

Growth and Flowering Response of Petunia (Calypso Cultivar) to Organic Fertilizer and Foliar-Applied Putrescine.

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Abstract

An experiment was conducted in the wooden lath house of the Department of Horticulture and Landscape Engineering, College of Agriculture, Anbar University in The city of Ramadi, the capital of Anbar Governorate in Iraq, is located at longitude [43.268] east and latitude [33.436] north. It is approximately [missing information] km west of the capital, Baghdad., from February 15, 2025, to June 1, 2025. The study investigated the effect of soil application of organic fertilizer and foliar spraying with the growth regulator Putrescine . The first factor involved adding four levels of organic fertilizer (0, 5, 10, and 15 ml L⁻¹) ten days after planting the seedlings, according to the recommendations of the approved company. The second factor involved spraying the foliage with three levels of Butyrosine foliar spray until completely saturated, with the addition of a surfactant (0, 50, and 75 mg L⁻¹). A randomized complete block design was employed . Means were compared using the LSD value at a 5% probability level. The findings revealed that applying organic fertilizer at a concentration of 15 ml/L⁻¹ resulted in a significant increase in leaf area, main stem diameter, number of flowers per plant, and fresh flower weight, with values of 26.22 cm², 8.29 mm, 31.32 flowers plant⁻¹, and 9.96 g, respectively. The F2 organic fertilizer treatment also recorded the highest values in plant spread area and carbohydrate content, reaching 67.66 cm² and 10.55%. Regarding the effect of putrescine, the P2 treatment, at a concentration of 75 mg/L, significantly improved leaf area, recording 26.37 cm². The P1 treatment also recorded a flavonoid content in petals of 45.675 (100 g per gram fresh weight).

Keywords: Petunia, Solanaceae plants, Putrescine, Organic fertilizers, Humic substances.

Introduction

As a result of its wide range of cultivars with different types of flower color and shape, Petunia is a major annual ornamental plant. This is a Solanaceae species of South America. Flowers of petunia are bell- or trumpet-shaped and have long blooming period; from the early spring to the middle or the late summer and this feature increase its aesthetic importance [1].

The hybrids of *P. axillaris* and *P. integrifolia* are the most exploited types in Iraqi gardens. They come in a variety of colors such as red, orange, purple, striped, white. The corolla lobes are entire and often fringed but are not suitable for commercial cutting. Petunia is highly versatile and widely used as a potted

plant in hanging baskets, beds, and balconies [2].

In developed countries, petunia is an economically important ornamental species grown as a flowering potted plant, bedding plant, or in hanging containers. However, under standard conditions, petunia tends to produce relatively few flowers with small diameters, and the floral longevity on the plant is generally limited.

Petunia is a sought-after economic plant in developed countries, bedding flower, or hanging basket plant. Petunia produces a small number of flowers of small diameter,

and the flower stays on the plant for a short time.

The white flowers of the Claissebo petunia suffer from rapid petal drop and flower deformity. This is either due to a lack of soil nutrients, so I suggest treating the plants with several levels of organic fertilizers. Alternatively, the petal drop may be due to environmental stress, so I suggest using Petrisin to treat this problem.

Organic fertilizer can be defined as a mixture of animal waste, plant waste, compost, green fertilizers, and microorganisms produced by decomposition processes [3]. Organic fertilizers are a part of non-living soil, consisting of carbohydrates, lignin, proteins, and some more complex substances. They play a fundamental role in improving soil physics and holding soil particles together in fixed locations. Organic matter has multiple functions, including chemical, physical, biological, and nutritional functions. It can be said that organic fertilizers, in general and depending on their source, improve production in terms of quantity and quality. They are also responsible for enhancing the fertility of soil for agriculture, as they actively improve the physical properties of soil [4]. They also supply plants essential macro and micronutrients, increase soil particle aggregation, stability and microorganism activity. They also do something to promote growth — they make the soil hold onto air and water better, which makes the mix more open and enables roots to grow more freely.

