



Response of *Pelargonium zonale* plants to some anti-stress materials

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Abstract

Two field experiments studies were conducted at the Floriculture Nursery of the Horticulture Department, Faculty of Agriculture at Moshtohor, Benha University, during 2016 to 2017 seasons to study the effect of spraying amino acid at the rate of 0.0, 1.0, 2.0 and 3 g/l and salicylic acid at the rates of 0, 50, 100 and 200 ppm as well as their interaction on vegetative, flowering growth and chemical composition of geranium plants.

Obtained results showed that, the tallest plants, the highest number of branches / plant, the greatest show value, the heaviest fresh and dry weights of leaves/ plant and the widest plant were recorded by 200 ppm SA-sprayed plants supplemented with amino acid at 3 g/ l in the two seasons. Moreover, sprayed geranium plants with salicylic acid at 200 ppm and supplemented with amino acid at 3 g / l is being the most effective one for producing the highest number of flowers / plant, the heaviest fresh and dry weights of flowers / plant (g), the longest duration of flower on plant (days) and flowering duration on plant (days) in the two seasons. Furthermore, the greatest leaf nitrogen, phosphorus, potassium, total carbohydrates % were recorded by the plants treated with amino acid at the high level and sprayed with salicylic acid at 200 ppm, in the two seasons of this experiment.

Conclusively, sprayed geranium plants with salicylic acid at 200 ppm and supplemented with amino acid at 3 g / l produced the best growth, chemical constituents and quality of this plant.

Keyword: Geranium, amino acid, salicylic acid, growth and flowering.

Introduction

Pelargoniums (*Pelargonium zonale*, L.) belongs to fam. Geraniaceae. The wild species are native in South Africa with few exceptions. The genus *Pelargonium* includes more than 400 botanical species. The most spreading species is Common garden or zonal Geraniums (*Pelargonium zonale* L.) " They are widely sold bedding plants. They have distinct, dark markings or bands (commonly called zones) on their leaves. Several newer, fancy-leaf varieties possess silver, white gold, red, or purple markings in the leaf. Flower colour includes red, pink, salmon and white. Common garden geraniums can be grown from cuttings or seeds. Pelargoniums are one of the most popular indoor and outdoor flowering plants and with good reason! There are a wide variety of geraniums that differ in flower colour, leaf shape, growth habit, and use. These versatile plants can be used as annual bedding plants, in hanging baskets, and in containers both indoors and outdoors (Hamza, et al., 2007)

The successful commercial cultivation of any crop depends on many factors like, climate, soil fertility, fertilization, season of growing, planting media etc. Among these amino acids and salicylic

acid. Amino acids have traditionally been considered as precursors and constituents of proteins. Many amino acids also act as precursors of other nitrogen containing compounds, e.g., nucleic acids. Amino acids can play wide roles in plants including acting as regulatory and signaling molecules. Amino acids also affect synthesis and activity of some enzymes, gene expression, and red oxhomeostasis (Rai, 2002). Many studies have reported that foliar application of amino acids caused an increase in the growth and development of plants. In this respect, Ahmed and Makki (2021) reported that foliar spray with amino acids improved the growth and chemical composition of *Solidago* plant.

Salicylic acid an endogenous plant growth regulator, has been found to generate a wide range of metabolic and physiological responses in plants thereby affecting their growth and development. Salicylic acid as a natural and safe phenolic compound exhibits a high potential in controlling post-harvest losses of horticultural crops. Salicylic acid as a plant growth regulators play an important role in plant growth and its role in the extension the vase life of cut flowers was approved. These compounds delay cell division and growth in the

beneath apex, but they do not have any effect on meristem (Hedayat,2001).

In this concern, **Mohammed and Abood (2020)** indicated that spraying *Gerbera jamesonii* with salicylic acid (75 mg L⁻¹) increased the number of leaves, leaf area, total chlorophyll, wet and dry weight of leaf, early flowering, number inflorescences, peduncle diameter and vase life.

Therefore, the present study was carried out to explore the effect of amino acids and salicylic acid as well as their combination on growth and flowering of geranium plants.

Materials and Methods

Two field experiments studies were conducted at the Floriculture Nursery of the Horticulture Department, Faculty of Agriculture at Moshtohor, Benha University, during 2016 to 2017 seasons to study the effect of spraying amino acid and salicylic acid as well as their interaction on vegetative, flowering growth and chemical composition of geranium plants.

Plant Material: geranium (*Pelargonium zonale*) seedlings were used for the present study, for this purpose well established three months old healthy and uniform sized seedlings having 8-10 leaves and 12-14 cm height, were selected for conducting this study.

Planting procedure and Lay-out of the Experiment:

The seedlings were obtained from Floriculture Nursery of the Horticulture Department, Faculty of Agriculture at Moshtohor, Benha University. The plants were replanting in clay loam soil in beds at 1 m² (four seedlings / bed) on 1st February, in the two seasons of this study (2016 and 2017).

Two factors were involved in the present study, the first was the amino acids and the second was salicylic acid.

