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THE EFFECT OF SOAKING WITH ATONIC, INOCULATION WITH BIO FERTILIZERS AND ORGANIC FERTILIZATION WITH WATER HYACINTHS COMPOST ON SOME GROWTH INDICATORS OF TUBEROSE PLANT (*POLIANTHES TUBEROSA* L.)

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ABSTRACT

The factorial experiment was conducted in green canopy of Department of Horticulture and Garden Engineering - College of Agricultural Engineering Sciences-University of Baghdad, for the spring season of 2022, to study the effect of soaking *Polianthes tuberosa* L. bulbs in Atonic solution and inoculation with bacterial biofertilizer *Stenotrophomonas malophilia* and fungal biofertilizer *Glomus mosseae*, along with the addition of two levels (3% and 4%) of water hyacinths compost (C:N=17) on some vegetative and floral growth traits of Peral variety of tuberose. The study was conducted using a randomized completely block design with three replicates. Tuberose bulbs were planted in black plastic bags containing 6 kg of a sandy loam soil. The total number of experimental units was 72, with each experimental unit containing 5 plants, resulting in a total of 360 plants in the experiment. The results showed that soaking the bulbs for 12 hours in Atonic before planting, as well as inoculation with biofertilizers and organic fertilization, led to a significant increase in all the studied vegetative and floral growth traits of this plant. The results of the triple interaction between the study factors showed the superiority of the treatment involving soaking with Atonic, inoculation with the biofertilizer combination, and fertilization with a 4% level of water hyacinths compost, significantly affecting the carbohydrate content, iron and manganese concentration in the leaves, fresh Peduncle weight, number of florets per plant and the number of bulbs. The recorded values were 4.271%, 549.7 mg kg-1 dry weight, 73.0 mg kg^{-1} dry weight, 126.70 g, and 55.33 flower plant^{-1}, and 17 bulbs plant^{-1}, respectively.

Keywords: Tuberose, Atonic, Biofertilizer, organic fertilizer, water hyacinths compost.

[*]**The article is taken from a master's thesis by the first researcher.**

تاثير التنقيع بالاتونك والتلقيح بالاسمدة الحيوية والتسميد العضوي بكمبوست زهرة النيل في بعض مؤشرات نمو نبات التيوبيروز

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الخلاصة

نفذت تجربة عامليه في الظلة الخضراء التابعة لقسم البستنة وهندسة الحدائق- كلية علوم الهندسة الزراعية– جامعة بغداد للموسم الربيعي للعام 2022 لدراسة تاثير تنقيع ابصال التيوبيروز *Polianthes tuberosa* L. بمحلول الاتونك والتلقيح بالسماد الحيوي البكتيري *Stenotrophomonas maltophilia* والفطري *Glomus mosseae* واضافة مستويين (3% و4%) من كمبوست زهرة النيل (C:N=17) في بعض صفات النمو الخضري والزهري لنبات التيوبيروز صنف peral. نفذت هذه الدراسة وفق تصميم القطاعات العشوائية الكاملة وبثلاثة مكررات وذلك بزراعة الابصال في اكياس بلاستيكية احتوت على 6كغم من تربة مزيجة رملية، اذ بلغ مجموع الوحدات التجريبية 72 وحدة واحتوت كل وحدة تجريبية على 5 نباتات وبذلك بلغ عدد نباتات التجربة 360 نبات .اظهرت النتائج ان نقع الابصال لمدة 12 ساعة بالاتونك قبل الزراعة والتلقيح بالاسمدة الحيوية والتسميد العضوي ادى الى سبب حصول زيادة معنوية في جميع صفات النمو الخضري والزهري المدروسة لهذا النبات . اظهرت نتائج التداخل الثلاثي بين عوامل الدراسة تفوق معاملة النقع بالاتونك والتلقيح بتوليفة المخصب الحيوي والتسميد بمستوى 4% من كمبوست زهرة النيل معنويا في صفات تركيز الكربوهيدرات والحديد والمنغنيز في الاوراق والوزن الطري لحامل النورة وعدد الزهيرات لكل نبات وعدد البصيلات اذ سجلت قيما بلغت 4.271 % و 549.7 ملغم كغم$^{-1}$ مادة جافة و 73.0 ملغم كغم$^{-1}$ مادة جافة و126.70 غم و55.33 زهيرة نبات$^{-1}$ و17.بصيلة نبات$^{-1}$ على التتابع.

الكلمات المفتاحية: تيوبيروز ، اتونك، اسمدة حيوية، كمبوست زهرة النيل، اسمدة عضوية.

