

## Impact of Anti-Stress Foliar Treatments on Productivity and Quality of Sugar Beet Under Different Sowing Dates

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### Abstract

During the 2021–2022 and 2022–2023 seasons, two experiments were conducted in El-Baquia village, El-Mansoura district, Dakahlia Governorate, Egypt, to explore the impact of foliar spraying utilizing anti-stress treatments *i.e.* amino acids at 1000, 2000 and 3000 ppm, cytokinin at 2, 3 and 4 ppm and salicylic acid at 1000, 2000 and 3000 ppm in comparing to control (without any treatment) on sugar beet efficiency and quality measures under various sowing dates (September 1<sup>st</sup>, October 1<sup>st</sup> and November 1<sup>st</sup>). Each planting date performed in a distinct experimentation. Each field experimentation of sowing dates achieved in a completely randomized block design in three replicates. Intermediate sowing date of sugar beet on October 1<sup>st</sup> yielded the greatest estimates of yield components, quality issues and root, top and corrected sugar yields/fad compared to other studied sowing dates for each season. Generally, the highest mean estimates of yield components, quality parameters, and root, top, and corrected sugar yields/fad occurred under the application of amino acids in the form of K-amino at 3000 ppm as foliar spraying. Therefore, planting sugar beet on October 1<sup>st</sup> under foliar application of amino acids at 3000 ppm twice after 50 and 70 days from planting could be suggested in order to get the best quality and productivity measures considering the Dakahlia Governorate's environmental conditions in Egypt.

**Keywords:** Sugar beet, sowing dates, anti-stress treatments, amino acids, cytokinin, salicylic acid.

### تأثير الرش الورقي بمعاملات مقاومة الإجهاد في إنتاجية وجودة بنجر السكر تحت مواعيد زراعة مختلفة

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#### المستخلص:

نفذت هذه الدراسة بمركز المنصورة (قرية البقلية)، محافظة الدقهلية، مصر خلال موسمي 2022/2021 و2023/2022 لدراسة تأثير الرش الورقي بمعاملات مقاومة الإجهاد (بدون رش ورقي، الرش الورقي بالأحماض الأمينية بمعدل 1000، 2000 و3000 جزء في المليون، الرش الورقي بالسيتوكينين بمعدل 2، 3 و4 جزء في المليون والرش الورقي بحمض الساليسيليك بمعدل 1000، 2000 و3000 جزء في المليون) على إنتاجية وجودة بنجر السكر تحت مواعيد زراعة مختلفة (الأول من سبتمبر، الأول من أكتوبر والأول من نوفمبر). تم إجراء كل موعد للزراعة في تجربة منفصلة، ثم تم تنفيذ كل تجربة حقلية لمواعيد الزراعة في تصميم القطاعات كاملة العشوائية في ثلاث مكررات. كان موعد زراعة بنجر السكر في الأول هو أكتوبر هو الأفضل للحصول على أعلى مكونات للمحصول وصفات الجودة ومحصول الجذور، العرش ومحصول السكر الأبيض بالمقارنة مع مواعيد الزراعة الأخرى تحت الدراسة. أدى الرش الورقي لنباتات بنجر السكر بالأحماض الأمينية بمعدل 3000 جزء في المليون إلى زيادة معنوية والحصول على أعلى القيم لمكونات المحصول وصفات الجودة ومحصول الجذور، العرش ومحصول السكر الأبيض في كلا موسمي الزراعة.

من النتائج المتحصل عليها من هذه الدراسة يوصى بزراعة بنجر السكر في الأول من أكتوبر والرش الورقي للنباتات مرتين بعد 50 و70 يوماً من الزراعة بالأحماض الأمينية بمعدل 3000 جزء في المليون للحصول على أعلى إنتاجية وجودة تحت الظروف البيئية لمحافظة الدقهلية، مصر.

### Introduction

One of the most popular sugar crops in many nations worldwide is the sugar beet (*Beta vulgaris* var. *saccharifera* L.). The value of sugar beet in agriculture extends beyond its usage in the production of sugar; it is also utilized in the manufacturing of numerous other goods. It is grown in 40 nations and contributes between 40 and 45 percent of global sugar production. Beets contain a sugar called sucrose, which ranges from 13 to 22%. This sugar is mostly utilized to make sucrose sugar and animal feed additives. Alcohol, medications, and food additives are all made from molasses that is left over after sugar is extracted (Shahl *et al.*, 2000 and Mohamed, 2023). Since 2012, sugar beet has emerged as Egypt's primary sugar source, with sugarcane coming in second. Numerous soil types and climates are suitable for growing sugar beet. In the 2022 season, Egypt's total sugar beet cultivation area was approximately 604103 faddan, and the overall production exceeded 13557071 million tons of roots, with an average of 22.442 tons per fad (FAO, 2024).

However, changes in climate can impact the characteristics of sugar beets (Sogut and Arioglu, 2004). Important cultural methods that limit sugar production and quality from sugar beets include planting dates, the development of high-yield cultivars, and foliar spraying with anti-stress treatments including amino acids, cytokinin, and salicylic acid.

