Egyptian Journal of Chemistry
http://ejchem.journals.ekb.eg/

The Impact of Spraying Selenium, Glutamic Acid and Seaweed Extract on Growth, Productivity, Physical and Chemical Fruit Properties of Banana

R.A. Eisa[a], M.A. Merwad[b], E.A.M. Mostafa[b], M.M.S. Saleh[b]* and N.E. Ashour[b]
[a]*Hort. Tech. Crop Dept. National Research Centre, El-Buhouth str., Dokki, Cairo, Egypt*
[b]*Pomology Dept., National Research Centre, El-Buhouth str., Dokki, Cairo, Egypt*

Abstract

This work was conducted through two successive seasons (2018 and 2019) on Grand Nain banana grown in a private orchard located at El-Kalubia Governorate, Egypt to evaluate seaweed extract, selenium and glutamic acid effects on vegetative growth, yield as well as physical and chemical properties of the fruits. Plants were sprayed four times (mid of April, May, June and July) with glutamic acid at 50 or 100 ppm, seaweed extract at 0.05 or 0.1% and selenium at 50 or 100 ppm, as a single or combined applications. Treatments were very effective in stimulating all vegetative growth parameters, bunch weight as well as physical and chemical fruit properties comparing with to the control treatment. A superior effect was obtained with the foliar spray of seaweed extract, followed by glutamic acid and selenium. Spraying banana plants four times with a mixture containing glutamic at 100 ppm + seaweed extract at 0.1%+ or selenium at 100 ppm recorded the best results with reference to vegetative growth, bunch weight and fruit properties.

Keywords: Banana; glutamic acid; seaweed extract; selenium; yield; fruit properties.

1. Introduction

Several investigators reported that glutamic acid, seaweed extract; selenium had a positive effect on the yield of different plants and improved the physical and chemical properties of the fruits.

Amino acids are important for the primary and secondary metabolism of the plants. There are many important compounds related to fruit quality and production could be synthesized by amino acids. The balance of the phenolic compounds is very substantial for the composition of the fruit. The asparagine amino acid and glutamate bind the carbon and nitrogen cycles which are the two important metabolic cycles of the plant, also have an effect on both sugars and proteins [1, 2, 3]. The apparent photorespiration which done by C^3 plants like mango trees is inhibited by glycine as an amino acid; it promotes the efficiency of photosynthesis with a higher sugar content and yield [4].

Spraying Kite and Tommy Atkins mango trees with amino acids (Tryptophan, methionine and arginine) at 0.05 % improved the yield, fruit weight, TSS and total sugars and reduced the total acidity compared with the control treatment [5]. Spraying El-Saidy date palms with three amino acids (Tryptophan, methionine and arginine) enriched with N,P, K, Mg, Zn, Fe, B and Mn at 0.1% three times maximized the yield, bunch weight and both physical and chemical properties of the fruits comparing with the control [6].

Seaweed extracts include a large number of organic and mineral compounds (micro and macronutrients). A lot of compounds are presented in these extracts such as phytohormones, indole acetic acid (IAA), gibberllic acid, cytokines, abscisic acid (ABA) and ethylene, complex organic compounds, simple and complex sugars, special polysaccharides (like alginates, laminarin and carragheenans),

*Corresponding author e-mail: hero1956@gmail.com.; (M.M.S. Saleh).
Receive Date: 25 February 2022, Revise Date: 30 March 2022, Accept Date: 06 April 2022.
DOI: 10.21608/EJCHEM.2022.123837.5529

vitamins, enzymes, betaines, proteins and amino acids, sterols [7]. Active compounds in seaweed extracts biologically have an affirmative effect on soil (effect on rhizosphere microbes, soil structure and moisture relation), on plant growth (root development and mineral absorption, photosynthesis and shoot growth, vegetative propagation, crop yield) and resistance to environmental stresses (alleviating biotic and abiotic stress in crop plants) [8].

Prior studies detected that using seaweed extract was very important in increasing growth and productivity of fruit crops [9, 10, 11, 12, 13, 14].

Selenium as an element similar to sulphur is considered an essential micro nutrient for human, animals, and some species of microorganism. It has many functions in the active site of a large number of enzymes such as glutathione-peroxidase, as anticancer and other physiological functions [15, 16]. A lower level of selenium in body is responsible for high incidence of cancer and disease [17]. It also impacts the nutrient balance in the plants [18].