INTRODUCTION

Tuberose (*Polianthes tuberosa* L.), belonging to the family *Asparagaceae*, is one of the most important perennial ornamental bulbs of the summer season. Recently, it has been given the common scientific name *Agave amica* L. Its native habitat is Mexico, and it is considered an important ornamental plant in the cut flower trade and extraction of its attractive fragrance oil. Due to the beauty of its flowers, it is also used in interior decoration of homes **(AL-Dur and Al-Atrakchii, 2021; Thiede and Govaers, 2017).**

Plant growth regulators have a significant influence on the physiology and morphology of plants, directly affecting their root, vegetative, and floral growth traits. All these traits are important for ornamental plants, in addition to their impact on ,vase life and promotion or delay of flowering **(Munikrishnappa and Chandrashekar, 2014; EL-Shoura and Arafa, 2018)**. A study conducted by **Al-Rawi et al. (2021)** showed that soaking Mung Bean seeds in a concentration of 7.5 ml L^{-1} of Atonic solution for 6 hours resulted in the best results in terms of plant height, number of branches, number of pods, and seeds.

In recent years, there has been a shift towards the use of organic fertilizers instead of chemical fertilizers to meet the requirements of sustainable agriculture, as they play an important role in improving some physical, chemical, and biological properties of the soil, as well as providing nutrients to the soil **(Lim *et al*., 2015).**

A study by **Basant *et al*., (2020)** found a significant increase in all vegetative and floral growth traits of tuberose plants when using a combination of different organic fertilizers during cultivation. Water hyacinths compost is characterized as an organic fertilizer with high nutrient content and the ability to retain water and exchange positive ions **(Villasenor *et al*., 2011).** Additionally, **Zorman *et al*., (2021)** found that the addition of water hyacinths compost (C: N=17) contributed to improving the visual and biochemical traits of lily plants. On the other hand **Jasin & Hamid (2023)** found that adding of compost and mycorrhiza improve soil physical properties and nutrients dissolved in soil solution.

The use of biofertilizers has gained great importance in recent years as promising alternatives to mineral fertilizers in clean agriculture, as they are environmentally friendly and cost-effective, and their effects remain in the soil for a long time. One of the newly used bacteria as a biofertilizer is *Stenotrophomonas maltophilia*, which has been found to produce antimicrobial compounds that protect plants and secrete various compounds that promote plant growth. It can colonize the internal tissue of plant roots without causing any harm, and it can spread in the rhizosphere soil **(AL-Obaidi & Abdul-Ratha).**

The study of **Kadhim *et al*., (2020)** found that the interaction between biofertilizers and chitosan contributed to a significant increase in the concentration of some active medicinal compounds in carnation plants, Additionally, **Kadhim *et al*., *(*2020)** confirmed that inoculating vinca plants with bacterial biofertilizers and adding 30% compost led to a significant increase in carbohydrate content, NPK concentration, and vegetative growth indicators for this plant.

The study of **Alexander *et al*., (2019)** found that *Stenotrophomonas maltophilia* plays an important role in nitrogen fixation in field peanuts and that inoculation with it contributes to an increase in certain fatty acids such as Omega-7 and Omega-6. Mycorrhizal fungi, on the other hand, are symbiotic fungi that contribute to improving soil structure by linking their hyphae together, thus accelerating the decomposition of organic compounds **(Thirkell *et al*, 2017).** The study of **Ahmed & Abdul-Latif) 2020)** showed that inoculating carnation plants achieved a significant increase in vegetative and floral growth indicators, as well as their tolerance to water stress. **Ahmed & Abdul-Latif (2020)** confirmed that inoculating carnation roots with mycorrhiza and adding salicylic acid in combination with different irrigation durations contributed to an increase in NPK concentration and plant dry weight.

Furthermore, **Hussien *et al*., (2019)** demonstrated that the addition of mycorrhiza, either alone or in combination with potassium-releasing bacteria and organic fertilizer, resulted in a significant increase in vegetative growth parameters and yield of maize. **Ahmed & Abdul-Latif (2020)** obtained similar results regarding the effect of mycorrhizal inoculation in combination with salicylic acid on improving carnation plant growth and increasing its drought tolerance. Additionally, **Waldan & Abdul-Ratha, (2022)** found that the use of these bacteria as biofertilizers contributed to an increase in the growth and yield of squash,In addition ,it has been found that the organic fertilizer mixyture gave the largest production amount of summer squash which amounted to 26>67 ton ha^{-1} (**AL-Halifi & AL-Azzawi,2022**)

The aim of the current study was to investigate the effect of pre-soaking *Polianthes tuberosa* bulbs with a solution of Atonic, as well as inoculation with bacterial and fungal biofertilizers, and fertilization with water hyacinths compost on certain growth indicators of *Polianthes tuberosa* plants.

