)
100% NRD		**5.82**	**3.91**	**557.2**	**22.28**	**5.55**	**3.42**	**597.7**	23.88
75%NRD+BIO		**6.72**	**4.52**	**598.1**	**23.92**	**5.96**	**3.97**	**629.8**	25.16
50%NRD+BIO		**5.14**	**3.30**	**537.5**	**21.49**	**5.73**	**3.63**	**568.1**	22.72
25%NRD+BIO		**4.25**	**2.95**	**517.5**	**20.60**	**4.44**	**2.97**	**529.3**	21.17
LSD at 5%		**0.08**	**0.05**	**2.6**	**0.22**	**0.10**	**0.08**	**2.8**	0.24
	Kelp grow set	**6.89**	**4.61**	**598.6**	**23.95**	**5.99**	**3.47**	**619.3**	24.76
	Growmin	**5.75**	**3.95**	**565.8**	**22.62**	**5.77**	**3.78**	**586.6**	23.44
	Cesar K	**5.23**	**3.44**	**527.7**	**21.11**	**5.66**	**3.58**	**552.9**	22.11
	Control	**4.51**	**2.89**	**510.3**	**20.42**	**4.27**	**3.16**	**515.2**	20.62
LSD at 5%		**0.06**	**0.04**	**2.2**	**0.18**	**0.09**	**0.10**	**2.3**	0.18
100% NRD	**Kelp grow set**	**5.91**	**4.67**	**598.7**	**23.95**	**5.92**	**3.37**	**611.4**	24.46
	Growmin	**5.85**	**4.10**	**565.6**	**22.61**	**5.62**	**3.73**	**579.1**	23.17
	Cesar K	**5.36**	**3.64**	**525.0**	**21.01**	**5.56**	**3.42**	**567.8**	22.68
	Control	**4.79**	**2.89**	**511.9**	**20.45**	**5.12**	**3.15**	**557.7**	22.23
75%NRD+BIO	**Kelp grow set**	**6.82**	**4.75**	**624.4**	**24.96**	**6.25**	**3.98**	**664.6**	26.57
	Growmin	**5.96**	**4.14**	**599.3**	**23.98**	**6.11**	**4.22**	**630.4**	25.23
	Cesar K	**5.47**	**3.94**	**564.6**	**22.57**	**5.92**	**4.05**	**601.2**	24.05
	Control	**5.11**	**3.13**	**528.0**	**21.13**	**5.56**	**3.65**	**570.1**	22.80
50%NRD+BIO	**Kelp grow set**	**5.52**	**3.56**	**576.0**	**23.05**	**6.01**	**3.58**	**603.1**	24.14
	Growmin	**5.23**	**4.06**	**568.9**	**22.75**	**5.84**	**3.91**	**599.6**	23.99
	Cesar K	**5.07**	**3.74**	**531.3**	**21.26**	**5.76**	**3.75**	**566.2**	22.67
	Control	**4.56**	**2.98**	**502.0**	**20.11**	**5.33**	**3.31**	**527.6**	21.10
25%NRD+BIO	**Kelp grow set**	**5.13**	**2.87**	**535.1**	**21.42**	**4.78**	**2.96**	**573.2**	22.88
	Growmin	**4.75**	**3.10**	**503.2**	**20.14**	**4.51**	**3.27**	**534.3**	21.38
	Cesar K	**4.36**	**2.94**	**490.5**	**19.60**	**4.24**	**3.11**	**501.6**	20.05
	Control	**4.10**	**2.05**	**456.3**	**18.25**	**4.06**	**2.53**	**484.3**	19.36
LSD at 5%		0.11	0.22	3.4	0.35	0.18	0.19	3.6	0.36

C: The interaction between mineral and biological nitrogen fertilizers with growth promoters on the crop and its components:

The application of 75% (NRD+BIO), in addition to foliar spraying of the seaweed extract group, showed the highest values for total fruit yield and its components per acre during the two study seasons. The highest values were also shown when spraying with different levels of the Kelp grow set compound during the two consecutive study seasons. Furthermore, this was followed by 100% NRD (control group), 50% NRD+BIO, and 25% NRD+BIO.

4: Chemical Quality of Strawberry Fruits:

Table 4 shows the effects of fertilization using different levels of mineral fertilizers at the recommended dose, in addition to biofertilizer, along with foliar spraying with different sources of growth promoters. The results also reveal the interaction between these fertilizers on the chemical quality of strawberry fruit, such as the content of total soluble solids (TSS), vitamin C, total acidity, total sugars, and anthocyanins in both the 2022/2023 and 2023/2024 seasons.

