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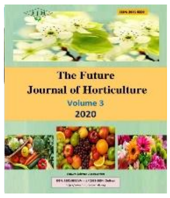

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THE ROLE OF COMPOST, AMINO ACIDS, SILICON AND SEAWEEDS EXTRACT IN ENHANCING THE GROWTH, YIELD AND ACTIVE INGREDIENTS OF ROSELLE PLANTS

Mahmoud, A. A.[1,*]; Ali, A. F.[1]; Amer, E.H.[1] and. Abd- El Naeem, G. F.[2]

[1]Hort. Dept. Fac. Agric., Al-Azhar Univ. Assiut Agric., **Egypt.**
[2]Bio. Chem. Dept. Fac. Agric., Minia, Uni., **Egypt.**

[*]**Corresponding author:** aboaltayeb46@gmail.com **Received:** 25 March 2021 **; Accepted:** 27 April 2021

ABSTRACT: This investigation was conducted at the Experimental Farm Faculty of Agriculture, Al-Azhar Univ., Assiut during the two successive seasons of 2018 and 2019 to determine the influence of compost as organic fertilization and foliar Spray with stimulant substance namely (amino acids [tryptophan + methionine + phenylalanine], silicon and seaweeds extract), as well as their interactions on plant growth traits, sepals. yield / plant and fed. and active ingredients of roselle (*Hibiscus sabdariffa*, L.) C.V. "Sabahia 17" dark line plants. Compost was applied at 0, 8, 16 and 24 m^3/ fed., and spraying the plants with the three examined stimulant substances as follows: control (no sprayed plants), amino acids at 300 ppm, silicon at 1 ml/L, seaweeds extract at 3 ml/L, amino acids + silicon, amino acids + seaweeds extract, silicon+ seaweeds extract, amino acids + silicon + seaweeds extract. The revealed results indicated that the use of compost at all levels led to a significant increase in plant growth traits (plant height, branch number / plant and herb dry weight/ plant) and also sepals dry yield/ plant and /fed., as well as % anthocyanin. In addition, all levels of compost significantly augmented acidity % except for the low one of compost (8 m^3/ fed.) in the second season. The highest values of these traits were detected by applying the high level of compost (24 m^3/ fed.). It could be noticed. That foliar spray with stimulant substances either single or together resulted a significant augment in these studied parameters, except for silicon treatment, mostly and, also amino acids treatment concerning acidity % in the second season. The application of the triple combined treatment (amino acids + silicon + seaweeds extract), followed, by the double combined one (amino acids + seaweeds extract) gave the highs values of plant growth characteristics. In connection, the highest values of sepals yield/ plant and fed., % acidity and anthocyanin % were given by foliar spray with the triple combined treatment (amino acids + silicon + seaweeds extract). The data showed that all studied traits were significantly affected by interaction treatments. Most combined treatments caused a significant increase in all examined parameters. In most cases, the addition of compost at the high level (24 m^3/ fed.) with foliar spray with the triple combined treatment (amino acids + silicon + seaweeds extract), followed by the double combined one (amino acids + seaweeds extract).

Key words: Roselle, compost, amino acids, silicon and seaweeds extract.

INTRODUCTION

Roselle (*Hibiscus sabdariffa*, L.) is one of the important medicinal plants grown in Egypt. It belongs to Family Malvaceae. The fiber of roselle is utilized for jute. Karkadeh drink is useful in folk medicine owing to their therapeutic action by lowering blood pressure without side effect **(Sharaf, 1962)**. It is cultivated mainly for its stem, leaves, seed and fruits **(Fasoyiro *et al.*, 2005)**. Sepals of roselle is the commercially important part. The whole plant is used as beverage and calyces with water and can be prepared hot or cold drinks. It has some medicinal properties **(Mohamed *et al*. 2012)**. Calyces roselle is rich in organic acids namely, malic acid and ascorbic acid, anthocyanin and minerals particularly Ca and Fe, while glucose is low **(Jung *et al*., 2013)**.

Organic fertilization are very save for human, animal and environment. There are many advantages for organic manures for examples: Minimize the need of chemical fertilizers, raise soil fertility, decrease the cost of production and, also lowering the rate of pollution in air, water and soil. **Bohn *et al*. (1985)**

suggested that organic matter is main source of N and P at 50-60%, S at 80% and also contains B and Mo at high concentrations. Organic plant manures as plant residues are source of available N and enhancing infertility soil production **(Khamis and Al-Metwally, 1998 and El- Mohandes, 1999)**. **Saha *et al*. (2008)** proved that applying organic materials impacts agricultural sustainability by improving physical, chemical and biological properties of soil. The enhancement in plant growth due to the use of organic manures were detected by many authors such as, **El-Keltawi *et al*. (2003)**, **El-Kouny *et al*. (2004)** and **Ali (2007)** on roselle, **Ali *et al*. (2017)** and **Hamed (2017)** on anise, Helmy, (2016) on cumin, **Fouad (2017)** on borage and **Ibrahim (2014)**, **Ali *et al*. (2016)** and **Mahmond (2017)** on Khella. Concerning the yield, **Abo El-Fadl *et al*. (1990)**, **Sidky *et al*. (1997)**, **EL-Kouny *et al*.**(2004) and **Ali (2007)** on roselle, **Rekaby (2013)**, **Ali *et al*.(2019)**, **Abdullatif (2019)** and **Acimovic (2013)** on coriander, **Abarghouei (2014)** and **Ali *et al*. (2016)** on Fennel -**Helmy (2016)** on cumin, **Ali *et al*.(2017) on** anise, **Ibrahim (2014)**, **Ali *et al*. (2016)** and **Mahmoud (2017)** on Khella and **Found (2017)** on barage, Regarding anthocyanin pigments and acidity, **Ali (2007)** on roselle.

