Egyptian J. Desert Res., **73**, No. 2, 695-712 (2023)

EFFECT OF FOLIAR SPRAY WITH UREA, HUMIC ACID, SALICYLIC ACID ON POMEGRANATE AND LIME SEEDLINGS

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Two pot experiments were carried out during the two successive seasons of 2019 and 2020 on pomegranate and lime seedlings at the nursery of Pomology Unit, Department of Plant Production, Desert Research Center, Egypt, to study the influence of foliar spray urea, humic acid, salicylic acid and their combinations on vegetative and root growth and leaf mineral content. All treatments were carried out at four times of both years i.e. mid- February, mid-March, mid-May and mid-July on Wonderful pomegranate and Egyptian lime seedlings. Obtained results indicated that all tested treatments significantly increased vegetative and root growth as well as leaf N, P, K, Fe, Mn and Zn content of pomegranate and lime seedlings. The combination of 5 g/L urea plus 20 g/L humic acid plus 200 ppm salicylic acid was the superior treatment in this respect, followed by the combination of 2.5 g/L urea plus 10 g/L humic acid plus 100 ppm salicylic acid to improve vegetative and root growth and leaf mineral content of pomegranate and lime seedlings.

Keywords: vegetative growth, root growth, leaf mineral content, lime, pomegranate, seedlings

INTRODUCTION

Nursery of Pomology Unit, Department of Plant Production, Desert Research Center, Egypt works on the development of fertilizers program of fruit seedlings to produce healthy and stronger seedlings, suitable to grow in arid and semi-arid conditions and tolerate drought under rainfed conditions to reduce seedlings lose after planted in the open field and to avoid seedlings death under those harsh conditions.

Egyptian lime fruits (*Citrus aurantifolia* Swingle) are one of the most popular fruits among citrus in Egypt. It represents about 10.3% of the total area of citrus. Lime seedlings are a good rootstock for citrus grafts growing on them. Because they are suitable for reclaimed soils and highly tolerate drought due to widespread densely root system (Al-Qatrani, 2014).

Pomegranate (*Punica granatum* L.) belongs to the family Punicaceae. It grows in a wide range of climates and soil conditions and favours semi-arid climates. It is one of the important fruit crops in Egypt and, it is used in the folk medicine, which have protective effects against many diseases (Bhowmik et al., 2015). Wonderful pomegranate was obtained from Spain and it grows successfully in the newly reclaimed soil.

Nitrogen fertilization is one of the important agricultural processes that is conducted in nurseries because nitrogen is the most essential element required after carbon and it also forms an essential part in the formation of chlorophyll molecule and encourages the vegetative growth of plants (Marschner, 2012). Therefore, it is necessary to work on improving seedlings growth by fertilizing with many nutrients necessary for growth, especially nitrogen. Urea is considered one of the most suitable forms of nitrogen due to its rapid absorption, translocation, metabolism and supporting regular plant growth and helping plants to defend against stress (El-Otmani et al., 2002 and Saud et al., 2017). Also, it contains a high percentage of N (46%) uptake and translocation. Because urea properties, such as rapid absorption by plants, low toxicity and high solubility in both soil and water; it is used frequently as a source of nitrogen fertilizer for both soil and foliar applications (Bondada et al., 2006). Urea foliar spray improved plant nutritional status and improved vegetative growth of rough lemon, sour orange, Cleopatra mandarin and olive seedlings (Mustafa et al., 2011 and Rattanpal and Singh, 2014). Also, urea foliar spray improved the growth of sour orange and Cleopatra mandarin seedlings at concentration of 0.5% and olive seedlings at concentrations of 0.5 and 0.75% (Pegah Sayyad and Shahsavar, 2012).

Humic acid (HA) as soil or foliar spra, increases auxin, cytokinin and gibberellin levels in plants (Abdel-Mawgoud et al., 2007). One of the widely used organic fertilizers is HA, which is one of the major components of humic substances (Metzer, 2010). HA increases tolerance to drought, temperature extremes and salinity (Fathy and El-Shall, 2010). HA and seaweed extract spray on mango seedlings increase N, P and K content in leaves Hameed and Mustafa (2019). As has been found by Ibrahim and Al-Sereh (2019), foliar spray of guava seedlings with potassium humate concentration of 4 ml/L increases leaves N, P and K content.

