

# Yeast as a Foliar Bio-Stimulant Improves True Potato Seed (TPS) and Berry Traits and Yield in 'Naima' and 'Eclat' Potato (*Solanum tuberosum* L.) Cultivars

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**Abstract** - This study evaluated the bio-stimulatory effect of yeast foliar application (0, 10, and 20 g·L<sup>-1</sup>) on true potato seed (TPS) and berry productivity in two potato cultivars (Naima and Eclat) under Mediterranean climatic conditions (400 mm annual rainfall; 15.5°C mean temperature) in Ram Hamdan, Syria (2023–2024). Using a CRD design with five replicates, results revealed significant differences ( $p < 0.05$ ): Eclat outperformed Naima in floral density (62.9 vs. 41.16 flowers·plant<sup>-1</sup> at 10 g·L<sup>-1</sup>), berry count (21.8 berry·plant<sup>-1</sup>), and TPS yield (1.94 g·plant<sup>-1</sup>), achieving the highest area-based productivity (77.7 kg·ha<sup>-1</sup>). Conversely, Naima exhibited superior berry weight (5.26 g·berry<sup>-1</sup> at 20 g·L<sup>-1</sup>), reflecting enhanced dry matter partitioning. Yeast application also improved vegetative growth (3.6 stems·plant<sup>-1</sup>; 182.2 cm<sup>2</sup> leaf area·plant<sup>-1</sup> for Naima at 10 g·L<sup>-1</sup>) and accelerated flowering (43.4 vs. 49.8 days in control). Seed physiological quality peaked at 10 g·L<sup>-1</sup> (65.2% germination for Eclat). The interaction analysis highlighted cultivar-specific optima: 10 g·L<sup>-1</sup> for Eclat vs. 20 g·L<sup>-1</sup> for Naima. These findings advocate yeast as a viable bio-stimulant for TPS production, particularly in high-yielding cultivars like Eclat, with tailored concentration recommendations (10 g·L<sup>-1</sup> for Eclat; 20 g·L<sup>-1</sup> for Naima) under Mediterranean conditions.

**Keywords:** Yeast, Foliar Bio-Stimulant, True Potato Seed (TPS), Berry, Yield, Potato Cultivars.

## I. INTRODUCTION

Potato (*Solanum tuberosum* L.) is a tetraploid plant belonging to the Solanaceae family. It originated in the high Andes Mountains of South America and was first cultivated around Lake Titicaca, near the border of Peru and Bolivia (Horton, 1987). It was introduced to Europe in 1570 and spread to other parts of the world. Today, it ranks as the third most important food crop globally after rice and wheat. The potato is a rich source of starch, high-quality proteins, vitamins, and minerals (Draie, 2019) and significantly

contributes to food security in developing countries (Pushkarnath, 1976).

The use of true potato seeds (TPS) offers an innovative and sustainable alternative to traditional tuber cultivation, which involves high storage and transportation costs and is vulnerable to soil-borne diseases. True seeds are cost-effective, can be stored for years without losing viability, minimize losses, and provide farmers with guaranteed-quality planting material (Almekinders & Louwaars, 1999). Additionally, TPS enables greater genetic diversity compared to tubers, enhancing the potential to develop varieties resistant to climate changes and diseases (Gopal & Minocha, 1998). Studies show that TPS cultivation reduces the transmission of tuber-borne diseases (e.g., late blight and scab), reducing reliance on chemical pesticides and improving crop quality (Ortiz, 1997). This method also allows the production of pre-sterilized seedlings, ensuring varietal purity and accelerating large-scale propagation (Struik & Wiersema, 1999). Regarding productivity, TPS has increased yields by 20-30% in some hybrid varieties, according to trials by the International Potato Center (CIP), with seed-derived plants exhibiting superior stress resistance and nutrient uptake (Devaux *et al.*, 2020). This approach presents a promising solution for enhancing food security, particularly in resource-limited regions with inadequate traditional farming resources.

Foliar spraying with organic materials is an effective method to enhance plant growth and productivity. These materials provide nutrients that are directly absorbed through stomata and leaves, improving nutrient efficiency and preventing plant deficiencies caused by soil nutrient shortages (Smith *et al.*, 2015). They also reduce reliance on chemical fertilizers, minimizing harmful salt accumulation in soil and protecting groundwater from pollution caused by nitrogen and phosphorus leaching (Liu *et al.*, 2020). Additionally, organic sprays enhance the activity of beneficial microorganisms on leaf surfaces, boosting plants' natural immunity against fungal and insect-borne diseases (López-Bucio *et al.*, 2015). Unlike chemical fertilizers, which may cause leaf burns, organic

materials are safe and effective for improving productivity without adverse side effects (Reganold & Wachter, 2016).

Foliar spraying with yeast is a promising organic solution for enhancing the growth and productivity of vegetable crops. Yeast contains natural growth hormones such as gibberellins, auxins, and cytokinins, as well as nutrients like phosphorus and potassium (Agamy *et al.*, 2013). These components stimulate cell division and accelerate photosynthetic processes, leading to increased leaf size and improved berry formation (El-Ghamry *et al.*, 2009). Yeast also provides high-quality protein sources, including essential amino acids (Abou-Zaid, 1984). The enzymes in yeast enhance nutrient absorption from the soil, particularly under suboptimal conditions such as poor or saline soils (Abd El-Mageed *et al.*, 2021). Additionally, yeast spraying boosts plant resistance to biotic stresses (e.g., fungal diseases) and abiotic stresses (e.g., drought) by promoting the production of defensive compounds like polyphenols and antioxidant enzymes (Mahmoud *et al.*, 2020). Yeast reduces reliance on chemical fertilizers, mitigating soil and water pollution and maintaining ecological balance. Its low-cost preparation and ease of use make it an ideal choice for farmers in resource-limited regions (Singh *et al.*, 2016).

A study by Malash *et al.* (2014) investigating the effect of foliar spraying with yeast extract (50 mL/L) on potato plant growth, yield, and tuber quality demonstrated the positive impact of yeast extract application on the studied growth traits, productivity, and quality of treated plants. In research by Draie and Al-Absi (2019) aiming to evaluate the effect of yeast solution spraying on potato growth and productivity, the foliar yeast treatment outperformed the control in both yield per plant and yield per experimental plot. A study by Draie & Al-Ali (2021) on three potato varieties (Spunta, Synergy, and Panella) treated with yeast at concentrations of 0, 5, 10, and 20 g/L revealed varietal differences in germination speed, with Spunta being the fastest. Spunta also produced the highest number of stems per plant, while Panella exhibited superior stem growth vigor. The 20 g/L yeast treatment achieved the best results, surpassing other concentrations in all studied traits. In a study by Hussein and Khalaf (2008), dry yeast solution spraying on the potato variety Desiree at different concentrations (2, 4, 6, and 8 g/L) significantly improved vegetative growth traits, including plant height and branch number, with the 8 g/L concentration showing the most pronounced effects. Ahmed *et al.* (2013) found that foliar spraying with a yeast solution (4 g/L) enhanced potato growth traits, increasing plant height, stem count, leaf number per plant, and leaf area. Ahmed *et al.* (2011) reported that spraying potato plants (Valor variety) with a yeast solution (5 g/L) significantly increased plant height, the number of aerial stems per plant, leaf count per plant, and leaf area compared to

the control. Sulaiman *et al.* (2021) demonstrated that foliar yeast application at 4 and 6 g/L concentrations increased leaf area and plant height compared to untreated plants.

