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NATURAL BIOSTIMULANTS FROM LICORICE AND YEAST CAN IMPROVE THE STEVIA (*STEVIA REBAUDIANA*) GROWTH AND PERFORMANCE

N.M. SALMAN[1], M.R. AL-SHAHEEN[2*], and A.J.A. AL-BAYATY[1]

[1]Department of Biology, College of Education for Women, University of Tikrit, Iraq
[2]Department of Biotechnology, College of Sciences, University of Anbar, Iraq
Corresponding author's email: ag.mustafa.riyadh@uoanbar.edu.iq
Email addresses of co-authors: alani2005ms@gmail.com, maymonahmalaysia2016@gmail.com

SUMMARY

This study investigated the effects of dry yeast and licorice on the growth and morphology of *Stevia rebaudiana*. The field experiment on *Stevia rebaudiana* Bertoni under the wooden cover commenced in 2023 at the Department of Horticulture and Gardening Engineering, University of Tikrit, Iraq. Using three different amounts of ground licorice (0, 5, and 10 g) and three varied quantities of dry yeast (0, 2.5, and 5 g) became factors to assess the response of *S. rebaudiana* Bertoni to them. The highest ratios of plant height, number of leaves per plant, and leaf thickness had ratings at 55.20 cm, 729 leaves, and 0.370 mm, respectively. The results demonstrated that the treatments involving ground addition with licorice (10 g) were considerably superior. However, when adding the dry yeast to the ground up, the optimal ratios of the previously mentioned qualities rose to 87.04 cm, 737 leaves, and 0.620 mm, respectively. The results showed that the treatments significantly improved plant height, number of leaves, and a leaf's thickness. The interaction between the dry yeast and licorice had the highest impact, resulting in a 97.50 cm plant height, 789 leaves, and 0.740 mm leaf thickness. These findings suggest that dry yeast and licorice combined can be eco-friendly fertilizers to promote Stevia growth.

Keywords: Stevia (*Stevia rebaudiana* Bertoni), nano bio-enriched, licorice and dry yeast, response, growth traits, leaf chlorophyll content, potassium

Key findings: By adding ground licorice (10 g) and dry yeast (5 g) to stevia plants, the highest plant height, number of leaves, and leaf thickness occurred with the interaction of these two factors, reaching maximum ratios of 97.50 cm, 789 leaves, and 0.740 mm, respectively.

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INTRODUCTION

Since ancient times, humans have recognized the potential of plants for both sustenance and healing. They would often utilize the plants found in their surroundings without processing or extracting active compounds, using them as remedies for various ailments. One such plant is lemongrass, which the Pharaohs employed for medicinal purposes and continuously became effective in traditional medicine. Many countries worldwide, such as China, Brazil, Cuba, India, and Egypt, have acknowledged the lemongrass therapeutic properties and incorporated them into their medicinal practices (Hassan *et al., 2018*).

Stevia is a member of the Asteraceae family and a native to specific regions of South America, such as Brazil and Paraguay. It naturally grows in low-lying areas with poor, sandy, and acidic soils adjacent to swamps. It has adapted to and required constantly wet conditions or shallow water tables. Stevia is a genus of about 200 species of herbs in the sunflower family. It grows up to 1 m tall, with leaves reaching 2–3 cm long. The leaves of Stevia are the source of diterpene glycosides, stevioside, and rebaudioside. Stevia is one of the essential anti-diabetic medicinal herbs. It is indigenous to the Rio Monday Valley of the Amambay mountain region at altitudes between 200 and 500 m. The compounds in its leaves, stevioside, and rebaudioside, taste about 300 times sweeter than sucrose (Hassan, 2023).

Licorice, a widely used medicinal and therapeutic plant, also serves as a natural sweetening source, with its sweetness being 17 to 50 times more intense than sucrose. Research conducted on licorice root extraction has revealed its significant impact. Foliar application of licorice root extraction at two concentrations (100% and 50%) on sunflower plants demonstrated a remarkable increase in plant height, leaf area, and leaf area index) Ahmed *et al.,* 2020). Similarly, Nasrallah reported a notable increase in total grain yield and protein content in sunflower plants treated with 50% licorice root extraction compared with plants with ground addition with water only. This enhancement can be due to the increased number and weight of seeds in the treated plants that also gave significant differences in total grain yield for treated popcorn plants with a 50% concentration of licorice root extracts (Khaitov *et al.,* 2022).