The application of Amino acids in horticultural practices is one of modern methods wheras that amino acids consistes of neccessity compounds which act important roles for examples: biosynthesis of vitamins, enzymes, co-enzymes, alkaloids, pigments, terpenoids, purine and pyrimidine bases **(Kamar and Omar, 1987)**. Phenylalanine, tryptophan and glutamic acid are precursors for secondary products such as, flavonoids, alkaloids, coumarins, glucosinolates, phenolic acids and cyanogenic glycosides **(Wink, 2010)**. The stimulating influence of amino acids on plant growth was insured by several investigators such as, **Ahmed *et al*. (2011)** and **Hassan (2013)** on roselle, **Rahmatzadeh *et al*. (2012)** on *Catharanthus roseus* **Ali *et al*. (2016)** and **Abd El-Rahman (2016)** on chamomile, **Talaat *et al*. (2005)** on *Nigella Sativa*, **Al- Qubaie (2012)** on sunflower, **Ali and Hassan (2013)** on *Tagetes erecta*, **Ali *et al*. (2019)** and **Abdullatif (2019)** on coriander and **Abd- Elghany (2020)** on dill. Regardening yield **Ahmed *et al*. (2011)** and **Hassan (2013)** on roselle, **Hendawy** and **Ezz El-Din (2010)** on fennel **Al- Qubaie. (2012)** on sunflowers, **Ali *et al*. (2019)** and **Abdlullatif (2019)** on coriander, and **Abd-Elghany (2020)** on dill. Concerning anthocyanin pigments and acidity, **Ahmed *et al*. (2011)** and **Hassan (2013)** on roselle, **shehata *et al*. (2011)** on anthocyanin of strawberry and **Ghoname *et al*. (2012)** on acidity of bell pepper.

Silicon is one of the important nutrients for plant growth **(Liang, *et al*., (2006). Abo-Baker *et al*. (2011)** indicated that supplying silicon enhanced nutritional balance under saline soil conditions, there by obtained better growth performance and consequence yield production. The silica acts augmenting resistance degree against pathogen and lodging of the plant **(Deren *et al*., 1994)**. The positive influence of silicon growth was obtained by **Abou-Baker *et al*. (2012)** on bean, **Liang *et al*. (2006)** on barely, **Gad El-Kareem (2012)** on Taimour mango trees, **Al Wasfy (2013)** on Sakkoti date palms. Regarding the yield, **Kim *et al*. (2012), Nolla *et al*. (2012)** on rice, **Gad El-Kareem (2012)** on Taimour mango trees, **Perreira *et al*. (2004)** on rice, **Abo-Baker et al. (2012)** on bean. Concerning plant pigments **Neumann** and **Zur-Nieden (2001), Gad El-Kareem (2012)** and **Al Wasfy (2013)**.

Seaweeds extract is an: excellent natural fertilizer and is considered as a good source of organic matter. It contains high concentrations of macro and micronutrients namely, N, P, K, S, Ca, Mg, Zn, Mn, Fe and C **(Tung *et al*., 2003 and Fornes *et al*. 2005)**. Recently, Matural seaweeds was applied as fertilizer **(Hong *et al*., 2007)** is allowed for substitution in conventional synthetic fertilizer **(Crouch** and **van Staden, 1993)**. It contains growth regulators such as gibberellins **(Wildgoose *et al*., 1978)**, Cytokinins (**Durand *et al*., 2003** and **Stirk *et al*., 2003**) and auxins (**Stirk *et al*., 2004**). Many authors explained the Importance of seaweeds extract in increasing the plant growth such as, **Thirumaran *et al*. (2009)** and **Ramya *et al*. (2011)** on guar, **Abdulrahman** and **Sadeeq (2014)** on *Vinca roseus*, **Sridhar** and **Rangasamy (2010)** on *Tagetes erecta*, **Hassan (2015)** on dill, **Ali *et al*. (2017)** and **Hamed (2017)** on anise and Regarding the yield, **Mohammad (2020)** on *Nigella sativa*. Regarding the yield, **Arthur *et al*. (2003)** on pepper, **Zodape *et al*. (2008)** on okra, **Hassan, (2015)** on dill, **Ali *et al*. (2017)** and **Hamed (2017)** on anise, **Mohammad (2020)** on *Nigella sativa*.

Therefore, the objective of the present work was to study the response of roselle plants to compost, amino acids, silicon and seaweeds extract treatments.

MATERIAL AND METHODS

Two field trials were conducted during the two successive seasons of 2018 and 2019 at the Experimental Farm, Faculty of Agriculture, Al-Azhar Univ., Assiut to examine the influence of compost, some amino acids, seaweeds extract and silicon, as well as their interactions on vegetative growth traits, yield and active ingredients of dark Line, Sabahia 17 roselle (*Hibiscus sadariffa*) plants. This study was set up in a split plot design with three replicates, compost levels as organic fertilization was considered as the main plots (A), while stimulant substance treatments (amino acids, seaweeds extract and silicon) in the Sub – plots (B). The seeds of roselle were obtained from Medicinal and Aromatic Plants Dept., Horticulture Research Institute, Giza, Egypt and were sown in the nursery on the first week of April, in the two seasons.

The seedlings were transplanted 45 days after the sowing date in 3 x 1.8 m plot with 60 cm distance between the rows, in hills 50 cm apart. Each plot contained 18 plants. Some physical and chemical properties of the experimental soil were analyzed according to **Jackson (1973)** and are shown in Table (1).

Table 1. Some physical and chemical properties of the experimental soil (average for two seasons)

Texture	E.C m.mohs/cm	PH (1:2.5)	O.M %	Caco3	Total N%	Available	
						P ppm	K (mg/100g soil)
Loamy	**2.03**	**7.5**	**0.6**	**2.25**	**0.10**	**0.15**	**3.1**

The used compost (Factor A) (called compost El-Neel) was obtained from New Minia City and was added factor at 4 levels 0, 8, 16 and 24m^3/ fed. during preparing the soil to cultivation, in both seasons. Physical and chemical properties of the used compost are shown in Table (2).

