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Effect of bio and mineral nitrogen fertilization on growth and quality of some sugar beet cultivars

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Key words: sugar beet, cultivars, varieties, biofertilization, nitrogen fertilizer levels, growth, root quality.

Abstract

Two field experiments were carried out at a private farm in Sharkia Governorate, Egypt, during 2017/2018 and 2018/2019 seasons to study the effect of bio and mineral nitrogen fertilization on growth and quality of some sugar beet cultivars. Each field experiment was carried out in split split-plot design with four replicates. The main-plots were occupied with cultivars (Hossam, Asus poly and Glorious). The sub-plots were allocated with biofertilization treatments *i.e.* treated Phosphorin, Cerealine and Potassiumag (450 g/fed of each) and control treatment. The sub sub-plots were devoted with nitrogen levels (70, 90 and 110kg N/fed). The results showed that Hossam cultivar significantly surpassed other cultivars in root fresh weight at 120 and 150 DFS, CGR, RGR and quality parameters. However, Asus poly cultivar registered the highest values of foliage fresh weight and LAI at 120 and 150 DFS. Treated soil with Cerealine produced the highest values of all studied growth attributes and quality characters. Fertilizing with 110kg N/fed resulted in the highest values of growth characters, followed by 90kg/fed and lastly 70kg N/fed. Whereas, fertilizing 90kg N/fed produced the best results of quality characters. It can be concluded that in order to maintain high growth and root quality of sugar beet at the same time reduce production costs and environmental pollution, it can be recommended that fertilizing Hossam cultivar with 90kg N/fed and treating soil with Cerealine under the environmental conditions similar to study region.

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Introduction

Sugar beet (*Beta valgaris* var. *saccharifera* L.) is one of main sugar crops in Egypt as well as many countries all over the world beside sugar cane (*Sacchurum officinarum* L.). Recently, sugar beet crop has an important position in Egyptian crop rotation as winter crop not only in the fertile soils, but also in poor, saline alkaline and calcareous soils. Thus, in Egypt, sugar beet has becomes an important crop for sugar production, hence the total cultivated area in 2018 season reached about 521427 faddan and the total production exceeded 11.223 million ton roots with an average of 21.523t/fed (FAO, 2020). The total amount of sugar produced is not adequate enough to our consumption. So, increasing the cultivated area and sugar production per unit area is considered one of the important national targets to minimize the gap between sugar consumption and production. Developing high yielding cultivars and improving agricultural practices such as; bio and mineral nitrogen fertilization are essential to enhance sugar beet growth and quality.

Chosen the high yielding ability cultivars undoubtedly is very important to raise sugar beet growth per unit area and quality parameters. Aly *et al.* (2015) found that sugar beet cultivars (Top, Sultan and Kawemira) significantly differed in growth characters, sucrose%, quality index%. Ahmed *et al.* (2017) showed that sugar beet cultivars differed significantly in sucrose, purity, impurities percentages. El-Emary (2017) indicated that root and leaves fresh weight at growth stages showed highest values with Charlston, Lamiaa, Nefertitis, Salma and Beta 398 varieties. Mohamed and El-Sebai (2019) stated that all studied cultivars (Sara, Dina and Oscar poly) significantly differed in quality traits (sugar extraction, sucrose, purity and extractability percentages). Mohamed *et al.* (2019) indicated that all studied cultivars *i.e.* Raspoly, Kawemira and Montibianco significantly differed in all quality parameters, *i.e.* sucrose, purity%, sugar extraction, Na, K, alpha amino N, and extractability percentages. The highest mean values of sugar beet quality were recording by Montbianco *cv.*, except impurities percentages. Thalooth *et al.* (2019) showed that significant differences among tested sugar beet cultivars (Heba, Sirana and Peti) in most studied characters, but cultivar Heba surpassed the other two cultivars in TSS, sucrose and purity percentages.