Amino acids treatments:

Geranium plants received amino acids at the rate of 0.0, 1.0, 2.0 and 3.0 g/l as foliar spraying seven times at monthly interval, starting after one month from planting time in the two seasons of this study. Common agricultural practices (irrigation, manual weed control, etc.) were conducted when needed.

Salicylic acid treatments:

Geranium seedlings were subjected to foliar spray with salicylic acid at the rates of 0, 50, 100 and 200 ppm seven times, each at one month interval, the first one was after one month from planting time in both seasons. A surfactant (Tween 20) at a concentration of 0.01% was added to all tested solutions including the control.

The layout of the experiment was designed to provide a factorial experiment in randomized complete blocks. The study contained 16 treatments (4 amino acids levels x 4 ascorbic acid concentrations) with three replicates. Each replicate contained 6 beds. The study was finished on 30th December during the two seasons (2016 and 2017).

Recorded data:

I-Vegetative growth parameters:

1-Plant height (cm), 2- Number of branches / plant (cm²), 3-Fresh and dry weights of leaves/plant (g) 4- Plant width (cm) and 5- show value as plant width / plant height

II-Flowering growth parameters:

1- Number of flowers / plant, 2-Fresh and dry weights of flowers / plant (g), 3-Duration of flower on plant (days) and 4-Flowering duration on plant (days)

III- Chemical composition determination:

A sample weight of 0.2 g fine powder of the dry leaves of geranium plants were digested using a mixture of hydrogen peroxide (H₂O₂) and concentrated sulphuric acid (H₂SO₄) (4:10). The clear digestion was quantitatively 100 ml volumetric flask. In this solution, the following elements were determined:

* Nitrogen (%) was determined according to the modified Microkjeldahle method as described by **A.O.A.C. (1990)**.

*Phosphorus (%) was determined colorimetrically by the spectrophotometer at wavelength of 650 μm according to the method of **A.O.A.C. (1990)**.

* Potassium (%) was determined using flame-photometry method according to **Cottenie et al. (1982)**.

* Total carbohydrates (%) were determined colorimetrically by the spectrophotometer according to the method of **A.O.A.C. (1990)**.

Statistical analysis:

All obtained data in both seasons of study were subjected to analysis of variance as factorial experiments in a complete randomized block design. L.S.D. method was used to differentiate between means according to **Snedecor and Cochran (1989)**.

Results and Discussion

Effect of amino acid and salicylic acid on growth and chemical composition of *Pelargonium zonale* plant:

a- Vegetative growth parameters:

1- Plant height (cm):

Data presented in Table,1 show that all tested levels of amino acid succeeded in increasing plant height of geranium plants as compared with untreated plants in both seasons. In this respect, the high level (3g/l) gave the highest values in this concern, followed by the medium level (2g/l) in both

seasons. Out of control plants, the shortest plants were scored by those received the low level of amino acid (1g/l) in the two seasons. On the other hand, there was a positive correlation between the plant height values and salicylic acid levels, so the values of plant height increased as the level of salicylic acid increased until reach to the maximum increasing at the high level (200 ppm). This trend was true in both seasons.

Moreover, data in Table,1 indicate that all the interactions between amino acid levels and salicylic acid concentration statistically increased plant height of geranium plants as compared with untreated plants in both seasons. In this concern, the tallest plants (36.9 and 38.1 cm) were recorded by 200 ppm salicylic acid sprayed plants supplemented with amino acid at 3 g/ l in the first and second seasons, respectively.

Table 1. Effect of amino acid and salicylic acid as well as their combination on plant height (cm) of *pelargonium zonale* plants during 2016 and 2017 seasons.

Parameter	Plant height (cm)				
	Salicylic acid	Amino acid			Mean
0.0		1cm/L	2cm/L	3cm/L	
1st season					
0.0	28.3	29.7	32.4	33.6	31.0
50 ppm	29.1	31.9	32.9	34.2	32.0
100 ppm	31.8	32.5	33.8	35.7	33.5
200 ppm	32.2	34.0	35.2	36.9	34.6
Mean	30.4	32.0	33.6	35.1	=====
L.S.D at 0.05 for	Amino acid =1.14		Salicylic acid =1.16	Interaction=2.28	
2nd season					
0.0	29.8	32.0	34.9	35.8	33.1
50 ppm	31.6	32.7	35.2	36.9	34.1
100 ppm	32.8	34.5	36.4	37.0	35.2
200 ppm	33.4	35.8	36.8	38.1	36.0
Mean	31.9	33.8	35.8	37.0	=====
L.S.D at 0.05 for	Amino acid =1.17		Salicylic acid = 1.18	Interaction=2.34	

2- Leaves fresh and dry weights / plant (g):

Data presented in Tables, 2 and 3 cleared that using amino acid at 3g/l was more effective in increasing the leaves fresh and dry weights of geranium plant, followed by using amino acid at 2g/l in the two seasons. In addition, there were a positive correlation between the concentration of salicylic acid and the values of geranium leaves fresh and dry weights, where the concentration of salicylic acid increased the values of fresh and dry weights increased at the highest concentration in the two seasons.

