EFFECT OF SOAKING WITH ATONIC, WATER HYACINTHS COMPOST AND BIOFERTILIZERS ON VEGETATIVE AND FLOWERING GROWTH OF TUBEROSE

* Z. H. ALI S. A. Abdul-Latif
Researcher Assist Prof.
Dept.of Horticulture and Gardens Engineering ,College of Agricultural Engineering Sciences,University of Baghdad,Iraq
E.mail : zainb.ali2105@coagri.uobaghdad.edu.iq

ABSTRACT

This study was aimed to investigate effect of soaking *Polianthes tuberosa* L. bulbs in Atonic solution and inoculation with *Stenotrophomonas maltophilia* and *Glomus mosseae*, and fertilizing with two levels (3% and 4%) of water hyacinths Compost on some vegetative and floral growth characters of the Peral variety of tuberose plants in a Factorial experiment during spring season of 2022 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 results of the three-way interaction showed that the treatment of soaking with Atonic, inoculation with the combination of the biofertilizer, and fertilization with 4% level of water hyacinths Compost significantly outperformed other treatments in plant height, number of inflorescences, dry weight of flowers, vase life, and aromatic oil concentration with values of 47.33 cm, 55.33 inflorescences plant^{-1}, 5.78 grams, 16 days,and 0.71% respectively, compared to the control treatment which resulted in values of 21.67 cm, 5.67 inflorescences plant^{-1}, 1.81 grams, 8 days,and 0.42% respectively.

Keywords: growth regulators, beneficial bacteria, organic fertilizer, ornamental plants
***Part of M.S.c thesis of the 1st author**

تاثير التنقيع بالاتونك والتلقيح بالمخصبات الحيوية والتسميد العضوي في بعض مؤشرات النمو الخضري والزهري للتيوبيروز

* زينب حسن علي سوسن عبدالله عبداللطيف
الباحثة استاذ مساعد
قسم البستنة وهندسة الحدائق – كلية علوم الهندسة الزراعية – جامعة بغداد

المستخلص

هدفت الدراسة الحالية تقييم تاثير تنقيع ابصال التيوبيروز في محلول الاتونك والتلقيح ببكتريا *Stenotrophomonas maltophilia* و *Glomus mosseae* والتسميد بمستويين (3% و4%) من كمبوست زهرة النيل في بعض صفات النمو الخضري والزهري لنبات التيوبيروز صنف peral في تجربة عاملية للموسم الربيعي 2022 باستعمال تصميم القطاعات العشوائية الكاملة وبثلاثة مكررات وذلك بزراعة الابصال في اكياس بلاستيكية سوداء اللون مثقبة من الاسفل احتوت على 6كغم من تربة مزيجة رملية ،. اظهرت نتائج التداخل الثلاثي تفوق معاملة النقع بالاتونك والتلقيح بتوليفة المخصب الحيوي والتسميد بمستوى 4% من كمبوست زهرة النيل معنويا في صفات ارتفاع النبات وعدد الزهيرات والوزن الجاف للازهار والعمر المزهري وتركيز الزيت العطري اذ بلغت 47.33 سم و55.33 زهيرة نبات$^{-1}$ و 5.78 غم و 16 يوم و0.71% على التتابع مقارنة بمعاملة المقارنة التي اعطت 21.67 سم و 5.67 زهيرة نبات$^{-1}$و 1.81 غم و 8 يوم 0.42% على التتابع.

الكلمات المفتاحية:منظمات النمو،البكتريا النافعة،التسميد العضوي،نباتات الزينة
***البحث مستل من رسالة ماجستير للباحث الاول**

Received: 11/2/2023, Accepted:4/6/2023

INTRODUCTION

Tuberose (*Agave amica* L.), belonging to the family Aparagaceae, is one of the important perennial ornamental bulbs that is also commonly known as *Polianthes tuberosa* L. Its native habitat is Mexico, and it is considered an important ornamental plant in the cut flower trade and for extracting its attractive aromatic oil. It is also used for interior decoration in homes due to the beauty of its flowers (7, 38). Plant growth regulators have significant importance in influencing the physiology and morphology of plants, as their effects can directly affect the root, vegetative and floral growth traits of the plant, vase life, obtaining a larger number of flowers, and promoting or delaying flowering (22, 24). A study conducted by Al-Rawi *et al.*, (14) found 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 plant height, number of branches, number of pods, and seeds. In recent years, there has been a shift towards clean agriculture through the use of organic fertilizers instead of mineral fertilizers, as they play an important role in improving some physical, chemical, and biological soil properties, as well as providing nutrients in the soil (9, 10, 28). Basan *et al.*, (19) 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 stands out as an organic fertilizer due to its high content of nutrients and its ability to retain water and exchange positive ions (42). Zorman etal (43) found that adding water hyacinths Compost at different levels contributed to improving the phenotypic and biochemical traits of lilium plants. 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 (5, 30, 3). The study of Alexander *et al.,* (8) 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 (2, 3, 38). Another study demonstrated that the addition of mycorrhiza, either alone or in combination with potassium-releasing bacteria and organic fertilizer, resulted in a significant increase in the vegetative or yield parameters of corn (28). Similarly, Ahmed *et al.,* (1) obtained similar results for the effect of mycorrhizal inoculation, in combination with salicylic acid, on improving the growth of Dianthus plants and increasing their drought tolerance. On the other hand, it was found that using *Stenotrophomonas maltophilia* as a biofertilizer contributed to increased growth and yield of zucchini squash (40). The aim of the current study was to investigate the effect of soaking tuberose bulbs in Atonic, adding water hyacinths Compost, and biofertilizers on certain vegetative and floral growth traits of tuberose.