Biological nitrogen, phosphorus and potassium fixation of sugar beet with non-symbiotic fixers play an important role in increasing growth and yield as well as decreasing chemical nitrogen fertilizer requirements and consequently minimizing environmental pollution by mineral fertilizers and to save its costs. Abdelaal and Tawfik (2015) showed that application the mixture of Microbeen + Rhizobacterin + Phosphorien produced the highest values of growth and quality parameters as compared with using each bio-fertilizer alone. It was followed by application the mixture of Microbeen + Rhizobacterin then application the mixture of Rhizobacterin + Phosphorien. Marajan *et al.* (2017) revealed that inoculation with *Azotobacter spp*. and Mycorrhizal fungi in two seasons had effect on sugar beet shoot and root fresh weight without significant differences between the treatments. Zaki *et al.* (2018) revealed that inoculation sugar beet seeds with ntrobin resulted the highest values of LAI and CGR in the first season. Inoculation with phosphorin + ntrobin obtained the highest NAR in the first season. Inoculation with phosphorin obtained the highest RGR in the first season. Mohamed and El-Sebai (2019) stated that bacteria treatments inoculation *i.e.* Phosphate Solubilizing Bacteria and Fungi (control untreated, PSB, PSF and PSB+PSF) improved quality parameters of sugar beet when compared with the untreated controls.

Nitrogen is the most important element of those supplied to sugar beet in fertilization. Application mineral nitrogen fertilizer to the plant increase the amount of protein, protoplasm and chlorophyll formed, building up metabolites and activation of enzymes that associate with accumulation of carbohydrates, which translated from leaves to increasing division and elongation of cells (Marschner, 1995). So that, nitrogen causes desirable effect on sugar beet growth and quality characters. In this concern, Hussein *et al.* (2016), Nemeata Alla (2016), Sayed-Ahmed *et al.* (2016), Abido and

Ibrahim (2017), Leilah *et al.* (2017), Makhlouf and Abd El-All (2017), Nemeata Alla *et al.* (2018) and Mohamed *et al.* (2019) concluded that increasing nitrogen mineral fertilizer levels up to 100 or 110kg N/fed significantly increased root length, root diameter, top yield/fed, root yield/fed and sugar yield/fed. Whereas, TSS, sucrose and purity percentages were decreased.

Therefore, this investigation was established to determine the effect of bio and mineral nitrogen fertilization as well as their interactions on growth and quality of some sugar beet cultivars under the environmental conditions of Awlad-Saqr Center, Sharkia Governorate, Egypt.

Materials and methods

Two series field experiments were carried out at a private farm in Al-Arab Manor, Bani-Hassan Village, Awlad-Saqr Center, Sharkia Governorate, Egypt, during seasons of 2017/2018 and 2018/2019 to study the response of growth and root quality of some sugar beet cultivars to bio and mineral fertilization.

Each field experiment was carried out in split split-plot design with four replicates. The main-plots were occupied with three imported sugar beet cultivars (Hossam, Asus poly and Glorious). The three studied cultivars are multigerm cultivars, and annually imported from Germany (Hossam and Glorious) and Holland (Asus poly) by Sugar Crop Research Institute, Agricultural Research Center, Giza, Egypt.

The sub-plots were allocated with biofertilization treatments *i.e.* treated soil with Phosphorin, Cerealine and Potassiumag at the rate of 450g/fed of each them in addition without biofertilization (control treatment). Phosphorin, Cerealine and Potassiumag as commercial products were produced by Biofertilizer Unit, Agriculture Research Center (ARC), Giza, Egypt, which included free-living bacteria able to fix phosphorus, atmospheric nitrogen and potassium, respectively in the rhizosphere of soil. The biofertilizer treatments were done before first irrigation directly by mixing the recommended dose of each biofertilizer with fine clay as side-dress near each hill.

The sub sub-plots were devoted at random with mineral nitrogen fertilizer levels (70, 90 and 110kg N/fed). Nitrogen in forms of ammonium nitrate (33.5% N) was applied in two equal doses, the first was applied after thinning sugar beet plants (30 days after sowing) and the second was done before the third irrigation (60 day after sowing).

Each experimental basic unit (sub sub-plot) included five ridges, each 60cm apart and 3.5m length, resulted an area of 10.5m^2 (1/400 fed). The preceding summer crop was rice (*Oryza sativa* L.) in the first and second seasons.

Soil samples were taken at random from the experimental field area at a depth of 0-30cm from soil surface and prepared for both mechanical and chemical analyses, according to Jackson (1973). The results of mechanical and chemical analyses are presented in Table 1.

Table 1. Physical and chemical soil properties of the experimental site during 2017/2018 and 2018/2019 seasons.