Furthermore, organic fertilizers increase cation exchange capacity [5]. Polyamines, like other plant hormones, participate in regulating plant growth. They are produced in small quantities and act both at their sites of production and in areas to which they are

transported. Polyamines include two or more amino groups, such as putrescine. These amines are involved in various growth and developmental processes, including cell division and differentiation, and play a key role in accelerating the flowering process [6]. These compounds are characterized by their low molecular weight, exhibiting good biological activities with various functions during physiological processes, being present in different parts of the plant.

Putrescine participates in various roles in the plant cell through the difference in its polarity, which helps it bind to other important compounds with high molecular weights, such as phenols of various types, nucleic acids, and proteins. It contributes to increasing the activity of RNA through replication, transcription, formation, and translation, in addition to its effective role in the process of photophosphorylation. Putrescine participates in modifying the activity of enzymes and in processes Various vital functions such as gene expression, protein synthesis, balance in cell division, differentiation, development and unfolding, and it has a role in leaf wilting, aging and maturation [7]. Polyamines resist various environmental stresses and have recently been introduced as substances with advanced biological effects as organic plant materials [8]. Polyamines are found in much higher concentrations than other hormones in plant tissues, and this amount varies according to the plant species, organs, nature of the tissue and different growth stages [9].

1. Materials and Methods

2.1	Study	Site
The trial was carried out in the wooden ceiling of Horticulture & Landscape Engineering College of Agriculture Anbar University at middle of February, 2025 . The seedlings were		

planted in plastic pots with a diameter of 35 cm and a height of 45 cm. An experiment was carried out to investigate the effect of soil applied organic manure and foliar application of growth regulator Putrescine on the growth and flowering of Petunia (Calypo) plants.

2.2 Experimental Factors and Design:

The first factor involved foliar application of the organic fertilizer produced by Libro Company (Table 1), applied at four levels:

1. Without application (control), denoted as F₀
2. Organic fertilizer at a concentration of 5 ml L⁻¹, denoted as F₁
3. Organic fertilizer at a concentration of 10 ml L⁻¹, denoted as F₂ [5].
4. Organic fertilizer at a concentration of 15 ml L⁻¹, denoted as F₃

The second factor was Putrescine Application: The plant growth regulator putrescine (with 98% active ingredient) was prepared by dissolving the required concentrations in a few drops of ethyl alcohol and bringing the volume up to the desired level with distilled water.

Foliar spraying with putrescine solution by Three sprays, one month apart, and spraying was done two weeks after planting, was conducted at three concentrations:

1. No spraying (control, using distilled water only), designated as P₀

2. Foliar spraying with putrescine at 50 mg L⁻¹, designated as P₁ [10]

3. Foliar spraying with putrescine at 75 mg L⁻¹, designated as P₂

The experiment involved the combination of four levels of organic fertilizer application and three concentrations of foliar-applied putrescine in a factorial arrangement (4 × 3) within a Randomized Complete Block Design (RCBD). Each treatment was replicated three times, with each replicate consisting of three saplings per treatment unit.

Data were statistically analyzed using the GenStat software package. Treatment means were compared using the Least Significant Difference (LSD) test at a 5% level of probability. The irrigation service was carried out using plastic pipes. Drippers were placed in each pot, with equal distances and quantities as possible. The seeds were planted in small plastic pots, 10 cm in diameter and 10 cm in height, at the beginning of planting. Fertilizers were not added as a fertilizer recommendation.

Table 1. The composition of the organic fertilizer

Component	Percentage
Nitrogen	15%
Calcium (CaO)	5%
Fulvic acid	5%
Seaweed	2%
Organic Matter	50%

2.3 Measured Traits

1. Leaf Area (cm²):
Leaf area was measured using graph paper of known dimensions, by tracing the outline of the leaf to determine its surface area.

2. Main Stem Diameter (mm):

The diameter of the main stem was measured using a Vernier caliper at a height of 5 cm above the soil surface in the pot. The average diameter was calculated for each treatment.

3. (cm²):

The canopy area was calculated using the

formula for the area of a circle:
 $A = \pi \times r^2$, where r is the radius of the canopy and $\pi \approx 3.14$.