Dry yeast can have multiple beneficial effects on plants. Dry yeast can harbor advantageous microorganisms that contribute to improving soil quality and enhancing nutrient absorption in plants. Furthermore, yeast could stimulate root growth and promote plant health and vitality. Additionally, yeast application can aid in preventing particular plant diseases and pests. Nevertheless, it is crucial to acknowledge that the impact of dry yeast on plants may vary depending on specific plant species and environmental conditions (Ahmed *et al.,* 2020; Al-Shaheen *et al.,* 2022). Therefore, a recommendation to engage in thorough research and seek experts' guidance is necessary before utilizing dry yeast as a plant supplement. The popularity of dry yeast licorice stems from its rich content of vitamins and minerals crucial in supporting plant growth. It is critical to recognize that, akin to humans, plants require supplementary vitamins and nutrients to thrive. Mere watering of plants is insufficient to ensure optimal health, as a deficiency in essential elements can lead to deteriorating plant conditions. Dry yeast stands out versus commercially available plant licorices due to its substantial calcium content, a component not commonly available in pre-packaged licorices. Moreover, dry yeast encompasses a variety of minerals and vitamins that contribute to its efficacy as a plant licorice (Al-Shaheen and Zuraini*,* 2022).

By assimilating the information presented in this discourse, individuals can readily produce their natural licorice plants, irrespective of their geographical location (Abdulrahman *et al.,* 2020; Hamad *et al.,* 2023). This approach offers a cost-effective alternative to expensive commercial products while simultaneously providing immense satisfaction and benefits to both the cultivator and the plants per se. The subsequent sections of this article will elucidate the process of crafting homemade plant licorice using dry yeast, enabling individuals to embark on a rewarding journey of nurturing their plants naturally (Sun *et al.*, 2019). The study objective is to test the response of *S. rebaudiana* Bertoni to the ground addition ***of*** licorice and dry yeast, carrying out a detailed experiment.

MATERIALS AND METHODS

Experimental design and procedure

The field experiment commenced in 2023 at the wooden canopy of the Department of Horticulture and Gardening Engineering, University of Tikrit, Iraq, to assess the response of *S. rebaudiana* Bertoni to the addition of licorice and dry yeast to the soil. The assessed response of *S. rebaudiana* Bertoni for ***the*** ground addition of licorice and dry yeast appears in Table 1. The experiment followed a randomized complete block design (RCBD) with three replicates for vegetative and chemical properties.0.5 PV. The experiment included factors, with the first factor as dry yeast with three treatments, i.e., F0 (No addition - control), F1 (2.5 g), and F2 (5 g). The second factor was adding licorice powder, also with three doses, i.e., P0 (No addition - control), P1 (5 g), and P2 (10 g).

Development of experimental factors

Preparation of dry yeast suspension

Preparing a suspension of dry yeast comprised of dissolving specific weights (5 and 10 g) in a liter of warm distilled water at a temperature of 32 °C with the addition of 2 gm of sugar (sucrose) to activate the yeast, then went on to place in an incubator at a temperature of 25 °C for two hours.

Preparation of licorice root infusion

A licorice root infusion preparation included a weight of 2.5 and 5) g of licorice root powder each, separately added with one liter of distilled water at 50 °C to each, and then sealed and placed in an incubator at a temperature of 30 °C for 25 h. Filtering the solution used two layers of burr cloth to obtain the required levels.

Preparation of the pots

Plastic pots measuring 15 kg had a 30 × 30 dimension. A medium made up of a sequential mixture of soil, organic matter, and peat moss at a ratio of 1:1:2 helped prepare the soil. As needed, applying organic and chemical licorices ensued. Watering the plants utilized a drip irrigation system.

Stevia planting

Following their purchase from the Palm Paradise Company for Textile Agriculture, the plants proceeded in plastic potting soil earlier prepared for planting and treated with fungicide to ward off fungal infection. Then, storing them inside the greenhouse for protection for two months helped preserve the plants from low temperatures during this time. Afterward, moving them to the wooden canopy, where maintenance work on the plant, including ventilation and follow-up care during the experimentation, continued.

Table 1. The components used in the peat moss.

Components	Percentage
N	2.8-2.2
P_2O_5	1.2-0.8
K_2O	1.8- 1.5
Na	0.01
Cl	0.8
O.M	70-60
PH	6.5-5.7
Moisture	15-12
C:N	18:1-14:1

Data recorded

The shoots per sapling and plant height (cm) measurement occurred before treatment implementation. Repeating these measurements at the end of the experiment continued in December 2022. Counting the number of leaves per sapling at the end of the experiment determined their amount. Calculating the average leaf area (dm²) used the method described by Chou (1966), with the leaf area per sapling extracted at the end of the experiment. The estimation of the percentage of potassium in leaves ensued in the fully-grown leaves at the end of the trial. The total chlorophyll content in leaves was in mg g^{-1} fresh weight.

