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# Effect of Different Seed Soaking Treatments on Growth and Productivity of Sugar Beet

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## Abstract

The question on which the idea of the work was based is: Does soaking sugar beet seeds in solutions or extracts of substances known in many previous works for their effects on enhancing growth lead to changes in the plant's performance throughout the growing season, reaching yield and quality? And the most important point is to monitor this effect under the challenges and obstacles of commercial production. Sugar beet is grown in the clay soils of El-Minya Governorate (one of the Central Egypt governorates) in a way that can be described as the most random in the world, but the fact that cannot be overlooked is that the sugar beet productivity under these conditions is high and exceeds the global average. Concentrations of 150 ppm gibberellic acid (T2), 500 ppm spirulina extract (T3), and 500 ppm potassium humate (T4) were used to soak the seeds of two sugar beet varieties (Husam, and Sahar). The effect of these treatments was studied and compared to the conventional method (without soaking: T1) in two field experiments at Mallawi Agricultural Research Station, El-Minya Governorate. A factorial experiment with a completely randomized block design in three replicates was applied during the 2020/21 and 2021/22 seasons. The obtained results showed the superiority of T2 in leaf area index, leaf area duration, and total dry matter. While T3 showed an appreciable improvement in quality parameters and sugar yield. In most cases, the values of relative growth rate were significantly correlated to the values of net assimilation rate

**Keywords:** sugar beet, soaking, gibberellic, spirulina, potassium humate

## Introduction

Sugar beet is a relatively new crop in Egypt, as its production began in 1972. The stages of its production development have followed a pattern similar to its growth, starting slowly, then gradually increasing, and finally experiencing rapid growth. The cultivated area has significantly expanded in various governorates, on different types of land~~s~~, and under various irrigation systems. It can be said that sugar beet~~,~~ has become the preferred choice for many farmers in Central Egypt~~,~~ during the winter season.

Based on the information from the Annual Report of Sugar Crops in Egypt~~,~~ for 2022, the cultivated area reached approximately 600 thousand fed. (1.0 fed. = 4200 $m^2$), with 65% of the area concentrated in old lands. El-Minya Governorate, where the experiment took place, cultivates 36.0 thousand fed. in old lands with highly fertile clay soils, achieving an average productivity of slightly less than 28.0 tons per fed. The planting of sugar beet now occurs over an extended period, with most sugar factories implementing a crop receipt system that divides contracted areas into four loops based on the sowing date, starting from September and ending with the late loop, which begins after October 16.

Numerous studies have investigated soaking seeds in various solutions to enhance production by affecting factors~~,~~ such as germination speed, dormancy breaking, stress resistance, or improving plant nutrition. Generally, pre-soaking seeds is a simple and cost-effective method that requires minimal materials, making it one of the most significant techniques that can be implemented if its activeness is demonstrated on a commercial level.

Several studies have demonstrated a positive effect of seed priming with $GA_3$ on germination, seedling vigor, stress resistance, and shoot density. Examples include research by **Jamil and Rha, 2007**, **Leilah and Khan, 2021** on sugar beet**, Sivakumar and Nadhita~~,~~ 2017** on mungbeans, **Lopez *et al.*~~,~~ 2009** on tomatoes, and **Du *et al.*~~,~~ 2022** on hemp. Studies suggest that GA3 can stimulate cell wall formation, increase division rates, and enhance photosynthesis and translocation efficiency. **Ma *et al.* (2018)** identified the stimulation of osmotic adjustment ability as a key mechanism by which $GA_3$ promotes successful adaptation in a perennial grass.

FAO documented in 1981 the possibility of replacing chemical fertilizers with blue-green algae to improve the properties of depleted soil, and this applies to spirulina (the biomass of cyanobacteria). The mode of action of spirulina extract is similar to the effect of growth regulators because it contains gibberellins, auxins, kinetin, and adenine. It stimulates cell division, enhances elongation, nutrient absorption, activates enzymes, and resistance to diseases **(EL-Sharnoby *et al.*, 2021** on sugar beet, **Al Fahad and Mohammad, 2018** on tobacco**; Htwe *et al.*, 2009** on chickpeas; **Abd El-Sadek and Ahmed, 2022** on *Capparis cartilage*, and **Anastasia *et al.*, 2012** on lentils).

Priming seeds with humic acid has been studied on several crops. Most of these studies have agreed on its positive effect on nutrient uptake, germination speed, root development, and stress resistance (**Hartwigsen and Evans (2000)** on marigold and geranium, **David *et al.* (1994)** on tomato, **Taha and Osman (2018)** on beans, **Vaughan and Linehan (1976)** on wheat, and **Waqas *et al.* (2014)** on mung bean).

Comparing the differences in plant characteristics resulting from the difference in seed priming may provide a clear picture of the changes occurring in growth behavior and their impact on yield. However, it is important to consider that any intervention that could alter the crop's growth environment may result in misleading data. Therefore, this study aims to investigate the effect of soaking sugar beet seeds before planting in the aforementioned materials on inducing changes in the growth and productivity of sugar beets under commercial production conditions.

## Materials and Methods

During two consecutive seasons (2020/21 and 2021/22), the growth behavior of two popular multi-germ sugar beet varieties ($V_1$: Husam, and $V_2$: Sahar) was studied after subjecting their seeds to four different soaking treatments ($T_1$: control, $T_2$: 150 *ppm* $GA_3$, $T_3$: 500 *ppm* spirulina extract, and $T_4$: 500 *ppm* potassium humate). This experiment was carried out on the farm of Malawi Agricultural Research Station (altitude of 27.720 N, longitude of 30.830 E, and elevation of 54.38 m above sea level), El-Minia Governorate, Egypt. The maximum and minimum temperatures during the growing seasons were plotted in Fig. 1.

**Table (1): Physical and chemical properties of soil sample from surface layer (0-25 cm)**

| Character | | 2021/22 | 2022/23 |
|---|---|---|---|
| Particle size | **Clay %** | 53.01 | 53.40 |
| | **Silt %** | 24.55 | 24.10 |
| | **Sand %** | 22.44 | 22.50 |
| Texture | | **Clay** | **Clay** |
| Bulk density (g.cm$^{-3}$) | | 1.28 | 1.32 |
| Field capacity % (v.v$^{-1}$) | | 42.01 | 46.62 |
| Wilting point % (v.v$^{-1}$) | | 30.44 | 32.27 |
| pH (1: 5) | | 8.30 | 7.90 |
| EC (dsm$^{-1}$) | | 1.36 | 1.52 |
| Organic matter % | | 1.40 | 1.45 |
| Soluble cations (*meq*.L$^{-1}$) | **$Ca^{++}$** | 7.45 | 7.50 |
| | **$Mg^{++}$** | 2.15 | 2.20 |
| | **$Na^{+}$** | 3.22 | 3.27 |
| | **$K^{+}$** | 0.20 | 0.25 |
| Soluble anions (*meq*.L$^{-1}$) | **$Cl^{-}$** | 4.10 | 4.15 |
| | **$CO_3$** | -- | -- |
| | **$HCO_3^{-}$** | 3.20 | 3.25 |
| Available nutrients (mg.kg$^{-1}$) | **N** | 20.25 | 20.52 |
| | **P** | 9.58 | 9.62 |
| | **K** | 186 | 188 |