Regarding the interaction effect between amino acid and salicylic acid data in the same

Tables referred that all interactions of amino acid and salicylic acid increased the leaves fresh and dry weights as compared with the un-treated plants in the two seasons. In this regard, the interaction of amino acid at 3 g / l showed to be the most pronounced one for producing the highest values, especially those received salicylic acid at 200 ppm in the two seasons. Regardless the control plant, the lowest leaves fresh and dry weights were gained by those sprayed with salicylic acid at 50 ppm and received no amino acids in the two seasons. The remained treatments occupied an intermediate position between the aforementioned treatments in the two seasons.

Table 2. Effect of amino acid and salicylic acid as well as their combination on leaves fresh weight of *pelargonium zonale* plants during 2016 and 2017 seasons.

Parameter	Leaves fresh weight / plant (g)				
	Salicylic acid	Amino acid			Mean
0.0		1cm/L	2cm/L	3cm/L	
1st season					
0.0	64.8	69.3	74.8	76.2	71.3
50 ppm	65.7	72.8	76.9	78.0	73.4
100 ppm	68.5	75.0	78.3	80.4	75.6
200 ppm	70.4	74.1	79.6	82.5	76.7
Mean	67.4	72.8	77.4	79.3	
L.S.D at 0.05 for	Amino acid =2.10		Salicylic acid =2.01	Interaction=4.02	
2nd season					
0.0	61.5	63.8	69.1	72.4	66.7
50 ppm	63.0	65.8	71.9	75.0	69.0

100 ppm	65.8	69.2	73.8	78.1	71.8
200 ppm	66.9	72.5	76.2	79.8	73.9
Mean	64.3	67.9	72.8	76.4	
L.S.D at 0.05 for	Amino acid =1.34 Salicylic acid = 1.38 Interaction=2.68				

Table 3. Effect of amino acid and salicylic acid as well as their combination on leaves dry weight of *pelargonium zonale* plants during 2016 and 2017 seasons.

Parameter	Leaves dry weight / plant (g)					
	Salicylic acid	Amino acid				Mean
		0.0	1cm/L	2cm/L	3cm/L	
			1 st season			
0.0		7.68	8.28	8.88	9.12	8.50
50 ppm		7.88	8.64	9.24	9.36	8.78
100 ppm		8.17	9.01	9.39	9.63	9.05
200 ppm		8.43	8.91	9.49	9.83	9.17
Mean		8.04	8.71	9.25	9.49	
L.S.D at 0.05 for		Amino acid =0.38 Salicylic acid =0.41 Interaction=0.76				
			2 nd season			
0.0		6.71	6.93	7.59	7.96	7.30
50 ppm		6.9	7.18	7.89	8.28	7.58
100 ppm		7.19	7.61	8.08	8.61	7.88
200 ppm		7.32	7.94	8.39	8.72	8.10
Mean		7.04	7.42	7.99	8.40	
L.S.D at 0.05 for		Amino acid =0.26 Salicylic acid = 0.29 Interaction=0.52				

3- Branches number/ plant

Table, 4 reveals that all studied amino acid and salicylic acid treatments as well as their interactions increased the number of branches /plant in both seasons. In this concern, the increment in leaves number were in parallel to applied levels of amino acid and salicylic acid concentration, so the highest levels of amino acid and salicylic acid

concentration significantly scored the highest number of branches/plant when compared with control in both seasons. In general, the highest number of branches / plant (10.68 and 9.02) was recorded by 200 ppm salicylic acid -sprayed plants combined with amino acid at 3 g/ l in the first and second seasons, respectively.

Table 4. Effect of amino acid and salicylic acid as well as their combination on number of branches of *pelargonium zonale* plants during 2016 and 2017 seasons.

Parameter	Number of branches / plant					
	Salicylic acid	Amino acid				Mean
		0.0	1cm/L	2cm/L	3cm/L	
			1 st season			
0.0		6.14	6.82	8.04	8.64	7.41
50 ppm		6.52	7.43	8.94	9.37	8.07
100 ppm		7.92	8.45	9.32	10.14	8.96
200 ppm		8.27	8.92	9.76	10.68	9.41
Mean		7.22	7.91	9.02	7.71	
L.S.D at 0.05 for		Amino acid =0.24 Salicylic acid =0.27 Interaction=0.48				
			2 nd season			
0.0		5.84	6.21	7.36	8.02	6.86
50 ppm		6.14	6.94	7.83	8.30	7.31
100 ppm		6.84	7.38	8.12	8.72	7.77
200 ppm		7.16	7.82	8.39	9.02	8.10
Mean		6.50	7.09	7.93	8.52	
L.S.D at 0.05 for		Amino acid =0.31 Salicylic acid = 0.33 Interaction=0.63				

4- Plant width (cm)

Table,5 reveals that all studied levels of amino acid increased the plant width of geranium plants as compared with un-treated plants in both seasons. In this regard, the high level (3g/ l) gave

the highest values in this concern, followed by the medium level (2g/l) in both seasons. On the other side, there was a positive relationship between the plant width values and salicylic acid levels, so the values of plant width increased as the level of

salicylic acid increased until reach to the maximum increasing at the high level (200 ppm). This trend was true in both seasons.