Foliar sprays of selenium (Se) at 0.01 or 0.02 % were very effective in enhancing the yield, bunch weight as well as physical and chemical properties of Zaghloul date palms fruits in compared to the check treatment [19].

Several authors showed that selenium when used either separately or combined with other amino acids, positively increased the yield per plant. At the same time improved the physical and chemical properties of the fruits [4, 19, 20, 21, 22, 23].

This investigation aimed to study the effect of glutamic acid, seaweed extract and selenium on yield and fruit quality of Grand Nain banana plants.

2. Methods

This investigation was executed though the two successive seasons of 2018 and 2019 on banana Grand Nain cultivar grown in a private orchard situated at El-Kalubia Governorate, Egypt to investigate the effect of glutamic acid, seaweed extract and selenium on vegetative growth, yield and fruit physical and chemical properties.

For achieving the above goal, 27 holes each with three plants were selected and devoted for this study.

- Glutamic acid molecular formula is: $C_5H_9NO_4$
- Chemical composition of seaweed extract is as follows:
  - Nutrients: 0.18% Nitrogen (N), 0.48% Phosphorus (P_2O_5), 1.89% Potassium (K_2O), 0.11% Calcium, 0.01% Magnesium, 0.13% Sodium, 256.0 ppm Iron, 11.87 ppm Zinc, 15.62 ppm Copper, 13.12 ppm Manganese.
  - Growth hormones: Cytokinin، Auxin, Gibberelin (Trace).

The experiment was designed in randomized complete block design and nine treatments were carried out as follow:

1. Control (without application)
2. Glutamic acid at 50 ppm
3. Glutamic acid at 100 ppm
4. Seaweed extract at 0.05 %
5. Seaweed extract at 0.1 %
6. Selenium at 50 ppm
7. Selenium at 100 ppm
8. Glutamic acid at 50 ppm+ Seaweed extract at 0.05 %+ Selenium at 50 ppm
9. Glutamic acid at 100 ppm+ Seaweed extract at 0.1 %+ Selenium at 100 ppm

The spraying of the above treatments was carried out four times per each season (mid of April, May, June and July). Each treatment contained three replicates.
The following parameters were determined as follow:

1. Vegetative growth:

At bunch shooting stage: pseudostem height and girth (cm) were measured, number of green leaves per plant was counted and leaf area (cm^2) was measured.

2. Yield and fruit properties:

At harvest: bunch weight (kg), number of hands/bunch, hand weight (kg) and number of fingers/hand were determined.

Finger weight (gm), length and diameter of finger (cm) were estimated.

Total soluble solids (TSS %), total acidity % (expressed as mg malic acid /100 gm pulp) and total sugars % were determined as the described method [24].

Statistical Analysis:

All acquired data were classified and statistically analyzed [25]. Means were identified using Rang test at the 0.05 level [26].

3. Results and Discussion

3.1. Vegetative growth

The results presented in Table (1) show that single or mixed treatments was significantly responsible for motivating the growth characters namely height and growth of pseudostem, leaf area and number of green leaves at bunch shooting of Grand Nain banana plants in compared to the control treatment.

Increasing concentrations of glutamic acid, seaweed extract and selenium in the study were associated with the promotion. The maximum values of pseudostem height (323.0 & 330.0 cm), pseudostem girth (91.4 & 90.9 cm), leaf area (2.18 & 2.29 m^2) and number of green leaves at bunch shooting (13.6 & 14.0) were observed on the plants received four sprays of a mixture containing glutamic acid at 100 ppm+ seaweed extract at 0.1 %+ selenium at 100 ppm, followed by a mixture containing glutamic acid at 50 ppm+ seaweed extract at 0.05 %+ selenium at 50 ppm in both experimental seasons, while the control plants recorded the minimum values in both seasons.

The effect of glutamic acid and seaweed extract on stimulating growth characters could be due to their essential actions on enhancing cell division and the biosynthesis of organic foods [27, 28]. In this respect, selenium was able to promote plant growth and improve leaf area of Valencia orange and Zagloul date palms [19, 20]. The results concerning the effect of seaweed extract on growth characters are in compact with the previous ones [9, 12].