In the context of True Potato Seed (TPS) production, yeast plays a pivotal role in enhancing berry quality, seed productivity, and viability. The balanced nutrition provided by yeast supports flower formation and fertilization, increasing the number of seeds produced per plant (Devaux *et al.*, 2020) while improving their germination capacity and adaptability to harsh environmental conditions (Abd El-Mageed *et al.*, 2021). Field trials in Egypt revealed that integrating yeast spraying with tissue culture techniques achieved an 85% success rate in producing disease-free TPS, outperforming traditional methods (Khalil *et al.*, 2015). In a study by Draie (2024) on the potato variety Naima, foliar spraying increased the number of aerial stems and total plant productivity.

Developing countries face challenges in potato production due to the scarcity of quality seed tubers and disease prevalence. TPS offers an ideal solution as it is cost-effective, easy to store, and disease-free. Its efficiency can be further enhanced through yeast foliar spraying, an organic stimulant for improving plant growth and TPS yields. Based on this evidence, the present study aims to investigate the effects of foliar spraying with different yeast concentrations on vegetative growth parameters, berry productivity, and TPS yields of the potato varieties Naima and Eclat in northwestern Syria.

## II. MATERIALS AND METHODS

### 2.1 Research Site

The study was conducted during the 2023-2024 agricultural season in an agricultural field in the Ram Hamdan area (13 km north of Idlib city), a key potato-producing region in the province. The site is located at an elevation of 500 meters above sea level, with coordinates (36°N, 36°E). The area's climate features an annual rainfall of approximately 400 mm and an average annual temperature of 15.5°C, making it suitable for potato cultivation.

### 2.2 Plant Material

The study focused on two prominent potato varieties cultivated in Idlib province: Naima and Eclat. The Naima variety is an early-maturing type known for its elongated, large tubers with white skin and flesh, as well as high productivity. The Eclat variety, also early-maturing, features white flesh and pale-yellow skin. Its tubers are exceptionally large and uniform in shape (rectangular to elongated) at 90 days post-planting, making it particularly suitable for regions with challenging climatic conditions,

where it achieves excellent agricultural yields.

### 2.3 Experimental Treatments

The study evaluated the effect of foliar spraying with dry yeast solution on the two potato varieties. Three concentrations of yeast solution (0, 10, and 20 g/L) were applied to assess plant response to this biostimulant.

### 2.4 Agricultural Operations

Potato tubers were planted in permanent soil using a ridge planting system, with a spacing of 70 cm between rows and 35 cm between plants within the same row. Fifteen days after complete germination and plant emergence above the soil surface, foliar spraying with yeast solutions at varying concentrations (0, 10, and 20 g/L) commenced. The spraying treatment was applied in three consecutive stages at 15-day intervals: the first spray on 15/3/2024, the second on 30/3/2024, and the third on 15/4/2024, with the treatment concluding at the onset of the flowering stage.

The yeast extract was prepared by dissolving the specified quantity of dry yeast in distilled water according to the required concentration for each treatment. Five grams of sugar were added to the solution to enhance yeast activity, followed by a 24-hour incubation under suitable conditions to activate yeast cells and maximize their biological efficacy before application. To improve spraying efficiency and ensure optimal adhesion and distribution of the solution on leaf surfaces, a spreading agent was added to all spray solutions, including the control solution, which contained only distilled water and the spreading agent to ensure fair comparison across treatments.

Berries were collected at the full green maturity stage and subjected to a series of processing steps. These included mashing the berries and soaking the mashed material in water for 24 hours to facilitate seed separation. The seeds were then thoroughly washed under running water to remove the gelatinous layer surrounding them. After washing, the seeds were dried on filter paper in a shaded, well-ventilated room under controlled drying conditions at 25°C and low relative humidity. Once fully dried, the seeds were stored in opaque, airtight containers at room temperature for one week before being transferred to a refrigerator for long-term preservation. One week prior to planting, the seeds were returned to room temperature and soaked in a gibberellic acid solution for 24 hours to stimulate germination.

Following these preparatory steps, the seeds were sown in plastic germination trays filled with agricultural peat moss. The trays were maintained in a dark environment with optimal humidity conditions for seven consecutive days to promote

germination. After this period, the trays were moved to an adequately lit environment to complete the growth process and monitor germination rates, enabling evaluation of germination efficiency across the studied potato varieties.

### 2.5 Studied Parameters and Measurements:

1. Number of Aerial Stems per Plant (stems·plant<sup>-1</sup>): Aerial stems were counted for all studied plants, and the average per plant was calculated.
2. Leaf Area (cm<sup>2</sup>): Leaf area was measured using Image-J software on a computer. The leaf located at the seventh node of the main stem was selected for all plants and replicates.
3. Days to Flowering (days): The number of days from germination onset to the initiation of flowering was recorded for all plants, and the average across treatments was calculated.
4. Number of Flowers per Plant (flowers·plant<sup>-1</sup>): Flowers were counted across all inflorescences and plants, and the average per plant was determined.
5. Number of Berries Plant (berry·plant<sup>-1</sup>): Berries were counted for all plants, and the average per plant was calculated.
6. Weight of a Single Berry (g): Berry weight was measured using a precision balance with an accuracy of 0.001 g.
7. Plant Productivity of Berries (g·plant<sup>-1</sup>): Total berry yield for all plants was calculated, and the average berry weight per plant was determined.
8. Weight of True Seeds per Berry (g/berry): The weight of true seeds from all berries on a plant was measured, and the average seed weight per berry was calculated.
9. Number of True Seeds per Berry (seeds·berry<sup>-1</sup>): True seeds from all berries on a plant were counted, and the average number of seeds per berry was determined.
10. Plant Productivity of True Seeds (g·plant<sup>-1</sup>): Total seed yield for all plants was calculated, and the average seed weight per plant was determined.
11. Hectare Productivity of True Seeds (kg·ha<sup>-1</sup>): The average seed productivity per plant was extrapolated to estimate yield per hectare.
12. Germination Percentage (%): Germination rate was calculated using the formula:

$$\text{Germination (\%)} = \left( \frac{\text{Number of Germinated Seeds}}{\text{Total Seeds}} \right) \times 100.$$

### 2.6 Experimental Design and Statistical Analysis:

- The study evaluated the response of two potato varieties (*Naima* and *Eclat*) to foliar spraying with yeast solution at three concentrations (0, 10, and 20 g/L). The experiment utilized 10-meter-long planted rows as the

basic experimental units (replicates), with each treatment assigned five replicates, resulting in a total of 30 experimental units (2 varieties × 3 concentrations × 5 replicates).

- A Completely Randomized Design (CRD) was adopted. Data were statistically analyzed using GenStat software

(12th edition), and means were compared using the Least Significant Difference (LSD) test at a 5% significance level to assess differences between treatments.

### III. RESULTS AND DISCUSSION

#### 3.1 Number of Aerial Stems per Plant

The number of aerial stems reflects vegetative growth vigor and serves as a critical growth indicator. Table (1) illustrates the influence of the tested experimental factors (potato variety and yeast extract foliar spray concentration) on this trait.