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The term "sowing date" refers to the large-scale impact of all environmental factors on crop growth and yield, which varies greatly by region. Furthermore, as environmental elements like temperature and light fluctuate depending on the planting date, the sowing date is a significant component that influences the timing and duration of the vegetative and ripening stages. While sowing dates allow for the superposition of the crucial times for oil yield and its components with the time of the growing season when more environmental resources are available, the earliest planting dates offer the best yield and quality (Leilah *et al.*, 2005). Furthermore, the primary cause of the decline in sugar beet output has been the restricted availability of water in semi-arid environments (Morillo-Velarde and Ober, 2006). Therefore, in order to get higher yields, it is crucial to choose a sugar beet planting date that meets the ideal limitations for these characteristics. Nemeata Alla (2016) came to the conclusion that planting sugar beet in October was more unexpected than planting on other dates in terms of the majority of sugar beet characteristics (root weight, root yield, and sugar yield). According to Ilkaee *et al.* (2016), different planting dates had a substantial impact on the percentage of root sugar. In comparison to plants sowed in November, Aly and Khalil (2017) discovered that planting sugar beet in October produced greater estimates of root, fresh weigh/plant, root and sugar yields/fad, as well as the sucrose% and impurities%. Both early and late seeding reduced sugar beet root and sugar content while increasing impurity contents, according to Gobarah *et al.* (2019). Out of 12 distinct planting dates, Lamani and Halikatti (2019) found that sowing on October 1st produced a greater yield and yield attributes than the other treatments. Planting dates significantly impacted root length, root diameter, root weight, sucrose and purity percentages, and root and sugar yields, according to Awadalla *et al.* (2022). Additionally, they planted sugar beet on October 15th, which produced the highest average sugar yield estimations. According to Mohammed and Xaraman (2023), as compared to other planting dates (16<sup>th</sup> and 31<sup>st</sup> October), the early planting date of October 1st demonstrated a high value of all the examined features.

The search for unconventional, safe, and natural growth-stimulating substances (such as amino acids, cytokinin, and salicylic acid) that can be applied topically, act as anti-stress treatments, and have a significant impact on plant growth parameters—that is, to increase plant productivity—has recently received a lot of attention in Egypt.

Amino acids are a recognized biostimulant that improves plant growth and yield while also considerably lowering biotic stress-induced damage. The ready-made building blocks for protein synthesis are provided by foliar nutrition in the form of protein hydrolyte, also referred to as amino acids liquid. Because their usage increases energy production and creates new cell biomass, amino acids are linked to plant health. This is because their use improves physiological characteristics and chemical composition, which in turn increases the amount and quality of plant production (El-Ghamry *et al.*, 2009). El-Desouky *et al.* (2011) demonstrated that the application of amino acid therapy resulted in a notable increase in numerous growth characteristics. Additionally, amino acids function as growth factors, precursors or activators of phytohormones, antioxidants to withstand environmental and water stressors, and numerous other crucial bio-constituents (Xing-Quan and Kyu-Seung, 2012). According to Ibrahim *et al.* (2013), the physical traits, yield component, quality metrics, and total sugar and root yields of the sugar beet were all enhanced by the addition of amino acids to the foliage. Applying a 0.4 ml/L treatment of vigamax (amino acids) to sugar beet plants has been shown by El-Gamal *et al.* (2016) to have potential advantages for root yield productivity and growth. Ibrahim *et al.* (2013) found that adding amino acids to the foliage improved the sugar beet's physical characteristics, yield component, quality metrics, and total sugar and root yields. El-Gamal *et al.* (2016) shown that applying a 0.4 ml/L treatment of vigamax (amino acids) to sugar beet plants may have benefits for growth and root yield productivity.

Organic substances other than food that have the capacity to alter plant physiological processes are referred to as bio-regulators, or plant growth regulators. Higher plants' growth and development are regulated in large part by the cytokinine families of plant hormones. According to Choi *et al.* (2010), plant-derived cytokinins increase yield components by enhancing plant immunity in conjunction with salicylic acid signaling. Unripe fruits and seeds, as well as the tips of roots, produce cytokinins. Along with promoting cell division, these hormones are in charge of lateral shoot growth (Kieber and Schaller, 2014). According to Zwack and Rashotte (2015), cytokinin is a hormone that is well-known for its involvement in many facets of growth and development, but there is also a wealth of evidence that suggests cytokinin also plays a role in stress reactions. According to Eid (2020), benzyladenine applied topically at a concentration of 100 parts per million has a positive impact on sugar beetroot growth, root yield, and quality. According to Sosnowski *et al.* (2023), exogenous application of cytokinins at suitable quantities improves the chemical composition and dry matter production of plants. Additionally, it promotes improved flowering, foliage growth, and tillering.

In plants, salicylic acid improved physiological processes such protein synthesis, ion absorption, enzyme activation, and cell elongation and division (Shakirova *et al.*, 2003 and Farouk, 2005). According to Amin *et al.* (2007), salicylic acid controlled plant development by promoting the activity of  $\alpha$ -amylase and nitrate reductase,

which sped up the movement of sugar from the leaves to the plant's storage organs. Furthermore, according to Ashraf *et al.* (2010), salicylic acid is essential for controlling a number of physiological processes in plants, including photosynthesis, growth, and stress tolerance. Salicylic acid spraying promoted plant development and abiotic stress tolerance, ultimately leading to higher sugar beet yields, as shown by Abido *et al.* (2015) and Merwad (2015). According to Cheraghabadi *et al.* (2016), using salicylic acid topically increased the amount of chlorophyll in sugar beet leaves and decreased membrane permeability. According to Abdelaal *et al.* (2020), applying 100 ppm of salicylic acid to sugar beet plants greatly increased yields and root fresh weight. According to El-Gamal *et al.* (2021), foliar application of 2000 ppm salicylic acid greatly increased sugar beetroot yields and root biomass. However, there were notable changes in sugar production, sucrose, and purity percentages as the concentration of salicylic acid increased. Ibrahim *et al.* (2022) demonstrated that when sugar beet plants were sprayed twice with potassium sulphate and salicylic acid, yield components, quality metrics, and yields gradually increased in comparison to when no spraying was done. According to Nassar *et al.* (2023), foliar spray of biostimulants (fulvic acid, salicylic acid, and hydroxyproline) had a substantial impact on sugar beet production, growth, and quality attributes.