4. Number of Deformed Flowers: The number of deformed and undesirable flowers was counted for all plants within each treatment, and the average was calculated.
5. Average Flower Diameter (mm): Flower diameter was measured for each experimental unit using a Vernier caliper, and the average was calculated per treatment.
6. Percentage of carbohydrate content in branches (%): The carbohydrate content of leaves was estimated by taking 10 mg of dry weight from the plant leaves and then adding 5 ml of 80% sulfuric acid (H₂SO₄) and 1 ml of 5% phenol. The solution was left to stand for 10 minutes until it turned orange, indicating the reaction response. The solution was then measured. At a wavelength of 490 nm, using a spectrophotometer for each treatment.
7. Flavonoid Content in Petals (mg/100 g Fresh Weight): Flavonoids were estimated using silver nitrate (AgNO₃) reagent [14].

3. Results and Discussion:

3.1 Single Leaf Area (cm²):

The results presented in Table 2 indicate a statistically significant increase in leaf area due to the studied factors and their interactions. The application of organic fertilizer at the highest concentration (F₃, 15 ml L⁻¹) resulted in the highest mean leaf area of 26.22 cm², compared to the control treatment (F₀), which recorded a mean of 12.73 cm².

In relation to the putrescine effect, 75 mg L⁻¹ (P₂) significantly promoted leaf area (mean 26.73 cm²), while under the control (P₀), this value was 17.07 cm².

The two-way interaction between organic fertilizer and putrescine was also significant. The treatment F₃ P₂ (organic fertilizer at 15 mL L⁻¹ + putrescine at 75 mg L⁻¹) provided superior leaf area, of 29.33 cm². The least leaf area was found in the untreated control (F₀ P₀) with a value of 10.20 cm².

Table 2. Effect of organic fertilizer, putrescine, and their interaction on single leaf area (cm²)

Organic fertilizer	Putrescine concentration			Mean F
	P ₀	P ₁	P ₂	
F ₀	10.200	14.177	13.820	12.732
F ₁	17.073	21.200	38.833	25.702
F ₂	16.870	25.677	24.937	22.494
F ₃	24.170	25.167	29.333	26.223
Mean P	17.078	21.555	26.731	
LSD 0.05	F	P	F*P	
	4.435	3.841	7.682	

3.2. Average main stem diameter (mm):

The results of Table 3 showed a statistical significant in the average main stem diameter. The F₃ organic fertilizer treatment significantly increased the average main stem

diameter and reached 8.29 mm, while the average stem diameter decreased in the control treatment and reached 6.84 mm. However, no significant differences were

observed among the putrescine growth regulator treatments.

However, the two-way interaction between the two factors revealed a significant effect. The combined treatment $F_3 P_2$ (organic fertilizer

at 15 mL L^{-1} + putrescine at 75 mg L^{-1}) resulted in the highest stem diameter, reaching 8.77 mm, while the lowest value was recorded in the untreated control $F_0 P_0$, with a diameter of 6.88 mm.

Table 3. Effect of organic fertilizer, putrescine, and their interaction on average main stem diameter (mm)

Organic fertilizer	Putrescine concentration			Mean F
	P_0	P_1	P_2	
F_0	6.883	7.777	5.883	6.848
F_1	8.667	7.110	7.553	7.777
F_2	7.667	8.330	8.107	8.034
F_3	8.443	7.663	8.777	8.294
Mean P	7.915	7.720	7.580	
LSD 0.05	F 0.752	P N.S	F*P 1.303	

3.2

3.3 Canopy Spread Area per Plant (cm^2):

Results presented in Table 4 indicate a significant increase in canopy spread area due to the organic fertilizer treatments and the interaction between the two studied factors. The application of organic fertilizer at 10 mL L^{-1} (F_2) resulted in a significant enhancement in canopy spread, reaching

67.66 cm^2 , compared to the control treatment (F_0), which recorded only **24.99 cm^2** .

However, no significant differences were observed among the putrescine treatments in terms of canopy spread.

In contrast, the two-way interaction showed a significant effect. The combination treatment $F_2 P_0$ (organic fertilizer at 10 mL L^{-1} + distilled water spray) achieved the highest canopy spread area of **69.99 cm^2** .

