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RESPONSE OF VARIOUS SUGAR BEET VARIETIES TO HUMIC ACID FERTILIZATION UNDER EL-FAYOUM CONDITIONS

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ABSTRACT: To assess the response of three sugar beet varieties to different levels of humic acid fertilizer on growth, yield, and quality of sugar beet, two field experiments were carried out at a private farm in El-Fayoum Governorate (latitude 29. 19° N and longitude 30. 49° E) during the 2022/2023 and 2023/2024 seasons. The study included nine treatments, which represented the combinations of three mono-germ sugar beet varieties (Nazarea, Jamajka, and Bts7715) and three levels of humic acid added as soil amendment (without, 4 and 8 liters/400 liters of water/fed). A randomized complete block design using a split-plot distribution with three replications was used. Results revealed that applying 8 L humic acid/fed appreciably increased root criteria, sucrose%, root, and sugar yields/fed while the sugar lost to molasses (SLM) % decreased over the two seasons and improved alkalinity coefficient value in the 2nd season, compared to those received 4 L humic acid. However, fertilizing beets with 4 or 8 L humic/fed (without a significant difference) gave the highest values of extracted sugar %, quality index, and foliage yield/fed compared to check treatment over the two seasons. The Nazarea variety outperformed the others by producing the thickest, heaviest roots and foliage fresh weight/plant. It also had the highest root yield/fed and alkalinity coefficient value, as well as the lowest SLM in the two growing seasons. while the Nazarea and Bts 7715 varieties achieved the highest foliage and sugar yields/fed (without a significant difference) in either season. Both Bts 7715 and Jamajka varieties (with no significant difference) displayed the highest sucrose and extracted sugar percentages with the lowest sodium content, resulting in an improved quality index.

Under the conditions of Fayoum Governorate, it is recommended to sow the mono-germ sugar beet variety "Nazaria" with fertilization of 8 L of humic acid to maximize the root and sugar yields/fed as well as reduce the root impurities content.

Keywords: Humic acid levels, sugar beet varieties, yield and quality

INTRODUCTION

Following sugar cane, sugar beet ranks as one of the most significant sugar crops worldwide and presently serves as Egypt's primary sugar source. The area planted with sugar beets in Egypt has reached 658,597 acres constituting approximately 63.8% of the country's total sugar production. This cultivation has resulted in a yield of 1.791 million tons of sugar (S.C.C., 2023). To maximize the benefits of sugar beet cultivation, selecting suitable conditions, including the choice of varieties, cultivation methods, planting density, and ensuring adequate plant nutrition and irrigation scheduling (Brar *et al.* 2015). Humic acid, an essential component of humic substances, plays a significant role as an organic compound in soil. These substances are formed through the decomposition of dead biological material and plant tissues, coupled with the activity of microorganisms. Humic acid can form complexes and ions that are frequently found in the environment, leading to the formation of humic colloids (Sible *et al.*, 2021). It is essential for enhancing soil properties, promoting plant growth, and optimizing agronomic factors. Recently, products derived from humic acid have attracted considerable attention from researchers aiming for sustainability in agricultural practices. In this regard, Shaban *et al.* (2014) stated that the addition of 10 kg of humic acid/fed considerably improved sucrose %, root and sugar yields/fed,

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in the 1st and 2nd seasons compared to untreated plots. They cleared that there were appreciable interaction impact between the beet varieties and humic acid on the root and sugar yields/fed. Enan *et al.* (2016) reported that treating sandy soil with 15 liters of humic acid produced the thickest and heaviest roots, as well as the highest yields of root, top, and sugar/fed. They found that gross sugar and corrected sugar percentages increased in the second season compared to using 10 liters of humic acid/fed. Nevertheless, insignificant differences were observed between the impacts of 10 and 15 liters of humic/fed on gross and corrected sugar yields. Thalooth *et al.* (2019) indicated that humic acid positively influences root diameter, foliage and root weights/plant, as well as root, sugar, and white sugar yields/fed. Abd El-Haleim (2020) found that enhancing humic acid levels from zero to 5 kg/fed markedly improved root diameter and fresh weight/plant in addition to yields of root, top, and sugar/fed all while improving the quality index. Nemeat Alla *et al.* (2021) showed that applying 7.5 kg potassium humate to beets resulted in higher values of root diameter, fresh and foliage weights/plant, sucrose, SLM, and extracted sugar percentages, as well as increased root and sugar yields/fed and quality index improved. Similarly, Nassar *et al.* (2023) noted that increasing potassium humate rates from zero to 24 kg/ha produced the highest sucrose%, root, top and sugar yields/fed. Regarding sugar beet varieties, all genotypes cultivated in Egypt are imported from foreign countries, therefore, it is better to test them under Egyptian soil conditions to select the best-suited ones. In this context, Enan *et al.* (2016) revealed that evaluated beet varieties significantly varied where the Polat variety showed superiority over Natoura and Henrike varieties, recording the highest root diameter, fresh and foliage weight values/plant and top yield/fed. However, root diameter, foliage fresh weight/plant in the first season and root fresh weight/plant in the second season did not significantly differ between the Henrike and Polat varieties. Thalooth *et al.* (2019) found significant differences among evaluated cultivars concerning root diameter, fresh weight per plant, foliage weight per plant, and yields of tops, roots, and sugar/fed. Similarly, Awadalla *et al.* (2021) and Hefny and Said (2021) revealed that the tested varieties appreciably varied in studied traits concerning root diameter, fresh weight/plant, sucrose %, root, and sugar yields/ha, as well as extracted sugar and SLM percentages.

