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Effect of Foliar Spraying with Organic Compounds on Progeny of True Potato Seeds

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***Abstract* - The research was conducted during the agricultural season of 2022-2023 in a protected greenhouse at the Faculty of Agricultural Engineering at Idlib University. The study focused on potato plants derived from true seed cultivation of the Naeema potato variety, planted during the spring season of 2022. Two foliar spray treatments were applied to the cultivated potato plants: amino acids and dry yeast, in addition to a control group that was sprayed with water only. The experiment followed a completely randomized design (CRD). The results showed that the foliar spray treatment with amino acids significantly outperformed the control group in all studied characteristics, including marketable tuber number, main stem length, tuber count per plant, tuber length, tuber diameter, tuber weight, and total tuber yield per plant. Similarly, the foliar spray treatment with dry yeast outperformed the control group in marketable tuber number, main stem length, tuber count per plant, tuber length, and total tuber yield per plant. However, the two treatments had no significant differences in tuber diameter and weight. Finally, the foliar spray treatment with amino acids showed superior results to the foliar spray treatment with dry yeast in marketable tuber number, length, diameter, weight, and total tuber yield per plant. No significant differences were observed between the two foliar spray treatments in main stem length and tuber count per plant.**

Keywords: Potato, True Potato Seed, Foliar Spray, Amino Acids, Yeast.

1. Introduction

Potatoes (*Solanum tuberosum L.*), from the Solanaceae family, are one of the most economically important and most widespread vegetable crops on the global level. They are the fourth most cultivated food crop after wheat, rice, and corn. They also currently rank first in the quantity of production among root crops and tubers. The mountainous regions of Central and South America constitute the original homeland of the potato plant, where wild types that are highly resistant to pathogens and have small, bitter-tasting tubers are currently widespread. Then potato cultivation moved from Peru to Spain in the mid-sixteenth century, and from there to Italy, Germany, and the rest of Europe. Then it spread rapidly in most countries of the world at the beginning of the nineteenth century (Oulabi and Al-Ware, 1997; Humaidan and Zidan, 2004).

The potato is propagated by tubers. However, due to the many problems and restrictions associated with seed tubers' production, use, and transportation, researchers have often sought alternatives to using tubers for propagation. One of the most important alternatives that have been reached is the use of true potato seeds, or the so-called TPS technology (Schmiediche, 1997). TPS is currently considered one of the promising technologies in potato production, as it is characterized by the use of a small amount of seeds required for planting (one dunum requires only 20 grams of TPS for 300 kg of seed tubers). Seed costs are also low when compared to the costs of seed tubers. Also, the process of transporting TPS is easy and inexpensive, and it is possible to store TPS seeds for the long term easily and at a very small cost. Another important advantage is that most diseases transmitted through seed tubers are not transmitted through true seeds (Rowell et al., 1986). The cost of seed tubers can represent up to 40-70% of the total production costs (Accatino and Malagamba, 1982; Upadhya, 1994). While the cost of producing TPS does not exceed 10% of the cost of seed tubers needed to cultivate the same area (CIP, 1985). In addition, the use of TPS contributes to the provision of food, as tubers prepared for sowing are provided and used as food.

Despite these advantages of using TPS, this technology is not widespread at the global level, due to some obstacles that hinder its use at the commercial level. The most important obstacles to using TPS technology include the slow growth of potato plants resulting from TPS in the early stages of their life and thus needing a longer period in the field (Gaur et al., 2000). However, this problem can be overcome by planting the seeds in the nursery and transporting them. Later the permanent planting place to shorten the crop's stay in the field and reduce service costs (Almekinders et al., 2009). The most important obstacle to using TPS technology is the low productivity due to the small size of the tubers and their heterogeneous sizes. However, this may not be an important

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obstacle, as the main goal of using TPS is to produce seed tubers and not the commercial potato crop (Malagamba, 1988). In addition, many studies have shown that it is possible to increase the productivity of marketable tubers by improving plant nutrition and ensuring nutritional needs appropriately for the crop during all stages of its growth, especially during the stages of tuber formation, growth, and development.

True potato seeds are produced after flowering and setting. Potato varieties differ in their ability to flower, some flower abundantly, others flower a few, and some potato varieties only give flower buds (Gopal, 1994). The fruit of the potato is a spherical grape, ranging in diameter from 12-25 mm. Its color is usually green, but it may be crimson or black when ripe. Potato fruits resemble tomatoes, except that they are not suitable for consumption because they contain toxic substances, the most important of which is solanine (Krtkova et al., 2011). The fruit contains many seeds that are suspended in the placenta, and the number of seeds in one fruit ranges between 0-500 seeds, depending on the variety. The seed is flat, oval, or kidney-shaped, and is yellow to yellowish brown (Draie, 2019). The most important factors that determine flowering and fruiting in potatoes are genotype, day length, temperature, and availability of mineral nutrients. Late-maturing varieties flower more profusely and for a longer period than early-maturing varieties (Gopal, 2003). Flowering and fruit setting are also better on long days (about 16 hours) with high humidity and cool temperatures (Almekinders and Struik, 1996; Sleper and Poehlman, 2006). High temperatures limit fruit and seed formation in potatoes (Malagamba, 1988).

