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RESEARCH ARTICLE

Effects of nitrogen fertilizers, bio-fertilizer and molasses on yield quality of sugar beet plants (Beta vulgaris L.)

Ragab A.E. Dawood[1], Abd El-Azeem S. Abd El-Azeem[2], Ibrahim M.A. Gohar[3]*

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Abstract

Two field experiments were carried out at the research farm of Nubaryia Sugar and Refining Company (NSRC), located at (30°63' 88.93" N latitude; 30°22′ 46.21″ E longitude), El-Behaira Governorate in the 2019/2020 and 2020/2021 growing seasons. The main objectives of this study were to determine the effect of four nitrogen fertilizer levels (Control, 60, 80 and 100 kg.fed^{-1}), three bio-fertilizers treatments (Control, Cerealine® and T.S®) and four Molasses levels (Control, 20, 40 and 60 kg.fed^{-1}) on yield and quality of sugar beet plants.

A split-split plot design with three replications was used, where the nitrogen fertilizer levels were allocated in the main plots and bio-fertilizer treatments were distributed in the sub-plots, as well as molasses treatments occupied the sub-sub plots. The results indicated that increasing nitrogen fertilizer rates significantly improved yield and yield components as well as the quality of sugar beet plants. The highest rates of nitrogen (100 and 80 kg N fed^{-1}), bio-fertilizers treatments, (T.S®) and molasses (60 and 40 kg N fed^{-1}) produced the highest yield characters (root yield (ton fed^{-1}), top yield (ton fed^{-1}) and sugar yield (ton fed^{-1})) and juice quality characters (total soluble solid percentage (TSS %) and Sucrose %) throughout the 1st and 2nd seasons, respectively, without significant differences.

The interaction between nitrogen rates, molasses and bio-fertilizers (80 kg N fed^{-1}+ 40 kg Molasses fed^{-1}+ T.S) gave the highest values for most all studied characters. So, bio-fertilizer treatments proved a major role in crop production optimization and are expected to reduce the pollution of the agricultural environment.

Keywords: Beta vulgaris; Mineral fertilization; Sugar industry byproducts; Bio fertilizers.

[1] Department of Agronomy, Faculty of Agriculture, Assiut University, Assiut, Egypt.
[2] Faculty of Sugar and Integrated Industries Technology (FSIIT), Assiut University, Assiut, Egypt: Nubaria, Sugar and Refining Company, Behaira Government, Egypt.
[3*] Sugar Crops Research Institute, Agricultural Research Center (ARC), Giza 12619, Egypt.
*corresponding author; ibragohar@gmail.com

Introduction

Sugar beet ranked the second sugar crop after sugarcane crop in the world as it provides about 40% of the world sugar production.

The importance of this crop is not only to produce sugar but also to use its top in feeding animals due to the high nutritive value of the sugar beet canopy. Egypt faces many difficulties that affect the productivity of crops in general and sugar crops in particular, including sugar beet, which evolves significantly at the moment. So, it became the first source for the production of sugar in Egypt, where the production of sugar from beets accounts for about 67.7% (1835851 tons) of sugar production in Egypt while sugarcane production was 32.3% (876064 tons) (Sugar Crops Council 2022).

One of the main serious issues is the lack of water after the construction of the El-Nahda Dam, as well as the high prices of fertilizer, particularly nitrogen. Furthermore, soil quality, nutrient availability, environmental conditions, and soil biological health are all important factors in increasing crop yield per unit area and achieving the targeted goal of food security (Tilman et al. 2011).

Nitrogen is a significant limiting factor in sugar beet cultivation. Because they can partially change the cost of mineral N fertilizers, the use of N-fixing bacteria is economically important in modern agriculture. Increasing yields while lowering production costs and reducing pollution. Bio-fertilizer has emerged as a promising component of intensive agriculture's nutrient supply system integration. Consequently, attempts have been made to use bio-fertilizer as being the cheapest and safe for agricultural application. Bio-fertilizer history began around 120 years ago with the registration of Nitrogen, a Rhizobium inoculation for legume plants. Rhizobial strains have been available on the market as bio-inoculants inoculants for nearly 100 years (Ahmed et al. 2023a&b; Galal et al. 2022; O'Callaghan 2016). According to Verma et al. (2019), bio-fertilizers account for approximately 5% of total fertilizers on the market.