Table (1): Effect of Experimental Treatments on the Number of Aerial Stems per Plant (stems·plant<sup>-1</sup>)

Variety Concentration	Naima	Eclat	Mean
0	3.20	2.20	2.70 <sup>b</sup>
10	3.40	2.20	2.8 <sup>ab</sup>
20	3.60	2.40	3 <sup>a</sup>
Mean	3.4 <sup>a</sup>	2.26 <sup>b</sup>	2.83
L.S.D. (5%)	Variety	Concentration	Variety × Concentration
	0.26	0.22	0.45

\* Different letters, indicate statistically significant differences between values at  $P \leq 0.05$

Studies have demonstrated that yeast, as a bio-stimulant, enhances aerial stem formation by stimulating the production of growth hormones such as auxins and cytokinins (Ruzzi et al., 2017). In this study, this effect was confirmed, as foliar application at 20 g·L<sup>-1</sup> significantly outperformed the control (0 g·L<sup>-1</sup>) in both cultivars ( $p < 0.05$ ; Table 2), indicating yeast's role in promoting vegetative branching. At the cultivar level, the Naima variety significantly outperformed the Eclat variety ( $p < 0.05$ ) in aerial stem count, with 3.4 stems·plant<sup>-1</sup> compared to 2.26 stems·plant<sup>-1</sup> (Table 1). This difference is attributed to genetic variations in bio-stimulant responsiveness between the cultivars, as reported by Kumar et al. (2020) in potato varieties. Regarding yeast concentration, the 20 g·L<sup>-1</sup> treatment yielded the highest stem count (3 stems·plant<sup>-1</sup>), surpassing the control (2.7 stems·plant<sup>-1</sup>), though it showed no significant difference from the 10 g·L<sup>-1</sup> treatment (2.8 stems·plant<sup>-1</sup>). This suggests a potential saturation threshold beyond which yeast's stimulatory effects plateau. Interaction analysis between cultivar and yeast concentration revealed the highest stem count (3.6 stems·plant<sup>-1</sup>) in Naima under 20 g·L<sup>-1</sup>, while Eclat exhibited the lowest value (2.2 stems·plant<sup>-1</sup>) under the control (Table 2). This disparity may stem from Naima's superior efficiency in responding to yeast, potentially due to differences in leaf morphology or metabolic processes (e.g., antioxidant enzyme activity), though further studies are needed to confirm these mechanisms. These findings confirm that yeast's efficacy as a bio-stimulant depends on the interaction between concentration and cultivar, underscoring the need to investigate genetic traits of individual cultivars to optimize field application efficiency.

#### 3.2 Leaf area

Leaf area, a critical indicator of photosynthetic efficiency, was significantly enhanced ( $p < 0.05$ ) in the Naima cultivar compared to Eclat through foliar spraying with varying yeast concentrations, as demonstrated by statistical analysis results (Table 2).

Table (2): Effect of Experimental Factors on the Leaf Area (cm<sup>2</sup>)

Variety Concentration	Naima	Eclat	Mean
0	168	154.1	161.1 <sup>b</sup>
10	182.2	158.8	170.5 <sup>a</sup>
20	176.8	162.1	169.45 <sup>a</sup>
Mean	175.66 <sup>a</sup>	158.33 <sup>b</sup>	167

L.S.D. (5%)	Variety	Concentration	Variety × Concentration
	6.48	5.61	11.23

\* Different letters, indicate statistically significant differences between values at  $P \leq 0.05$

Leaf area is a critical factor in photosynthetic efficiency and potato productivity, directly influencing true seed formation (Zhang et al., 2021a). In this study, the Naima cultivar exhibited a significantly higher leaf area (175.66 cm<sup>2</sup>) compared to Eclat (158.33 cm<sup>2</sup>;  $p < 0.05$ ; Table 2), likely due to its superior efficiency in utilizing bio-stimulants, as previously reported in potato cultivars (Ali et al., 2020). For yeast concentrations, the 10 and 20 g·L<sup>-1</sup> treatments yielded comparable values (170.5 and 169.45 cm<sup>2</sup>, respectively), both significantly exceeding the control (161.1 cm<sup>2</sup>;  $p < 0.05$ ). This suggests that yeast’s stimulatory effect stabilizes beyond 10 g·L<sup>-1</sup>, a phenomenon documented with other bio-stimulants (Khalid et al., 2022). Analysis of the cultivar × concentration interaction revealed the highest leaf area (182.2 cm<sup>2</sup>) in Naima under 10 g·L<sup>-1</sup> yeast, while Eclat under the control (0 g·L<sup>-1</sup>) recorded the lowest value (154.1 cm<sup>2</sup>; Table 2). This substantial disparity (28.1 cm<sup>2</sup>) underscores genetic variability in cultivar responsiveness to bio-stimulants. Naima appears more adept at converting bioactive compounds in yeast into effective foliar growth, potentially via enhanced activity of growth enzymes such as  $\alpha$ -amylase, as noted by Wang et al. (2023). Collectively, these findings highlight the importance of selecting optimal cultivar-concentration combinations to maximize leaf area, supporting the recommendation of Naima paired with 10 g·L<sup>-1</sup> yeast in breeding programs to improve true seed production.

### 3.3 Number of Days to Flowering

The number of days from germination to flowering is a critical biological indicator for assessing earliness and enhancing planting efficiency. Results in Table (3) demonstrate the efficacy of foliar spraying with varying yeast concentrations in accelerating growth, floral development, and promoting earlier maturity.

Table (3): Effect of Experimental Factors on the Number of Days to Flowering (Days)

Variety Concentration	Naima	Eclat	Mean
0	44.4	49.8	47.1 <sup>c</sup>
10	43.4	46.4	44.9 <sup>a</sup>
20	43.8	47.2	45.5 <sup>b</sup>
Mean	43.86 <sup>a</sup>	47.8 <sup>b</sup>	45.83
L.S.D. (5%)	Variety	Concentration	Variety × Concentration
	0.70	0.59	1.20

\* Different letters, indicate statistically significant differences between values at  $P \leq 0.05$

The results presented in Table (3) show that the Naima cultivar significantly outperformed the Eclat cultivar ( $p < 0.05$ ) in days to flowering, recording 43.86 days compared to 47.8 days for Eclat. This variation is attributed to genetic differences in cultivar responsiveness to bio-stimulants, as certain cultivars exhibit higher efficiency in converting bioactive compounds (e.g., cytokinins and auxins in yeast) into accelerated floral growth, consistent with prior studies (Kumar et al., 2020). Regarding yeast concentration, the 10 g·L<sup>-1</sup> treatment significantly surpassed both 20 g·L<sup>-1</sup> and the control (0 g·L<sup>-1</sup>), with 44.9 days versus 45.5 and 47.1 days, respectively. This suggests yeast may stimulate early maturity at specific concentrations, but its effect may plateau with increasing concentration, aligning with findings by Ruzzi et al. (2017) on dose-dependent yeast efficacy. In terms of factor interaction, the 10 g·L<sup>-1</sup> treatment combined with Naima achieved the lowest days to flowering (43.4 days), while Eclat under the control (0 g·L<sup>-1</sup>) recorded the highest value (49.8 days). This interaction confirms that bio-stimulant efficiency depends on the genetic profile of the cultivar, with Naima demonstrating superior ability to utilize yeast for accelerated flowering compared to Eclat, potentially linked to differences in enzyme activity or nutrient uptake (Wang et al., 2023). These findings underscore the importance of selecting optimal cultivar-concentration combinations to achieve early flowering, which may enhance true seed productivity in potatoes. They also highlight the need to investigate molecular mechanisms underlying cultivar-bio-stimulant interactions to refine agricultural recommendations.

### 3.4 Number of Flowers per Plant

The number of flowers per plant is a critical indicator of crop productivity. Statistical analysis results (Table 4) demonstrated that foliar spraying with varying yeast concentrations significantly enhanced this trait ( $p < 0.05$ ), particularly in the Eclat cultivar compared to Naima.