Nutrients play an important role in the growth and development of potato plants, and a deficiency of these elements leads to weak plant growth and a lack of production of flowers and fruits, and thus true seeds. Therefore, providing these elements according to the needs of potato plants is very necessary to obtain good economic production of true tubers and seeds. Spraying nutrients directly onto the leaves ensures that they are quickly available to the plants (Gonzalez et al., 2010). Foliar spraying is also characterized by low application rates and homogeneous distribution of nutrients, in addition to the fact that in cases of invisible deficiency, it can be easily controlled by applying foliar fertilization (Umer et al., 1999). Moreover, foliar fertilization reduces the accumulation and fixation of fertilizer elements in the soil, their loss in groundwater, and their causes of salinity and nitrate pollution, and thus reduces negative consequences for humans and the environment (Swietlik and Faust, 1984). Studies have shown that foliar spray treatments achieved significant increases in productivity, resistance to insects and diseases, enhanced resistance to drought, and improved fruit quality (Kuepper, 2008).

Organic fertilizers constitute an essential source of the various nutrients that plants need. These fertilizers have not received sufficient attention from farmers due to the widespread spread of chemical fertilizers, but the damage resulting from the extensive use of chemical fertilizers on humans, animals, plants, and the environment has imposed the necessity of searching for clean sources. To feed the plant. Hence the importance of organic compounds of various types emerges as one of the most important alternatives to chemical fertilizers for fruit orchards in general and vegetable plants in particular.

Many studies have reported that foliar spraying of potato plants with yeast solution has significantly improved both growth and production, quantitatively and qualitatively (Gomaa et al., 2005; Ahmed et al., 2011). Spraying with yeast gave a significant increase in plant height, the number of tubers stems, and leaves, productivity on the plant, and the length and diameter of the tuber (Hussain and Khalaf, 2008; Sarhan and Abdullah, 2010; Ahmed et al., 2011; Lazim and Ahmed, 2013).In research conducted byDraie and Al-Absi, (2019) to study the effect of spraying with yeast solution on the growth and productivity of the potato crop, the combined treatment of soaking and foliar spraying outperformed the control plants and the other treatments in all the studied traits. The foliar spraying treatment with yeast solution also outperformed the characteristics of productivity on the plant and productivity in the experimental plot on the control and the soaking treatment with yeast.The results of spraying dry yeast solution on the potato crop of the Desiree variety showed a significant effect on the characteristics of vegetative growth and productivity, as it achieved a significant increase in the length of the plant, the number of branches, and the number of tubers on the plant (Hussein and Khalaf, 2008).In a field experiment to study the effect of fertilization with arginine acid and yeast on potato productivity, the spraying treatment with a mixture of yeast and arginine acid resulted in the highest number of tubers, the highest tuber weight, and the highest yield per plant (Shamri et al., 2017). In a study conducted on a private farm in Babil Governorate, Iraq, to evaluate the effect of adding dried poultry manure and spraying with dry bread yeast, the results showed the superiority of the interaction of poultry waste fertilizer with spraying with dry bread yeast extract on the vegetative growth characteristics (represented in plant height, the number of aerial stems on the plant, the number of branches and leaves on the plant, and the plant leaf area), and the quantitative and qualitative productivity characteristics (represented in the number of tubers on the plant, the weight of the tuber, the productivity of one plant, the productivity of marketable tubers, the total productivity of tubers, and the specific weight of the tubers), (Al-Bayati, 2019).