The objective of this work was to find out the appropriate humic fertilization level and variety to obtain better growth, yield and improved quality attributes of beets cultivated under conditions of El-Fayoum Governorate.

MATERIALS AND METHODS

Two field experiments were conducted on a private farm in El-Fayoum governorate (latitude 29. 19° N and longitude 30. 49° E) during the 2022/2023 and 2023/2024 seasons to assess the response of three sugar beet varieties to different levels of humic acid fertilizer on growth, yield, and quality of sugar beet (*Beta vulgaris var*. saccharifera, L.). The work included nine treatments, which represented the combinations of three mono-germ sugar beet varieties namely, Nazarea, Jamajka, and Bts7715, and three levels of humic acid as soil amendment (without humic acid; 4 and 8 liters/400 liters of water/fed). A randomized complete block design in a split-plot distribution with three replicates was used. The three humic acid levels were allocated in the main plots, while the three evaluated varieties were scattered to the subplots. The sub-plot area was 21 m^2, including 5 ridges of 7 m in length and 60 cm in width, with 20 cm between hills. Phosphorus fertilizer was added at a rate of 200 kg/fed in calcium superphosphate form of (15% P_2O_5) at seedbed preparation. Nitrogen fertilizer was applied as urea (46.5% N) at a rate of 90 kg N/fed in two equal doses: the 1st after thinning (4-leaf stage) and one month later. Potassium fertilizer was added as potassium sulfate (48% K_2O) at the rate of 50 kg/fed in two equal doses: with 1st and 2nd doses of nitrogen fertilizer. The sugar beet varieties were sown in the first week of October and harvested 210 days later, over two growing seasons. Humic acid was sourced from Setra Company in Tanta, Egypt. The analysis revealed the following composition:

humic acid content of 85%, fulvic acid content of 0.8%, potassium oxide (K_2O) content of 5%, nitrogen content of 0.7%, phosphorus pentoxide (P_2O_5) content of 0.06%, calcium content of 0.99%, magnesium content of 0.39%, iron content of 0.89%, manganese content of 0.044%, zinc content of 0.014%, copper content of 0.056%, boron content of 0.048%, and soluble matter content of 5%. The humic acid was applied before sowing, following the recommended field practices of the Sugar Crop Research Institute. The country of origin and types of the examined beet varieties are shown in Table 1. Soil physical and chemical properties of the upper 30 cm were analyzed according to the method (A.O.A.C., 2005) as shown in Table 2.

Table 1. Country of origin and source of the examined sugar beet varieties

Sugar beet varieties	Type of seeds	Country of origin	The producing company
Nazarea	Mono-germ	Germany	KWS
Jamajka	Mono-germ	Poland	KHBC
Bts7715	Mono-germ	Germany	Beta seed

Table 2. Physical and chemical analysis of soil at the experimental site in the 2022/2023 and 2023/2024 seasons

Particle size distribution	2022/2023	2023/2024
Sand %	25.32	24.10
Silt %	23.26	20.10
Clay %	51.42	55.80
Soil texture	Clay loam	Clay loam
Organic matter (%)	0.56	0.61
pH	8.0	7.90
available N (ppm)	36.7	38.9
available P (ppm)	5.19	5.39
available K (ppm)	165	175
E.C (dSm^{-1})	2.12	2.09
Soluble cations (meq/L)		
Ca_2^+	7.82	7.98
Mg_2^+	4. 47	4.17
Na^+	5.20	5.67
K^+	1.59	0.99
Soluble anions (meq/L)		
$HCO3^-$	8.41	9.35
Cl^-	6.29	6.11
SO_4^{--}	4.38	3.35
CO_3^{--}	-	-

The studied traits:

At harvest, ten guarded plants were taken randomly from the inner rows of each subplot to determine the following characteristics:

1. Root diameter (cm).
2. Root fresh weight/plant (RFW) (g).
3. Foliage fresh weight/plant (FFW) (g).
4. Quality analysis was conducted on fresh samples of sugar beet roots at the El-Fayoum Sugar Company Laboratory in Egypt. The following traits were assessed:

Impurities: It was estimated that the roots' alpha-amino nitrogen, potassium, and sodium contents were meq/100 g of beet. Sodium and potassium were determined in the digested solution using a flame photometer, while alpha-amino N was assessed as described by Cooke and Scott (1993).