MATERIALS AND METHODS

An experimental study was conducted using a randomized completely block design (RCBD) with three replicates in the green canopy belonging to the Department of Horticulture and Gardens Engineering, College of Agricultural Engineering Sciences, University of Baghdad, during spring season of 2022. The aim was to investigate the response of *Pollianthes tuberosa* L. (tuberose) to soaking with the growth regulator Atonic and the effect of adding biofertilizers and organic compost (water hycanths compost) on the growth and flowers of this plant, as well as the possibility of its successful cultivation in the central region of Iraq.

Preparation of Biofertilizer and water hycanths compost: The mycorrhizal inoculant *Glomus mosseae* was obtained from the Ministry of Science and Technology - Department of Agricultural Research. The bacterial inoculant *Stenotrophomonas maltophilia* was obtained from the Department of Soil Science and Water Resources - College of Agricultural Engineering Sciences, University of Baghdad. As for water hycanths compost, it was obtained from the Ministry of Agriculture - Department of Crop Protection.

Preparation of the growing medium

A silty loam soil was obtained from one of the banks of the Tigris River for use in cultivation. Table (1) shows some of its chemical and physical properties before cultivation. It was mixed with peat moss in a ratio of 1:3, thoroughly mixed, and placed in black plastic bags with a height of 28 cm and a diameter of 13 cm, each bag containing 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 A_1). Soaking with plain water for 12 hours (coded as A_0).

Factor 2: Biofertilizer, including four types: A- Control treatment (no biofertilizer added, coded as B_0). B- Bacterial biofertilizer (*Stenotrophomonas maltophilia*) with a numerical density of 8.2* 10^9 CFU ml^{-1} (coded as B_1). C- Fungal biofertilizer (*Glomus mosseae*) with a spore density of 50 spores g^{-1} (coded as B_2). D- Combination of bacterial and fungal biofertilizer (coded as B_3).

Factor 3: Organic fertilization with water hyacinths compost, with three levels: A- No addition of water hycanths compost compost (coded as O_0). B- Addition of Nile flower compost at 3% of the soil weight (coded as O1). C- Addition of Nile flower 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 Nile flower compost (180 g bag^{-1}) was added to 120 bags, while 4% (240 g bag^{-1}) was added to another 120 bags. The remaining 120 bags were left without the addition of organic fertilizer.

Table 1. Chemical and fertility properties of field soil

propertity	Value		Unit
EC 1:1	1.9		ds m^{-1}
PH 1:1	7.21		-----
Available N	31		mg kg^{-1} soil
Available P	2.14		
Available K	147.2		
OM	7.3		g kg^{-1} soil
Carbonate minerals	247.3		
Ca^{+2}	14.25		
Mg^{+2}	8.39		meq L^{-1}
Na^{+}	1.29		
HCO_3	0.8		
Cl^{-1}	18.57		
K^{+}	0.86		
Soil Texture	sandy loam		
Soil Separates	Sand	512	g kg^{-1} soil
	Clay	68	
	Silt	420	

Tuberose Planting: 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 (16).

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 (15).

Characters studied: The study examined some vegetative growth traits, including plant height, leaf area, and relative chlorophyll content in the leaves. It also assessed some floral growth traits; including spike length, dry flower weight, and vase life.in addition the essential oil of the flowers was estimated.

Estimating of essential oil concentration in the flowers (%): Flower samples of 10 gram were taken and placed in a flask. 100 milliliters of distilled water were added to the flask, and it was placed in a distillation apparatus for 3 hours. The oil was collected, and 5 milliliters of hexane were added to separate the oil from the water droplets accumulated with the oil. The oil was collected and stored in the refrigerator until the analysis (18).

$$\text{Oil percentage (\%)} = \frac{\text{(Weight of flask before extraction} - \text{Weight of flask after extraction)}}{\text{Weight of the sample}} * 100$$

RESULTS AND DISCUSSION

Plant height (cm)

The results shows a significant effect of soaking seeds with Atonic on the plant height (Table 2), reaching 42.39 cm compared to the control treatment soaked with regular water at 38.47 cm. The addition of biofertilizer had a significant effect compared to the non-inoculated treatment. The highest plant height was recorded in the treatment inoculated with mycorrhizae at 43.61 cm, which was not significantly different from the treatments inoculated with bacterial biofertilizer or the combination of biofertilizers, which recorded 42.61 cm and 42.33 cm, respectively.

Table 2. Effect of soaking with atonic, water hyacinths compost and biofertilizers on plant height (cm)

Bio fertilizer	Organic fertilizer	Growth regulator A0	Growth regulator A1	B * O
B0	O0	21.67	32.00	26.83
	O1	28.00	38.00	33.00
	O2	38.00	41.33	39.67
B1	O0	41.33	43.67	42.50
	O1	39.67	42.67	41.17
	O2	42.00	44.67	43.33
B2	O0	43.67	42.00	42.83
	O1	41.67	45.33	43.50
	O2	44.33	44.67	44.50
B3	O0	39.00	41.33	40.17
	O1	39.67	45.67	42.67
	O2	42.67	47.33	45.00
LSD B*O*A		6.023		LSD B*O 4.259

B * A	A0	A1	Mean Bio-fert .
B0	29.22	37.11	33.17
B1	41.00	43.67	42.33
B2	43.22	44.00	43.61
B3	40.44	44.78	42.61
LSD B*A	3.477		LSD B 2.459

O * A: Organic fertilizer	A0	A1	Mean Organic fert.
O0	36.42	39.75	38.08
O1	37.25	42.92	40.08
O2	41.75	44.50	43.12
LSD O*A	3.012		LSD O 2.129

A: Growth regulator	A0	A1
Mean Growth regulator	38.47	42.39
LSD A	1.739	

The non-inoculated treatment recorded a height of 33.17 cm. Furthermore, the addition of Nile flower compost resulted in a significant increase in plant height at 43.12 cm in the treatment with 4% of this organic fertilizer. The statistical analysis showed a significant three-way interaction effect between the study factors on plant height. The treatments B3O2A1, B3O1A1, B1O1A1, and B2O2A1 performed better, with plant heights of 47.33 cm, 45.67 cm, 45.33 cm, and 44.67 cm, respectively, compared to the treatment B0O0A0, which recorded 21.67 cm.