Salicylic acid (SA) is one of the natural plant hormones as a phenolic compound and endogenously synthesized as signaling molecules in plants and influences physiological and biochemical functions in plants. It plays an important signaling and competing various biotic and abiotic stresses. So, it increases drought stress tolerance and salt stress tolerance as well as enzyme activity and photosynthesis efficiency (Khan et al., 2015). On the other hand, Al-Taey (2010) on olive transplant mentioned that acetyl SA increases leaf area, shoots length, fresh and dry weight of shoots and total chlorophyll content and it improves the plants tolerance to salinity stress. Moreover, sour orange seedlings treated with 200 mg/L SA increased plant height, leaf area, fresh and dry weight of vegetative parts and roots under salinity stress (Abdulhussein and Awadh, 2014). SA foliar spray increased growth and chlorophyll of orange seedlings (El-Shazly et al., 2015) and olive tree sprayed with SA at of 100 and 200 mg/L resulted in increased leaf N content (Jassim, 2018).

This work aimed to study the effect of foliar spray with urea, HA, SA and their combinations on vegetative and root growth, leaf mineral content of Wonderful pomegranate and Egyptian lime seedlings.

MATERIALS AND METHODS

This investigation was conducted during two consecutive seasons of 2019 and 2020 at the Nursery of Pomology Unit, Department of Plant Production, Desert Research Center, Egypt, to throw some light on the effect of urea, HA, SA and their combinations on plant growth and leaf mineral content of Wonderful pomegranate and Egyptian lime seedlings.

Wonderful pomegranate seedlings were obtained from cuttings of Wonderful pomegranate planted in Feburury, 2018 and 2019 seasons and Egyptian lime seedlings obtained from lime seeds planted in September, 2018 and 2019 seasons.

In mid-February of both seasons, one-year-old "Wonderful" pomegranate and six-months-old Egyptian lime seedlings were transplanted individually, each in black plastic bag filled with 2.5 kg of clay and sandy soil at the ratio of 1:1. The mechanical and chemical analyses of the experimental soil are reported in Table (1).

Table (1). Classification and chemistry of the experimental soil.

Texture class	pH of soil paste	E.C. (dSm^{-1})	Organic matter %	Soluble cations (meq/l)				Soluble anions (meq/l)			
				Ca^{++}	K^{+}	Na^{+}	Mg^{++}	Cl^{-}	$SO_4^{=}$	HCO_3^{-}	$CO_3^{=}$
Sand clay	7.8	1.6	0.18	5.0	1.7	4.8	4.0	7.0	4.5	4.0	-

Selected seedlings were healthy, nearly uniform in growth, vigour and received regularly recommended culture care. This investigation had two main pot experiments. The first pot experiment was carried out on Wonderful pomegranate seedlings and the second pot experiment on Egyptian lime seedlings.

Wonderful pomegranate and lime seedlings were foliar sprayed four times a year i.e. mid- February, mid-March, mid-May and mid-July with one of the following solutions: (1) tap water "control", (2) 2.5 g/L urea, (3) 5 g/L urea, (4) 10 g/L HA, (5) 20 g/L HA, (6) 100 ppm SA, (7) 200 ppm SA, (8) 2.5 g/L urea+10 g/L HA+100 ppm SA, (9) 5 g/L urea+20 g/L HA+200 ppm SA.

Moreover, Tween-20 as a surfactant was used at 0.1% in all treatments including the control. These treatments were arranged in a randomized complete block design with four replicates for each treatment and each replicate was represented by two seedlings in each experiment.

The effect of these treatments on Wonderful pomegranate and Egyptian lime seedlings was handled as follows:

1. Seedlings and Roots Growth Parameters

At the end of October of each season, plant height (cm), number of leaves per plant were determined. Leaf chlorophyll content was determined by Minolta chlorophyll meter SPAD-502, leaf surface area (cm^2) was determined by using cl-202 AREAMETER and stem diameter (cm) was measured at 5 cm above the soil.

In mid-December at the termination of the experiments, seedlings were gently removed, and root length (cm) and number of lateral roots were determined. Moreover, total vegetative (leaves and stem) and root systems were oven dried at 70°C until a constant weight was obtained and dry weight of the previously mentioned organs was recorded.

2. Leaf Mineral Content

Dried leaves of both Wonderful pomegranate and Egyptian lime seedlings were ground, digested and prepared for analysis using the method described by Chapman and Pratt (1961). Nitrogen was determined by the Micro-Kjeldahl method (Bremner, 1965), phosphorus was estimated by the method of Matt (1968). Potassium was determined by flame-photometer according to Brown and Lilleland (1946). Calcium and magnesium were determined by titration against versenate solution (NaEDTA) (Chapman and Pratt, 1961). Zinc, iron and manganese were determined by using the Atomic Absorption Spectrophotometer "GBC 932AA".

3. Statistical Analysis

Data recorded in both seasons for the two conducted experiments were subjected to analysis of variance according to Clarke and Kempson (1997) and means were differentiated using Duncan multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

1. The First Pot Experiment

1.1. Transplant growth

Data reported in Table (2) show the effect of urea, HA, SA and their combinations on growth of one year old pomegranate seedlings during 2019 and 2020 seasons.