- Sucrose percentage (Pol %) was determined in according to the method of Le-Docte (1927)**.**
- Sugar lost to molasses percentage (SLM %) was calculated using the formula provided by Devillers (1988)**.**

SLM = 0.14 (Na + K) + 0.25 (α–amino N) + 0.5

- Quality index (QI) was calculated according to the equation of Cooke and Scott (1993) as follows:

QI = extracted sugar % / sucrose %.

- Extracted sugar percentage (ES %) was calculated using the following equation of Dexter *et al.* (1967):

ES % = sucrose % - SLM % - 0.6.

5. The alkalinity coefficient (AC) was determined from the major non-sugars K, Na, and alpha-amino N using the equation by Devillers (1988):

Alkalinity Coefficient = (K+ Na) ÷ α-amino N.

6. Root yield/fed (ton).
7. Sugar yield/fed (ton) was calculated according to the following equation:

Sugar yield/fed (ton) = root yield fed/(ton) × extracted sugar %.

Statistical analysis

The obtained data were statistically analyzed using the “Co-STAT” computer software package to estimate the analysis of variance (ANOVA) for the split-plot design, as outlined by Gomez and Gomez (1984). The least significant difference (LSD) method was used to test the differences between treatment means at the 5% level of probability established by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1. Root diameter, fresh and foliage weights/plant

Root diameter, fresh, and foliage weights/plant significantly increased as the level of soil-applied humic acid was raised from zero to 8 L/fed in both seasons (Table 3). Fertilizing beet plants with 8 L humic increased root diameter, fresh and foliage weights/plant amounted to (0.90 cm, 147.0 g, and 87.50 g) and (0.70 cm, 93.0 g, and 56.0 g), in 1st and 2nd seasons consecutively, compared to those receiving 4 L humic/fed. These increases in the mentioned traits can be attributed to the role of humic acid, which primarily forms complexes with various mineral elements. In addition, it plays a vital role in photosynthesis and respiration, stimulating metabolism and promoting active cell and root division. The results are agree with those found by Enan *et al.* (2016). Furthermore, the macro elements at critical levels in the experimental soil were insufficient to meet the growth requirements of the sugar beet, as indicated in Table 2.

Root diameter, fresh, and foliage weights/plant varied markedly among the examined sugar beet varieties in the two seasons (Table 3). The Nazarea variety produced the thickest, heaviest roots and more foliage than the other two. These results suggest that the genetic characteristics of tested varieties may influence these traits, consistent with the findings of Hefny and Said (2021).

Table 3. Root diameter (cm), fresh and foliage weights/plant (g) as affected by humic acid levels of three sugar beet varieties in the 2022/2023 and 2023/2024 seasons

Treatments	Root diameter (cm)		Root fresh weight /plant (g)		Foliage fresh weight /plant (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Humic acid level/fed (L)						
Without	9.0	10.1	883.0	788.0	315.9	275.4
4	11.5	11.3	1083.0	1031.0	412.3	318.3
8	12.4	12.0	1230.0	1124.0	499.8	374.3
LSD at 0.05	0.89	0.56	69.3	89.4	25.50	10.4
Evaluated sugar beet varieties						
Nazarea	12.0	12.4	1279.0	1139.0	466.6	369.1
Jamajka	9.8	10.3	841.0	827.0	338.7	284.8
Bts 7715	11.1	11.3	1076.0	977.0	422.6	314.0
LSD at 0.05	0.89	0.99	89.5	63.3	17.24	26.1

Significant interaction effect

The foliage fresh weight/plant in (1st season), was considerably influenced by the interaction between varieties and humic acid fertilization levels (Table 4). It was clear that the differences in foliage fresh weight between the Nazarea and Bts 7715 varieties were insignificant when fertilized with 8 L humic acid/fed. However, in the second season, significant differences appeared between these two varieties when fertilized with 4 L or not fertilized with humic acid in the 2nd season. The Bts 7715 reached more foliage fresh weight values than the Jamajka variety when grown in soil fertilized with 8 L humic acid/fed. This result may suggest that the Bts7715 plants, due to their variable genetic structure, interacted positively with the environmental conditions and benefitted more than the jamaika and Nazarea varieties when fertilized with 8 L humic acid/fed.