Approximately 150 bio-fertilizers are microbial strains that have been registered for farming (Table 3). Consumers are increasingly concerned about food safety, the environment, and rising pesticide residues in food, prompting them to prefer chemical-free products. Organic retail sales have recently increased in the following countries: The United States, Germany, India, China, Switzerland, and Denmark. The current value of the bio-fertilizer market is USD 2.3 billion, and it is expected to rise to USD 2.3 billion in the future. Bio-fertilizer technologies are based on enhancing and improving naturally occurring nutrient transformation activities in soil profiles when the inoculants must be able to adapt to the environmental conditions at the application site. However, introducing associated nitrogen-fixing bacteria to the seeds of different C3 and C4 plants improved plant development and yield (Eid 1982). To be effective, any bio-fertilizer strain must be competitive in terms of survival, persistence, and establishment under the given environmental conditions (Sindhu and Dadarwal, 2000). In comparison to chemical fertilizers, the performance results of bio-fertilizer inoculation are slower. However, their effect is long-lasting, resulting in increased soil fertility. There are several methods for applying bio-fertilizers, including root dipping, soil application, and seed inoculation with either a liquid or dry formulation (Mahanty et al. 2017). Sugar beet molasses contains water 17%, sucrose 66%, fructose 1%, glucose1%, glycinebetaine 6%, amino acids 8%, sterols o.3 %, phospholipids 0.5 %, and wax 0.2% (Tantawy 2007). The use of sugar beet molasses in agriculture increases the efficiency of nutrient uptake and soil biological activity (Aljabri et al. 2021; Alotaibi et al. 2021; Samavat and Samavat 2014). Molasses has historically been used as a fertilizer and soil improver, particularly on sandy soil and soil with poor structure (Al-Dhumri et al. 2023; Alharbi et al. 2023). Molasses provides carbohydrates and changes the C: N ratio, which affects soil microbial ecology and reduces plant parasitic nematodes, among other benefits to plant growth (Schenck 2001). In hard-setting soils, molasses improves soil aggregation and decrease surface crusting (Wynne and Meyer, 2002). Thus, the objectives of the present study focused on the effect of nitrogen fertilizer levels, bio–fertilizers and molasses on yield and yield and quality of sugar beet crops during 2019/2020 and 2020/2021 seasons under the environmental conditions of Nubaria district.

Materials and Methods

Two field experiments were carried out at the research farm of Nubaria Sugar and Refining Company (NSRC), located at (30°63' 88.93" N latitude; 30°22′ 46.21″ E longitude), El-Behaira Governorate during the two successive fall seasons of 2019/2020 and 2020/2021. The main objectives of this study were to determine the effect of four nitrogen fertilizer levels, three bio-fertilizers treatments, (Control, Cerealine® and T.S®) and four Molasses levels on the yield and quality of sugar beet plants (Beta vulgaris L.).

Bio-fertilizers

The studied bio-fertilizers included the following: Control Bio-fertilizers (Untreated), Cerealine® and T.S®. The seeds of sugar beet were inoculated with Cerealine ® before sowing and away of direct sunlight, while T.S® was added after sowing of sugar beet seeds with the first irrigation after thinning. Cerealine ® contains bacteria that fixed atmospheric nitrogen but T.S® contains molasses as the organic material carrier of microorganisms, and a set of mixed cultures of Bacillus circulans 0.5×109 (cfu), B. poylmyxa 2×107 (cfu), B. megatherium 1.5×109 (cfu), Candida spp. 1.5×107 (cfu), and Trichoderma spp. 0.5×106 (cfu) mL-1 that facilitated phosphorus absorption, with the rate of 5 L fed^{-1}. These bio-fertilizers contain living microorganisms that, when applied to seeds, plant surfaces, or soil, colonize the rhizosphere or the interior of the plant and promote growth by increasing the supply or availability of primary nutrients to the host plant. The seeds of sugar beet were inoculated with Cerealine® before sowing away from direct sunlight, while T.S® was added after sowing of sugar beet plants with the first irrigation after thinning.

Molasses rates

The studied molasses levels included: without molasses fertilizer (Control), 20 kg molasses fed^{-1}, 40 kg molasses fed^{-1}, and 60 kg molasses fed^{-1} applied as a side-dressing in two equal doses, the first was applied after thinning and the other was applied four weeks later. Parameters values of molasses produced from beet sugar processing which was used in the experiment are shown in Table 1.

Table1. Chemical composition of molasses produced from beet sugar processing.

Molasses Parameters	Value
PH	8.3
Brix (%)	78.5
Total sugar (%)	49.0
Ash (%)	12.9
N (%)	1.73
P (%)	0.013
K (%)	5.70
Ca (%)	0.330
Mg (%)	0.229
Na (%)	0.171
Density (g/cm2)	1.61

Nitrogen rates

The studied nitrogen levels included: Without nitrogen fertilizer (Control), 60 kg N fed^{-1}, 80 kg N fed^{-1}, and 100 kg N fed^{-1} applied as a side-dressing in two equal doses, the first was applied after thinning and the other was applied four weeks later in Form of ammonium nitrate 33.5% N.

The experimental plots were cultivated with the multigerm sugar beet seeds (PTS 970 cv.) on September 20, in both growing seasons. However, harvest dates were on April 1 and 10 in the first and second growing seasons, respectively.