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As for spraying with amino acids, Zidan and Dayup, (2005) reported that spraying potato leaves with amino acids led to an increase in both the length and number of plant stems, an increase in the leaf surface area, and an acceleration in the growth of tubers and an increase in their weight compared to the control. Ahmad et al., (1999) found that spraying potatoes with tryptophan acid led to a significant increase in tuber yield and plant height. In an experiment conducted by Abd El-Raheem et al., (2020) in the Ismailia Governorate in Egypt during the years 2017 and 2018, to study the effect of foliar spraying of potato plants with humates and amino acids on the growth and productivity of potato plants of the Spunta variety. The results showed the superiority of the combined spray treatment in plant height, tuber diameter, total productivity, and marketable yield of potatoes. In an experiment on the growth response of potatoes (Folar variety) to some fertilizing compounds such as thiamine, riboflavin, ascorbic acid, succinic acid, arginine acid, and proline acid. The results indicated a significant increase in plant height and the number of leaves/plant with the addition of succinic acid, the number of branches/plant and the number of stems/plant increased with the addition of proline acid, the leaf area increased significantly with the addition of ascorbic acid to the leaves, and the total yield, average weight of tubers and yield increased. The yield of tubers increased significantly with the addition of ascorbic acid, compared to other treatments (Gouda et al., 2015). Awad et al., (2007) indicated that the total yield of two potato varieties (Alpha and King Edward) increased significantly because of foliar spraying with amino acid solutions. The best growth indicators for potatoes were recorded when glycine and lysine were added together, and the highest total tuber production, number of tubers, and tuber weight were obtained in both seasons of the experiment.

Based on what was mentioned above, the research aimed to study the effect of foliar spraying with organic fertilizers (yeast and amino acids) on the growth and productivity of potato plants (Progeny of true potato seeds) from the tuber crop.

2. Materials and Methods

2.1 Experimental Location:

The research was carried out during the 2022-2023 agricultural season under greenhouse conditions at the College of Agricultural Engineering at the University of Idlib. The greenhouse has an area of (8 x 5) m² and a height of 4 m. It is exposed to direct sunlight from ten in the morning until the end of the day. It provides complete protection for the plants grown within it from the effects of wind and rain (the amount of water added to the plants within it is controlled). It reduces the effects of cold and frost inside the house, except that it is not heated in the winter.

2.2 Plant materials

The research was conducted on potato plants produced by sowing of true seeds. These seeds were extracted from the fruits of the Naima potato variety grown in the northwest of Syria (Idlib Governorate) in the spring season of 2022. The Naima potato variety is a French variety, highly productive, early maturing, with elongated and large tubers, and the color of the peel and pulp is white, (Fig. 1-1).

Fruits were collected at the fully ripe stage (Fig. 1-2) on 06/01/2022, from spring shoot plants grown in the Ram-Hamdan area. After collecting the fruits, they were left for about a month in normal room conditions (shade, ventilation, and temperature of about 25°C) to increase their looseness and facilitate the extraction of seeds from them. On 07/01/2022, the fruits were taken and mashed. The mash was then placed in water for 24 hours to facilitate the separation of the seeds. Then the seeds were washed under tap water to remove the gelatinous material surrounding them. Then the seeds were dried in a shaded, well-ventilated room at a temperature of 25°C and low relative humidity. After the seeds were completely dry (Fig. 1-3), they were stored in an opaque, tightly sealed glass container until planting.

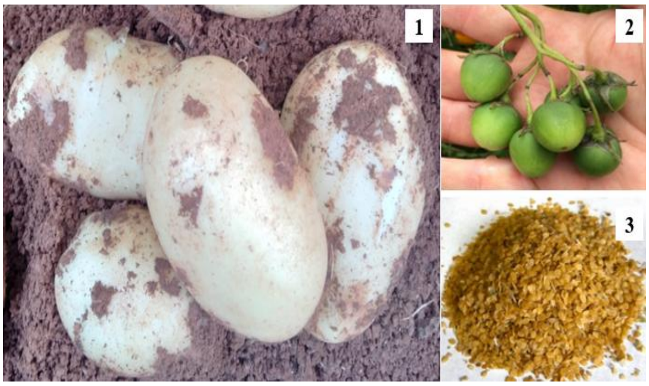

Figure 1: Tubers (1), fruits (2), and seeds (3) of the Naima potato variety

2.3 Experimental Steps:

The seeds were planted in plastic germination trays in the beat-moss medium on 01/12/2022 at a rate of two seeds in each hole, after treatment with the hormone gibberellin at a concentration of 20 mg/L for 15 min to break the dormancy phase in the seeds and accelerate their germination.

The germination trays were covered with black mulches after planting the seeds, for a full week (to maintain the appropriate temperature and humidity for germination). The mulches were then removed, and the germination rate was calculated (61%). When the seedlings reached the

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transplanting stage (Fig.2), the seedlings were transferred to pots with a capacity of 5 liters (01/02/2023), where a seedling was planted in each pot (Fig.3). The pot contained an agricultural mixture consisting of 50% soil and 50% % fermented organic fertilizer.