Leaf area (cm²)

The results in Table (3) show a significant effect of soaking seeds with Atonic on the leaf area, with 785 cm² compared to the control treatment soaked with regular water at 602 cm². Inoculation with biofertilizers also had a significant effect with the treatment using a combination of bacterial and fungal biofertilizer (B3) outperforming the non-inoculated treatment, with a leaf area of 849 cm² compared to 521 cm². The addition of Nile flower compost also resulted in a significant increase in the leaf area, with treatment O2 performing better and giving a leaf area of 786 cm². The statistical analysis showed a significant three-way interaction effect between the study factors on the leaf area, with treatments B3O1A1 and B3O2A1 performing better and giving leaf areas of 1108 cm² and 1030 cm², respectively, compared to the treatment B0O0A0, which recorded 253 cm².

Table 3. Effect of soaking with atonic, water hyacinths compost and biofertilizers on leaf area (cm²)

Biofertilizer	Organic fertilizer	Growth regulator A0	Growth regulator A1	B * O
B0	O0	253	310	282
	O1	457	575	516
	O2	661	869	765
B1	O0	612	608	610
	O1	494	881	687
	O2	566	747	656
B2	O0	601	821	711
	O1	558	846	702
	O2	837	857	847
B3	O0	765	770	767
	O1	692	1108	900
	O2	728	1030	879
LSD B*O*A		267		LSD B*O 189

B * A

Biofertilizer	A0	A1	Biofertilizer mean
B0	457	585	521
B1	557	745	651
B2	665	841	753
B3	728	969	849
LSD B*A	154		LSD B 109

O * A

Organic fertilizer	A0	A1	Organic fertilizer mean
O0	558	627	592
O1	550	852	701
O2	698	875	786
LSD O*A	133		LSD O 94

A

Growth regulator	A0	A1
Growth regulator mean	602	785
LSD A	77	

Dry matter (%)

The results showed a significant effect of soaking seeds with Atonic on increasing the percentage of dry matter (Table 4). Treatment A1 gave a percentage of 9.61% compared to treatment A0 (9.45%). Inoculation with biofertilizers also led to increased plant growth and an increase in this percentage. Treatment B1 with bacterial biofertilizer performed better with percentage of dry weight of 11.87%, followed by the treatment with a combination of biofertilizers at 10.11%, while the non-inoculated treatment recorded 6.52%. The addition of Nile flower compost also resulted in a significant increase, with treatment O2 performing better at 10.06% compared to treatment O0, which reached 8.96%. Additionally, the statistical analysis showed a significant effect of the two-way and three-way interactions between the study factors on this trait. Treatments B1O2A0, B1O1A1, B1O0A1, and B3O2A1 performed better, giving values of 14.69%, 13.58%, and 11.16%, respectively, compared to the treatment B0O0A0, which recorded 4.59%.

Table 4. Effect of soaking with atonic, water hyacinths compost and biofertilizers on Percentage of Dry Matter (%)

Biofertilizer	Organic fertilizer	Growth regulator A0	Growth regulator A1	B * O
B0	O0	4.59	5.60	5.09
	O1	6.45	7.46	6.96
	O2	7.25	7.79	7.52
B1	O0	11.48	11.58	11.53
	O1	10.40	13.58	11.99
	O2	14.69	9.48	12.08
B2	O0	8.77	10.46	9.61
	O1	9.30	8.95	9.12
	O2	10.52	9.67	10.09
B3	O0	9.69	9.53	9.61
	O1	10.28	10.03	10.15
	O2	9.96	11.16	10.56
LSD $_{B*O*A}$		3.64		LSD $_{B*O}$ 2.58
		B * A		
Biofertilizer		A0	A1	Biofertilizer mean
B0		6.10	6.95	6.52
B1		12.19	11.55	11.87
B2		9.53	9.69	9.61
B3		9.98	10.24	10.11
LSD $_{B*A}$		2.10		LSD $_{B}$ 1.46
		O * A		
Organic fertilizer		A0	A1	Organic fertilizer mean
O0		8.63	9.29	8.96
O1		9.11	10.01	9.56
O2		10.60	9.53	10.06
LSD $_{O*A}$		1.82		LSD $_{O}$ 1.29
		A		
Growth regulator		A0	A1	
Growth regulator mean		9.45	9.61	
LSD $_{A}$		1.05		

Relative chlorophyll content (%)

The results indicate a significant effect of soaking the seeds with Atonic on increasing the relative chlorophyll content in the leaves (Table 5). Treatment A1 gave a value of 54.2 SPAD units compared to treatment A0, which gave 49.8 SPAD units. Inoculation with biofertilizers also resulted in a significant increase with treatment B3 performing better at 54.7 SPAD units, while it was 47.9 SPAD units in treatment B0. The addition of Nile flower compost also led to a significant increase in the chlorophyll content, with treatment O2 performing better and recording 54.6 SPAD units, while treatment O0 recorded 47.0 SPAD units. Furthermore, the statistical analysis showed a significant effect of the two-way and three-way interactions. Treatment B3O2A1 performed better, giving a value of 60.7 SPAD units compared to the treatment B0O0A0, which recorded 35.0 SPAD units.