Table 1 Effect of glutamic acid, seaweed extract and selenium sprays on pseudostem length, pseudostem girth, leaf area and number of green leaves of Grand Nain banana plants during 2018 and 2019 seasons

Treatments	Pseudostem length (cm)		Pseudostem girth (cm)		Leaf area (m^2)		Number of green levels	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Control	268.0 g	270.0 i	76.76 g	80.40 f	1.66 g	1.76 e	11.60 f	12.76 f
Glutamic acid (GA) at 50 ppm	274.0 f	298.0 f	80.86 e	82.06 de	1.76 f	1.83 de	12.40 d	13.20 e
Glutamic acid (GA) at 100 ppm	281.0 e	303.0 e	81.50 de	83.16 d	1.79 e	1.86 d	12.53 cd	13.40 d
Seaweed extract (SWE) at 0.05 %	291.0 d	307.0 d	82.16 d	85.66 c	1.87 d	1.98 c	12.70 c	13.60 c
Seaweed extract (SWE) at 0.1 %	303.0 c	316.0 c	85.00 c	88.00 b	1.92 c	2.07 b	13.20 b	13.83 b
Selenium (Se) at 50 ppm	264.0 h	276.0 h	79.33 f	80.53 f	1.66 g	1.85 d	11.90 e	13.03 e
Selenium (Se) at 100 ppm	269.0 g	280.0 g	80.33 ef	80.83 ef	1.68 g	1.82 de	12.00 e	13.10 e
GA 50 ppm +SWE 0.05+Se 50 ppm	317.0 b	325.0 b	89.16 b	88.13 b	2.15 b	2.22 a	13.46 a	13.70 bc
GA 100 ppm +SWE 0.1+Se 100 ppm	323.0 a	330.0 a	91.40 a	90.96 a	2.18 a	2.29 a	13.63 a	14.03 a
LSD at 0.05 level	**3.43**	**3.49**	**1.23**	**1.42**	**0.03**	**0.07**	**0.17**	**0.18**

3.2. Yield and bunch parameters

It is illustrated by the obtained results in Table (2) that the single or mixed treatments were significantly accompanied with improving bunch weight, number of hands/ bunch, hand weight and number of fingers/ hand comparing with the control. The heaviest bunch weight was obtained from the mixed treatment of glutamic acid at 100 ppm + seaweed extract at 0.1 % + selenium at 100 ppm which recorded 30.4 and 30.5 kg in the two seasons, respectively. Also, the same treatment gave the height number of hands/ bunch (13.6 & 13.43), hand weight (2.19 & 2.20 kg) and number of fingers/ hand (21.1 & 20.9) in both seasons, respectively. Meanwhile, the control treatment recorded the lowest bunch weight (21.6 & 23.7), number of hands/ bunch (11.86 & 12.00), hand weight (1.69 & 1.77 kg) and number of fingers/ hand (18.8 & 19.3) in the first and the second seasons, respectively.

The effect of glutamic acid and selenium on enhancing the biosynthesis of carbohydrates and proteins, saving plant water balance, erectness of leaves, photosynthesis activity and structure of xylem vessels under high transpiration rates might be

responsible for their effect on increasing bunch weight. These results are in agreement with those observed before [22, 29, 30, 31, 32, 33, 34].

The increment in yield due to selenium sprays may be due to increasing finger weight and number of fingers/ hand. These findings are in agreement with the results obtained by many researchers [19, 20, 21, 35] who found that selenium increased fruit weight and number of fruits per tree of Navel and Valencia oranges, Zaghloul date palms and mango trees.

The results of amino acid are in harmony with the findings previously on Flame seedless grapevines, Ewais and Figery Kelan mango trees and on Keitte mango trees, since the amino acids enhanced and increased the fruit yield parameters [36. 37, 38].

Table 2 Effect of glutamic acid, seaweed extract and selenium sprays on bunch weight, number of hands/bunch, hand weight and number of fingers/ hand of Grand Nain banana plants during 2018 and 2019 seasons