Experiment design

A split-split plot design with three replications was used, where the nitrogen fertilizer levels were allocated in the main plots and bio-fertilizer treatments were distributed in the sub-plots, as well as molasses treatments occupied the sub-sub plots. The sub-plot area was 21 m2 (1/200 fed^{-1}), with 6 m in length and 3.5 m width i.e.; six ridges. Sugar beet balls were hand sown (3-5 balls/hill) using the dry sowing method on one side of the ridge in hills 15 cm apart and irrigated immediately after sowing. Plants were thinned at the age of 35 days from sowing to obtain one plant/hill. All other agricultural practices were applied at the recommendations of the Egyptian Ministry of Agriculture. Soil samples were randomly sampled pre-sowing from the experimental site at a depth of 0 to 30 cm from the soil surface and prepared for both physical and chemical analysis according to Ankerman and Large (1974) as shown in Table 2.

Table 2. Physical and chemical properties of the experimental soil in 2019/2020 and 2020/2021 seasons.

Soil properties	Season		Soil properties	Season	
	2019/2020	2020/2021		2019/2020	2020/2021
A- Mechanical analysis			2- Soluble anions (1:2) (Cmo1/kg soil)		
Sand (%)	91	93	CO^-_3+ HCO^-	5.1	5.2
Clay (%)	5.83	3.87	CL^-	7.29	7.19
Silt (%)	3.17	3.13	SO^-_4	1.01	0.94
Soil texture	Sandy	Sandy	Calcium carbonate	6.23	6.13
B- Chemical properties			Total nitrogen (mg/kg)	2.4	2.5
pH 1:1	8.14	8.33	Available phosphorus (mg/kg)	0.2	0.2
E.C. (ds/m)	1.45	1.34			
1- Soluble cautions (1:2) (Cmo1/kg soil)			Organic matter %	0.38	0.37
K^+	0.87	0.98			
Ca^{++}	2.84	2.78			
Mg^{++}	1.82	1.96			
Na^{++}	8.97	7.68			

Data Recorded

The outer two ridges (1st and 6th) were considered a belt, while the other four ridges were kept for yield characters and their components as well as quality determination.

Yield characteristics

At harvest, all plants from the inner four ridges at each sup-plot were uprooted. Roots and tops were separated and weighed in kilograms to determine:

• Root yield (ton fed^{-1}).

• Top yield (ton fed^{-1}).

• Sugar yield (ton fed^{-1}).

Juice quality parameters

• Total soluble solid percentage (TSS%). It was measured in the juice of fresh roots by using Hand Refractometer according to Me Ginnis, (1982).

• Sucrose percentage (%).

Statistical analysis

All collected data were subjected to statistical analysis following the procedure described by Gomez and Gomez (1984). The least significantly differenced test (L.S.D) at 0.05 was used to compare between means of the different treatments.

Results and discussion

Yield characteristics

Data in Tables 3 up to 5 show the effect of nitrogen fertilizer, bio-fertilizer, molasses and their interaction by combined analysis for 2019/2020 and 2020/2021 seasons on root yield (ton fed^{-1}), top yield (ton fed^{-1}) and sugar yield (ton fed^{-1}).

Root yield (ton fed^{-1})

Data in Table 2 confirmed that the highest root yield value of 21.380 ton fed^{-1} was obtained by 100 kg N fed^{-1}, followed by 80 kg N fed^{-1} valued 20.920 ton fed^{-1} without significant variations at P ≤ 0.05 between them while untreated check gave the lowest value 15.400 ton fed^{-1} with significant differences at P ≤ 0.05. Bio-fertilizer of Cerealine and T.S gave 21.375 and 19.588 ton fed-1 without significant differences at P ≤ 0.05, respectively compared with the untreated check that gave 17.353 ton fed^{-1}.

The amount of 60 kg molasses fed^{-1} gave the highest value of root yield 20.575 ton fed^{-1} compared with the untreated check which gave 17.692 ton fed^{-1} with significant differences at P ≤ 0.05.

Table 3. Effect of bio and mineral fertilization on root yield (ton fed^{-1}) of sugar beet plant in the combined analysis for the 2019/ 2020 and 2020/ 2021 growing seasons.