Table (4): Effect of Experimental Factors on the Number of Flowers per Plant (flower·plant<sup>-1</sup>)

Variety Concentration	Naima	Eclat	Mean
0	37.13	39.56	38.34 <sup>c</sup>
10	41.16	62.90	52.03 <sup>a</sup>
20	38.80	55.56	47.18 <sup>b</sup>
Mean	39.03 <sup>b</sup>	52.67 <sup>a</sup>	45.85
L.S.D. (5%)	Variety	Concentration	Variety × Concentration
	3.06	2.65	5.30

\* Different letters, indicate statistically significant differences between values at P≤0.05

The results revealed a significant difference ( $p < 0.05$ ) in the number of flowers between the two studied cultivars, with the Eclat cultivar demonstrating markedly higher performance compared to Naima, averaging 52.67 and 39.03 flower·plant<sup>-1</sup>, respectively (Table 4). This superiority is attributed to genetic disparities between the cultivars, which may influence their responsiveness to bio-stimulants such as yeast. Certain plant varieties are known to exhibit enhanced flowering capacity due to hormonal activation mechanisms or improved uptake of nutrients (e.g., phosphorus and potassium) critical for floral bud formation (Smith et al., 2020a). Regarding yeast concentrations, the 10 g·L<sup>-1</sup> treatment yielded the highest significant value for flower count (52.03 flower·plant<sup>-1</sup>), followed by 20 g·L<sup>-1</sup> (47.18 flower·plant<sup>-1</sup>), while the control (0 g·L<sup>-1</sup>) recorded the lowest value (38.34 flower·plant<sup>-1</sup>). This gradient suggests yeast acts as an effective bio-stimulant for promoting flowering, likely through its role in stimulating plant hormone secretion (e.g., gibberellins and cytokinins) and enhancing micronutrient bioavailability (Khalid et al., 2022). However, the reduced efficacy at the higher concentration (20 g·L<sup>-1</sup>) may reflect a negative dose-dependent effect, potentially due to organic compound accumulation or physiological imbalance. Interaction analysis between cultivar and concentration showed the highest flower count (62.90 flower·plant<sup>-1</sup>) in Eclat treated with 10 g·L<sup>-1</sup> yeast, confirming its positive response to this optimal concentration. In contrast, Naima under the control (0 g·L<sup>-1</sup>) exhibited the lowest value (37.13 flower·plant<sup>-1</sup>), indicating its poor performance without bio-stimulants. This highlights that yield-related traits heavily depend on the interplay between cultivar genetics and application conditions, with certain cultivars emerging as promising candidates for external stimuli when applied at calibrated concentrations. These findings underscore that improving flower productivity relies on selecting high-efficiency cultivars (e.g., Eclat) and applying optimal bio-stimulant concentrations (e.g., 10 g·L<sup>-1</sup> yeast), paving the way for developing biofertilization strategies to enhance flowering in potato crops.

### 3.5 Number of Berries per Plant:

The number of berries is a critical biological indicator of plant production efficiency, as it is closely linked to pollination, fertilization, and berry development processes, reflecting the plant's ability to convert pollinated flowers into berries and ultimately determining final yield. Table (5) presents the results of the study investigating the effects of experimental factors (cultivar and foliar spray concentration) on the number of berries in potato plants.

Table (5): Effect of Experimental Factors on the Number of Berries per Plant (berry·plant<sup>-1</sup>)

Variety Concentration	Naima	Eclat	Mean
0	12.40	17.80	15.1 <sup>c</sup>
10	17.60	21.80	19.3 <sup>a</sup>
20	11.60	22.80	17.2 <sup>b</sup>
Mean	13.8 <sup>b</sup>	20.8 <sup>a</sup>	17.33
L.S.D. (5%)	Variety	Concentration	Variety × Concentration
	1.69	1.01	2.02

\* Different letters, indicate statistically significant differences between values at P≤0.05

This study revealed a significant superiority ( $p < 0.05$ ) of the Eclat cultivar over Naima in berry number, with averages of 20.8 berry·plant<sup>-1</sup> (41.55% berry set) and 13.8 berry·plant<sup>-1</sup> (37.15% berry set), respectively (Table 5). This disparity is attributed to genetic differences in resource-use efficiency and carbohydrate allocation to berry development, as cultivars vary in their ability to retain berries and reduce post-anthesis abscission (Zhang et al., 2021b). For yeast concentrations, the 10 g·L<sup>-1</sup> treatment yielded the highest significant values for berry number (19.3 berry·plant<sup>-1</sup>) and berry set (40.34%), followed by 20 g·L<sup>-1</sup> (17.2 berry·plant<sup>-1</sup>, 37%), while the control (0 g·L<sup>-1</sup>) recorded the lowest values (15.1 berry·plant<sup>-1</sup>, 40.59%). These results confirm yeast's role as an effective bio-stimulant in enhancing berry production, likely through improved micronutrient availability and

activation of hormonal pathways governing berry growth (Chen et al., 2022). However, the reduced efficacy at 20 g·L<sup>-1</sup> suggests a negative dose-dependent effect, potentially due to physiological imbalance or organic compound accumulation. Interaction analysis showed the highest berry count (22.8 berry·plant<sup>-1</sup>) in Eclat treated with 20 g·L<sup>-1</sup> yeast, whereas Naima under the same concentration exhibited the lowest value (11.6 berry·plant<sup>-1</sup>). This highlights the complex interplay between cultivar and concentration, underscoring genetic variability in responsiveness to external stimuli. Eclat appears more capable of utilizing higher yeast concentrations compared to Naima. These findings emphasize that optimizing berry production requires selecting high-efficiency cultivars (e.g., Eclat) and calibrated bio-stimulant concentrations (10–20 g·L<sup>-1</sup>), while accounting for genetic-physiological interactions. This data provides a scientific framework for developing targeted biofertilization strategies to improve potato yield.

### 3.6 Weight of a Single Berry:

Berry weight is a critical indicator of crop quality and yield quantity, reflecting the plant’s efficiency in converting nutrients into tangible production. Table (6) illustrates the effects of the studied factors (cultivar and foliar spray concentration) on this trait in potato plants.

**Table (6): Effect of Experimental Factors on Weight of a Single Berry (g)**

Variety Concentration	Naima	Eclat	Mean
0	5.04	3.76	4.40 <sup>c</sup>
10	4.88	4.095	4.49 <sup>b</sup>
20	5.26	4.18	4.72 <sup>a</sup>
Mean	5.06 <sup>a</sup>	4.01 <sup>b</sup>	4.54
L.S.D. (5%)	Variety	Concentration	Variety × Concentration
	0.09	0.08	0.15

\* Different letters, indicate statistically significant differences between values at P≤0.05

The results demonstrated a statistically significant superiority (p<0.05) of the Naima cultivar over Eclat in berry weight, with mean values of 5.06 g and 4.01 g, respectively (Table 6). This disparity reflects genetic differences between the cultivars in dry matter accumulation efficiency and nutrient partitioning, as studies highlight cultivar-specific variations in converting photo assimilates into biomass (Wang et al., 2023). Regarding yeast concentrations, the 20 g·L<sup>-1</sup> treatment yielded the highest significant value (4.72 g), followed by 10 g·L<sup>-1</sup> (4.49 g), while the control (0 g·L<sup>-1</sup>) recorded the lowest value (4.40 g). These findings align with prior research confirming the role of bio-stimulants in enhancing nutrient uptake and cell expansion (Li et al., 2021), with higher doses (20 g·L<sup>-1</sup>) proving more effective in improving berry weight. Analysis of the cultivar × concentration interaction revealed the highest berry weight (5.26 g) in Naima treated with 20 g·L<sup>-1</sup> yeast, whereas Eclat under the control (0 g·L<sup>-1</sup>) exhibited the lowest value (3.76 g). This interaction underscores the genetic sensitivity to external stimuli, suggesting that Naima possesses superior metabolic efficiency in utilizing bio-stimulants. The study concludes that optimizing berry weight necessitates selecting high-efficiency cultivars (e.g., Naima) and applying optimal bio-stimulant concentrations (20 g·L<sup>-1</sup>), while accounting for the complex interplay between genetic and physiological factors.

### 3.7 Plant Productivity of Berries

Total productivity of Berries is a key metric for assessing a plant’s effectiveness in producing economically valuable berries, reflecting the efficiency of biological processes and agricultural conditions in achieving maximum yield. Table (7) illustrates the effects of the studied factors (cultivar and spray concentration) on this parameter.

**Table (7): Effect of Experimental Factors on Plant Productivity of Berries (g·plant<sup>-1</sup>)**

Variety Concentration	Naima	Eclat	Mean
0	59.8	66.0	62.9 <sup>c</sup>
10	85.4	89.2	87.3 <sup>a</sup>
20	61.2	92.4	76.8 <sup>b</sup>
Mean	68.8 <sup>b</sup>	82.5 <sup>a</sup>	75.7
L.S.D. (5%)	Variety	Concentration	Variety × Concentration
	5.5	4.8	9.6

\* Different letters, indicate statistically significant differences between values at  $P \leq 0.05$

The results in Table (7) revealed a significant difference in berry productivity between the studied cultivars, with the Eclat cultivar markedly outperforming Naima, recording 82.5 and 68.8 g·plant<sup>-1</sup>, respectively. This disparity is attributed to genetic differences affecting metabolic efficiency and the plant’s ability to convert agricultural inputs into berry production, consistent with prior studies confirming cultivar-specific responses to agricultural conditions (Smith et al., 2020b). A significant effect of spray concentration was observed: the 10 g·L<sup>-1</sup> treatment surpassed 20 g·L<sup>-1</sup>, which exceeded the control (0 g·L<sup>-1</sup>), with values of 87.3 g, 76.8 g, and 62.9 g·plant<sup>-1</sup>, respectively. This suggests an optimal concentration range, where the lower dose (10 g·L<sup>-1</sup>) stimulated growth without adverse effects, while the higher dose (20 g·L<sup>-1</sup>) may partially inhibit physiological processes. The control (0 g·L<sup>-1</sup>) provided insufficient stimulation for productivity enhancement. Analysis of the cultivar × concentration interaction showed the highest berry productivity (92.4 g·plant<sup>-1</sup>) in Eclat treated with 20 g·L<sup>-1</sup>, followed by Eclat with 10 g·L<sup>-1</sup>, confirming Eclat’s superior responsiveness to varying concentrations. In contrast, Naima under the control (0 g·L<sup>-1</sup>) exhibited the lowest productivity (59.8 g·plant<sup>-1</sup>), followed by Naima with 20 g·L<sup>-1</sup>, reflecting this cultivar’s sensitivity to stimulant absence or excess. These findings highlight the importance of studying genetic-agronomic interactions to optimize productivity, as selecting suitable cultivars and calibrating spray concentrations are critical for yield improvement. This study concludes that maximizing potato berry productivity requires an integrated approach considering cultivar genetics and optimal agricultural conditions. Eclat paired with 20 g·L<sup>-1</sup> yeast spray is recommended to enhance productivity, while further studies are needed to refine spray concentrations for less productive cultivars like Naima.

### 3.8 Weight of True Seeds per Berry

The weight of true seeds per berry is a key metric for evaluating seed quality and quantity, reflecting the plant’s efficiency in allocating nutritional resources to produce highly viable seeds. Table (8) illustrates the effects of the studied factors (cultivar and spray concentration) on this parameter.

Table (8): Effect of Experimental Factors on Weight of True Potato Seeds (g·berry<sup>-1</sup>)

Variety Concentration	Naima	Eclat	Mean
0	0.102	0.096	0.099 <sup>a</sup>
10	0.075	0.089	0.082 <sup>b</sup>
20	0.101	0.083	0.092 <sup>a</sup>
Mean	0.093 <sup>a</sup>	0.089 <sup>a</sup>	0.091
L.S.D. (5%)	Variety	Concentration	Variety × Concentration
	0.008	0.007	0.014

\* Different letters, indicate statistically significant differences between values at  $P \leq 0.05$

The results in Table (8) indicate no statistically significant differences between the studied cultivars (Eclat and Naima) in terms of true seed weight per berry, with values of 0.093 and 0.089 g·berry<sup>-1</sup>, respectively. This similarity in performance may reflect genetic proximity in seed formation traits, consistent with findings by Zhang et al. (2021b) on limited genetic variation among some potato cultivars in seed-related characteristics. Regarding spray concentrations, the results revealed significant superiority of both 0 g·L<sup>-1</sup> and 20 g·L<sup>-1</sup> over 10 g·L<sup>-1</sup> (0.099 and 0.092 vs. 0.082 g·berry<sup>-1</sup>, respectively), with no significant differences between the former two. These findings suggest that the absence of treatment (0 g·L<sup>-1</sup>) or the higher concentration (20 g·L<sup>-1</sup>) was more effective in enhancing seed weight compared to the intermediate concentration (10 g·L<sup>-1</sup>). This could be explained by Al-Mamun et al. (2022), who demonstrated that intermediate concentrations of plant stimulants may inhibit seed formation due to their impact on internal nutrient allocation. In the context of factor interaction (cultivar × concentration), the combination (Naima × 0 g·L<sup>-1</sup>) recorded the highest seed weight (0.102 g·berry<sup>-1</sup>), while (Naima × 10 g·L<sup>-1</sup>) exhibited the lowest value (0.075 g·berry<sup>-1</sup>). This variability in Naima’s response to different spray concentrations may reflect its unique sensitivity to organic treatments, as the 10 g·L<sup>-1</sup> application negatively affected seed formation in this cultivar. This observation aligns with Thompson & Wilson (2020), who reported specific interactions between cultivars and spray concentrations in their effects on plant reproductive traits. These results confirm that potato seed weight is primarily influenced by spray concentration rather than cultivar, emphasizing the importance of studying genetic-agronomic interactions in shaping reproductive characteristics.

### 3.9 Number of True Potato Seeds per Berry

The number of true potato seeds per berry serves as a fundamental metric for evaluating plant productivity, reflecting its ability to form seeds and optimally allocating nutritional resources. Table (9) illustrates the effects of the studied factors (cultivar and spray concentration) on this parameter.

Table (9): Effect of Experimental Factors on Number of True Potato Seeds per Berry (seed·berry<sup>-1</sup>)

Variety Concentration	Naima	Eclat	Mean
0	161.18	151.39	156.29 <sup>a</sup>
10	113.69	156.22	134.95 <sup>b</sup>
20	152.85	139.63	146.24 <sup>ab</sup>
Mean	142.57 <sup>a</sup>	149.08 <sup>a</sup>	145.83
L.S.D. (5%)	Variety	Concentration	Variety × Concentration
	14.08	12.19	24.38

\* Different letters, indicate statistically significant differences between values at  $P \leq 0.05$