MATERIALS AND METHODS

An experimental study was conducted using a randomized complete block design (RCBD) with three replicates in the green canopy belonging to the Department of Horticulture and Garden Engineering, College of Agricultural Engineering Sciences, University of Baghdad, for the spring season of 2022. The aim of this study was to investigate the response of *Polianthes tuberosa* L. to bulb pre-soaking with the growth regulator Atonic, as well as the effect of inoculation with biofertilizers and organic fertilization with Nile flower compost on the growth and flowers of this plant.

Preparation of Biofertilizer and Nile flower compost:

The mycorrhizal inoculant *Glomus mosseae* was obtained from the Ministry of Science and Technology- Department of Agricultural Research. The bacterial inoculant *Stenotrophomonas maltophilia* which is nitrogen-fixing and capable of solubilizing insoluble phosphate compounds was obtained from the Department of Soil Science and Water Resources, College of Agricultural Engineering Sciences, University of Baghdad. As for the Nile flower compost (containing total nitrogen, phosphorus, and potassium at the rate of 15, 4.10, and 16.30 g kg^{-1}, respectively), it was obtained from the Ministry of Agriculture, Plant Protection Department.

Preparation of the growing medium

A sandy loam soil was obtained from one of the banks of the Tigris River for use in agriculture, and Table (1) illustrates some of its chemical and physical properties before cultivation. It was mixed with peat moss (of Dutch origin) in a ratio of 1:3, thoroughly blended, and placed in black plastic bags with a height of 28 cm and a diameter of 13 cm. Each bag contained 6 kg of the mixture.

Experimental Factors:

Factor 1: Soaking with the growth regulator (Atonic) at two levels:
A- Soaking with Atonic at a concentration of 0.5 ml l^{-1} for 12 hours (coded as A1).
Soaking with plain water for 12 hours (coded as A0).

Factor 2: Biofertilizer, including four types:
A- Control treatment (no biofertilizer added, coded as B0).
B- Bacterial biofertilizer (*Stenotrophomonas maltophilia*) with a numerical density of 8.2* 109 CFU ml^{-1} (coded as B1).
C- Fungal biofertilizer (*Glomus mosseae*) with a spore density of 50 spores g^{-1} (coded as B2).
D- Combination of bacterial and fungal biofertilizer (coded as B3).

Factor 3: Organic fertilization with water hyacinths compost, with three levels:
A- No addition of water hyacinths compost (coded as O0).
B- Addition of water hyacinths compost at 3% of the soil weight (coded as O1).
C- Addition of water hyacinths compost at 4% of the soil weight (coded as O2).

Planting Bulbs:

Tuberose bulbs with a size of 1.5-2.5 cm were planted in the soil after creating a small hole in the bag's soil. Then, 15 g of *mycorrhizal inoculant* was added at a depth of 5 cm from the soil surface for the respective treatments. Additionally, 12 g of bacteria inoculant loaded on peat moss was added to separate holes for their respective treatments. The bacterial and fungal biofertilizers were added together in another hole for the combined biofertilizer treatment. Furthermore, 3% of water hyacinths compost (180 g bag^{-1}) was added to 120 bags, while 4% (240 g per bag) was added to another 120 bags. The remaining 120 bags were left without the addition of organic fertilizer.

Peral variety tuberose bulbs were planted on March 6, 2022, in the early morning at a depth of 5 cm from the soil surface. Plant maintenance tasks, such as weeding, were performed. NPK fertilizer with a ratio of 20:20:20 was applied according to the recommended fertilization guidelines **(AL-Sanam, 2021).** The experiment consisted of three replicates, with 24 treatments per replicate resulting from the combinations of the study factors. This resulted in a total of 72 experimental units for the three replicates. Each treatment included five plants, making a total of 360 plants for the experiment. The Genstat software was used for data analysis, and means were compared using the least significant difference (LSD) test at a significance level of 0.05 **(Al-Rawi & Kalaf Allha, 1980)**

Table (1): Chemical and fertility properties of field soil.