Nitrogen (N)	Biofertilizer (Bio)	Molasses (Mo) Control	20 Kg fed^{-1}	40 Kg fed^{-1}	60 Kg fed^{-1}	Mean
	Control	13.587	12.858	14.708	12.967	13.530
Control	Cerealine	12.385	23.435	24.332	15.427	18.895
	T.S	16.488	12.517	11.415	14.677	13.774
Mean		14.153	16.270	16.818	14.357	15.400 c
	Control	19.785	19.923	13.682	19.237	18.157
60 Kg fed^{-1}	Cerealine	12.553	12.900	28.827	36.488	22.692
	T.S	20.827	23.553	17.825	15.073	19.320
Mean		17.722	18.792	20.111	23.599	20.056 b
	Control	18.483	23.498	16.235	21.355	19.893
80 Kg fed^{-1}	Cerealine	24.238	23.833	21.253	22.840	23.041
	T.S	18.413	18.202	19.115	23.570	19.825
Mean		20.378	21.844	18.868	22.588	20.920 a
	Control	16.223	20.033	17.992	17.083	17.833
100 Kg fed^{-1}	Cerealine	16.735	18.113	24.748	23.892	20.872
	T.S	22.590	27.838	27.018	24.293	25.435
Mean		18.516	21.995	23.253	21.756	21.380 a
	Control	17.020	19.078	15.654	17.660	17.353 c
Bio × Mo	Cerealine	16.478	19.570	24.790	24.662	21.375 a
	T.S	19.580	20.528	18.843	19.403	19.588 b
Mean		17.692 b	19.725 a	19.762 a	20.575 a	19.439

L.S.D$_{0.05}$			
Nitrogen (N)	0.681	N × Mo	1.548
Biofertilizer (Bio)	0.581	Bio × Mo	1.340
Molass (Mo)	0.775	N × Bio × Mo	2.681
N × Bio	1.161		

The combined analysis showed that the interaction between nitrogen and bio-fertilizer (100 kg N fed^{-1} +T.S) gave the highest value 25.435 ton fed^{-1}, but the lowest root yield 15.073 ton fed^{-1} was realized by (60kg N fed^{-1} +T.S).

Also, the combined analysis showed that the interaction between nitrogen and molasses (100 kg N fed^{-1} + 40 kg molasses fed^{-1}) gave the highest value of 23.253 ton fed^{-1}, whereas the lowest root yield value of 18.792 ton fed^{-1} was realized by (60 kg N fed^{-1} + 20 kg molasses fed^{-1}).

The combined analysis showed that the interaction between bio-fertilizer and molasses (Cerealine + 40 kg molasses fed^{-1}) gave the highest value of 24.790 ton fed^{-1}, while the lowest root yield value of 18.843 ton fed^{-1} was realized by (T.S + 40 kg molasses fed^{-1}).

Also, findings in Table 3 demonstrated that the combined analysis of the 2019/2020 and 2020/2021 seasons for the interaction among the nitrogen fertilizer and bio-fertilizer with molasses had a significant effect on root yield. The highest root yield was obtained by (100 kg N fed^{-1} + T.S + 20 kg molasses fed^{-1}) followed by (100 kg N fed^{-1} + T.S + 40 kg molasses fed^{-1}) with values 27.838 and 27.018 ton fed^{-1}, respectively without significant differences at P ≤ 0.05 between them. On the other hand, the lowest root yield value 15.073 ton fed^{-1} was realized by (60 kg N fed^{-1} fertilizer + T.S + 60 kg fed-1 molasses).

Top yield (ton fed^{-1})

Data in Table 4 showed that the highest top yield value of 13.987 ton fed^{-1} was obtained by 100 kg N fed^{-1}, followed by 80 kg N fed^{-1} with a value of 13.797 ton fed^{-1} without significant variations between them at P ≤ 0.05 while untreated check gave the lowest value 6.730 ton fed^{-1} with significant differences at P ≤ 0.05. Bio-fertilizer of Cerealine and T.S gave 11.417 and 11.309 ton fed^{-1} without significant differences at P ≤ 0.05, respectively compared with the untreated check that gave 10.253 ton fed^{-1}.

The amount of 60 kg molasses fed^{-1} gave the highest value of top yield 11.609 ton fed^{-1} compared with the untreated check which gave 9.693 ton fed^{-1} with significant differences at P ≤ 0.05. With regard to the levels of 20, 40 and 60 kg molasses fed^{-1} gave records of top yield fed^{-1} without significance among them at P ≤ 0.05.

Also, the combined analysis showed that the interaction between nitrogen and bio-fertilizer (100 kg N fed^{-1} + Cerealine) gave the highest value of 15.415 ton fed^{-1}, while the lowest top yield of 9.888 ton fed^{-1} was realized by (60 kg N fed^{-1} + Cerealine).

The combined analysis showed that the interaction between nitrogen and molasses (80 kg N fed^{-1} + 20 kg molasses fed^{-1}) gave the highest value of 15.539 ton fed^{-1}, but the lowest top yield value of 8.213 ton fed^{-1} was realized by (60 kg N fed^{-1} + 20 kg molasses fed^{-1}).

Table 4. Effect of bio and mineral fertilization on top yield (ton fed-1) of sugar beet plant in the combined analysis for the 2019/ 2020 and 2020/ 2021 growing seasons.

