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RESPONSE OF SOME SUGAR BEET VARIETIES TO INORGANIC AND BIO-NITROGEN FERTILIZERS UNDER NUBARIA CONDITIONS

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ABSTRACT

In the 2020/2021 and 2021/2022 seasons, this study was performed in the Nubaria region, Fifth Section, El-Beheira Governorate, Egypt (latitude 30° 53' N and longitude 30° 04' E) to assess performance of three multi-germ varieties and their response to different levels of liquid bio-nitrogen fertilizer (EM) and inorganic nitrogen on growth, yield, and quality of Sugar beet (*Beta vulgaris* var. saccharifera) in sandy clay loamy soil properties. Eighteen treatments included three sugar beet cultivars (Pleno, Nader, and Bts 970), three inorganic nitrogen levels (60, 90, and 120 kg N /fed) and two effective microorganism levels in soil (without addition and 6 L /fed). Split-split plot distribution with three replications were employed for a randomized complete block design. Over the two seasons, the Bts 970 variety recorded the highest root diameter (RD), fresh weight (FW), leaf area index (LAI), potassium content, sucrose and extracted sugar percentages, as well as root and sugar yields/fed, while simultaneously demonstrating the lowest sodium and alpha-amino N content. In both seasons, soil treated with effective microorganisms recorded the highest root diameter (RD), fresh weight (FW), leaf area index (LAI), potassium and alpha-amino nitrogen contents, sucrose and sugar lost to molasses percentages (SLM %) and sugar beet root and sugar yields/fed. An increase in extracted sugar values was noted in the second season. However, sodium content significantly decreased, in both seasons. Planting variety Bts 970 in soil treated with EM and fertilizing N with 120 kg/fed can be

recommended to give the highest root and sugar yields under Nubaria conditions.

Keywords: Bio-N, Nitrogen fertilizer, Sugar beet varieties.
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INTRODUCTION

Sugar beet holds great importance as a key crop in Egypt, significantly contributing to local sugar production and fulfilling the needs of the domestic market. Nonetheless, the productivity of sugar beet in Nubaria section remains unsatisfactory. This shortfall can be linked to various reasons, such as the quality of the soil and how well fertilization practices are being implemented. To increase sugar beet productivity in these new areas, appropriate fertilization techniques must be used. Bio-fertilizers, such as effective microorganisms (EM), are particularly important as they improve soil fertility and increase nutrient availability to plants. The combined use of bio-fertilizers with inorganic fertilizers can lead to better nutrient absorption, which ultimately results in better growth and higher productivity of the sugar beet.

Regarding to variety variances, according to **(Enan *et al.*, 2016)** the three tested varieties Natoura, Henrike, and Polat illustrated appreciable variances in RD and FW. They noted that variety Polat demonstrated superiority in comparing with Natoura and Henrike, achieving highest measurements for RD and FW/plant. Conversely, it was determined that there had been no substantial variations among the varieties concerning their impact on sugar yield/fed. According to **(Gobarah *et al.*, 2019)** differences attributed to varieties were evident across all examined characteristics. Variety Ras-Poly showed best results in terms of FW, RD, sucrose, extracted sugar percentages, and sugar yields/fed, with varieties Dema-poly & Gloria, respectively. Sirona produced greater yield of root and sugar/fed in comparison with cultivars Dina, Belatos, and Athos poly **(El-Bakary, 2021)**. Conversely, the Belatos and Athos poly cultivars had greater Na and α-amino nitrogen content levels than Dina variety, which had lower percentage values of potassium and sugar lost to molasses.

According to **(Nemeat Alla *et al.*, 2023)**, the Zoom variety outperformed Aladdin and Lulu varieties, producing thickest and heaviest roots. It also achieved the highest percentages of sucrose and extracted sugar, as well as the highest root and sugar yields/fed. Additionally, Zoom and Lulu varieties observed the highest LAI values, with no significant difference between them, surpassing the Aladdin variety.

Because it is a crucial part of chlorophyll, nitrogen is important to plant growth. Chlorophyll allows plants to capture sunlight and convert into necessary energy. It is also essential for amino acids, which are considered the essential components of proteins necessary for tissues and organs development. In this concern, gradual and considerable improvements in RD and FW, SLM %, root and sugar yields/fed, occurred when addition levels increased from 80 to 100 and 120 kg N/fed, as reported by **(Elwan and Helmy, 2018). (Nemeat Alla *et al.*, 2023)** revealed that the applied 120 kg N/fed considerably enhance RD and FW/plant, as well as LAI, and both root and sugar yields/fed. In contrast, adding 95 kg N recorded the highest amount of sucrose, extracted sugar % (ES %), quality index (QI) and reduced contents of α-amino N and SLM %. **(Enan and Nemeatalla, 2024)**, found that using 288.0 kg N/ha in sugar beet fertilization increased RD, FW, root impurities and SLM %. They added that enriching beets with 230.4 and/or 288.0 kg N/ha provided the highest LAI, sucrose, percentages of extracted sugar, quality index, root and sugar yields/ha.