Table 2. Physical and chemical properties of the compost applied in the present investigation (average for two seasons).

Content	Values	Content	Values
PH (1-2.5)	7.6	**Total phosphorus%**	0.7
E.C. (mm/cm)	3.5	**Total potassium%**	0.87
C: N Ratio	15.6	**Fe ppm**	1650
Organic matter%	39.0	**Mn ppm**	98
Organic carbon%	21.8	**Cu ppm**	180
Total nitrogen%	1.4	**Zn ppm**	90

The treatments of (B) were as follows: Control (no sprayed plants, amino acids at 300 ppm, Seaweeds extract at 3 ml/ l, Silicon at 1 ml /l, amino acids + seaweeds extract, amino acids silicon, seaweeds extract + silicon and amino acids + seaweeds extract + silicon. Amino acids were applied as a mixture (tryptophan, methionine + phenylalanine) and were obtained from Al-Gomhoria Chemical Company.

Oligo x product contains seaweeds extract was obtained from United for Agricultural Development. The chemical properties of seaweeds extract used in this investigation are shown in Table (3).

Table 3. Chemical properties of Seaweed extract used in the present study

Organic components	Value	Growth regulators	Value	Macro and micro elements	Value
Carbohydrates	**35%**	**IAA**	**0.03%**	**Organic (N)**	**3.12%**
Total amino acids	**6%**	**Cytokynins**	**0.02%**	**P2O5**	**2.61%**
Manitol	**4%**	**Adenine**		**K2O**	**4.71%**
Alginic acid	**10%**			**Cao**	**0.25%**
Betaines	**0.04%**			**S**	**3.56%**
				Mg	**0.58%**
				Fe	**150ppm**
				Zn	**70ppm**
				Mn	**13ppm**
				B	**60 ppm**
				Organic (N)	**3.12%**
				I	**30 ppm**

Silicon in from potassium silicate (25% Si O_2, 10% K_2o) at 1ml/ l and was obtained from Abu Ghanima for fertilizers and chemical industries.

The plants were foliar sprayed with the three examined stimulant substances, three times at two-week intervals starting June 12th for both seasons, one day period was allowed between the spraying of the three substances. The plants were sprayed till run off. Triton B at 0.05% was applied as a wetting agent to all sprays. Control plants were sprayed with water containing Triton B.

All agricultural practices were performed as usual. At the termination (the last week of October) in both seasons, the following data were recorded: plant height (cm), branch number / plant, herb dry weight (g) plant, sepals dry weight (g)/ plant and per fed. from the air dried sepals, anthocyanin% was determined by method of **Fulcki** and **Francis (1968)** and developed by **Du** and **Francis (1973)**. Also, titrable acidity in the air-dried sepals as citric acid was estimated and calculated by the method of titration against alkali **(A.O.A.C, 1970)**. The obtained data were tabulated and statistically analyzed according to **MSTATE - C (1986)** using the L.S.D. test at 5%. to know the differences among all treatments according to **Mead *et al*. (1993)**.

RESULTS AND DISCUSSION

Plant height (cm)

The presented data in Table (4) revealed that supplying roselle plants with compost as organic manure at all levels led to significant increase in plant height, during the two experimental seasons, as compared to unfertilized ones. It is clear that the highest values of this parameter were observed when using the high level of compost (24 m^3/ fed.) reached 14.3% and 14.6 % over control, in the two seasons, respectively.

The capability of organic fertilization augmenting plant height reported by **Khatab (2016)** on roselle, **Mohamed and Ahmed (2003)** on sweet fennel, **Swaefy *et al*. (2007)** on mint plant, **Khalid and Shafei (2005)** on *Anethum graveolens*, **Santos *et al.* (2009)** on *Melissa officinalis*, **Amran (2013)** on *Pelargonium graveolens*, **Abdu *et al*. (2012), Ali *et al*. (2016)** on fennel. **Mahmoud (2017)** on *Ammi visnaga*.

As for stimulant substance treatments, the listed data in Table (4) indicated that spraying roselle plants with the three examined substance either single or mixed, in both seasons, significantly increased plant height, except for the treatment of silicon at 1ml/l in the second season, comparing to untreated plants. Apparently, the longest plants were detected by foliar spray with the triple combined treatment (amino acids + silicon+ seaweeds extract) followed by the double combined treatment (amino acids + seaweeds extract) which increased it by 15.9 %,14.1 %,14.5 % and by12.6 % over unsprayed plants, in the first and second respectively.

The beneficial influence of amino acids on plant height was also obtained by **Gamal El-Din** and **Abd El-Wahed (2005)**, **Haj SeyedHadi *et al*., (2011)** and **Omer *et al*., (2013)** on chamomile plant, **Balbaa and Talaat (2007)** on rosemary plants, **El-Awadi and Hassan (2010)** on fennel plant, **Sarojnee *et al*. (2009)** on hot peppers, **Hassan** and **Ali (2010)** on coriander, **Talaat (2005)** on *Pelargonium graveolens*, **Abd El-Rahman *et al*. (2008)** on fennel, **Ali (2007)** on caraway

Concerning silicon, **Abdelkader *et al*., (2016)** on roselle growth (*Hibiscus sabdariffa* L.), Kamenidou **(2005)** on *Zinnia elegans*, **Abo El-Enien *et al.*, (2017)** on citrus seedlings and **Magouz (2017)** on *Catharanthus roseus,* L.

Regarding seaweeds extract, **El-Leithy *et al.* (2019)** on *Plectranthus* amboinicus, **Nasiroleslami and Safaridolatabad (2014)** on dill, **Abou ElYazied *et al*. (2012)** on snap bean, **Ramya *et al*. (2011)** on guar, **Sridhar and Rangasamy (2010)** on *Tagets erecta*,

Its worthy mention that the interaction between the two studied factors, in the two seasons, was statistically significant effect on plant height of roselle.