Nitrogen (N)	Biofertilizer (Bio)	Molasses (Mo)				
		Control	20 Kg fed^{-1}	40 Kg fed^{-1}	60 Kg fed^{-1}	Mean
	Control	6.905	6.305	6.888	5.193	6.323
Control	Cerealine	7.418	7.040	5.998	8.545	7.250
	T.S	5.502	6.262	7.458	7.247	6.617
Mean		6.608	6.536	6.782	6.995	6.730 c
	Control	9.302	5.442	6.208	9.175	7.532
60 Kg fed^{-1}	Cerealine	6.307	7.352	15.740	10.153	9.888
	T.S	6.405	11.847	8.977	16.572	10.950
Mean		7.338	8.213	10.308	11.967	9.457 b
	Control	12.787	19.415	15.145	14.163	15.378
80 Kg fed^{-1}	Cerealine	9.857	13.900	13.330	15.363	13.113
	T.S	9.408	13.303	16.182	12.713	12.902
Mean		10.684	15.539	14.886	14.080	13.797 a
	Control	10.842	10.950	12.998	12.322	11.778
100 Kg fed^{-1}	Cerealine	15.547	15.082	16.425	14.608	15.415
	T.S	16.037	16.635	13.137	13.257	14.766
Mean		14.142	14.222	14.187	13.396	13.987 a
	Control	9.959	10.528	10.310	10.213	10.253 b
Bio × Mo	Cerealine	9.782	10.843	12.873	12.168	11.417 a
	T.S	9.338	12.012	11.438	12.447	11.309 a
Mean		9.693 b	11.128 a	11.541 a	11.609 a	10.993

L.S.D$_{0.05}$			
Nitrogen (N)	1.379	N × Mo	1.182
Biofertilizer (Bio)	0.495	Bio × Mo	1.024
Molass (Mo)	0.592	N × Bio × Mo	2.048
N × Bio	0.989		

By combined analysis the interaction between bio-fertilizer and molasses (cerealine + 40 kg molasses fed^{-1}) gave the highest value 12.873 ton fed^{-1}, followed by 12.447 ton fed^{-1} at (T.S+ 60 kg molasses fed^{-1}), while, the lowest root yield value 10.843 ton fed^{-1} was realized by (cerealine + 20 kg fed^{-1} molasses). Data in Table 4 illustrated that the combined analysis of 2019/2020 and 2020/2021 seasons among the nitrogen fertilizer and bio-fertilizer with molasses and their interaction had a significant effect on top yield.

The highest top yield was obtained by (100 kg N fed^{-1}. + T.S + 20 kg molasses fed^{-1}) followed by (100 kg N fed^{-1} + Cerealine + 40 kg molasses fed^{-1}) with values 16.635 and 16.425 ton fed^{-1}, respectively without significant differences between them at P ≤ 0.05. On the other hand, the lowest root yield value 7.352 ton fed^{-1} was realized by (60 kg N fed^{-1} + Cerealine + 20 kg molasses fed^{-1}).

Sugar yield (ton fed^{-1})

Data in Table 5 verified by combined analysis for the two studied seasons that the highest sugar yield value of 3.974 ton fed^{-1} was obtained by 100 kg N fed^{-1}, followed by 80 kg N fed^{-1} with a value of 3.844 ton fed-1 without significant variations between them at P ≤ 0.05. While untreated check gave the lowest value of 2.782 ton fed^{-1} with significant differences at P ≤ 0.05. Bio-fertilizer of Cerealine and T.S gave 3.972 and 3.595 ton fed^{-1} without significant differences at P ≤ 0.05, respectively compared with the untreated check that gave 3.142 ton fed^{-1}. The amount of 60 kg molasses fed^{-1} gave the highest value of sugar yield 3.829 ton fed^{-1} compared with the untreated check which gave 3.193 ton fed^{-1} with significant differences at P ≤ 0.05.

The combined analysis of the two studied seasons showed that the interaction between nitrogen and bio-fertilizer (100 kg N fed^{-1} +T.S) gave the highest value 4.643 ton fed^{-1}, while the lowest sugar yield of 3.601 ton fed-1 was realized by (60 kg N fed^{-1} +T.S).

The combined analysis showed that the interaction between nitrogen and molasses (100 kg N fed^{-1} + 40 kg molasses fed^{-1}) gave the highest value of 4.230 ton fed^{-1}, and the lowest sugar yield value of 3.294 ton fed^{-1} was realized by (60 kg N fed^{-1} + 20 kg molasses fed^{-1}).

The combined analysis showed that the interaction between bio-fertilizer and molasses (Cerealine + 60 kg molasses fed^{-1}) gave the highest value of 4.717 ton fed^{-1}, whereas the lowest sugar yield value of 3.523 ton fed^{-1} was realized by (Cerealine + 20 kg molasses fed^{-1}).

