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Yield and Fruit Properties of Khalas Date Palms as Affected by Spraying Some Antioxidants

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Abstract

This study was conducted over two successive seasons on Khalas date palms. The chosen palms were sprayed with citric, ascorbic, and salicylic acids at 500, 500, and 100 ppm, respectively, as antioxidant treatments, either individually or in combinations, to investigate their effects on productivity and fruit physical and chemical properties. The findings demonstrate that, when compared to the untreated palms (control), foliar application of the antioxidants under investigation, either alone or in combination, improved the fruit set, fruit retention, bunch weight, yield per palm, fruit weight, fruit dimensions, flesh weight, total soluble solids, total sugars, reducing sugars, non-reducing sugars, and N, P, K, Ca, Mg, and Fe values in the fruits. In decreasing order, citric, ascorbic, and salicylic acids were used to promote these characteristics. Applying these antioxidants together was more practical in this regard than applying them separately. Spraying a combination of citric, ascorbic, and salicylic acids four times (on the first of March, April, May, and June) had the greatest effects on Khalas date palms' production and fruit quality.

Keywords: Ascorbic Acid, Citric Acid, Fruit Properties, Khalas date palms, Salicylic Acid, Yield.

1. Introduction

One of the biggest and most significant issues facing date palm producers is the poor cropping of Khalas date palms cultivated on sandy soil. Antioxidants including organic acids, amino acids, and vitamins have been shown to improve development, nutritional status, yield, and fruit quality in a number of fruit crops, including date palm, citrus, mango, banana, and olive. This helps to address the issue of low yielding [1-15].

When modest amounts of antioxidants are added to a material, they react quickly with the free radical intermediates of an auto-oxidation chain to prevent further processing. Free radicals that include oxygen have recently drawn more attention due to their potential involvement as causative agents in the genesis of a number of chronic diseases in biological systems [16]. Consequently, the methods of action and beneficial biochemical roles of naturally occurring antioxidants in the cells of the organisms that possess them are being studied [17]. Additionally, it has been noted that plants with high inherent or induced antioxidant levels are more resistant to this type of oxidative damage [18].

Crops' physiological states were prolonged in large part by organic acids. Citric acid applied topically has been identified as a workable way to increase plant tolerance to conservational challenges and, therefore, crop output. Citric acid is a six-carbon organic acid having a central role in the Krebs cycle. Applying citric acid to plants can increase their capacity to withstand salt, which will ultimately increase the production [19]. Moreover, applying citric acid increases the high photosynthetic pigment content and alters an antioxidant defense system, which affects secondary metabolites and increases plant yield in stressed soil [20]. Previous research has shown that by enhancing the activity of antioxidant defense mechanisms, exogenous citric acid treatment can reduce oxidative stress in plants [19].

Carotenoids, ascorbate, glutathione, vitamin E, flavonoids, phenolic acids, other phenols, alkaloids, polyamines, chlorophyll derivatives, amino acids, amines, and other substances are the main constituents of this antioxidant system. Ascorbic acid is a tiny, water-soluble antioxidant that works as a primary substrate in the cyclic pathway for hydrogen peroxide enzymatic detoxification. It is also thought to be the most significant reducing substrate for the removal of H2O2 [21-24]. It has been reported that ascorbic acid acts as a bio-regulator of plant growth and development [25].

Salicylic acid molecules are crucial to the process of development, and certain of them are essential to the mechanism that leads to environmental adaptation. It has long been recognized that salicylic acid is a signal molecule that triggers defense systems in plants [26-27]. Investigations have shown that the use of salicylic acid, a significant antioxidant, was crucial for enhancing fruiting and development [28-31].

The purpose of this study was to demonstrate how certain antioxidants, namely salicylic acid, citric acid, and ascorbic acid, improve the yield, fruit characteristics, and mineral contents of Khalas date palms cultivated in sandy soil.