Table 5. Effect of soaking with atonic, water hyacinths compost and biofertilizers on Relative Chlorophyll Content (%)

Biofertilizer	Organic fertilizer	Growth regulator A0	Growth regulator A1	B * O
B0	O0	35.0	46.0	40.5
	O1	47.8	53.4	50.6
	O2	50.1	55.0	52.5
B1	O0	50.2	51.9	51.1
	O1	51.6	54.2	52.9
	O2	51.7	56.8	54.3
B2	O0	52.5	53.3	52.9
	O1	50.2	52.8	51.5
	O2	50.1	57.8	53.9
B3	O0	51.7	55.4	53.5
	O1	52.5	53.4	52.9
	O2	54.5	60.7	57.6
LSD $_{B*O*A}$		3.57		LSD $_{B*O}$ 2.52
		B * A		
Biofertilizer		A0	A1	Biofertilizer mean
B0		44.3	51.5	47.9
B1		51.2	54.3	52.8
B2		50.9	54.6	52.8
B3		52.9	56.5	54.7
LSD $_{B*A}$		2.06		LSD $_{B}$ 1.46
		O * A		
Organic fertilizer		A0	A1	Organic fertilizer mean
O0		47.3	51.7	49.5
O1		50.5	53.5	52.0
O2		51.6	57.6	54.6
LSD $_{O*A}$		1.78		LSD $_{O}$ 1.26
		A		
Growth regulator		A0	A1	
Growth regulator mean		49.8	54.2	
LSD $_{A}$		1.03		

Length of peduncle (cm)

The results revealed a significant effect of soaking the seeds with Atonic on the length of the peduncle (Table 6). Treatment A1 performed better, measuring 90.28 cm compared to treatment A0, which measured 85.86 cm. Inoculation with the three biofertilizers also resulted in a significant increase in peduncle length. Treatment B3 with the bacterial-fungal biofertilizer performed the best, measuring 96.94 cm, followed by treatments B1, B2, and B0, which measured 91.44 cm, 88.94 cm, and 74.94 cm, respectively. Furthermore, the addition of Nile flower compost had a significant effect on the length of the peduncle. Treatment O2 outperformed others, measuring 93.0 cm compared to treatment O0, which measured 83.12 cm. Statistical analysis indicated significant two-way and three-way interactions. Treatments B3O2A0, B3O1A1, and B2O2A1 performed the best, measuring 99.00 cm, 97.00 cm, and 96.33 cm, respectively, compared to control treatment B0O0A0 with 44.33 cm.

Table 6. Effect of soaking with atonic, water hyacinths compost and biofertilizers on length of peduncle (cm)

Biofertilizer	Organic fertilizer	Growth regulator A0	Growth regulator A1	B * O
B0	O0	44.33	76.33	60.33
	O1	80.00	80.00	80.00
	O2	86.67	82.33	84.50
B1	O0	85.00	88.33	86.67
	O1	84.00	90.33	87.17
	O2	93.33	92.67	93.00
B2	O0	90.00	93.33	91.67
	O1	86.00	91.00	88.50
	O2	92.00	96.33	94.17
B3	O0	93.67	94.00	93.83
	O1	96.33	97.00	96.67
	O2	99.00	101.67	100.33
6.31		LSD $_{B*O}$ 6.31		4.462 6.31

Biofertilizer	A0	A1	Biofertilizer mean
B0	70.33	79.56	74.94
B1	87.44	90.44	88.94
B2	89.33	93.56	91.44
B3	96.33	97.56	96.94
LSD $_{B*A}$	3.643		LSD $_B$ 2.576

O * A

Organic fertilizer	A0	A1	Organic fertilizer mean
O0	78.25	88.00	83.12
O1	86.58	89.58	88.08
O2	92.75	93.25	93.00
LSD $_{O*A}$	3.155		LSD $_O$ 2.231

A

Growth regulator	A0	A1
Growth regulator mean	85.86	90.28
LSD $_A$	1.821	

Flowers dry weight (g)

Results indicate a significant effect of soaking the seeds with Atonic on the dry weight of flowers (Table 7). Treatment A1 yielded an average of 4.22 g compared to treatment A0, which recorded 3.47 g. Inoculation with the biofertilizers also had a significant effect on this trait. Treatment B3 with the biofertilizer performed better than the other treatments, recorded an average of 4.56 g, while treatment B0 recorded 2.98 g. Additionally, the addition of Nile flower compost led to a significant increase. Treatments O2 and O1 yielded values of 4.33 g and 3.90 g, respectively, compared to treatment O0 at 3.30 g. Statistical analysis indicated significant two-way and three-way interactions for this trait. Treatments B3O2A1 and B3O1A1 performed the best, measuring 5.78 g and 5.31 g, respectively, in comparison to control treatment B0O0A0, which recorded 1.81 g.