Figure 2: Production of potato seedlings in plastic germination trays

Figure 3: Plantation of potato plants in experimental pots (5 liters)

- After planting the seedlings in plastic pots (capacity of 5 liters), they were monitored daily during the various stages of growth. The plants were irrigated twice a week, the first on Saturday with plain water and the second on Tuesday with a nutrient solution containing the macro and micro-elements (Ancofer composed of [weight/volume]: 29% nitrogen, 29% phosphorus, 29% potassium, 2% magnesium, in addition to the microelements Mn, Cu, B, Fe, Zn in the form of residues, produced by UNCoD).The seedlings were also sprayed with appropriate preventive and therapeutic pesticides when necessary.
- According to the specified experiment scheme, ▪ Plants were foliar-spayed with organic compounds (dry yeast and amino acids).The dispersing agent Agral was added to the spray solution, to facilitate the process of adhesion and absorption by plant leaves. The control plants were sprayed with the water in addition to the spreading material, in the same amount and time as the other treatment plants.
- A concentration of 5 ml/L of the amino acid compound was used (Magic Booster consists of [w/w]: 23% organic matter, 13% free amino acids, 6.5% total nitrogen, 6.5% potassium oxide, 0.6% alginic acid, produced by BioFarm). A dry yeast solution was prepared, where 10 grams of dry yeast were added to a liter of water and 10 grams of sugar, the solution was then left for 24 hours to activate yeast divisions and replication. All foliar spray treatments were carried out in the early morning, and the spraying process was carried out until the plants were completely wet. Finally, plants were harvested on 06/01/2023 (Fig.4) and completed all determined reads.

Figure 4: Harvesting of potato tubers from experimental treatments

2.4 Studied Indicators:

1) Number of main aerial stems (stem/plant).
2) Plant height (cm): Measured with a ruler at the end of the growing season of the longest aerial stem in each of the studied plants, from the point of contact of the plant with the soil until the end of the growing apex.
3) The number of tubers per plant.
4) Tuber length (cm): Use the caliper tool to measure the length of the tuber.
5) Tuber diameter (cm): Use the caliper tool to measure the diameter of the tuber.
6) Tuber size (cm^3): It was done using the displaced water method, using a graduated cylinder with a capacity of 1 liter.
7) Tuber weight (g): Use a sensitive scale with an accuracy of 3 numbers after the comma.
8) Total productivity of tubers per plant (g): Use a sensitive scale with an accuracy of 3 numbers after the comma.

2.5 Experiment design and statistical analysis:

- Three foliar spray treatments were applied to the cultivated potato plants. Dry yeast compounds and amino acids were used in the foliar spray, in addition to the control, which was sprayed with water only.
- All treatments were distributed according to a completely randomized design (CRD). The plants were planted in pots with a capacity of 5 liters per pot, with 10 replicates for each treatment. The total number of plants studied was 30 plants.

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- The results were analyzed on the computer using the statistical analysis program (SigmaStat-10), and comparisons were made between the means using the least significant difference (LSD) test at the significance level (5%).

3. Results & Discussion

Through the study we conducted, we reached the results shown in Table (1).

Table 1: Results of foliar spraying with yeast and amino acids on the studied traits of potato plants

Trait	Control	Yeast	Amino Acids	LSD
Number of aerial stems	4.00	5.10	6.50	1.02
Main stem length (cm)	40.10	60.15	67.15	8.46
Number of tubers/plant	10.56	11.98	12.64	0.86
Tuber length (cm)	3.23	3.97	4.49	0.26
Tuber diameter (cm)	1.61	1.68	1.96	0.10
Tuber size (cm^3)	7.68	8.22	9.49	0.73
Tuber weight (g)	7.19	7.70	8.89	0.92
Total productivity/plant (g)	75.88	92.25	112.37	8.19

3.1 Number of aerial stems per plant:

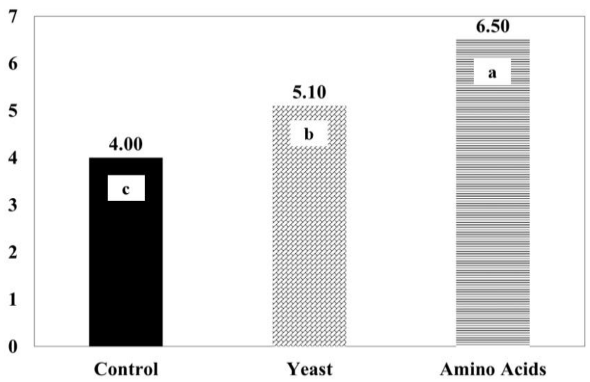

Figure 5: Effect of foliar spraying with yeast and amino acids on the number of aerial stems per plant
(L.S.D. = 1.02, different letters indicate significant differences)

Fig. (5) shows that the foliar spray treatment with amino acids was superior to the yeast spray treatment and the control treatment in terms of the number of aerial stems per plant, as the number of stems in the foliar spray treatment with amino acids reached 6.5 stems. The foliar spray treatment with yeast also outperformed the control treatment, as the number of aerial stems in the foliar spray treatment with yeast reached 5.1 stems, and 4 stems in the control treatment.