Table 4. A Significant interaction effect between beet varieties and humic acid levels on foliage fresh weight/plant of sugar beet in the 2022/2023 season

Treatments	**2022/2023 season**		
	Humic acid level/fed (L)		
Sugar beet variety	without	4 liters	8 liters
Nazarea	372.1	492.0	535.8
Jamajka	245.7	323.0	447.5
Bts 7715	330.0	421.9	516.0
LSD at 0.05	31.00		

2. Sucrose% and impurities (Na, K, and alpha-amino N contents)

Data in Table (5) indicated that the applied humic acid rates on beet soil appreciably influenced sucrose% in either season, root potassium and sodium contents in the first season and the alpha-amino N in the second one. Supplying the soil with 8 L humic/fed gave higher root sucrose content in both seasons and lower root sodium and potassium contents, compared with an addition of 4 L humic. In addition, the lowest content of alpha-amino nitrogen was observed in plant roots grown in soil untreated with humic acid compared to the addition of 4 or 8 L humic acid/fed in the 2nd season. This result partially agrees with Olk *et al.* (2018), who stated that increasing humate substance rates in soil reduces the sodium content of sugar beet roots.

Data in the same Table showed significant variations in technological traits, including sucrose% and potassium content in the two growing seasons, as well as sodium and alpha-amino nitrogen contents in 1st season among different sugar beet varieties. The Bts7715 and Jamajka varieties exhibited the highest sucrose%, in the two seasons and the lowest sodium content in the 1st one, without significant variance between. Nevertheless, the Nazarea variety had the highest root potassium and alpha-amino N contents compared to the other two varieties in the 1st season. These variations among varieties can be attributed to differences in their growth traits and responses to climatic or environmental conditions, which influence the formation of soluble solids. These results are in a line with those mentioned by Awadalla *et al.* (2021) and Hefny and Said (2021).

Table 5. Some technological traits of three sugar beet varieties as affected by humic fertilization levels in the 2022/2023 and 2023/2024 seasons

Treatments	Sucrose %		Impurities contents (meq/100 g beet)					
			Sodium		Potassium		Alpha-amino N	
	1st Season	2nd season	1st Season	2nd season	1st Season	2nd season	1st Season	2nd season
Humic acid level/fed (L)								
Without	17.63	18.24	5.85	5.51	4.08	3.89	2.20	1.80
4	17.83	18.03	5.63	5.27	3.85	3.58	2.14	2.05
8	18.25	18.26	5.44	5.37	3.64	3.89	2.17	2.00
LSD at 0.05	0.40	0.15	0.20	NS	0.12	NS	NS	0.18
Evaluated sugar beet varieties								
Nazarea	17.09	18.3	6.00	5.40	3.93	3.94	2.26	1.87
Jamajka	18.10	17.60	5.38	5.41	3.86	3.45	2.09	1.99
Bts 7715	18.53	18.64	5.54	5.34	3.78	3.97	2.16	1.98
LSD at 0.05	0.93	0.11	0.17	NS	0.10	0.18	0.09	NS

Significant interactions effect

The cornerstone of sugar production is not only the weight of the roots but also their concentrations of sugar and non-sugar substances, which must be taken into account to increase the efficiency of sugar crystallization and production, as the data in Table (6) show. The application of humic acid in the beet soil had a significant effect on the sucrose%, root potassium, and sodium contents in the first season and the alpha-amino N content in the second season. The difference between the Nazarea and Jamajka varieties in sucrose% was insignificant when fertilized with 4 L humic/fed. However, the difference between these two varieties reached the level of significance, when given 8 L humic/fed and/or without humic acid application. As for root sodium content, there was insignificant variance between the Nazarea and Bts 7715 varieties, when they fertilized with 8 L humic acid. However, the difference between these two varieties was significant in the case of fertilizing them with 4 L and/or the absence of humic acid in 1st season. Similar results were observed in the 2nd season. Concerning root potassium content, insignificant variance between the Nazarea and Bts 7715 varieties was detected, when they were untreated with humic, with a significant variance between these two varieties, when they were fertilized with 4 or 8 liters humic acid/fed, in the 1st season. In the 2nd one, the difference between Bts 7715 and Jamajka in root potassium content was insignificant when fertilized with 8 L of humic acid. However, the difference was significant as the two varieties were fertilized with 4 L of humic acid or those left without humic treatment. Concerning alpha-amino N content, the insignificant variance between the Nazarea and Bts 7715 varieties was when 4 L of humic acid was applied. However, this difference was significant in the case of 8 L of humic being used or not adding humic fertilization in the first season. Meantime, this difference was insignificant between Jamajka and Bts 7715 varieties fertilized with 8 L humic acid despite the difference reaching the significance level when they fertilized with 4 L humic and/or untreated with humic acid in 2nd season. While humic fertilization levels have distinct individual effects on varieties concerning root sucrose % and impurities content, the interaction effects between these two factors do not significantly improve or diminish the results. As a result, it is best to concentrate on the most important effects to maximize yield and quality. Fertilizing the Bts 7715 variety with 4 and/or 8 liters humic acid/fed (without significant variance between them) gained the highest sucrose % and the lowest sodium content.

Table 6. A significant interaction effect between beet variety and humic acid levels on sucrose%, impurities contents of sugar beet in the 2022/2023 and 2023/2024 seasons

Treatments		Sucrose %	Impurities contents (meq/100 g beet)					
			Sodium		Potassium		Alpha amino-N	
Humic acid level/fed (L)	Sugar beet variety	1st season	1st season	2nd season	1st season	2nd season	1st season	2nd season
without	Nazarea	18.49	6.39	5.84	4.11	3.72	2.38	1.79
	Nazarea	17.60	5.37	5.60	4.08	3.68	2.07	2.01
	Bts7715	18.63	5.78	5.08	4.06	4.27	2.16	1.61
4 liters	Nazarea	18.17	5.80	4.97	3.73	3.82	2.19	1.93
	Nazarea	17.80	5.49	5.15	3.64	3.22	2.16	1.87
	Bts7715	18.82	5.03	5.68	3.55	3.70	2.18	2.33
8liters	Nazarea	18.23	5.82	5.38	3.94	4.28	2.21	1.88
	Nazarea	17.40	5.27	5.52	3.87	3.44	2.15	2.11
	Bts7715	18.47	5.80	5.26	3.74	3.90	2.06	2.02
LSD at 0.05		0.39	0.20	0.13	0.12	0.48	0.11	0.21

3. Alkalinity coefficient, quality index, and percentages of sugar lost to molasses and extracted sugar

Since sodium, potassium, and alpha-amino nitrogen are the most melasmogenic substances in the aqueous sugar beet extract and are not substantially eliminated during processing to extract sucrose, the data in Table (7) derived from equations use these values. Data showed that except for the alkalinity coefficient in the first season, the levels of humic acid applied significantly influenced extracted sugar, SLM percentages and the quality index during the growing seasons. Increasing the humic acid level to 8 L/fed raised the alkalinity coefficient in the 2nd season and reduced SLM % in either seasons compared to the lower dose of humic acid (4 L/fed). Adding both the 8 or 4 liters' doses of humic acid/fed (without significant differences) achieved higher values for extracted sugar % and quality index than the control treatment, in both seasons. These results may be due to higher sucrose content and the lower values of non-sugar components, which are essential for the quality index of sugar beet, as shown in (Table 5). This result aligns with Pollach's (1984) observation that the alkalinity coefficient should remain above 1.8 to prevent root corrosion at high evaporation temperatures. Notably, the ability to recover sucrose present in the mother solution of sugar crystallization is significantly hampered by the action of melassigenic substances, which include all soluble extract components other than sucrose.

Results in the same Table confirmed that the three tested beet varieties significantly varied in alkalinity coefficient, quality index, and LM and ES percentages, in the two seasons. The Nazarea variety exhibited the highest alkalinity coefficient juice, and the lowest SLM % compared to the other two cultivars over both seasons. However, the Jamajka and Bts7715 varieties outperformed the Nazaea cultivar, achieving the highest extracted sugar and quality index values (with insignificant variances between them) in both seasons. The variations among the evaluated cultivars for these traits may be due to their genetic structure as noted by Enan *et al.* (2016) and Thalooth *et al.* (2019).

Table 7. Alkalinity coefficient, quality index, sugar lost to molasses, and extracted sugar percentages of three sugar beet varieties as affected by humic fertilization levels in the 2022/2023 and 2023/2024 seasons

Treatments	Alkalinity coefficient (AC)		Quality Index		Sugar lost to molasses %		Extracted sugar %	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Humic acid level/fed (L)								
Without	4.51	4.38	77.8	79.8	3.30	3.08	13.73	14.56
4	4.24	4.65	79.4	80.3	3.15	3.06	14.23	14.38
8	4.37	5.26	79.7	79.7	3.00	2.92	14.50	14.75
LSD at 0.05	NS	0.49	0.65	0.58	0.11	0.13	0.43	0.39
Evaluated sugar beet varieties								
Nazarea	4.40	5.01	77.1	80.0	3.06	2.92	13.18	14.63
Jamajka	4.30	4.44	79.7	80.0	3.11	3.07	14.44	14.10
Bts7715	4.32	4.83	80.1	80.3	3.31	3.11	14.84	14.93
LSD at 0.05	0.10	0.37	1.11	0.61	0.07	0.13	0.45	0.84

Significant interactions effect

Data in Table (8) showed that there were considerable interaction impact between varieties and humic acid levels on alkalinity coefficient, SLM %, in the two growing seasons, and quality index in the 2nd one. The differences between the Nazarea and Jamajka varieties in alkalinity coefficient were insignificant when they were fertilized with 4 L humic acid/fed. However, the differences between these two varieties reached significance when they were supplied with 8 L humic/fed and planted without humic acid addition in the 1st season. In the second one, it was noted that the differences between the varieties Bts 7715 and Jamajka were insignificant when receiving 8 kg of humic acid. However, the differences between these two varieties were significant when fertilized with 4 L and when sown without humic acid addition. Concerning sugar lost to molasses%, the differences between the Jamajka and Bts 7715 varieties were insignificant when were untreated with humic acid; however, these differences reached a significant level in the case of, raising the humic acid level from 4 to 8 liters humic in 1st season. However, in the second one, the differences between the varieties Nazarea and Jamajka were insignificant when they were treated with 4 L of humic acid meanwhile; these differences between them were significant when adding 8 L of humic acid and in the absence of humic acid fertilization. Regarding the quality index in the second season, the differences between the Jamajka and Bts 7715 varieties were insignificant when 8 L of humic acid was applied. However, when the soil was left without humic, or fertilized with 4 L humic acid these differences reached the significance level.

Table 8. A Significant interaction effect between beet variety and humic acid levels on alkalinity coefficient, sugar lost to molasses% and quality index of sugar beet in 2022/2023 and 2023/2024 seasons

Treatments		Alkalinity coefficient (AC)		Sugar lost to molasses%		Quality Index
Humic acid level/fed (L)	Sugar beet variety	1st season	2nd season	1st season	2nd season	2nd season
without	Nazarea	4.41	5.34	3.52	3.22	79.8
	Jamajka	4.48	4.62	3.13	3.06	79.2
	Bts7715	4.42	5.83	3.27	3.05	80.4
4 liters	Nazarea	4.36	4.55	3.17	2.89	80.8
	Jamajka	4.43	4.47	3.01	2.74	80.0
	Bts7715	3.93	4.12	2.83	3.13	80.2
8liters	Nazarea	4.43	5.15	3.25	3.18	79.3
	Jamajka	4.26	4.24	3.17	2.95	79.6
	Bts7715	4.55	4.56	3.02	3.03	80.3
LSD at 0.05		0.16	0.31	0.15	0.16	0.97

4. Top, root and sugar yields/fed (ton)

Applying humic acid had a marked impact on yields of root, top, and sugar/fed during the two seasons, according to the results in Table (9). Fertilizing beets with 8 L humic acid/fed increased root yield/fed by 1.71 and 2.36 tons and sugar yield by 0.43 and 0.24 tons compared to beets receiving 4 L humic acid/fed, in the 1st and 2nd seasons, successively. In addition, beets supplied with either 4 or 8 liters humic acid had the highest top yield/fed (with insignificant variance between them) compared to plants grown in soils without humic acid, in both seasons. These results underline the importance of humic acid as a soil amendment to increase the quality and quantity of sugar beet yields as it improves soil fertility and water use efficiency. Additionally, the application of humic acid can stimulate microbial and enzymatic processes, promote beet growth, and facilitate the translocation of nutrients. These findings are in line with previous studies by Abd El-Haleim (2020) and Nassar *et al.* (2023).

As for the beet varieties, results in the same table revealed variances in root, top, and sugar yields/fed for the evaluated sugar beet varieties, in either season. The Nazarea variety was superior to the other evaluated varieties concerning root yield/fed exceeding the Jamajka variety by (5.95 and 5.23 tons) and the Bts7715 variety by (3.11 and 2.75 tons), respectively in 1st and 2nd seasons. Meantime, both Nazarea and Bts 7715 recorded the highest values of top and sugar yields/fed (with insignificant variance between them), compared to the Jamajka variety. These results can be attributed to the observed growth trait values, as detailed in Table (4). The variations among sugar beet cultivars may also stem from differences in genetic makeup and their response to ecological conditions. These findings are consistent with Awadalla *et al.* (2021) and (Hefny and Said 2021).

Table 9. Yields of top, root and sugar/fed (ton) of three sugar beet varieties as affected by humic fertilization levels in the 2022/2023 and 2023/2024 seasons

Treatments	Top yield/fed (ton)		Root yield/fed (ton)		Sugar yield/fed (ton)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Humic acid level/fed (L)						
Without	9.38	7.77	21.70	20.61	3.82	3.84
4	10.83	9.48	23.98	22.47	4.26	4.20
8	12.97	10.55	25.69	24.83	4.69	4.44
LSD at 0.05	0.75	1.32	2.29	2.92	0.51	0.14
Evaluated sugar beet varieties						
Nazarea	11.84	10.54	26.81	25.30	4.59	4.53
Jamajka	10.04	8.82	20.86	20.07	3.77	3.63
Bts7715	11.30	9.44	23.70	22.55	4.40	4.31
LSD at 0.05	0.96	0.75	1.83	2.17	0.39	0.23

Table 10. Analysis of the correlation coefficient for root diameter, fresh weight, root and sugar yields/fed and quality index under varying levels of humic acid of three sugar beet varieties in the 2022/2023 and 2023/2024 seasons.

Traits	Root diameter (cm)		Root yield/fed (ton)		Sugar yield/fed (ton)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Root diameter (cm)	1.000	1.000	0.983**	0.996**	0.967**	0.996**
Root fresh weight/plant (g)	0.984**	0.974**	1.000**	0.949**	0.997**	0.991**
Root yield/fed (ton)	0.983**	0.996**	1.000	1.000	0.997**	0.983**
Sugar yield/fed (ton)	0.967**	0.996**	0.997**	0.983**	1.000	1.000
Quality Index	0.919**	-0.570	0.832**	- 0.150	0.787**	0.330

In the correlation analysis of the investigated traits, the data in Table 10 show that root yield is significantly positively correlated with root diameter (r = 0.983** and r = 0.996**), fresh weight (r = 1.000** and r = 0.949**) and sugar yield (r = 0.997** and r = 0.983**) in the first and second season, successively at a 1% probability level. A strong positive correlation is also observed between root diameter, both root fresh weight (r = 0.984** and r = 0.974**), root yield (r = 0.983** and r = 0.996**), and sugar yield (r = 0.967** and r = 0.996**) at the same level of significance in the 1t and 2nd seasons, successively. In addition, a positive correlation is detected between sugar yield and each of the following traits: Root diameter (r = 0.967** and r = 0.996**), root weight (r = 0.997** and r = 0.991**) and root yield/fed (r = 0.997** and r = 0.983**) in the 1st and 2nd season, respectively at a 1% probability level. The scientific rationale behind these findings lies in the interconnected nature of the studied traits. The significant positive correlations suggest that as one trait increases, the other tends to increase as well. Specifically, the strong positive correlation between root yield and traits such as root diameter, fresh weight per plant, and sugar yield indicates that thicker and heavier roots contribute to higher overall yields. The positive relationship between root diameter and fresh weight per plant highlights that thicker roots result in greater biomass, which in turn increases yield. The consistency of these correlations across both seasons further emphasizes their reliability as indicators of overall plant performance. Conversely, a negative correlation is observed between the quality index and both root diameter and yield in the second-season traits. These findings align with those reported by Assey *et al.* (2005).

CONCLUSION

Under Fayoum conditions, sowing the Nazarea variety with a soil application of 8 kg of humic acid/fed enhances root and sugar yield/fed and reduces root sodium content.

REFERENCES

A.O.A.C. (2005). Association of Official Analytical Chemists. Official Methods of Analysis, 26th Ed. AOAC Inter., Washington DC, USA.

Abd El-Haleim, Manal S. (2020). Effect of irrigation intervals and potassium humate on sugar beet productivity *J. of Plant Production, Mansoura Univ.,* 11 (12): 1239 – 1243.

Assey, A.A; H.G.H. Geweifel; M.A. Comaa and A.M. Gehan (2005). Yield analysis of some sugar beet cultivars under bio and inorganic nitrogen fertilization conditions. *Zagazig J. Agric. Res*., 32: 1071-1086.

Awadalla, A.O; Ahmed, A.Z. and Shereif, M. M. (2021). Possibility of sugar beet production in

Toshka Region: II- Effects of water stress on some sugar beet varieties. *Egypt. J. Agron*. 43 (3): 403-415.

Brar, N. S.; Dhillon, B. S.; Saini, K.S. and Sharma, P.K. (2015). Agronomy of sugar beet cultivation-A review. Agri. Review., 36 (3): 184-197

Cook, D.A. and R.K. Scott (1993). The sugar beet crops. scientific. practice. publ. by Chapman and Hall, London.

Devillers, P. (1988). Prevsion du sucre melasse. Scurries francases, 129, 190-200. (C.F. Sugar Beet Book)

Dexter, S. T.; Frakes, M. G. and Snyder, F. W. (1967). A rapid and practical method of determining extractable white sugar may be applied to the evaluation of agronomic practices and grower deliveries in the sugar beet industry. J. Am. Soc. Sugar Beet Tech. 14: 433–454.

Enan, S.A.A.M.; Aly, E.F.A. and Badr, A. I. (2016). Effect of humic acid and potassium on yield and quality of some sugar beet varieties in sandy soil. *J. Plant Production, Mansoura Univ.,* 7 (2): 289- 297.

Gomez, K.A. and Gomez, A.A. (1984) Statistical procedure for agricultural research. 2nd ed, John Wiley and Sons, New York, USA

Hefny A.M. Y. and Said, A. A. (2021). Effect of nano-micronutrients fertilization on yield and quality of some sugar beet varieties under early and late sowing dates. *Egypt. J. Agron.* 43 (1): 55- 68.

Le-Docte, A. (1927). Commercial determination of sugar beet in the beet roots using Sachs Le_Docte process. *Int. Sugar J*., 29: 488-492.

Nassar, M.A.A.; El-Magharby, Samia S.; Ibrahim, N.S.; Kandil, E.E. and Abd El-Salam, N.R. (2023). Productivity and quality variations in sugar beet induced by soil application of k-humate and foliar application of bio stimulants under salinity condition. *Journal of Soil Science and Plant Nutrition* 23:3872–3887

Nemeat-Alla1 E.A. H.; El-Gamal, I. S.H. and El-Safy, Nadia K. (2021). Effect of Potassium Humate and boron fertilization levels on yield and quality of sugar beet in sandy soil. *Alexandria Science Exchange J,* 42(2):395- 405

Olk, D. C.; Dinnes, D.; Scoresby, J. R.; Callaway, C. R. and Darlington, J. W. (2018). Humic products in agriculture: potential benefits and research challenges─a review. J Soil Sediment. 2881-2891.

Pollach, G. (1984). Development and utilization of quality criteria for sugar beet in Austria. Paper presented to the 27th techno. Conf., British sugar Plc. 22 PP.

S.C.C., (2023). The annual report of the sugary crops and sugar production in Egypt. Ministry of Agriculture, Egypt.

Shaban, KH.A.H.; Abdel Fatah, Eman M. and Syed, Dalia A. (2014). Impact of humic acid and mineral nitrogen fertilization on soil chemical properties and yield and quality of sugar beet under saline soil. *J. Soil Sci. and Agric. Eng., Mansoura Univ.,* 5 (10): 1317-1335.

Sible, C. N.; Seebauer, J. R. and Below, F. E. (2021). Plant biostimulants: a categorical review, their implications for row crop production, and relation to soil health indicators. Agronomy 11, 1297. doi: 10.3390/agronomy11071297

Snedecor, G.W. and Cochran, W.C. (1980). Statically methods. 6th Ed. Lowa State Univ. Press, AmestIowa U.S.A.

Thalooth, T.; Tawfik, M.M.A.; Badre, E. A. and Mohamed, M. H. (2019). Yield and quality response of some sugar beet (Beta vulgaris L.) varieties to humic acid and yeast application in newly reclaimed soil. *Middle East J. Agric. Res.*, 8(1): 56-65.

استجابة بعض أصناف بنجر السكر للتسميد بحمض الهيوميك تحت ظروف محافظة الفيوم

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الملخص العربى

أقيمت تجربتان حقليتان في مزرعة خاصة بمحافظة الفيوم – مصر، خلال موسمي الزراعة ٢٠٢٣/٢٠٢٢ و ٢٠٢٤/٢٠٢٣ لتقييم استجابة ثلاثة أصناف من بنجر السكر وحيدة الأجنة (نازاريا، جاماجكا و بتس ٧٧١٥) لمستويات مختلفة من حمض الهيومك كإضافة أرضية (بدون إضافة، ٤ ، ٨ لتر/ ٤٠٠ لتر ماء/ فدان) علي نمو وإنتاجية وجودة بنجر السكر. استخدام تصميم القطاعات كاملة العشوائية وتم توزيع المعاملات بنظام القطع المنشقة مرة واحدة حيث تم توزيع مستويات الهيومك الثلاثة عشوائيا في القطع الرئيسية، بينما تمت زراعة الأصناف عشوائيا في القطع المنشقة.

أهم النتائج:

– أدى معاملة بنجر السكر بـ ٨ لتر/فدان حمض الهيومك إلي زيادة مقاييس الجذر، والنسبة المئوية للسكروز ، ومحصول الجذور والسكر/فدان (طن)، في حين انخفضت نسبة السكر المفقود في المولاس في كلا الموسمين، كما تحسنت قيمة مُعامل قلوية العصير في الموسم الثاني، مقارنة بتلك النباتات المسمدة بـ ٤ كجم هيومك/فدان.

– حققت نباتات بنجر السكر المسمدة بمعدل ٤ أو ٨ لتر من حمض الهيوميك/فدان (بدون فرق معنوي بينهما) أعلى القيم لنسبة السكر المستخلص ومؤشر الجودة ومحصول العرش/فدان (طن) وذلك مقارنة بعدم إضافة الهيوميك في كلا الموسمين.

– تفوق صنف نازاريا على الأصناف الأخرى المختبرة فى صفات سمك ووزن الجذور، وزن الأوراق الطازج/نبات، محصول الجذور/فدان (طن)، ومُعامل قلوية العصير، أقل القيم لنسبة السكر المفقود في المولاس في كلا الموسمين. في الوقت نفسه حقق كل من صنفي " نازاريا وبتس ٧٧١٥" أعلى القيم لمحصول السكر، والعرش/فدان (طن) (بدون فرق معنوي بينهما) في كلا الموسمين. كما أظهرت النتائج تفوق صنفي " بتس ٧٧١٥ وجاماجكا" في النسب المئوية للسكروز والسكر المستخلص، فى حين سجلا أقل محتوى من الصوديوم بالجذور، مما أدي إلي تحسين مؤشر الجودة في كلا الموسمين.

– تحت ظروف محافظة الفيوم، يُوصي بزراعة صنف بنجر السكر وحيد الأجنة " نازاريا" مع تسميده بمعدل ٨ لتر من حمض الهيوميك لزيادة محصول الجذور والسكر/فدان مع تقليل محتوى الجذور من الشوائب.

الكلمات المفتاحية : معدلات حمض الهيومك، أصناف بنجر السكر، المحصول، الجودة.