Alinteri J. of Agr. Sci. (2022) 37(1): 09-16
e-ISSN: 2587-2249
info@alinteridergisi.com

http://www.alinteridergisi.com/
DOI:10.47059/alinteri/V37I1/AJAS22003

RESEARCH ARTICLE

Effect of Organic Fertilization with Humic Acid and Foliar Spraying with Bread Yeast Extract on the Growth and Yield of the *Solanum Melongena* L

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ARTICLE INFO

Article History:
Received: 18.03.2022
Accepted: 10.04.2022
Available Online: 20.04.2022

Keywords:
Humic Acid
Bread Yeast
Solanum Melongena L
Vegetative Characteristics
Yield Characteristics

ABSTRACT

A pot experiment was conducted in one of the orchards in Al Salam district at the Diyala governorate during the 2021 agricultural season. The purpose is to investigate the effect of Humic acid and *Saccharomyces cerevisiae* (bread yeast) on the growth and productivity of the *Solanum melongena* L plant (eggplant). The study involved plant watering with three concentrations (0, 2, and 4 $g.l^{-1}$) of Humic acid, and leaves spraying with three concentrations of bread yeast (0, 5 and 10 $g.l^{-1}$). The study also investigates the synergistic effect between the two additives on the growth and productivity of the plant. The experiment was conducted according to a completely randomized design (CRD) with three replications. The results revealed significant improvement (5%) in the vegetative characteristics and yield trait due to the watering with Humic acid (2, and 4 $g.l^{-1}$), and the best obtained average improvement was at Humic acid concentration of 4 $g.l^{-1}$. The results, also, indicated significant development in all the studied traits due to the spraying with bread yeast at concentrations 5 and 10 $g.l^{-1}$. The best achieved averages were due to the spraying with the higher yeast concentration (10 $g.l^{-1}$). Moreover, combination that consists of 4 $g.l^{-1}$ Humic acid + 10 $g.l^{-1}$ bread yeast (H 4 $g.l^{-1}$ + Y 10 $g.l^{-1}$) yielded the highest averages for all studied traits except the fruit diameter where the combination (H 4 gl^{-1} + Y 5 gl^{-1}) developed the highest averages. However, the lowest averages were obtained from the control combination (Y 0 $g.l^{-1}$ + H 0 $g.l^{-1}$).

Please cite this paper as follows:

Ibrahim, N.S., Shakir, W.M., Abaas, R.A., Kadhom, I.M. and Hassen, W.A. (2022). Effect of Organic Fertilization with Humic Acid and Foliar Spraying with Bread Yeast Extract on the Growth and Yield of the *Solanum Melongena* L. *Alinteri Journal of Agriculture Sciences, 37*(1): 09-16. doi: 10.47059/alinteri/V37I1/AJAS22003

Introduction

Eggplant is a summer crop; it belongs to the Solanaceae family which has a significant economic importance. It is grown in India, Bangladesh, Pakistan, China, the Philippines, Egypt, France, Italy and the United States (Rao and Kumar, 2017). Eggplant is one of the important vegetable crops that are grown for their fruits. Normally, eggplant is eaten after cooking or is used in making pickles; also it can be kept frozen or canned for exporting purposes.

It is a good source for carbohydrates, proteins, fats, fiber and water. In addition to that, it is characterized by its content of vitamins including vitamin A, B1, B2, B3, C, and mineral salts, especially the potassium and iron (Mirani and Goli, 2021). Furthermore, Eggplant contains high percentage of anthocyanin and phenolic compounds which are considered as powerful antioxidants (Naeem and Ugur, 2019). Its fruits are used for many diseases treatment, such as diabetes, neuronal problems, cardiovascular disorders, and cancer. Further, it plays significant role in lowering the cholesterol level in the blood, and treating liver diseases (Kashyap et al., 2003, Tajik et al., 2017).

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In recent decades, stakeholders have tended to utilize the organic fertilization in planting more than the chemical one to reduce the pollution and to obtain healthy safe environment. Humic acids have the ability to stimulate plant growth through their effects on photosynthesis, cell respiration, protein synthesis, and stimulating enzyme activity. They also act to increase the water and nutrient uptake (Chen et al., 2004, Fahramand et al., 2014). The utilization of organic acids, in low quantities, significantly improves the physical, chemical and biological properties of the soil, and increases the roots' respiratory activity. This may be positively reflected on the growth of the root system and the vegetative system, and consequently enhances the productivity of the plant (Coelho et al., 2016).