Soil analysis	First season 2017/2018	Second season 2018/2019
A: Mechanical analysis:		
Sand (%)	23.81	23.51
Silt (%)	29.74	29.95
Clay (%)	46.45	46.54
Texture	Clay	Clay
B: Chemical analysis		
Soil reaction pH	7.86	7.95
EC ds m^{-2}	1.40	1.35
Organic matter (%)	1.09	1.12
Available N (ppm)	46.63	47.8
Available P (ppm)	1.36	1.15
Exchangeable K (ppm)	160.12	151.26

Sugar beet seeds (balls) were hand sown on the first week of October at the rate of 3-5 balls/hill using dry sowing method on one side of the ridge in hills 20cm apart in both seasons. The plots were irrigated immediately after sowing directly. Plants were thinned at the age of 30 days from planting to obtain one plant/hill (35000 plants/fed). Potassium sulphate (48% K_2O) at the rate of 50kg/fed was applied before the third irrigation. Other cultural practices for growing sugar beet were performed as recommendations of Ministry of Agriculture, except the factors understudy. Sugar beet plants harvesting at 210 days after planting in both seasons.

Studied characters

A. Growth attributes

Two samples were taken during the growth period (120 and 150 days from sowing), *i.e.* five guarded plants were chosen at random from outer ridges of each sub sub-plot. Each sample was separated into foliages and roots, then the roots and foliages were cut to small pieces. The following growth attributes was determined:

1. Root fresh weight (g/plant).
2. Foliage fresh weight (g/plant).
3. Leaf area index (LAI). Leaf area measurement determined by the disk method using 10 disks of 1.0cm diameter according to Watson (1958) and then following equation was used:

$$LAI = \frac{\text{Leaves area per plant } (cm^2)}{\text{Plant ground area } (cm^2)}$$

4. Crop growth rate (CGR) in g/day: Determined according to Radford`s (1967), where**:** W_1 and W_2 refer to dry weight of plant at sampling time T_1 (120 DFS) and T_2 (150 DFS), respectively.

$$CGR = \frac{W_2 - W_1}{T_2 - T_1}$$

To determine root and foliage dry weight, all plant fractions were air-dried, then oven dried at 70 °C till constant weight obtained.

5. Relative growth rate (RGR) in g/g/day: Determined according to Watson (1958).

$$RGR = \frac{\log_e W_2 - \log_e W_1}{T_2 - T_1}$$

6. Net assimilation rate (NAR) in $g/cm^2/day$: Determined according to Radford`s (1967), where: W_1, A_1 and W_2, A_2, respectively refer to dry weight and leaf area of plant at sampling time T_1 and T_2, respectively.

$$NAR = \frac{(W_2 - W_1)(\log_e A_2 - \log_e A_1)}{(T_2 - T_1)(A_2 - A_1)}$$

B. Quality characters

At maturity (after approximately 210 days from planting) five plants were chosen at random from the outer ridges of each sub sub-plot to determine quality characters as follows:

1. Total soluble solids percentages (TSS%). It was measured in juice of fresh roots by using Hand Refractometer.

2. Sucrose percentage (%). It was determined Polarimetrically on lead acetate extract of fresh macerated roots according to the method of Carruthers and Old Field (1960).

3. Apparent purity percentage (%). It was determined as a ratio between sucrose% and TSS% of roots as the method outlined by Carruthers and Old Field (1960).

All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for split split-plot design as published by Gomez and Gomez (1984). Least significant of difference (LSD) method was used to test the differences among treatment means at 5% level of probability as described by Snedecor and Cochran (1980). All statistical analyses were performed using analysis of variance technique (ANOVA) by means of "MSTAT-C"computer software package.

Results and discussion

Cultivars performance

As shown from the obtained data in Tables 2 and 3 in this study, there were significant differences among studied sugar beet cultivars (Hossam, Asus poly and Glorious) in root fresh weight/plant at 120 and 150 days from sowing (DFS), leaf area index (LAI) at 120 and 150 (DFS), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) at growth stages during the two growing seasons. Whereas, foliage fresh weight/plant at 120 and 150 (DFS), total soluble solids (TSS), sucrose and apparent purity percentages of fresh juice of roots at harvest did not significantly differed due to the studied cultivars in both seasons. Hossam cultivar significantly surpassed other studied cultivars (Asus poly and Glorious) in root fresh weight/plant at 120 and 150 DFS, crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) at growth stages, total soluble solids (TSS), sucrose and apparent purity percentages of fresh juice of roots at harvest, which recorded the highest values of these characters in the two growing seasons. However, Asus poly cultivar registered the highest values of foliage fresh weight/plant at 120 and 150 (DFS) and leaf area index (LAI) at 120 and 150 (DFS) in both seasons. Whereas, Glorious cultivar recorded the lowest values of root and foliage fresh weights/plant at 120 and 150 (DFS), leaf area index (LAI) at 120 and 150 (DFS), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) at growth stages, total soluble solids (TSS), sucrose and apparent purity percentages of fresh juice of roots at harvest in both seasons of this study. The variation among sugar beet cultivars in growth and quality characters may be due to the genetical variation among them. These results are in good harmony with those obtained by Ahmed *et al.* (2017), El-Emary (2017), Mohamed and El-Sebai (2019), Mohamed *et al.* (2019) and Thalooth *et al.* (2019).