Treatments	Bunch weight (kg)		Number of hands / bunch		Hand weight (kg)		Number of fingers / hand	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Control	21.60 f	23.70 f	11.86 g	12.00 f	1.69 e	1.77 d	18.80 e	19.30 f
Glutamic acid (GA) at 50 ppm	29.00 b	28.76 bc	12.86 c	12.76 c	1.93 b	1.95 c	19.36 d	19.66 def
Glutamic acid (GA) at 100 ppm	29.43 b	28.50 cd	12.96 c	12.90 c	1.97 b	1.94 c	19.30 d	19.80 de
Seaweed extract (SWE) at 0.05 %	26.86 d	27.80 d	12.43 e	12.46 de	1.83 cd	1.91 c	20.00 c	20.06 cd
Seaweed extract (SWE) at 0.1 %	27.76 c	28.86 bc	12.63 d	12.83 c	1.87 c	1.91 c	20.20 c	20.30 bc
Selenium (Se) at 50 ppm	23.70 e	24.60 f	12.20 f	12.30 e	1.85 cd	1.78 d	18.73 e	19.33 ef
Selenium (Se) at 100 ppm	23.80 e	26.20 e	12.43 e	12.50 d	1.81 d	1.83 d	19.03 de	19.63 def
GA 50 ppm +SWE 0.05+Se 50 ppm	29.43 b	29.50 b	13.33 b	13.20 b	2.16 a	2.07 b	20.63 b	20.70 ab
GA 100 ppm +SWE 0.1+Se 100 ppm	30.43 a	30.50 a	13.60 a	13.43 a	2.19 a	2.20 a	21.06 a	20.90 a
LSD at 0.05 level	**0.58**	**0.95**	**0.17**	**0.19**	**0.04**	**0.06**	**0.37**	**0.49**

3.3. Fruit physical properties

The result in Table (3) show that spraying Grand Nain banana with glutamic acid at 50 or 100 ppm, seaweed extract at 0.05 or 0.1 % and selenium at 50 or 100 ppm as single or mixed treatments, significantly had a positive effect on improving finger weight, finger length and finger diameter compared with the control treatment. In this concern, spraying seaweed extract at 0.1% was significantly favorable than spraying glutamic acid at 100 ppm and selenium at 100 ppm in both seasons of the study.

Spraying mixture of glutamic acid at 100 ppm + seaweed extract at 0.1 % and selenium at 100 ppm gave the highest values of finger weight (91 & 95 gm), finger length (21.5 & 21.8 cm) and finger diameter (4.40 & 4.56 cm), followed by foliar spray of glutamic acid at 50 ppm + seaweed extract at 0.05 % + selenium at 50 ppm, which recorded 89.1 and 91.66 gm as finger weight, 21.3 and 20.96 cm as finger length, 4.3 and 4.4 cm as finger diameter in both experimental seasons, respectively. Meanwhile, the control treatment recorded 79 and 86 gm as finger weight, 19 and 20.2 cm as finger length, 3.20 and 3.23 cm as finger diameter.

The obtained results are in harmony with those cleared that amino acids treatment significantly increased fruit physical parameters compared with the control [13, 22].

Table 3 Effect of glutamic acid, seaweed extract and selenium sprays on fruit physical properties of Grand Nain banana plants during 2018 and 2019 seasons

Treatments	Finger weight (g)		Finger length (cm)		Finger diameter (cm)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Control	79.00 f	86.00 e	19.00 h	20.20 f	3.20 f	3.23 e
Glutamic acid (GA) at 50 ppm	88.33 bc	88.00 cd	20.26 e	20.53 e	3.60 cd	3.80 bc
Glutamic acid (GA) at 100 ppm	87.86 bc	89.00 c	20.46 d	21.03 c	3.83 b	3.96 b
Seaweed extract (SWE) at 0.05 %	86.70 cd	92.26 b	20.33 de	21.36 b	3.36 e	3.53 d
Seaweed extract (SWE) at 0.1 %	89.23 ab	92.66 b	21.03 c	21.80 a	3.46 de	3.60 d
Selenium (Se) at 50 ppm	83.33 e	86.00 e	19.26 g	20.46 ef	3.50 cde	3.70 cd
Selenium (Se) at 100 ppm	85.00 de	86.66 de	19.50 f	20.70 de	3.63 c	3.63 cd
GA 50 ppm +SWE 0.05+Se 50 ppm	89.13 ab	91.66 b	21.30 b	20.96 cd	4.30 a	4.40 a
GA 100 ppm +SWE 0.1+Se 100 ppm	91.00 a	95.00 a	21.50 a	21.80 a	4.40 a	4.56 a
LSD at 0.05 level	**2.13**	**1.84**	**0.19**	**0.27**	**0.15**	**0.19**

3.4. Fruit chemical properties

Considering total soluble solids (TSS%), results in Table (4) show that spraying Grand Nain banana with glutamic acid at 50 or 100 ppm, seaweed extract at 0.05 or 0.1 % and selenium at 50 or 100 ppm solely or as mixed treatments, significantly improved fruit quality in terms of increasing total soluble solids (TSS%) and total sugars percentage compared with the control treatment in both experimental seasons.