Table 7. Effect of soaking with atonic, water hyacinths compost and biofertilizers on dry weight of flowers (g)

Biofertilizer	Organic fertilizer	Growth regulator A0	Growth regulator A1	B * O
B0	O0	1.81	2.62	2.21
	O1	2.87	3.23	3.05
	O2	3.14	4.20	3.67
B1	O0	2.98	3.78	3.38
	O1	3.40	4.27	3.84
	O2	3.40	4.82	4.11
B2	O0	3.33	3.53	3.43
	O1	3.62	4.46	4.04
	O2	4.59	4.87	4.73
B3	O0	4.58	3.76	4.17
	O1	4.07	5.31	4.69
	O2	3.88	5.78	4.83
LSD $_{B*O*A}$		1.061		LSD $_{B*O}$ 0.75
		B * A		
Biofertilizer		A0	A1	Biofertilizer mean
B0		2.61	3.35	2.98
B1		3.26	4.29	3.77
B2		3.85	4.29	4.07
B3		4.18	4.95	4.56
LSD $_{B*A}$		0.612		LSD $_{B}$ 0.433
		O * A		
Organic fertilizer		A0	A1	Organic fertilizer mean
O0		3.18	3.42	3.30
O1		3.49	4.32	3.90
O2		3.75	4.92	4.33
LSD $_{O*A}$		0.53		LSD $_{O}$ 0.375
		A		
Growth regulator		A0	A1	
Growth regulator mean		3.47	4.22	
LSD $_{A}$		0.306		

Vase life (days)

Results shows a significant effect of soaking seeds with Atonic on the Vase life (Table 8). Treatment A1 had a Vase life of 14.17 days compared to treatment A0, which had 13.50 days. Inoculation with the biofertilizers also had a significant effect on vase life. Treatment B3 with the bacterial-fungal biofertilizer performed better, recording a vase life of 15.22 days, followed by treatment B2 with mycorrhizal biofertilizer at 14.83 days. Furthermore, the addition of Nile flower compost led to a significant increase in the vase life. Treatment O2 had a vase life of 14.42 days compared to treatment O0, which had 12.79 days. Statistical analysis indicated significant two-way and three-way interactions for vase life. Treatments B3O2A1, B2O2A1, B2O1A1, B1O2A1, and B1O1A1 outperformed, with an average vase life of 16.00 days, 15.67 days, 15.67 days, 15.67 days, and 15.67 days, respectively, compared to control treatment B0O0A0, which recorded 8.00 days.

Table 8. Effect of soaking with atonic, water hyacinths compost and biofertilizers on Vase life (day)

Biofertilizer	Organic fertilizer	Growth regulator A0	Growth regulator A1	B * O
B0	O0	8.00	10.00	9.00
	O1	11.00	12.33	11.67
	O2	11.33	11.33	11.33
B1	O0	13.00	13.67	13.33
	O1	14.67	15.67	15.17
	O2	15.00	15.67	15.33
B2	O0	14.00	14.00	14.00
	O1	14.67	15.67	15.17
	O2	15.00	15.67	15.33
B3	O0	14.67	15.00	14.83
	O1	15.33	15.00	15.17
	O2	15.33	16.00	15.67
LSD $_{B*O*A}$		1.48		LSD $_{B*O}$ 1.04
		B * A		
Biofertilizer		A0	A1	Biofertilizer mean
B0		10.11	11.22	10.67
B1		14.22	15.00	14.61
B2		14.56	15.11	14.83
B3		15.11	15.33	15.22
LSD $_{B*A}$		0.85		LSD $_{B}$ 0.60
		O * A		
Organic fertilizer		A0	A1	Organic fertilizer mean
O0		12.42	13.17	12.79
O1		13.92	14.67	14.29
O2		14.17	14.67	14.42
LSD $_{O*A}$		0.74		LSD $_{O}$ 0.52
		A		
Growth regulator		A0	A1	
Growth regulator mean		13.50	14.17	
LSD $_{A}$		0.43		

Concentration of essential oil in flowers (%)

The results shows a significant effect of the study factors on the concentration of essential oil in the flowers of the Tuberosa plant (Table 9). The results indicated that the treatment of soaking the bulbs with Atonic extract outperformed significantly and recorded an essential oil concentration of 0.66%. On the other hand, the treatment of soaking with regular water recorded a concentration of 0.60%. Furthermore, the statistical analysis revealed the superiority of the treatment that incorporated a 4% level of organic fertilizer compost of the water hyacinths achieved a significant concentration of 0.72% compared to the treatment without the addition of organic fertilizer, at 0.53%. Additionally, the inoculation with the three biofertilizers led to an increase in the concentration of essential oil. The treatment with the bacterial-fungal biofertilizer combination outperformed and achieved an essential oil concentration of 0.66%, while the non-inoculated treatment recorded 0.54%. The results also indicated a significant interaction effect between organic fertilization and Atonic soaking. The treatment O_2A_1 showed the highest concentration of 0.75%, while the treatment O_0A_0 had the lowest concentration of 0.51%. Moreover, the statistical analysis confirmed significant differences between the treatments of the interaction between biofertilization and Atonic soaking. The treatment B_3A_1 recorded a concentration of 0.72%, whereas the lowest concentration in these interactions was observed in the treatment B_0A_0, which achieved 0.49%. There was also a significant interaction effect between biofertilization and organic fertilization in this trait. Th**e** treatment B_3O_2 achieved the highest concentration of 0.76%, while the treatment B_0A_0 had the lowest concentration of 0.37%. The statistical analysis shows significant three-way interaction. The treatment $B_3O_2A_1$

outperformed and recorded a concentration of 0.81%, with an increase of 161.29% compared to the treatment $B_0O_0A_0$, which achieved a concentration of 0.31%.

Table 9. Effect of soaking with atonic, water hyacinths compost and biofertilizers on concentration of essential oil in flowers (%)

Biofertilizer	Organic fertilizer	Growth regulator A0	Growth regulator A1	B * O
B0	O0	0.31	0.42	0.37
	O1	0.52	0.64	0.58
	O2	0.64	0.70	0.67
B1	O0	0.51	0.55	0.53
	O1	0.60	0.63	0.61
	O2	0.67	0.74	0.71
B2	O0	0.59	0.62	0.61
	O1	0.63	0.70	0.67
	O2	0.71	0.76	0.74
B3	O0	0.64	0.63	0.63
	O1	0.64	0.71	0.68
	O2	0.71	0.81	0.76
LSD $_{B*O*A}$		0.06		LSD $_{B*O}$ 0.04
		B * A		
Biofertilizer		A0	A1	Biofertilizer mean
B0		0.49	0.59	0.54
B1		0.59	0.64	0.62
B2		0.64	0.70	0.67
B3		0.66	0.72	0.69
LSD $_{B*A}$		0.03		LSD $_B$ 0.02
		O * A		
Organic fertilizer		A0	A1	Organic fertilizer mean
O0		0.51	0.56	0.53
O1		0.60	0.67	0.64
O2		0.68	0.75	0.72
LSD $_{O*A}$		0.04		LSD $_O$ 0.02
		A		
Growth regulator		A0	A1	
Growth regulator mean		0.60	0.66	
LSD $_A$		0.02		

The soaking bulbs with the Atonic growth regulator resulted in a significant increase in all the studied vegetative and floral growth traits. This may be attributed to its impact on the intensity of photosynthetic processes and its stimulation of plant roots to absorb larger quantities of water. Additionally, it exhibits physiological effects as a growth regulator, leading to an increase in internal auxin content, control of enzymatic activities, activation of metabolic processes, and consequently an increase in meristematic activity through cell division and elongation, resulting in increased plant height ,Moreover, the Atonic growth regulator also affects the relative water content in leaves, chlorophyll content, biomass, carbohydrate content, and various hormones and nutrients within the plant (21, 22). The inoculation with biofertilizers showed a significant effect on vegetative and floral growth traits. In particular, the inoculation with the bacterium *Stenotrophomonas maltophilia* resulted in a significant increase in these traits. This could be attributed to the role of this bacterium in producing growth regulators, especially auxins, and antibiotics that contribute to suppressing plant diseases. Furthermore, it secretes organic acids and enzymes that break down insoluble phosphate compounds, enhancing the availability of nutrients in the soil. Additionally, these bacteria possess nitrogen-fixing enzymes, increasing nitrogen concentration in plants, which in turn promotes chlorophyll and carbohydrate content. The ability of these bacteria to produce enzymes such as Phosphatase and Phytase may contribute to sulfur oxidation in the soil, leading to the production of sulfuric acid and lowering the soil's pH value. These bacteria also release potassium from mineral sources in the soil, thereby increasing its availability. Moreover, they actively secrete plant hormones and growth regulators responsible for cell division and elongation, contributing to root system growth, surface area of the absorption zone, and increased water and nutrient absorption. Additionally, mycorrhizal inoculation resulted in a significant increase in all vegetative and floral growth indicators, which can be attributed to the various mechanisms possessed by these fungi to improve and support plant growth. These mechanisms include the production of enzymes such as phosphatases, extensive hyphal growth, and long-distance exploration in the soil, allowing plants to explore larger areas in search of water and nutrients, leading to increased nutrient uptake (29) and these results came in agreement with (4). Furthermore, mycorrhizae can produce siderophores, which provide plants with iron and other elements such as copper, zinc, and manganese, positively influencing plant health (13). Mycorrhizae also secrete the enzyme ACC Deaminase, which is involved in the ethylene pathway, inhibiting its synthesis and delaying plant senescence by reducing degradation processes and preserving chlorophyll, thus prolonging the building processes (35). Moreover, mycorrhizae produce Glomalin, a sugar protein that contributes to the stability, formation, and aeration of soil aggregates (26). Additionally, the combination of bacterial-fungal biofertilizers resulted in increased production of auxins and cytokinins, stimulating cell division and stem diameter for nutrient absorption, including potassium, which is involved in carbohydrate and protein synthesis, as well as in the division and expansion of vascular cambium cells (36). These results are consistent with previous findings on chrysanthemum plants (37). Furthermore, mycorrhizae may have enhanced bacterial nitrogen fixation, as indicated in a previous study as well as what (6, 11, 28, 40) reached the significant effect of the combination of bacterial-fungal biofertilizers in the concentration of nutrients in the plant. Organic compost fertilization with water hyacinths compost resulted in 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, pH levels, and a suitable energy source (12, 41). Additionally, the interaction between organic and biofertilizers confirms the important role of biofertilizers in sustaining the live microbial biomass in the soil. The organic fertilizer plays an important role in the formation of organic acids, which leads to a reduction in soil pH and, consequently, an increase in phosphorus availability (10, 32, 39). Organic fertilizer also contributes to reducing the adsorption process, thereby increasing the release of phosphorus into the soil solution. Furthermore, organic fertilizer plays a crucial role in the chelating of certain cations such as calcium and magnesium, making phosphorus more soluble in the soil solution. Additionally, organic fertilizer works to coat soil particles and oxides, reducing the process of phosphorus fixation in the soil (23), These results were consistent with what (17) obtained. On the other hand, the low carbon-to-nitrogen ratio (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 and its uptake by plants, which reflects on vegetative growth traits (10, 31).

REFERENCES

1.Ahmed, M. SH., & S. A. Abdullateef 2020. Mycorrhiza and salsalic acid improving drought tolerance in carnation *dianthns caryophyllus*. Plant Archives, 20(1), 875-885.

2.Ahmid,M.SH., and S.A. Abdu Latif 2020. Role of Mycorrhiza and salicylic acid in carryingthe carnation plant dainthus caryophullus to water stress.Plant Archives.20(1):389-394.