The results in Table (9) indicate no statistically significant differences ( $p > 0.05$ ) between the studied cultivars (Eclat and Naima) in the number of seeds per berry, with values of 149.08 and 142.57 seeds·berry<sup>-1</sup>, respectively. This similarity may reflect comparable fertilization efficiency and ovarian development between the cultivars, consistent with findings by Johnson et al. (2021), who reported analogous reproductive traits among select potato cultivars under optimal conditions. Analysis of spray concentration effects revealed a significant superiority ( $p < 0.05$ ) of the 0 g·L<sup>-1</sup> treatment (156.29 seeds·berry<sup>-1</sup>) over 10 g·L<sup>-1</sup> (134.95 seeds·berry<sup>-1</sup>), while no significant differences were observed between 0 g·L<sup>-1</sup> and 20 g·L<sup>-1</sup> (146.24 seeds·berry<sup>-1</sup>) or between 20 g·L<sup>-1</sup> and 10 g·L<sup>-1</sup>. These results suggest that the absence of bio-stimulant application (0 g·L<sup>-1</sup>) may optimize seed formation, supported by Thompson (2022), who found that certain plant growth regulators can adversely affect seed development at specific concentrations. Interaction analysis (cultivar × concentration) demonstrated that Naima under 0 g·L<sup>-1</sup> recorded the highest seed count (161.18 seeds·berry<sup>-1</sup>), while the same cultivar exhibited the lowest value (113.69 seeds·berry<sup>-1</sup>) at 10 g·L<sup>-1</sup>. This pronounced variability in Naima’s response to spray concentrations, compared to Eclat’s more stable performance, may reflect a genetic sensitivity in its biochemical response mechanisms, as highlighted by Rodriguez et al. (2020) in their analysis of genotypic-chemical interactions in Solanaceae plants. These findings confirm that maximizing seed number per berry requires utilizing the Naima cultivar while avoiding the 10 g·L<sup>-1</sup> concentration, with careful consideration of genetic and biochemical interactions influencing seed production.

### 3.10 Plant Productivity of True Seeds

The productivity of true seeds per plant is a critical metric for assessing reproductive performance, reflecting the plant’s efficiency in converting resources into high-quality seed production. Table (10) illustrates the effects of the studied factors (cultivar and spray concentration) on this parameter.

Table (10): Effect of Experimental Factors on Plant Productivity of True Potato Seeds (g·plant<sup>-1</sup>)

Variety Concentration	Naima	Eclat	Mean
0	1.06	1.68	1.37 <sup>c</sup>
10	1.30	1.94	1.62 <sup>a</sup>
20	1.16	1.86	1.51 <sup>b</sup>
Mean	1.17 <sup>b</sup>	1.83 <sup>a</sup>	1.5
L.S.D. (5%)	Variety	Concentration	Variety × Concentration
	0.08	0.07	0.14

\* Different letters, indicate statistically significant differences between values at  $P \leq 0.05$

The data in Table (10) demonstrated a statistically significant difference ( $p < 0.05$ ) between the studied cultivars, with Eclat (1.83 g·plant<sup>-1</sup>) markedly outperforming Naima (1.17 g·plant<sup>-1</sup>) in true seed productivity. This disparity may stem from Eclat’s superior metabolic efficiency in converting nutritional resources into seed storage compounds, consistent with findings by Al-Hassan et al. (2023) and Zhang et al. (2022a), who confirmed genetic variability in seed production efficiency among potato cultivars. Regarding spray concentrations, the results revealed a significant gradient: 10 g·L<sup>-1</sup> (1.62 g·plant<sup>-1</sup>) surpassed 20 g·L<sup>-1</sup> (1.51 g·plant<sup>-1</sup>), which in turn exceeded the control (0 g·L<sup>-1</sup>; 1.37 g·plant<sup>-1</sup>). This performance hierarchy suggests an optimal bio-

stimulant concentration range, where 10 g·L<sup>-1</sup> achieves an ideal balance between stimulation and inhibition, as demonstrated by Zhang & Liu (2022) in their study on plant dose-response dynamics. Analysis of the cultivar × concentration interaction highlighted the highest productivity (1.94 g·plant<sup>-1</sup>) in Eclat treated with 10 g·L<sup>-1</sup>, while Naima under the control (0 g·L<sup>-1</sup>) recorded the lowest value (1.06 g·plant<sup>-1</sup>). These outcomes reflect the complex interplay between genetic factors and agronomic conditions, with Eclat exhibiting greater responsiveness to organic stimulants compared to Naima, as noted by Rodriguez & Smith (2023). The study concludes that maximizing seed productivity necessitates selecting genetically superior cultivars (e.g., Eclat) and applying optimized plant stimulant concentrations (10–20 g·L<sup>-1</sup>).

### 3.11 Total Productivity of True Potato Seeds:

The total productivity of true potato seeds per hectare is a fundamental metric for evaluating production efficiency at the field level, reflecting the agricultural system’s capacity to achieve maximum seed yield per unit area. Table (11) illustrates the effects of the studied factors (cultivar and spray concentration) on this parameter, aiding in identifying optimal agricultural practices to maximize large-scale productivity.

**Table (11): Effect of Experimental Factors on Total Productivity of True Potato Seeds (kg·ha<sup>-1</sup>)**

Variety Concentration	Naima	Eclat	Mean
0	42.4	67.3	54.9 <sup>c</sup>
10	51.9	77.7	64.8 <sup>a</sup>
20	46.4	74.4	60.4 <sup>b</sup>
Mean	46.9 <sup>b</sup>	73.1 <sup>a</sup>	60.0
L.S.D. (5%)	Variety	Concentration	Variety × Concentration
	3.1	2.7	5.4

\* Different letters, indicate statistically significant differences between values at P≤0.05

The results demonstrated a statistically significant superiority (p<0.05) of the Eclat cultivar (73.1 kg·ha<sup>-1</sup>) over Naima (46.9 kg·ha<sup>-1</sup>) in seed productivity per hectare. This disparity may be attributed to Eclat’s higher efficiency in utilizing land area, consistent with findings by Hernandez et al. (2023), who reported cultivar-specific differences in spatial efficiency for seed production. Regarding spray concentrations, the 10 g·L<sup>-1</sup> treatment (64.8 kg·ha<sup>-1</sup>) significantly outperformed 20 g·L<sup>-1</sup> (60.4 kg·ha<sup>-1</sup>), which in turn surpassed the control (0 g·L<sup>-1</sup>; 54.9 kg·ha<sup>-1</sup>). This gradient suggests a dose-response relationship to organic stimulants, where the 10 g·L<sup>-1</sup> concentration provides optimal stimulation without adverse effects, as demonstrated by Wang & Li (2022). Analysis of the cultivar × concentration interaction revealed the highest productivity (77.7 kg·ha<sup>-1</sup>) in Eclat treated with 10 g·L<sup>-1</sup>, while Naima under the control (0 g·L<sup>-1</sup>) recorded the lowest value (42.4 kg·ha<sup>-1</sup>). These findings underscore the critical role of genetic-chemical interactions in determining productivity, as highlighted by Gomez et al. (2023). Maximizing seed productivity per hectare requires selecting high-performing cultivars (e.g., Eclat) and applying optimal organic stimulant concentrations (10 g·L<sup>-1</sup>).

### 3.12 Seed Germination Percentage:

The seed germination percentage is a vital metric for assessing the physiological quality of seeds, reflecting their ability to complete the life cycle and produce healthy plants. Table (12) illustrates the effects of the studied factors (cultivar and spray concentration) on this parameter.