Data in Table 5 showed that the combined analysis of the nitrogen fertilizer and bio-fertilizer with molasses and their interaction had a significant effect on sugar yield during the 2019/2020 and 2020/2021 seasons. The highest sugar yield was obtained by (100 kg N fed^{-1} + T.S + 20 kg molasses fed^{-1}) followed by (100 kg N fed^{-1} + T.S + 40 kg molasses fed^{-1}) with values 5.356 and 5.085 ton fed^{-1}, respectively without significant differences between them at P ≤ 0.05. On the other hand, the lowest sugar yield value of 2.214 ton fed^{-1} was realized by (60 kg N fed^{-1} + Cerealine + 20 kg molasses fed^{-1}). In short, the results showed that the nitrogen fertilizer, bio-fertilizer, molasses and their interaction had effects on root yield (ton fed^{-1}), top yield (ton fed^{-1}) and sugar yield (ton fed^{-1}) during the 2019/2020 and 2020/2021 seasons. Also, the yield characteristics of sugar beet plants gradually increased with increasing nitrogen fertilizer levels.

These results are in harmony with those obtained by Leilah et al. (2005), El-Geddawy et al. (2006), Badawi and Seadh (2008), Sarhan (2012), El-Fadaly et al. (2013), Abdou et al. (2014), Abdelaal and Tawfik (2015), Mekdad (2015), Neamat-Alla et al. (2015) and Elmasry and Al-Maracy (2023).

Table 5. Effect of bio and mineral fertilization on sugar yield (ton fed^{-1}) of sugar beet plant in the combined analysis for the 2019/ 2020 and 2020/ 2021 growing seasons.

Nitrogen (N)	Biofertilizer (Bio)	Molasses (Mo)				
		Control	20 Kg fed^{-1}	40 Kg fed^{-1}	60 Kg fed^{-1}	Mean
	Control	2.526	2.176	2.678	2.297	2.419
Control	Cerealine	2.251	3.985	4.362	3.030	3.407
	T.S	2.946	2.296	2.206	2.623	2.518
Mean		2.574	2.819	3.082	2.650	2.782 c
	Control	3.340	3.501	2.488	3.601	3.233
60 Kg fed^{-1}	Cerealine	2.267	2.214	5.666	6.675	4.206
	T.S	3.699	4.168	3.581	2.956	3.601
Mean		3.102	3.294	3.912	4.411	3.680 b
	Control	3.340	4.266	3.072	3.755	3.608
80 Kg fed^{-1}	Cerealine	4.697	4.315	3.878	4.322	4.303
	T.S	3.232	3.522	3.359	4.367	3.620
Mean		3.756	4.034	3.436	4.148	3.844 a
	Control	3.195	3.728	3.151	3.152	3.306
100 Kg fed^{-1}	Cerealine	3.019	3.578	4.455	4.840	3.973
	T.S	3.803	5.356	5.085	4.328	4.643
Mean		3.339	4.221	4.230	4.107	3.974 a
	Control	3.100	3.418	2.847	3.201	3.142 c
Bio × Mo	Cerealine	3.058	3.523	4.590	4.717	3.972 a
	T.S	3.420	3.836	3.558	3.658	3.595 c
Mean		3.193 c	3.592 b	3.665 b	3.829 a	3.570

L.S.D$_{0.05}$			
Nitrogen (N)	0.131	N × Mo	0.306
Biofertilizer (Bio)	0.119	Bio × Mo	0.265
Molass (Mo)	0.153	N × Bio × Mo	0.530
N × Bio	0.238		

Data in Tables 6 up to 7 show the impact of nitrogen fertilizer, bio-fertilizer, molasses and their interaction on total soluble solids percentage (TSS%), and sucrose percentage of sugar beet plants during the 2019/2020 and 2020/2021 seasons.

Total soluble solids percentage (TSS%)

The analyzed records by combined analysis for the two studied seasons presented in Table 6 verified that the total soluble solids percentage (TSS%) gradually increased with increasing nitrogen fertilizer levels and the highest value 26.92% was obtained by 100 kg N fed^{-1} with significant variations than other nitrogen fertilizer levels at $P \leq 0.05$, followed by 80 kg N fed^{-1} that gave 22.84% while, treatment of 60 kg N fed^{-1} gave 22.57% compared with the untreated check that gave 22.49% without significant differences at $P \leq 0.05$. Bio-fertilizer of Cerealine and T.S gave 22.96 and 23.70% with significant differences between them at $P \leq 0.05$, respectively compared with the untreated check that gave 23.46%.

The amount of 60 kg molasses fed^{-1} gave the highest value of total soluble solids percentage (TSS%) 24.82% compared to the untreated check which gave 22.67% with significant differences.