Furthermore, data in Table, 5 indicate that all the interactions between amino acid levels and salicylic acid concentration statistically increased

plant width of geranium plants as compared with untreated plants in both seasons. In this sphere, the widest geranium (27.4 and 28.9 cm) was recorded by 200 ppm salicylic acid-sprayed plants supplemented with amino acid at 3 g / l in the first and second seasons, respectively.

Table 5. Effect of amino acid and salicylic acid as well as their combination on plant width of *pelargonium zonale* plants during 2016 and 2017 seasons.

Parameter	Plant width (cm)					
	Salicylic acid	Amino acid				Mean
	0.0	1cm/L	2cm/L	3cm/L		
		1 st season				
0.0	18.4	21.9	22.8	23.4	21.6	
50 ppm	21.8	22.6	23.7	24.6	23.2	
100 ppm	22.7	23.5	24.2	26.8	24.3	
200 ppm	23.1	24.3	26.1	27.4	25.2	
Mean	21.5	23.1	24.2	25.6		
L.S.D at 0.05 for	Amino acid =1.02	Salicylic acid =1.06	Interaction=2.04			
		2 nd season				
0.0	20.3	23.1	25.0	25.8	23.6	
50 ppm	23.6	24.3	25.6	27.1	25.2	
100 ppm	24.2	25.6	27.3	28.2	26.3	
200 ppm	25.0	26.4	27.9	28.9	27.1	
Mean	23.3	24.9	26.5	27.5		
L.S.D at 0.05 for	Amino acid =1.12	Salicylic acid = 1.15	Interaction=2.24			

Show value (plant width/plant height)

Data presented in Table, 6 cleared that using amino acid at 3g/l was more effective in increasing the show value of geranium plant as it scored 0.74 and 0.75 g, followed by using amino acid at 2g/l in the two seasons. In addition, there were a positive correlation between the concentration of salicylic acid and the values of geranium show value, where the concentration of salicylic acid increased the values of show value increased at the highest concentration in the two seasons.

Regarding the interaction effect between amino acid and salicylic acid data in the same Table referred that all interactions between amino acid and salicylic acid increased the show value as compared with the un-treated plants in the two seasons. In this regard, the interaction of amino acid at 3 g/l showed to be the most pronounced one for producing the highest values, especially those received salicylic acid at 200 or 100 ppm in the two seasons.

Table 6. Effect of amino acid and salicylic acid as well as their combination on show value of *pelargonium zonale* plants during 2016 and 2017 seasons.

Parameter	Show value (plant width / plant height)					
	Salicylic acid	Amino acid				Mean
	0.0	1cm/L	2cm/L	3cm/L		
		1 st season				
0.0	0.65	0.74	0.71	0.70	0.70	
50 ppm	0.75	0.71	0.72	0.72	0.73	
100 ppm	0.72	0.73	0.72	0.75	0.73	
200 ppm	0.72	0.72	0.75	0.75	0.74	
Mean	0.71	0.73	0.73	0.73		
L.S.D at 0.05 for	Amino acid =0.02	Salicylic acid =0.05	Interaction=0.08			
		2 nd season				
0.0	0.69	0.73	0.72	0.72	0.71	
50 ppm	0.75	0.74	0.73	0.74	0.74	
100 ppm	0.74	0.75	0.75	0.77	0.75	
200 ppm	0.75	0.74	0.76	0.76	0.75	
Mean	0.73	0.74	0.74	0.75		
L.S.D at 0.05 for	Amino acid =0.03	Salicylic acid =0.04	Interaction=0.06			

The aforementioned results of SA go on line with those obtained by **Anwar et al., (2014)** on tuberose, **Miri et al., (2015)** on *Thymus vulgaris* L., **Hashish et al., (2015)** on *Calendula officinal*, **Amir et al., (2017)** on zinnia cultivars, **Alwan et al., (2018)** on iris plants, **Mohammed and Abood (2020)** on *Gerbera jamesonii*, **Saeed (2020)** on *Gazania rigens* L. cv. Frosty Kiss Mixed, **El-Kinany (2020)** on *Viola wittrockiana* Gams, and **El-Ashwah (2020)** on *Cortaderia selloana*. Whereas, the results of amino acid are in conformity with those gained by **Abd El-Aziz and Balbaa (2007)** on *Salvia farinacea* plants, **EL-Naggar and Sewedan (2009)** on *Amaryllis (Hippeastrum vittatum)*, **Abdel Aziz, et al., (2010)** on *Thuja orientalis* L. plant, **Zaghloul et al., (2011)** on *Codiaeum variegatum* L. Plants, **Soffar (2021)** on *Philodendron selloum* L. and **Ahmed and Makki (2021)** on *Solidago SP*.

b- Flowering growth parameters

1- Number of flowers / plant

It is clear from Table, 7 that using the high level of amino acid was more effective in

increasing the number of flowers per geranium plants as it gave 6.58 and 5.97, followed by using the medium level which recorded 6.42 and 5.75 flowers per plant, without significant differences between them in the first and second seasons, respectively. Also, data in the same Table revealed that there were a positive relationship between the values of flowers number and the used concentration of salicylic acid, hence as the salicylic acid concentration increased the values of flowers number increased till reach to the greatest increment at 200 ppm-sprayed plants as it gave 6.69 and 6.16 flowers per plant in the first and second seasons, respectively.