Statistical analysis

A factorial experiment with two factors used a randomized complete block design (RCBD). The experiment included three replications per treatment and three saplings per experimental unit. Data analysis used the statistical software GenStat, with the means compared utilizing the Least Significant Difference ($LSD_{0.05}$) test.

RESULTS AND DISCUSSION

Plant height

The results indicated the superiority of the treatments with the addition of the ground licorice compared with that of licorice powder (Table 2). The highest rate of plant height recorded emerged on the plants with ground addition of licorice at maximum percentage (55.20 cm), with a significant difference from other treatments (48.50 cm). The lowest rate of plant height (45.30 cm) occurred at plants without licorice ground addition along the growing season, recording a substantial decrease from other studied treatments. As for the fry yeast, a clear response by plant height appeared, where the utmost plant height rate resulted in plants with ground addition of the dry yeast's highest rate (87.04 cm). A significant difference with other study treatments showed, with a rate of 64.50 cm. The minimum plant height was evident at the comparison treatments (45.30 cm).

The interaction between the two factors of the experiment led to a meaningful impact on the plant height, providing the highest rate of plant height at the combination of licorice and dry yeast, with a plant height of 97.50 cm. Meanwhile, the lowest plant height rate came in plants without ground addition of licorice and dry yeast. The plant height reached 45.30 cm, significantly reduced compared with other treatments.

The outcomes further demonstrated the superior effects of adding licorice powder and dry yeast on plant height (Table 2). Ground addition with licorice powder resulted in the tallest plant height, particularly with the maximum percentage of licorice. Similarly, the highest plant height was visible when treating plants with the utmost rate of dry yeast. The interaction between licorice and dry yeast significantly affected plant height, with the combination resulting in the tallest plants. Conversely, plants without the addition of licorice and dry yeast had the shortest plant height. These findings highlight the positive influence of licorice and dry yeast on plant growth, receiving support from Hassan (2018).

Table 2. Effects of licorice and dry yeast on the plant height.

Licorice (g)	Dry yeast (g)			Means (cm)
	0	2.5	5	
0	45.30	64.50	87.04	65.73
5	48.50	71.40	88.50	69.47
10	55.20	81.40	97.50	78.03
Means (cm)	49.67	72.43	91.13	

$LSD_{0.05}$ Licorice: 3.764, Dry yeast: 3.764, Licorice × Dry yeast: 6.519

Numerous experiment-related factors can be the reason for the observed potassium levels' rise and fall. Potassium-rich substances found in licorice powder include glycyrrhizin and other minerals. The licorice powder helps release potassium ions into the soil, with plant roots absorbing these ions. It causes plants treated with licorice powder to have higher potassium levels. In addition to licorice powder, dry yeast may have raised the potassium levels. Among the nutrients found in dry yeast is potassium. Higher potassium levels manifested in treated plants when adding dry yeast to the soil, giving the plants another source of potassium (Abed and Al-Shaheen, 2021).

These findings align with the study conducted by Hassan (2018), which supports the increase in potassium levels attributed to the licorice powder available. Licorice powder contains potassium-rich substances, such as glycyrrhizin and other minerals. The release of potassium ions into the soil by licorice powder allows plant roots to uptake these ions, resulting in higher potassium levels in treated plants. Additionally, adding dry yeast may have contributed to the rise in potassium levels. Dry yeast contains nutrients, including potassium. Adding dry yeast to the soil serves as another source of potassium for plants, leading to increased potassium levels in treated plants.

Leaves per plant

The results revealed the transactions involving the ground addition at a high level of licorice are superior (729 leaves), with the most number of leaves produced per plant compared with other treatments (Table 3). The minimum number of leaves per plant appeared in the treatments without licorice (702 leaves) (check), and the lowest rate was evident in treatments not including licorice (695 leaves), which was significantly lower than other treatments. The findings provided in the table demonstrated superior treatments, including the ground addition with the greatest proline concentration (300 g), resulting in a rate of leaves produced per plant remarkably higher than other treatments (765 leaves). The treatments without ground addition of dry yeast (the control) had the minimum amount of leaves per plant, with a rate of 695 leaves, significantly lower than the rates of other treatments.