Effect of biofertilization treatments

Regarding the effect of biofertilization treatments *i.e.* treated soil with Phosphorin (450 g/fed), Cerealine (450 g/fed) and Potassiumag (450 g/fed) in addition without biofertilization (control treatment) on root and foliage fresh weights/plant at 120 and 150 (DFS), leaf area index (LAI) at 120 and 150 (DFS), crop growth rate (CGR) and net assimilation rate (NAR) at growth stages, total soluble solids (TSS), sucrose and apparent purity percentages of fresh juice of roots at harvest, it was significant in the two seasons of study (Tables 2 and 3). On the other hand, relative growth rate (RGR) at growth stages insignificantly affected by studied biofertilization treatments in the two seasons. All studied growth attributes and quality characters were markedly increased and achieved maximum values in treatment of treated soil with Cerealine before first irrigation directly as compared with other biofertilization treatments in the first and second seasons of this study. The arrangement of biofertilization treatments after Cerealine treatment was Potassiumag and Phosphorin treatment, then control treatment with respect their desirable effect on growth attributes, yield components, quality and yield characters during the two seasons. This increase in growth and quality characters by biofertilization treatments may be due to the role of biofertilization in nitrogen fixation via free living bacteria which reduce the soil pH especially in the rhizosphere which led to increase the availability of most essential macro and micro-nutrients, consequently increase growth and root quality. These findings were proportionately with those reported by Abdelaal and Tawfik (2015), Marajan *et al.* (2017), Zaki *et al.* (2018) and Mohamed and El-Sebai (2019).

Effect of nitrogen fertilizer levels

With indication to the effect of nitrogen fertilizer levels on growth attributes (root and foliage fresh weights/plant at 120 and 150 (DFS), leaf area index (LAI) at 120 and 150 (DFS), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) at growth stages) and quality characters (total soluble solids (TSS), sucrose and apparent purity percentages of fresh juice of roots at harvest), it is apparent from obtained results that each increase in nitrogen fertilizer levels from 70 to 90 and 110kg N/fed was accompanied with significant effect in all studied characters in both seasons (Tables 2 and 3).

Fertilizing sugar beet with 110kg N/fed surpassed the other two nitrogen levels and resulted in the highest values of root and foliage fresh weights/plant at 120 and 150 (DFS), leaf area index (LAI) at 120 and 150 (DFS), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) at growth stages, followed by fertilizing with 90kg/fed and lastly 70kg N/fed, which recorded the lowest means of these characters in the two growing seasons.

Whereas, fertilizing sugar beet with 90kg N/fed produced the highest percentages of total soluble solids (TSS), sucrose and apparent purity of fresh juice of roots at harvest, while the further incremental level of 110kg N/fed significantly reduced these quality parameters in the two growing seasons. These results are attributed to the role of nitrogen in increases the vegetative growth through enhancing leaf initiation, increasing increment chlorophyll concentration in leaves and photosynthetic area per plant, which led to more photosynthesis production and therefore increasing dry matter accumulation and consequently raising growth and quality characters.

The previous results are in good agreement with those obtained by Abido and Ibrahim (2017), Leilah *et al.* (2017), Makhlouf and Abd El-All (2017), Nemeata Alla *et al.* (2018) and Mohamed *et al.* (2019).

Effect of interactions

There are many significant interaction effects among studied factors (cultivars, biofertilization treatments and nitrogen fertilizer levels) on most of studied growth and quality characters in both seasons as shown in Tables 2 and 3. We present only the significant interactions among the studied factors on growth and quality characters in both seasons.

Table 2. Averages of root and foliage fresh weights/plant and leaf area index (LAI) of sugar beet at 120 and 150 days from sowing (DFS) as affected by cultivars, biofertilization treatments and nitrogen fertilizer levels as well as their interaction during 2017/2018 and 2018/2019 seasons.

Characters / Treatments	Root fresh weight (g/plant)				Foliage fresh weight (g/plant)				Leaf area index (LAI)			
	120 DFS		150 DFS		120 DFS		150 DFS		120 DFS		150 DFS	
	2017 /2018	2018 /2019	2017 /2018	2018 /2019	2017 /2018	2018 /2019	2017 /2018	2018 /2019	2017 /2018	2018 /2019	2017 /2018	2018 /2019
A. Cultivars:												
Hossam.	357.0	362.7	617.6	623.8	349.0	351.2	588.4	593.2	3.07	2.76	4.44	4.27
Asus poly.	355.5	356.1	616.0	614.5	350.8	354.3	591.5	596.7	3.51	3.14	4.67	4.58
Glorious.	349.6	355.1	609.9	613.0	345.0	349.9	577.2	582.3	2.89	2.63	4.22	4.01
LSD at 5%	6.1	6.2	8.4	9.3	NS	NS	NS	NS	0.28	0.26	0.35	0.39
B. Biofertilization treatments:												
Phosphorin.	358.6	361.1	655.3	656.4	358.3	360.9	637.4	633.1	3.39	3.06	4.66	4.50
Cerealine.	371.3	377.8	664.7	666.0	360.7	367.8	645.6	657.5	3.49	3.11	5.29	5.20
Potassiumag.	365.4	369.5	657.5	664.6	358.5	363.0	641.4	654.0	3.41	3.07	4.72	4.64
Without.	320.8	323.6	480.7	481.5	315.4	315.5	418.4	418.4	2.34	2.14	3.09	2.80
BLSD at 5%	8.2	7.1	9.5	9.0	4.8	4.2	13.2	12.9	0.25	0.22	0.44	0.42
C. Nitrogen fertilizer levels:												
70kg N/fed.	334.7	338.4	545.8	556.4	318.2	321.1	521.6	521.1	2.71	2.44	3.92	3.77
90kg N/fed.	358.2	358.7	612.3	615.3	350.0	357.4	593.9	599.2	3.17	2.85	4.34	4.32
110kg N/fed.	369.1	376.9	685.5	679.8	376.6	376.9	641.6	651.9	3.59	3.24	5.07	4.77
BLSD at 5%	7.0	7.4	11.4	10.4	3.2	3.6	11.8	10.9	0.17	0.15	0.35	0.32
D. Interactions (F. test):												
A ×B	NS	NS	*	*	NS	NS	NS	NS	NS	*	NS	NS
A ×C	*	*	NS	NS	NS	*	*	*	NS	NS	NS	*
B ×C	NS	*	*	*	*	*	*	*	*	*	*	*
A ×B ×C	*	NS	NS	*	NS	*	NS	*	*	*	*	NS

Root fresh weight/plant of sugar beet at 120 days from sowing (DFS) in 2017/2018 season and at 150 DFS in 2018/2019 season was significantly affected by the interaction among cultivars, biofertilization treatments and nitrogen fertilizer levels.

From obtained results it could be observed that the highest values of root fresh weight (395.6g/plant) at 120 DFS in 2017/2018 season and (751.0g/plant) at 150 DFS in 2018/2019 season were obtained when mineral fertilizing Hossam cultivar plants with 110kg N/fed and treating soil with Cerealine (Table 4).

This treatment followed by fertilizing Hossam cultivar plants with 110kg N/fed and treating soil with Potassiumag without significant differences between them. On the other hand, the lowest values of root fresh weight (288.0g/plant) at 120 DFS in 2017/2018 season and (417.3g/plant) at 150 DFS in 2018/2019 season were resulted from fertilizing Glorious cultivar plants with 70kg N/fed without biofertilization.

Table 3. Averages of crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR) at growth stages and total soluble solids (TSS), sucrose and apparent purity percentages of fresh juice of sugar beet roots at harvest as affected by cultivars, biofertilization treatments and nitrogen fertilizer levels as well as their interaction during 2017/2018 and 2018/2019 seasons.

Characters / Treatments	CGR (g/day)		RGR (g/g/day)		NAR (g/cm²/day)		TSS (%)		Sucrose (%)		Apparent purity (%)	
	2017 /2018	2018 /2019	2017 /2018	2018 /2019	2017 /2018	2018 /2019	2017 /2018	2018 /2019	2017 /2018	2018 /2019	2017 /2018	2018 /2019
A. Cultivars:												
Hossam.	2.439	2.358	0.061	0.061	0.874	0.811	22.00	22.00	18.13	18.38	83.12	83.80
Asus poly.	1.849	1.906	0.057	0.058	0.590	0.469	21.82	21.87	18.05	18.19	82.62	83.63
Glorious.	1.762	1.676	0.057	0.056	0.538	0.431	21.63	21.67	17.73	18.03	82.29	83.44
LSD at 5%	0.263	0.239	0.003	0.002	0.106	0.096	NS	NS	NS	NS	NS	NS
B. Biofertilization treatments:												
Phosphorin.	2.026	1.939	0.058	0.058	0.689	0.474	21.81	21.70	17.96	18.28	82.35	83.82
Cerealine.	2.128	2.122	0.059	0.060	0.887	0.946	22.15	22.23	18.35	18.59	85.24	85.61
Potassiumag.	2.043	1.953	0.059	0.058	0.726	0.575	22.15	21.81	18.20	18.48	83.07	84.72
Without.	1.870	1.907	0.058	0.058	0.369	0.287	21.16	21.66	17.38	17.44	80.04	80.34
BLSD at 5%	0.222	0.210	NS	NS	0.126	0.112	0.51	0.46	0.58	0.56	2.49	2.62
C. Nitrogen fertilizer levels:												
70kg N/fed.	1.746	1.833	0.056	0.057	0.431	0.501	21.19	21.49	17.79	18.53	84.27	84.43
90kg N/fed.	2.045	1.987	0.059	0.059	0.749	0.560	22.39	22.13	18.67	18.63	85.52	86.46
110kg N/fed.	2.258	2.120	0.060	0.060	0.822	0.651	21.88	21.92	17.45	17.44	78.23	79.98
BLSD at 5%	0.163	0.171	0.002	0.001	0.128	0.118	0.53	0.52	0.50	0.55	2.98	2.82
D. Interactions (F. test):												
A ×B	NS	NS	NS	NS	*	*	*	NS	NS	NS	NS	NS
A ×C	*	*	*	*	NS	NS	NS	NS	NS	NS	NS	NS
B ×C	*	*	*	*	NS	*	*	*	*	*	*	*
A ×B ×C	*	*	NS	NS	NS	NS	*	NS	NS	NS	NS	NS

Table 4. Averages of root fresh weight/plant of sugar beet at 120 days from sowing (DFS) in 2017/2018 season and at 150 DFS in 2018/2019 season as affected by the interaction among cultivars, biofertilization treatments and nitrogen fertilizer levels.

Cultivars	Biofertilization treatments	Nitrogen fertilizer levels					
		70kg N/fed	90kg N/fed	110kg N/fed	70kg N/fed	90kg N/fed	110kg N/fed
		120 DFS in 2017/2018 season			150 DFS in 2018/2019 season		
Hossam	Phosphorin	339.6	363.3	363.0	591.0	620.3	734.6
	Cerealine	344.6	376.0	395.6	602.3	693.3	751.0
	Potassiumag	341.0	373.3	394.3	593.3	646.3	747.3
	Without	311.0	308.3	351.6	468.3	496.6	542.0
Asus poly	Phosphorin	330.6	358.0	384.0	573.6	647.3	722.0
	Cerealine	366.3	373.3	391.3	592.3	675.3	728.6
	Potassiumag	349.6	367.3	387.0	588.0	672.0	734.3
	Without	305.0	336.3	334.6	456.0	463.6	503.3
Glorious	Phosphorin	342.0	366.0	346.0	595.0	642.3	720.0
	Cerealine	351.0	380.0	391.0	604.3	689.0	724.0
	Potassiumag	348.3	360.6	375.0	595.3	677.6	723.0
	Without	288.0	336.3	316.0	417.3	459.6	527.3
LSD at 5%			24.2				

Foliage fresh weight/plant of sugar beet at 120 and 150 days from sowing (DFS) in 2018/2019 season was significantly affected by the interaction among cultivars, biofertilization treatments and nitrogen fertilizer levels. From obtained results it could be observed that the highest values of foliage fresh weight (416.3g/plant at 120 DFS and 748.6g/plant at 150 DFS in 2018/2019 season) were obtained when mineral fertilizing Asus poly cultivar plants with 110kg N/fed and treating soil with Cerealine (Table 5). This treatment followed by fertilizing Hossam cultivar plants with 110kg N/fed and treating soil with Cerealine without significant differences between them 150 DFS in 2018/2019 season. On the other hand, the lowest values of foliage fresh weight (306.3g/plant at 120 DFS and 375.3g/plant at 150

DFS in 2018/2019 season) were resulted from fertilizing Glorious cultivar plants with 70kg N/fed without biofertilization treatment.

Leaf area index (LAI) of sugar beet at 120 days from sowing (DFS) during 2017/2018 and 2018/2019 seasons and at 150 DFS during 2017/2018 season was significantly affected by the interaction among cultivars, biofertilization treatments and nitrogen fertilizer levels. From obtained results it could be observed that the highest values of LAI (4.75 and 4.18 at 120 DFS in 2017/2018 and 2018/2019 seasons, respectively and 5.95 at 150 DFS in 2017/2018 season) were obtained when mineral fertilizing Asus poly cultivar plants with 110kg N/fed and treating soil with Cerealine (Table 6). This treatment followed by fertilizing Asus poly cultivar plants with 110kg N/fed and treating soil with Potassiumag without significant differences between them at 120 DFS in both seasons and at 150 DFS in the first season. On the other hand, the lowest values of LAI (1.73 and 1.64 at 120 DFS in 2017/2018 and 2018/2019 seasons, respectively and 2.25 at 150 DFS in 2017/2018 season) were resulted from fertilizing Glorious cultivar plants with 70kg N/fed without biofertilization treatment.

Crop growth rate (CGR) of sugar beet plants was significantly affected by the interaction among cultivars, biofertilization treatments and nitrogen fertilizer levels in both growing seasons.

From obtained results it could be observed that the highest values of CGR (3.686 and 3.220g/day) were obtained when mineral fertilizing Hossam cultivar plants with 110kg N/fed and treating soil with Cerealine in the first and second seasons, respectively (Table 7). This treatment followed by fertilizing Hossam cultivar plants with 110kg N/fed and treating soil with Potassiumag without significant differences between them in both season. On the other hand, the lowest values of CGR (0.924 and 1.446g/day) were resulted from fertilizing Glorious cultivar plants with 70kg N/fed without biofertilization treatment in the first and second seasons, respectively.

Total soluble solids (TSS) percentage of fresh juice of sugar beet roots at harvest during 2017/2018 season was significantly affected by the interaction among cultivars, biofertilization treatments and nitrogen fertilizer levels. From obtained results it could be observed that the highest percentage of TSS (23.62%) was obtained when mineral fertilizing Hossam cultivar plants with 90kg N/fed and treating soil with Cerealine in the first season (Table 7). This treatment followed by fertilizing Hossam cultivar plants with 90kg N/fed and treating soil with Potassiumag without significant differences between them in the first season. On the other hand, the lowest percentage of TSS (19.04%) was resulted from fertilizing Glorious cultivar plants with 70kg N/fed without biofertilization treatment in the first season.

Table 5. Averages of foliage fresh weight/plant of sugar beet at 120 and 150 from sowing (DFS) as affected by the interaction among cultivars, biofertilization treatments and nitrogen fertilizer levels during 2018/2019 season.

Cultivars	Biofertilization treatments	Nitrogen fertilizer levels					
		70kg N/fed	90kg N/fed	110kg N/fed	70kg N/fed	90kg N/fed	110kg N/fed
		120 DFS in 2018/2019 season			150 DFS in 2018/2019 season		
Hossam	Phosphorin	321.6	362.6	390.6	526.3	635.0	698.0
	Cerealine	328.3	366.3	399.6	596.0	671.6	744.0
	Potassiumag	322.0	365.3	392.6	587.6	657.6	701.3
	Without	307.6	316.3	326.0	416.3	428.6	456.6
Asus poly	Phosphorin	321.0	363.6	395.0	525.3	621.0	716.3
	Cerealine	324.6	398.0	416.3	547.0	661.3	748.6
	Potassiumag	321.0	367.3	397.0	537.3	635.6	741.0
	Without	307.6	315.3	325.0	388.0	403.3	462.6
Glorious	Phosphorin	331.0	359.3	387.6	546.0	668.0	676.6
	Cerealine	335.0	373.6	395.3	616.6	699.0	736.3
	Potassiumag	328.0	369.0	394.0	591.6	688.3	728.0
	Without	306.3	313.6	322.3	375.3	412.3	422.6
LSD at 5%			11.0			37.9	

Table 6. Averages of leaf area index (LAI) of sugar beet at 120 days from sowing (DFS) during 2017/2018 and 2018/2019 seasons and at 150 DFS during 2017/2018 season as affected by the interaction among cultivars, biofertilization treatments and nitrogen fertilizer levels.

Cultivars	Biofertilization treatments	Nitrogen fertilizer levels								
		70kg N/fed	90kg N/fed	110kg N/fed	70kg N/fed	90kg N/fed	110kg N/fed	70kg N/fed	90kg N/fed	110kg N/fed
		120 DFS						150 DFS		
		2017/2018 season			2018/2019 season			2017/2018 season		
Hossam	Phosphorin	2.75	2.86	3.15	2.48	2.58	2.84	3.62	4.11	5.31
	Cerealine	2.87	3.22	3.94	2.58	2.89	3.55	4.74	5.13	5.51
	Potassiumag	2.85	3.16	3.83	2.56	2.84	3.46	4.29	4.44	5.37
	Without	2.05	2.33	2.62	1.84	2.10	2.36	3.01	3.02	3.56
Asus poly	Phosphorin	2.80	3.47	3.30	2.53	3.12	2.98	4.16	4.58	5.49
	Cerealine	3.56	4.25	4.75	3.21	3.83	4.18	4.73	6.01	5.95
	Potassiumag	3.25	4.15	4.65	2.62	3.75	4.29	4.33	4.89	5.59
	Without	2.54	2.63	2.82	2.28	2.37	2.53	3.06	3.61	3.67
Glorious	Phosphorin	2.70	2.79	3.48	2.43	2.51	3.15	3.06	4.56	5.30
	Cerealine	2.79	3.84	4.09	2.51	3.46	3.69	5.46	5.19	5.86
	Potassiumag	2.70	3.45	3.96	2.43	3.12	3.57	3.86	4.72	5.84
	Without	1.73	1.83	2.53	1.64	1.82	2.28	2.25	2.29	3.36
LSD at 5%			0.59			0.54			1.23	

Table 7. Averages of crop growth rate (CGR) in g/day during 2017/2018 and 2018/2019 seasons and total soluble solids (TSS) percentage (%) in roots at harvest during 2017/2018 season as affected by the interaction among cultivars, biofertilization treatments and nitrogen fertilizer levels.

Cultivars	Biofertilization treatments	CGR (g/day)						TSS (%)		
		70kg N/fed	90kg N/fed	110kg N/fed	70kg N/fed	90kg N/fed	110kg N/fed	70kg N/fed	90kg N/fed	110kg N/fed
		2017/2018 season			2018/2019 season			2018/2019 season		
Hossam	Phosphorin	1.990	2.032	2.639	2.075	2.096	2.608	21.31	22.30	21.49
	Cerealine	2.498	2.499	3.686	2.277	2.567	3.220	22.83	23.62	22.94
	Potassiumag	2.384	2.462	3.271	2.134	2.346	3.188	22.19	23.38	22.52
	Without	1.904	1.943	1.958	1.698	1.974	2.118	20.89	21.86	20.97
Asus poly	Phosphorin	1.142	1.540	1.981	1.438	1.621	1.703	20.42	22.22	21.98
	Cerealine	2.389	2.448	2.834	1.778	1.919	2.620	22.39	23.08	22.37
	Potassiumag	1.146	2.041	2.339	1.575	1.634	1.704	21.88	22.48	22.25
	Without	1.112	1.534	1.708	1.129	1.543	1.586	19.26	21.06	20.26
Glorious	Phosphorin	1.430	1.841	2.047	1.713	1.854	1.860	20.89	22.49	21.90
	Cerealine	1.977	2.114	2.383	2.196	2.242	2.384	21.86	23.06	22.46
	Potassiumag	1.569	1.880	2.108	1.851	1.865	2.188	21.30	23.03	22.37
	Without	0.924	1.509	1.331	1.446	1.478	1.656	19.04	21.20	19.94
LSD at 5%			0.563			0.591			1.86	

Conclusion

It can be concluded that mineral fertilizing Hossam cultivar plants with 110kg N/fed and treating soil with Cerealine at the rate of 450g/fed before first irrigation directly to achieve highest growth and root quality of sugar beet. While, in order to maintain high growth and root quality of sugar beet at the same time reduce production costs and environmental pollution, it can be recommended that mineral fertilizing Hossam cultivar plants with 90kg N/fed and treating soil with Cerealine under the environmental conditions of Bani-Hassan Village, Awlad-Saqr Center, Sharkia Governorate, Egypt.

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