As for the interaction effect between amino acid and salicylic acid, data in Table, 7 showed that spraying geranium plants with salicylic acid at 200 ppm and supplemented with amino acid at 3 g / l is being the most effective one for producing the highest number of flowers per plant (7.14 and 6.35 in the first and second seasons, respectively).

Table 7. Effect of amino acid and salicylic acid as well as their combination on number of flowers of *Pelargonium zonale* plants during 2016 and 2017 seasons.

Parameter	Number of flowers / plant				
	Salicylic acid	Amino acid			Mean
	0.0	1cm/L	2cm/L	3cm/L	
		1 st season			
0.0	5.12	5.36	5.69	5.82	5.50
50 ppm	5.39	5.82	6.21	6.41	6.00
100 ppm	5.92	6.29	6.87	6.94	6.51
200 ppm	6.24	6.49	6.89	7.14	6.69
Mean	5.67	5.99	6.42	6.58	
L.S.D at 0.05 for	Amino acid =0.13		Salicylic acid =0.15	Interaction=0.28	
		2 nd season			
0.0	4.82	5.06	5.21	5.34	5.11
50 ppm	5.04	5.28	5.62	5.94	5.47
100 ppm	5.37	5.82	5.97	6.24	5.85
200 ppm	5.92	6.17	6.21	6.35	6.16
Mean	5.29	5.58	5.75	5.97	
L.S.D at 0.05 for	Amino acid =0.14		Salicylic acid = 0.15	Interaction=0.29	

2- Fresh and dry weights of flowers / plant (g):

Data presented in Tables, 8 and 9 showed that the heaviest fresh and dry weights of flowers per plant were recorded by using the high level of amino acid, followed in descending order by the medium concentration in the two seasons. Moreover, all tested concentration of salicylic acid increased these characters, especially the high concentration as compared with un-treated plants in

the two seasons. As for the interaction effect between amino acid and salicylic acid, data in the same Tables, showed that all resulted interactions increased the fresh and dry weights of flowers in the two seasons. In this respect, the heaviest flowers fresh and dry weights were obtained by those received amino acid at 3g/l and sprayed with salicylic acid at 200 ppm, in the two seasons.

Table 8. Effect of amino acid and salicylic acid as well as their combination on flowers fresh weight of *Pelargonium zonale* plants during 2018 and 2019 seasons.

Parameter	Fresh weight of flowers/ plant (g)					Mean
	Salicylic acid	Amino acid				
	0.0	1cm/L	2cm/L	3cm/L		
		1 st season				
0.0	32.4	36.2	39.4	41.8	37.5	
50 ppm	34.7	38.1	42.0	42.9	39.4	
100 ppm	36.2	39.8	43.2	44.5	40.9	
200 ppm	37.9	41.8	43.9	46.8	42.6	
Mean	35.3	39.0	42.1	44.0	====	
L.S.D at 0.05 for	Amino acid =1.42 Salicylic acid =1.44 Interaction=2.89					
		2 nd season				
0.0	29.3	31.4	34.0	35.8	32.6	
50 ppm	31.4	32.6	34.8	38.0	34.2	
100 ppm	32.9	32.8	35.1	38.8	34.9	
200 ppm	34.1	36.2	36.9	39.7	36.7	
Mean	31.9	33.3	35.2	38.1	=====	
L.S.D at 0.05 for	Amino acid =1.51 Salicylic acid = 1.53 Interaction=3.04					

Table 9. Effect of amino acid and salicylic acid as well as their combination on flowers dry weight of *Pelargonium zonale* plants during 2016 and 2017 seasons.

Parameter	Dry weight of flowers/ plant (g)					Mean
	Salicylic acid	Amino acid				
	0.0	1cm/L	2cm/L	3cm/L		
		1 st season				
0.0	3.56	3.98	4.33	4.60	4.12	
50 ppm	3.82	4.19	4.62	4.72	4.34	
100 ppm	3.98	4.38	4.75	4.90	4.50	
200 ppm	4.17	4.60	4.84	5.16	4.69	
Mean	3.88	4.29	4.64	4.85		
L.S.D at 0.05 for	Amino acid =0.11 Salicylic acid =0.12 Interaction=0.22					
		2 nd season				
0.0	3.51	3.76	4.08	4.30	3.91	
50 ppm	3.76	3.92	4.17	4.56	4.10	
100 ppm	3.94	3.94	4.21	4.66	4.19	
200 ppm	4.10	4.34	4.42	4.76	4.41	
Mean	3.83	3.99	4.22	4.57		
L.S.D at 0.05 for	Amino acid =0.12 Salicylic acid = 0.15 Interaction=0.26					

3- Duration of flower on plant (days)

Data in Table, 10 pointed out that using the high level of amino acid was more effective in increasing the duration of flower on geranium plant (18.5 and 17.5 days), followed by the medium concentration which scored 18.0 and 17.1 days, without significant differences between them in the first and second seasons, respectively. Referring to the effect of salicylic acid in Table, 10 indicated that all tested concentration of salicylic acid increased the duration of flower on plant with

superior for the highest concentration (200 ppm) as it scored 19.2 and 18.8 days, in the first and second seasons, respectively. As for the interaction effect between amino acid and salicylic acid data in Table 10 showed that the combination of amino acid at the high level showed to be the most effective one for producing the highest values in this concern, especially those sprayed with salicylic acid at the high concentration as it recorded 19.7 and 19.4 days, in the first and second seasons respectively.