Spraying seaweed extract at 0.1% had a favourable significant effect than spraying glutamic acid at 100 ppm and selenium at 100 ppm on total soluble solids and total sugars percentages in both seasons.

Spraying mixture of glutamic acid at 100 ppm plus seaweed extract at 0.1% and selenium at 100 ppm gave the highest value of total soluble solids (19.2 & 19.3%) and total sugars (16.7 & 17%), followed by spraying mixture of glutamic acid at 50 ppm + seaweed at 0.05 % + selenium 50 ppm, which recorded 18.76 & 18.76% as TSS and 16.50 & 16.60 % as total sugars % in the first and the second seasons, respectively.

Unfavourable the total soluble solids recorded 16.1 and 16.36 %, also total sugars recorded 14.86 and 15.26 % with the untreated plants (control).

As for total acidity, results in Table (4) clear that spraying Grand Nain banana with glutamic acid at 50 or 100 ppm, seaweed extract at 0.05 or 0.1% and selenium at 50 or 100 ppm as single treatment or in mixture, decreased total acidity comparing with the control in both experimental seasons.

The highest total acidity percentage was obtained from the control which gave 0.14 and 0.15 % in the first and second seasons, respectively. Meanwhile, the lowest total acidity value was found due to the foliar spray with selenium at 100 ppm (0.090 and 0.086 %) in both seasons, respectively. The present results are in agreement with those obtained on banana [13, 22].

Otherwise, the results of foliar spray of amino acids are in harmony with the findings on grapes, pistachio and mango trees, since the foliar application of amino acids increased TSS %, total sugars percentage and decreased fruit acidity [4, 39, 40]. Also the obtained results are in agreement with some researches on selenium, since the it increased fruit dimensions, total soluble solids of Zaghloul date palms, Navel and Valencia oranges but decreased total acidity percentage [19, 20, 35].

Table 4 Effect of glutamic acid, seaweed extract and selenium sprays on fruit chemical properties of Grand Nain banana plants during 2018 and 2019 seasons

Treatments	TSS (%)		Total acidity (%)		Total sugars (%)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Control	16.13 h	16.36 h	0.143 a	0.150 a	14.86 e	15.26 f
Glutamic acid (GA) at 50 ppm	16.90 ef	17.03 f	0.113 b	0.113 b	15.63 d	15.73 d
Glutamic acid (GA) at 100 ppm	17.20 e	17.63 d	0.116 b	0.110 bc	15.83 cd	15.73 d
Seaweed extract (SWE) at 0.05 %	18.00 d	18.40 c	0.110 b	0.103 cd	16.00 c	16.20 c
Seaweed extract (SWE) at 0.1 %	18.40 c	18.90 b	0.110 b	0.106 bc	16.30 b	16.40 bc
Selenium (Se) at 50 ppm	16.40 gh	16.76 g	0.093 cd	0.090 ef	15.63 d	15.43 ef
Selenium (Se) at 100 ppm	16.63 fg	17.33 e	0.090 d	0.086 f	15.66 d	15.60 de
GA 50 ppm +SWE 0.05+Se 50 ppm	18.76 b	18.76 b	0.100 c	0.096 de	16.50 ab	16.60 b
GA 100 ppm +SWE 0.1+Se 100 ppm	19.20 a	19.33 a	0.100 c	0.096 de	16.70 a	17.00 a
LSD at 0.05 level	**0.30**	**0.23**	**0.09**	**0.09**	**0.26**	**0.24**

4. Conclusions

The superior results concerning vegetative growth, yield as well as physical and chemical properties of the fruits of banana Grand Nain cultivar were obtained when a mixture containing glutamic acid at 100 ppm+ seaweed at 0.1 %+ selenium at 100 ppm were sprayed four times (mid of April, May, June and July).

5. References

[1] Davies, D.D. (1982). Physiological Aspects of Protein Turnover. In: Boulter D., Parthier B. (eds) Nucleic Acids and Proteins in Plants I. Encyclopedia of Plant hysiology, vol. **14** / A. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-68237-7_7.

[2] Ahmed, F.F., Gad El-Kareem, M.R. and Oraby-Mona, M.M. (2013a). Response of Zaghloul date palms to spraying boron, silicon and glutathione. Stem Cell, **4**, 29-34.