<table>
<tr><th>Property</th><th colspan="2">Value</th><th>Unit</th></tr>
<tr><td>EC 1:1</td><td colspan="2">1.9</td><td>ds m^{-1}</td></tr>
<tr><td>PH 1:1</td><td colspan="2">7.21</td><td>-----</td></tr>
<tr><td>Available N</td><td colspan="2">31</td><td rowspan="3">g kg^{-1} soil</td></tr>
<tr><td>Available P</td><td colspan="2">2.14</td></tr>
<tr><td>Available K</td><td colspan="2">147.2</td></tr>
<tr><td>OM</td><td colspan="2">7.3</td><td rowspan="2">g kg^{-1} soil</td></tr>
<tr><td>Carbonate minerals</td><td colspan="2">247.3</td></tr>
<tr><td>Ca^{+2}</td><td colspan="2">10.25</td><td rowspan="6">meq L^{-1}</td></tr>
<tr><td>Mg^{+2}</td><td colspan="2">8.39</td></tr>
<tr><td>Na^{+}</td><td colspan="2">1.29</td></tr>
<tr><td>HCO_3</td><td colspan="2">0.8</td></tr>
<tr><td>Cl^{-1}</td><td colspan="2">18.57</td></tr>
<tr><td>K^{+}</td><td colspan="2">0.86</td></tr>
<tr><td>Soil Texture</td><td colspan="2">sandy loam</td><td></td></tr>
<tr><td rowspan="3">Soil Separates</td><td>Sand</td><td>512</td><td rowspan="3">g kg^{-1} soil</td></tr>
<tr><td>Clay</td><td>68</td></tr>
<tr><td>Silt</td><td>420</td></tr>
</table>

Study Indications

Some characteristics of vegetative growth were studied, including the concentration of carbohydrates, iron and manganese in leaves, fresh weight of Peduncle, number of florets per plant, and number of bulbs per plant.

RESULTS AND DISCUSSION

Carbohydrate content in leaves (%)

The results in table 2 revealed a significant effect of soaking the bulbs with Atonic on the carbohydrate content in the leaves, reaching 3.619% compared to soaking in regular water at 3.387%. Additionally, the inoculation with biofertilizers had a significant effect on this trait, with the bacterial-fungal biofertilizer combination B_3 outperforming non-inoculated treatment, giving 3.948% compared to 2.372%. The addition of water hyacinths composts significantly increased the carbohydrate concentration, with treatment O_2 outperforming the non-compost addition treatment at 3.782% compared to 3.086%. The statistical analysis indicated a significant three-way interaction effect between the study factors in this trait, with treatment $B_3O_2A_1$ outperforming treatment $B_0O_0A_0$, recording 4.271% compared to 1.299%.

Table (2): Effect of soaking with Atonic, water hyacinths compost and biofertilizers on Carbohydrate content in leaves (%).

Bio fertilizer	**Organic fertilizer**	**Growth regulator**		**B * O**	
		A0	**A1**		
B0	O0	1.299	1.297	1.298	
	O1	2.241	3.167	2.704	
	O2	2.947	3.283	3.115	
B1	O0	3.496	3.652	3.574	
	O1	4.031	3.989	4.010	
	O2	3.752	4.059	3.905	
B2	O0	3.817	3.847	3.832	
	O1	3.870	4.001	3.935	
	O2	3.979	4.173	4.076	
B3	O0	3.615	3.668	3.641	
	O1	3.811	4.022	3.916	
	O2	3.791	4.271	4.031	
LSD_{B*O*A}		0.550		LSD_{B*O}	0.389
B * A					
Biofertilizer		**A0**	**A1**	**Mean Bio-fert .**	
B0		2.162	2.582	2.372	
B1		3.760	3.900	3.830	
B2		3.889	4.007	3.948	
B3		3.739	3.987	3.863	
LSD_{B*A}		0.318		LSD_{B}	0.225
O * A					
Organic fertilizer		A0	A1	Mean Organic fert.	
O0		3.057	3.116	3.086	
O1		3.488	3.795	3.641	
O2		3.617	3.947	3.782	
LSD_{O*A}		0.275		LSD_{O}	0.194
A					
Growth regulator		A0	A1		
Mean Growth regulator		3.387	3.619		
LSD_{A}		0.159			

Iron in Leaves (mg kg^{-1} dry matter)