A: The effect of using mineral and biofertilizers on physical fruit quality:

The positive effect of mineral fertilizers at the recommended dose levels (75% NRD + BIO) on physical fruit quality may be due to the higher measurements for all studied traits during both seasons compared to the other treatments or the control. The values reached 19.73, 4.41, 3.44, and 255.2, respectively, for the first season, and 21.30, 4.63, 3.51, and 273.1, respectively, for the second season. All studied trait measurements increased for the second season (2023/2024) compared to the first season (2022/2023) during the study. The 100% NRD treatment ranked next. The highest values for fruit quality parameters may be due to increased moisture content in fruit cells, as well as increased cell size and number due to the combination of mineral fertilizers with organic fertilizers, which affects the measured chemical fruit quality. The positive effect of nitrogen levels on physical and chemical fruit quality may be attributed to their effective influence on vegetative growth and the storage of a large amount of dry matter, which results in high-quality yields **(El-Dissoky, 2019)**. These results are consistent with those of **Ulvi et al. (2009)** and **Mosalim (2014).**

Table 4. The results of the effect of mineral and biological nitrogen fertilizers, foliar spraying, and their interaction on the chemical quality characteristics of Fortuna strawberry fruits during the two study seasons.

Treatments		2022/2023						2023/2024					
Soil addition	Foliar spray	T. S. S %	V. C mg/100 g	Acidity %	Total sugars %	Reducing sugars %	Anthocyanin mg/100	T. S. S %	V. C mg/100 g	Acidity %	Total sugars %	Reducing sugars %	Anthocyanin mg/100
100% NRD		9.58	52.45	0.72	6.51	3.45	85.49	10.13	58.16	0.78	6.94	3.59	97.99
75%NRD+BIO		9.77	56.72	0.82	6.79	3.65	91.13	10.34	63.04	0.87	7.18	3.85	110.5
50%NRD+BIO		9.67	54.36	0.77	6.69	3.53	89.69	10.23	61.17	0.83	7.02	3.72	103.7
25%NRD+BIO		9.43	50.39	0.67	6.42	3.32	80.09	9.97	55.40	0.74	6.74	3.49	91.57
LSD at 5%		0.17	0.98	0.03	0.15	0.08	1.21	0.25	1.42	0.03	0.16	0.08	1.58
	Kelp grow set	9.63	53.88	0.73	6.60	3.48	87.40	10.22	59.96	0.79	6.96	3.63	102.4
	Growmin	9.73	56.20	0.79	6.74	3.60	89.80	10.27	61.38	0.86	7.11	3.76	106.2
	Cesar K	9.59	53.22	0.76	6.64	3.54	86.04	10.19	59.05	0.82	7.02	3.68	99.78
	Control	9.50	50.63	0.70	6.43	3.31	83.15	9.99	57.39	0.76	6.80	3.54	95.50
LSD at 5%		0.10	1.10	0.04	0.10	0.10	1.66	0.20	1.15	0.02	0.11	0.09	1.97
100% NRD	Kelp grow set	9.60	52.75	0.70	6.50	3.46	85.80	10.16	58.90	0.78	6.95	3.57	100.2
	Growmin	9.68	55.50	0.79	6.63	3.56	89.60	10.22	60.0	0.83	7.07	3.69	103.8
	Cesar K	9.57	51.80	0.73	6.54	3.49	84.30	10.14	57.40	0.80	7.0	3.60	96.75
	Control	9.48	49.75	0.68	6.38	3.30	82.25	10.00	56.35	0.73	6.75	3.50	91.25
75%NRD+BIO	Kelp grow	9.78	57.10	0.82	6.79	3.65	91.75	10.37	63.70	0.86	7.19	3.58	112.3

	set												
	Growmin	9.89	59.75	0.86	6.95	3.80	94.25	10.43	65.25	0.92	7.30	3.98	115.3
	Cesar K	9.75	56.80	0.83	6.83	3.75	90.0	10.38	62.20	0.88	7.21	3.89	109.2
	Control	9.67	53.25	0.78	6.60	3.40	88.50	10.19	61.0	0.82	7.05	3.68	105.3
50%NRD+ BIO	Kelp grow set	9.69	54.50	0.77	6.70	3.54	90.45	10.28	61.0	0.82	7.0	3.72	104.3
	Growmin	9.80	57.20	0.82	6.83	3.65	92.50	10.32	62.50	0.89	7.18	3.84	109.3
	Cesar K	9.66	53.75	0.79	6.72	3.58	89.15	10.25	61.0	0.85	7.09	3.75	102.1
	Control	9.54	52.00	0.73	6.52	3.37	86.65	10.05	60.02	0.79	6.83	3.58	99.25
25%NRD+ BIO	Kelp grow set	9.45	51.15	0.66	6.41	3.30	81.60	10.05	56.25	0.73	6.70	3.41	92.80
	Growmin	9.56	52.35	0.72	6.55	3.42	82.85	10.12	57.75	0.80	6.90	3.56	96.25
	Cesar K	9.40	50.55	0.69	6.47	3.37	80.70	10.00	55.59	0.76	6.78	3.49	91.0
	Control	9.32	47.50	0.61	6.25	3.19	75.20	9.74	52.0	0.70	6.60	3.41	86.25
LSD at 5%		0.18	2.21	0.04	0.19	0.20	3.33	0.39	2.50	0.04	0.21	0.17	3.94