These results are consistent with the findings of Al-Bayati (2019), who showed that foliar spraying with yeast extract led to a clear significant increase in the number of aerial stems compared to the control treatment. It is also consistent with the study conducted by Gouda et al., (2015), who obtained a significant increase in the number of aerial stems when foliar spraying of potato plants with amino acids was carried out, compared to the control.

3.2 Main stem length (cm):

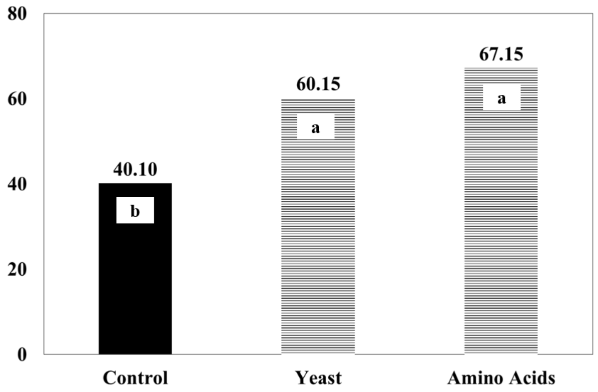

Figure 6: Effect of foliar spraying with yeast and amino acids on the main stem length trait (cm)
(L.S.D. = 8.46, different letters indicate significant differences)

The results of the statistical analysis (Fig.6) show the significant superiority of the foliar spray treatments with amino acids and yeast over the control treatment in the main stem length characteristic, with stem length values reaching 67.15 cm, 60.15 cm, and 40.10 cm in the treatments mentioned in the order, while there were no significant differences between the treatments of spraying with amino acids and spraying with yeast.

Our results are consistent with what previous studies indicated about the effect of spraying potato plants with amino acids and yeast in increasing the length of the main stem of the plant (plant height). Zidan and Dayup, (2005) indicated that spraying potato leaves with amino acids led to an increase in the length of the plants' stems. Ahmad et al.,(1999) also showed that foliar spraying with tryptophan acid increased plant height, and the maximum plant height was 67.25 cm when 0.5 M of tryptophan was applied, with an increase of about 20% over the control. Abd El-Raheem et al., (2020) explained that foliar spraying with amino acids achieved a significant increase in plant height compared to the control, and a concentration of 1000 ppm of amino acids achieved the best result. A study by Hussain and Khalaf, (2008) also indicated that the foliar spraying of dry yeast solution on the potato crop, the Desiree variety, achieved a significant effect on plant height by 20.13% when spraying at a concentration of 8 g/L compared to the control treatment (spraying with water only). A study conducted by Al-Bayati, (2019) also indicated that foliar spraying of potato plants with yeast extract 8 g/L increased plant height with a significant difference over the control.

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3.3 Number of tubers /plant:

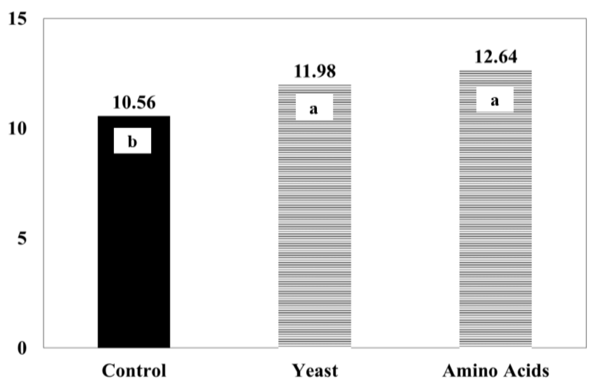

Figure 7: Effect of foliar spraying with yeast and amino acids on the number of tubers per plant
(L.S.D. = 0.86, different letters indicate significant differences)

The results shown in Fig. (7) indicate the significant superiority of the two foliar spray treatments with amino acids and yeast over the control treatment in the number of tubers per plant, as the number of tubers in these treatments was 12.64 tubers, 11.98 tubers, and 10.56 tubers, respectively. Although the number of tubers in the amino acid spray treatment was greater than the number of tubers in the yeast treatment, the results of the statistical analysis showed that there were no significant differences between the two treatments.