[3] Hassan, H.S.E. (2014). Attempts for reducing alternate bearing in Balady mandarin trees by spraying some amino acids and vitamins. M.Sc. Thesis, Fac. Agric., Minia Univ., Egypt.

[4] Taiz, L. and Zeiger, E. (2002). Plant physiology. Sunderland: Sinauer, P.690.

[5] Fathalla, A.M. (2013). Physiological studies on some mango cultivars. Ph.D. Thesis, Fac. Agric., Menofuia Univ., Egypt.

[6] Ahmed, F.F., Ali, A.H.S., Sayed, E.S. and Sayed-Ola, M.O. (2014). Using some amino acids enriched with certain nutrients for improving productivity of El-Saidy date palms. World Rural Observations, **6**, 20-27.

[7] Du Jardin P. (2012). The Science of Plant Biostimulants - A Bibliographic Analysis, Ad hoc Study Report. Brussels: European Commission. Available online at: http://hdl.handle.net/2268/169257 (Accessed April 25, 2013).

[8] Khan, W.; Rayirath, U.P.; Subramanian, S.; Jithesh, M.N.; Rayorath, P. and Hodges, D.M., (2009). Seaweed extracts as biostimulants of plant growth and development. J. Plant Growth Regul., **28**, 386–399.

[9] El-Sawy, Y.A. (2005). Studies on the effect of some organic fertilizers, ammonium nitrate and the biofertilzer (Algae extract) on growth and productivity of Williams banana (*Musa Cavendishii* L.). M.Sc. Thesis, Fac. Agric., Minia Univ., Egypt.

[10] Merwad, M.M.A. (2011). Effect of nitrogen sources, rates, some biostimulants and

antioxidants on growth and productivity of banana plants. Ph.D. Thesis, Fac. Agric., Zagazig Univ., Egypt.

[11] Mahmoud, Kh.M.H. (2012). Reducing inorganic N fertilizer in Balady mandarin orchard through application of extracts of yeast, seaweed and farmyard manure. M.Sc. Thesis, Fac. Agric., Minia Univ., Egypt.

[12] Oraby, A.A.F. (2013). Partial replacement of inorganic nitrogen fertilizer by spraying some vitamins, yeast and seaweed extract in Ewase mango orchard under Upper Egypt conditions. M.Sc. Thesis, Fac. of Agric., Minia Univ., Egypt.

[13] Roshdy, Kh.A. (2014). Effect of spraying silicon and seaweed extract on growth and fruiting of Grand naine banana. Egypt. J. Agric. Res., **92,** 3, 979-991.

[14] Merwad, M.A., Mostafa, E.A.M., Ashour, N.E. and Saleh. M.M.S. (2019). Effect of boron, zinc and seaweed sprays on yield and fruit quality of Barhee date palms. Plant Archives, **19**, 2, 393-397.

[15] Rayman, M.P. (2002). The argument for increasing selenium intake. Proc. Nutr. Soc., **61,** 2, 203-215.

[16] Turakainen, M., Hartikainen, H. and Seppänen, M.M. (2004). Effects of selenium treatments on potato (*Solanum tuberosum* L.) growth and concentrations of soluble sugars and starch. J. Agric. Food Chem., **52**, 17, 5378–5382.

[17] Gupta, U.C., Gupta, S.C. and Gupta, M.D. (2000). Selenium in soils and crops, its deficiencies in livestock and humans, implication for management. Commun. Soil Sci. Plant Anal., **31**, 1791 – 1807.

[18] Nowak-Barbara, H. (2008). Effect of selenium on selected macronutrients in maize plants. J. Elemental, **13,** 4, 513 – 519.

[19] Gad El-Kareem, M.R., Abdel Aal, A.M.K and Mohamed, A.Y. (2014). The synergistic effects of using silicon and selenium on fruiting of Zaghloul date palm (*Phoenix dectylifera* L.). International Journal of Agricultural and Biosystems Engineering, 8, 3, 959-964.

[20] Ibrahim, H.I.M. and Al-Wasfy, M.M. (2014). The promotive impact of using silicon and selenium with potassium and boron on fruiting of Valencia orange trees grown under Minia region conditions. World Rural Observations, **6,** 2, 28-36.