1.1.1. Seedling height

In 2019 and 2020 seasons, all tested treatments increased seedling height as compared with the control. The highest seedlings were obtained by spraying with 2.5 g/L urea+10 g/L HA+100 ppm SA in both seasons followed by 5 g/L urea+20 g/L HA+200 ppm SA in first season. Other treatments induced statistically similar stimulating effects in this concern (Table 2).

Table (2). Effect of urea, humic acid, salicylic acid and their combinations on seedlings growth and dry weight of Wonderful pomegranate seedlings during 2019 and 2020 seasons.

Treatments	Plant height (cm)	No. of leaves/plant	Leaf area (cm^2)	Chlorophyll content	Stem thickness (cm)	Veg. dry weight (g)
			First season (2019)			
Control	57.90E	93.3G	3.27F	34.39C	0.50G	9.68D
2.5 g/L urea	63.13DE	153.3D	5.11D	45.77AB	0.64F	16.90C
5 g/L urea	94.70B	165.6C	5.98B	46.50AB	0.41H	17.16C
10 g/L HA	82.73C	126.0E	5.06D	45.01AB	0.82D	16.66C
20 g/L HA	88.37BC	127.3E	5.48C	47.10AB	0.64F	18.20BC
100 ppm SA	60.90E	107.6F	4.27E	39.37BC	0.93C	12.26D
200 ppm SA	70.23D	119.6E	4.32E	40.32B	1.17B	13.40D
2.5 g/L urea+10 g/L HA+100 ppm SA	103.90A	182.0B	5.92B	47.70A	1.23AB	20.53AB
5 g/L urea+20 g/L HA+200 ppm SA	103.90A	202.6A	6.36A	50.35A	1.29A	23.10A
			Second season (2020)			
Control	55.00E	85.0G	3.15F	33.00F	0.51G	9.00D
2.5 g/L urea	67.23D	148.3D	4.96D	42.34CD	0.74E	16.32BC
5 g/L urea	96.67B	158.3C	5.20CD	45.34B	0.44H	16.66BC
10 g/L HA	79.67C	129.3E	5.01D	42.00D	0.79E	13.34CD
20 g/L HA	85.00C	129.3E	5.31C	45.00BC	0.67F	18.00B
100 ppm SA	62.00DE	101.6F	4.19E	36.65E	0.90D	11.00D
200 ppm SA	69.31D	112.0F	4.28E	38.32E	1.15C	11.54D
2.5 g/L urea+10 g/L HA+100 ppm SA	100.00AB	175.6B	5.66B	50.00A	1.25B	19.67AB
5 g/L urea+20 g/L HA+200 ppm SA	105.00A	190.6A	6.35A	52.67A	1.34A	24.34A

Means within each column followed by the same letter (s) are not significantly different at 5% level.

1.1.2. Number of leaves per seedling

In both seasons, all tested treatments resulted in high increases in number of leaves per plant in comparison with the control. However, 5 g/L urea+20 g/L HA+200 ppm SA produced the greatest number of developed leaves.

1.1.3. Leaf area

Tabulated data reveal that in both seasons, all studied treatments increased leaf area of pomegranate seedlings in comparison with the control. However, 5 g/L urea+20 g/L HA+200 ppm SA treatment reported highly significant increases in this respect.

1.1.4. Leaf chlorophyll content

It is clear that in 2019 and 2020 seasons, leaf chlorophyll content showed a highly increase due to all tested treatments as compared with the control. The highest leaf chlorophyll content values were observed in treatments of 2.5 g/L urea+10 g/L HA+100 ppm SA and 5 g/L urea+20 g/L HA+200 ppm SA. On the contrary, the control treatment induced the lowest value of leaf chlorophyll content followed by 100 ppm SA spray.

1.1.5. Stem thickness and vegetative dry weight

All seedlings stem thickness and vegetative dry weight were greatly increased due to urea, HA and SA treatments and their combinations as compared with the control in both seasons. However, the highest increases of vegetative dry weight were observed with 5 g/L urea+20 g/L HA+200 ppm SA in 2019 and 2020 seasons.

1.2. Roots growth

Table (3) shows the effect of urea, HA, SA treatments and their combinations on root growth of pomegranate seedlings during 2019 and 2020 seasons.

Table (3). Effect of urea, humic acid, salicylic acid and their combinations on roots growth and dry weight of Wonderful pomegranate seedlings during 2019 and 2020 seasons.