The results show that soaking the bulbs has a significant effect on increasing the iron concentration in plant leaves. The soaking treatment with Atonic increased the iron concentration to 361.6 mg kg^{-1}, compared to the regular water soaking treatment at 310.8 mg kg^{-1}. Organic fertilization with water hyacinths compost led to a significant increase in iron concentration in the leaves, with treatment O_2 recorded the highest concentration of 382.70 mg kg^{-1}, while the no- addition treatment had the lowest iron concentration in the leaves, recording 272.60 mg kg^{-1}. Inoculating the bulbs with the three biofertilizers B_3, B_2, and B_1 also resulted in a significant increase in iron concentration in the leaves. The combination of the biofertilizer with mycorrhiza (B_3) outperformed the other biofertilizers and the non-inoculated treatment, recording 436.5 mg kg^{-1} compared to treatment B_0, which recorded 223.9 mg kg^{-1}. Furthermore, the statistical analysis showed a significant three-way interaction effect between the three study factors in this regard. Treatment $B_3O_2A_1$ exhibited the highest concentration of 549.7 mg kg^{-1}, with a percentage increase of 227.39% compared to the lowest average of 167.9 mg kg^{-1} dry matter in treatment $B_0O_0A_0$.

Table (3): Effect of soaking with Atonic, water hyacinths compost and biofertilizers on iron in leaves (mg kg^{-1} dry matter).

Bio fertilizer	Organic fertilizer	Growth regulator		B * O	
		A0	A1		
B0	O0	167.9	177.4	172.6	
	O1	246.9	253.3	250.1	
	O2	233.3	264.6	249.0	
B1	O0	250.4	293.3	271.9	
	O1	319.3	425.7	372.5	
	O2	306.0	525.9	416.0	
B2	O0	286.8	331.7	309.3	
	O1	336.1	348.3	342.2	
	O2	326.3	356.5	341.4	
B3	O0	319.9	353.3	336.6	
	O1	437.3	459.6	448.5	
	O2	499.3	549.7	524.5	
LSD B*O*A		111.4		LSD B*O	78.77
B * A					
Biofertilizer		A0	A1	Mean Bio-fert .	
B0		216.0	231.8	223.9	
B1		291.9	415.0	353.4	
B2		316.4	345.5	331.0	
B3		418.9	454.2	436.5	
LSD B*A		64.31		LSD B	45.48
O * A					
Organic fertilizer		A0	A1	Mean Organic fert.	
O0		256.30	288.90	272.60	
O1		334.90	371.70	353.30	
O2		341.20	424.20	382.70	
LSD O*A		55.7		LSD O	39.38
A					
Growth regulator		A0	A1		
Mean Growth regulator		310.8	361.6		
LSD A		32.16			

Manganese Concentration in Leaves (mg kg^{-1} dry matter)

The results demonstrate a significant effect of soaking the bulbs with Atonic in increasing the manganese concentration in the leaves (Table 4). Treatment A_1 recorded a concentration of 55.1 mg kg^{-1} dry matter, compared to treatment A0 (49.9 mg kg^{-1} dry matter). The statistical analysis revealed a significant effect of adding organic fertilizer at levels O_1 and O_2 in increasing the manganese concentration in the leaves. Treatment O_2 outperformed the others, with the highest value of 59.6 mg kg^{-1}. In contrast, the control treatment O_0 had the lowest concentration at 43.6 mg kg^{-1}. Additionally, inoculation with the three biofertilizers B_3, B_2, and B_1 had a significant impact on increasing this trait compared to the non-inoculated treatment. Treatment B_3 performed the best, with a concentration of 60.7 mg kg^{-1}, compared to treatment B_0, which achieved 38.2 mg kg^{-1}. The statistical analysis indicated a significant three-way interaction effect among the study factors. Treatment $B_3O_2A_1$ had the highest value of 73.0 mg kg^{-1}, with a percentage increase of 156.14% compared to the lowest average concentration of manganese in treatment $B_0O_0A_0$, which recored 28.5 mg kg^{-1}.

Table (4): Effect of soaking with Atonic, water hyacinths compost and biofertilizers on manganese concentration in leaves (mg kg^{-1} dry matter).