[21] Shimaa, M., Abou-Rawash, M., El-Wakeel, H. and Omaima, M. El-Sayed (2016). Effect of magnetite soil application and selenium foliar spray on adult mango trees grown under drip irrigation system in sandy soil. J. Biol. Chem. Environ. Sci., **11,** 3, 585-604.

[22] Wassel, A. H. and Ali, H.S. (2018). Effect of silicon, glutamic acid and selenium on the yield of Williams Banana cv. and its components. Minia J. Agric. Res. & develop., **38**, 17-28.

[23] Bakr, B.M., El-Gazzar, A.A., Noha, A., Mansour and Fawzy, M.I. (2019). Effect of spraying Washington navel orange trees with selenium on vegetative growth, productivity and fruit quality. Arab Univ. J. Agric. Sci. (AUJAS), Ain Shams Univ., Cairo, Egypt (Special Issue), **26,** 2D, 2311-2323.

[24] Association of Official Analytical Chemists (A.O.A.C.) (2000). "Official Methods of Analysis". 17th Edition, The Gaithersburg, MD, USA., 490-510.

[25] Clarke, G.M. and Kempson, R.E. (1997). Introduction to the design and analysis of experiments. Arnold, a Member of the Holder Hendline Group, 1st Edit. London, UK.

[26] Duncan, D.B. (1955). Multiple range and multiple "F" tests. Biometrics, 11: 1-42.

[27] Kulk, M.M. (1995). The potential for using cyanobacteria (blue-green algae) and algae in the biological control of plant pathogenic bacteria and fungi. European J. Plant Pathology, **101,** 6, 585–599.

[28] Strick, W.A., Staden, J. and van Staden, J. (1997). Screening of some South African seaweeds for cytokinin like activity. South Africa J. Botany, **63,** 3, 61-164.

[29] Brian, G.F. and Peter, J.L. (2007). Glutamate in plants: metabolism, regulation, and signaling. J. Exp. Bot., 58, 9, 2339-2358.

[30] Mateja, G., Vekoslava, S. and Ivan, K. (2007). Metabolic importance of selenium for plants. The European Journal of Plant Science and Biotechnology, **1,** 1, 91-97.

[31] Mateja, G. and Vekoslava, S. (2007). Selenium and plants. Acta Agriculture Slovenica, **89**, 1, 65-71.

[32] Rejane, P. and Guillaume, P. (2014). Regulation of amino acid metabolic enzymes and transporters in plants. Journal of Experimental Botany, **65**, 19, 5535–5556.

[33] Apolonia, S., Andrzej, K. and Maria F. (2015). Involvement of selenium in protective mechanisms of plants under environmental stress conditions – review. Acta Biologica Cracoviensia Series Botanica, **57**, 9-20.

[34] Meetu, G. and Shikha, G. (2017). An overview of selenium uptake, metabolism, and toxicity in plants. Frontiers in Plant Science, vol. **7**, article 2074, pp.14.

[35] Elham Z. Abdel-Moty and Salw Orabi, A. (2013). The beneficial effect of using zinc, yeast and selenium on yield, fruit quality and antioxidant defense system in Navel orange trees grown under newly reclaimed sandy soil. J. Appl. Sci. Res., **9,** 1, 6487-6497.

[36] Belal, B.E.A., El-Kenawy, M.A. and Wakiem M.K.U. (2016). Foliar application of some amino acid and Vitamins to improve growth, physical and chemical properties of Flame seedless grapevines. Egypt. J. Hort., **4, 3**1, 123-136.

[37] Khattab, M.M., Shaban, A.E.A. and Hassan, A.E. (2016). Impact of Foliar Application of Calcium, Boron and Amino Acids on Fruit Set and Yield of Ewais and Fagry Kelan Mango Cultivars. Journal of Horticultural Science & Ornamental Plants, **8,** 2, 119-124.

[38] Amr, M.E. and Alaa, M.G. (2017). Fruiting of Keitte mango trees in relation to application of glutathione and boron. Hortscience Journal of Suez Canal University, **6**, 73-80.

[39] Rahdari, P., Panahi, B. and Mozaphari, A. (2012). Effect of free amino acids spray on the some nutrient elements accumulation in Pistachios (*Pistachio vera* L.) Ohadi (Foudoghi) cultivar. Advances in Environmental Biology, **6,** 5, 1780-1785.

[40] Morales, J.P. (2015). Amino acids on mango yield and fruit quality at Sunmedia San Francisco region. Brazial Acta. Hort., **12,** 1, 1066-1075.