Treatments	Root length (cm)	No. of lateral roots/ plant	Root dry weight (g)
		First season (2019)	
Control	11.60F	4 D	13.73C
2.5 g/L urea	19.43C	12BC	14.77BC
5 g/L urea	23.10B	13ABC	15.36BC
10 g/L HA	15.86D	11C	14.50BC
20 g/L HA	20.30C	13ABC	17.46B
100 ppm SA	14.46E	13ABC	14.40BC
200 ppm SA	16.93D	14ABC	14.50BC
2.5 g/L urea+10 g/L HA+100 ppm SA	24.36B	15AB	22.86A
5 g/L urea+20 g/L HA+200 ppm SA	25.83A	16A	23.00A
		Second season (2020)	
Control	11.00F	6 F	12.34D
2.5 g/L urea	19.66C	9 EF	16.66C
5 g/L urea	25.00AB	12CDE	18.41B
10 g/L HA	14.33DE	11DE	15.10C
20 g/L HA	20.33C	12CDE	20.34B
100 ppm SA	12.66EF	14BCD	13.00D
200 ppm SA	16.30D	15ABC	14.32CD
2.5 g/L urea+10 g/L HA+100 ppm SA	24.00B	16AB	23.00AB
5 g/L urea+20 g/L HA+200 ppm SA	26.66A	18A	25.00A

Means within each column followed by the same letter (s) are not significantly different at 5% level.

1.2.1. Root length

All studied treatments increased root length as compared with the control in both seasons. However, 5 g/L urea+20 g/L HA+200 ppm SA treatment recorded the highest values in this concern.

1.2.2. Number of lateral roots/ plant

All studied treatments succeeded in increasing the number of lateral roots per seedling as compared with the control in both seasons. Besides, the treatment of 5 g/L urea +20 g/L HA +200 ppm SA in the first seasons and the treatments of 2.5 g/L urea+10 g/L HA+100 ppm SA and 5 g/L urea+20 g/L HA+200 ppm SA in the second season gave the highest number of roots.

1.2.3. Root dry weight

In both seasons, dry weight was increased due to all treatments as compared with the control. The highest increase in root dry weight was observed with 2.5 g/L urea+10 g/L HA+100 ppm SA and 5 g/L urea+20 g/L HA+200 ppm SA treatments in both seasons.

1.3. Leaf mineral content

Data present in Table (4) show the effect of urea, HA, SA applications and their combinations on leaf mineral content of pomegranate seedlings during 2019 and 2020 seasons. In both seasons, all studied treatments improved leaf N, P, K, Fe, Mn and Zn content as compared with the control. Finally, 5 g/L urea+20 g/L HA+200 ppm SA treatment caused highly significant increases in leaf N, P, K, Fe, Mn and Zn content as compared with the control and the other treatments in both seasons.

The obtain results regarding the effect of urea on pomegranate seedlings agree with the findings of Mustafa et al. (2011) and Rattanpal and Singh (2014). They mentioned that urea foliar spray improves vegetative growth and plant nutritional status of rough lemon, pomegranate, sour orange, Cleopatra mandarin and olive seedlings. Pegah Sayyad and Shahsavar (2012) mentioned that urea foliar spray at 0.5 and 0.75% improves growth and plant nutrients status of sour orange and Cleopatra mandarin seedlings. Furthermore, Eisa et al. (2016) illustrated that foliar application of urea twice at the end of April and two weeks later improved growth and nutritional status of Nonpareil almond seedlings.

The stimulating effect of urea on pomegranate seedlings growth and leaf mineral content might be due to that supply of essential N compounds is required in each plant cell for normal cell division, growth, and respiration. Moreover, it is a constituent of amino acids, proteins, enzymes and chlorophyll which enables plants to use the energy of sunlight to form sugars from carbon dioxide and water (Zekri and Obreza, 2013).

Nitrogen is one of the main elements for the plant. It plays important roles in forming dry matter (Leghari et al., 2016). Spraying Sour orange and Volkamer lemon seedlings with urea or nano-nitrogen solutions at a concentration of 750 mg/L enhances growth of seedling rootstocks and thus reduces the time and cost of seedlings production according to Abobatta and

Ahmed (2023). All of these reflected in improving vegetative and root growth as well as leaf mineral content of pomegranate seedlings.

Table (4). Effect of urea, humic acid, salicylic acid and their combinations on leaf mineral content of Wonderful pomegranate seedlings during 2019 and 2020 seasons.