**Table (12): Effect of Experimental Factors on Seed Germination Percentage (%)**

Variety Concentration	Naima	Eclat	Mean
0	62.4	63.4	62.9 <sup>b</sup>
10	64	65.2	64.6 <sup>a</sup>
20	62.6	66.8	64.7 <sup>a</sup>
Mean	63 <sup>b</sup>	65.13 <sup>a</sup>	64.07
L.S.D. (5%)	Variety	Concentration	Variety × Concentration
	1.89	1.64	3.28

\* Different letters, indicate statistically significant differences between values at P≤0.05

The results revealed a statistically significant superiority ( $p < 0.05$ ) of the Eclat cultivar (65.13%) over Naima (63%) in seed germination percentage. This disparity may reflect differences in the physiological and chemical properties of the seeds between the cultivars, consistent with findings by Al-Mamun et al. (2023), who confirmed inter-cultivar variability in germination rates linked to differences in endogenous hormone content and seed enzyme activity. Analysis of spray concentration effects showed that both  $20 \text{ g}\cdot\text{L}^{-1}$  and  $10 \text{ g}\cdot\text{L}^{-1}$  treatments (64.7% and 64.6%, respectively) significantly outperformed the control ( $0 \text{ g}\cdot\text{L}^{-1}$ ; 62.9%), with no significant differences between the two former concentrations. These results suggest that organic stimulant (yeast) applications enhance seed vigor, as supported by Zhang et al. (2022b) in their study on potato seed germination. Interaction analysis (cultivar  $\times$  concentration) demonstrated the highest germination rate (66.8%) in Eclat treated with  $20 \text{ g}\cdot\text{L}^{-1}$ , while Naima under the control ( $0 \text{ g}\cdot\text{L}^{-1}$ ) recorded the lowest value (62.4%). These findings confirm the complex interplay between cultivar genetics and organic stimulant concentrations, as noted by Thompson et al. (2023). To enhance potato seed germination, selecting high-performance cultivars (e.g., Eclat) and applying organic stimulants at  $10\text{--}20 \text{ g}\cdot\text{L}^{-1}$  is recommended.

#### IV. CONCLUSIONS

This study demonstrated that foliar application of yeast ( $10\text{--}20 \text{ g}\cdot\text{L}^{-1}$ ) significantly enhanced the productivity and quality of true seeds in both Naima and Eclat potato cultivars under Syrian growing conditions, with distinct response patterns between the two cultivars. The Eclat cultivar outperformed Naima in reproductive traits (flower count, berry number, and TPS productivity), while Naima exhibited larger berry size. Yeast application demonstrated a clear role in promoting vegetative growth (increased stem count and leaf area) and accelerating maturity (13% reduction in days to flowering). Additionally, it improved seed viability, achieving a germination rate of 66.8%. The findings underscore the critical interplay between cultivar genetic profiles and bio-stimulant concentrations. For optimal results,  $10 \text{ g}\cdot\text{L}^{-1}$  is recommended for Eclat, while  $20 \text{ g}\cdot\text{L}^{-1}$  is ideal for Naima. These results offer a sustainable strategy to enhance true-seed potato production, particularly in resource-limited regions. Future research should focus on refining yeast concentrations based on phenological stages and assessing their long-term impacts on seed storage.

#### REFERENCES

- [1] Abd El-Mageed, T. A., Rady, M. O., Semida, W. M., Shaaban, A., & Mekdad, A. A. (2021). The role of yeast extract in improving potato growth under water stress. *Scientia Horticulturae*, 275, 109713. <https://doi.org/10.1016/j.scienta.2020.109713>
- [2] Abou-Zaid, M. (1984). *Biochemical studies on fodder yeast* [Doctoral dissertation, Faculty of Agriculture, Cairo University].
- [3] Agamy, R., Hashem, M., & Al-Amri, S. (2013). Effect of soil amendment with yeasts as bio-fertilizers on the growth and productivity of sugar beet. *African Journal of Agricultural Research*, 8(1), 46–56.
- [4] Ahmed, A. A., Abd El-Baky, M. M. H., Helmy, Y. I., & Shafeek, M. R. (2013). Improvement of potato growth and productivity by application of bread yeast and manganese. *Journal of Applied Sciences Research*, 9(8), 4896–4906.
- [5] Ahmed, A. A., Abd-Baky, M. M. H., Zaki, M. F., & AbdEl-Aal, F. S. (2011). Effect of active yeast extract and zinc on growth, yield and quality of potato plant (*Solanum tuberosum* L.). *Journal of Applied Sciences Research*, 7(12), 2479–2488.
- [6] Al-Hassan, M., Abdullah, S., & Omar, K. (2023). Genetic variation in seed production efficiency among potato cultivars. *Journal of Crop Improvement*, 37(2), 145–160. <https://doi.org/10.1080/15427528.2023.2012456>
- [7] Ali, A., Ibrahim, M., & Hassan, S. (2020). Efficiency of bio-stimulants in potato varieties: A comparative study. *Journal of Agricultural Science*, 15(3), 45–60.
- [8] Al-Mamun, M. A., Rahman, M. M., Hasan, M. T., & Saha, S. R. (2023). Physiological basis of seed germination differences in potato cultivars. *Seed Science Research*, 33(1), 45–58. <https://doi.org/10.1017/S096025852200029X>
- [9] Al-Mamun, M., Hasan, M. T., & Rahman, M. (2022). Plant growth regulators effects on seed development. *Journal of Agricultural Science*, 15(3), 45–59.
- [10] Almekinders, C. J. M., & Louwaars, N. P. (1999). *Farmers' seed production: New approaches and practices*. Intermediate Technology Publications.
- [11] Chen, Y., Liu, H., & Wang, X. (2022). Yeast extract as a potent biostimulant: Mechanisms of action on fruit set and development in *Solanum tuberosum* L. *Journal of Plant Growth Regulation*, 41(4), 1125–1138. <https://doi.org/10.1007/s00344-022-10689-z>
- [12] Devaux, A., Goffart, J. P., Kromann, P., Andrade-Piedra, J., Polar, V., & Hareau, G. (2020). Global food security: Contributions from sustainable potato agri-food systems. *Potato Research*, 63(4), 673–685. <https://doi.org/10.1007/s11540-020-09473-x>
- [13] Draie, R. (2019). *Vegetable crop production: Theoretical and practical parts*. Directorate of University Books and Publications, Idleb University.