Our results are consistent with previous studies that showed an increase in the number of tubers when potato plants were sprayed with amino acids or yeast. A study conducted by Shamri et al., (2017) showed that all foliar spray treatments with amino acids and yeast, singly or in combination, were significantly superior to the control in the number of tubers on the plant, and the best concentration of amino acids was 300 mg/L. A study conducted by Awad et al., (2007) on two potato varieties (Alpha and King Edward) also showed that the number of tubers increased significantly as a result of foliar spraying with amino acids (glycine and lysine). Al-Bayati (2019) also indicated that foliar spray treatments with yeast concentration of 8 g/L were significantly superior to the control treatment in the number of tubers per plant. A study conducted by Sarhan and Abdullah, (2010) also confirmed that foliar spraying of potato plants with yeast achieved a significant increase in the number of tubers on the plant. A study conducted by Draie and Al-Absi, (2019) confirmed that foliar spraying with yeast solution achieved a significant increase in the number of tubers per plant compared to the control. In a study conducted by Hussein and Khalaf, (2008), they confirmed that foliar spraying with dry bread yeast at a concentration of 8 g/L achieved a significant increase in the number of tubers on the plant by 47.25% compared to the control.

3.4 Tuber length (cm):

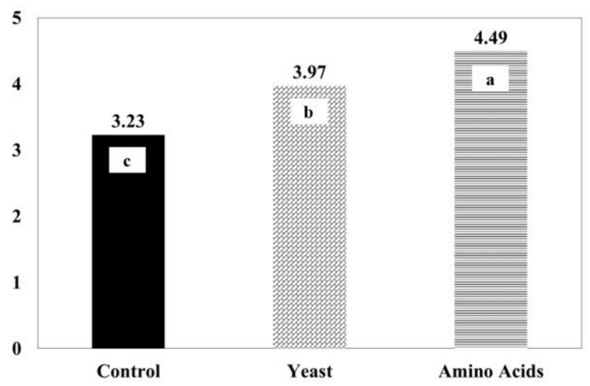

Figure 8: Effect of foliar spraying with yeast and amino acids on tuber length (cm)
(L.S.D. = 0.26, different letters indicate significant differences)

The results shown in Fig. (8) show that the foliar spray treatment with amino acids was superior to the treatments sprayed with yeast and the control in terms of tuber length (cm), as the length of the tuber in the foliar spray treatment with amino acids reached 4.49 cm. The foliar spray treatment with yeast was also superior to the control treatment, and the tuber length in the two treatments reached 3.97 cm and 3.23 cm, respectively.

Our results are consistent with the results of previous studies, which showed that foliar spraying with amino acids and yeast achieved a significant increase in tuber length compared to the control. Ahmed et al., (2011) reported that foliar spraying of potato plants with yeast achieved a significant increase in tuber length compared to the control. Abd El-Raheem et al., (2020) also reported that foliar spraying of the Spunta potato variety with amino acids at a concentration of 1000 ppm significantly increased tuber length compared to the control.

3.5 Tuber diameter (cm):

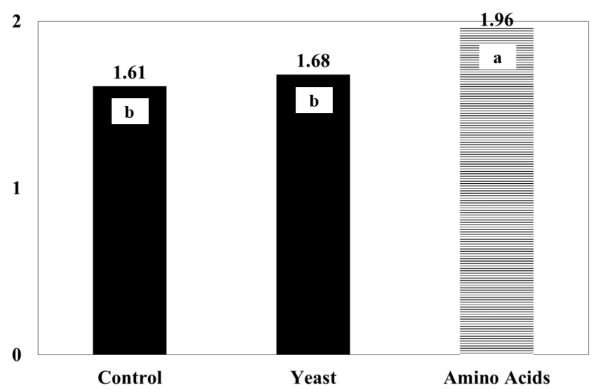

Figure 9: Effect of foliar spraying with yeast and amino acids on tuber diameter (cm)
(L.S.D. = 0.10, different letters indicate significant differences)

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It is clear from Fig. (9) that the foliar spray treatment with amino acids was significantly superior to the two foliar spray treatments with yeast and the control treatment in terms of tuber diameter, with a value of 1.96 cm, while there were no significant differences between the foliar spray treatment with yeast and the control treatment, where the values were1.68 cm and 1.61 cm, respectively.

Some of our results are consistent with the results of previous studies, while others are not consistent with the results of previous studies that talked about the effect of foliar spraying of potato plants with amino acids and yeast. A study conducted by Lazim and Ahmed, (2013) showed a significant increase in tuber diameter when spraying potato plants with yeast extract. A study conducted by Abd El-Raheem et al., (2020) indicated a significant increase in the diameter of potato tubers after spraying the plants with an amino acid solution, and the best results were when using a concentration of 1000 ppm. While the results of our study gave significant differences when spraying with amino acids, they did not give significant differences when spraying with yeast extract, compared to the control plants.