Treatments	N %	P %	K %	Fe (ppm)	Mn (ppm)	Zn (ppm)
			First season (2019)			
Control	1.41E	0.453E	1.41F	2.49DE	66.90G	35.4F
2.5 g/L urea	1.51D	0.686D	1.60E	2.68BCD	70.76F	39.0E
5 g/L urea	1.51D	0.773C	1.70D	2.45E	76.90D	43.2D
10 g/L HA	1.64C	0.793BC	1.56E	2.60CDE	73.73E	38.3E
20 g/L HA	1.64C	0.843B	1.77C	2.74ABC	79.83C	45.2CD
100 ppm SA	1.53D	0.823BC	1.80BC	2.58CDE	73.30E	40.3E
200 ppm SA	1.67C	0.836BC	1.81B	2.72ABC	80.23C	47.3C
2.5 g/L urea+10 g/L HA+100 ppm SA	1.80B	0.990A	1.81B	2.81AB	83.90B	54.4B
5 g/L urea+20 g/L HA+200 ppm SA	2.15A	0.997A	1.88A	2.90A	89.93A	66.3A
			Second season (2020)			
Control	1.37F	0.423F	1.39G	2.45C	66.65F	34.0F
2.5 g/L urea	1.47E	0.616E	1.60E	2.66ABC	71.00E	37.0E
5 g/L urea	1.52DE	0.746D	1.68D	2.82AB	76.33D	41.6D
10 g/L HA	1.66C	0.786CD	1.55F	2.59ABC	74.31D	38.0E
20 g/L HA	1.63C	0.813C	1.77C	2.74ABC	81.00C	45.6C
100 ppm SA	1.55D	0.820C	1.78C	2.57BC	73.65DE	41.0D
200 ppm SA	1.65C	0.836C	1.80BC	2.69ABC	80.00C	46.0C
2.5 g/L urea+10 g/L HA+100 ppm SA	1.78B	0.896B	1.82AB	2.78ABC	84.32B	51.0B
5 g/L urea+20 g/L HA+200 ppm SA	1.98A	0.950A	1.85A	2.93A	88.00A	59.6A

Means within each column followed by the same letter (s) are not significantly different at 5% level.

Humic substances positively affect aerial part and root system of papaya seedlings and seedling quality of papaya are improved by HA foliar spray (Cavalcante et al., 2011). Besides, similar results of HA and seaweed extract spray in increasing N, P and K contents in leaves were reported by Hameed and Mustafa (2019) on mango seedlings. Also, Aml et al. (2011) mentioned that HA increases olive seedlings height, main shoot diameter, the number of leaves and leaf area.

Moreover, the improvement of seedlings growth and leaf mineral content of pomegranate seedlings due to HA may be attributed to the biochemical constituent of humus. Moreover, it increased water content in the root zone as well as the ions' exchangeable ability between the soil solution and plant roots. Also, it increases root system and shoot growth due to improving nutrients absorption and promoting the chelation of many elements and making them available to plants (Khaled and Fawy, 2011 and Sajadian and Hokmabadi, 2015).

Furthermore, HA spray increased cells membrane permeability that resulted in increasing nutrient absorption through these membranes and that explained the increased leaf mineral content of plants. HA (soil application or foliar spray) increases auxin, cytokinin and gibberellin levels in plants (Abdel-Mawgoud et al., 2007). Al-Alalaf (2012) reported that to improve vegetative growth of Loquat seedlings, urea spray and application of HA improve vegetative growth of loquat seedlings. Moreover, the increase in total chlorophyll content and leaf area after HA application may be due to the increase in leaf nitrogen content (Abobatta, 2014). All of these led to improving seedling vegetative and root growth as well as leaf mineral content of pomegranate seedlings.

Moreover, the effect of SA on growth and leaf mineral content of pomegranate seedlings is confirmed by the findings of Al-Hayani et al. (2017), who evaluated the effect of SA on vegetative and root growth and found an increase in the leaves number, wet and dry weight of the shoots and roots as well as plant tolerance of salt stress of several citrus rootstocks. Also, Abdulhussein and Awadh (2014) mentioned that 200 mg/L of SA application increases the height of sour orange seedlings, leaf area, fresh and dry weight of vegetative and roots irrigated with saline water. Al-Taey (2010) mentioned that acetyl SA application increases olive transplant growth parameters and improves the tolerance of plants to salinity stress. Moreover, El-Shazly et al. (2015) indicated that foliar spray of SA increased growth parameters and chlorophyll content of orange seedlings.

Also, the enhancement of growth and leaf mineral content of pomegranate seedlings as a result of SA application may be plays an important role in the resistance to water stress in roots zone and facilitates these nutrients availability for absorption by plant roots and plant leaves. SA has a role in increasing the accumulation of chlorophyll in the leaves and improves the photosynthesis process of plants under stress conditions (Hadi and Alhayany, 2021).

The obtained results regarding the effect of the combination of urea, HA and SA on vegetative growth and leaf mineral content are in harmony with the findings of Eisa et al. (2016), who illustrated that foliar application of 3 g/L urea+2 g/L HA or 3 g/L urea+3 g/L HA twice at the end of April and two weeks later improves growth parameters and leaf mineral content of Nonpareil almond seedlings. Hadi and Alhayany (2021) reported that HA at 3% and SA at 400 mg/L alone or in combination as foliar spray increased lead, N, P, K contents and total chlorophyll content in two months old papaya seedlings.