2. Materials and Methods

The present study was carried out during two successive seasons on 10 years old Khalas date palms grown in a private orchard situated at 63 kilometers from Cairo-Alexandria-desert road. Palms had been planted at 7×7 meters apart, and irrigated through drip system. The chosen palms had almost steady growth vigor and fruiting, and were in good condition. The various agricultural treatments were the same for all palms under investigation. The leaves of palms under the study were thinned at the rate of eight leaves per one bunch, and the number of spathes per palm was adjusted to 10 bunches for each palm.

The three antioxidants (citric acid, ascorbic acid, and salicylic acid) were applied as single or combined treatments in the experiment as follows:-

T1. Control (untreated palms).

T2. Citric acid at 500 ppm.

T3. Ascorbic acid at 500 ppm.

T4. Salicylic acid at 100 ppm.

T5. Combination of treatments T2 + T3 + T4

Palms were sprayed with the three antioxidants four times (on the first of March, April, May, and June) during each growing season.

One palm was used for each of the three replications of each treatment. All spraying solutions of the antioxidants under investigation were applied till run off with a motor sprayer, and Triton B was utilized as a wetting agent with all treatments at a concentration of 0.1%.

The randomized complete block design (RCBD) was used to arrange the treatments in this experiment.

Ten strands/spathe were attached to each of the three bunches/palms in order to count the number of fruit sets per strand. Following a month of artificial pollination, the percentage of fruit set was determined as follows:

Ultimate fruit setting % = No. of retained fruits per strand / No. of fruit set per strand × 100

The following measurements were recorded for all treatments under investigation:

2.1. Yield Per Palm (Kg)

At harvest time, number of bunches/palm was counted and weight of all bunches were recorded to estimate the total yield per palm.

2.2. Fruit Properties

Samples of 50 fruits were randomly collected at the peak of color stage from each palm to determine the physical and chemical fruit properties.

2.3. Fruit Physical Properties

Fruit weight (gm), fruit dimensions (cm), flesh and seed weight (gm) were measured.

2.4. Fruit Chemical Properties

A hand refractometer was used to measure the percentage of total soluble solids (TSS), total sugars, reducing sugars, and non-reducing sugars, as well as the tetratable acidity (measured as the percentage of malic acid) as the methods of AOAC [32].

2.5. Determination of Fruit Minerals

Determination of nitrogen was done in the digested samples of the fruits using micro Kjeldahl method and the other minerals (P, K, Ca, Mg, and Fe) were determined by atomic absorption and the standard methods outlined according to Chapmann and Pratt (1961)[33].

2.6. Statistical Analysis

New LSD at 5% was used to tabulate all of the collected data and perform the appropriate statistical analysis according to Mead et al. (1993) [34].

3. Results

3.1. Fruit Set and Fruit Retention Percentages and Palm Yield (Kg)

The obtained results in Table (1) show that all foliar applications of citric, ascorbic and salicylic acids individually or in combinations were increased fruit set significantly, as well as fruit retention of Khalas date palms compared to the control during both studied seasons. Mixture of the three antioxidants together was preferable in enhancing the fruit set and fruit retention percentages than using each of them solely. The palms received the mixture containing the three antioxidants together recorded the highest fruit set percentage (70.3 & 71.0%), and fruit retention percentage (38.2 & 37.5%) in both studied seasons.

The lowest fruit set percentages (59.7 & 60.0%), and fruit retention (33.5 & 31.3%) were obtained with the control treatment during the both seasons.

The heaviest bunches (12.6 & 12.9 Kg), and palm yield (126.0 & 129.0 Kg) had been recorded with spraying the three antioxidants together. While, the lowest bunch weight (8.2 & 8.4 Kg), and the yield per palm (82.0 & 84.0 Kg) were reached due to the control treatment in the two studied seasons.

Table 1. Effect of some antioxidants on fruit set, fruit retention, bunch weight and yield per palm of Khalas date palms during the two seasons.