3.6 Tuber size (cm³)

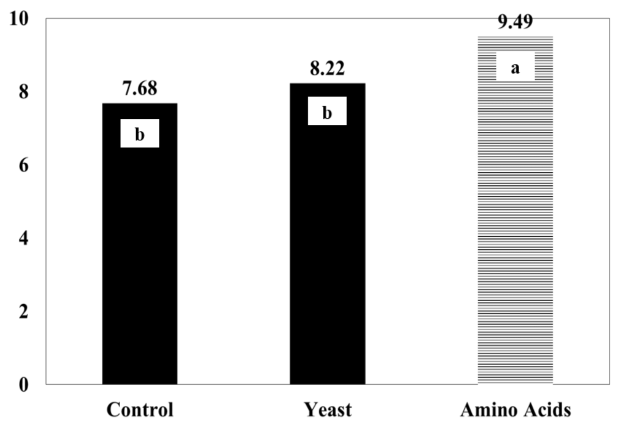

Figure 10: Effect of foliar spraying with yeast and amino acids on tuber size (cm³)
(L.S.D. = 0.73, different letters indicate significant differences)

It appears from Fig. (10) that the foliar spraying treatment with amino acids was significantly superior to the foliar spraying treatments with yeast and the control in terms of tuber weight, with a value of 9.49 cm³, while the foliar spraying treatment with yeast did not achieve a significant superiority over the control treatment even though the size of the tuber was larger. The tuber size in these two treatments was 8.22 cm³ and 7.68 cm³, respectively.

The results of some previous studies indicated what we found in our study. Al-Hamdani and Muhammad (2014) reported that foliar spraying with amino acids significantly increased the size of Riviera potato tubers compared to control plants.

3.7 Tuber weight (g):

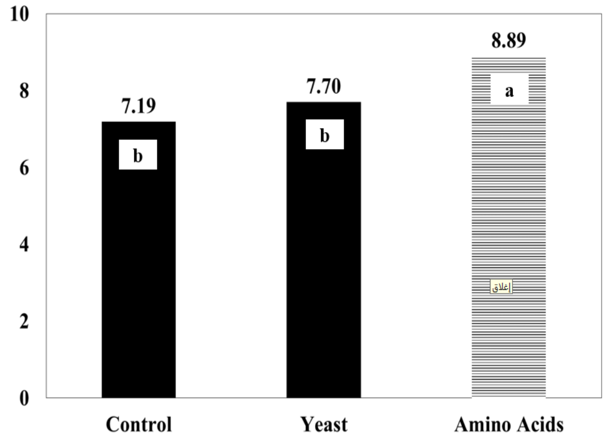

Figure 11: Effect of foliar spraying with yeast and amino acids on tuber weight (g)
(L.S.D. = 0.92, different letters indicate significant differences)

Fig. (11) shows that the foliar spray treatment with amino acids was significantly superior in terms of tuber weight to both the foliar spray treatment with yeast and the control treatment, with a value of 8.89 g. At the same time, there were no significant differences between the foliar spray treatment with yeast and the control treatment, with values of 7.70 g and 7.19 g, respectively.

Our results regarding the effect of foliar spraying with amino acids are consistent with those of previous studies. In a study conducted by Shamri et al., (2017), they indicated that all foliar spray treatments of potato plants with amino acids achieved a significant increase in the tuber weight compared to the control, and the spray treatment with arginine acid at a concentration of 300 mg/L achieved the best weight for the largest tuber. Awad et al., (2007) confirmed that foliar spraying with amino acids (glycine and lysine) together significantly increased tuber weight compared to the control. Zidan and Dayup (2005) also confirmed that foliar spraying of potato plants with amino acids significantly increased the weight of tubers compared to the control. However, our results were inconsistent with studies that showed a significant increase in tuber weight compared to the control when potato plants were sprayed with yeast extract. Shamri et al., (2017) showed that foliar spraying of the Luna potato variety with yeast extract significantly increased the tuber weight compared to the control. Al-Bayati (2019) also indicated that all foliar spray treatments were significantly superior to the control treatment, and the foliar spray treatment with yeast extract 8 g/L achieved the best increase in tuber weight on the plant.