The Humic acid (HA) is a product of the humic substances decomposition process. It is one of the most important organic acids that plays significant role in nutrients absorption by the plants' roots. It contributes to promote the availability and transport of macronutrients, such as nitrogen, phosphorous and potassium (Taj AL-Deen, & AL-Baraka, 2016). Several studies have investigated the role of the Humic acid in promoting the plant growth and improving its productivity. These studies specified that Humic acid could promote early flowering of the plants (Baldotto and Baldotto, 2013), increase the area of the leaf (Hashem et al., 2019), and increase leaf content of the chlorophyll (Khorasaninejad et al., 2018). It could also improve the leaves' content of various nutrients, such as potassium (K), calcium (Ca), magnesium (Mg), phosphorous (P), iron (Fe) and zinc (Zn) (Nikbakht et al., 2008).

On the other hand, the past two decades have witnessed a dramatic increase in the use of biostimulants to promote the growth and productivity of the agricultural crops. This was considered as a promising strategy to reduce crop losses under unstable environmental conditions (Latef et al., 2019). These biostimulants act to motivate plant growth by improving the root and vegetative group growth. Also, they act to increase the plant's resistance to unsuitable environmental conditions which eventually enhance its yield (Van Oosten et al., 2017, Yang et al., 2018).

Bread yeast is an important biostimulant, it is a mixture of amino acids, vitamins, carbohydrates, trace minerals, plant hormones, nuclear materials and micronutrients (Boegel, 2020, Manea et al., 2019). Several studies have reported the importance of the yeast in promoting the plant growth and increasing its productivity (Mahmood et al., 2020, S Taha et al., 2021, Al-Juthery et al., 2020). Yeast also contribute to stimulate the cell division and expansion, formation of chlorophylla and protein, and DNA synthesis (Khedr and Farid, 2000, Heikal, 2005, El-Desouky et al., 2007, El-Hawary et al., 2019). The importance of the yeast is attributed to its vital role in improving the plant's resistance to the environmental conditions stress. This is because yeast is rich in plant hormones and amino acids which can promote the plant growth, and increase its chlorophyll content (Kasim et al., 2017). Therefore, the present study aimed to shed more light on the effect of organic fertilizers based on ground fertilization with humic acid and biostimulants based on foliar spraying with bread yeast extract on the growth and productivity of eggplant.

Materials and Methods

Plant Material and the Study Site

To investigate the effect fertilization with Humic acid and bread yeast extract leaves spraying on the growth and yield of the eggplant, a pot experiment was conducted during March of the 2021 agricultural season. The experiment was performed at one of the orchards of the Al-Salam district that is located to the north of Diyala governorate, about 55 km north-east of Baghdad governorate. Before planting, random samples were taken from the agricultural soil at different depths (0 – 30 cm) from the soil surface to analyze its physical and chemical properties, the analysis results are shown in Table 1 below. Healthy and apparently disease free eggplant seedlings were selected from one of the neighboring nurseries at Al-Salam district. The selected seedlings were 5-6 cm long, and they were transferred to plastic pots.

Treatments and Experiment Design

Eggplant seedlings were moved to plastic pots of 10 kg soil capacity, 3 seedlings were put in each pot. NPK fertilizer was then added at a rate of 300 kg per hectare, in two batches. First batch was added 10 days later the moving of the seedlings to the pots while the second batch was two weeks after the adding of the first batch. According to the CRD, the experiment comprised of 9 treatments (T1-T9) (Table 2). The treatments consisted of 3 levels (0, 2, 4 $g.l^{-1}$) of the Humic acid (potassium humate, containing 80% humic acid) and 3 levels of the bread yeast extract (0, 5, 10 $g.l^{-1}$). Each treatment was repeated for 3 times, so the total number of the experimental units was 27.