Bio fertilizer	Organic fertilizer	Growth regulator		B * O	
		A0	A1		
B0	O0	28.5	32.5	30.5	
	O1	39.7	42.8	41.2	
	O2	45.0	41.0	43.0	
B1	O0	44.5	48.5	46.5	
	O1	55.7	62.9	59.3	
	O2	65.0	71.0	68.0	
B2	O0	45.7	49.0	47.3	
	O1	49.6	58.3	54.0	
	O2	55.0	61.0	58.0	
B3	O0	48.0	52.0	50.0	
	O1	56.1	69.1	62.6	
	O2	66.0	73.0	69.5	
LSD $_{B*O*A}$		4.67		LSD $_{B*O}$	3.3
B * A					
Biofertilizer		A0	A1	Mean Bio-fert .	
B0		37.7	38.8	38.2	
B1		55.1	60.8	57.9	
B2		50.1	56.1	53.1	
B3		56.7	64.7	60.7	
LSD $_{B*A}$		2.7		LSD $_{B}$	1.91
O * A					
Organic fertilizer		A0	A1	Mean Organic fert.	
O0		41.7	45.5	43.6	
O1		50.3	58.3	54.3	
O2		57.8	61.5	59.6	
LSD $_{O*A}$		2.33		LSD $_{O}$	1.65
A					
Growth regulator		A0	A1		
Mean Growth regulator		49.9	55.1		
LSD $_{A}$		1.35			

Fresh weight of Peduncle (g)

The results indicate a significant effect of soaking the bulbs with Atonic on the fresh weight of the peduncle (Table 5). Treatment A_1 outperformed the others, with an average of 92.5 grams compared to treatment A_0, which recorded 82.5 grams. Inoculation with biofertilizers also had a significant effect on this trait, and treatment B_3 performed better than the other treatments, with an average of 105.40 g, while treatment B_0 achieved 71.10 grams. Furthermore, organic fertilization with Nile flower compost led to a significant increase in this trait, with treatment O2 recording 100.20 grams compared to treatment O_0, which recorded 78.10 grams. The statistical analysis revealed a significant effect of the three-way interactions on this trait. Treatment $B_3O_2A_1$ showed the highest values, measuring 126.70 grams, while treatment $B_0O_0A_0$ had the lowest fresh weight of the peduncle at 35.70 grams.

Table (5): Effect of soaking with Atonic, water hyacinths compost and biofertilizers on fresh weight of peduncle (g).

Bio fertilizer	**Organic fertilizer**	**Growth regulator**		**B * O**	
		A0	**A1**		
B0	O0	35.70	58.70	47.20	
	O1	74.30	86.00	80.20	
	O2	84.00	88.00	86.00	
B1	O0	72.30	86.30	79.30	
	O1	77.00	72.00	74.50	
	O2	89.70	112.00	100.80	
B2	O0	79.00	86.30	82.70	
	O1	90.70	77.00	83.80	
	O2	88.30	110.30	99.30	
B3	O0	101.00	105.70	103.30	
	O1	95.70	101.00	98.30	
	O2	102.70	126.70	114.70	
LSD_{B*O*A}		17.15		LSD_{B*O}	12.13
B * A					
Biofertilizer		A0	A1	Mean Bio-fert .	
B0		64.70	77.60	71.10	
B1		79.70	90.10	84.90	
B2		86.00	91.20	88.60	
B3		99.80	111.10	105.40	
LSD_{B*A}		9.9		LSD_B	7.0
O * A					
Organic fertilizer		A0	A1	Mean Organic fert.	
O0		72.00	84.20	78.10	
O1		84.40	84.00	84.20	
O2		91.20	109.20	100.20	
LSD_{O*A}		8.57		LSD_O	6.06
A					
Growth regulator		A0	A1		
Mean Growth regulator		82.5	92.5		
LSD_A		4.95			

Number of florets (floret plant^{-1})

The results showed a significant effect of soaking the bulbs with Atonic, as indicated by the results in Table (6). Treatment A_1 outperformed the others, with an average of 44.14 florets plant^{-1} compared to treatment A_0, which recorded 39.64 florets plant^{-1}. Inoculation with biofertilizers also had a significant effect on this trait. Treatment B_3, which involved the combination of bacterial and fungal biofertilizers, recorded 47.89 florets plant^{-1}, while treatment B_0 achieved 38.67 florets plant^{-1}. Additionally, organic fertilization with water hyacinths compost led to a significant increase in the number of florets, with treatment O_2 showing a higher value of 45.33 florets plant^{-1} compared to treatment O_0, which recorded 38.50 florets plant^{-1}. The statistical analysis revealed a significant effect of the three-way interactions on this trait. Treatment $B_3O_2A_1$ showed the highest average number of florets plant-1 at 55.33, surpassing treatment $B_0O_0A_0$, which recorded 5.67 florets plant^{-1}.

Table (6): Effect of soaking with Atonic, water hyacinths compost and biofertilizers on number of florets (floret plant^{-1}).