Thus, the purpose of this study was to investigate how anti-stress foliar spraying treatments affected sugar beet production and quality metrics over three planting dates in the El-Mansoura region of the Dakahlia Governorate, Egypt.

### Materials and Methods

During the 2021–2022 and 2022–2023 seasons, the current study was conducted in El-Baqulia village, El-Mansoura district, Dakahlia Governorate, Egypt. This study's primary goal was to ascertain whether foliar spraying with anti-stress treatments improved sugar beet (Hossam multigermin cultivar) productivity and quality metrics under three distinct planting dates.

Every planting date (September 1st, October 1st, and November 1st) in the growing seasons of 2021–2022 and 2022–2023 was planned and carried out as a distinct experiment. In each field experiment, dates were sown in both growth seasons using a completely randomized block design (CRBD) in three replicates. Anti-stress therapies were applied as foliar treatments in the following ways: without foliar spraying (control treatment), foliar spraying with amino acids in the form of K-Amino, which contains 17.22% of amino acids from plant origin (aspartic 1.54%, glutamic 1.98%, serine 2.34%, histidine 0.12%, glycine 1.29%, treonine 0.97%, arginine 1.29%, alanine 0.97% and tyrosine acids 0.17%), 10 % nitrogen and 5% potassium as K<sub>2</sub>O at the rates of 1000, 2000 and 3000 ppm of spraying water, foliar spraying with cytokinin in the form of Natur-Auxi, which contains 4% of 6-BA (6-benzylaminopurine cytokines) at 2, 3 and 4 ppm of spraying water and foliar spraying with salicylic acid at 1000, 2000 and 3000 ppm of spraying water.

Salicylic acid was produced by El-Nasr Pharmaceutical Chemicals Co., Egypt, and acquired from El-Gomhouria Company for Trading Pharmaceutical Chemical & Medical; commercial K-Amino was produced by Avan Europe, Spain; and commercial Natur-Auxi, a source of cytokines, was introduced by Evergreen for Agricultural Development. The volume of the foliar solution was 200 liters/fed, and two times after 50 and 70 days of planting, the experimental plots were sprayed by hand using a sprayer till the saturation point. The concentration of Tween-20 utilized as a wetting agent was 0.02%.

Five ridges, each 60 cm wide and 3.5 m long, made up each experimental unit. These ridges took up 10.5 m<sup>2</sup> (1/400 fad). For every season, rice (*Oryza sativa* L.) was the previous summer crop.

As per Page (1982), soil samples were extracted from the experimental field between 0 and 30 cm below the surface and processed for both chemical and mechanical examinations. The findings from the chemical and mechanical analyses are shown in Table 1.

**Table 1: Analyses of the Experimental field's Mechanical and Chemical Characteristics During the Two Growing Seasons of 2021–2022 and 2022–2023.**

Soil analysis	2021/2022	2022/2023
<b>A. Mechanical analysis:</b>		
Sand %	10.6	10.4
Silt %	40.9	41.7
Clay %	48.5	47.9
Texture class	Clayey loam	Clayey loam
<b>B. Chemical analysis:</b>		
Organic matter %	1.49	1.52
Obtainable N ppm	16.4	17.7
Obtainable P ppm	8.7	9.3
Obtainable K ppm	211.3	222.1
pH	8.1	7.7
EC	3.9	3.6

Table 2 displays the monthly temperature (in degrees Celsius) and relative humidity (in percentages) for El-Mansoura district in the Dakahlia Governorate for the two growing seasons of 2021–2022 and 2022–2023.

**Table 2: Monthly high and low temperatures (°C) and relative humidity (%) in El-Mansoura district, Dakahlia Governorate, during the seasons of 2021–2022 and 2022–2023.**

Month	Temperature (°C)				Relative humidity (%)			
	2021/2022		2022/2023		2021/2022		2022/2023	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
September	33.2	20.0	32.2	19.6	95.6	36.4	97.0	40.0
October	29.8	16.9	30.5	17.7	96.5	33.9	96.8	34.9
November	24.6	13.9	26.0	16.2	97.4	45.3	97.2	50.9
December	19.9	9.2	20.2	11.0	93.0	46.6	93.8	33.8
January	18.3	8.2	19.0	9.0	97.0	48.8	90.9	39.7
February	20.8	8.7	19.7	8.5	96.8	44.5	92.3	35.8
March	22.9	9.9	21.5	10.1	96.9	38.5	91.3	34.0
April	26.1	11.9	25.2	13.1	94.3	31.2	95.3	30.3
May	29.8	14.6	30.5	15.6	93.6	31.1	94.6	29.9

There was good preparation in the experimental field. 200 kg/fed of calcium super phosphate (15.5% P2O5) was sprayed throughout the soil preparation process. On one side of the ridge, sugar beet seeds were planted in hills 20 cm apart on the specified dates for each season. When the plants were 35 days old after planting, they were trimmed to one plant per hill (35,000 plants/fed). Two equal doses of nitrogen fertilizer in the form of ammonium nitrate (33.5%) at a rate of 80 kg N/fad were administered; the first dose was applied prior to the second irrigation and after the sugar beet plants had thinned, and the second dose was put prior to the third irrigation. Prior to the third watering, 50 kg/fad of potassium sulphate (48 percent K2O) was sprayed. Other farming methods for sugar beet cultivation were carried out in accordance with the Sugar Crops Research Institute's recommendations.