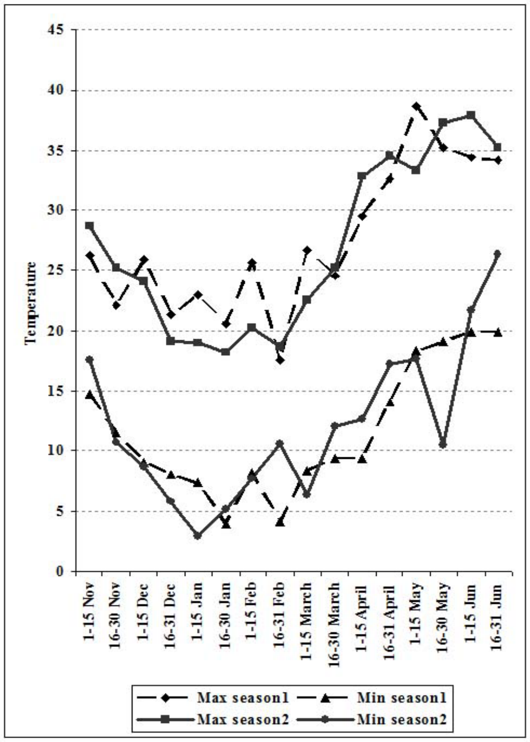

**Fig. (1): Maximum and minimum temperatures during the growing seasons**

The studied varieties were chosen based on their wide dispersal in the region. According to Abu-Qurqas Sugar Factory contracts, the planted area of these two varieties reached about 6,000 fed. in 2021 and exceeded 9,500 fed. in 2022. The experimental soil was clay, and its mechanical and chemical analyses are presented in Table 1.

1.0 kg seeds of each variety were placed in a sealed gauze bag and immersed in a pot containing 10 liters of the soaking solution being tested for 12 hours. After that, the seeds of each treatment were placed separately on a piece of burlap and left to dry in the open air until the morning of sowing (approximately 14.0 hours).

Sowing was done on November 7th and 10th, for the 1st and 2nd seasons, respectively, using the traditional method followed in most clay soils in the region. This method involves manually tapping dry seeds into the upper third of the row in dry soil followed by immediate irrigation.

Hoeing and thinning operations were carried out; the 1st dose of fertilization was added at a rate of 45.0 kg.fed$^{-1}$, followed by irrigation. After the soil dried, the 2nd hoeing and the 2nd dose of nitrogen were carried out at the same rate as the 1st.

To make the results more realistic, all of the mentioned points were taken into account when designing the experimental layout. An area of 2000 m$^2$ was prepared and planned with 60 cm between rows after addition of 15.0 kg $P_2O_5$. This area was divided into four strips separated by three irrigation canals, each containing six plots. Each experimental plot consists of 16.0 rows, 8.0 meters long. The studied measurements were taken from the middle ten rows, where five adjacent rows were allocated for periodic samples and the other five for final yield measurements. To ensure that all treatments were exposed to the same conditions as commercial production, no uncultivated gaps were left between plots, and their identification was limited to wooden signs.

The growth measurements were taken at three dates, representing the periods between 120 to 150 and 150 to 180 days after planting. In each experimental plot, the number of plants was counted, and a random sample of 10 plants was uprooted, bringing the total number of studied plants to 960 for a season. The weight of each plant was recorded separately. The plants were divided into roots and shoots, and the weight of each part was recorded separately.

After removing all the damaged and yellow leaves, the number and weight of leaves for each plant are re-recorded. This is because the weight of these damaged leaves cannot be ignored, as part of the plant's biological production and their area cannot be considered part of the future assimilatory system. Subsequently, samples of roots and leaves are crushed, and 50 grams of each are taken and dried until a constant weight is achieved. Eight disks with a known area from the green leaves of each sample are taken, weighed, and then dried until a constant weight is achieved. All weight values taken have been adjusted and standardized to kg.m$^{-2}$.

These measurements were used to estimate leaf area index (LAI) according to **Watson D.J., 1947**, leaf area duration (LAD) according to **Power *et al*., 1967**, leaf area ratio (LAR) and net assimilation rate (NAR) according to **Radford, 1967**, and relative growth rate (RGR) according to **Blackman, 1919** for each studied growth stage.

The harvest was done at 210 days in the 1st season and 216 days in the 2nd one. The roots of the five rows allocated to the yield from each experimental plot were uprooted and weighed to record the roots yield (RY) as a ton.fed$^{-1}$. Then a random sample of 10 roots was taken from each plot in a bag marked with the plot code and sent immediately to the Quality Control Department at the Abu Qurqas Sugar Factory to measure the POL according to **A.O.A.C.**, **2005**, impurities [sodium (Na), Potassium (K), and amino nitrogen (AmN)] according to **Cooke and Scott, 1993**, and sugar recovery % according to **Saparonova *et al*., 1979** which is multiplied with RY to produce the sugar yield (SY) as a ton.fed$^{-1}$.

A two-factor randomized complete block design was used in three replicates, and all collected data were analyzed by analysis of variance (ANOVA) procedures using M-State software. Differences between means were compared by LSD at a 0.05 significance level (**Gomez and Gomez, 1984**).

## Results and Discussions

### The 1st period: 120 to 150 days after planting (Table 2)

The data at Table 2 describe the results of this stage and give an indication of how the plants under the studied treatments cope with various growth challenges.

$T_1$-plots contained the smallest number of leaves in the two growing seasons compared to the other three treatments studied, which showed no significant differences between them in the 1st season. However, LAI values show superiority with $T_2$ in both seasons, suggesting that the plants whose seeds were soaked in $GA_3$ had larger leaves than the others. **Almanza, 2000,** and **Bultynka and Lambers, 2004** also observed a positive effect of $GA_3$ on leaf area development, attributing it to its stimulation of increasing the rate of cell wall formation, cell elongation, and division rate.

Total dry matter was significantly affected by soaking treatments in both seasons, and its values were logically in the same order as the LAI. In addition, varieties also differed significantly in their interaction with soaking treatments, and in most cases with both varieties, $T_2$ had the largest TDMs while $T_1$ had the lowest.

This order changed completely when looking at the allocation pattern of dry matter between roots and shoots, which is shown by the RSR values. In both seasons, the dry matter distribution of $T_2$ plants was more skewed toward the shoots. However, $T_3$ in the 1st season and $T_4$ in the 2nd one allocated more biomass to the root, which may indicate a higher ability to compete underground. **Vaughan, 1974,** and **David *et al*., 1994** also observed an increase in the root's dry weight of *Pisum sativum* as a result of introducing humic acid into the growth environment. **Vaughan, 1974** attributed this to the formation of compounds that stimulate the continued growth of secondary roots, and those compounds resulted from the association of humic acid with iron.