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3.8 Total productivity/plant (g):

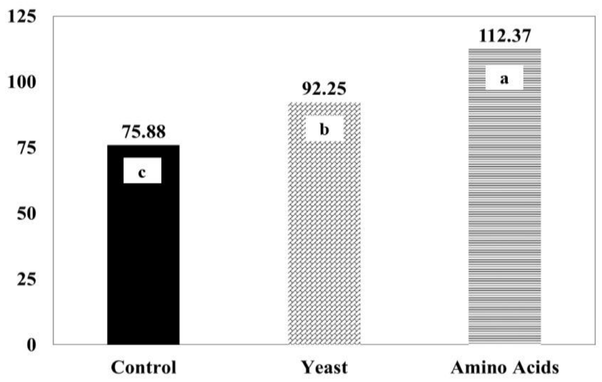

Figure 12: Effect of foliar spraying with yeast and amino acids on the total productivity of tubers/plant (g) (L.S.D.=8.19, different letters indicate significant differences)

The results shown in Fig. (12) show a significant superiority of all foliar spray treatments with amino acids and yeast over the control in terms of total tuber productivity per plant, as the total weight of tubers in the control plants reached 75.88 g. On the other hand, the foliar spray treatment with amino acids was significantly superior to the foliar spray treatment with yeast, and the total weight of tubers on the plant reached 112.37 g and 92.25 g in the two treatments, respectively.

Our results are consistent with the results of previous studies, which showed that foliar spraying with amino acids and yeast gave a significant increase in tuber productivity compared to the control. Lazim and Ahmed, (2013) showed that foliar spraying of potato plants with yeast achieved a significant increase in the total productivity of tubers on the plant compared to the control. El-Desuki and El-Gereadly (2006) also indicated that foliar spraying with 3% yeast increased the quantity and quality of production. Draie and Al-Absi, (2019) showed that foliar spraying with yeast at a concentration of 10 g/L led to an increase in the productivity of tubers per plant. Hussein and Khalaf (2008) also showed that the total productivity of the plant increased by 53.59% and 51.88% when spraying with yeast solutions of 8 and 6 g/plant, respectively. Al-Bayati (2019) confirmed that foliar spraying with yeast at a concentration of 8 g/L significantly increased the total number of tubers compared to the control. Abd El-Raheem et al., (2020) stated that all foliar spray treatments with amino acids achieved significant superiority over the control in terms of overall tuber productivity, and the concentration of 1000 ppm achieved the best results. In an experiment conducted by Awad et al., (2007), they confirmed that foliar spraying with amino acids (glycine and lysine) achieved a significant increase in the total productivity of tubers on the plant compared to the control.

The results of the study show the importance of foliar spraying of potato plants with amino acids and dry bread yeast in improving vegetative growth and improving tuber production quantitatively and qualitatively, as the foliar spraying treatment with amino acids outperformed the control in all the studied traits, and the foliar spraying treatment with yeast also outperformed the control in most of the studied traits. On the other hand, the foliar spray treatment with amino acids gave the best results and was superior to the foliar spray treatment with dry bread yeast in most of the characteristics studied. The positive effect of the yeast compound is due to it containing many nutritional elements. It is one of the richest sources of proteins and essential amino acids (Abou-Zaid, 1984), and is rich in major and trace mineral elements (Ca, N, P, K, Mg, Co, Fe) (Hesham and Mohamed, 2011), in addition to carbohydrates, enzymes, and vitamins (Khedr and Farid, 2000). Yeast also contains growth regulators such as auxins, gibberellins, and cytokinins (El-Ghamriny et al., 1999; Fathy et al., 2000). As for amino acids, their effect comes from their basic role in the process of synthesis of proteins that work to build the structure of the plant and contribute to the processes of nutritional transformation and transport within the plant. Proteins constitute a storehouse of amino acids within the plant. They also work to increase the concentration of chlorophyll in the plant, which leads to the activation and increase of the photosynthesis process (Al-Sarwi, 2017).

4. Conclusions

Through the results of the research we conducted, to study the effect of foliar spraying with amino acids and dry bread yeast on the productivity of the potato crop (TPS progeny) from tubers, we conclude that the foliar spraying treatment with amino acids was significantly superior to the control treatment in all the traits studied (the number of aerial stems, the length of the main stem, the number of tubers on the plant, the tuber length, diameter, size, and weight, and the total productivity of tubers per plant).The foliar spray treatment with dry bread yeast also outperformed the control treatment in the characteristics of the number of aerial stems, the length of the main stem, the number of tubers on the plant, the tuber length, and the total productivity of tubers on the plant. There were no significant differences between the two treatments in the characteristics of tuber diameter and weight. The foliar spray treatment with amino acids was superior to the foliar spray treatment with dry bread yeast in terms of the number of aerial stems, tuber length, diameter, size, and weight, and total tuber productivity per plant. While there were no significant differences between the two treatments in the main stem length and number of tubers on the plant. Finally, we suggest foliar spraying of potato plants with amino acids at a concentration of 5 ml/L at least once a week. It is

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also possible to spray with bread yeast extract (as an alternative to amino acids) at least once a week.

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