Table 10. Effect of amino acid and salicylic acid as well as their combination on duration of flower of *Pelargonium zonale* plants during 2016 and 2017 seasons.

Parameter	Duration of flower on plant (days)					Mean
	Salicylic acid	Amino acid				
	0.0	1cm/L	2cm/L	3cm/L		
		1 st season				
0.0	14.6	15.2	16.8	17.2	16.0	

50 ppm	15.8	16.1	17.4	18.0	16.8
100 ppm	17.3	17.9	18.3	18.9	18.1
200 ppm	18.6	19.2	19.4	19.7	19.2
Mean	16.6	17.1	18.0	18.5	
L.S.D at 0.05 for	Amino acid =0.43 Salicylic acid =0.45 Interaction=0.89				
2 nd season					
0.0	13.4	13.8	14.6	14.9	14.2
50 ppm	15.2	15.9	16.7	16.8	16.2
100 ppm	16.5	17.4	18.2	18.8	17.7
200 ppm	18.2	18.7	19.0	19.4	18.8
Mean	15.8	16.5	17.1	17.5	
L.S.D at 0.05 for	Amino acid =0.41 Salicylic acid = 0.44 Interaction=0.83				

4- Flowering duration on plant (days)

Data in Tables, 11 indicated that the longest flowering duration of geranium were recorded by using amino acid at 3g/ l, followed in descending order by amino acid at 2g/l in the two seasons. While, the shortest flowering duration of geranium was gained by un-treated plants, followed in ascending order by using amino acid at 1g/ plant in the two seasons. Moreover, flowering duration of geranium plants were increased by increasing salicylic acid concentration in the two seasons. In

general, all resulted combination between amino acid and salicylic acid increased the flowering duration of geranium plant with significant differences in most cases when compared with un-treated plants in the two seasons of this study. Generally, the longest flowering duration of geranium plant were obtained by those received amino acid at 3g/plant and sprayed with salicylic acid at 200 ppm in the two seasons.

Table 11. Effect of amino acid and salicylic acid as well as their combination on flowering duration of *Pelargonium zonale* plants during 2016 and 2017 seasons.

Parameter	Flowering duration on plant (days)					Mean
	Salicylic acid	Amino acid				
		0.0	1cm/L	2cm/L	3cm/L	
1 st season						
0.0		74.7	78.3	81.2	83.6	79.5
50 ppm		79.3	81.8	84.6	86.7	83.1
100 ppm		85.9	89.2	91.4	92.3	89.7
200 ppm		88.7	92.4	94.6	97.9	93.4
Mean		82.2	85.4	88.0	90.1	
L.S.D at 0.05 for		Amino acid =2.17 Salicylic acid =2.18 Interaction=4.34				
2 nd season						
0.0		68.4	72.3	74.8	76.9	73.1
50 ppm		72.6	74.8	77.6	78.4	75.9
100 ppm		78.2	83.2	86.1	87.2	83.7
200 ppm		84.5	89.4	90.3	92.8	89.3
Mean		75.9	79.9	82.2	83.8	
L.S.D at 0.05 for		Amino acid =1.83 Salicylic acid = 1.85 Interaction=3.68				

The aforementioned results of SA are in harmony with those **Soltani (2014)** on *Calendula officinalis* L., **Elbohy et al., (2018)** on *Zinnia elegans*, **Mohammad Saeed (2019)** on gerbera, **Abbass et al., (2020)** on *Freesia hybrida*, **Mohammed and Abood (2020)** on *Gerbera jamesonii*, **Saeed (2020)** on *Gazania rigens* L. cv. Frosty Kiss Mixed, **El-Kinany (2020)** on *Viola wittrockiana* Gams, and **El-Ashwah (2020)** on *Cortaderia selloana*.

Whereas the results of Amino acid are in conformity with those reported by **Abd El-Aziz and Balbaa (2007)** on *Salvia farinacea* plants, **EL-Naggar and Sewedan (2009)** on *Amaryllis (Hippeastrum*

vittatum and **Ahmed and Makki (2021)** on *Solidago SP*.

c- Chemical composition determinations

1- Leaf nitrogen %

Data in Table, 12 indicated that using amino acid at the high level exhibited to be the most promising one for detecting the highest leaves nitrogen percentage in the two seasons. Also, all tested applications of salicylic acid increased the values of this parameter, especially using the highest rate (200 ppm) as it recorded 1.35 and 1.39 %, when compared with un-treated plants in the first and second seasons, respectively. As for the interaction effect between amino acid and salicylic

acid, data in Table, 12 showed that all resulted combination between amino acid and salicylic acid succeeded in increasing the values of this parameter, with superiority for the combination of Amino acid at 3 g/l in both seasons. In this concern,

the greatest leaf nitrogen percentage (1.41 and 1.46) was recorded by the plants treated with amino acid at the high level and sprayed with salicylic acid at 200 ppm, in the two seasons of this experiment.