Regarding the interaction between the nano bio-enriched and dry yeast, the combination that produced the highest rate of leaves per plant (789 leaves) gave the highest rate of leaves per plant recorded (695 leaves). The treatments without ground addition with licorice and dry yeast (control) had the lowest rate of leaves per plant, with a significantly lower rate than other combinations. The results demonstrated that the transactions with ground addition at the maximum degree of enrichment (100 mg) and the maximum rate of leaf thickness had a considerable advantage over other treatments.

However, the minimum rate of leaf thickness appeared in the treatments with no licorice ground addition (0.330 mm) (control), and the lowest rate was apparent in plants without ground addition with licorice (0.210 mm), with a notable decrease compared with other treatments. The study's findings demonstrated the superiority of the coefficients for ground addition with dry yeast at the highest rate of leaf thickness (0.640 mm), which was meaningfully higher than the control treatment (0.620 mm), and at the lowest rate

Table *3.* Effects of licorice and dry yeast on the number of leaves per plant.

Licorice (g)	Dry yeast (g)			Means (#)
	0	100	200	
0	695	765	737	732
50	702	755	765	740
100	729	767	789	761
Means (#)	708	762	763	

$LSD_{0.05}$ Nano-Licorices: 6.31, Dry yeast: 6.31, Licorice × Dry yeast: 10.93

of leaf thickness (0.210 mm), which was significantly higher than other treatments. The measured maximum rate of leaf thickness was in plants with ground addition (0.740 mm), whereas the minimum rate in plants unreached with ground addition with any of the experiment's factors, giving the leaf thickness at 0.210 mm.

Licorice is a rich source of active plant compounds and beneficial chemicals. It contains various beneficial plant compounds, such as organic acids, flavonoids, terpenes, glycyrrhizinates, and steroids. The improvements in plant growth and productivity may be due to the effects of these active compounds in licorice on plant growth and activation of biological processes within the plant.

Licorice root extract's resemblance to gibberellins in promoting plant vegetative development is another potential explanation for its effects (AL-Shaheen *et al*., 2022). Yeast also contains nutrients, thiamine, riboflavin, niacin, vitamin B12, and folic acid, all known to promote growth. Other growth regulators in yeast that have helped stimulate plant growth include auxins, gibberellins, and cytokinins. The shoots have flourished because of these factors' positive effects on vegetative growth. Potassium is also present in the yeast solution, which is necessary for transporting the products of photosynthesis to storage organs and increasing the dry matter content (Abed and Al-Shaheen, 2021).

Leaf chlorophyll content

The data revealed the measurement of chlorophyll for plants with ground-added licorice powder compared with treatments without ground-added licorice powder (Table 4). The highest rate of chlorophyll was evident when plants attained ground addition with the highest percentage of licorice (6.05 mg 100 g^{-1} fresh weight) with a significant difference from other treatments reaching 4.04 mg 100 g^{-1} fresh weight). Meanwhile, the lowest rate of chlorophyll was 3.89 mg 100 g^{-1} fresh weight. A clear correlation between the amount of chlorophyll and the amount of licorice powder was prominent. The amount of chlorophyll recorded at the highest level was in plants with ground addition of the maximum amount of licorice powder (5.86 mg 100 g^{-1} fresh weight), which was 4.77 mg 100 g^{-1} fresh weight), indicating a significant difference from other studied treatments.

The comparative treatments reached 3.89 mg 100 g^{-1} fresh weight as the lowest reported percentage of chlorophyll. The interaction of the two experimental components significantly influenced chlorophyll, with its highest proportion at the combination of licorice powder and the licorice powder with chlorophyll (8.75 mg 100 g^{-1} fresh weight). The lowest fraction of chlorophyll recorded in plants was without ground addition with licorice powder and the licorice powder, where the chlorophyll reached 3.89 mg 100 g^{-1} fresh weight, providing a significant reduction compared with other treatments.

Dry yeast contains a high proportion of protein, vitamins, and essential minerals for plant growth. Dry yeast can enhance nutrition and improve the availability of nutrients for plants, leading to increased growth and productivity. The characteristics of dry yeast and licorice are responsible for these effects. Numerous bioactive substances in licorice, including triterpenoids, glycyrrhizin, and flavonoids, have proven to have plant growth-promoting properties. These substances could

Table 4. Effects of licorice and dry yeast on the chlorophyll content in leaves.