Bio fertilizer	**Organic fertilizer**	**Growth regulator**		**B * O**	
		A0	**A1**		
B0	O0	5.67	29.00	17.33	
	O1	33.33	36.67	35.00	
	O2	35.67	40.00	37.83	
B1	O0	39.33	47.33	43.33	
	O1	36.67	40.33	38.50	
	O2	44.00	45.67	44.83	
B2	O0	48.67	44.00	46.33	
	O1	50.33	46.00	48.17	
	O2	45.67	49.67	47.67	
B3	O0	46.33	47.67	47.00	
	O1	43.33	48.00	45.67	
	O2	46.67	55.33	51.00	
LSD $_{B*O*A}$		17.15		5.075	

B * A				
Biofertilizer	A0	A1	Mean Bio-fert .	
B0	24.89	35.22	30.06	
B1	40.00	44.44	42.22	
B2	48.22	46.56	47.39	
B3	45.44	50.33	47.89	
LSD $_{B*A}$	4.144		LSD $_B$	2.93

O * A				
Organic fertilizer	A0	A1	Mean Organic fert.	
O0	35.00	42.00	38.50	
O1	40.92	42.75	41.83	
O2	43.00	47.67	45.33	
LSD $_{O*A}$	3.589		LSD $_O$	2.538

A			
Growth regulator	A0	A1	
Mean Growth regulator	39.64	44.14	
LSD A	2.072		

The number of bulbs (bulb plant^{-1})

The results demonstrated a significant effect of bulb soaking on the number of bulbs plant-1 (Table 7). Treatment A_1 outperformed with an average of 10.67 bulbs plant^{-1} compared to treatment A_0, which recorded 8.39 bulbs plant^{-1}. Additionally, the addition of biofertilizers had a significant impact on this trait. Treatment B3, involving the combination of biofertilizers, recorded 12.56 bulbs plant^{-1} compared to the lower numbers in treatment B0, which achieved 4.56 bulbs plant^{-1}. Moreover, organic fertilization with Nile flower compost led to a significant increase in the number of bulbs, with treatment O_2 showing a higher value of 10.83 bulbs plant^{-1} compared to treatment O_0, which recorded 7.79 bulbs plant^{-1}.

The statistical analysis revealed a significant effect of three-way interactions between the study factors on this trait. Treatment $B_3O_2A_1$ showed the highest averages for the number of bulbs plant, with 17.00 bulbs plant^{-1}whilethe, treatment $B_0O_0A_0$ had the lowest average number of bulbs, reaching 3.0 bulbs per plant**.**

Table (7): Effect of soaking with Atonic, water hyacinths compost and biofertilizers on number of bulbs (bulb plant^{-1}).

Bio fertilizer	**Organic fertilizer**	**Growth regulator**		**B * O**	
		A0	**A1**		
B0	O0	3.00	4.00	3.50	
	O1	4.33	5.00	4.67	
	O2	4.67	6.33	5.50	
B1	O0	8.67	9.00	8.83	
	O1	9.67	14.33	12.00	
	O2	9.67	14.33	12.00	
B2	O0	9.00	9.33	9.17	
	O1	9.33	10.67	10.00	
	O2	9.67	12.33	11.00	
B3	O0	9.00	10.33	9.67	
	O1	11.00	15.33	13.17	
	O2	12.67	17.00	14.83	
LSD $_{B*O*A}$		1.34		LSD $_{B*O}$	0.95
B * A					
Biofertilizer		A0	A1	Mean Bio-fert .	
B0		4.00	5.11	4.56	
B1		9.33	12.56	10.94	
B2		9.33	10.78	10.06	
B3		10.89	14.22	12.56	
LSD $_{B*A}$		0.77		LSD $_B$	0.55
O * A					
Organic fertilizer		A0	A1	Mean Organic fert.	
O0		7.42	8.17	7.79	
O1		8.58	11.33	9.96	
O2		9.17	12.50	10.83	
LSD $_{O*A}$		0.67		LSD $_O$	0.47
A					
Growth regulator		A0	A1		
Mean Growth regulator		8.39	10.67		
LSD $_A$		0.39			

Soaking the bulbs with the growth regulator Atonic led to a significant increase in all studied vegetative and floral growth traits. This can be attributed to its mechanism of action, which affects the intensity of photosynthetic processes and stimulates plant roots to uptake more water. Additionally, its physiological effects as a growth regulator result in an increase in internal auxin content, control of enzymatic activities, activation of metabolic processes, and consequently an increase in meristematic activity by stimulating cell division and elongation, leading to increased internodes length. This, in turn, reflects an increase in carbohydrate concentration. Atonic also has an effect on the relative water content in leaves, as well as the concentration of iron and manganese. **(Bologa *et al.*, 2020).**