**Table (2): Growth measurements at 120 days and growth analysis from 120 to 150 days of two sugar beet var affected by soaking treatments and their interactions on 2020/2021 and 2021/2022 seasons**

| *2020-2021 season* | | At 120 days | | | | From 120 to 150 days | | | |
|---|---|---|---|---|---|---|---|---|---|
| Treatments | | LN | LAI | TDM | RSR | LAD | LAR | NAR | RGR |
| Husam | ($V_1$) | 24.10 | 2.08 | 1.442 | 1.11 | 0.92 | 0.58 | 15.68 | 09.12 |
| Sahar | ($V_2$) | 21.26 | 2.30 | 1.464 | 1.02 | 0.95 | 0.60 | 14.92 | 08.60 |
| Control | ($T_1$) | 20.87 | 1.64 | 1.368 | 1.07 | 0.75 | 0.55 | 15.98 | 08.51 |
| 150 *ppm* GA3 | ($T_2$) | 23.45 | 2.72 | 1.535 | 1.00 | 1.12 | 0.67 | 13.59 | 08.86 |
| 500 *ppm* Sp. | ($T_3$) | 23.27 | 2.38 | 1.505 | 1.20 | 0.99 | 0.59 | 14.89 | 08.71 |
| 500 *ppm* Hum. | ($T_4$) | 23.12 | 2.00 | 1.405 | 1.00 | 0.88 | 0.56 | 16.74 | 09.35 |
| | $V_1T_1$ | 21.72 | 1.55 | 1.367 | 1.19 | 0.73 | 0.62 | 12.94 | 07.95 |
| | $V_1T_2$ | 25.12 | 2.65 | 1.454 | 1.03 | 1.11 | 0.61 | 17.78 | 10.87 |
| | $V_1T_3$ | 25.08 | 2.34 | 1.508 | 1.27 | 0.99 | 0.57 | 16.39 | 09.28 |
| | $V_1T_4$ | 24.46 | 1.77 | 1.439 | 0.94 | 0.85 | 0.54 | 15.60 | 08.39 |
| | $V_2T_1$ | 20.02 | 1.73 | 1.369 | 0.94 | 0.78 | 0.48 | 19.02 | 09.07 |
| | $V_2T_2$ | 21.78 | 2.80 | 1.616 | 0.97 | 1.13 | 0.73 | 09.40 | 06.85 |
| | $V_2T_3$ | 21.45 | 2.42 | 1.501 | 1.12 | 0.99 | 0.61 | 13.38 | 08.14 |
| | $V_2T_4$ | 21.77 | 2.22 | 1.371 | 1.07 | 0.90 | 0.59 | 17.88 | 10.32 |
| | V | ns | ns | ns | ns | ns | ns | ns | ns |
| LSD$_{0.05}$ | T | 0.76 | 0.09 | 0.012 | 0.01 | 2.40 | 0.05 | 1.58 | 0.22 |
| | VxT | ns | ns | 0.018 | 0.02 | ns | 0.08 | 2.25 | 0.32 |
| *2021-2022 season* | | | | | | | | | |
| Husam | ($V_1$) | 22.84 | 2.01 | 1.208 | 0.72 | 0.88 | 0.66 | 14.28 | 09.33 |
| Sahar | ($V_2$) | 21.05 | 1.86 | 1.200 | 0.72 | 0.84 | 0.60 | 15.78 | 09.36 |
| Control | ($T_1$) | 19.16 | 1.56 | 1.142 | 0.74 | 0.73 | 0.58 | 14.82 | 08.58 |
| 150 *ppm* GA3 | ($T_2$) | 25.08 | 2.22 | 1.278 | 0.61 | 0.95 | 0.70 | 14.68 | 09.91 |
| 500 *ppm* Sp. | ($T_3$) | 22.58 | 2.14 | 1.221 | 0.72 | 0.92 | 0.63 | 15.20 | 09.63 |
| 500 *ppm* Hum. | ($T_4$) | 20.97 | 1.83 | 1.175 | 0.82 | 0.85 | 0.61 | 15.43 | 09.27 |
| | $V_1T_1$ | 19.38 | 1.59 | 1.121 | 0.75 | 0.75 | 0.58 | 15.71 | 09.09 |
| | $V_1T_2$ | 26.21 | 2.24 | 1.304 | 0.53 | 0.95 | 0.79 | 12.29 | 09.63 |
| | $V_1T_3$ | 23.15 | 2.18 | 1.225 | 0.68 | 0.92 | 0.64 | 15.42 | 09.84 |
| | $V_1T_4$ | 22.63 | 2.05 | 1.181 | 0.92 | 0.89 | 0.65 | 13.70 | 08.78 |
| | $V_2T_1$ | 18.94 | 1.54 | 1.163 | 0.73 | 0.71 | 0.58 | 13.92 | 08.06 |
| | $V_2T_2$ | 23.96 | 2.20 | 1.251 | 0.68 | 0.94 | 0.61 | 17.07 | 10.18 |
| | $V_2T_3$ | 22.00 | 2.11 | 1.217 | 0.75 | 0.91 | 0.63 | 14.97 | 09.43 |
| | $V_2T_4$ | 19.30 | 1.61 | 1.168 | 0.72 | 0.82 | 0.57 | 17.16 | 09.76 |
| | V | ns | ns | ns | ns | ns | ns | ns | ns |
| LSD$_{0.05}$ | T | 0.89 | 0.13 | 0.012 | 0.01 | 2.56 | 0.07 | ns | 0.19 |
| | VxT | ns | ns | 0.018 | 0.02 | ns | 0.10 | 2.39 | 0.27 |

GA3 is 150 *ppm* gibberellic acid, Sp. is 500 *ppm* spirulina extract, Hum. is 500 *ppm* humic acid, LN is number of leaves per plant, LAI is leaf area index, TDM is total dry matter kg.m$^2$, RSR is root to shoot ratio, LAD is leaf area duration m$^2$.day$^{-1}$ LAR is leaf area ratio m$^2$.kg$^{-1}$, NAR is net assimilation rate g.m$^2$day$^{-1}$, and RGR is relative growth rate mg.g$^{-1}$.day$^{-1}$.

The interaction was significant in both seasons. The highest RSR for each variety was observed with $T_3$ in most cases. This indicates that the plots whose seeds were soaked in spirulina extract invested more energy in their roots.

**Table (3): Person coefficients for sugar beet growth measurements through 1st period for the 1st and 2nd seasons**

*The 1st season*

| | **TDM** | **RSR** | **LAD** | **LAR** | **NAR** | **RGR** |
|---|---|---|---|---|---|---|
| LAI | **0.77** | *-0.01* | **0.98** | **0.59** | *-0.29* | *0.07* |
| TDM | | *-0.02* | **0.79** | **0.60** | **-0.64** | **-0.49** |
| RSR | | | *-0.04* | *0.07* | *-0.05* | *0.09* |
| LAD | | | | ***0.56*** | **-0.27** | **0.08** |
| LAR | | | | | *-0.83* | **-0.38** |
| NAR | | | | | | *0.81* |

*The 2nd season*

| | **TDM** | **RSR** | **LAD** | **LAR** | **NAR** | **RGR** |
|---|---|---|---|---|---|---|
| LAI | **0.80** | *-0.26* | **0.94** | **0.64** | *-0.26* | **0.54** |
| TDM | | **-0.64** | **0.81** | **0.70** | *-0.28* | **0.53** |
| RSR | | | *-0.27* | **-0.45** | *0.11* | **-0.44** |
| LAD | | | | **0.59** | *-0.13* | **0.67** |
| LAR | | | | | **-0.80** | *0.15* |
| NAR | | | | | | **0.46** |

Bold **font means significant.** *Italic* **font means insignificant**

The growth indicators in the 1st period showed that soaking sugar beet seeds in $GA_3$ increased the plant's ability to maintain the green area, as evidenced by the LAD values. It is easy to see that $T_2$ was the highest and exceeded $T_1$ by more than 33.0 and 23.0 % in the 1st and 2nd seasons, respectively. **Humphries and French, 1965**, summarized that although the dry weight was equal between GA3-treated and untreated sugar beet plants, the LAI of $GA_3$-treated plants was high due to high LAD. Moreover, **Li *et al.*, 2022**, emphasized that the assimilatory area duration is as important as the assimilatory area itself, and the two together represent the main factors driving dry matter accumulation and yield formation.

The $GA_3$ treatment also showed high efficiency in utilizing dry matter to produce leaf area, which was demonstrated by the LAR averages. The square meter of $T_2$ plants invested 1.0 kg of dry matter to produce a leaf area of 67.0 and 70.0 cm$^2$ for the 1st and 2nd seasons, respectively. The other three treatments studied seemed to be statistically equivalent. The high LAR values presented by $T_2$ with the two tested varieties are the only reason that made the interaction significant. LAR is a relationship between LA and TDM, meaning that increasing LA leads to higher LAR. Based on the observations of many researchers, $GA_3$ stimulates a significant increase in the assimilatory area by increasing the number of leaves (**Mu and Yamagishi, 2001** on rice), increasing the length and width of the leaf (**Dawood and Aboud, 2017** on Sorghum bicolor), and increase the survival time of leaves (**Humphries and French, 1965** on sugar beet and, **Lopez *et al.*, 2009** on tomato).

According to the same table, only in the 1st season soaking treatments significantly affect the plant's assimilation capacity, as represented by the NAR values. It can be seen that $T_4$-plants outperformed $T_2$-plants at a daily rate of about 3.15 g of dry matter per $m^2$ of leaf area.

The varieties exhibited different interaction behaviors with the soaking treatments. However, the data was scattered in an unclear order. By examining the LAR values and the correlation coefficient values (Table 3) which demonstrate a significant inverse correlation between LAR and NAR, it becomes evident that treatments resulting in high LAR values also yielded low NAR values and vice versa. **Konings 1989, Poorter and Remkes, 1999** also observed an inverse correlation between NAR and LAR, they attributed this to the fact that high investment in photosynthesis capacity leads to a decrease in specific leaf area and, consequently, a decrease in LAR.

When the increase in dry matter is attributed to the contribution of dry matter present from the beginning, it can be noted from 1st season's data that the $T_4$-plants gave the highest RGR values, superior by about 0.84 $mg.g^{-1}.day^{-1}$ compared to $T_1$. Insignificant differences appeared between the other two treatments. Also, Pearson coefficient (Table 3) showed that RGR was strongly related to NAR. In the 2nd season, $T_2$ presented the largest value, while the ranking of $T_4$ was delayed. The closeness of the NAR values led to the appearance of the treatments that allocated extra investment in their assimilatory area (high LAR) at the forefront of the RGR order. **Atkin *et al*., 1996 and Medec *et al*., 2007** also attributed the variation in RGR due to differences in LAR.

The RGR was significantly affected by the interaction between V and T. It is clear that each variety presented its highest RGR with $T_2$. These results were true in both seasons, with one exception being the noticeable decrease in the RGR of $V_2T_2$ in the 1st season. This decrease was due to the large increase in LAR, which led to a significant decrease in NAR.

### The 2nd period: 150 to 180 days after planting (Table 4)

The 2nd period began with a significant superiority of $T_2$ on the number of leaves per plant showing an increase of about 30.4 and 18.5% compared to its 1st-period values for the 1st and 2nd seasons respectively. Although many works, such as **Humphries and French, 1965 and Garrod, 1974**, agree that $GA_3$ restricts the formation rate of sugar beet leaves, they also agree on its positive effect in delaying senescence, and which increases the plant's ability to maintain a greater number of leaves despite severe competitive difficulties. Comparing with the 1st period values, it can be observed that $T_2$ achieved an increase in LAI by about 42.5 and 46.5% and in TDM by about 1.30 and 1.25 $kg.m^2$ for the 1st and 2nd seasons, respectively. **Humphries and French, 1965** also observed that the higher the concentration of $GA_3$ used, the longer the petioles of sugar beet leaves.

Other than that, the order of treatments did not change from the beginning of the 1st period, as $T_3$ and $T_4$ treatments were close in number of leaves, but $T_3$-plants formed larger leaves and also excelled in TDM. **Shedeed *et al*., 2022** also found a positive effect of priming Lupine seeds with spirulina extract on improving leaf length and thus leaf area.

Moreover, the interaction shows that the highest TDMs were listed with $V_1T_2$ in both seasons. The significant positive correlation between LAI and TDM (Table 5) explained why $T_2$ was the greatest.

**Table (4): Growth measurements at 120 days and growth analysis from 120 to 150 days of two sugar beet var affected by soaking treatments and their interactions on 2020/2021 and 2021/2022 seasons**

| *2020-2021 season* | | **At 150 days** | | | | **From 150 to 180 days** | | | |
|---|---|---|---|---|---|---|---|---|---|
| Treatments | | **LN** | **LAI** | **TDM** | **RSR** | **LAD** | **LAR** | **NAR** | **RGR** |
| Husam | **($V_1$)** | 29.99 | 4.07 | 2.719 | 4.79 | 0.76 | 0.22 | 24.83 | 5.41 |
| Sahar | **($V_2$)** | 29.23 | 4.03 | 2.646 | 4.30 | 0.76 | 0.25 | 13.40 | 3.22 |
| Control | **($T_1$)** | 25.44 | 3.38 | 2.464 | 4.54 | 0.60 | 0.21 | 22.02 | 4.64 |
| 150 *ppm* GA3 | **($T_2$)** | 33.21 | 4.73 | 2.837 | 4.06 | 0.96 | 0.28 | 14.53 | 3.64 |
| 500 *ppm* Sp. | **($T_3$)** | 29.91 | 4.23 | 2.749 | 4.83 | 0.79 | 0.24 | 18.28 | 4.25 |
| 500 *ppm* Hum. | **($T_4$)** | 29.88 | 3.86 | 2.682 | 4.76 | 0.69 | 0.22 | 21.63 | 4.72 |
| | **$V_1T_1$** | 26.79 | 3.32 | 2.365 | 4.80 | 0.59 | 0.23 | 26.03 | 5.89 |
| | **$V_1T_2$** | 33.90 | 4.76 | 3.081 | 4.41 | 0.97 | 0.22 | 21.23 | 4.71 |
| | **$V_1T_3$** | 29.93 | 4.27 | 2.863 | 4.69 | 0.80 | 0.21 | 22.88 | 4.89 |
| | **$V_1T_4$** | 29.35 | 3.92 | 2.568 | 5.27 | 0.69 | 0.21 | 29.19 | 6.15 |
| | **$V_2T_1$** | 24.09 | 3.44 | 2.562 | 4.28 | 0.61 | 0.19 | 18.01 | 3.38 |
| | **$V_2T_2$** | 32.52 | 4.70 | 2.593 | 3.72 | 0.95 | 0.33 | 07.83 | 2.57 |
| | **$V_2T_3$** | 29.89 | 4.19 | 2.634 | 4.97 | 0.77 | 0.27 | 13.68 | 3.61 |
| | **$V_2T_4$** | 30.42 | 3.81 | 2.796 | 4.25 | 0.70 | 0.23 | 14.07 | 3.30 |
| | **V** | ns | ns | ns | ns | ns | ns | 2.71 | 1.33 |
| $LSD_{0.05}$ | **T** | 1.31 | 0.08 | 0.012 | 0.24 | 1.79 | 0.04 | 0.49 | 0.10 |
| | **VxT** | ns | ns | 0.018 | 0.34 | ns | 0.06 | ns | 0.15 |
| *2021-2022 season* | | | | | | | | | |
| Husam | **($V_1$)** | 29.08 | 3.84 | 2.305 | 4.76 | 0.79 | 0.30 | 16.59 | 4.88 |
| Sahar | **($V_2$)** | 29.22 | 3.76 | 2.296 | 4.09 | 0.77 | 0.26 | 20.14 | 5.28 |
| Control | **($T_1$)** | 26.45 | 3.30 | 2.065 | 5.04 | 0.72 | 0.28 | 15.98 | 4.43 |
| 150 *ppm* GA3 | **($T_2$)** | 30.81 | 4.09 | 2.532 | 3.98 | 0.81 | 0.29 | 19.52 | 5.65 |
| 500 *ppm* Sp. | **($T_3$)** | 29.23 | 3.95 | 2.375 | 4.32 | 0.78 | 0.27 | 19.19 | 5.23 |
| 500 *ppm* Hum. | **($T_4$)** | 30.11 | 3.86 | 2.229 | 4.38 | 0.82 | 0.27 | 18.76 | 5.02 |
| | **$V_1T_1$** | 25.96 | 3.41 | 2.100 | 5.10 | 0.74 | 0.28 | 15.15 | 4.14 |
| | **$V_1T_2$** | 30.16 | 4.12 | 2.537 | 3.91 | 0.90 | 0.34 | 16.98 | 5.74 |
| | **$V_1T_3$** | 30.52 | 3.97 | 2.417 | 4.84 | 0.77 | 0.29 | 17.59 | 5.00 |
| | **$V_1T_4$** | 29.69 | 3.88 | 2.165 | 5.21 | 0.74 | 0.28 | 16.63 | 4.64 |
| | **$V_2T_1$** | 26.94 | 3.20 | 2.030 | 4.97 | 0.69 | 0.28 | 16.82 | 4.73 |
| | **$V_2T_2$** | 31.46 | 4.06 | 2.527 | 4.05 | 0.71 | 0.25 | 22.06 | 5.55 |
| | **$V_2T_3$** | 27.93 | 3.94 | 2.333 | 3.80 | 0.79 | 0.26 | 20.79 | 5.45 |
| | **$V_2T_4$** | 30.54 | 3.83 | 2.294 | 3.56 | 0.90 | 0.26 | 20.89 | 5.40 |
| | **V** | ns | ns | ns | ns | ns | ns | 1.97 | ns |
| $LSD_{0.05}$ | **T** | 1.49 | 0.12 | 0.039 | 0.06 | 2.63 | ns | 1.57 | 0.20 |
| | **VxT** | ns | ns | 0.055 | 0.08 | ns | 0.02 | ns | ns |

GA3 **is 150 *ppm* gibberellic acid,** Sp. **is 500 *ppm* spirulina extract,** Hum. **is 500 *ppm* humic acid,** LN **is number of leaves per plant,** L**AI is leaf area index, TDM is total dry matter kg.m$^2$,** RSR **is root to shoot ratio,** LAD **is leaf area duration m$^2$.day$^{-1}$** LAR **is leaf area ratio m$^2$.kg$^{-1}$,** NAR **is net assimilation rate g.m$^2$day$^{-1}$, and** RGR **is relative growth rate mg.g$^{-1}$.day$^{-1}$.**

In terms of the dry matter distribution within the plant, $T_2$ continued to be the least in directing plant activity toward the roots in both seasons. **Bultynck and Lambers, 2004** stated that $GA_3$ increased biomass allocation to the leaves at the cost of allocation to the roots. On the contrary, $T_3$ and $T_4$ exhibited the highest RSR in the 1st season. The notable observation is the significant superiority of $T_1$ in the 2nd season which indicating that these plants invested much energy in their roots.

**Table (5): Person coefficients for sugar beet growth measurements through 2nd period for the 1st and 2nd seasons**

| | TDM | RSR | LAD | LAR | NAR | RGR |
|---|---|---|---|---|---|---|
| *The 1st season* | | | | | | |
| | **TDM** | **RSR** | **LAD** | **LAR** | **NAR** | **RGR** |
| LAI | **0.66** | *-0.32* | **0.98** | **0.51** | *-0.38* | *-0.29* |
| TDM | | *-0.19* | **0.66** | *-0.11* | *-0.09* | *-0.13* |
| RSR | | | **-0.42** | **-0.44** | **0.72** | **0.76** |
| LAD | | | | **0.53** | **-0.42** | *-0.35* |
| LAR | | | | | **-0.74** | **-0.50** |
| NAR | | | | | | **0.93** |
| *The 2nd season* | | | | | | |
| | **TDM** | **RSR** | **LAD** | **LAR** | **NAR** | **RGR** |
| LAI | **0.84** | **-0.53** | **0.52** | *0.09* | **0.48** | **0.72** |
| TDM | | **-0.63** | **0.43** | *0.17* | **0.47** | **0.78** |
| RSR | | | **-0.66** | *0.10* | **-0.71** | **-0.85** |
| LAD | | | | *0.35* | *0.17* | **0.55** |
| LAR | | | | | **-0.66** | *0.07* |
| NAR | | | | | | **0.70** |

Bold **font means significant.** *Italic* **font means insignificant**

$T_4$ gave the highest RSR with $V_1$, while its interaction with $V_2$ recorded the lowest. In the 1st period of the 1st season, RSR did not correlate with any of the growth measurements (Table 5), which indicates a balance in the energy investment between the assimilatory area production and the rate of its translocation to the roots. In the 2nd period, RSR showed a strong positive correlation with NAR and a moderate inverse one with LAR. This indicates that the rate of photosynthesis has increased, but the metabolic products tended to be distributed toward the roots.

In the 2nd season, RSR was inversely related to LAR in the 1st period and NAR in the 2nd one. Those two cases show that increasing energy investment in the roots harmed both the area of the assimilatory system in the 1st period and the rate of photosynthesis in the 2nd one.

It is known in advance that RGR is the product of LAR multiplied by NAR, and therefore a positive or inverse correlation of RSR with either of them leads to a similar correlation with RGR. This indicates that the dry matter distribution within the plant is the most important determinant in illustrating growth behavior.

Nothing new was observed regarding the LAD. $T_2$ was the best, superiors by about 17.0 $cm^2day^{-1}$ over $T_3$ and by about 36 $cm^2day^{-1}$ over the control. In the 2nd season, only $T_1$ gave a small value while insignificant differences were observed between the other three treatments.

LAR was appreciably affected by the studied soaking treatments only in the 1st season. There is a clear difference in the ranking of LAR in this period. $T_3$-Plants made a significant investment in producing and maintaining the assimilatory area with LAR values that were statistically equal to $T_2$. The interaction followed the same order as in the 1st-period, in which only some $T_2$-combinations were higher than the rest.

Varieties significantly influenced NAR values, with $V_1$ in the 1st season giving nearly twice the NAR of $V_2$, which had the highest NAR in the 2nd season. Moreover, the $T_1$-NAR in the 1st season increased by about 6.04 $g.m^2.day^{-1}$ compared to its NAR at 120 days. $T_4$ plants also exhibited a high NAR, but the net increase between the two periods was much greater in $T_1$. Everything changed in the second season, with $V_2$ being the highest, $T_1$ being the lowest and the other three soaking treatments being statistically equal. The data from the 1st season indicated that $V_2$ exhibited a 40% increase in RGR compared to $V_1$. Additionally, $T_1$ demonstrated significant superiority and collaborated with $T_4$ to achieve the highest RGR, attributed to the strong correlation between NAR and RGR. The RGR of $T_2$ decreased significantly compared to the others, confirming that plants investing more energy in the assimilatory area have a lower RGR under high-temperature conditions (Figure 1). In the 2nd season, $T_2$ showed significant superiority over the others. This was due to insignificant differences in LAR between the treatments, and NAR values also showed insignificant differences among the three soaking materials. This resulted in the disappearance of the logarithmic effect of the initial dry matter contribution, leading to the RGR order being determined solely by the daily dry matter increase. The interaction was significant only in the 1st season, where $V_1T_4$ plants had the highest RGR. It can also be noted that all the combinations of $V_1$ showed high RGRs, to the extent that the smallest of them ($V_1T_2$) was significantly higher than the largest RGR of the $V_2$ combinations ($V_2T_1$) by about 1.33 $mg.g^{-1}.day^{-1}$. Sugar beet producers in this region face many challenges at the end of the season, the most important of which is mold infection. This is due to the irrigation system that provides the appropriate conditions for mold growth. Additionally, some winter weeds, such as fennel, become more active due to the increase in temperature and the decrease in sugar beet canopy cover, causing them to grow taller and create significant shading. Therefore, farmers during this period resort to rapid irrigation and avoid saturating the soil with water. These conditions are considered another challenge that causes many changes in the behavior of the crop during this period.

Measurements taken after 180 days (Table 6) and compared to those taken at 150 days (Table 4) show that plants in the control plots experienced the greatest loss in the assimilatory area, losing more than 60 and 41% of leaves, and retaining less than 18 and 26% of LAI for the 1st and 2nd seasons respectively. In contrast, under the same conditions, $GA_3$-treated plants maintained more than 54 and 65% of leaves and more than 35 and 49% of LAI for the 1st and 2nd seasons, respectively. This indicates the ability of these plants to continue their activity in conditions that seemed less suitable for other tested treatments. The ability of plants to invest more energy in the assimilatory area at a later age is a phenomenon of great importance that is reflected in quality characteristics due to its inverse relationship with sucrose content. However, sugar beet producers face a major challenge on the ground, as the areas ready for harvest are much larger than what the transportation systems of sugar factories can accommodate. The results of this problem are reflected in the inability of farmers to determine the optimal time to stop irrigation before harvesting (weaning). Also, irrigation in this case is risky because the soil is cracked due to the high temperature, which may inevitably lead to root rot. All of these conditions lead to damage that varies depending on the plant's ability to withstand it. $T_4$ had the highest total dry matter for the 1st season, with an increase of about 1.04 $kg.m^{-2}$ compared to the beginning of the 2nd period. However, in the 2nd season, $T_2$ produced the greatest TDM and outperformed the control treatment by more than 900 $g.m^{-2}$. Varieties and soaking treatments showed significant differences in RSR for both seasons. $V_1$ had the highest RSR, and $T_2$ was significantly superior to the rest. The interaction was also significant, and in most cases, each variety showed its highest TDM and RSR with $T_2$ and the lowest with $T_1$.

**Quality parameters (Table 7)**

The quality of sugar beet roots is determined by a relationship that combines the sucrose content of the roots and their content of impurities that prevent the extraction or crystallization of sucrose.

**Table (6): parameters at 180 days of two sugar beet varieties as affected by soaking treatments and their interaction on 2020-2021 and 2021-2022 seasons**

| Treatments | | **2020-2021 season** | | | | **2021-2022 season** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **LN** | **LAI** | **TDM** | **RSR** | **LN** | **LAI** | **TDM** | **RSR** |
| Husam | **($V_1$)** | 13.14 | 1.00 | 3.940 | 12.01 | 17.99 | 1.46 | 3.241 | 13.37 |
| Sahar | **($V_2$)** | 14.73 | 1.02 | 3.306 | 08.97 | 18.18 | 1.36 | 3.313 | 10.86 |
| Control | **($T_1$)** | 10.06 | 0.60 | 3.395 | 09.83 | 15.58 | 0.89 | 2.804 | 08.73 |
| 150 *ppm* GA3 | **($T_2$)** | 17.98 | 1.66 | 3.681 | 11.53 | 20.09 | 2.01 | 3.740 | 15.02 |
| 500 *ppm* Sp. | **($T_3$)** | 14.48 | 1.02 | 3.696 | 10.57 | 18.57 | 1.48 | 3.407 | 13.19 |
| 500 *ppm* Hum. | **($T_4$)** | 13.23 | 0.76 | 3.720 | 10.04 | 18.10 | 1.25 | 3.156 | 11.53 |
| | **$V_1T_1$** | 09.64 | 0.59 | 3.554 | 10.69 | 15.27 | 1.08 | 2.795 | 08.82 |
| | **$V_1T_2$** | 16.48 | 1.68 | 4.265 | 13.29 | 19.98 | 1.87 | 3.772 | 12.89 |
| | **$V_1T_3$** | 13.48 | 1.09 | 4.012 | 12.62 | 18.72 | 1.55 | 3.414 | 16.80 |
| | **$V_1T_4$** | 12.98 | 0.65 | 3.929 | 11.45 | 17.98 | 1.34 | 2.982 | 14.98 |
| | **$V_2T_1$** | 10.48 | 0.61 | 3.236 | 08.97 | 15.89 | 0.70 | 2.814 | 08.64 |
| | **$V_2T_2$** | 19.48 | 1.65 | 3.097 | 09.77 | 20.21 | 2.15 | 3.709 | 17.15 |
| | **$V_2T_3$** | 15.48 | 0.96 | 3.380 | 08.51 | 18.41 | 1.41 | 3.401 | 09.59 |
| | **$V_2T_4$** | 13.48 | 0.87 | 3.511 | 08.63 | 18.22 | 1.17 | 3.330 | 08.07 |
| | **V** | ns | ns | ns | 2.37 | ns | ns | ns | 1.91 |
| $LSD_{0.05}$ | **T** | 1.42 | 0.08 | 0.012 | 0.04 | 1.06 | 0.10 | 0.012 | 0.09 |
| | **VxT** | 2.01 | 0.11 | 0.018 | 0.06 | 1.50 | 0.15 | 0.018 | 0.12 |

GA3 **is 150 *ppm* gibberellic acid,** Sp. **is 500 *ppm* spirulina extract,** Hum. **is 500 *ppm* humic acid,** LN **is number of leaves per plant,** LAI **is leaf area index, TDM is total dry matter kg.m$^2$, and** RSR **is root to shoot ratio**

**Table (7): Quality characteristics at harvest of two sugar beet varieties as affected by soaking treatments and interaction on 2020-2021 and 2021-2022 seasons**

| Treatments | | **POL** | | **K** | | **Na** | | **Amino N** | | **S. rec.** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1$^{st}$ season** | **2$^{nd}$ season** | **1$^{st}$ season** | **2$^{nd}$ season** | **1$^{st}$ season** | **2$^{nd}$ season** | **1$^{st}$ season** | **2$^{nd}$ season** | **1$^{st}$ season** | **2$^{nd}$ season** |
| | **($V_1$)** | 16.92 | 16.05 | 4.18 | 4.07 | 1.23 | 1.74 | 3.33 | 3.87 | 14.46 | 13.40 |
| | **($V_2$)** | 16.60 | 16.17 | 4.48 | 3.29 | 1.20 | 2.84 | 3.42 | 5.25 | 14.03 | 13.28 |
| | **($T_1$)** | 17.01 | 16.82 | 4.06 | 3.84 | 1.23 | 2.25 | 3.35 | 4.26 | 14.59 | 14.04 |
| | **($T_2$)** | 15.28 | 14.92 | 4.63 | 3.54 | 1.30 | 2.65 | 3.87 | 4.91 | 12.59 | 12.05 |
| | **($T_3$)** | 17.71 | 16.90 | 4.27 | 3.80 | 0.97 | 2.08 | 2.93 | 4.53 | 15.35 | 14.17 |
| | **($T_4$)** | 17.03 | 15.80 | 4.37 | 3.56 | 1.36 | 2.18 | 3.35 | 4.55 | 14.47 | 13.11 |
| | **$V_1T_1$** | 17.38 | 16.73 | 3.92 | 4.33 | 1.12 | 2.03 | 3.31 | 3.37 | 15.05 | 13.94 |
| | **$V_1T_2$** | 15.12 | 14.99 | 4.49 | 3.71 | 1.24 | 1.77 | 3.85 | 4.31 | 12.50 | 12.42 |
| | **$V_1T_3$** | 17.83 | 16.41 | 4.04 | 4.22 | 1.06 | 1.39 | 2.89 | 4.09 | 15.52 | 13.81 |
| | **$V_1T_4$** | 17.35 | 16.07 | 4.26 | 4.03 | 1.50 | 1.77 | 3.28 | 3.72 | 14.78 | 13.44 |
| | **$V_2T_1$** | 16.63 | 16.90 | 4.19 | 3.34 | 1.34 | 2.46 | 3.40 | 5.14 | 14.12 | 14.14 |
| | **$V_2T_2$** | 15.45 | 14.85 | 4.77 | 3.37 | 1.37 | 3.53 | 3.89 | 5.50 | 12.69 | 11.67 |
| | **$V_2T_3$** | 17.58 | 17.39 | 4.50 | 3.38 | 0.88 | 2.77 | 2.98 | 4.96 | 15.17 | 14.52 |
| | **$V_2T_4$** | 16.72 | 15.53 | 4.47 | 3.09 | 1.21 | 2.59 | 3.41 | 5.39 | 14.16 | 12.78 |
| | **V** | ns | ns | ns | ns | ns | 0.95 | ns | 1.03 | ns | ns |
| $LSD_{0.05}$ | **T** | 1.05 | 0.81 | ns | ns | 0.22 | 0.54 | ns | ns | 1.22 | 0.94 |
| | **VxT** | ns | ns | ns | ns | ns | ns | ns | ns | 1.70 | 1.34 |

GA3 **is 150 *ppm* gibberellic acid,** Sp. **is 500 *ppm* spirulina extract,** Hum. **is 500 *ppm* humic acid,** ns **is insignificant,** POL **is sucrose %,** K **is potassium *meq.L$^{-1}$*, Na is sodium *meq.L$^{-1}$*, Amino N is alpha amino nitrogen *meq.L$^{-1}$*, and** S. rec **is sugar recovery %**

POL was significantly affected by the studied soaking treatments. This is due to the lower POL of $T_2$ plants than the other treatments, which showed insignificant differences among each other. This was apparent from the results of the two seasons.

Varieties differed significantly in sodium content only in the 2nd season, where $V_2$ recorded a significantly greater value. The soaking treatments also had a significant effect in both seasons, due only to the lower sodium content in the $T_3$ roots. Root amino nitrogen content was affected by varieties only in the 2nd season, with $V_2$ presenting a value more than 26% higher than that of $V_1$. **Enan *et al.* (2016)** also observed a decrease in the sodium content of the roots and an increase in the extracted sugar values with each increase in the concentration of the spirulina extract used to spray sugar beets, up to 3,500 *ppm*.

The sugar recovery % differed insignificantly between the varieties, while the soaking treatments and the interaction had a significant effect in both seasons. Two points can be noted from Table 7: the first is that all combinations that included $T_2$ gave low values, and the second point is that high percentages of the sugar recovery were always linked to the effect of $T_3$, whether directly or interacting with varieties. This is due to the high sucrose content and low impurity values in the roots of $T_3$-plants. **EL-Sharnoby *et al.*, 2021** confirmed a significant improvement in the sugar beet root quality as a result of foliar feeding with spirulina extract and that increasing the extract concentration was accompanied by an increase in sucrose and purity values.

**Roots and sugar yields (Table 8)**

In fact, for sugar beet producers in this region, the root yield is the only guarantee of a financial return at the end of the season. This is because they are not convinced of the accuracy and efficiency of evaluation processes based on quality attributes, and they believe that quality rates are almost constant for most late-loop areas.

The results of the two seasons showed that all the studied soaking treatments were significantly superior in root yield to the traditional method ($T_1$). $T_2$-plots were the most superior, and this was expected given their superiority in most of the studied growth metrics during the season, it can be said that this superiority began to appear almost after germination. Keeping high LAI throughout the growing season (high LAD) is the main reason for the high root productivity, and this gives an idea of what the soaking process added to the plants with this treatment. There were no significant differences between $T_3$ and $T_4$ in the 1st season, but $T_3$ was significantly superior in the 2nd.

Sugar yield is a complex characteristic that depends on all the conditions that plants experience during the season, the effects of which can be combined under one term, which is balance (the balance between investing energy in vegetative growth and investing it in storing sugar). Sugar yield data provide further evidence that soaking seeds before planting has caused a change in the plant's behavior in dealing with the surrounding environment.

**Table (8): Root and sugar yields (ton.fed$^{-1}$) of two sugar beet varieties as affected by soaking treatments and thei interactions on 2021-2021 and 2021-2022 seasons**

| Treatments | | Root yield | | Sugar yield | |
|---|---|---|---|---|---|
| | | **1st season** | **2nd season** | **1st season** | **2nd season** |
| Husam | **($V_1$)** | 40.44 | 38.20 | 5.81 | 5.10 |
| Sahar | **($V_2$)** | 40.89 | 40.03 | 5.73 | 5.29 |
| Control | **($T_1$)** | 37.20 | 34.94 | 5.43 | 4.90 |
| 150 *ppm* GA3 | **($T_2$)** | 44.11 | 43.64 | 5.56 | 5.26 |
| 500 *ppm* Sp. | **($T_3$)** | 40.93 | 40.55 | 6.27 | 5.75 |
| 500 *ppm* Hum. | **($T_4$)** | 40.41 | 37.34 | 5.84 | 4.89 |
| | **$V_1T_1$** | 37.27 | 34.29 | 5.61 | 4.77 |
| | **$V_1T_2$** | 44.99 | 42.59 | 5.63 | 5.29 |
| | **$V_1T_3$** | 40.31 | 39.22 | 6.24 | 5.43 |
| | **$V_1T_4$** | 39.20 | 36.70 | 5.79 | 4.93 |
| | **$V_2T_1$** | 37.14 | 35.59 | 5.25 | 5.03 |
| | **$V_2T_2$** | 43.23 | 44.68 | 5.49 | 5.22 |
| | **$V_2T_3$** | 41.55 | 41.88 | 6.31 | 6.07 |
| | **$V_2T_4$** | 41.63 | 37.97 | 5.89 | 4.85 |
| | **V** | ns | ns | ns | ns |
| $LSD_{0.05}$ | **T** | 1.49 | 1.36 | 0.42 | 0.37 |
| | **VxT** | ns | ns | ns | ns |

GA3 **is 150 *ppm* gibberellic acid,** Sp. **is 500 *ppm* spirulina extract,** Hum. **is 500 *ppm* humic acid,** ns **is insignificant, and** ton.fed$^{-1}$ **is tons per 4200 m$^2$**

By studying growth behavior through changes in weight and distribution of dry matter, soaking treatment with spirulina extract ($T_3$) has not been mentioned much. Because its value on most occasions was neither the highest nor the lowest and was always in the middle. However, the roots of this treatment contained the highest sucrose and the lowest impurities at harvest. It can be noted that $T_3$ outperformed $T_1$ by about 200 g of sugar per m$^2$, knowing that there were no significant differences between $T_1$, $T_2$, and $T_4$.

Considering that sugar yield is the primary goal and assuming that soaking seeds has added new capabilities to plants under competitive conditions, it can be said that soaking seeds in spirulina extract has added to plants the ability to balance energy investment.

How energy is invested is an expression of how the plant deals with the environment and is constantly affected by any change in its characteristics. In many previous studies, it was suggested to use spirulina extract to solve several problems, such as improving the growth characteristics of *Sisymbrium Irio* Callus, as demonstrated by **Amin *et al.*, 2009** that supplementing the growth media with amounts of spirulina extract instead of auxin and kinetin resulted in a four-fold increase in the relative growth rate and twelve-fold in the total antioxidant capacity. It was observed through the HPLC profile that the spirulina extract contains a ratio of 8:1 auxin:benzyladenine and they confirmed that this ratio is the best for stimulating growth.

Also, **Abd El-Sadek and Ahmed, 2022** succeeded in improving the rooting strength of the *Capparis cartilaginea* plant, which is threatened with extinction because it is difficult to propagate, by supplying the callus growth media with spirulina extract, which resulted in the emergence of very strong and very healthy roots. Additionally, **Du Jardin, 2015; Povero *et al.*, 2016** and **Michalak *et al.*, 2016** confirmed that the use of spirulina extract as a biostimulant leads to the production of high-quality food crops without containing any harmful residues. Accordingly, it can be said that spirulina extract contains balanced proportions of phytohormones, vitamins, sugars, and micronutrients, which is the main reason for the balance of energy investment and the emergence of the high storage capacity of the studied sugar beet plants.

## Conclusion

The two tested varieties showed great similarity in their behaviors, and the slight changes that appeared on some occasions were rarely repeated. This indicates the high adaptation of these varieties to the region's conditions.

Soaking seeds before planting leads to radical changes in plant performance throughout the growing season and up to the level of yield and quality, but this effect can only be seen under competitive environment conditions.

Soaking seeds in gibberellic acid was superior in most growth characteristics, and this led to delayed maturity. It is assumed that introducing one of the appropriate growth inhibitors sufficiently before harvest may address this matter.

Soaking seeds in spirulina extract led to a significant superiority in quality characteristics and sugar yield, with a somewhat decrease in root yield compared to the gibberellic acid treatment, making it the most successful in terms of financial return.

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