When the plant reached the stage of 3-4 leaves, bread yeast extract at the concentration of 0, 5, and 10 $g.l^{-1}$ was used to spray the leaves. The spraying process was performed early in the morning, and 3 drops of liquid soap were added in each spray as a diffusion substance. Three days later, Humic acid (0, 2, 4 $g.l^{-1}$) was added to the ground. Upon reaching the flowering stage, the ground addition and leaves spraying were repeated with the same concentrations given above.

Table 1. Physical properties and chemical analysis of the experiment soils

Physical properties			
Sandy	Clay	Silt	Texture
6%	52%	42%	Clay loam
Chemical analysis			
pH	7.5		
Ec	1.9 ds m^{-1}		
O.M	0.9%		
Elements concentration	N	P	K
	56ppm	5.9 ppm	366 ppm

Table 2. Experiment treatments design

Treatments	Humic acid ($g.l^{-1}$)	Yeast ($g.l^{-1}$)
T1	0	0
T2	0	5
T3	0	10
T4	2	0
T5	2	5
T6	2	10
T7	4	0
T8	4	5
T9	4	10

Plant watering was regularly carried out, and weeding process was done when needed, taking into consideration the climatic conditions of the study site, especially the temperatures.

Characteristics Considered in the Study

- ***Vegetative Characteristics***

When the flowering stage is reached (70 days after transferring the seedlings), the plant vegetative characteristics were measured. Plant height (cm), number of leaves (leaf.plant^{-1}) and number of branches (branch.plant^{-1}) were measured according to (Mahmood & Zeboon, 2019), in addition to shoot fresh weight (gm), and shoot dry weight (gm).

- ***Yield Characteristics***

Upon completion of the flowering stage, the number of flowers per plant was counted. When the harvesting stage was reached, the number of fruits (fruit.plant^{-1}), fruit length (cm), fruit diameter (cm) and fruit yield (kg.plant^{-1}) were calculated.

Statistical Analysis

The CRD was employed to design the experiment, and SAS system was adopted to analyze the results according to Duncan's polynomial test at a probability level of 5%.

Results

Vegetative Characteristics

- ***Plant Height (cm)***

Table 3 indicates significant differences in the plant height due to the treatment with Humic acid (H) with different concentrations (0, 2, and 4 $g.l^{-1}$). The results revealed that the best obtained plant height was at the concentration of 4 $g.l^{-1}$, with a percentage of increase (4.97% and 16.97%) compared to the 2 $g.l^{-1}$ and control treatment respectively. Table 3 also shows significant differences between the plant height averages as a result of its treatment with yeast extract (Y) with different concentrations (0, 5, 10) $g.l^{-1}$. The best obtained average was due to the spraying with yeast suspension concentration of 10 $g.l^{-1}$ which represents a percentage of increase (3.94% and 7.99%) compared to the 5 $g.l^{-1}$ and control treatment respectively. Moreover, Table 3 depicts substantial differences between the plant height averages due to the treatment with the Humic acid and bread yeast extract combination. The highest obtained average was due to suing a mixture that consists of H 4 $g.l^{-1}$ + Y 10 $g.l^{-1}$, this signify (25.32%) higher than the combination control treatment (H 0 $g.l^{-1}$ + Y 0 $g.l^{-1}$) which recorded the lowest average.

Table 3. The effect of organic fertilization with Humic acid and foliar spraying with bread yeast extract on the plant height (cm)

	Yeast ($g.l^{-1}$)			The average of the effect of humic acid
Humic acid ($g.l^{-1}$)	Y0	Y1	Y2	
H0	22.23f	22.76ef	23.76de	22.92c
H1	24.46dc	25.60bc	26.56ab	25.54b
H2	25.70bc	26.86ab	27.86a	26.81a
The average of the effect of yeast	24.13c	25.07b	26.06a	

The different letters in the column indicate a significant difference between the treatments at the level (P<0.05).

- ***Number of Leaves (leave.plant^{-1})***

Result in Table 4 show significant differences in number of leaves per plant due to treatment with Humic acid. The concentration (4 $g.L^{-1}$) gave the best average in this trait where (9.37% and 24.07%) increase was obtained compared to the 2 $g.l^{-1}$ and control treatment respectively. The results also depict significant differences in the leaves number of eggplant plants that have been treated with the yeast extract. The highest obtained average was due to the treatment with yeast extract concentration (10 $g.L^{-1}$) where (6.00% and 23.32%) increase was achieved compared to the 5 $g.l^{-1}$ concentration and control treatment respectively. This trait has also been found to be highly influenced by the treatment with the Humic acid and yeast extract combination. The results indicate that the treatment with a combination that consists of (H 4 $g.L^{-1}$ + Y10 $g.L^{-1}$) provides the best average which is (48.38%) higher than the combination control treatment.