Characters / Treatments	Fruit set %		Fruit retention %		Bunch weight (Kg)		Yield/palm (Kg)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	59.7	60.0	33.5	31.3	8.2	8.4	82.0	84.0
T2	61.7	60.7	36.0	33.7	9.8	10.3	98.0	103.0
T3	63.6	62.7	34.8	32.7	9.6	10.0	96.0	100.0
T4	60.8	60.3	34.8	33.3	9.2	9.9	92.0	99.0
T5	70.3	71.0	38.2	37.5	12.6	12.9	126.0	129.0
LSD at 0.05 level	1.52	1.19	1.8	1.3	0.21	0.32	7.94	8.39

3.2. Fruit Physical Properties

From Table (2), it is worth to mention that the single or the combination of citric, ascorbic, salicylic acids show a significant impact on improving fruit properties such as fruit weight, both fruit length and width, as well as flesh weight.

The highest values of weight, length, and diameter of the fruit [(12.6 & 12.2 gm), (3.4 & 3.6 cm), (2.4 & 2.5 cm), respectively], as well as flesh weight (11.2 & 10.9 gm) were presented with the palms received the mixture containing the three antioxidants together. These results were obtained in both seasons.

The least values of weight, length, diameter of the fruit [(10.1 & 9.7 gm), (2.9 & 3.0 cm), (2.2 & 2.2 cm), respectively], and also the weight of flesh (8.9 & 8.5 gm) were recorded from the untreated palms in the two seasons.

Table 2. Effect of some antioxidants on fruit weight, fruit dimensions, flesh weight and seed weight of Khalas date palms during the two seasons.

Characters / Treatments	Fruit weight (gm)		Fruit length (cm)		Fruit diameter (cm)		Flesh weight (gm)		Seed weight (gm)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	10.1	9.7	2.9	3.0	2.2	2.2	8.9	8.5	1.2	1.2
T2	10.9	10.4	3.1	3.2	2.3	2.3	9.5	9.1	1.4	1.3
T3	11.4	11.1	3.2	3.4	2.2	2.3	10.1	9.8	1.3	1.3
T4	10.8	10.6	3.1	3.3	2.3	2.4	9.6	9.3	1.2	1.3
T5	12.6	12.2	3.4	3.6	2.4	2.5	11.2	10.9	1.4	1.3
LSD at 0.05 level	0.26	0.32	0.11	0.12	0.07	0.05	0.34	0.35	0.07	0.11

3.3. Fruit Chemical Properties

Table 3 shows that the individual treatments or the combination one of the three antioxidants had a significant improvement concerning chemical properties of the fruit in terms of increasing the total soluble solids, TSS/acid ratio, while decreasing the total acidity in compared to the control in both studied seasons.

The highest percentage of total soluble solids (31.9 & 31.3%) and TSS/acid ratio (184.4 & 184.3) were presented with Khalas date palms that received the sprays of the mixture containing the three antioxidants together, while, the least TSS value (29.2 & 28.8%), and TSS/acid ratio (139.1 & 130.8) had been recorded due to the control treatment during both studied seasons.

A significant impact on fruit quality was observed when using the combined applications of the three antioxidant rather than the application of each material solely.

Table 3. Effect of some antioxidants on TSS, acidity and TSS/acid ratio of Khalas date palms during the two seasons.

Characters / Treatments	TSS %		Acidity %		TSS/acid ratio	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	29.2	28.8	0.21	0.22	139.1	130.8
T2	30.3	30.0	0.20	0.19	154.3	157.7
T3	31.1	30.3	0.19	0.19	163.9	162.6
T4	31.0	30.3	0.19	0.18	160.9	165.4
T5	31.9	31.3	0.17	0.17	184.4	184.3
LSD at 0.05 level	0.99	0.84	0.001	0.005	11.97	6.27

Table 4 results, obviously reveal that the individual or combined treatments of citric, ascorbic, and salicylic acids had a positive and significant effect on percentages of reducing, non-reducing, as well as total sugars in Khalas fruit rather than the untreated palms. This was true in the two studied seasons. The combined application was superior to the individual ones.