2. The Second Pot Experiment

2.1. Seedlings growth

Data present in Table (5) show the effect of urea, HA, SA applications and their combinations on the growth on one year old Egyptian lime seedlings during 2019 and 2020 seasons.

Table (5). Effect of urea, humic acid, salicylic acid and their combinations on seedlings growth and dry weight of Egyptian lime seedlings during 2019 and 2020 seasons.

Treatments	Plant height (cm)	No. of leaves/plant	Leaf area (cm^2)	Chlorophyll content	Stem thickness (cm)	Veg. dry weight (g)
			First season (2019)			
Control	41.36E	38.00F	13.62G	42.03G	0.236F	7.43E
2.5 g/L urea	44.80D	55.66DE	15.28F	66.81B	0.266DE	9.53D
5 g/L urea	49.03C	60.00C	14.83F	52.14E	0.256EF	9.86D
10 g/L HA	47.30CD	52.67E	16.21E	62.63C	0.280CD	10.00D
20 g/L HA	49.60C	54.67DE	17.26BC	51.31E	0.290C	13.40C
100 ppm SA	48.76C	52.33E	16.42DE	46.52F	0.276CDE	13.43C
200 ppm SA	49.03C	57.00CD	17.26BC	59.00D	0.283CD	14.16BC
2.5 g/L urea+10 g/L HA+100 ppm SA	52.40B	64.66B	17.68B	72.31A	0.320B	15.10AB
5 g/L urea+20 g/L HA+200 ppm SA	59.03A	71.66A	19.80A	69.95A	0.370A	16.16A
			Second season (2020)			
Control	38.66D	36.00F	13.00E	41.34F	0.250F	7.90F
2.5 g/L urea	45.67C	53.00E	14.67D	64.66B	0.270DE	9.00EF
5 g/L urea	48.10BC	55.43DE	15.66CD	55.00D	0.260EF	9.80DE
10 g/L HA	49.00BC	56.96CD	16.10C	61.33C	0.290BC	10.50D
20 g/L HA	50.07BC	59.00C	16.76BC	53.33D	0.293B	12.00C
100 ppm SA	47.68BC	56.40CD	16.40C	50.00E	0.276CD	12.50C
200 ppm SA	52.20B	58.70C	16.70BC	59.66C	0.293B	13.00BC
2.5 g/L urea+10 g/L HA+100 ppm SA	57.05A	62.00B	17.74B	69.33A	0.303B	14.00AB
5 g/L urea+20 g/L HA+200 ppm SA	60.10A	67.36A	19.13A	69.66A	0.363A	15.00A

Means within each column followed by the same letter (s) are not significantly different at 5% level.

2.1.1. Seedling height

All tested treatments increased seedlings height as compared with the control in both seasons. Whereas the highest seedlings were obtained with 5 g/L urea+20 g/L HA+200 ppm SA treatment in the first season. Also, 2.5 g/L urea+10 g/L HA+100 ppm SA and 5 g/L urea+20 g/L HA+200 ppm SA gave similar and the highest values in the second season. Other treatments induced statistically similar stimulating effect in this concern.

2.1.2. Number of leaves per seedling and leaf area

In the 2019 and 2020 seasons, all tested treatments resulted in highly increases in number of leaves per plant and leaf area in comparison with the control. Furthermore, 5 g/L urea+20 g/L HA+200 ppm SA gave the highest values in this concern.

2.1.3. Leaf chlorophyll content

Leaf chlorophyll content showed a high increase in response to all tested treatments as compared with the control in both seasons. The highest leaf chlorophyll content values were observed in treatments 2.5 g/L urea+10 g/L HA+100 ppm SA and 5 g/L urea+20 g/L HA + 200 ppm SA in both seasons.

2.1.4. Stem thickness and vegetative dry weight

Tabulated data indicate that all tested treatments increased stem thickness and vegetative dry weight in comparison with the control in both seasons. The treatment of 5 g/L urea+20 g/L HA+200 ppm SA showed a highly significant increase in this respect.

2.2. Root growth

Data present in Table (6) show the effect of urea, HA and SA applications on root growth of pomegranate seedlings during 2019 and 2020 seasons.

2.2.1. Root length

All tested treatments increased root length as compared with the control in both seasons, and the best treatment in the first season belonged to 5 g/L urea+20 g/L HA+200 ppm SA, whereas in the second season, 2.5 g/L urea +10 g/L HA+100 ppm SA and 5 g/L urea+20 g/L HA+200 ppm SA treatments recorded similar response with the highest values in this concern.