Table 4. The effect of organic fertilization with Humic acid and foliar spraying with bread yeast extract on the number of leaves (leaf. plant^{-1})

	Yeast ($g.l^{-1}$)			The average of the effect of humic acid
Humic acid ($g.l^{-1}$)	Y0	Y1	Y2	
H0	6.20e	6.86d	7.26dc	6.77c
H1	6.90d	7.73c	8.43b	7.68b
H2	7.10d	8.90ab	9.20a	8.40a
The average of the effect of yeast	6.73c	7.83b	8.30a	

The different letters in the column indicate a significant difference between the treatments at the level (P<0.05).

- ***Number of Branches (branch.plant^{-1})***

The treatment of eggplant plants with Humic acid with different concentrations (0, 2, 4 *g.l^{-1}*) has shown remarkable differences, below the 5% probability level, in the number of plant branches. The results given in Table 5 show that the best averages for this trait were obtained as a result of organic fertilization with Humic acid concentration (4 *g.l^{-1}*). This provides (22.91% and 76.11%) increase in the number of branches per plant compared to the 2 *g.l^{-1}* and control treatment respectively. The results also show notable differences in the averages of the trait as a result of spraying the plant with bread yeast extract. The concentration (10 *g.l^{-1}*) gave the highest average which is (13.26% and 54.16%) higher than the 5 *g.l^{-1}* treatment and control treatment respectively. The results in Table 5, also, indicate considerable differences in the number of plant branches as a result of treatment with Humic acid and bread yeast extract mixture. The highest average was obtained from the combination that consists of (H 4 *g.l^{-1}* + Y10 *g.l^{-1}*), this treatment provided (163.63%) increase compared to the combination control treatment which recorded the lowest average for this trait.

Table 5. The effect of organic fertilization with Humic acid and foliar spraying with bread yeast extract on the number of plant branches (branch. plant^{-1})

	Yeast (*g.l^{-1}*)			The average of the effect of humic acid
Humic acid (*g.l^{-1}*)	**Y0**	**Y1**	**Y2**	
H0	1.10e	1.43ed	1.50ed	1.34c
H1	1.50ed	2.00bcd	2.26abc	1.92b
H2	1.73cde	2.46ab	2.90a	2.36a
The average of the effect of yeast	1.44b	1.96a	2.22a	

The different letters in the column indicate a significant difference between the treatments at the level (P<0.05).

- ***Shoot Fresh Weight (g)***

Result in Table 6 show significant differences in the plant soft vegetative weight due to treatment with Humic acid with different concentrations (0, 2, and 4 *g.l^{-1}*). The highest average of this trait was obtained as a result of treatment with Humic acid concentration (4 *g.l^{-1}*). This represents (9.66% and 19.56%) increase compared to the 2 *g.l^{-1}* concentration and control treatments respectively. For the bread yeast extract effect, the results signified significant differences between the averages of this trait due to the treatment with different concentrations of yeast extract (0, 5, and 10 *g.l^{-1}*). The highest obtained average was when the plants were sprayed with 10 *g.l^{-1}* extract concentration. This represents (6.46% and 16.51%) increase relative to the treatments with the other two concentrations (5 and 0 *g.l^{-1}* respectively). As for the treatments combinations and their impact on the shoot fresh weight, Table 6 shows that the highest average of this trait was achieved by a combination consists of H 4 *gl^{-1}*+ Y10 *gl^{-1}*, this developed (43.50%) increase compared to the combination control treatment.