It is appeared that the use of all combined treatments, in the two seasons, caused a significant augment in plant height, except for 0 compost plus silicon at 1ml/L in the second season, comparing to untreated plants. Obviously, the addition of compost at the high level (24 m^3/ fed. with the triple combined treatment (amino acids + silicon+ seaweeds extract) followed by the double combined treatment. (amino acids + seaweeds extract).

Registered the highest values of plant height, in comparison with those resulted by other combination treatments, during the two growing seasons.

Table 4. Effect of compost, stimulant substance treatments and their interaction on plant height (cm) of roselle plant during the two seasons of 2018 and 2019

Compost levels (m^3/ fed.) (A)	Stimulant substance treatments (B)								
	Control	Amino acids (300ppm)	Silicon (1 ml/l)	Seaweeds extract (3 ml/l)	Amino acids + Silicon	Amino acids + Seaweeds extract	Silicon + Seaweeds extract	Amino acids + Silicon + Seaweeds extract	Mean (A)
					First season				
Control	140.3	152.1	147.4	161.4	151.2	166.8	162.3	169.6	**156.4**
8	153.6	163.5	157.0	164.6	171.3	174.4	165.2	176.4	**165.8**
16	162.2	171.5	162.7	173.1	177.1	180.8	174.4	184.6	**173.3**
24	166.5	174.4	167.7	178.9	182.1	187.0	183.7	189.6	**178.7**
Mean (B)	**155.4**	**165.4**	**158.7**	**169.5**	**170.4**	**177.3**	**171.4**	**180.1**	
L.S.D. at 5 %		**A = 5.7**			**B = 2.5**			**A×B = 5.0**	
					Second season				
Control	141.5	152.5	146.3	157.4	149.8	161.0	157.6	165.7	**154.0**
8	152.8	164.5	158.3	167.5	171.0	177.2	172.1	179.5	**167.9**
16	161.5	170.4	161.7	171.4	175.4	178.9	173.9	181.9	**171.9**
24	167.3	175.5	165.9	173.6	180.4	184.7	177.8	186.5	**176.5**
Mean (B)	**155.8**	**165.7**	**158.1**	**167.5**	**169.3**	**175.5**	**170.3**	**178.4**	
L.S.D. at 5 %		**A = 2.5**			**B = 2.6**			**A×B = 5.2**	

Number of branches/ plant

Shown data in Table (5) that branch number/ plant, of roselle was increased, in the two consecutive seasons, due to applying compost at all levels, as compared to the check treatment. Clearly such trait was gradually significantly augmented with increasing the levels of compost, during the two seasons. Therefore, the use of the high level of compost (24 m³/ fed.) proved to be more effective in increasing branch number / plant than other treatments, during both seasons. This previous superior treatment increased branch number by 26.9 % and by 25.6 % over control, during the two experimental seasons, respectively.

The positive effect of organic fertilization on branch number was also demonstrated by, **Abou-Aly and Gomaa (2002)** on coriander plant and **Shaalan (2005)** on *Nigella sativa* L. plant, **Khalid and Shafei (2005)** on *Anethum graveolens,* **Santos *et al.* (2009)** on *Melissa officinalis*, **Carrubba (2009)** on *Coriandrum sativum*.

In relation to stimulant substance treatments, the application of these materials either separately or in combination during the two-growing season, resulted a significant augment in branch number/ plant of roselle, except for silicon treatment in the first season, as compared to no sprayed plants.

However, the most effective treatments in increasing such trait were noticed from adding the triple combined treatment (amino acids + silicon+ seaweeds extract), followed by the double combined treatment (amino acids + seaweeds extract) comparing to other treatments, during both seasons. Numerically, the two above mentioned superior treatments augmented branch number by 17.7 %, 14.2 %, 26.0 % and 23.6 % over the check treatment, in the two seasons, respectively, as clearly shown in Table (5).

The role of amino acids in enhancing branch number was also discussed by **Hendawy (2000)** on *Echinacea purpurea*, **Datir *et al*., (2012)** on *Capsicum annum* L., **Youssef *et al*., (2004)** on Datura plants, **Omer *et al*., (2013)** and **Gamal El-Din** and **Abd El-Wahed (2005)** on chamomile plant.

Regarding silicon, **Bradbury and Ahmed (1990)** on *Prosopis juliflora*, (**Adatia and Besford, 1986** and **Crusciol *et al*., 2009**)., **El-Hifny *et al*. (2008)** on Cauliflower, **El-Eslamboly and Abdel-Wahab (2014)** on cantaloupe.

Concerning seaweeds extract, **Abou El-Yazied *et al*., (2012**) on snap bean, **Khalil (2002)** on rosemary plants and **Khalil *et al.* (2008)** on fennel, **El- Gamal and Ahmed, (2016)** on dill.

Table (5) cleared that the combined effect between the two examined factors on branch number/ plant of roselle was statistically significant, during the two experimental seasons. Obviously, such parameter was significantly increased in both seasons, as a result of applying all combined treatments. Moreover, the highest values of branch number/ plant were given by receiving the plants compost at the high level (24 m³/fed) plus the triple combined treatment (amino acids + silicon + seaweeds extract), in comparison with those obtained by other combination treatments, during both seasons.

Herb dry weight (g)/ plant

The given results in Table (6) emphasized that fertilizing roselle plants with comport at all levels, in both seasons, resulted a significant augment in here dry weight/ plant, as compared to the check treatment.

It seems that the heaviest herb, was obtained when adding compost at the high level (24 m³/fed.) as ranged 38.9 % and 28.5 % over unfertilized plants, during the two seasons, respectively.

The efficiency of organic fertilization on augmenting herb weight was also disclosed by, **Abou El-Ghait *et al.* (2012)** on Indian fennel, **El-Gendy *et al.* (2012)** on roselle plants, **Mohamed *et al.* (2012)** on *Stevia rebaudiana*, **Amran (2013)** on *Pelargonium graveolens*, **Sakr *et al.* (2014)** on roselle plants, **Youssef (2014)** on roselle plants.