2.2.2. Number of lateral roots/ plant

All tested treatments succeeded in increasing the number of lateral roots per seedling as compared with the control in both seasons. Besides, 2.5 g/L urea+10 g/L HA+100 ppm SA and 5 g/L urea +20 g/L HA+200 ppm SA gave similar response with the highest number of roots.

2.2.3. Root dry weight

In both seasons, dry weight was increased due to all treatments as compared with the control. The highest increment in root dry weight was belonged to 2.5 g/L urea+10 g/L HA+100 ppm SA and 5 g/L urea+20 g/L HA+200 ppm SA treatments in both seasons.

2.3. Leaf mineral content

Data reported in Table (7) show the effect of urea, HA and SA applications on leaf mineral content of lime seedling during 2019 and 2020 seasons. In both seasons, all studied treatments enhanced leaf N, P, K, Fe, Mn and Zn content in comparison with the control. The treatment of 5 g/L urea+20 g/L HA+200 ppm SA caused highly significant increases in leaf P, Mn and Zn content as compared with the control in both seasons, except leaf N and K content in the first season. Whereas the highest increase in leaf N and K content was observed with 2.5 g/L urea+10 g/L HA+100 ppm SA and 5 g/L urea+20 g/L HA+200 ppm SA treatments. However, in the second season, the highest increase in leaf N and K content was recorded with 5 g/L urea+20 g/L

HA+200 ppm SA treatment. While the highest increase in leaf Fe content was reported with 2.5 g/L urea+10 g/L HA+100 ppm SA and 5 g/L urea+20 g/L HA+200 ppm SA treatments in both seasons.

The obtained results regarding the effect of urea on vegetative growth and leaf mineral content of lime seedlings are in harmony with the findings of Mustafa et al. (2011) and Rattanpal and Singh (2014). Furthermore, Eisa et al. (2016) illustrated that foliar application of urea at 3/1 twice at the end of April and two weeks later improved growth and nutritional status of Nonpareil almond seedlings.

Spraying of HA on Cleopatra mandarin seedlings improves vegetative growth parameters and leaves chlorophyll content, phosphorus and potassium under irrigation water salinity (Al-Hayani et al., 2016). The obtained results regarding the effect of HA on vegetative growth and leaf mineral content of lime seedlings are in harmony with the findings of Hadi and Alhayany (2021) on Papaya seedlings and Aml et al. (2011) on olive seedling.

Table (6). Effect of urea, humic acid, salicylic acid and their combinations on root growth and dry weight of Egyptian lime seedlings during 2019 and 2020 seasons.

Treatments	**Root length (cm)**	**No. of lateral roots/ plant**	**Root dry weight (g)**
	First season (2019)		
Control	16.73E	2.46E	3.40F
2.5 g/L urea	17.70DE	2.69BC	4.50E
5 g/L urea	18.53CD	2.51DE	5.00E
10 g/L HA	19.70ABC	2.74B	6.00D
20 g/L HA	20.23AB	2.61CD	7.20C
100 ppm SA	18.60CD	2.51DE	8.06BC
200 ppm SA	19.16BC	2.63C	8.83AB
2.5 g/L urea+10 g/L HA+100 ppm SA	20.50AB	2.75B	9.43A
5 g/L urea+20 g/L HA+200 ppm SA	21.00A	2.92A	9.60A
	Second season (2020)		
Control	16.10E	2.38E	3.76F
2.5 g/L urea	17.30D	2.49D	4.53E
5 g/L urea	18.30C	2.55CD	4.80E
10 g/L HA	18.46C	2.64B	5.83D
20 g/L HA	19.83B	2.66B	6.66C
100 ppm SA	18.00CD	2.53CD	7.86B
200 ppm SA	19.50B	2.57C	8.03B
2.5 g/L urea+10 g/L HA+100 ppm SA	21.00A	2.68B	8.76A
5 g/L urea+20 g/L HA+200 ppm SA	21.90A	2.75A	9.13A

Means within each column followed by the same letter (s) are not significantly different at 5% level.

Table (7). Effect of urea, humic acid, salicylic acid and their combinations on leaf mineral content of Egyptian lime seedlings (2019 and 2020 seasons).