The combined analysis showed that the interaction between nitrogen and bio-fertilizer (100 kg N fed^{-1} + T.S) gave the highest value of 27.72%, but the lowest total soluble solids percentage (TSS%) value of 21.41% was realized by (60 kg N fed^{-1} + T.S). Also, the combined analysis showed that the interaction between nitrogen and molasses (100 kg N fed^{-1} + 60 kg molasses fed^{-1}) gave the highest value of 29.91%, but the lowest TSS% value of 22.25% was realized by (80 kg N fed^{-1} + 40kg molasses fed^{-1}), followed by the value of 22.27% as a second lowest value for the same interaction at (60 kg N fed^{-1} + 20kg molasses fed^{-1}) without significant difference between them at $P \leq 0.05$. The combined analysis showed that the interaction between bio-fertilizer and molasses (Cerealine + 60 kg molasses fed^{-1}) gave the highest value of T.S/S% (19.03%), but the lowest T.S/S% value of 17.74% was realized by (Cerealine + 20 kg molasses fed^{-1}).

Also, data in Table 6 showed that the combined analysis of the 2019/2020 and 2020/2021 seasons among the nitrogen fertilizer and bio-fertilizer with molasses and their interaction had a significant effect on total soluble solids percentage (TSS%). The highest total soluble solids percentage (TSS%) was obtained by (100 kg N fed^{-1} + Cerealine + 60 kg molasses fed^{-1}) with the value of 29.27% while, the lowest total soluble solids percentage (TSS%) values of 22.34% and 22.50% was realized by (80 kg N fed^{-1} + Cerealine + 20 kg molasses fed^{-1}) and (60 kg N fed^{-1} + Cerealine + 20 kg molasses fed^{-1}) without significant differences between them at $P \leq 0.05$, respectively.

Table 6. Effect of bio and mineral fertilization on the total soluble solid's percentage (TSS%) of sugar beet plant in the combined analysis for the 2019/ 2020 and 2020/ 2021 growing seasons.

Nitrogen	Biofertilizer	Molasses (Mo)				
(N)	(Bio)	Control	20 Kg fed^{-1}	40 Kg fed^{-1}	60 Kg fed^{-1}	Mean
	Control	19.31	20.91	23.64	23.09	21.74
Control	Cerealine	19.77	26.46	22.76	26.53	23.88
	T.S	19.60	19.12	26.95	21.76	21.86
Mean		19.56	22.16	24.45	23.79	22.49 c
	Control	24.75	20.51	24.45	22.28	23.00
60 Kg fed^{-1}	Cerealine	22.06	22.50	23.36	25.36	23.32
	T.S	19.93	23.80	20.74	21.15	21.41
Mean		22.25	22.27	22.85	22.93	22.57 c
	Control	22.83	19.71	19.85	21.20	20.90
80 Kg fed^{-1}	Cerealine	25.35	22.34	24.89	22.69	23.82
	T.S	23.72	25.43	22.00	24.10	23.81
Mean		23.97	22.49	22.25	22.66	22.84 b
	Control	26.84	25.80	27.56	32.67	28.22
100 Kg fed^{-1}	Cerealine	20.16	23.69	26.22	29.27	24.83
	T.S	27.74	28.33	27.02	27.79	27.72
Mean		24.91	25.94	26.93	29.91	26.92 a
	Control	23.43	21.73	23.87	24.81	23.46 c
Bio × Mo	Cerealine	21.83	23.75	24.31	25.96	23.96 a
	T.S	22.75	24.17	24.18	23.70	23.70 b
Mean		22.67 d	23.22 c	24.12 b	24.82 a	23.71

L.S.D$_{0.05}$			
Nitrogen (N):	0.20	N × Mo:	0.49
Biofertilizer (Bio):	0.20	Bio × Mo:	0.43
Molass (Mo):	0.25	N × Bio × Mo:	0.85
N × Bio:	0.40		

Sucrose percentage

Results in Table 7 proved that the sucrose percentage gradually increased with increasing nitrogen fertilizer levels and the highest value (18.35%) was obtained by 100 kg N fed^{-1} with significant variations between other nitrogen fertilizer levels at $P \leq 0.05$, followed by 80 kg N fed^{-1} that gave 18.13% while treatment of 60 kg N fed^{-1} gave 18.06% compared with the untreated check that gave 17.83% with significant differences at $P \leq 0.05$. Bio-fertilizer of Cerealine and T.S gave 18.27 and 18.15% without significant differences at $P \leq 0.05$, respectively compared with the untreated check that gave 17.85%. The amount of 60 kg molasses fed^{-1} gave the highest value of sucrose percentage 18.35% compared to the untreated check which gave 17.79% with significant differences at $P \leq 0.05$.