Licorice (g)	Dry yeast (g)			Means (mg. 100 g^{-1} fresh weight)
	0	2.5	5	
0	2.86	5.88	7.22	5.32
5	3.99	6.11	7.55	5.88
10	4.33	6.88	8.34	6.51
Means (mg. 100 g^{-1} fresh weight)	3.72	6.29	7.70	

$LSD_{0.05}$ Dry yeast: 0.3652, Licorice: 0.3652, Dry yeast × Licorice: 0.6326 enhance nutrient uptake, encourage root growth, and advance plant development. The exceptional performance of the licorice root extract may refer to the presence of trace metals like iron, zinc, and manganese, as well as mineral components like phosphorus, potassium, calcium, and magnesium. The activation of enzymes involved in several growth processes, including photosynthesis and the integration of mineral elements into the structure of RNA and DNA, two crucial building blocks for cell division, depend on these elements. (Hassan and AL-Shaheen, 2021).

The interaction of dry yeast, licorice powder, and potassium further increased potassium. Dry yeast and licorice powder may work in concert to improve plants' ability to absorb and use potassium. The highest potassium levels seen in the study are the consequence of applying licorice powder, dry yeast, and potassium together, as they create an ideal environment for potassium uptake and assimilation in plants***.*** On the other hand, the potassium levels were lower in plants without ground up, did not receive dry yeast, and no licorice-powder addition. It shows that lower potassium levels and decreased potassium uptake occurred due to the lack of licorice powder and extra nutrients from dry yeast in these treatments (Shurson, 2018).

Total potassium

The plants with the most added licorice powder had the highest rate of potassium (6.51%), which was significantly higher than other treatments (Table 5). In contrast, plants with no licorice powder had the lowest potassium level (5.32%). The plants with ground up, along with the amount of dry yeast used at its highest (5 g), achieved the maximum (6.51%), demonstrating a noticeable response to the addition of potassium, which was a notable departure from the other trial treatments. The lowest potassium level emerged in comparison treatments (2.86%). The interaction between the two experimental elements significantly affected potassium levels; the highest potassium level was evident when combining licorice powder and dry yeast, with potassium at 8.34%. The plants without crushed up added to the dry yeast and licorice powder had the minimum potassium levels, reaching 7.70%, with a substantially lower level than other treatments.

Numerous studies and agricultural experiments have extensively used lemongrass extracts to enhance fruit plant growth and productivity. Spraying lemongrass extract at a concentration of 4 g/liter has proven to improve the vegetative growth characteristics of Zahdi date palm trees. Similarly, foliar spraying of apple trees with concentrations of 5.2 and 5 g/liter of lemongrass extract improved their vegetative growth traits. Similarly, using lemongrass extract at 2 and 4 g/liter concentrations increased strawberry plants' leaf area and chlorophyll content. Additionally, foliar spraying with lemongrass extract at a concentration of 2 g/liter raised carbohydrate concentration in leaves and new branches, as well as the diameter of the main stem of peach trees (Sun *et al.,* 2019).

In general, the improved performance of licorice root extract is attributable to its mineral and trace element content, similarity to gibberellins in boosting development and growth-promoting agents and regulators in yeast. Together, these elements support

Table 5. Effects of licorice and dry yeast on the total potassium.

Licorice (g)	Dry yeast (g)			Means (%)
	0	2.5	5	
0	2.86	5.88	7.22	5.32
5	3.99	6.11	7.55	5.88
10	4.33	6.88	8.34	6.51
Means (%)	3.72	6.29	7.70	

$LSD_{0.05}$ Nano-Licorices: 0.3652, Nano proline: 0.3652, Nano-Licorices x Nano proline: 0.6326 increased vegetative advance and the buildup of dry matter in plants. Conversely, dry yeast is a better source of vital nutrients like phosphorus, nitrogen, and diverse vitamins. These nutrients are essential to plant growth and development. Phosphorus is crucial for energy transfer and root progress, while nitrogen is necessary for protein synthesis and complete plant growth. Dry yeast contains specific nutrients that can improve plant height and general growth (Shurson, 2018)).

The findings show that adding dry yeast and licorice to the ground benefited plant height. Licorice offers helpful bioactive compounds, and dry yeast provides vital nutrients that cause plants to grow taller. Licorice and dry yeast worked together to promote plant height synergistically. These results demonstrate the potential of utilizing dry yeast and licorice as growth-promoting agents in a plant culture (Hassan, 2023).

CONCLUSIONS

Incorporating licorice and dry yeast can enhance the growth and performance of *Stevia rebaudiana*. This method can help reduce reliance on chemical fertilizers and minimize their harmful environmental impact. The experiment demonstrated that adding 10 g of ground licorice and 5 g of dry yeast, individually or in combination, significantly improved the growth parameters and leaf quality of *S. rebaudiana*. These findings suggest that licorice and dry yeast utilization can be beneficial for cultivating this plant species.

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