3.Ahmed,M.SH,and S.A. Abdul Lateef. (2020).Mycorrhiza and salsalic acid improving

drought tolerance in carnation dianthus caryophyllus.Plant Archives.20(1):875-885.
4.Abdul Latif. S. A and H.A Mustafa(2019).Effect of biofertilizers and carbolizer on growth of gerbera plant(*Gerbera jamesonii*).Plant Archives.19(1):1733-1754.
5.Alaylar, B. M.,M. Gulluce Karadayi,T.Y. Koc, & G.Karadayi,. 2021. Rhizospheric PGPR strains of wheat, barley and trefoil grown in agri province. Turk Doga ve Fen Dergisi, 10(2), 182-190.
6.Alkobaisy, J. S, and N. A. Mutlag. 2021. Effect of the use of vermicompost and rhizobial inoculation on some soil characteristics, growth and yield of mung bean *Vigni radiate* L. Iraqi Journal of Agricultural Sciences, 52(1): 163-169. https://doi.org/10.36103/ijas.v52i1.1248
7.AL-Dur, E. T. H., and A. O. AL-atrakchii,. 2021. Effect of bulb diameter and concentrations of gibberellic acid and microelements on the growth and yield of bulbs and bulblets of *Polianthes tuberosa* L. JAVS, 1(1).
8.Alexander, A.,A. Mishra, and B. Jha,. 2019. Plant growth promoting rhizobacteria *Stenotrophomonas maltophilia* BJOI augments endurance against N2 Starvation by modulating physiology and biochemical activities of arachis hypogea. Plos one, 14(9), eO222405. doi:10.1371
9.Ali, U.,N. Sajid,., A.Khalid,., L.Riaz,., M.Rabbani,.,H. Syed,., &N.R. Malik. 2015. A review on vermicomposting of organic wastes. Journal of Environmental Progress & Sustainable Energy, 34(4), 1050-1062.
10.Al-Khafaji, A. M. H. H., N. J. K. Al-Amri, and N. H. A. Al-Dulaimi. 2022. Growth, yield, and antioxidant traits of different parts of beetroot as affected by vermicompost and glutathione. Iraqi Journal of Agricultural Sciences, 53(5): 1107-1114. https://doi.org/10.36103/ijas.v53i5.1623
11.ALmamori, H. A., and H.A. Abdul-Ratha,. 2020. Effect of addition of vermicompost, bio and mineral fertilizer on the availability of some nutrients in soil and potato yield. Iraqi Journal of Agricuural Sciences, 51(2), 644-656. https://doi.org/10.36103/ijas.v51i2.992
12.AL-Obaidi, S. M. J., and H.A. Abdul-Ratha. 2021. Evaluation of the combination of bacterial bioferilizer and vermicompost in the availability of N, P, K and some of plant parameters of bean (*Phaseolus vulgaris* L.). Iraqi Journal of Agricultural Sciences, 52(4), 960-970. https://doi.org/10.36103/ijas.v52i4.1406
13.AL-Hasnawi, H. A. K., T.H.Khaleel., &J.K. Hussein,. 2018. Effect of agricultural media, biofertilizers, and spraying with potassium in the Growth of Gladiolus Plant. Euphrates Journal of Agriculture Science, 10(2), 229-248.
14.AL-Rawi, A. R. M., M.H I .AL-Ani,., and A.M.AL-Falahi,. 2021. Effect of Concentration and period of seed soaking with Atonic on some quantitative traits of mungbean. 3rd Scientific & Ist International Conference of Desert Studies. IOP Conf.Series: Earth and Environmental Sciences, 904(2021)012070. doi:10.1088/1755-1315/904/1/012070.
15.Al-Rawi, Kh. M. &A.A. Khalafallah,. 1980. Design and Analysis of Agricultural Experiments. Ministry of Higher Education and Scientific Research, Dar Al-Kutub for Printing and Publishing, University of Mosul
16.Al-Sanam, M. A. 2021. Effect of Storage, Shading and Chitosan on Growth, Flowering and Some Chemical and Anatomical Characteristics of Lily *Agave amica* L. Master's thesis, College of Agriculture, University of Tikrit.
17.Al-Silmawy. N. A. J. K. , H.A.Abdul-Ratha. 2023. Effect of biofertilizer, vermicompost and phosphate fertilizer on growth and yield of cauliflower (*Brassica oleraceae* var.botrytis). Iraqi Journal of Agricultural Sciences, 54(2): 505-515. https://doi.org/10.36103/ijas.v54i2.1726
18.AOAC (Association of Official Analytical Chemists) . 1995. Official Methods of Analysis 16th Edition .AOAC International, Gaithersburg, MD
19.Basant, D. K.,L.S. Verma., R. Singh,., and I. R. Markam,. 2020. Effect of nutrient management on growth, flowering and flower yield of tuberose (*Polianthes tuberose* L.) under chhattisgrah plain condition. International Journal of Chemical Studies, 8(2), 249-253.
20.Batool, S., H. N. Asghar, M. A., M. A. Shehzad,., S. Yasin,., M. Sohaib., F. Nawaz, and M. Uzair,. 2021. Znic-sSolubilizing