The highest values concerning non-reducing sugars (13.2 & 13.6%), reducing sugars (36.5 & 37.3%) and total sugars (49.7 & 50.9%) were obtained from the mixture containing the three antioxidants (citric, ascorbic and salicylic acids) in the two seasons, respectively. In this concern, the untreated palms produced the lowest values [(11.9 & 12.4%), (35.0 & 36.3%), (46.9 & 48.7%)] for the non-reducing, reducing, and total sugars, respectively in both studied seasons.

Table 4. Effect of some antioxidants on fruit non-reducing, reducing and total sugars of Khalas date palms during the two seasons.

Characters / Treatments	Non-reducing sugars %		Reducing sugars %		Total sugars %	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	11.9	12.4	35.0	36.3	46.9	48.7
T2	12.3	13.0	35.5	36.3	47.8	49.3
T3	12.6	12.9	35.6	36.7	48.2	49.6
T4	12.2	12.9	35.3	36.2	47.5	49.1
T5	13.2	13.6	36.5	37.3	49.7	50.9
LSD at 0.05 level	0.19	0.31	0.12	0.93	0.23	1.11

3.4. Fruit Mineral Contents

It is clear from Table (5) that various treatments significantly affected fruit mineral content.

Single or combined treatments of the three antioxidants improved significantly the mineral contents in Khalas date palm fruit as compared to the control treatment in the two studied seasons.

The maximum values were recorded from the palms sprayed with the three antioxidants together, while, the least values were observed in the fruits that picked from the unsprayed palms. These results were detected in both seasons.

Table 5. Effect of some antioxidants on fruit contents of N, P, K, Ca, Mg and Fe of Khalas date palms during the two seasons.

Char. / Treat.	N%		P%		K%		Ca%		Mg%		Fe ppm	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1	0.42	0.51	57.8	63.0	0.82	0.85	44.6	46.3	39.1	37.8	1.97	1.98
T2	0.55	0.57	65.5	65.2	1.20	1.20	50.0	49.3	42.2	39.9	2.18	2.16
T3	0.53	0.55	64.4	64.7	0.97	1.10	52.8	53.5	46.9	45.0	2.39	2.39
T4	0.55	0.57	61.5	63.5	0.86	0.93	53.8	51.5	42.4	44.6	2.30	2.33
T5	0.80	0.86	77.7	78.2	1.70	1.80	67.0	62.8	54.6	54.5	2.91	2.92
LSD at 0.05 level	0.03	0.03	2.03	0.73	0.04	0.04	2.88	1.38	1.06	0.63	0.04	0.03

4. Discussion

Generally, the obtained results are in line with those obtained in many investigations [15, 35-37]. In this concern, the positive effect for the used three antioxidants on fruit set, productivity and fruit properties of Khalas date palms could mainly due to their catching impact on the free radicals, prolonging shelf life of plant cell, delaying ethylene production and protecting plants from different disorders. However, the explanation of the antioxidants metabolic activities in the plants, probably due to the increasing of endogenous hormones (auxin and gibberellins) [38-40]. Also, the antioxidants show enhancing in the metabolic processes in the direction of increasing total phenols and total indols in chamomile plants [41-42]. Moreover, the antioxidants enhanced protein synthesis and delayed senescence [2, 43-44].

The obtained results concerning the fruit sugar contents may be explained due to the effect of antioxidants on increasing total carbohydrates in different plant organs [43, 45, 46]. On the other side, ascorbic acid is recognized for its role in the oxidation-reduction system, functioning as both an electron donor and acceptor during the photosynthetic process [47]. Furthermore, it has been documented that ascorbic acid effectively scavenges free radicals, which contribute to the increased oxidation observed in plant tissues [48].