In respect to stimulant substance treatments, the obtained results postulated that foliar spray with these substances either alone or together, in both seasons, led to a significant increase in herb dry weight/ plant of roselle, except for silicon at 1 ml/ L in the second season, comparing to no sprayed plants. Apparently, foliar spray with the triple combined. Treatment (amino acids + silicon + seaweeds extract), followed by the double combined one (amino acids + seaweeds extract) proved to be more effective in increasing herb dry weight than other treatments, during the two growing seasons. Numerically, these previous superior treatments augmented such trait by 31.3 %, 26.3%, 27.5 % and 24.0 % over control plants, in the two consecutive seasons, respectively, as clearly declared in Table (6) .

The stimulating effect of amino acids on herb weight was also insured by, **Youssef *et al*., (2004)** on Datura plants, **Gamal El-Din and Abd El-Wahed (2005)** on chamomile plant, **Balbaa and Talaat (2007)** on rosemary, **Haj SeyedHadi *et al*., (2011)** on chamomile plant, **Datir *et al*., (2012)** on *Capsicum annum*.

Concerning silicon, (**Adatia and Besford, 1986** and **Crusciol *et al*., 2009**)., **El-Hifny *et al*. (2008)** on Cauliflower, **El-Eslamboly and Abdel-Wahab (2014)** on cantaloupe.

Table 5. Effect of compost, stimulant substance treatments and their interaction on branch number / plant of roselle plant during the two seasons of 2018 and 2019

Compost levels (m^3/ fed.) (A)	Stimulant substance treatments (B)								
	Control	**Amino acids (300ppm)**	**Silicon (1 ml/l)**	**Seaweeds extract (3 ml/l)**	**Amino acids + Silicon**	**Amino acids + Seaweeds extract**	**Silicon + Seaweeds extract**	**Amino acids + Silicon + Seaweeds extract**	**Mean (A)**
First season									
Control	9.4	12.3	10.5	12.6	12.3	13.0	11.9	13.3	**11.9**
8	11.1	12.8	11.9	13.2	12.4	13.9	12.8	14.0	**12.8**
16	12.4	13.0	12.6	13.7	14.0	14.6	13.7	15.8	**13.7**
24	14.1	14.4	14.1	14.8	15.0	16.1	15.3	16.6	**15.1**
Mean (B)	**11.8**	**13.1**	**12.3**	**13.6**	**13.4**	**14.3**	**13.4**	**14.9**	
L.S.D. at 5 %		**A = 0.4**			**B = 0.6**			**A×B = 1.1**	
Second season									
Control	10.1	12.8	10.8	13.2	12.6	14.1	12.9	13.8	**12.5**
8	11.8	13.1	12.1	13.7	12.9	14.4	13.4	14.9	**13.3**
16	12.7	13.9	12.9	14.1	13.8	15.7	14.4	16.1	**14.2**
24	14.8	15.1	14.9	15.8	15.8	16.4	15.9	17.2	**15.7**
Mean (B)	**12.3**	**13.7**	**12.6**	**14.2**	**13.8**	**15.2**	**14.1**	**15.5**	
L.S.D. at 5 %		**A = 0.5**			**B = 0.6**			**A×B = 1.2**	

Table 6. Effect of compost, stimulant substance treatments and their interaction on herb dry weight / plant (g) of roselle plant during the two seasons of 2018 and 2019

Compost levels (m^3/ fed.) (A)	Stimulant substance treatments (B)								
	Control	Amino acids (300ppm)	Silicon (1 ml/l)	Seaweeds extract (3 ml/l)	Amino acids + Silicon	Amino acids + Seaweeds extract	Silicon + Seaweeds extract	Amino acids + Silicon + Seaweeds extract	Mean (A)
					First season				
Control	285.4	307.1	300.1	338.7	317.2	360.0	342.0	377.5	**328.5**
8	307.6	351.0	338.8	359.8	364.9	394.1	386.6	412.8	**364.5**
16	350.1	387.2	381.2	401.2	370.2	435.7	421.3	448.4	**399.4**
24	378.5	453.4	441.5	466.0	462.9	479.2	473.0	496.1	**456.3**
Mean (B)	**330.4**	**374.7**	**365.4**	**391.4**	**378.8**	**417.2**	**405.8**	**433.7**	
L.S.D. at 5 %		**A = 23.6**			**B = 15.4**			**A×B = 30.8**	
					Second season				
Control	284.1	309.6	305.0	329.8	317.7	384.7	315.7	345.1	**319.5**
8	304.4	332.7	313.1	340.2	359.6	385.7	349.5	408.5	**349.2**
16	315.4	365.9	335.0	374.5	392.5	404.2	371.1	424.9	**373.0**
24	369.7	414.5	360.1	420.3	430.3	441.0	403.3	445.9	**410.6**
Mean (B)	**318.4**	**355.7**	**328.4**	**366.2**	**375.0**	**394.9**	**359.9**	**406.1**	
L.S.D. at 5 %		**A = 26.2**			**B = 17.7**			**A×B = 35.4**	

Regarding seaweeds extract, (**Featonby-Smith (1984)**, **Fan *et al.*, (1993)** and **Zamani *et al.*, (2013).**, **Chouliraras *et al.*, (2009); Abd El-Motty *et al.*, (2010);** and **Abd El-Salam, (2014)**.

As for the interaction between the two tested factors, the data in Table (6) proved that it was statistically significant effect on herb dry weight/ plant of roselle, in both seasons. It is obvious that most combined treatments resulted a significant increase in such parameter, during the two seasons, as compared to untreated ones. Clearly, the highest values of herb dry weight were detected from applying compost at the high level (24 m³/ fed.) with the triple combined treatment (amino acids+ silicon+ seaweeds extract), followed by the double combined one (amino acids + seaweeds extract), in comparison with those detected by other combination treatments, during both seasons.

Sepals dry yield (g)/ plant and Kg/ fed.