#### The studied characters:

To determine the yield components, including the fresh weight of the roots and leaves (g/plant), as well as the diameter and length of the roots (cm), five plants were chosen at random from each plot during harvest.

In Dakahlia Sugar Company, Bilkas Sugar Factory Laboratories, Dakahlia Governorate, the following root quality attributes were assessed: the percentages of sodium (Na%), potassium (K%), and  $\alpha$ -amino nitrogen ( $\alpha$ -N%). The gross sucrose percentage was calculated by polarimetric analysis using the technique of **Carruthers and Oldfield (1960)**. As demonstrated by Harvey and Dutton (1993), the extracted sucrose %, or extractable white sucrose (correct sugar content), of beet roots was determined by combining the beet non-sugar, K, Na, and  $\alpha$ -amino nitrogen (converted as a meq/100 g beet) using the following formula:

Extractable white sugar (%) = Gross sugar (%) - [0.343 (K + Na) + 0.094  $\alpha$ -amino N + 0.29]

Sugar beet root juice's quality index (%) was calculated using a published technique of **Carruthers and Old Field (1960)**.

Root and top yields per plot were measured in kilograms during harvest and converted to tons per season. Additionally, sugar yield/fad (ton) was computed using the formula below:

$$\text{Root yield/fed (ton)} \times \text{extracted sucrose \%} = \text{sugar yield/fed (ton)}$$

All gathered data were statistically examined using the analysis of variance (ANOVA) approach for the completely randomized block design to each experiment (sowing dates) using the Statistix-9 computer software package. A combined analysis between sowing dates was carried out after the homogeneity test error mean squares between sowing dates, as published by **Gomez and Gomez (1984)**, was finished. The treatment means were compared at the 5% level of probability using Duncan's multiple range tests, as described by **Duncan (1955)**.

## Results and Discussion

### 1. Effect of sowing dates:

According to Table 3, the fresh weights of root and foliage plant-1, root length, and root diameter were among the sugar beet yield components that were significantly impacted by the planting dates that were evaluated, which were generally September 1st, October 1st, and November 1st. The yield components, which include root, top, and corrected sugar yields/fad, as shown in Table 5, and quality parameters, such as sodium (Na), potassium (K),  $\alpha$ -amino-nitrogen, gross sucrose, extracted sucrose, and quality index percentages in sugar beet root juice, as shown in Table 4, also showed the same effects.

Data in Table 3 showed that the intermediate sowing date of sugar beet on October 1st led to a highly significant increase of fresh weights of root and foliage per plant, root length and root diameter giving 951.2 and 990.5 g, 298.7 and 311.0 g, 28.81 and 30.00 cm and 12.62 and 13.14 cm in the 1<sup>st</sup> and 2<sup>nd</sup> season, respectively. While, the lowest mean estimates of root and foliage per plant, root length and root diameter were obtained when delaying sowing of sugar beet on November 1st, where recorded 828.1 and 862.3 g, 256.6 and 267.2 g, 24.89 and 25.92 cm and 10.93 and 11.38 cm in the 1<sup>st</sup> and 2<sup>nd</sup> season, respectively. Meanwhile, data in Table 4 cleared that intermediate sowing date of sugar beet on October 1st resulted the lowest contents of impurities *i.e.* Na (1.397 and 1.455 %), K (4.23 and 4.40 %) and  $\alpha$ -amino-nitrogen (2.89 and 3.01 %) and consequently attained higher estimates of gross sucrose (17.15 and 17.86 %), extracted sucrose (14.63 and 15.24 %) and quality index (78.23 and 81.46 %) in sugar beet root juice in the 1<sup>st</sup> and 2<sup>nd</sup> season, respectively. Moreover, the results in Table 5 indicated that intermediate sowing date of sugar beet on October 1st caused significant increases in root, top and corrected sugar yields/fad amounted by 1.158 and 1.206, 0.454 and 0.473 and 0.098 and 0.102 tons/fad in comparison with early sowing date of sugar beet on September 1st and amounted by 2.717 and 2.828, 0.948 and 0.987 and 0.432 and 0.450 tons/fad in comparison with delay sowing of sugar beet on November 1st in the 1<sup>st</sup> and 2<sup>nd</sup> season, respectively.

**Table 3:** Sugar beet root and foliage fresh weights per plant, root length, and root diameter as influenced by when to sow and when to apply foliar sprays with anti-stress treatments, as well as how these factors interact

Treatments	Characters Seasons	Weight of fresh root (g/plant)		Weight of fresh foliage (g/plant)		Length of root (cm)		Diameter of root (cm)	
		2021/ 2022	2022/ 2023	2021/ 2022	2022/ 2023	2021/ 2022	2022/ 2023	2021/ 2022	2022/ 2023
<b>A. Sowing dates:</b>									
1 <sup>st</sup> Sept.		867.4 b	903.2 b	280.8 ab	292.4 ab	27.98 a	29.14 a	12.57 a	13.09 a
1 <sup>st</sup> Oct.		951.2 a	990.5 a	298.7 a	311.0 a	28.81 a	30.00 a	12.62 a	13.14 a
1 <sup>st</sup> Nov.		828.1 b	862.3 b	256.6 b	267.2 b	24.89 b	25.92 b	10.93 b	11.38 b
<b>B. Foliar spraying with anti-stress treatments:</b>									
Without		717.1 i	746.7 i	234.7 h	244.4 h	25.83 e	26.89 e	10.21 j	10.63 i
Amino acids at 1000 ppm		774.8 g	806.9 g	253.6 f	264.2 f	26.85 cde	27.96 cde	11.03 g	11.48 g
Amino acids at 2000 ppm		953.0 d	992.3 d	295.3 d	307.5 d	27.63 bcd	28.77 bcd	12.17 d	12.68 d
Amino acids at 3000ppm		1074.1 a	1118.4 a	333.2 a	347.0 a	29.02 a	30.21 a	14.87 a	15.49 a
Cytokinin at 2 ppm		737.9 hi	768.3 hi	241.6 gh	251.6 gh	26.58 de	27.68 de	10.50 i	10.94 i
Cytokinin at 3 ppm		907.6 e	945.0 e	281.2 e	292.9 e	26.84 cde	27.95 cde	11.60 e	12.08 e
Cytokinin at 4 ppm		1022.8 b	1065.1 b	317.3 b	330.4 b	28.19 ab	29.35 ab	14.16 b	14.74 b
Salicylic acid at 1000 ppm		759.6 gh	790.9 gh	248.7 fg	258.9 fg	26.09 e	27.16 e	10.81 h	11.26 h
Salicylic acid at 2000 ppm		882.0 f	918.5 f	273.3 e	284.6 e	27.36 bcd	28.49 bcd	11.27 f	11.74 f
Salicylic acid at 3000 ppm		994.0 c	1035.1 c	308.3 c	321.1 c	27.91 bc	29.06 bc	13.76 c	14.33 c
<b>C- Interaction (F. text):</b>									
A × B		*	*	*	*	NS	NS	*	*

A significant difference at  $p < 0.05$  is indicated by different later within a column.

There is no doubt that, adherence to the planting date is considered one of the determining factors for crop production due to the association of optimal weather factors (temperature, humidity and rainfall) for plant growth. The favorable impact of the intermediate sowing date of October 1st for sugar beet on yield components, quality parameters, and root, top, and corrected sugar yields/fad may therefore be attributed to the seasonable environmental conditions that occur during this time, such as temperature, relative humidity (Table 2), day length, and light intensity, which enable rapid germination, establishment, vegetative growth, development, and ripening, thereby increasing growth attributes, yield components, quality parameters, and root, top, and corrected sugar yields/fad. These outcomes concur with those that were published by Nemeata Alla (2016), Aly and Khalil (2017), Gobarah *et al.* (2019), Awadalla *et al.* (2022) and Mohammed and Xaraman (2023).

## 2. Effect of foliar spraying with anti-stress treatments:

The studied foliar spraying with anti-stress treatments *i.e.* amino acids at the rates of 1000, 2000 and 3000 ppm, cytokinin at the rates of 2, 3 and 4 ppm and salicylic acid at the rates of 1000, 2000 and 3000 ppm of spraying water had a noteworthy impact on yield components, as indicated in Table 3, including fresh weights of roots and foliage per plant, root length, and root diameter when compared to the control (without treatment). Similarly, yields (root, top, and adjusted sugar yields/fad) as shown in Table 5 and quality parameters (sodium (Na), potassium (K),  $\alpha$ -amino-nitrogen, gross sucrose, extracted sucrose, and quality index percentages in sugar beet root juice (Table 4).

**Table 4: The percentages of sodium (Na), potassium (K),  $\alpha$ -amino-nitrogen, gross sucrose, extracted sucrose, and quality index in sugar beet root juice as influenced by the dates of planting and foliar spraying with anti-stress treatments over the 2021–2022 and 2022–2023 seasons.**

Treatments	Characters Seasons	Na (%)		K (%)		$\alpha$ -amino-nitrogen (%)		Gross sucrose (%)		Extracted sucrose (%)		Quality index (%)	
		2021/ 2022	2022/ 2023	2021/ 2022	2022/ 2023	2021/ 2022	2022/ 2023	2021/ 2022	2022/ 2023	2021/ 2022	2022/ 2023	2021/ 2022	2022/ 2023
<b>A. Sowing dates:</b>													
	1 <sup>st</sup> Sept.	1.521 b	1.584 b	4.24 b	4.41 b	3.19 b	3.32 b	16.59 b	17.28 b	14.09 b	14.67 b	73.11 b	76.13 b
	1 <sup>st</sup> Oct.	1.397 c	1.455 c	4.23 b	4.40 b	2.89 c	3.01 c	17.15 a	17.86 a	14.63 a	15.24 a	78.23 a	81.46 a
	1 <sup>st</sup> Nov.	1.738 a	1.810 a	5.74 a	5.97 a	3.89 a	4.05 a	15.21 c	15.84 c	12.01 c	12.50 c	60.01 c	62.49 c
<b>B. Foliar spraying with anti-stress treatments:</b>													
	Without	1.744 a	1.816 a	5.83 a	6.07 a	3.56 a	3.71 a	15.60 e	16.25 e	12.62 g	13.14 g	67.00 d	69.77 d
	Amino acids at 1000 ppm	1.615 d	1.680 d	5.40 c	5.62 c	3.29 f	3.43 f	16.48 b	17.16 b	13.32 de	13.87 de	67.21 d	69.98 d
	Amino acids at 2000 ppm	1.497 f	1.559 f	4.38 e	4.56 e	3.19 g	3.32 g	16.29 bc	16.97 bc	13.64 c	14.20 c	72.40 ab	75.38 ab
	Amino acids at 3000ppm	1.331 i	1.387 i	3.61 g	3.76 g	3.09 h	3.21 h	17.11 a	17.82 a	14.68 a	15.29 a	74.27 a	77.34 a
	Cytokinin at 2 ppm	1.661 e	1.731 e	5.55 bc	5.78 dc	3.39 d	3.53 d	16.05 cd	16.71 cd	12.99 f	13.53 f	70.73 bc	73.65 bc
	Cytokinin at 3 ppm	1.542 e	1.604 e	4.51 de	4.68 dc	3.28 f	3.42 f	16.19 c	16.87 c	13.54 cd	14.10 cd	69.16 cd	72.01 cd
	Cytokinin at 4 ppm	1.371 h	1.426 h	3.72 fg	3.87 fg	3.18 g	3.31 g	17.00 a	17.70 a	14.22 b	14.81 b	73.43 ab	76.46 ab
	Salicylic acid at 1000 ppm	1.710 b	1.782 b	5.72 ab	5.95 ab	3.49 b	3.64 b	15.74 e	16.39 e	13.16 ef	13.71 ef	68.73 cd	71.57 cd
	Salicylic acid at 2000 ppm	1.614 d	1.684 d	4.73 d	4.93 d	3.45 c	3.59 c	15.84 de	16.49 de	13.59 cd	14.15 cd	68.95 cd	71.79 cd
	Salicylic acid at 3000 ppm	1.436 g	1.496 g	3.90 f	4.06 f	3.34 e	3.47 e	16.85 a	17.55 a	13.99 b	14.56 b	72.62 ab	75.62 ab
<b>C- Interaction (F. text):</b>													
A × B		*	*	*	*	*	*	*	*	*	*	NS	NS

A significant difference at  $p < 0.05$  is indicated by different later within a column.

**Table 5: Root, top and corrected sugar yields/fad of sugar beet as affected by sowing dates and foliar spraying with anti-stress treatments as well as their interaction during 2021/2022 and 2022/2023 seasons.**

Treatments	Characters Seasons	Root yield (t/fad)		Top yield (t/fad)		Corrected sugar yield (t/fad)	
		2021/ 2022	2022/ 2023	2021/ 2022	2022/ 2023	2021/ 2022	2022/ 2023
<b>A. Sowing dates:</b>							
	1 <sup>st</sup> Sept.	25.978 ab	27.050 ab	11.614 ab	12.093 ab	3.8488 ab	4.008 ab
	1 <sup>st</sup> Oct.	27.136 a	28.256 a	12.068 a	12.566 a	3.9468 a	4.110 a
	1 <sup>st</sup> Nov.	24.419 b	25.428 b	11.120 b	11.579 b	3.5148 b	3.660 b
<b>B. Foliar spraying with anti-stress treatments:</b>							
	Without	22.692 h	23.629 h	10.516 g	10.950 g	3.206 g	3.338 g
	Amino acids at 1000 ppm	24.519 f	25.530 f	11.362 e	11.831 e	3.464 e	3.607 e
	Amino acids at 2000 ppm	27.211 c	28.335 c	12.142 b	12.642 b	4.003 c	4.168 c
	Amino acids at 3000ppm	29.668 a	30.893 a	12.892 a	13.424 a	4.472 a	4.658 a
	Cytokinin at 2 ppm	23.349 g	24.314 g	10.821 f	11.267 f	3.299 fg	3.435 fg
	Cytokinin at 3 ppm	25.914 d	26.984 d	11.563 d	12.040 d	3.812 d	3.969 d
	Cytokinin at 4 ppm	28.253 b	29.419 b	12.278 b	12.785 b	4.259 b	4.435 b
	Salicylic acid at 1000 ppm	24.198 f	25.196 f	11.262 e	11.727 e	3.339 ef	3.477 ef
	Salicylic acid at 2000 ppm	25.184 e	26.223 e	11.237 e	11.701 e	3.704 d	3.857 d
	Salicylic acid at 3000 ppm	27.457 c	28.590 c	11.932 c	12.425 c	4.139 b	4.310 b
<b>C- Interaction (F. text):</b>							
A × B		*	*	*	*	*	*

A significant difference at  $p < 0.05$  is indicated by different later within a column.

When sugar beet plants were foliar-sprayed with amino acids, cytokinin, and salicylic acid at varying rates 50 and 70 days after seeding, yield components, quality parameters, and root, top, and corrected sugar yields/fad increased gradually and significantly in comparison to the two growing seasons when foliar spraying was not used (control treatment). The results obtained in Table 3 demonstrated that foliar spraying sugar beet plants with K-Amino, an amino acid, at a rate of 3000 ppm considerably raised the mean estimates of fresh weights of root and foliage per plant, root length, and root diameter by (357.0 and 371.7 g), (98.5 and 102.6 g), (3.19 and 3.32 cm) and (4.66 and 4.86 cm) compared with control treatment (without foliar spraying) and by (51.3 and 53.3 g), (15.9 and 16.6 g), (0.83 and 0.86 cm) and (0.71 and 0.75 cm) compared with foliar spraying beet plants with cytokinin at the rate of 4 ppm and by (80.1 and 83.3 g), (24.9 and 25.9 g), (1.11 and 1.15) and (1.11 and 1.16 cm) compared with foliar spraying beet plants with salicylic acid at the rate of 3000 ppm in the 1<sup>st</sup> and 2<sup>nd</sup> season, respectively. In the meantime, Table 4's data demonstrated that the control treatment—which did not involve foliar spraying—led to increased levels of impurities (Na, K, and  $\alpha$ -amino-nitrogen) in the roots. However, greater estimations of total sucrose, extracted sucrose, and quality index percentages were obtained when beet plants were sprayed with amino acids at a rate of 3000 ppm. Additionally, Table 5's results showed that when amino acids were treated at a rate of 3000 ppm, root, top, and corrected sugar producing per /fad increased, reaching to (1.415 and 1.474 t/fad), (0.614 and 0.639 t/fad) and (0.213 and 0.223 t/fad) as compared with foliar spraying beet plants with cytokinin at the rate of 4 ppm, (2.211 and 2.303 t/fad), (0.960 and 0.999 t/fad) and (0.333 and 0.348 t/fad) as compared with foliar spraying beet plants with salicylic acid at the rate of 3000 ppm and (6.976 and 7.264 t/fad), (2.376 and 2.474 t/fad) and (1.266 and 1.320 t/fad) as compared with control treatment (without foliar application) in the 1<sup>st</sup> and 2<sup>nd</sup> season, respectively. Since their application results in the production of new cell biomass and increased energy production, followed by the activation of physiological characters and chemical composition, which improves the quantity and quality of plant product, the beneficial effects of foliar spraying beet plants with amino acids at a rate of 3000 ppm may be attributed to their association with plant health (El-Ghamry *et al.*, 2009). As antioxidants, amino acids help the body withstand environmental stressors, protein synthesis, growth factors, phytohormone activators, and many other vital bioconstituents (Xing-Quan and Kyu-Seung, 2012). Furthermore, cytokinins' function in promoting cell division and proliferation may be the reason for their beneficial effect at a concentration of 4 ppm (Kieber and Schaller, 2014). simultaneously. The four enzymes—peroxidase, polyphenol oxidase, catalase, and phenylalanine ammonia lyase—as well as the total phenol content, which shields the plant from stress, may be more active when cytokinin is present (Musa, 2016). Salicylic acid's alluring impact at 3000 ppm can also be attributed to improving physiological features of plants, including protein synthesis, ion uptake, enzyme activity, and cell elongation and division (Shakirova *et al.*, 2003 and Farouk, 2005). Additionally, salicylic acid-controlled plant growth by promoting the activity of nitrate reductase and  $\alpha$ -amylase, which sped up the movement of sugar from the leaves to the plant's storage organs (Amin *et al.*, 2007).

Furthermore, salicylic acid is essential for controlling a number of physiological processes in plants, including photosynthesis, growth, and stress tolerance (Ashraf *et al.*, 2010). These findings align with the assertions made by Ibrahim *et al.* (2013), Abido *et al.* (2015), Merwad (2015), Zwack and Rashotte (2015), El-Gamal *et al.* (2016), Abdelaal *et al.* (2020), El-Gamal *et al.* (2021), Ibrahim *et al.* (2022) and Sosnowski *et al.* (2023).

### 3. Effect of the interaction:

As shown graphically in Figs. 1, 2, and 3, the intermediate sowing date of October 1st for sugar beet and the foliar spraying of plants twice with amino acids in the form of K-Amino at a rate of 3000 ppm of spraying water produced the highest mean estimates of root, top, and corrected sugar yields/fad. The second-highest impact on root, top, and corrected sugar yields/fad was caused by the interaction between the intermediate sowing date of October 1st for sugar beet and foliar spraying plants twice with cytokinin at a rate of 4 ppm liter. This was followed by the intermediate sowing date of October 1st for sugar beet and foliar spraying plants twice with salicylic acid at a rate of 3000 ppm in both growing seasons. However, in both growth seasons, the lowest mean estimates of root, top, and corrected sugar yields/fad were obtained from delayed sugar beet seeding on November 1st without foliar spraying with anti-stress treatments.

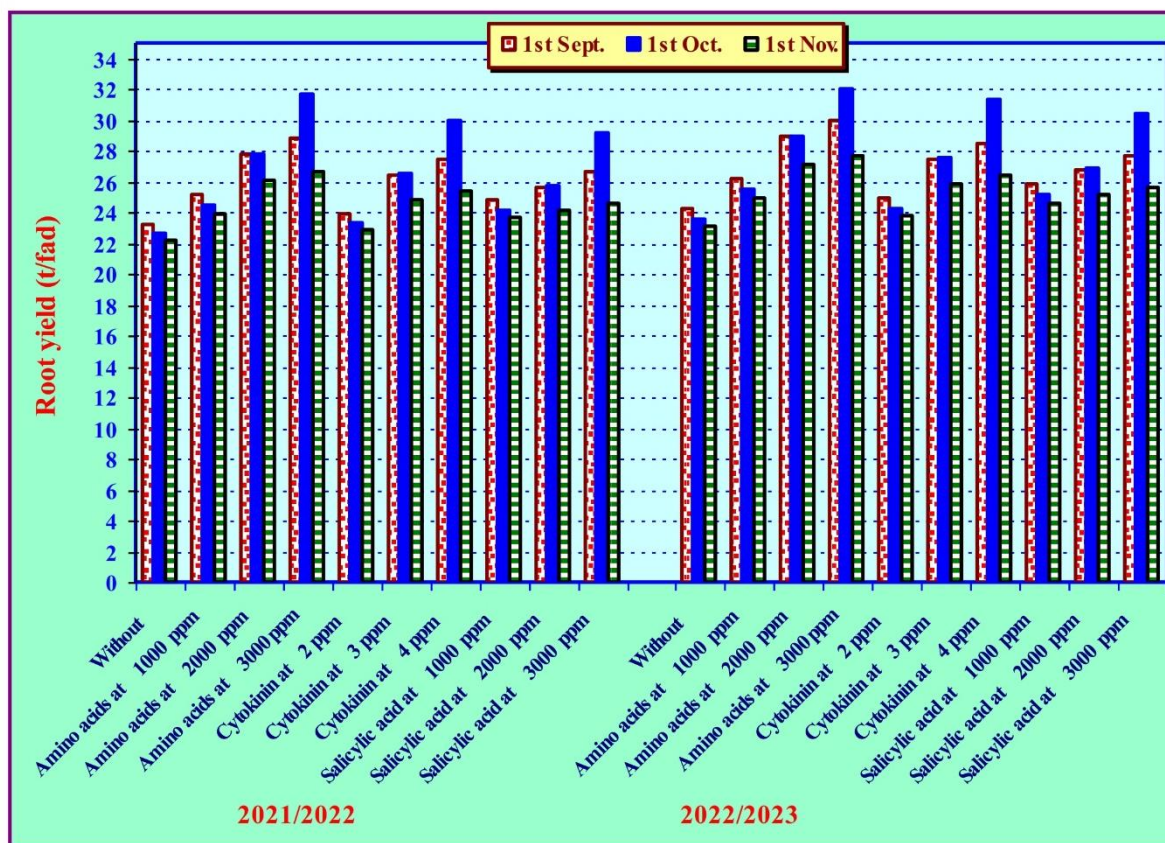


Fig. 1: Sugar beet root yield and fad as influenced by the timing of sowing and foliar spraying with anti-stress treatments in the 2021–2022 and 2022–2023 seasons.



Fig. 2: Sugar beet top yield and fad as influenced by the timing of sowing and foliar spraying with anti-stress treatments in the 2021–2022 and 2022–2023 seasons.

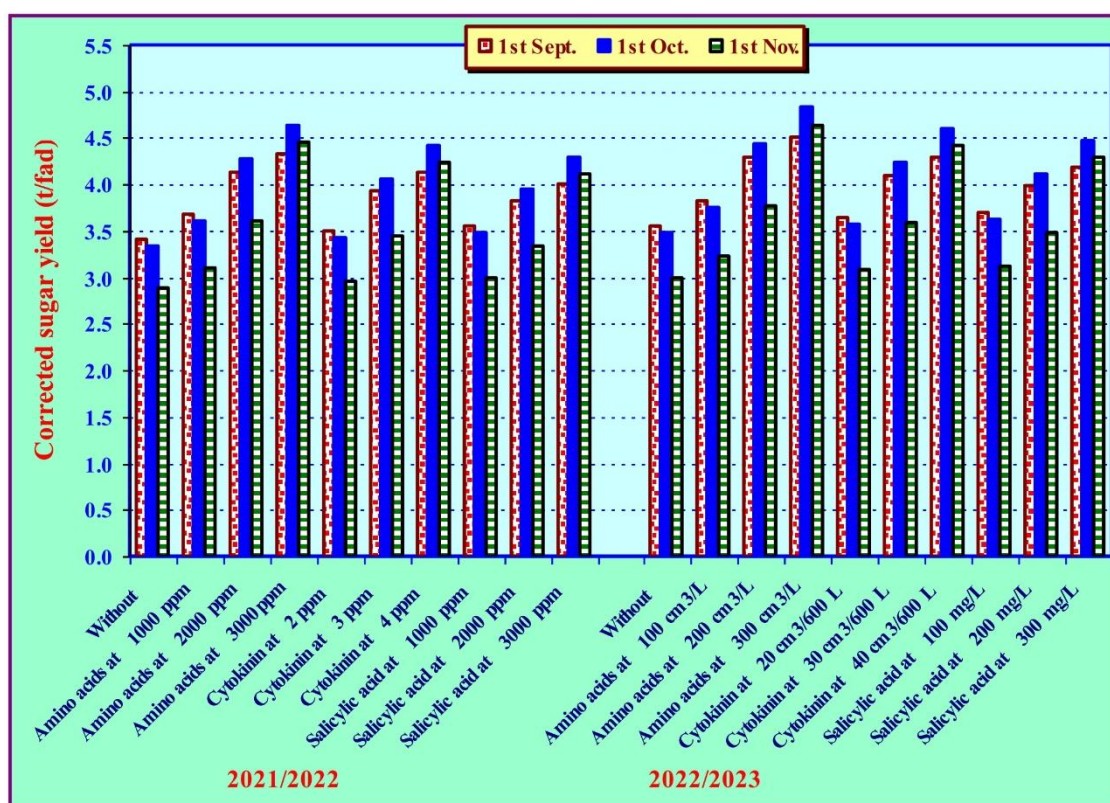


Fig. 3: The impact of the dates of planting and foliar spraying with anti-stress treatments on the corrected sugar/fad of sugar beet over the 2021–2022 and 2022–2023 seasons.

## Conclusion

In order to achieve the highest productivity and quality parameters, it is advised that sugar beet be sown on October 1st as an intermediate date and that plants be sprayed twice after 50 and 70 days of sowing with amino acids in the form of K-Amino at a rate of 300 cm<sup>3</sup>/liter of spraying water.

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