Effective microorganisms contain groups of beneficial microorganisms like photo-synthetic and lactic acid bacteria, as well as actinomycetes and yeast. It is intended to interact with the soil ecology for several benefits, such as mitigating plant diseases, preserving energy, solubilizing minerals in the soil, improving microbial equilibrium, promoting photosynthetic efficiency, and facilitating nitrogen fixation. **(Olle and Williams, 2013)**. EM contains a combination of live microorganisms derived from rich soils, beneficial for agricultural production. EM's primary function is to raise soil micro flora diversity leading to higher crop yields. Research has shown that adding EM to the soil can increase the photosynthetic rate and stomatal conductance in leaves, improve soil fertility and preserve the natural environment **(Golec *et al.*, 2007; Mohan and Srinivasan, 2008)**.

This work aimed to assess three different varieties of beets to determine suitable variety/varieties, also the optimal dose from inorganic and bio- N fertilizer, to obtain the best production and quality characteristics of the tested varieties under Nubaria conditions.

MATERIALS AND METHODS

A field experiment was executed in the Nubaria region, Fifth Section, El-Beheira Governorate, Egypt, (lat. 30° 53 N and long. of 30° 04 E) in seasons (2020/2021 & 2021/2022) to assess three multi-germ varieties performance and their reaction to varying concentrations of liquid bio-nitrogen fertilizer: commercially named (EM) and inorganic N on different production and quality traits of sugar beet under sandy loam soil. This study consisted of eighteen conducts, representing combinations of three varieties namely: (Pleno, Nader and Bts 970 varieties), three inorganic N levels (60, 90 and 120 kg N/fed) and two levels of EM as soil application (without adding and applying 6 L/fed). A randomized complete block design was used in a split-split plot distributed with three replications.

Beets varieties were assigned to the main plots, while three levels of N were randomly distributed in the sub-plots, and two levels of bio-fertilizer were allocated in the sub sub-plots. EM fertilizer containing *Lactobacillus casei* (9×10^{7} cfu), *Lactococcus lactis* (5×10^{7} cfu), *Saccharomyces cerevisiae* (2×10^{6} cfu), *Rhodopseudomonas palustris* (4×10^{6} cfu) including photosynthetic and lactic acid bacteria, as well as yeast and actinomycetes was obtained from “ARC, Giza, Egypt” and applied to the soil three times: after thinning, then 20 and 40 days later, as soil drenches before irrigation. The area of the experimental unit measured 21.60 m^2, consisting of 6 ridges, each 6.0 m long and 0.6 m wide, with a spacing of 20 cm between the hills. The tested multi-germ varieties were planted on 2nd week of September in the two seasons while harvesting took place after 210 days from sowing date in each season. At the 4-leaf stage, plants were thinned so that each hill had one plant. During seedbed preparation, usage superphosphate (15 % P) rate was 30 kg P_2O_5/fed.

The inorganic N used in this study was ammonium nitrate (33.5% N), which utilized three equal doses for each rate. First application occurred after trimming, succeeded by two applications spaced 20 days apart. At the start and end of N fertilizer treatments, two equal doses of potassium sulfate (48% K) were applied at a rate of 48 kg K_2O/fed. Additional field procedures were executed as SCRI, ARC, Giza, Egypt, recommendation. The provenance of the examined sugar beet cultivars presented in **Table 1**. The technique specified by **(AOAC, 1995)** was used to collect soil samples from the experimental location at a depth of (0-30 cm) and analyze their physicochemical parameters, as illustrated in **Table 2**.

Table 1: Country of provenance and source of the evaluated varieties.

Varieties	Seeds type	Homeland	Manufacturer
Pleno	Multi-germ	Netherland	VanderHave
Nader	Multi-germ	Netherland	VanderHave
Bts 970	Multi-germ	Germany	Beet seeds

Sources: Sugar Crops Research Institute, Agricultural Research Centre, Giza, Egypt.

The studied traits

The following traits were assessed by selecting ten plants randomly from the mid ridges of each sub-subplot at harvest: root fresh weight (RFW)/plant (g) and root diameter (RD) (cm).

From the inner rows of each sub sub-plot five plants were assembled unplanned at 130 days after planting to determine: The leaf area index (LAI) was quantified as describes by **(Watson, 1952)**, using the next equation: LAI = leaf area/plant (cm^2) ÷ plant ground area (cm^2). The quality examination was conducted on fresh samples of roots at the lab of Nubaria Sugar Company, Egypt, including the following criteria:

Impurities: The concentrations of Na, K, and α-amino-nitrogen in roots were quantified as meq/100 g, Sodium and potassium levels were measured by "Flame photometer" in digested solution, while the determination of α-amino N was carried out through hydrogenation as described by **(Cooke and Scott, 1993).**

Table 2: Physicochemical properties for the experimental soil site's seasons of 2020/2021 and 2021/2022.