Table 12. Effect of amino acid and salicylic acid as well as their combination on leaves N % of *Pelargonium zonale* plants during 2016 and 2017 seasons.

Parameter	Leaves N %					
	Salicylic acid	Amino acid				Mean
	0.0	1cm/L	2cm/L	3cm/L		
		1 st season				
0.0	1.14	1.21	1.29	1.31	1.24	
50 ppm	1.19	1.28	1.34	1.31	1.28	
100 ppm	1.26	1.24	1.36	1.39	1.31	
200 ppm	1.29	1.32	1.38	1.41	1.35	
Mean	1.22	1.26	1.34	1.36		
L.S.D at 0.05 for	Amino acid =1.14		Salicylic acid =1.14	Interaction=2.28		
		2 nd season				
0.0	1.23	1.29	1.28	1.34	1.29	
50 ppm	1.29	1.33	1.31	1.37	1.33	
100 ppm	1.31	1.30	1.35	1.41	1.34	
200 ppm	1.34	1.38	1.39	1.46	1.39	
Mean	1.29	1.33	1.33	1.40		
L.S.D at 0.05 for	Amino acid =1.17		Salicylic acid = 1.17	Interaction=2.34		

2-Leaf phosphorus %:

Data outlined in Table, 13 reported that the richest leaf phosphorus percentage was scored by using the high level of amino acid as it scored 0.152 and 0.144 % in the first and second seasons, respectively. Moreover, all tested concentration of salicylic acid increased this character, especially the high level (0.149 and 0.144 %) when compared with un-treated plants in the

two seasons. Referring to the interaction effect between amino acid and salicylic acid, data in the same Table, declared that all resulted interactions increased leaf phosphorus percentage in both seasons. In general, the highest leaf phosphorus percentage (0.157 and 0.149 %) was registered by those received amino acid at the high level and sprayed with salicylic acid at 200 ppm in the two seasons.

Table 13. Effect of amino acid and salicylic acid as well as their combination on leaves P % of *Pelargonium zonale* plants during 2016 and 2017 seasons.

Parameter	Leaves P %					
	Salicylic acid	Amino acid				Mean
	0.0	1cm/L	2cm/L	3cm/L		
		1 st season				
0.0	0.132	0.139	0.143	0.148	0.141	
50 ppm	0.136	0.135	0.145	0.149	0.141	
100 ppm	0.142	0.148	0.147	0.153	0.148	
200 ppm	0.145	0.146	0.149	0.157	0.149	
Mean	0.139	0.142	0.146	0.152		
L.S.D at 0.05 for	Amino acid =1.14		Salicylic acid =1.16	Interaction=2.27		
		2 nd season				
0.0	0.128	0.134	0.132	0.139	0.133	
50 ppm	0.134	0.136	0.138	0.142	0.138	
100 ppm	0.139	0.143	0.142	0.144	0.142	
200 ppm	0.142	0.141	0.143	0.149	0.144	
Mean	0.136	0.139	0.139	0.144		
L.S.D at 0.05 for	Amino acid =1.17		Salicylic acid = 1.18	Interaction=2.35		

14- Leaf potassium %

Data in Table, 14 revealed that amino acid at the high level was more effective in increasing leaf potassium percentage of geranium plant in the

two seasons of this study. In addition, data in the same Table showed that leaf potassium percentage increased by used all concentration of salicylic acid, with superior for 200 ppm-sprayed plants which

gave 1.36 and 1.35 % in the first and second seasons, respectively. As for the interaction effect between amino acid and salicylic acid, data in Table, 14 cleared that sprayed geranium plants with salicylic acid at the high concentration and enriched

with Amino acid at 3 g / l is being the most effective one for producing the greatest values as it scored 1.39 and 1.42 % in the first and second seasons, respectively.

Table 14. Effect of amino acid and salicylic acid as well as their combination on leaves K % of *Pelargonium zonale* plants during 2016 and 2017 seasons.

Parameter	Leaves K %				
	Salicylic acid	Amino acid			Mean
	0.0	1cm/L	2cm/L	3cm/L	
		1 st season			
0.0	1.12	1.18	1.24	1.29	1.21
50 ppm	1.26	1.24	1.31	1.34	1.29
100 ppm	1.31	1.30	1.36	1.37	1.34
200 ppm	1.32	1.35	1.37	1.39	1.36
Mean	1.25	1.27	1.32	1.35	
L.S.D at 0.05 for	Amino acid =1.14		Salicylic acid =1.16	Interaction=2.29	
		2 nd season			
0.0	1.18	1.24	1.29	1.28	1.25
50 ppm	1.24	1.29	1.28	1.31	1.28
100 ppm	1.28	1.36	1.35	1.39	1.35
200 ppm	1.30	1.29	1.37	1.42	1.35
Mean	1.25	1.30	1.32	1.35	
L.S.D at 0.05 for	Amino acid =1.18		Salicylic acid = 1.17	Interaction=2.38	