The obtained data in Tables (7 and 8) pointed out that the use of compost at all levels, in both seasons, caused a significant increase in sepals dry yield/ plant and fed. as compared to the check treatment. Apparently, these traits were gradually significant augmented with increasing comport levels, during the two seasons. Therefore, plants treated with compost at the high level (24 m³/ fed.) produced the maximum value of sepals dry weight reached 28.4 % and 25.7 % over unfertilized plants, in the first and second seasons, respectively. This previous superior treatment yielded (590.4) and (573.8), in relative to control (459.8) and (455.8) Kg. dry sepals, during the two consecutive seasons, respectively. The increment in sepals yield due to applying organic matters have been also explored by, **Sakr *et al.* (2014)** on roselle plants and **Youssef (2014)** on roselle plant**, El-Sherif and Sarwat (2007)** on roselle**, Radwan and Farahat (2002)** oncoriander plant,

It is evident from the revealed data in Tables (7 and 8) that spraying roselle plants with the three examined stimulant substances either individual or a mixture in both seasons, resulted a significant augment in sepals dry yield/ plant and /fed., except for silicon treatment in the two season, comparing to no sprayed ones. In connection, the application of the triple combined treatment (amino acids + silicon+ seaweeds extract) produced the heaviest dry sepals as ranged 25.6 % and 23.8 % over untreated plants, in the first and second seasons, respectively. This aforementioned superior treatment amounted (591.3) and (575.7) Kg. while control gave (470.9) and (465.0) Kg. dry sepals, In the two seasons, respectively.

Many authors came to similar conclusion detected in this research that amino acids improved fruit yield such as, **Hassan (2013)** on rselle, **Abd El-Aziz and Balbaa (2007)** on *Salvia farinacea*, **Sewedan and Osman (2014)** on *Dendranthema grandiflorum* and **Khattab *et al*. (2016)** on *Gladiolus grandiflorum*.

Concerning silicon, **Kim et al. (2012), Nolla *et al*. (2012)** on rice, **Gad El-Kareem (2012)** on Taimour mango trees, **Perreira *et al*. (2004)** on rice.

Regarding seaweeds extract, **Mohammad (2020)** on *Nigella sativa*, **Arthur *et al*. (2003)** on pepper, **Zodape *et al*. (2008)** on okra, **Hassan, (2015)** on dill, **Ali *et al*. (2017)** and **Hamed (2017)** on anise.

With respect to the combined effect between the two studied factors, the presented data in Tables (7 and 8) cleared that sepals dry yield/ plant and / fed. of roselle were significantly affected by the interaction treatments, during the two experimental seasons. It could be noticed that most combined treatments resulted a significant augment in these traits, for both seasons, comparing to untreated plants. Obviously, supplying roselle plants compost at the high level (24 m³/ fed.) plus the triple combined treatment (amino acids + silicon + seaweeds extract), followed by the double combined one (amino acids + seaweeds extract) produced the heaviest dry sepals as ranged 66.6 %, 59.2 %, 53.8 % and 49.8 % over the check treatment, in the first and second seasons, respectively. These previous superior treatments yielded 661.8, 632.4, 629.3 and 613.3 in relative to control produced 397.3. and 409.3 Kg. dry sepals, during both seasons, respectively.

Acidity %

The obtained data in Table (9) indicated that the acidity % in the dried sepals of roselle was significantly increased, in the two growing seasons, due to using compost at all levels, except for the low one (8 m³/ fed.) in the second season, as compared to unfertilized plants. It is obvious that such trait was gradually significantly augmented with increasing compost levels, during both seasons. Therefore, applying compost at the high level (24 m³/ fed.) proved to be more effective in increasing the acidity % than those obtained by other treatments, in the two seasons. This previous superior treatment increased the acidity % by 7.8 % and 6.4 % over control, during the two experimental seasons, respectively.

The promoting effect of organic manures on the acidity declared by was also **Ali (2007)** on roselle. In relation to the influence of stimulant substance treatments, the listed data in Table (9) revealed that foliar spray substances either single or together, in both seasons, led to a significant increase in the acidity %, except for the treatment of silicon in the two seasons and also amino acids in the second season. Treatment in the second one, in relative to no sprayed plants. Clearly, the use of the triple combined treatment (amino acids+ silicon+ seaweeds extract) gave the highest values of the acidity % reached 7.6 % and 8.7 % over no sprayed ones, during the two consecutive seasons, respectively.

Table 7. Effect of compost, stimulant substance treatments and their interaction on sepal dry weight / plant (g) of roselle plant during the two seasons of 2018 and 2019

Compost levels (m^3/ fed.) (A)	Stimulant substance treatments (B)								
	Control	Amino acids (300ppm)	Silicon (1 ml/l)	Seaweeds extract (3 ml/l)	Amino acids + Silicon	Amino acids + Seaweeds extract	Silicon + Seaweeds extract	Amino acids + Silicon + Seaweeds extract	Mean (A)
				First season					
Control	29.8	34.0	31.7	35.5	34.2	36.8	35.6	38.2	**34.5**
8	34.3	36.6	34.6	38.0	37.2	41.2	39.1	43.3	**38.0**
16	37.5	39.6	37.9	41.4	40.8	44.7	42.6	46.3	**41.3**
24	39.7	43.3	40.5	44.9	43.6	47.4	45.4	49.6	**44.3**
Mean (B)	**35.3**	**38.4**	**36.2**	**40.0**	**38.9**	**42.5**	**40.6**	**44.4**	
L.S.D. at 5 %		**A = 1.3**				**B = 1.1**		**A×B = 2.5**	
				Second season					
Control	30.7	33.8	31.0	34.9	33.9	36.2	35.0	37.9	**34.2**
8	33.7	36.1	33.8	37.8	36.6	40.6	38.1	42.8	**37.4**
16	36.5	38.3	36.9	40.9	39.7	43.3	41.3	44.8	**40.2**
24	38.5	42.6	39.6	43.6	42.8	46.0	44.1	47.2	**43.0**
Mean (B)	**34.9**	**37.7**	**35.3**	**39.3**	**38.3**	**41.5**	**39.6**	**43.2**	
L.S.D. at 5 %		**A = 1.3**				**B = 1.2**		**A×B = 2.5**	