Table 6. The effect of organic fertilization with Humic acid and foliar spraying with bread yeast extract on the shoot fresh weight (g)

	Yeast (*g.l^{-1}*)			The average of the effect of humic acid
Humic acid (*g.l^{-1}*)	**Y0**	**Y1**	**Y2**	
H0	110.70e	124.56d	133.16c	122.80c
H1	125.53d	135.43c	140.70b	133.88b
H2	135.16c	146.46b	158.86a	146.82a
The average of the effect of yeast	123.79c	135.48b	144.24a	

The different letters in the column indicate a significant difference between the treatments at the level (P<0.05)

- ***Shoot Dry Weight (g)***

The plant treatment with different concentrations of the Humic acid showed important differences among the averages of the dry vegetative weight trait at the 5% probability level. Table 7 shows that the highest average of this trait was obtained using the Humic acid concentration 4 *g.l^{-1}* which yield (3.57%) increase compared to the control treatment. The results, also, highlight significant differences among the averages of this trait due to the leaves spraying with different concentrations of the yeast extract. The concentration (10 *g.l^{-1}*) provided the highest average which signposts (2.14% and 3.88%) increase compared to the other concentrations (5 and 0 *g.l^{-1}* respectively).

The combination of the Humic acid and yeast extract has also shown vital effect of the dry vegetative weight trait. The results in Table 7 show that the best average for this trait was obtained from the H 4 *g.l^{-1}* + Y 10 *g.l^{-1}* combination, this provided (7.87%) increase compared to the control treatment which provided the lowest average.

Table 7. The effect of organic fertilization with Humic acid and foliar spraying with bread yeast extract on the shoot dry weight (g)

	Yeast (*g.l^{-1}*)			The average of the effect of humic acid
Humic acid (*g.l^{-1}*)	**Y0**	**Y1**	**Y2**	
H0	12.70d	12.90cd	13.00bcd	12.86b
H1	12.93cd	13.06bcd	13.40ab	13.13a
H2	12.96cd	13.30bc	13.70a	13.32a
The average of the effect of yeast	12.86c	13.08b	13.36a	

The different letters in the column indicate a significant difference between the treatments at the level (P<0.05).

Yield Characteristics

- ***Number of Fruits (fruit.plant^{-1})***

The treatment with different concentrations of the Humic acid showed important differences among the averages of the number of fruit per plant, as shown in Table 8. The results revealed that the highest average of this trait was due to treatment with 4 g.*l^{-1}* Humic acid. This

represents (7.41% and 30.78%) increase compared to the lower concentration (2 $g.l^{-1}$) and the control treatments respectively. Further, Table 8 shows vital differences between the averages of this trait due plant spraying with bread yeast extract. The highest achieved average was due to the 10 $g.l^{-1}$ yeast extract concentration. This denotes (9.09%) increase compared to the spraying concentration (5 $g.l^{-1}$), and (17.48%) compared to the control treatment which signified the lowest average for this trait.

The results in Table 8, also, indicate important differences among the averages of the number of fruit per plant trait due to treatment with different combinations of Humic acid and yeast extract. The highest average was due to treatment with the combination (H 4 $g.l^{-1}$ + Y 10 $g.l^{-1}$), this produces a development of (56.65%) higher than the control treatment.

Table 8. The effect of organic fertilization with Humic acid and leaves spraying with bread yeast extract on the number of fruits per plants (fruit.plant^{-1})

	Yeast ($g.l^{-1}$)			The average of the effect of humic acid
Humic acid ($g.l^{-1}$)	**Y0**	**Y1**	**Y2**	
H0	4.06g	4.30fg	4.60ef	4.32c
H1	4.66ef	5.30cd	5.83b	5.26b
H2	5.03de	5.56bc	6.36a	5.65a
The average of the effect of yeast	2.86c	3.08b	3.36a	

The different letters in the column indicate a significant difference between the treatments at the level (P<0.05).

- ***Fruit Length (cm)***

Results in Table 9 indicate significant differences among the averages of the fruit length trait. The results show the superiority of the Humic acid concentration (4 $g.l^{-1}$) compared to the other concentrations where (8.96%) increase is reported compared to the (2 $g.l^{-1}$), and (30.11%) compared to the control treatment. Moreover, the bread yeast extract concentration (10 $g.l^{-1}$) surpassed the rest of the concentrations with a percentage increase of (16.91%) compared to the lower concentration and the control treatment respectively. Table 9, also, highlights important differences among the fruit length averages due to the treatment with different concentrations of Humic acid and yeast extract combination. The combination (H 4 $g.l^{-1}$ + Y 10 $g.l^{-1}$) gave the best fruit length compared to the other combinations and surpassed the control combination by (47.77%).