Table 4. Effect of organic fertilizer, putrescine, and their interaction on canopy spread area per plant (cm^2)

Organic fertilizer	Putrescine concentration			Mean F
	P_0	P_1	P_2	
F_0	21.443	23.443	30.110	24.999
F_1	56.887	43.110	57.777	52.591
F_2	69.997	68.440	64.553	67.663
F_3	60.993	64.997	66.107	64.032
Mean P	52.330	49.998	54.637	
LSD 0.05	F 4.274	P N.S	F*P 7.403	

4. Number of Deformed Flowers (flowers/plant)

Table 5 indicates that the control treatment recorded the lowest number of deformed flowers, at 24.99 flowers/plant. In contrast, the F3 treatment showed a higher number of deformed flowers, reaching 31.32

flowers/plant. The putrescine treatments did not differ significantly in this trait. The lowest number of deformed flowers was observed in the control treatment F0P0, which recorded 21.33 flowers/plant.

Table 5. Effect of organic fertilizer, putrescine, and their interaction on number of deformed flowers (flowers/plant)

Organic fertilizer	Putrescine concentration			Mean F
	P ₀	P ₁	P ₂	
F ₀	21.330	23.997	29.660	24.996
F ₁	31.217	34.993	24.330	30.180
F ₂	26.107	29.327	37.663	31.032
F ₃	32.107	29.440	32.440	31.329
Mean P	27.690	29.439	31.023	
LSD 0.05	F	P	F*P	
	3.357	N.S	5.814	

5. Fresh Weight of Flowers (g)

Table 6 shows a significant increase in the fresh weight of flowers for organic fertilizer treatments F3 and F2, reaching 9.96 g and 9.89 g, respectively. The control treatment, however, recorded the lowest fresh flower weight at 7.38 g. The P1 putrescine treatment,

at a concentration of 50 mg/L, was significantly superior to the other treatments, with a fresh weight of 9.70 g. No significant differences were observed among the interaction treatments.

Table 5. Effect of organic fertilizer, putrescine, and their interaction on number of deformed flowers (flowers/plant)

Organic fertilizer	Putrescine concentration			Mean F
	P ₀	P ₁	P ₂	
F ₀	7.233	9.090	7.193	7.839
F ₁	7.817	9.067	8.170	8.351
F ₂	9.660	10.250	9.760	9.890
F ₃	11.443	10.427	8.010	9.960
Mean P	9.038	9.708	8.283	
LSD 0.05	F	P	F*P	
	1.272	1.101	N.S	

6. Carbohydrate Percentage in Shoots (%)

Table 7 results indicated a significant increase in the carbohydrate percentage in shoots when treated with organic fertilizer at treatments F2 and F3, reaching 10.557% and 10.097%, respectively. This percentage decreased in the control treatment, recording 9.530%. No significant differences were observed among

the putrescine growth regulator treatments. The interaction treatment F2P0 showed a significant superiority, reaching 11.683%, while the control treatment recorded the lowest value at 8.690%.

Table 7. Effect of organic fertilizer, putrescine, and their interaction on carbohydrate percentage in shoots (%)

Organic fertilizer	Putrescine concentration			Mean F
	P ₀	P ₁	P ₂	
F ₀	8.690	9.520	10.380	9.530
F ₁	10.253	10.380	10.950	10.528
F ₂	11.683	10.133	9.853	10.557
F ₃	10.003	9.573	10.713	10.097
Mean P	10.158	9.902	10.474	
LSD 0.05	F	P	F*P	
	0.787	N.S	1.364	

3.7. Flavonoids in Petals (100 mg per g fresh weight)

Table 8 results indicated a significant increase in the flavonoid content of petals in the control treatment, which reached 46.08 (100 mg per g fresh weight) While this amount decreased when treated with F2 I registered 39.41 (100 mg per g fresh weight). Among the putrescine growth regulator treatments, the P1

treatment showed a significant superiority It recorded a score of 45.67 (100 mg per g fresh weight) While it decreased when treating P2 and recorded 41.51 (100 mg per g fresh weight) . Furthermore, the interaction treatment F3P1 was significantly superior, recording 47.200 (100 mg per g fresh weight)