Table 8. Effect of compost, stimulant substance treatments and their interaction on sepal dry weight / fed. (kg) of roselle plant during the two seasons of 2018 and 2019

Compost levels (m^3/ fed.) (A)	Stimulant substance treatments (B)								
	Control	Amino acids (300ppm)	Silicon (1 ml/l)	Seaweeds extract (3 ml/l)	Amino acids + Silicon	Amino acids + Seaweeds extract	Silicon + Seaweeds extract	Amino acids + Silicon + Seaweeds extract	Mean (A)
First season									
Control	397.3	453.8	422.7	473.3	455.5	491.1	475.1	509.3	**459.8**
8	456.9	488.4	461.8	507.1	495.5	549.3	521.8	577.3	**507.3**
16	500.0	528.0	505.3	552.0	543.5	595.5	567.5	616.9	**551.1**
24	529.3	577.3	539.5	598.2	581.3	632.4	603.1	661.8	**590.4**
Mean (B)	**470.9**	**511.9**	**482.3**	**532.7**	**519.0**	**567.1**	**541.9**	**591.3**	
L.S.D. at 5 %		**A = 20.8**			**B = 18.1**			**A×B = 36.2**	
Second season									
Control	409.3	450.8	413.8	465.8	452.4	482.7	466.3	505.3	**455.8**
8	450.2	485.8	455.5	503.5	493.3	541.8	507.5	570.2	**501.0**
16	487.1	511.1	492.0	545.8	529.3	577.3	551.1	597.8	**536.4**
24	513.3	567.5	527.5	580.9	571.1	613.3	587.5	629.3	**573.8**
Mean (B)	**465.0**	**503.8**	**472.2**	**524.0**	**511.5**	**553.8**	**528.1**	**575.7**	
L.S.D. at 5 %		**A = 20.1**			**B = 19.8**			**A×B = 39.6**	

The beneficial effect of stimulant substance treatments on the acidity was also studied by **Ahmed *et al*. (2011)** and **Hassan (2013)** on roselle, **Neumenn** and **Zur-Nieden (2011) Gad El-Kareem (2012)** and **Al Wasfy (2013)**.

Table (9) emphasized that the interaction between the two examined factors on the acidity % in the dried sepals of roselle was significant effect in the two seasons. Obviously, such parameter was significantly augmented, as was result of applying most combined treatments, in relative to control, during both seasons. Moreover, the highest of the acidity % were detected values by using the high level of compost (24 m^3/ fed.) + the triple combined treatment (amino acids + silicon + seaweeds extract), followed by the double combined one (amino acids + seaweeds extract), in comparison with those given by other combination treatments, during the two experimental seasons.

Anthocyanin%

It is obvious from the revealed data in Table (10) that applied compost at all levels, in both seasons, to roselle plants resulted an augment in anthocyanin % in the dried sepals, comparing to unfertilized plants. It is clear that with increasing compost levels anthocyanin % was gradually increased, during the two seasons. Therefore, the highest anthocyanin % was detected by receiving the plants compost at the high level (24 m^3/ fed.) which increased it by 18.9 % and by 15.5 % over control, in the two seasons, respectively.

The efficiency of organic matters on augmenting anthocyanin was also proved by **Ali (2007)** and **Nabila and Aly (2002)** on roselle.

Accordingly, spraying roselle plants with the three studied substances either separately or mixed caused a significant augment in anthocyanin % as compared to no sprayed ones, in both seasons. The application of the triple combined treatment (amino acids + silicon + seaweeds extract) proved to be more effective in augmenting anthocyanin % reached 19.5 % and 20.4 % over untreated plants, during the two growing seasons respectively, as clearly postulated in Table (10).

The enhancement in anthocyanin due to the application of stimulant substance treatments was also discussed by, **Ahmed *et al*. (2011)** and **Hassan (2013)** on roselle, **shehata *et al*. (2011)** on anthocyanin of strawberry and **Ghoname *et al*. (2012)** on acidity of bell pepper, **Neumenn** and **Zur-Nieden (2011) Gad El-Kareem (2012)** and **Al Wasfy (2013)**.

As for the interaction effect, the listed data in Table (10) cleared that it was statistically significant on anthocyanin % in the dried sepals of roselle, during both seasons.

Most combined treatments resulted a significant augment in anthocyanin % as compared to control, during the two seasons. Moreover, the most effective treatment was noticed when applying compost at the high level (24 m^3/fed.) with the triple combined treatment (amino acids + silicon+ seaweeds extract), in comparison with those obtained by other combination treatments, during the two seasons.

From the obtained results, it could be discussed as follows: The increments in the growth, yield and chemical constituents of roselle plants in this investigation due to the addition of comport as organic manures reflects the positive, physiological and biological roles of organic manures which were explored by many authors such as, **Bohn *et al*. (1985)** suggested that organic manure is a main source of the elements N, P and S, as well as, is contains high concentrations of B and Mo.