Treatments	N %	P %	K %	Fe (ppm)	Mn (ppm)	Zn (ppm)
			First season (2019)			
Control	1.26E	0.180F	1.25E	37.00E	31.70D	45.80D
2.5 g/L urea	1.29E	0.220E	1.53D	60.90D	35.40CD	56.00C
5 g/L urea	1.43D	0.350C	1.75C	74.90B	47.10B	52.10C
10 g/L HA	1.62C	0.230E	1.74C	70.26C	37.60CD	55.30C
20 g/L HA	2.20B	0.360C	1.85B	76.06B	49.50AB	64.20AB
100 ppm SA	2.17B	0.310D	1.77C	70.30C	40.50C	62.30B
200 ppm SA	2.30AB	0.370BC	1.84B	84.43AB	48.70B	63.50B
2.5 g/L urea+10 g/L HA+100 ppm SA	2.37A	0.390AB	1.93A	90.13A	51.10AB	65.70AB
5 g/L urea+20 g/L HA+200 ppm SA	2.42A	0.410A	1.94A	91.46A	55.20A	68.40A
			Second season (2020)			
Control	1.26G	0.170F	1.24H	36.40F	28.00E	44.00E
2.5 g/L urea	1.32 F	0.210E	1.51G	63.00E	34.66D	54.00CD
5 g/L urea	1.40F	0.340C	1.65F	73.00C	47.00BC	50.00DE
10 g/L HA	1.59E	0.240E	1.71E	71.16CD	35.00D	57.00BC
20 g/L HA	2.16D	0.350BC	1.80C	75.00C	47.00BC	63.00AB
100 ppm SA	2.20CD	0.300D	1.76D	67.00DE	43.00C	61.00AB
200 ppm SA	2.24BC	0.360BC	1.83C	81.00B	46.00BC	63.10AB
2.5 g/L urea+10 g/L HA+100 ppm SA	2.27B	0.380AB	1.91B	89.63A	50.00AB	64.30AB
5 g/L urea+20 g/L HA+200 ppm SA	2.32A	0.400A	1.95A	91.34A	54.00A	66.00A

Means within each column followed by the same letter (s) are not significantly different at 5% level.

Al-Abbasi et al. (2016) recorded that the foliar application of SA on lemon seedlings has an improving effect on all vegetative growth characteristics, including plant's height, leaves number, and leaves area. Also, in an experiment conducted by Al-Hayani et al. (2017) on several citrus rootstocks to evaluate the effect of SA on vegetative and root growth, the study revealed an increase in the leaves number, wet and dry weight of the shoots and roots. Such results are in harmony with those obtained by Abdulhussein and Awadh (2014) on sour orange seedlings, Al-Taey (2010) on olive transplant and El-Shazly et al. (2015) on orange seedlings.

The obtained results regarding the effect of the combination of urea, HA and SA on vegetative growth and leaf mineral content of lime seedlings are in harmony with the findings of Eisa et al. (2016) on Nonpareil almond seedlings and Al-Abadi and Abd Al-hayany (2021) on papaya seedlings.

CONCLUSION

The results of all tested treatments showed significant differences in vegetative growth i.e. plant height, number of leaves per plant, leaf chlorophyll content, leaf surface area, stem diameter, vegetative dry weight, root length, lateral roots/plant, root dry weight, and leaf N, P, K, Fe, Mn, Zn content of Wonderful pomegranate or Egyptian lime seedlings. So, under similar conditions, it is preferable to apply foliar spray of the combination of 5 g/L urea+20 g/L HA+200 ppm SA to improve vegetative and root growth and leaf mineral content of pomegranate or lime seedlings.

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تأثير الرش الورقي باليوريا وحمض الهيوميك وحمض السالسيليك على شتلات الرمان والليمون

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تم إجراء تجربتين في أوعية على موسمين متتاليين ٢٠١٠ و٢٠٢٠ على كل من شتلات الرمان وشتلات الليمون المصري في مشتل مركز بحوث الصحراء بمصر. لدراسة تأثير رش الورقي باليوريا وحمض الهيوميك وحمض الساليسيليك وتوليفاتهم على النمو الخضري والجذر ومحتوى الأوراق من العناصر . تتم جميع المعاملات أربع مرات في السنة بداية من منتصف فبراير، ومنتصف مارس، ومنتصف مايو، ومنتصف يوليو على شتلات الرمان "وندرفول" والليمون المصري. أشارت النتائج المتحصل عليها إلى أن جميع المعاملات المختبرة أدت إلى زيادة معنوية في النمو الخضري والجذر وكذلك محتوى الأوراق من النتروجين والفوسفور والبوتاسيوم والحديد والمنجنيز والزنك لشتلات الرمان أو الليمون. وأخيرًا، كان توليفة ٥ جرام/لتر من اليوريا + ٢٠ جرام/لتر حمض الهيوميك + ٢٠٠ جزء في المليون من حمض الساليسيليك هي المعاملة الأفضل في هذا الصدد يليها توليفة ٢.٥ جرام/لتر من اليوريا + ١٠ جرام/لتر حمض الهيوميك + ١٠٠ جزء في المليون من حمض الساليسيليك) هما الأفضل في تحسين النمو الخضري والجذري والمحتوى المعدني للأوراق في شتلات الرمان أو الليمون.