B: Effect of the use of growth stimulants on the chemical fruit quality of strawberry plants:

Total sugars, total acidity, total soluble solids (TSS), and vitamin C demonstrated their full effect on growmin and kelp grow set, and the results obtained were valid across both study seasons. Spraying plants with growmin significantly improved fruit quality in all previous measurements compared to the control treatment. Furthermore, **Rosa et al. (2018); Hussein Nory and Hussein Habeeb (2024).** demonstrated that diameters, total soluble solids, and titratable acidity improved the measured chemical components. This improved effect of the use of the tested growth stimulants on the measured chemical components is attributed to their positive effects on photosynthesis rates, which in turn may influence the accumulation of these induced chemical compounds in storage organs (plant fruits). The results obtained are consistent with those reported by **Al-Hamzawi (2010), Benias et al. (2012), and Ahmadi et al. (2018)** on strawberries using amino acids and zinc.

A: The effect of the interaction between mineral and biological nitrogen fertilizers with growth stimulants on chemical fruit quality:

The interaction results were as follows: The highest values were recorded for all chemical fruit quality traits studied as a result of using mineral fertilizers with biological fertilizers and foliar spraying with growth stimulants, compared to the other interaction treatments. The highest values of total fruit acidity were recorded as a result of using 75% mineral fertilizer at the recommended dose along with foliar spraying with Growmin (an amino acid proline and zinc), with values reaching 9.89, 59.75, 0.86, 6.95, 3.80, and 94.25 for the first season, and 10.43, 65.25, 0.92, 7.30, 3.98, and 115.3 for the second season. Overall, all values for all studied traits for the second season were higher than those for the first season.

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تأثير التسميد النيتروجيني المعدني والحيوي مع الرش الورقي بالأحماض الأمينية + الزنك ومستخلص الطحالب وسيليكات البوتاسيوم وأثرها على إنتاجية وجودة نباتات الفراولة.

دينا خالد رشاد – سمر سعيد حلاوة – مصطفى حمزة محمد

قسم البساتين – كلية الزراعة – جامعة بنها

خلال فصل الشتاء تم تطبيق التجربتين الميدانيتين في كلا الموسمي (2023/2022 و2024/2023) ، لدراسة تأثيرات الأسمدة النيتروجينية المعدنية والبيولوجية، بالإضافة إلى محفزات النمو المطبقة كرشات ورقية على النمو الخضري والتركيب الكيميائي للنبات وإنتاجية وجودة ثمار الفراولة. شملت هذه التجربة 16 معاملة ناتجة عن الجمع بين أربع معاملات سماد نيتروجين وأربع معاملات رش ورقي على النحو التالي، ف1 :100% من الجرعة الموصى بها من الأسمدة النيتروجينية المعدنية / فدان، ف2 : 75% من الجرعة الموصى بها من الأسمدة النيتروجينية المعدنية / فدان، ف3 : 50% من الجرعة الموصى بها من الأسمدة النيتروجينية المعدنية / فدان، ف4 : 25% من الجرعة الموصى بها من الأسمدة النيتروجينية المعدنية / فدان)، وكذلك معاملات الرش الورقي بمستخلص الطحالب كيلبجروست 2.5 مل / لتر، وحمض أميني + زنك منتج الجرومين 5 مل / لتر،والسيزار كي سيليكات بوتاسيوم 5 مل / لتر والمعاملة الكنترول (رش الماء).

أظهرت النتائج المتحصل عليها أن إضافة الجرعة الموصى بها من الأسمدة المعدنية النيتروجينية 150 كجم نيتروجين/فدان تعادل 450 كجم نترات الأمونيوم 33% نيتروجين/فدان) + سماد النيتروجين الحيوي نيتروبين 20 لتر/فدان بالإضافة إلى مستخلص الطحالب أظهرت أعلى القيم في جميع معايير النمو المقاسة والمكونات الكيميائية لأوراق النبات (النيتروجين الكلي والفوسفور والبوتاسيوم والكربوهيدرات) وإنتاجية الثمار ومكوناتها (العائد القابل للتصدير والعائد القابل للتسويق وإنتاجية الثمار الكلية لكل نبات وفدان) وكذلك جودة الثمار الكيميائية (المواد الصلبة الذائبة الكلية والحموضة الكلية وفيتامين ج والسكريات الكلية بالإضافة إلى محتوى الأنثوسيانين) لنباتات الفراولة خلال موسمي الدراسة في صنف فرتونا