Table 9. The effect of organic fertilization with Humic acid and foliar spraying with bread yeast extract on the fruit length (cm)

	Yeast ($g.l^{-1}$)			The average of the effect of humic acid
Humic acid ($g.l^{-1}$)	**Y0**	**Y1**	**Y2**	
H0	9.00d	9.33d	10.26cd	9.53c
H1	10.66c	11.16bc	12.33ab	11.38b
H2	11.03	12.86a	13.30a	12.40a
The average of the effect of yeast	10.23c	11.12b	11.96a	

The different letters in the column indicate a significant difference between the treatments at the level (P<0.05).

- ***Fruit Diameter (cm)***

Significant differences happened between the averages of the fruit diameter trait as a result of adding the Humic acid at different concentrations (2 and 4 $g.l^{-1}$). The concentration (4 $g.l^{-1}$) gave the highest average which is (24.49%) higher than the control treatment. Furthermore, significant differences were obtained in this trait as a result of treating the plant with bread yeast extract. The concentration (5 g.l^{-1}) gave the highest average for the fruit diameter trait which is (17.68%) higher than that of the control treatment which recorded the lowest average, (Table 10). The results also show that the combination that consists of (H 4 g.l^{-1} + Y5 g.l^{-1}) recorded the highest average for this trait compared to the other combinations, a percentage of increase (51.11%) was achieved compared to the control treatment.

Table 10. The effect of organic fertilization with Humic acid and foliar spraying with bread yeast extract on the fruit diameter (cm)

	Yeast ($g.l^{-1}$)			The average of the effect of humic acid
Humic acid ($g.l^{-1}$)	**Y0**	**Y1**	**Y2**	
H0	3.13d	3.76c	3.53cd	3.47b
H1	3.63cd	4.40ab	4.03bc	4.02a
H2	3.60cd	4.73a	4.63a	4.32a
The average of the effect of yeast	3.45b	4.30a	4.06a	

The different letters in the column indicate a significant difference between the treatments at the level (P<0.05).

- ***Fruit Weight (g)***

Results given in Table 11 show significant differences between the averages of the fruit weight trait in the plants that were treated with Humic acid concentrations 2 and 4 g.l^{-1}. The higher concentration gave the better average of this trait which is (5.78% and 16.20%) higher than the lower concentration and the control treatment respectively. In a similar way, significant differences happened between the averages as a result of treating the plants with different concentrations of the bread yeast extract (5 and 10 g.l^{-1}). The concentration (10 g.l^{-1}) gave the highest averages with percentages of increase (2.87% and 9.26%) compared to the concentration (5 g.l^{-1}) and the control treatment (0 g.l^{-1}) respectively.

The results in Table 11 also signpost important differences between the averages of the fruit weight trait when treated with Humic acid and bread yeast extract combination with different concentrations. The combination that consisted of (H 4 g.l^{-1} + Y10 g.l^{-1}) recorded the highest average for this trait with a percentage of increases (29.29%) compared to the control treatment combination.

Table 11. The effect of organic fertilization with Humic acid and foliar spraying with bread yeast extract on the fruit weight (g.plant^{-1})

	Yeast (*g.l*$^{-1}$)			**The average of the effect of humic acid**
Humic acid (*g.l*$^{-1}$)	**Y0**	**Y1**	**Y2**	
H0	140.30f	151.63e	155.30ed	149.07c
H1	158.96cd	163.96bc	168.33b	163.75b
H2	162.96bc	175.33a	181.40a	173.23a
The average of the effect of yeast	154.07c	163.64b	168.34a	

The different letters in the column indicate a significant difference between the treatments at the level (P<0.05).

- ***Fruit Yield (Kg.plant^{-1})***

Table 12 shows significant differences between the averages of the fruits yield (kg.plant^{-1}) trait as a result of treating the plant with different concentrations of the Humic acid (0, 2, and 4 *g.l*$^{-1}$). The higher concentration gave the better average for this trait which is (18.07% and 53.12%) higher than the lower concentration and the control treatment respectively. Further, significant differences happened between the fruit yield averages as a result of treating the plants with different concentrations of the bread yeast extract. The concentration (10 g.*l*$^{-1}$) gave the highest averages with significant percentages increase of (28.16%) compared to the control treatment (0 g.*l*$^{-1}$), though, the increase was not that important relative to the lower concentration (5 g.*l*$^{-1}$).