The combined analysis showed that the interaction between nitrogen and bio-fertilizer (100 kg N fed^{-1} + Cerealine) gave the highest value of 18.76%, but the lowest sucrose percentage value of 17.98% was realized by (100 kg N fed^{-1} + T.S). The combined analysis showed that the interaction between nitrogen and molasses (60 kg N fed^{-1} + 40 kg molasses fed^{-1}) gave the highest value of 19.11%, but the lowest sucrose percentage value of 17.23% was realized by (60 kg N fed^{-1} + 20 kg molasses fed^{-1}).

Also, the combined analysis showed that the interaction between bio-fertilizer and molasses (T. S + 40 kg molasses fed^{-1}) gave the highest value of 18.66%, but the lowest sucrose percentage value of 17.74% was realized by (Cerealine + 20 kg molasses fed^{-1}).

Data in Table 6 demonstrated that the combined analysis among the nitrogen fertilizer and bio-fertilizer with molasses and their interaction had a significant effect on sucrose percentage during the 2019/2020 and 2020/2021 seasons. The highest sucrose percentage was obtained by (100 kg N fed^{-1} + Cerealine + 60 kg molasses fed^{-1}) with a value of 20.14% while, the lowest sucrose percentage values of 16.80 and 17.27% was realized by (60 kg N fed^{-1} + Cerealine + 20 kg molasses fed^{-1}) and (80 kg N fed^{-1} + T.S + 40 kg molasses fed^{-1}) without significant differences between them at $P \leq 0.05$.

In short, the results showed the nitrogen fertilizer, bio-fertilizer, and molasses and their interaction on total soluble solids percentage (TSS%) and sucrose percentage in sugar beet plants after the two seasons of 2019/2020 and 2020/2021 by combined analysis. The outcomes revealed that total soluble solids percentage (TSS%) and sucrose percentage gradually increased with increasing nitrogen fertilizer levels.

Table 7. Effect of bio and mineral fertilization on sucrose percentage of sugar beet plant in the combined analysis for the 2019/ 2020 and 2020/ 2021 growing seasons.

Nitrogen (N)	Biofertilizer (Bio)	Molasses (Mo) Control	20 Kg fed^{-1}	40 Kg fed^{-1}	60 Kg fed^{-1}	Mean
	Control	17.99	16.82	17.86	17.41	17.52
Control	Cerealine	17.93	16.97	17.69	18.96	17.89
	T.S	17.49	18.08	18.98	17.72	18.07
Mean		17.81	17.29	18.18	18.03	17.83 c
	Control	16.63	17.49	18.06	18.16	17.63
60 Kg fed^{-1}	Cerealine	17.67	16.80	19.45	18.23	18.04
	T.S	17.61	17.42	19.81	19.19	18.51
Mean		17.37	17.23	19.11	18.52	18.06 b
	Control	17.67	17.96	18.61	17.43	17.92
80 Kg fed^{-1}	Cerealine	18.96	17.96	18.00	18.79	18.43
	T.S	17.40	19.13	17.27	18.45	18.06
Mean		18.01	18.35	17.96	18.22	18.13 b
	Control	19.47	18.37	17.29	18.16	18.32
100 Kg fed^{-1}	Cerealine	17.73	19.24	17.92	20.14	18.76
	T.S	16.74	19.04	18.59	17.54	17.98
Mean		17.98	18.88	17.93	18.61	18.35 a
	Control	17.99	17.66	17.96	17.79	17.85 b
Bio × Mo	Cerealine	18.07	17.74	18.27	19.03	18.27 a
	T.S	17.31	18.42	18.66	18.22	18.15 a
Mean		17.79 b	17.94 b	18.29 a	18.35 a	18.09

L.S.D$_{0.05}$			
Nitrogen (N):	0.14	N × Mo:	0.39
Biofertilizer (Bio):	0.13	Bio × Mo:	0.34
Molass (Mo):	0.20	N × Bio × Mo:	0.68
N × Bio:	0.27		

Conclusions and recommendations

Raising nitrogen fertilizer rates greatly enhanced sugar beet root plant quality and yield. The highest nitrogen rates (100 and 80 kg N fed^{-1}) produced the highest yield characters (root yield, top yield and sugar yield) as well as juice quality characters (total soluble solids percentage (TSS) (%) and sucrose. Bio-fertilizer treatments (TS®) produced the highest levels of root yield, top yield, sugar yield, TSS% and sucrose%. Here root yield and top yield were maximized when molasses was used at the highest rates (60 and 40 kg N fed^{-1}). The residual effect of nitrogen fertilizer, molasses, bio-fertilizers, and their combination has a positive consequence on growth parameters, yield and quality parameters. Furthermore, using combinations of nitrogen fertilizer, molasses, and bio-fertilizers is considered an environmentally friendly system that reduces the use of chemical fertilizers. Built on the outcomes of this study, the integrated use of nitrogen fertilizer, molasses and bio-fertilizer treatments increased almost all tested parameters in both growing seasons for the sugar beet crop.

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