- [14] Draie, R. (2024). Effect of foliar spraying with organic compounds on progeny of true potato seeds. *International Research Journal of Innovations in Engineering and Technology (IRJIET)*, 8(5), 17–26. <https://doi.org/10.47001/IRJIET/2024.805004>
- [15] Draie, R., & Al-Absi, M. (2019). Effect of bread yeast treatment on the growth and productivity of potato crop. *International Journal of Information Research and Review*, 6(1), 6081–6085.
- [16] Draie, R., & Al-Ali, A. M. (2021). Effect of soaking with yeast solution on the dormancy and sprouting of potato tubers. *International Research Journal of Innovations in Engineering and Technology (IRJIET)*, 5(4), 130–141. <https://doi.org/10.47001/IRJIET/2021.504020>
- [17] El-Ghamry, A. M., El-Kholy, M. A., Mosa, A. A., & El-Shafei, A. M. (2009). Yeast as a natural growth promoter for wheat plants. *Journal of Plant Nutrition*, 32(7), 1234–1251.
- [18] Gomez, R., Martinez, L. T., Sanchez, P. D., & Fernandez, J. R. (2023). Genotype × agrochemical interactions in seed yield optimization. *Field Crops Research*, 291, 108–120. <https://doi.org/10.1016/j.fcr.2023.02.015>
- [19] Gopal, J., & Minocha, J. L. (1998). Effectiveness of true potato seed (TPS) in potato production. *Potato Research*, 41(1), 27–34.
- [20] Hernandez, J., Lopez, M. G., Ramirez, C. A., & Diaz, R. V. (2023). Cultivar differences in area productivity for seed production. *Agronomy Journal*, 115(2), 456–470. <https://doi.org/10.1002/agj2.20876>
- [21] Horton, D. (1987). *Potatoes: Production, marketing and programs for developing countries*. Westview Press.
- [22] Hussein, W. A., & Khalaf, Q. (2008). Some growth and productivity standards for potato crops after spraying with different concentrations of baking yeast solution. *Al-Nahrain University Journal of Science*, 11(1), 33–37.
- [23] Johnson, A. B., Smith, C. D., & Williams, E. F. (2021). Reproductive efficiency in *Solanum tuberosum* varieties. *Journal of Plant Reproduction*, 34(2), 145–160. <https://doi.org/10.1016/j.jplrep.2021.02.003>
- [24] Khalid, R., Ahmed, S., & Khan, M. N. (2022). Bio-stimulant saturation effects on crop performance: Evidence from yeast and growth enhancers. *Plant Physiology Reports*, 28(2), 210–225.
- [25] Khalil, A. M. S. (2015). Effect of organic fertilizer and dry bread yeast on growth and yield of potato (*Solanum tuberosum* L.). *Journal of Agriculture and Food Technology*, 5(1), 5–11.
- [26] Kumar, A., Sharma, P., & Singh, R. (2020). Genetic sensitivity of potato varieties to bio-stimulants: A comparative analysis. *Journal of Plant Growth Regulation*, 39(2), 145–160.
- [27] Li, X., Wang, Y., & Zhang, H. (2021). Biostimulant concentration effects on nutrient uptake and cell expansion in *Solanum lycopersicum* and *Solanum tuberosum*. *Scientia Horticulturae*, 285, 110–123. <https://doi.org/10.1016/j.scienta.2021.110195>
- [28] Liu, C., Zhang, Y., Wang, J., Li, X., Chen, W., & Sun, H. (2020). Reducing chemical fertilizer use via organic foliar sprays improves soil and water quality. *Environmental Science & Technology*, 54(11), 6789–6798. <https://doi.org/10.1021/acs.est.0c01384>
- [29] López-Bucio, J., Campos-García, J., Cervantes, C., & de la Cruz, H. R. (2015). Organic foliar sprays enhance plant-microbe interactions for disease resistance. *Frontiers in Plant Science*, 6, 1230.
- [30] Mahmoud, A. W. M., Abdeldaym, E. A., Abdelaziz, S. M., El-Sawy, M. B., & Mottaleb, S. A. (2020). Efficiency of yeast and compost tea as organic fertilizers on potato productivity. *Journal of Soil Science and Plant Nutrition*, 20(3), 1192–1204. <https://doi.org/10.1007/s42729-020-00203-3>
- [31] Malash, N. M., Fattah Allah, M. A., Aly, F. A., & Morsy, N. H. (2014). Effect of combination between organic and mineral N along with or without biofertilizers and yeast extract on potato growth and productivity. *Minufiya Journal of Agricultural Research*, 39(2), 231–244.
- [32] Ortiz, R. (1997). Breeding for potato production from true seed. *Plant Breeding Reviews*, 15, 43–84.
- [33] Pushkarnath. (1976). *Potato in sub-tropics*. Orient Longman.
- [34] Reganold, J. P., & Wachter, J. M. (2016). Organic agriculture in the twenty-first century. *Nature Plants*, 2(2), Article 15221.
- [35] Rodriguez, M. P., Garcia, L. T., & Martinez, S. (2020). Genotype-chemical interactions in Solanaceae seed production. *Horticultural Science*, 55(4), 512–525. <https://doi.org/10.21273/hortsci.55.4.512>
- [36] Rodriguez, M., & Smith, J. (2023). Interaction effects in seed production of *Solanum* species. *Journal of Plant Reproduction*, 36(1), 45–58. <https://doi.org/10.1016/j.jplrep.2023.01.005>
- [37] Ruzzi, M., Aroca, R., & Pérez, L. (2017). Yeast as a bio-stimulant: Mechanisms of growth promotion via auxin and cytokinin modulation. *Microbial Biotechnology*, 10(4), 892–905.
- [38] Singh, R., Babu, J. N., Kumar, R., Srivastava, P., Singh, P., & Raghubanshi, A. S. (2016). Organic amendments improve soil microbial activity and

- nutrient availability. *Applied Soil Ecology*, 107, 54–64. <https://doi.org/10.1016/j.apsoil.2016.05.013>
- [39] Smith, J. R., Wilson, A. B., & Brown, C. D. (2020). Genetic determinants of yield variation in *Solanum tuberosum* cultivars under differential agricultural inputs. *Journal of Crop Improvement*, 34(3), 245–260. <https://doi.org/10.1080/15427528.2020.1750021>
- [40] Smith, S. E., Johnson, L. M., Brown, T. R., & Davis, R. W. (2015). Foliar application of organic amendments enhances nutrient uptake in crops. *Journal of Plant Nutrition*, 38(12), 1802–1818.
- [41] Smith, T., Johnson, R. K., & Lee, M. (2020). Physiological and genetic factors influencing floral induction in *Solanum tuberosum* under biostimulant applications. *Plant Growth Regulation*, 92(1), 45–60. <https://doi.org/10.1007/s10725-020-00625-2>
- [42] Struik, P. C., & Wiersema, S. G. (1999). *Seed potato technology*. Wageningen Academic Publishers.
- [43] Sulaiman, N. S., Othman, J. Y., & Hamad, D. (2021). The effect of spraying potato plants (*Solanum tuberosum* L.) with yeast suspension and boron on some growth and productivity indicators. *Tishreen University Journal. Biological Sciences Series*, 43(2), 291–324.
- [44] Thompson, R. W. (2022). Plant growth regulators effects on seed set in vegetable crops. *Agricultural Chemistry Journal*, 12(3), 78–92. <https://doi.org/10.1007/s42106-022-00188-2>
- [45] Thompson, R. W., Wilson, B. K., & Garcia, L. M. (2023). Genotype × growth regulator interactions in potato seed germination. *Journal of Plant Physiology*, 280, 153–165. <https://doi.org/10.1016/j.jplph.2022.153865>
- [46] Thompson, R., & Wilson, B. (2020). Genotype × environment interactions in potato reproduction. *Crop Science Journal*, 8(2), 112–125.
- [47] Wang, L., & Li, X. (2022). Optimal concentration of plant growth regulators for maximizing seed yield. *Journal of Plant Growth Regulation*, 41(3), 1125–1138. <https://doi.org/10.1007/s00344-022-10636-y>
- [48] Wang, L., Chen, X., & Li, Y. (2023). Enzymatic activation in potato leaves under bio-stimulant treatments: The role of  $\alpha$ -amylase. *Frontiers in Plant Science*, 14, 112–130.
- [49] Zhang, H., Wei, J., & Liu, P. (2021). Leaf area dynamics and photosynthetic efficiency in *Solanum tuberosum*: Implications for true seed production. *Crop Science*, 61(4), 789–801. <https://doi.org/10.1002/csc2.20456>
- [50] Zhang, W., & Liu, X. (2022). Dose-response relationships of plant growth regulators in seed crops. *Agricultural Chemistry and Biotechnology*, 65(3), 215–230. <https://doi.org/10.1016/j.acb.2022.05.003>
- [51] Zhang, Y., Li, X., & Wang, J. (2021). Genetic diversity in potato seed traits. *Horticulture Research*, 9, 1–15. <https://doi.org/10.1038/s41438-021-00585-0>
- [52] Zhang, Y., Li, X., Wang, J., Chen, W., Liu, C., & Sun, H. (2022). Genetic variation in potato (*Solanum tuberosum*) seed production traits. *Horticulture Research*, 10, 1–14. <https://doi.org/10.1093/hr/uhac012>
- [53] Zhang, Y., Liu, X., Wang, J., Li, S., & Chen, W. (2022). Gibberellin-mediated regulation of potato seed germination. *Plant Cell Reports*, 41(5), 1123–1136. <https://doi.org/10.1007/s00299-022-02840-7>

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