Inoculation with biofertilizers has shown a significant effect on vegetative and floral growth traits. Inoculation with the bacterium *S. maltophilia* resulted in a significant increase in these traits. This can be attributed to the role of this bacterium in secreting growth regulators, especially auxins, and producing antibiotics that contribute to suppressing plant pathogens. Additionally, it secretes organic acids and enzymes that degrade insoluble phosphate compounds, leading to an increase in the availability of these nutrients in the soil. Moreover, this bacterium is capable of nitrogen fixation through the activity of the nitrogenase enzyme it possesses, which results in an increased nitrogen concentration in plants. This, in turn, contributes to increased iron, manganese, and carbohydrate concentrations. Furthermore, this bacterium secretes plant hormones and some growth regulators responsible for cell division and elongation, promoting the growth and development of the root system and increasing the surface area of the absorption zone. Consequently, it enhances the water and nutrient uptake rate. These results are consistent with the findings of **Abdul-Latif and Mustafa (2019)** regarding the inoculation of Gerbera plants with Azotobacter and Bacillus bacteria, as well as mycorrhizal fungi, which led to a significant increase in nutrient concentration and vegetative growth indicators. Also, what was obtained by **Aldolaimy *et al.* (2022)** showed a significant impact of the bacterial, fungal, and organic fertilizer combination on increasing the vegetative growth and yield indices of cauliflower. Similarly, the inoculation with *S. maltophilia* and the addition of organic fertilizer contributed to an increase in vegetative growth indicators and yield of zucchini, as confirmed by **Waldan and Abdul-Ratha (2022).** This can be attributed to the different mechanisms possessed by these fungi in improving and supporting plant growth, such as the production of phosphate enzymes, hyphal growth nature, and extensive extension, allowing plants to explore greater distances in the soil in search of water and nutrients, thus increasing the absorption rate of these nutrients **(Hussien *et al*., 2019**). Additionally, mycorrhizal fungi's ability to produce siderophores compounds contributes to the supply of iron and other elements such as copper, zinc, and manganese, which reflects on the plant's health **(Al-Mammori & Abdul-Ratha, 2020)**. Furthermore, the fungus produces Glomalin, which is a proteinaceous sugar compound that contributes to the stability of soil aggregates and improves their structure and aeration **(Haselwandter *et al.*, 2020).** The combined bacterial-fungal biofertilizer also stimulated the secretion of auxins and cytokinins, promoting cell division and increasing stem diameters for nutrient uptake, including potassium, which plays a role in carbohydrate and protein synthesis, as well as the division and expansion of cambium cells **(AL-Hasnawi *et al,* 2018).** It is possible that mycorrhizal fungi enhanced bacterial nitrogen fixation, and these results are consistent with the findings of **AL-Silmawy & Abdul-Ratha (2021)**, who reported a significant interaction between mycorrhizal inoculation and organic fertilization with vermicompost, resulting in an increase in vegetative growth indicators and yield of cauliflower. Similarly, **Aldolaimy *et al.* (2022)** confirmed the significant effect of organic-biological fertilization using mycorrhizae, Trichoderma, and Azotobacter, in combination with organic fertilization, on the significant increase in growth indicators and yield of cauliflower, these results came in agreement with **AL-Obaidi and Abdul-Ratha (2021)** for the effect of combination of biofertilizer and vermicompost in the growth and yield of bean.

Organic fertilization with water hyacinths compost led to a significant increase in all studied vegetative and floral growth indicators. Organic fertilizers provide a suitable environment for the growth of microorganisms, including the biofertilizers used in this study, by providing appropriate moisture levels, pH interaction, and a suitable energy source, as indicated by **Ali *et al.* (2015).** On the other hand, the interaction between organic and biological fertilization confirms the important role of biological fertilization in sustaining the live microbial biomass in the soil. Organic fertilizers also play an important role in the formation of organic acids, leading to a decrease in soil pH and thus increasing the availability of certain nutrients **(Lim *et al.*, 2015).**

Furthermore, C:N ratio of water hyacinths compost and its content of easily decomposable compounds by microorganisms result in the release of nitrogen into the soil, which is then absorbed by plants. This has a positive effect on vegetative growth characteristics **(Lim *et al.*, 2015).**

CONCLUSIONS:

Soaking tuberose bulbs,Inoculation with bacterial and fungal biofertilizer and fertilization with water hyacinths compost increase growth and flowering of this plant**.**

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