The present results can elucidate the beneficial effects of salicylic acid in enhancing the tolerance of fruit crop species to both biotic and abiotic stresses, as well as its role in the biosynthesis of sugars, amino acids, and plant pigments, along with its promoting effect on cell division [49, 50].

On the other hand, when sunflower plants were sprayed with antioxidants namely Thiamine, nicotinamide and ascorbic acid at different concentrations, all treatments led to significant increase in seed yield per plant and seed weight [51]. The application of α-Tocopherol, ascorbic acid, and nicotinamide to faba bean plants resulted in an increase in the number of seeds per plant, seed yield, and seed weight [46]. Moreover, treating Picual olive trees with antioxidants namely α-Tocopherol, ascorbic acid and nicotinamide had a positive impact on rising fruit weight and enhancing fruit properties, fruit oil content and reduced the acidity percentage compared to the untreated trees [52].

The obtained results are supported by many of the previous investigations [2, 3, 8, 9, 11, 13, 15, 26, 29, 31, 35, 36, 54].

5. Conclusion

The application of a mixture of three antioxidants namely citric acid at 500 ppm, ascorbic acid at 500 ppm, and salicylic acid at 100 ppm on Khalas date palms, as spaying treatments four times, demonstrates significant potential. This treatment yielded optimal outcomes in terms of fruit set, retention, bunch weight, mineral content, yield per palm, as well as the physical and chemical properties of the fruit.

References

Abd EL- Wahab, A.Y. (1999). Studies on the effect of foliar spraying with magnesium, boron and some vitamins on some vegetative and fruiting characters of Washington navel oranges (Citrus sinensis osb). M.Sc. Thesis, Fac. of Agric., Minia Univ., Egypt.

Hammam, M.S. & Abdalla, B.M. & Mohamed, S.G. (2001). The beneficial effects of using ascorbic acid with some micronutrients on yield and fruit quality of Hindy Bisinnara mango trees. Assuit J. of Agric. Sci., 32 (5): 181–193.

Ahmed, F.F. & Ahmed, M.A. & Morsy, M.H. (2001). Studies on the influence of spraying some nutrients and ascorbic acid on inflorescence malformation and fruiting of Taimor mangoes. 6th International Symposium on Fruit Nut and Vegetable Production Engineering, Potsdam, Germany, pp. 10-20.

Ahmed, F.F. & Ragab, A.M. (2003). New trail to stimulate growth and nutritional status of Picual olive transplants. 1st Inter. Conf. on olive cultivation, protection and Processing, 25-27 Sept. El-Arish, Egypt.
Abo El-Komsan, E.E. & Hegab, M.Y. & Fouad Amera, A. (2003). Response of Balady orange trees to foliar application of some nutrients and citric acid. Egypt. J. Agric. Res., 1 (1): 73-90.
Gobara, A.A. (2004). Growth and fruiting of Washington navel oranges in relation to foliar application of some antioxidants. Minia J. of Agric. Res. & Develop, 24 (4): 580-600.
Sharawy, A.M.A. (2005). Response of Balady lime trees to organic and biofertilization. Minia J. of Agric. Res. & Develop, 25 (1): 1-18.
Gamal, A.F. (2006). Response of Washington navel orange trees to some antioxidants and biofertilization treatments. M.Sc. Thesis, Fac. of Agric., Minia Univ., Egypt.
Ahmed, F.F. & Y. Mohamed & B.M. Abdalla (2007). The relation between using some antioxidants and productivity of Sewy date palms. Minia J. of Agric. Res. & Develop, 27(4): 753-770.
Hamad, A.S.A. (2008). Response of the two mango cvs. Timour and Zebda to fertilization and some antioxidants. Ph.D. Thesis, Fac. of Agric., Minia Univ., Egypt.
Zagzog, O.A.I. (2009). Effect of foliar spraying with vitamin C and dry yeast on growth and fruit quality of mango Cv. Hindy. J. