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Sugar Beet Growth, Yield, and Quality in Relation to Nitrogen Levels and Yeast Addition Times

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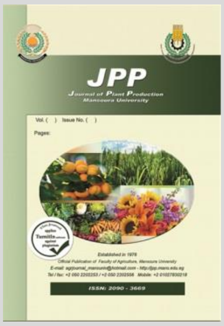

ABSTRACT

To examine the effects of soil nitrogen addition rates, yeast addition timing, and foliar yeast spraying on the quantity and quality traits of sugar beet throughout 2020–2021 and 2021–2022 seasons, two trials were undertaken at a field in Wazeer Village, Belqas District, Dakahlia Governorate, Egypt. Four duplicates of each field experiment were used in the strip-split plot design. The greatest values of root length and diameter, plant fresh weights of roots and foliage, and roots and top yields/fad were reached when fertilizing by 115 kg N/fad. The greatest values of total soluble solids, sucrose and apparent juice purity, extractable white sugar percentages, and sugar yield/fad were obtained with 69 kg nitrogen fad^{-1} fertilization. By fertilizing with 92 kg N/fad, gross white sugar yield/fad reached their peak. The highest root and leaf fresh weights per plant, root length and diameter, extractable white sugar %, and root, top, and gross sugar yield/fad were produced by foliar spraying at 100-days after seeding or adding yeast to soil. Highest values of total soluble solids, sucrose, apparent purity and extractable white sugar percentages and white sugar yield/fad were obtained with using yeast as soil addition and foliar spraying at 50 days after sowing in the two seasons. It is possible to suggest fertilizing sugar beet plants with 92 kg N/fad to maintain high productivity and quality of sugar beet while also reducing production expenses and environmental damage and sprayed yeast on plants' leaves at 50 days after planting in addition to soil addition.

Keywords: Sugar beet, nitrogen levels, yeast, addition time.

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is one of the world's most important sugar crops, both in Egypt and many other countries. The value of sugar beet in agriculture extends beyond merely producing sugar and includes a variety of other products. In the recent past, the sugar beet crop held a crucial place in addition to rich soils, low, salty, basic, and chalky soils are also included in the Egyptian agricultural rotation as a winter crop. As a result, sugar beet production in Egypt grew dependent on it, leading to a total growing area in the 2020 season of approximately 627232 fadden and a total output of more than 13.044 million tons of roots with a mean of 20.795 tons/fad (FAO, 2022).

Many temperatures and soil types are used to cultivate sugar beet. Creating high yielding cultivars and enhancing agricultural methods like mineral nitrogen fertilization and the timing of the addition of bio-stimulants like yeast are crucial for boosting sugar beet quality and output.

The most crucial material given to sugar beet during fertilization is nitrogen. When nitrogen fertilizer is applied to plants, more chlorophyll is produced, which builds up metabolites and activates enzymes linked to glucose buildup. As a result, there will be more cell division and elongation in the leaves (Marschner, 1995). Hence, nitrogen has a desired impact on sugar beet development and yield characteristics (Seadh *et al*,. 2013 ; Abdou and Badawy, 2014 ; Abdou *et al.*, 2014 ; Mekdad, 2015 ; Hussein *et al.*, 2016 ; Leilah *et al.*, 2017 ; Mohamed *et al.*, 2019 ; Kandil *et al.*, 2020 ; Idris *et al.*, 2021 and Kandil *et al.*, 2021). On the other hand, there was a decrease on root quality traits result of increased fertilization of minerals with nitrogen; this might be because of increases in amino-compounds brought on by increased nitrogen intake (Abdelaal and Tawfik, 2016).

On the basis of their abundance in Na, Mg, K, P, S, Zn, Cu, Ni, Va, and Li as well as protein (47%), carbohydrates (33%), and nucleic acid (8%) bio stimulants like yeast are assessed (Nagodawithana, 1991). Folic acid and bitartrate act as cofactors for more than 60 enzymes that catalyze numerous biochemical pathways involving amino acids and remove amino groups from amino acids to be used for energy that are involved in numerous bioactivities, alongside thiamin, riboflavin, pyridoxine, vitamins (B1, B2, B3, B5 and B6), hormones, and endogenous growth regulators (GA3 and IAA) (Mok and Mok, 2001). Hence, yeast treatments applied to the soil or as a foliar spray promote healthy cell division and growth (Natio *et al.*, 1981), the creation of chlorophyll, the synthesis of protein and nucleic acid (Castelfranco and Beale, 1983). Although it initially depends on the rise (concentration) of carbon dioxide surrounding the plant cover, the process of yeast when applied topically varies from that when applied in the soil. It is used by plants during photosynthesis, but in the second case it is reliant on rising soil carbon dioxide levels, which react with soil water to generate carbonic acid, increasing soil acidity and promoting sugar beet roots to take up nutrients from the soil. El-Tarabily (2004) reported that the fresh weights of sugar beet leaves and roots were greatly raised by introducing yeast. Yeast's ecological function as a source of cytokinins, which have an enhanced influence on cell division and proliferation as well as the production of

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protein nucleic acids and chlorophyll pigments, may be the reason for this effect. For the sugar beet plant's top, root, and sugar yields, these particular impacts are crucial. According to Stemwedel (2009), the reason why yeast has a positive effect on plants is because it helps to enhance soil quality and encourages beet roots to absorb more K and P from the soil. Sugar beet may absorb nutrients from the soil more quickly than almost any other crop when yeast is utilized in the soil. As a result, yeast contains high concentrations of Mg, Na, Cu, Mn, Fe, and Zn as well as other vital biological components.

According to Ferweez and Abd El-Monem (2018), the amount of time that yeast was added to the soil had a substantial impact on sugar beet yield qualities, beet root physical characteristics, and vegetative features.

Foliar fertilization with bio-stimulants is often used to address nutritional deficiencies in plants that are impacted by insufficient nutrient delivery to roots. Foliar fertilizers are completely soluble in water, making them readily available to plants. It is hence excellent for treating nutritional deficits. Moreover, foliar spraying encourages plants to produce exudations in the roots, which encourages microorganisms to work harder and improves soil nutrient absorption. Without replacing root fertilization techniques, foliar fertilizers play a minor fertilizing role in regulating a significant increase in the intensity of the productive consumption of soil elements and soil-applied nutrients. Foliar fertilizers are complementary in stabilizing and adjusting the fertilization system that is applied to crops (Romheld and El-Fouly, 1999). According to Thalooth *et al.* (2019), foliar yeast use has a stimulating influence on root creatures (length and diameter), fresh top, root, and total weight of top and roots, yield of top, root, and total weight of top and roots, as well as root quality metrics. According to Rania, Eid (2020), the use of yeast in foliar applications considerably improved all root vegetative development traits. When compared to control plants, foliar treatment of yeast considerably improved the characteristics and quality of the root produce.

The purpose of this experiment, which was conducted in the ecologically friendly Belqas District, Dakahlia Governorate, Egypt, was to ascertain the effect of soil additions such as yeast and nitrogen levels as well as foliar applications such as spraying yeast on leaves on sugar beet quality and production.

MATERIALS AND METHODS

Two series field trials were conducted at a personal farm in Wazeer Village, Belqas District, Dakahlia Governorate, Egypt, through 2020/2021 and 2021/2022 seasons. This investigation's primary goal was to determine how the Zwan-Pleno cultivar of sugar beet was affected by nitrogen levels, the timing of yeast's addition to the soil, and both foliar and soil spray applications.

Each field trial was conducted using 4-replication strip-split plot design. The 3 nitrogen amounts (69, 92, and 115 kg N/fad.) were used in the vertical plots. Two equal doses of nitrogen in the form of urea (46.0% N) were applied; the 1st dosage was practical at 35 days afterward the sugar beet plants were planted, and the 2nd dose was practical beforehand the 3rd watering (60 days after planting).

Horizontal plots were distributed with 4 treatments of yeast adding times at a rate of 100 liters/fad as a soil supplement *i.e.,* without yeast adding (control treatment), adding yeast at 50 and 100 days after sowing. Yeast was added as a soil addition with immediately before irrigation by placing it in a small, graduated package that opens like tap water in the bottom of the main ridges at the aforementioned times.

The four treatments of yeast addition periods at a rate of 100 ml/liter as a foliar spraying—without yeast addition (control treatment), spraying with yeast after 50 and 100 days after sowing—were applied to subplots at random. At the aforementioned periods, yeast was applied as a foliar spray using a manual sprayer and 200 liters of liquid, up until the point of fullness. The moistening ingredient Tween-20 was used at a concentration of 0.02%.

Five ridges, each measuring 60 cm in width and 7.0 m in length and causing an area of 21.0 m^2 (1/200 fad), were present in each trial basic unit (sub-plot). Throughout the two seasons, maize (Zea mays L.) was planted before the summer crop.

Soil samples were randomly collected from the trial field area and processed for physical and chemical analyses, in accordance with Jackson (1973), at a depth of 0–30 cm from the soil surface. Table 1 displays the findings of physical and chemical analyses.

The research field was meticulously prepared by two ploughing, flattening, and compacting operations, both of which delivered 50 kg/fad of potassium sulphate (48% K_2O) and calcium superphosphate (12.0% P2O5) at a rate of 250 kg/fad utilized during the soil preparation process, division, and then into the experimental units after that.

Using the dry technique of planting, sugar beet seeds were manually sown on one side of ridges in hills 20 cm apart in both seasons during the 1st week of October at a rate of 3-5 seeds/hill (Afeer). After planting, plots were immediately irrigated. Thirty-five days after sowing, plants were pruned in order to produce one plant $hill^{-1}$ (35000 plants fad^{-1}). Aside from the variables under investigation, several agricultural techniques for sugar beet cultivation have been finished as commendations of the Agriculture Ministry. In both seasons, sugar beet plants began to gather 210 days afterward sowing.

Table 1.Physio-chemical soil estates of the investigational site throughout 2020/2021 and 2021/2022 seasons.

Soil properties		1st season (2020-2021)	2nd season (2021-2022)
B: Physical properties:			
Particles size distribution (%)	Sand	20.19	20.21
	Silt	29.92	29.87
	Clay	49.89	49.92
B: Chemical properties:			
EC (dS m^{-1})		2.38	2.40
pH (1:2.5 soil suspension)		8.02	8.10
$CaCO_3$, %		1.17	1.20
Organic matter "OM"(%)		1.22	1.30
Soluble ions (meq L^{-1})	Ca^{++}	4.42	4.63
	Mg^{++}	13.87	3.22
	Na^{+}	13.84	13.89
	K^{+}	0.52	0.62
	HCO_3^{-}	2.60	2.64
	Cl^{-}	13.45	13.56
	SO_4^{-}	6.12	6.16
CEC cmol kg^{-1}		48.00	50.00

Five plants were randomly selected from each sub-outer plot's ridges at maturity (about 210 days after planting) to assess the characteristics that make up growth and yield, comprising root length (cm), root diameter, root fresh weight (g/plant), and fresh weight of the leaves (cm).

The amount of total soluble solids (TSS%) in fresh root juice was calculated using a hand refractometer.

The Al-Dakahlia Sugar Company Laboratory in Bilkas District, Dakahlia Governorate, imposed the following root quality restrictions:

Sucrose percentage *i.e.,* gross sugar (%) affording to Carruthers and OldField (1960) method, apparent juice clarity percentage (%) as Carruthers and OldField (1960) method and extractable white sugar percentage (ZB) was computed Contains non-sugar, potassium, sodium, and alfa-amino nitrogen in beets, presented as milliequivalents per 100 g of beet, equating to Harvey and Dutton (1993) using the subsequent equivalence:

$$ZB = Pol - [0.343\ (K + Na) + 0.094\ Am\ N + 0.29]$$

Where, **ZB = adjusted sugar content (% per beet) or extractible white sugar, Pol = Gross sugar % and AmN = α-amino nitrogen defined by the "Blue number method".**

White sugar yield (tons/fad) was established as follows:

$$\text{White sugar yield (tons/fad)} = \text{yield of roots (tons/fad)} \times \text{White sugar \%}.$$

The two inner ridges of each sub-producing plot's plants were harvested and cleaned before harvest. To determine the yield of roots (tons/fad), top (tons/fad), and gross sugar (tons/fad), roots and tops were separated and weighed in kilos.

According to Gomez and Gomez's (1984) recommendations, the obtained data were statistically evaluated using the analysis of variance (ANOVA) method for strip-split plot designs. According to Snedecor and Cochran's (1980) definition, the least significant difference (LSD) approach was used to examine the differences between treatment means at a 5% level of probability. The MSTAT-C computer application was used to apply the analysis of variance (ANOVA) approach to all geometric analyses.

RESULTS AND DISCUSSION

1-The impact of nitrogen fertilizer levels

The acquired results of this study make it clear that the impact of nitrogen fertilizer doses (69, 92, and 115 kg N fad^{-1}) on growth and yield components features (root length, root diameter, leaf fresh weight/plant, root fresh weight/plant), root quality parameters (total soluble solids "TSS %", sucrose *i.e.* gross sugar, apparent juice purity and extractible of white sugar percentages, yield of white sugar fad^{-1}) and yield characters (yield of roots fad^{-1}, yield of foliage fad^{-1} and yield of gross sugar fad^{-1}) were significantly exaggerated by nitrogen levels in both seasons (Tables 2, 3 and 4).

Analysis of variance of the obtained results of this study revealed that root length, root diameter, root yield/fad, foliage fresh weight/plant, top yield/fad, and root fresh weight/plant were fertilized with 92 kg N/fad at each of the two growing seasons after fertilizing sugar beet plants with 115 kg N/fad to reach their maximum levels. Nevertheless, plants of sugar beet fertilized by 69 kg N fad^{-1} in both seasons produced the lowest amounts of root and leaf fresh weight per plant, root length, root diameter, root yield, and top yield per fad.

Using 69 kg N/fad to fertilize sugar beet plants was superior to the other two nitrogen levels (92 and 115 kg N/fad) in terms of total soluble solids (TSS), sucrose, or gross sugar and apparent juice purity, extractable white sugar percentages, and white sugar yield/fad, which resulted in the highest values, followed by fertilized with 92 kg fad^{-1}, and finally fertilized by 115 kg N/fad, which gave the smallest values in the two seasons.

Analysis of variance of the attained results of this research discovered that gross sugar yield fad^{-1} achieved its maximal when fertilizing at 92 kg N/fad, followed by fertilizing at 69 kg, and the smallest possible values were occasioned from fertilizing at 115 kg N fad^{-1} in both growing seasons.

As a result of its function in accumulating metabolites that promote enzymes and carbohydrates that are transported from leaves to growing roots, which in turn increased length and diameter of roots, fresh weight of root plant^{-1}, and ultimately yield of roots fad^{-1}, nitrogen fertilization's enhanced effect on sugar beet growth and productivity may be attributed. While nitrogen improves the weight and width of roots, the water content of tissues, and the partitioning of more photosynthetic energy to the tops than to the roots of beet plants, the quality of roots may be lowered because of excessive nitrogen use (Abdelaal and Tawfik, 2016). These results agree with those obtained by Abdou *et al.* (2014), Mekdad (2015), Hussein *et al.* (2016), Mohamed *et al.* (2019), Kandil *et al.* (2020), Idris *et al.* (2021) and Kandil *et al.* (2021).

2. Addition times of yeast as a soil addition:

As shown from the obtained results of the investigation, there were significant differences among considered addition times of yeast as a soil addition (without yeast addition, addition yeast at 50 and 100 days after sowing) in growth and yield components characters and root quality characteristics (Tables 2, 3 and 4).

Yeast addition times as a soil addition at 50 days after sowing during the two growth seasons resulted in maximum values for the fresh weight of root and foliage plant^{-1}, root length, root diameter, extractible white sugar percentage, white sugar yield fad^{-1}, roots yield fad^{-1}, foliage yield fad^{-1}, and gross sugar yield fad^{-1}. With the addition of yeast as a soil amendment, the second-best values of these features were obtained at 100 days after sowing in the two growing seasons. The least amounts of fresh root and leaf plant-1 weight, root length and diameter, extractible white sugar percentage, root yield/fad, top yield/fad, and gross sugar yield/fad were obtained in the two growth seasons with no yeast addition (control treatment).

After introducing yeast as a soil addition at 50 days after sowing in the two growth seasons, the maximum values of total soluble solids (TSS), sucrose, or gross sugar, apparent juice purity, extractable white sugar percentages, and white sugar yield/fad were attained. At 50 days after sowing during each of the two growing seasons, add yeast to the soil. The lowest levels of total soluble solids (TSS), sucrose (gross sugar), apparent juice purity, extractable white sugar percentages, and white sugar yield/fad were obtained in the two growth seasons when yeast was not added (treated as control).

These outcomes may be explained by the fact that the soil treated with yeast showed growth in the amount of humus and organic carbon as well as a much lower specific gravity than the soil treated with chemical fertilizer. The favorable effects of yeast may be attributable to their role in improving soil qualities and promoting an increase in K and P absorption by the roots of the sugar beet plant. Also, due to yeast's soil treatment, sugar beet plants absorb nutrients from the soil more quickly than almost any other crop, and as a result, yeast is unusually abundant in Mg, Na, Cu, Mn, Fe, and other organic elements (Stemwedel, 2009). These outcomes are in great agreement with those achieved by Abdou (2015).

3. Addition times of yeast as a foliar spraying:

Regarding the effect of addition times of yeast as foliar spraying *i.e.* without yeast addition and foliar spraying with yeast at 50 and 100 days after sowing on growth and yield components characters (root fresh weight/plant, foliage fresh weight/plant, root length and root diameter), root quality parameters (TSS %, sucrose *i.e.* gross sugar, apparent juice purity, extractable white sugar and loss sugar percentages and white sugar yield fad^{-1}) and yield characters (roots yield fad^{-1}, foliage yield fad^{-1} and gross sugar yield fad^{-1}), it was significant in the two seasons of study (Tables 2, 3 and 4).

Fresh weight of root and foliage plant^{-1}, length and diameter of root, extractable white sugar percentage, white sugar and root yields fad^{-1}, foliage yield fad^{-1} and gross sugar yield fad^{-1} were clearly increased and accomplished maximum values in treatment of foliar spraying sugar beet plants with yeast at 50 days after sowing as compared with other addition time of yeast as foliar spraying in the two seasons of study. The arrangement of addition times of yeast a foliar spraying after at 50 days after sowing treatment was foliar spraying sugar beet plants with yeast after 100 days after sowing, and then control treatment (without foliar spraying with yeast) with respect their desirable effect on these characters in the two seasons.

Foliar spray plants of sugar beet with yeast at 100-days after sowing was accompanied with maximum means of total soluble solid (TSS), sucrose *i.e.,* gross sugar, apparent juice purity and extractible white-sugar percentages and white-sugar yield fad^{-1} in both growth seasons. Noteworthy, foliar spraying with yeast at 50 days after sowing treatment approached in the 2nd rank after aforesaid treatment in the two growth seasons. Nevertheless, the lowermost values of total soluble solids (TSS), sucrose *i.e.*, gross sugar, apparent juice purity and extractable white-sugar percentages and white-sugar yield fad^{-1} were documented with control treatment (exclusive addition of yeast) in both growth-seasons.

This effect of the yeast foliar spray may be attributable to yeast's role as a natural supply of cytokinin, which promotes cell division and growth as well as the synthesis of protein, nucleic acid, and chlorophyll (Mohamed, 2012), consequently cumulative plant development dry matter accretion, in addition sugar root quality and sugar-beet productivity. These results corresponded in proportion to those published by Abdou (2015), Thalooth *et al*. (2019), Eid (2020), and Sarhan *et al.* (2020).

4-Interactions:

As demonstrated in Tables 2, 3 and 4, there are numerous significant interactions between the examined parameters (nitrogen fertilizer levels and yeast addition times as soil additions and foliar sprayings) that have an impact on the studied features. Only the triple significant interaction on root and gross-sugar yields fad^{-1} was sufficiently covered.

Table 2. Means of sugar beet root length and width as influenced by nitrogen fertilizer levels, yeast addition time as a soil addition and a foliar spraying, as well as their interactions over the 2020–2021 and 2021–2022 seasons.

Characters	Root fresh weight (g/plant)		Foliage fresh weight (g/plant)		Root length (cm)		Root diameter (cm)	
Treatments	**2020/ 2021**	**2021/ 2022**	**2020/ 2021**	**2021/ 2022**	**2020/ 2021**	**2021/ 2022**	**2020/ 2021**	**2021/ 2022**
A. Nitrogen fertilizer levels:								
69 kg N/fad.	794.6	790.5	472.4	430.1	28.55	27.64	8.87	8.70
92 kg N/fad.	882.5	868.0	580.1	414.9	33.24	31.46	10.30	9.69
115 kg N/fad.	897.0	960.5	582.5	604.8	34.11	34.17	10.64	11.07
LSD at 5 %	14.7	13.5	12.3	11.8	0.42	0.45	0.14	0.15
B. Addition times of yeast as a soil addition:								
Without	824.0	853.5	516.7	457.1	30.82	30.33	9.50	9.44
50 days after sowing	875.1	891.3	569.7	498.0	32.73	31.55	10.21	10.06
100 days after sowing	875.0	874.3	548.6	494.7	32.35	31.38	10.11	9.95
LSD at 5 %	8.3	7.0	11.5	12.6	0.20	0.22	0.24	0.21
C. Addition times of yeast as a foliar spraying:								
Without	854.3	865.9	534.7	478.4	31.51	30.70	9.79	9.73
50 days after sowing	863.3	881.2	556.2	489.8	32.26	31.30	10.04	9.90
100 days after sowing	856.5	872.0	544.1	481.6	32.13	31.27	9.98	9.83
LSD at 5 %	8.5	9.9	8.7	8.0	0.21	0.23	0.16	0.15
D. Interactions (F. test):								
A × B	*	*	*	*	*	*	*	*
A × C	*	*	*	*	*	*	NS	NS
B × C	*	*	*	*	*	*	NS	NS
A × B × C	*	*	*	*	*	*	*	*

Table 3. Means of total soluble solids (TSS), sucrose, apparent purity and extractable white sugar percentages and white sugar yield/fad. as affected by nitrogen fertilizer levels and addition time of yeast as a soil addition and a foliar spraying as well as their interactions during 2020/2021 and 2021/2022 seasons.

Characters Treatments	TSS (%)		Sucrose (%)		Apparent purity (%)		Extractable white sugar (%)		White sugar yield (t/fad.)	
	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022
A. Nitrogen fertilizer levels:										
69 kg N/fad.	25.20	25.33	19.32	19.97	76.73	78.90	16.82	17.48	4.658	4.819
92 kg N/fad.	22.41	23.61	16.22	16.93	72.49	72.27	13.34	14.07	4.101	4.265
115 kg N/fad.	22.06	21.97	15.98	15.87	72.44	71.74	12.78	12.69	3.995	4.230
LSD at 5 %	0.75	0.73	0.22	0.25	1.71	1.63	0.23	0.26	0.140	0.145
B. Addition times of yeast as a soil addition:										
Without	22.88	23.45	16.69	17.24	72.91	73.41	13.70	14.28	4.164	4.348
50 days after sowing	23.22	23.60	17.26	17.60	74.25	74.45	14.37	14.71	4.245	4.382
100 days after sowing	23.57	23.86	17.57	17.93	74.48	75.04	14.86	15.25	4.346	4.585
LSD at 5 %	0.25	0.20	0.29	0.27	0.78	0.84	0.28	0.25	0.115	0.105
C. Addition times of yeast as a foliar spraying:										
Without	23.04	23.40	16.95	17.45	73.50	73.20	14.05	14.57	4.193	4.383
50 days after sowing	23.11	23.63	17.13	17.53	74.07	74.50	14.28	14.69	4.239	4.421
100 days after sowing	23.52	23.89	17.44	17.79	74.08	75.21	14.61	14.98	4.323	4.510
LSD at 5 %	0.32	0.31	0.22	0.20	0.60	0.58	0.22	0.21	0.095	0.101
D. Interactions (F. test):										
A × B	NS	NS	*	NS	NS	NS	*	NS	*	*
A × C	NS	NS	NS	*	NS	NS	NS	*	NS	*
B × C	NS	NS	NS	*	NS	NS	NS	*	NS	*
A × B × C	NS	NS	NS	*	NS	NS	NS	*	*	*

Table 4. Means of root, top, and gross sugar yields/fads of sugar beet as influenced by nitrogen fertilizer concentrations, addition time of yeast as a soil addition and a foliar spraying, as well as their interactions over the 2020–2021/2021/2 seasons.

Characters	Root yield (t/fad.)		Top yield (t/fad.)		Gross sugar yield (t/fad.)	
Treatments	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022	2020/ 2021	2021/ 2022
A. Nitrogen fertilizer levels:						
69 kg N/fad.	27.724	27.566	16.483	14.999	4.995	5.290
92 kg N/fad.	30.775	30.273	20.233	14.469	5.355	5.506
115 kg N/fad.	31.261	33.341	20.300	20.994	4.987	5.131
LSD at 5 %	0.540	0.523	0.410	0.385	0.162	0.160
B. Addition times of yeast as a soil addition:						
Without	28.732	30.465	18.019	15.922	5.027	5.207
50 days after sowing	30.531	31.008	19.876	17.326	5.232	5.414
100 days after sowing	30.496	29.707	19.120	17.214	5.078	5.306
LSD at 5 %	0.258	0.240	0.413	0.405	0.116	0.106
C. Addition times of yeast as a foliar spraying:						
Without	29.785	30.358	18.645	16.654	5.071	5.245
50 days after sowing	30.095	30.685	19.389	17.043	5.170	5.369
100 days after sowing	29.880	30.137	18.982	16.765	5.096	5.312
LSD at 5 %	0.364	0.355	0.304	0.298	NS	NS
D. Interactions (F. test):						
A × B	*	*	*	*	*	*
A × C	*	*	*	*	NS	*
B × C	*	*	*	*	NS	*
A × B × C	*	*	*	*	*	*

For the 2020–2021 and 2021–2022 growing seasons, there was a strong interaction between nitrogen fertilizer levels, yeast addition times as a soil addition, and foliar spraying. The highest values of root yield fad^{-1} (32.583 and 35.516 tons fad^{-1}) were produced by mineral fertilizing sugar beet plants with 115 kg N/fad, adding yeast to the soil 50 days after sowing, and spraying the plants with yeast 50 days after sowing, respectively (Table 5). This interaction treatment was followed by mineral fertilizing sugar-beet plants with 115 kg N fad^{-1}, soil addition of yeast at 50 days after sowing, and foliar application of yeast at 50 days after sowing without appreciable differences between them. This interaction treatment was also followed by mineral fertilizing sugar beet plants with 115 kg N fad^{-1}, soil addition of yeast at 50 days after sowing, and foliar application of yeast at 50 days after sowing in both seasons. While the sugar beet plants were fertilized with 69 kg of nitrogen per day without yeast addition as a soil addition or a foliar spraying, the lowest values of root yield/fad (26.097 and 26.258 tons fad^{-1}) in the 1st and 2nd seasons, correspondingly, were the consequence.

Table 5. Means of sugar beet root production (tons fad^{-1}) throughout the 2020–2021 and 2021–2022 growing seasons, as influenced by the interaction of nitrogen fertilizer levels and yeast addition time as a soil addition and a foliar spraying.

Nitrogen fertilizer levels	Addition time of yeast as a soil addition	Addition time of yeast as a foliar spraying					
		Without	50 days after sowing	100 days after sowing	Without	50 days after sowing	100 days after sowing
		2020/2021 season			2021/2022 season		
69 kg N/fad.	Without	26.097	27.273	26.527	26.258	26.619	26.522
	50 days after sowing	27.166	28.028	27.650	27.718	28.141	28.067
	100 days after sowing	28.663	29.356	28.757	27.872	28.521	28.373
92 kg N/fad.	Without	28.718	30.526	29.759	28.378	30.503	29.239
	50 days after sowing	30.622	31.382	31.032	30.058	30.991	30.726
	100 days after sowing	31.108	32.443	31.388	30.669	31.097	30.800
115 kg N/fad.	Without	28.673	31.004	29.890	28.576	33.415	28.616
	50 days after sowing	31.131	32.119	31.365	34.378	35.045	34.726
	100 days after sowing	32.034	32.583	32.548	34.733	35.516	35.058
LSD at 5 %			1.075			1.066	

In the seasons 2020–2021 and 2021–2022, there was a substantial interaction between yeast addition times as a soil addition and a foliar spraying and nitrogen fertilizer levels. The maximum values of gross sugar yield fad^{-1} (5.764 and 5.751 tons fad^{-1}, respectively) were created by mineral fertilizing sugar beet plants with 92 kg N/fad, adding yeast to the soil 50 days after sowing, and spraying the plants with yeast 50 days after sowing (Table 6). This interaction treatment was followed by mineral fertilizing sugar-beet plants with 92 kg N/fad, soil addition of yeast at 50 days after sowing, and foliar application of yeast at 50 days after sowing without noticeably differing from each other. This interaction treatment was also followed by mineral fertilizing sugar-beet plants with 92 kg N/fad, soil addition of yeast at 50 days after sowing, and foliar application of yeast at 100 days after sowing in both seasons. The lowest gross sugar yield fad^{-1} values, in contrast, were attained by fertilizing sugar-beet plants with 115 kg nitrogen fad^{-1} without adding yeast through foliar spraying or soil addition in the first and second seasons, respectively (4.575 and 4.537 tons fad^{-1}).

Table 6. Means of sugar-beet gross-sugar production (tons fad^{-1}) as influenced by the interaction between nitrogen fertilizer levels and yeast addition time as a soil addition and a foliar spraying over the 2020–2021 and 2021–2022 seasons.

Nitrogen fertilizer levels	Addition time of yeast as a soil addition	Addition time of yeast as a foliar spraying					
		Without	50 days after sowing	100 days after sowing	Without	50 days after sowing	100 days after sowing
		2020/2021 season			2021/2022 season		
69 kg N/fad.	Without	4.823	5.026	4.863	4.558	5.521	4.571
	50 days after sowing	4.924	5.134	5.068	5.441	5.591	5.522
	100 days after sowing	5.097	5.168	5.101	5.141	5.644	5.620
92 kg N/fad.	Without	5.121	5.194	5.139	5.166	5.417	5.315
	50 days after sowing	5.338	5.363	5.356	5.492	5.622	5.603
	100 days after sowing	5.355	5.764	5.561	5.502	5.751	5.685
115 kg N/fad.	Without	4.575	4.940	4.902	4.537	5.138	4.840
	50 days after sowing	4.925	5.035	4.964	4.854	5.340	5.291
	100 days after sowing	5.056	5.152	5.086	5.144	5.519	5.514
LSD at 5 %			0.322			0.324	

CONCLUSION

To maximize yield, sugar beet plants should receive 115 kg N/fad of mineral fertilizer, as well as soil addition of yeast at 50 days after sowing and foliar application of yeast at 50 days after sowing. In the conservational situations of Belqas District, Dakahlia Governorate, Egypt, it is possible to recommend mineral fertilizing sugar-beet plants with 92 kg N fad^{-1} and soil addition of yeast at 50 days after sowing and foliar spraying plants with yeast at 50 days after planting to preserve high productivity and highest root-quality traits of sugar-beet while reducing production costs and environmental pollution.

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استجابة نمو ومحصول وجودة بنجر السكر لمستويات السماد النيتروجيني ومواعيد إضافة الخميرة

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الملخص

أقيمت تجربتان حقليتان في مزرعة خاصة بقرية وزير - مركز بلقاس - محافظة الدقهلية خلال موسمي الزراعة 2020 / 2021 و2021/ 2022 م لدراسة تأثير مستويات السماد النيتروجيني (69، 92، 115 كجم نيتروجين/فدان) ومواعيد الإضافة الأرضية والرش الورقي بالخميرة (بدون، الإضافة بعد 50 و100 يوماً من الزراعة) على إنتاجية وجودة بنجر السكر. نفذت التجارب فى تصميم الشرائح المتعامدة المنشقة فى أربع مكررات. نتجت أعلى القيم لصفات الوزن الغض للجذر / نبات، الوزن الغض للعرش / نبات، طول الجذر، قطر الجذر، محصول الجذر/ فدان ومحصول العرش / فدان من تسميد نباتات بنجر السكر بمعدل 115 كجم نيتروجين / فدان. أدى تسميد نباتات بنجر السكر بـ 69 كجم نتروجين / فدان للحصول على أعلى القيم لصفات النسبة المئوية للمواد الصلبة الذائبة الكلية، النسبة المئوية للسكروز، النسبة المئوية للنقاوة الظاهرية، النسبة المئوية للسكر الأبيض المستخلص ومحصول السكر الأبيض /فدان. نتجت أعلى القيم لصفات محصول السكر الكلى / فدان من تسميد نباتات بنجر السكر بـ 92 كجم نيتروجين / فدان. نتجت أعلى القيم لصفات الوزن الغض للجذر / نبات، الوزن الغض للعرش / نبات، طول الجذر، قطر الجذر، محصول الجذر/ فدان، محصول العرش / فدان، محصول السكر الكلى / فدان من إضافة الخميرة كإضافة للتربة أو رش ورقى بعد 50 يوماً من الزراعة. أما أعلى القيم لصفات النسبة المئوية للمواد الصلبة الذائبة الكلية، النسبة المئوية للسكروز، النسبة المئوية للنقاوة الظاهرية، النسبة المئوية للسكر الأبيض المستخلص، محصول السكر الأبيض /فدان تم الحصول عليها من إضافة الخميرة كإضافة للتربة أو رش ورقى بعد 100 يوماً من الزراعة. من نتائج هذه الدراسة يمكن استنتاج أن التسميد المعدني لبنجر السكر بـ 115 كجم نتروجين مع إضافة الخميرة للتربة بعد 50 يوماً من الزراعة والرش الورقي بالخميرة بعد 50 يوماً من الزراعة لتحقيق أقصى إنتاجية. بينما من أجل الحفاظ على إنتاجية عالية وأعلى جودة لجذر بنجر السكر وفي نفس الوقت التقليل من تكاليف الإنتاج والتلوث البيئي، يمكن التوصية بالتسميد المعدني لبنجر السكر بـ 92 كجم نتروجين مع إضافة الخميرة للتربة بعد 50 يوماً من الزراعة والرش الورقي بالخميرة بعد 50 يوماً من الزراعة.