Table 8. Effect of organic fertilizer, putrescine, and their interaction on flavonoids in petals (100 mg per g fresh weight)

Organic fertilizer	Putrescine concentration			Mean F
	P ₀	P ₁	P ₂	
F ₀	43.400	51.500	43.350	46.083
F ₁	49.200	44.750	39.417	44.456
F ₂	39.050	39.250	39.950	39.417
F ₃	39.650	47.200	43.350	43.400
Mean P	42.825	45.675	41.517	
LSD 0.05	F	P	F*P	
	2.907	2.518	5.036	

4. Discussion:

The reason for the lack of significant differences in the treatments of putrescine in some vegetative and floral traits may be due to the help of putrescine as a cofactor for enzymes and thus contributing to the analysis of auxin and gibberellins, which led to its effect on plant growth in general.

The significant increase in vegetative and floral growth characteristics when treated with organic fertilizers is due to the effect of the soil addition of organic fertilizers to the treated plants, with the exception of the average dry weight of flowers. The addition of fertilizers led to an increase in the permeability of the leaf cell membranes, and thus the occurrence of vital processes such as absorption and energy transfer, and thus an increase in the movement of elements and their transfer through the plant. This is attributed to the products of vital processes, which leads to an increase in growth in vegetative characteristics. I also believe that the role of humic substances is similar to the role of plant hormones, as it was observed that they work to increase the effectiveness of many enzymes, especially respiratory enzymes, in addition to stimulating the enzymes Transaminase phosphatase Invertase, and ATPase -H⁺, as well as raising the level of protein representation and DNA formation. This is attributed to the increased growth of the plant and the improvement of its vegetative characteristics. In addition, humic materials also have a direct effect on growth stimulation by providing a good pool of macro and micronutrients, and certain plant hormones as gibberellins, cytokinins and auxins. These substances also improve the activities of the enzymes, nutrients uptake and metabolism, which in turn leading to a better plant performance [11].

The endogenous levels of IAA Increased Most of the biochemical parameters namely endogenous levels of IAA were significantly increased by application of humic substances. IAA is involved in induction of chlorophyll and phenolic compounds synthesis, thereby leading to increased photosynthetic capacity and vigor of plants [12].

Furthermore, increasing the concentration of liquid humus in fertilizer formulations has been linked to higher carbohydrate content in plant tissues. This is likely due to the presence of fulvic acid , which contains carbohydrates and amino acids that are readily available for plant uptake when applied foliarly. These compounds are directly absorbed by plant leaves , thus accelerating metabolic processes and improving plant growth and flowering [13].

As for the significant effects of putrescine on certain growth traits, this may be attributed to its role as a polyamine-based growth regulator, which stimulates various physiological activities , including enhanced photosynthesis , hormone synthesis , and enzyme activation . Putrescine, being a secondary growth regulator, is known to modulate gene expression, cell division, and developmental processes , which collectively enhance plant growth and flowering performance .

In conclusion, the application of organic fertilizers, particularly at higher concentrations , significantly improves vegetative growth , flowering characteristics , and biochemical parameters in *Petunia* cv. Calyspo. The positive interaction between organic fertilizers and biotracine further highlights the potential of integrating organic and biostimulant approaches in ornamental plant production to optimize growth, yield,

and quality without compromising environmental sustainability.

5. Conclusion:

It can be concluded from this study that putrescine did not have a stimulating effect on most of the studied traits, in addition to the fact that the effect of putrescine affected the floral traits, including the flavonoid pigment.

The present study reveals that the use of organic fertilizer, especially at the rates of 10 and 15 mL L⁻¹, significantly improved vegetative growth, flowering attributes and biochemical attributes of *Petunia* cv. Calypso. Similarly, foliar treatment of putrescine at 75 mg L⁻¹ resulted in benefits on several growth parameters and some of the interaction effects were significant when combined with higher fertilizer levels. The findings enhance the synergistic action of organic inputs and biostimulants in increasing plant vigor and ornamental quality, propounding a sustainable and effective approach for improving *Petunia* production in protected cultivation.

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