4-Leaf total carbohydrates %

Data in Table, 15 reported that amino acid at the high concentration is being the most effective one in increasing leaf total carbohydrates percentage of geranium plant in the two seasons of this study. Besides, data in the same Table indicated that leaf total carbohydrates percentage increased gradually by increasing salicylic acid concentration, in the two seasons. Regarding the interaction effect between amino acid and salicylic acid, data in

Table, 15 showed that the highest values of leaves total carbohydrates % was obtained by those received amino acid at 3g/l and sprayed with salicylic acid at 200 ppm as it scored 23.2 and 21.6 % in the first and second seasons, respectively.

Conclusively, sprayed geranium plants with salicylic acid at 200 ppm and supplemented with amino acid at 3 g / l produced the best growth, chemical constituents and quality of this plant.

Table 15. Effect of amino acid and salicylic acid as well as their combination on leaves total carbohydrates % of *Pelargonium zonale* plants during 2016 and 2017 seasons.

Parameter	Leaves total carbohydrates %				
	Salicylic acid	Amino acid			Mean
	0.0	1cm/L	2cm/L	3cm/L	
		1 st season			
0.0	17.9	18.4	19.6	19.4	18.8
50 ppm	18.4	18.2	19.7	20.2	19.1
100 ppm	19.6	20.0	19.8	22.4	20.5
200 ppm	19.8	21.6	22.0	23.2	21.7
Mean	18.9	19.6	20.3	21.3	
L.S.D at 0.05 for	Amino acid =1.14		Salicylic acid =1.15	Interaction=2.27	
		2 nd season			
0.0	16.4	17.1	17.9	18.2	17.4
50 ppm	17.3	17.6	18.4	19.0	18.1
100 ppm	18.2	18.1	18.9	20.3	18.9
200 ppm	18.8	19.9	19.8	21.6	20.0
Mean	17.7	18.2	18.8	19.8	
L.S.D at 0.05 for	Amino acid =1.18		Salicylic acid = 1.17	Interaction=2.35	

The aforementioned results of SA concerning chemical constituents are in conformity with those reported by **Muhammad *et al.*, (2014)** on tuberose, **Rodolfo *et al.*, (2015)** on *Sinningia speciosa* Benth., **Abou El-Ftough *et al.*, (2018)** on *Calendula officinalis* L., **Saeed (2020)** on *Gazania rigens* L. cv. Frosty Kiss Mixed, **El-Kinany (2020)** on *Viola wittrockiana* Gams, and **El-Ashwah (2020)** on *Cortaderia selloana*. While, the abovementioned results of amino acid are in conformity with those gained by **Abd El-Aziz and Balbaa (2007)** on *Salvia farinacea* plants, **EL-Naggar and Sewedan (2009)** on *Amaryllis (Hippeastrum vittatum)*, **Abdel Aziz, et al., (2010)** on *Thuja orientalis* L. plant, **Zaghoul et al., (2011)** on *Codiaeum variegatum* L. plants, **Soffar (2021)** on *Philodendron selloum* and **Ahmed and Makki (2021)** on *Solidago SP*.

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استجابة نباتات الجارونيا لبعض مواد مضادات الاجهاد

أجرينا تجربتين حقليتين بمزرعة قسم البساتين بكلية الزراعة بمشتر - جامعة بنها خلال موسمي 2016/2017 وذلك لدراسة تأثير الرش بالاحماض الامينية بتركيز صفر - 1 - 2 - 3 جرام/لتر وحمض السالسيليك بتركيزات صفر - 50 - 100 - 200 جزء في المليون وتفاعلاتهم المختلفه علي النمو الخضري والزهري والمحتوي الكيماوي لنباتات الجارونيا وقد اوضحت النتائج المتحصل عليها أن أطول النباتات و اكبر عدد من الأفرع/نبات و اكبر وزن طازج و جاف للاوراق و اكبر عرض للنبات و اعلي قيمه جماليه قد تم الحصول عليها باستخدام المعامله المختلفه بين الاحماض الامينية بمعدل 3جرام/لتر + الرش بحامض السالسيليك بتركيز 200 جزء في المليون في كلا الموسمين.

كما وجد ان رش النباتات بنفس المعامله السابقه قد اعطي اكبر عدد من الازهار / نبات و اكبر وزن طازج و جاف للازهار و اطول فتره ازهار علي النبات في كلا الموسمين.

كما وجد ان اكبر محتوى للاوراق من النيتروجين و الفوسفور و البوتاسيوم و الكربوهيدرات تم الحصول عليه عند رش النباتات بالاحماض الامينية بتركيز 3جرام / لتر + رش النباتات بحامض السالسيليك بتركيز 200 جزء في المليون في كلا الموسمين .

وللحصول علي افضل نمو خضري و زهري و محتوى كيماوي لنبات الجارونيا ينصح برش النباتات بالاحماض الامينية بتركيز 3 جرام / لتر + حامض السالسيليك بتركيز 200 جزء ف المليون .