The results in Table 12 also signpost important differences between the averages of the fruit yield trait when treated with different concentrations of Humic acid and bread yeast extract combination. The combination that consistes of (H 4 g.*l*$^{-1}$ + Y10 g.*l*$^{-1}$) recorded the highest average for this trait with a percentage of increases (101.75%) compared to the control treatment.

Table 12. The effect of organic fertilization with Humic acid and foliar spraying with bread yeast extract on the fruit yield (Kg.plant^{-1})

	Yeast (*g.l*$^{-1}$)			**The average of the effect of humic acid**
Humic acid (*g.l*$^{-1}$)	**Y0**	**Y1**	**Y2**	
H0	0.57d	0.65cd	0.71cd	0.64c
H1	0.74cd	0.86bc	0.89ab	0.83b
H2	0.82bc	0.97ab	1.15a	0.98a
The average of the effect of yeast	0.71b	0.82a	0.91a	

The different letters in the column indicate a significant difference between the treatments at the level (P<0.05).

Discussion

A remarkable development in the eggplant vegetative and productive traits was achieved as a result of treating the plants with Humic acid and bread yeast (individual and combined additives). The reason behind that development is attributed to the indirect role of the Humic acid which acts to improve the chemical, physical and biological properties of the soil. Humic acid reduces the pH of the soil, and increases the activity of microorganisms to liberate the essential nutrients, such as nitrogen, phosphorous and potassium from their unavailable forms and reducing their loss. Moreover, it activates the roots, increases the nutrients absorption, and improves the soil ability to retain water (Mackowiak et al., 2021) which, eventually, enhances the plant vegetative growth (Hosam and Nassour, 2016). However, the direct action of the Humic acid is signified by its role in increasing the nutrients membranes permeability. Further, it affects the plant's various biological processes that occur in the cytoplasm, such as respiration, photosynthesis, protein synthesis, and various enzymatic reactions. In other words, Humic acid has an effects, similar to plant hormones, that causes an increase in the growth and provides the best conditions for its cell division (Zhang and Schmidt, 2000, Zhang et al., 2003, Kulikova et al., 2003). These results, of the current study, conform well with what have been reported by (ZHANG& SCHMIDT, 2000; Colpas-Castillo et al., 2018, Jaafar and Abbass, Rady et al., 2018).

On the other hand, the reason behind the increase in the studied traits due to the treatment with high concentrations of yeast extract is attributed to the yeast ability to increase the production of plant growth hormones, especially gibberellin, auxin and cytokinin. These hormones work to enhance the plants cell division, and increase their elongation. In addition to that, bread yeast contains nutrients, vitamins, amino acids and enzymes which are necessary for the plant's various vital activities (Ismail, 2020). Another reason for the plant evolution is credited to the catalytic role of bread yeast for the photosynthetic pigments, the photosynthesis process, and the activity of enzymes that are involved in the process which in turn stimulate the vegetative growth (El-Sherbeny et al., 2007). These developments in the plant vegetative traits reflect positively on plant yield and on the yield characteristics. These are represented by the number of fruits, length of the fruit, the diameter of the fruit, the weight of the fruits in a single plant, and the yield of a single plant. The results of this research were consistent with what was found by (Ismail, 2020, Fouda and Abd-Elhamied, 2017, Ei-Tohamy et al., 2008; Abdulrazzaq & Mohammed, 2019).

Conclusion

Individual application of humic acid had offered good vegetative characteristics and the significantly higher yield. Furthermore, the interaction effect of both substances showed that the yeast extract led to enhance the effect of humic acid. Nevertheless.

Humic acid enhances the effect of yeast extract. It could be recommended that the application of a combination of humic acid at 4 g l $^{-1}$ with yeast extract at 10g. l^{-1} proved to be the best for developing vegetative characteristics, increasing production and improving its

quality. Further studies were needed to clarify the interaction effect of both substances by using the higher modern technique.

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