Soil Traits		S1	S2
Soil texture			
Sandy clay loam	Sand	60.5	60.2
	Silt	11.5	10.7
	Clay	28.0	29.1
Soil chemical prosperities			
Soluble Cations (meq/L)	Ca^{+2}	6.82	5.98
	Mg^{+2}	2.74	3.22
	Na^{+}	9.73	9.65
	K^{+}	2.11	2.84
Soluble Anions (meq/L)	$CO3^{-2}$	-	-
	$HCO3^{-}$	3.79	3.68
	Cl^{-}	10.66	11.32
	SO_4^{-2}	6.95	6.68
Available nutrients (mg/kg soil)	N	26.8	29.9
	P	4.97	5.66
	K	145.2	160.4
	EC (ds/m)	2.14	2.11
	OM (%)	0.45	0.49

- S1 (season 2020/2021) - S2 (season 2021/2022)

The procedure of **(Le Docte, 1927),** was employed to ascertain the sucrose percentage in fresh macerated root. The proportion of sugar lost to molasses (SLM) % was computed using **(Devillers, 1988)** equation:

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

Quality index (QI) was computed using the equation of **(Cooke and Scott, 1993)** as follows:

QI = ES % ÷ sucrose %

Extracted sugar percentage (ES %) was calculated by the equation of **(Dexter *et al.*, 1967):**

ES % = sucrose % - SLM % - 0.6

Root yield/fed (ton): sugar yield/fed (ton) was calculated according to the following equation:

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

Statistical analysis

The statistical analysis of the received data was carried out using the "Co-STATC" computer software program, to estimate (ANOVA) for the split-split plot design following the guidelines laid forth by **(Gomez and Gomez, 1984).** The (LSD) approach was employed to examine differences between applications means at the 5 % level of probability, as stated **(Snedecor and Cochran, 1994)**.

RESULTS AND DISCUSSIONS

Root diameter, fresh weight/plant and leaf area index

Data presented in Table 3 indicated that the three evaluated beet cultivars exhibited substantial differences in root weight, diameter, and LAI in either season. The Bts 970 variety recorded the uppermost values of RW per plant, diameter and LAI over those gained from the other two varieties. The variations observed among varieties can be linked to their genetic makeup. These findings align with those attained by **(Enan *et al.*, 2016** and **Abazied and Al-Maracy, 2023)**.

The same table cleared that applying 120 kg N/fed significantly led to greater values of root weight, diameter, and LAI compared to those received 60 and/or 90 kg Nitrogen/fed 1^{st} and 2^{nd} seasons, respectively. These obtained results might be caused by nitrogen role in building up plant organs, specifically the leaves, which efficiently capture and utilize solar radiation in manufacturing dry matter. These findings aligned with those presented by **(Nemeat Alla *et al.*, 2023).**

Soil drenches with bio-N fertilizer enhanced fresh weight of roots, diameter, and LAI of sugar beets, over two seasons compared to those left without bio-N fertilization. These growth improvements may result from anti-microbial substances produced by EM involved in this study, which, by using sugars and amino acids from photosynthetic bacteria, organic matter, and plant roots, also encourage plant growth, size, and durability of sugar beet leaf canopies. Additionally, the applied bio-N fertilizer contained bioactive ingredients like phytohormones and enzymes from yeasts, which can stimulate active cell and root division, as pointed out by **(Golec *et al.*, 2007)**.

Table 3: Influence of inorganic and bio-nitrogen levels on root weight, diameter and leaf area index of different sugar beet varieties in 2020/2021 and 2021/2022 seasons

Treatments	**RD (cm)**		**RFW/plant (gm)**		**LAI**	
	S1	**S2**	**S1**	**S2**	**S1**	**S2**
Varieties						
Pleno	11.32	11.79	993.70	935.36	2.32	2.47
Nader	12.02	12.11	1025.46	967.90	2.74	2.88
Bts 970	13.03	13.41	1095.20	1057.35	3.28	3.46
LSD (0.05)	**0.27**	**0.13**	**40.87**	**36.03**	**0.39**	**0.13**
In-organic nitrogen fertilizer rates/fed (kg)						
60	11.71	11.92	1012.58	966.88	2.54	2.69
90	12.19	12.32	1026.07	967.83	2.76	2.93
120	12.46	13.02	1075.70	1025.90	3.04	3.19
LSD (0.05)	**0.23**	**0.15**	**7.61**	**14.02**	**0.18**	**0.20**
Bio-N levels/fed (L)						
Without Bio-N	11.61	11.57	993.89	941.64	2.42	2.56
6 L Bio-N	12.63	13.31	1082.40	1032.10	3.14	3.31
LSD (0.05)	**0.21**	**0.12**	**13.77**	**13.85**	**0.11**	**0.51**

- S1 (season 2020/2021) - S2 (season 2021/2022)