bacteria mediated enzymatic and physiological regulations confer znic biofertification in chickpea (*Cicer arietinum* L.). Journal of Soil Science and Plant Nutrition, 21(3), 2456-2471.
21.Bologa, C. M.,S. Cristina,.,M. Alina-Elena, and J. carmenica-Doina,. 2020. The action of growth regulators on the process of photosynthesis in sunflower. Lucrari Stiltifice, 63(1), 51-56.
22.Djanaguiraman, M., J. Annie, , & U. Bangarusamy,. 2005. Effect of atonik seed treatment on seedling physiology of cotton and tomato. Journal of Biological Sciences, 5(2), 163-169.
23.Dubey, K. K., and M. H. Fulekar,. 2011. Mycorrhizosphere development and management: The role of nutrients, microorganisms and biochemical activities, environmental biotechnology laboratory, department of life sciences, university of mumbaisantacruz. Agric. Biol. J. N. Am., 2(2), 315-332.
24.EL-Shoura, H. A. S., &F.F. Arafa,. 2018. Effect of soaking tuberose bulb (*Polianhest tuberosa* L.) in growth regulators and thiorea on growth and flowering. Middle East Journal of Applied Sciences, 8(1), 79-82.
25.Guevara, H. A, P. 2019. Effect of phosphate Fertilization on *Rhizosphere Microbiome* of Crops. (Doctoral Dissertation, Colorado State University).
26.Haselwandter, K., H. Haas, G. Haninger., and G. Winkelman,. 2020. Siderophores in Plant root tissue: tagetes patule nana colonized by the arbuscular mycorrhizal fungi *Gigaspora margarita*. Springer, 33(2-3), 137-146.
27.Havlin, J. L.,J.D. Beaton,., S.L.Tisdale,., &W.L. Nelson.. 2005. Soil Fertility & Fertilizers: An Introduction to Nutrient Management (7th ed.). Prentice Hall.
28.Hussien, A. S., H. A. Abdul-Ratha., and H. A. Hadwan,. 2019. Evaluation use of *Bacillus mucilaginosus* as biofertilizer interfer with *Glomus mosseae* on growth and yield of corn. Iraqi Journal of Agricultural Sciences, 50(Special Issue), 64-75. https://doi.org/10.36103/ijas.v50iSpecial.178
29.Kandil, H., N. Gad,., and M. T. Abdelhamid. 2013. Effect of different rates of phosphorus and molybdenum application on two varieties common bean of (*Phaseolus vulgaris* L.). J. Agric. Food Tech., 3(3), 8-15.
30.Kadhim,A.A.,A.A.Hadi. and S.A. ABDUL-Latif..(2020).Effect of biofertilizer and chitosan on medical active compounds of salty stressful vinca plants.Plant Archives. 20.(2):116-125.
31..Kurve, G., S. M. Vidhya., K. Anuj., and O. P. Singh,. 2018. Effect of pre soaking of bulbs in plant growth regulataors on flowering and vase life of tuberose (*Polianthes tuberosa* Linn). I.*J.OF Chemical Studies*, College of Horticulture Gwalior, India, 6(1), 1485-1490 cv.Prajwal. Chemical Science Review and Letters, 10(37), 82-89.
32.Lim, S. L., T. Y. Wu,., P. N. Lim., and K. P. Y. Shak,. 2015. The use of vermicompost in organic farming: overview, effects on soil and economics. Journal of the Science of Food and Agriculture, 95(6), 1143-1156.
33.Lalitha, S. 2017. Plant-Promoting Microbes: a boon for sustainable agriculture. In sustainable agriculture towards food security (pp. 22-). Springer.
34.Munikrishnappa, P. M., & S. Chandrashekar. 2014. Effect of growth regulators on growth and flowering of chinas aster-A Review. Journal of Agricultural Research Communication Conter, 35(1), 57-63.
35.Safeena, S. A., Priya, D. S., Desai, A. R., and Sing, N. P. 2015. Ready Reckoner on Cultivation of Tuberose. Technical Bulletin No: 50, ICAR-Central Coastal Agricultural Research Institute (Indian Council of Agricultural Research), Ela, Old Goa-403402, Goa, India.
36.Prasaol, K., A.Aggarwal.,K. Yadav, and A. Tanwar,. 2012. Impact of different levels of superphosphate using arbuscular mycorrhizal fungi and *Pseudomonas fluorescens* on *Chrysanthemum indicum* L. Journal of Soil Science and Plant Nutrition, 12(3), 451-462.
37.Richards, A. E.,J.M. Barea.,A.M. Neil., and C.P. Combaret. 2009. Acquisition of phosphor and nitrogen in the rhizosphere and plant growth promotion by microorganisms. Plant Soil, 321, 305-339.
38.Thirkell, T. J., M. D., Charters.,A. J., S. M. Elliott., and K. J. Field. 2017. Are mycorrhizal fungi our sustainable saviours considerations for achieving food security.J.ECOL.105:921-929

39.Thiede, J., and R.H.A. Govaerts. 2017. New Combination in agave (Asparagaceae): A. amica, A. nanchitlensis, and A. quilae. Phytotaxa, 306(3),237-240. doi:10.11646/phttotaxa.306.3.7.

40. Shilan H. S. and Shara J. H. Ama. 2022. Effect of NPK and organic fertilizers on yield and seed oil content of rapeseed (*Brassica napus* L.).Iraqi Journal of Agricultural Sciences.53(4): 878-889. https://doi.org/10.36103/ijas.v53i4.1600

41.Villasenor, J., L.Rodriguez., and F. J. Fernandez. 2011. Composting domestic sewage sludge with natural zeolites in a rotary drum reactor. Bioresource Technology, 102(2), 1447-1454.

42.Yassen, A. A., K.H. Abd El-Rheem., Y.A. EL-Damarawy., and S.M.Zaghloul. 2019. The promotive effect of vermicompost and compost for improving vegetative growth and nutrients status of cauliflower plants. World Applied Sciences Journal, 37, 368-374.

43.Zorman, I., M. Karimi., and H. Moradi. 2021. The Effect of water hyacinth compost and humic acid on morphological and biochemical properties in lily flower (*Longiflorum Asiatic* cv Eyeliner). Journal of Plant Process and Function, Iranian Society of Plant Physiology, 45(10), 303-314.