They showed that organic matter is a source of energy for Azotobacter growth. Organic manure contain growth promoting hormones (GA_3 and IAA), macronutrients essential micronutrients and useful microorganisms **(Natarajan, 2007 and Sreenivasa *et al*., 2010)**. The enhancement in all studied traits as a result of foliar spray with amino acids may be due to the positive, physiological and biological roles of amino acids which were studied by several investigators such as**, El Shabasi *et al*. (2005)**, **Shaheen *et al*. (2010)**, **Sarojnee *et al*. (2009)** and **Papenfus *et al*. (2013)** mentioned that available amino acids enhanced fertilizer assimilation, augment the uptakes of water and nutrients, enhance the rate of photosynthetic and dry matter, as well as increase crop yield. Amino acids improve plant growth traits, yield and mitigates the injuries by a biotic stress **Kowalezyk** and **Zielony (2008)**. Tryptophan is precursor of IAA, but methionine is precursor of ethylene **(Taiz** and **Zeiger, 2002)**. The positive influence of silicon on studied characteristics in the present work might be attributed to the beneficial roles of silicon which were explained by some researchers. For examples: **Pereira *et al*. (2004)** emphasized that fertilizers containing silicon are routinely utilized to many crops including rice to augment crop yield and quality. Many authors indicated that the addition of silicon was useful for counteracting the adverse effects of water stress on plant growth and nutritional status. It is known that silicon augment plant of drought tolerance by maintaining water balance in plant, photosynthesis, activity, erectness of leaves and xylem vessels structure under higher the rate of transpiration. Silicon is responsible for encouraging the transport of water and root growth under unfavorable conditions and also stimulating antioxidants against system **(Matoh *et al*., 1999, Epstein 1999, Alvarez** and **Datnoff, 2001, Aziz *et al*., 2002, Melo *et al*., 2003, Epstein and Bloom, 2003** and **Hattori *et al*., 2005).**

Table 9. Effect of compost, stimulant substance treatments and their interaction on Acidity % of roselle plant during the two seasons of 2018 and 2019

Compost levels (m^3/ fed.) (A)	Stimulant substance treatments (B)								
	Control	**Amino acids (300ppm)**	**Silicon (1 ml/l)**	**Seaweeds extract (3 ml/l)**	**Amino acids + Silicon**	**Amino acids + Seaweeds extract**	**Silicon + Seaweeds extract**	**Amino acids + Silicon + Seaweeds extract**	**Mean (A)**
					First season				
Control	8.24	8.50	8.43	8.59	8.54	8.76	8.37	8.86	**8.54**
8	8.41	8.56	8.53	8.67	8.57	9.08	8.95	9.25	**8.75**
16	8.62	8.85	8.68	8.83	8.97	9.15	9.06	9.31	**8.93**
24	9.00	9.15	8.90	9.16	8.28	9.43	9.36	9.45	**9.21**
Mean (B)	**8.57**	**8.77**	**8.64**	**8.82**	**8.84**	**9.11**	**8.94**	**9.22**	
L.S.D. at 5 %		**A = 0.12**			**B = 0.14**			**A×B = 0.29**	
					Second season				
Control	8.16	8.30	8.20	8.33	8.32	8.73	8.53	8.93	**8.44**
8	8.34	8.45	8.36	8.53	8.42	8.75	8.63	9.11	**8.57**
16	8.53	8.63	8.50	8.62	8.74	8.91	8.83	9.23	**8.75**
24	8.71	8.87	8.69	8.91	9.03	9.25	9.04	9.38	**8.98**
Mean (B)	**8.43**	**8.56**	**8.44**	**8.60**	**8.63**	**8.90**	**8.76**	**9.16**	
L.S.D. at 5 %		**A = 0.17**			**B = 0.17**			**A×B = 0.36**	

Table 10. Effect of compost, stimulant substance treatments and their interaction on anthocyanin % of roselle plant during the two seasons of 2018 and 2019

Compost levels (m^3/ fed.) (A)	Stimulant substance treatments (B)								
	Control	Amino acids (300ppm)	Silicon (1 ml/l)	Seaweeds extract (3 ml/l)	Amino acids + Silicon	Amino acids + Seaweeds extract	Silicon + Seaweeds extract	Amino acids + Silicon + Seaweeds extract	Mean (A)
First season									
Control	2.07	2.15	2.14	2.29	2.27	2.31	2.21	2.35	**2.22**
8	2.15	2.28	2.23	2.41	2.44	2.51	2.48	2.59	**2.39**
16	2.62	2.38	2.34	2.49	5.55	2.62	2.61	2.74	**2.50**
24	2.36	2.48	2.54	2.65	2.65	2.79	2.76	2.88	**2.64**
Mean (B)	**2.21**	**2.33**	**2.31**	**2.46**	**2.48**	**2.56**	**2.52**	**2.64**	
L.S.D. at 5 %		**A = 0.03**			**B = 0.07**			**A×B = 0.12**	
Second season									
Control	2.06	2.13	2.12	2.18	2.22	2.25	2.22	2.32	**2.19**
8	2.14	2.22	2.19	2.26	2.34	2.43	2.42	2.51	**2.31**
16	2.18	2.39	2.27	2.39	2.40	2.53	2.52	2.72	**2.41**
24	2.27	2.41	2.32	2.52	2.54	2.75	2.64	2.83	**2.53**
Mean (B)	**2.16**	**2.26**	**2.23**	**2.34**	**2.37**	**2.49**	**2.45**	**2.60**	
L.S.D. at 5 %		**A = 0.08**			**B = 0.05**			**A×B = 0.12**	

The enhancement in the previous studied traits in the present work resulting from the application of seaweeds extract may be due to the positive, physiological and biological roles of seaweeds extract which were discussed by several authors such as, Seaweeds extract is an excellent natural fertilizer and a good source of organic matter. It contains higher concentrations of elements namely N, P, K, S, Ca, Mg, Zn, Mn, Fe and C (**Tung *et al*. 2003** and **Fornes *et al*., 2005).** Furthermore, seaweeds are considered a good source of bioactive compounds i.e. vitamins, mineral, protein, carotenoids, essential fatty acids and dietary fiber **(Osman** and **Salem, 2011)**. From the revealed results, it could be recommended to supply the soil of roselle (*Hibiscus sabdariffa*, L.) plants, cv." Sabahia 17" dark line with compost at 24 m^3/ fed. and foliar spray with amino acids (tryptophan + methionine + phenylalanine) at 300 ppm, silicon at 1 ml/ L and, seaweeds extract at 3 ml/ L to enhance the growth, sepals yield and active ingredients under the present study conditions.

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