Significant interactions effect

Interaction between cultivars and inorganic-N levels substantially influenced the RD and FW/plant of sugar beet (Table 4). The variations in root diameter between Nader and Pleno cultivars were found to be insignificant under a nitrogen application of 120 kg N/fed. Nonetheless, the disparities between the two varieties attained statistical significance when fertilized by 60 and 90 kg N/fed throughout the first season. In the second one, insignificant variance was found between the Nader and Pleno varieties in root diameter, when fertilized with 90 and 120 kg N/fed. However, the Nader variety significantly produced thicker roots than that recorded by Pleno, as they were fertilized with 60 kg N/fed. As for root fresh weight, there was an insignificant difference between Pleno and Nader varieties in this trait, when they were given 90 kg N, in 1st season. However, when the Nitrogen amount was raised to 120 kg N per fed, the Nader substantially surpassed Pleno, producing heavier roots. In the second season, the Nader variety markedly recorded topmost values of root fresh weight/plant than that of Pleno, when they were fertilized with 60 and/or 90 N/fed, without significant variance between the two cultivars, when they treated with 120 kg N/fed. These results possibly by reason of the genetic structure of varieties, which variably responded to the applied levels of inorganic nitrogen.

Table 4: Significant interaction effect between beet variety and in-organic nitrogen levels on root diameter and fresh weight in 2020/2021 and 2021/2022 seasons

Treatments		**RD (cm)**		**RFW (g)**	
Varieties	**In-organic nitrogen rates/fed (kg)**	**S1**	**S2**	**S1**	**S2**
Pleno	**60**	10.51	11.00	970.41	915.54
	90	11.49	11.85	989.46	917.39
	120	11.95	12.52	1021.24	973.15
Nader	**60**	11.72	11.67	1010.71	964.21
	90	12.20	11.97	1007.49	946.06
	120	12.14	12.71	1085.18	993.43
Bts 970	**60**	12.91	13.10	1056.63	1020.90
	90	12.87	13.14	1081.27	1040.03
	120	13.29	13.99	1147.70	1111.13
LSD (0.05)		**0.40**	**0.27**	**18.20**	**24.28**

- S1 (season 2020/2021) - S2 (season 2021/2022)

The interaction between various varieties and fertilization levels of bio-nitrogen markedly influenced RD and LAI (Table 5). The impact

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of varieties Nader and Pleno on root diameter wasn't significant when planted in sandy soil treated with 6 L of bio-fertilizer/fed. However, the differences between the same two varieties reached a significant level in the state they were planted in the soil left without effective microorganisms, in 1st season. In next season the results were similar to that obtained in the first season. Interestingly, the Bts 970 variety produced significantly thicker roots than the Pleno and Nader varieties when grown in soil treated with 6 liters of EM/fed compared with sowing them in soil untreated with EM. Regarding root fresh weight, there was an insignificant difference between the Nader and Bts 970 varieties in their effect on this trait, when they were sown in soil treated with 6 L bio-N. Nevertheless, the differences between the same mentioned varieties attained the significance level when sown in absent EM, in both seasons. The Nader and Bts 970 varieties exhibited a higher leaf area index than the Pleno variety, in both seasons. According to these findings EM playing an important role in holding nutrients in the root zone of plants until required and the behavior performance of the Bts 970 variety grown in soil was treated with effective microorganisms as recorded by **(Olle and Williams, 2013).**

Table 5: Significant interaction between variety and bio-nitrogen levels impact on root diameter weight and leaf area index of sugar beet in 2020/2021 and 2021/2022 seasons

Treatments		**RD (cm)**		**LAI**	
Varieties	**Bio-nitrogen levels/fed (L)**	**S1**	**S2**	**S1**	**S2**
Pleno	**Without Bio-N**	10.64	10.82	1.92	2.03
	6 L Bio-N	12.00	12.76	2.72	2.90
Nader	**Without Bio-N**	11.48	11.63	2.26	2.38
	6 L Bio-N	12.55	12.86	3.22	3.38
Bts 970	**Without Bio-N**	12.71	12.51	3.06	3.28
	6 L Bio-N	13.34	14.31	3.49	3.65
LSD (0.05)		**0.37**	**0.22**	**0.19**	**0.22**

- S1 (season 2020/2021) - S2 (season 2021/2022)

Table 6 demonstrated that root diameter and fresh weight were significantly affected by the interaction between inorganic N and bio-nitrogen fertilization levels. It was found that the variances in beet root diameter and fresh weight fertilized with 60 and 90 kg inorganic N/fed were insignificant when planted in soil treated with EM bio-fertilizer compared to those received 120 kg N. However, in the first growing season these differences between the same N rates achieved the significance level when plants sown in soil left without adding EM. In next season, likewise results were obtained for the first one. In two seasons, the maximum values of RD and FW/plant were observed when beets were sown in soil that was treated with 6 L/fed bio-fertilizer and received 120 kg inorganic N/fed. These results demonstrate the complementary effect of the role of nitrogen and bio-fertilizers in improving photosynthesis. The results align with **(Mohan and Srinivasan, 2008),** who noted that microorganisms enhance photosynthetic rates and stomatal conductance in leaves, boost soil fertility and help preserve the natural environment, particularly in the presence of nitrogen fertilization.

Table 6: Significant interaction between inorganic and bio-nitrogen rates impact on root diameter and fresh weight of beets in 2020/2021 and 2021/2022 seasons

Treatments		**RD (cm)**		**RFW (gm)**	
Inorganic nitrogen rates/fed (kg)	**Bio-nitrogen levels/fed (L)**	**S1**	**S2**	**S1**	**S2**
60	**Without Bio-N**	10.74	10.63	947.85	896.99
	6 L Bio-N	12.69	13.20	1077.32	1036.78
90	**Without Bio-N**	12.01	11.51	990.80	920.78
	6 L Bio-N	12.36	13.14	1061.34	1014.87
120	**Without Bio-N**	12.08	12.56	1042.85	1007.15
	6 L Bio-N	12.84	13.58	1108.56	1044.66
LSD (0.05)		**0.37**	**0.22**	**23.85**	**24.00**

- S1 (season 2020/2021) - S2 (season 2021/2022)

Potassium, sodium and alpha-amino N contents

Data presented in Table 7 demonstrated substantial differences in technological characteristics, specifically in the contents of K, Na, and α-amino N, between varieties during both seasons. The Bts 970 variety had the lowest Na and α-amino N contents in comparison to the Pleno and Nader varieties, in both seasons. Nevertheless, the Bts 970 variety recorded the highest K content, in both seasons. These differences potential attributed to the variations in growth traits and reactions to ecological circumstances throughout the process of forming soluble solids in plants. The findings of this study align with the observation by **(Aly *et al.*, 2017)**, who noted significant differences in technological traits between the sugar beet varieties that were assessed.

Table 7: Influence of inorganic N levels and EM on Na, K and α-amino N contents of three varieties in 2020/2021 and 2021/2022 seasons.

Treatments	Impurities contents (meq/100 g beet)					
	K		Na		α-amino N	
	S1	S2	S1	S2	S1	S2
Varieties						
Pleno	2.97	3.42	1.69	1.71	1.74	1.85
Nader	3.98	4.24	1.49	1.50	1.49	1.43
Bts 970	4.73	4.80	1.16	1.23	1.15	1.17
LSD (0.05)	**0.71**	**0.98**	**0.31**	**0.33**	**0.34**	**0.44**
Inorganic nitrogen fertilizer rates/fed (kg)						
60	3.39	3.61	1.38	1.19	1.32	1.21
90	3.93	4.34	1.40	1.58	1.41	1.46
120	4.37	4.51	1.56	1.67	1.65	1.77
LSD (0.05)	**0.63**	**0.38**	**0.17**	**0.16**	**0.11**	**0.17**
Bio-nitrogen levels/fed (L)						
Without Bio-N	3.53	3.77	1.59	1.63	1.27	1.29
6 L Bio-N	4.26	4.54	1.30	1.33	1.66	1.67
LSD (0.05)	**0.70**	**0.72**	**0.13**	**0.17**	**0.13**	**0.20**

- S1 (season 2020/2021) - S2 (season 2021/2022)

Fertilizing beets with 120 kg inorganic-N/fed increased K and α-amino N contents, in comparison to the other doses of nitrogen, in both seasons. However, fertilized beets with lowest rate of nitrogen/fed attained the lowest levels of Na content paralleled with applying of 90 or 120 without significant variance between them in both seasons. These results were in agreement with **(Hozayn *et al.*, 2014)** who stated that rising N level to 100 kg recorded the highest root potassium content, while the highest α-amino N was scored in beets treated with 200 kg N/fed.

The data in same table stated that higher potassium and α-amino N contents with lower values of sodium content were obtained when applying a soil drench of 6 L/fed of bio-nitrogen, compared with the absence of applying EM to the soil, during the two seasons.

Sucrose, SLM % and QI

Results in Table 8 confirmed that the three tested cultivars had significant differences in sucrose % in either season, in addition to the QI, in 1st season. On the other hand, the QI in the following season and the percentage of SLM did not vary significantly across cultivars in any season. The Bts 970 variety surpassed the other two cultivars and was given the highest sucrose, in both seasons and QI, in 1st one. The variation among the evaluated cultivars in sucrose and quality index may be due to genetic structure as mentioned by **(Gobarah *et al.*, 2019)**.

Fertilizing beets with inorganic nitrogen levels significantly influenced sucrose and SLM percentages however, the QI failed to attain insignificancy level, in each season (Table 8). The elevation of N levels to 120 kg/fed correlated with a progressive rise in sucrose and the percentage of SLM across both seasons. According to **(Elwan and Helmy, 2018),** These findings prove that nitrogen is essential in metabolic processes**.**

Except for the quality index, data showed that treating soil with EM significantly impacted all identified traits in both seasons compared to untreated soil. Adding EM to sandy loam soil increased sucrose and sugar lost to molasses percentages. Otherwise, there was an insignificant difference in the quality index between plants that were sown in soil treated with bio-N and those left without EM. These data may be ascribed to the function of EM as explained by **(Ghaemi and Bahrami, 2014),** who reported that adding effective microorganisms increases the sugar content in roots and reduces impurities.

While inorganic nitrogen levels and bio-N have distinct individual effects on sucrose content, the percentage of SLM, and the QI, the interaction effects of these two factors generally do not appreciably enhance or diminish the results in the tested varieties. Therefore, when making decisions about fertilization and microbial amendments, it is advisable to focus on the main effects to optimize yield and quality, rather than complicating management strategies with considerations of interactions. Additionally, further research could provide deeper insights into the independent contributions of these additions.

Table 8: Influence of inorganic and bio-nitrogen on sucrose, sugar lost to molasses (SLM) percentages and quality index (QI) of three varieties in 2020/2021 and 2021/2022 seasons

Treatments	Sucrose %		SLM %		QI	
	S1	S2	S1	S2	S1	S2
Varieties						
Pleno	17.83	17.90	1.59	1.68	87.73	87.27
Nader	18.42	18.64	1.64	1.66	87.85	87.88
Bts 970	19.18	19.36	1.61	1.64	88.48	88.46
LSD (0.05)	**0.35**	**0.29**	**NS**	**NS**	**0.61**	**NS**
Inorganic nitrogen rates/fed (kg)						
60	17.71	17.65	1.50	1.47	88.15	88.21
90	18.42	18.80	1.60	1.69	88.05	87.79
120	19.31	19.46	1.74	1.81	87.86	87.62
LSD (0.05)	**0.18**	**0.17**	**0.08**	**0.07**	**NS**	**NS**
Bio-nitrogen levels/fed (L)						
Without Bio-N	18.36	18.33	1.53	1.58	88.39	88.10
6 L Bio-N	18.59	18.94	1.69	1.74	87.65	87.65

- S1 (season 2020/2021) - S2 (season 2021/2022)

Extracted sugar %, root and sugar yields/fed (ton)

The tested cultivars illustrated marked variances in extracted sugar percentage, root yields and sugar yields per metric ton of fed in the two seasons, as shown in Table 9. The Bts 970 variety performed better and surpassed the other beet varieties, producing (0.57 and 0.51 in extracted sugar percentage), (2,72 and 1.75 tons of roots) and (0.57 and 0.40 tons of sugar), in 1st and 2nd seasons, successively over those gained from the Nader variety. The variability among the evaluated cultivars in these characteristics could be associated to genetic variations and their responses to ecological circumstances. These findings are consistent with those observed by **(Gobarah *et al.*, 2019).**

Extracted sugar percentage, root yields and sugar yields/fed all increased gradually in every season when nitrogen was increased from 60 to 120 kg/fed (Table 5). Compared to the application of 90 kg N/fed, the use of 120 kg/fed resulted in a higher percentage of extracted sugar and increased root and sugar yields/fed over the two seasons. These findings suggest that nitrogen positively influences vegetative growth by promoting leaf initiation and photosynthesis, which increases root fresh weight and diameter. This, in turn, increases both number of cambium rings and the distance between them, which is associated with sucrose concentration. (Table 3). These results coincide with those found by **(Elwan and Helmy, 2018** and **Nemeat Alla *et al.*, 2023).**

Table 9: Influence of inorganic and bio-nitrogen levels on extracted sugar %, root and sugar yield/fed (ton) of three varieties in 2020/2021 and 2021/2022 seasons

Treatments	**ES %**		**RY/fed (ton)**		**SY/fed (ton)**	
	S1	**S2**	**S1**	**S2**	**S1**	**S2**
Varieties						
Pleno	15.86	15.86	18.95	19.74	3.01	3.14
Nader	16.18	16.38	19.65	21.34	3.19	3.51
Bts 970	16.75	16.89	22.37	23.09	3.76	3.91
LSD at (0.05)	**0.34**	**0.26**	**0.54**	**0.65**	**0.16**	**0.12**
Inorganic nitrogen fertilizer rates/fed (kg)						
60	15.61	15.57	18.92	20.14	2.96	3.15
90	16.22	16.51	20.28	21.25	3.29	3.52
120	16.96	17.05	21.77	22.80	3.70	3.89
LSD (0.05)	**0.14**	**0.21**	**0.44**	**0.45**	**0.10**	**0.11**
Bio-nitrogen levels/fed (L)						
Without Bio-N	16.27	16.19	18.51	19.46	3.02	3.16
6 L Bio-N	16.26	16.56	22.13	23.32	3.62	3.87
LSD (0.05)	**NS**	**0.18**	**0.33**	**0.36**	**0.07**	**0.06**

- S1 (season 2020/2021) - S2 (season 2021/2022)

Data from the same Table 9 demonstrated that the addition of 6 L/fed EM as a soil fertilization significantly rising root and sugar yields/fed in each season, as well as ES % in the second season only. In the first and second seasons, the root and sugar yields/fed increased by 3.62 and 3.86 tons of roots and 0.60 and 0.71 tons of sugar, respectively, compared to untreated soil. The observed improvements in root and sugar yields may be due to the function of bio-fertilizers as effective alternatives to inorganic fertilizers. These bio-fertilizers enhance soil fertility because they contain living microorganisms, which are derived either from plant roots or cultivated soil, as noted by **(Attarde *et al.*, 2012).**

Significant interactions effect

The extracted sugar % and root yield of sugar beet were markedly influenced by the interaction between varieties and levels of inorganic nitrogen fertilization (Table 10). It was evident that the difference in extracted sugar % between the Nader and Bts 970 varieties was insignificant when they were given 120 kg N/fed. However, this difference was significant when they were fertilized with 60 and 90 kg/fed, in 1st season. In the second one, parallel results were detected. The Nader and Bts 970 varieties produced higher values of extracted sugar compared to the Pleno variety when fertilized with 120 kg N/fed.

Regarding root yield/fed, there was an insignificant difference between the Pleno and Nader varieties when given 90 kg N, in first season. However, when the N rate was reduced to 60 kg/fed, the variance between the Nader and Pleno varieties remained insignificant. Otherwise, significant differences emerged between the Nader and Pleno varieties when fertilized with 90 and 120 kg N/fed, in next season. Additionally, Bts 970 variety outperformed the other varieties in terms of root yield per feddan, in two seasons.

Table 10: Significant interaction between inorganic nitrogen levels and varieties impact on extracted sugar % and root yield in the 2020/2021 and 2021/2022 seasons

Treatments		ES (%)		RY/fed (ton)	
Varieties	**Inorganic nitrogen levels/fed (kg)**	**S1**	**S2**	**S1**	**S2**
Pleno	**60**	15.47	14.63	17.66	19.06
	90	15.75	15.84	19.10	19.72
	120	16.37	17.08	20.09	20.46
Nader	**60**	15.27	15.53	18.66	19.84
	90	16.10	16.58	19.60	21.24
	120	17.19	17.03	20.86	22.95
Bts 970	**60**	16.10	16.53	20.45	21.51
	90	16.81	17.11	22.12	22.79
	120	17.34	17.35	24.53	24.99
LSD (0.05)		**0.26**	**0.36**	**0.77**	**0.79**

- S1 (season 2020/2021) - S2 (season 2021/2022)

The interaction between adding beneficial microorganisms and varieties appreciably impacted root and sugar yields/fed among the traits under study (Table 11). An inconsequential disparity in root and sugar yields per fed was observed between the Pleno and Nader varieties when cultivated in soil devoid of Bio-N during the initial season. In contrast to planting in treated soil with bio-nitrogen, the second season showed negligible differences in root and sugar yields between Nader and Bts 970 varieties when planted in soil that had not been treated with Bio-N. The Bts 970 variety exhibited better performance and gave the greatest values of root and sugar yields when planted in soil treated with 6 liters of effective microorganisms in comparison to Nader and Pleno varieties. This favorable effect was earlier observed on RD and FW as shown in (Table 3) and finally, yields resulting from the interaction between the genetic composition and the environment in which these varieties are sown.

Table 11: Significant interaction between effective microorganisms and varieties impact on root and sugar yields/fed in the 2020/2021 and 2021/2022 seasons

Treatments		**RY/fed (ton)**		**SY/fed (ton)**	
Varieties	**Bio-nitrogen levels/fed (L)**	**S1**	**S2**	**S1**	**S2**
Pleno	**Without Bio-N**	17.61	17.64	2.80	2.77
	6 L Bio-N	20.29	21.84	3.22	3.52
Nader	**Without Bio-N**	18.15	20.08	2.93	3.27
	6 L Bio-N	21.14	22.61	3.44	3.75
Bts 970	**Without Bio-N**	19.77	20.67	3.32	3.46
	6 L Bio-N	24.97	25.52	4.19	4.35
LSD (0.05)		**0.57**	**0.62**	**0.14**	**0.20**

- S1 (season 2020/2021) - S2 (season 2021/2022)

In Table 12, root yield is positively correlated with RD (r=0.732** and 0.893**), RFW/plant (r=0.887** and 0.855**), and SY (r=0.976** and 0.969**) at a 1% probability level in the 1^{st} and 2^{nd} seasons, respectively. At the 1% probability level in the two seasons, root diameter is positively correlated with RFW/plant (r=0.785** and 0.908**), RY/plant (r=0.732** and 0.893**), and SY/fed (r=0.721** and 0.887**). In both seasons, SY/fed is positively correlated with RD (0.721** and 0.887**), RW/plant (r=0.858** and 0.826**), and RY/fed (r=0.976** and 0.969**) at a 1% probability level. Science explains these findings because the qualities tested are connected. Positive correlations show that as one attribute rises, the other rises also. Root yield's significant positive association with root diameter, fresh weight per plant, and sugar yield shows that thicker, heavier roots increase yields.

Root diameter increases fresh weight/plant, supporting the assumption that bigger roots sustain more biomass and increase production. The constant connection of these features over both seasons shows their dependability as plant performance markers.

On the other hand, a negative association exists between the quality index and the aforementioned characteristics, as similarly reported by **(Assey *et al.*, 2005).**

Table 12: Correlation coefficient analysis for root diameter, yields of root and sugar/fed and some studied characteristics under various levels of inorganic and bio-nitrogen levels on three sugar beet varieties in the 2020/2021 and 2021/2022 seasons

Traits	RD (cm)		RY/fed (ton)		SY/fed (ton)	
	S1	S2	S1	S2	S1	S2
RD (cm)	1.000	1.000	0.732 **	0.893 **	0.721 **	0.887 **
RFW/plant (g)	0.785 **	0.908 **	0.887 **	0.855 **	0.858 **	0.826 **
QI	- 0.682**	- 0.604 **	- 0.682 **	- 0.568 **	- 0.535 **	- 0.495 **
RY/fed (ton)	0.732 **	0.893 **	1.000	1.000	0.976 **	0.969 **
SY/fed (ton)	0.721 **	0.887 **	0.976 **	0.969 **	1.000	1.000

** Significance at 0.01
- S1 (season 2020/2021) - S2 (season 2021/2022)

Conclusion

Considering the current study conditions, planting Bts 970 variety in soil treated with soil amendment of bio-fertilizer (EM) along with fertilizing it with 120 kg in-organic N/fed might be suggested to achieve maximum root and sugar yields/fed.

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الملخص العربي

إستجابة بعض اصناف بنجر السكر للتسميد النيتروجيني غير العضوي والحيوي تحت ظروف النوبارية

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تم تنفيذ تجربة حقلية خلال موسمى 2020/2021 و 2021/2022 فى القطاع الخامس بمنطقة النوبارية (دائرة عرض 53′ 30° شمالاً وخط طول 04′ 30° شرقاً) بمحافظة البحيرة – مصر. لتقييم أداء ثلاثة أصناف من بنجر السكر (بلينو، نادر وبي تي إس 970). تمت زراعتهم في أرض رملية لومية عُوملت بإضافة سماد نيتروجيني-حيوى سائل (المُسمَّى تجارياً EM) والمحتوى على كائنات حية دقيقة بمعدل 6 لتر للفدان وأخري تُرِكت دون معاملة، وتم تسميد أصناف البنجر بثلاثة مستويات من النيتروجين غير العضوى (60 ، 90 و120 كجم نيتروجين للفدان). تم إستخدام تصميم القطاعات كاملة العشوائية وتم توزيع المعاملات بنظام القطع المنشقة مرتين - حيث تم وضع الأصناف الثلاثة عشوائياً فى القطع الرئيسية، بينما تم توزيع مستويات السماد النيتروجيني غير العضوى عشوائياً فى القطع المنشقة، وتم إضافة معدلى السماد النيتروجينى-الحيوى فى القطع تحت المنشقة.

حقق الصنف "بي تي إس 970" أعلي القيم لقطر ووزن الجذر الطازج ودليل مساحة الأوراق، وأعلي نسبة سكروز وسكر مُستخلَص، فضلاً عن أعلي انتاجية من حاصلي الجذور والسكر للفدان - بينما سجل أقل محتوي من الصوديوم و الألفا أمينو نيتروجين بالجذور.

أدى رفع مستوي السماد النيتروجيني غير العضوى من 60 الي 120 كجم نيتروجين للفدان إلي زيادة تدريجية في قطر ووزن الجذر ودليل مساحة الأوراق ونسبة السكروز والسكر المستخلص والسكر المفقود إلي المولاس، وحاصلي الجذور والسكر للفدان في كلا الموسمين - في حين إنخفض محتوي الصوديوم بالجذور. زاد قطر الجذور والوزن الطازج ودليل مساحة الأوراق وكذلك النسبة المئوية للسكروز والسكر المُستخلَص، ومحتوى الجذور من الألفا امينو-نيتروجين، وكذلك حاصلي الجذور والسكر/ فدان للأصناف المُختبرَة عند زراعتها بالتربة المعاملة بإضافة 6 لتر من السماد النيتروجينى الحيوى للفدان مقارنة بتلك النامية في التربة غير المعالجة به، بينما إنخفض محتوى الجذور من الصوديوم، في كلا الموسمين.

يمكن التوصية بزراعة صنف بنجر السكر "بي تي إس 970" وتسميده بإضافة 120 كجم نيتروجين غير عضوى للفدان، وإضافة 6 لتر سماد نيتروجينى حيوى سائل للتربة للفدان، للحصول علي أعلى انتاجية من حاصلي الجذور والسكر للفدان مقارنةً بالتوليفات الأخرى من العوامل المدروسة، تحت ظروف منطقة النوبارية.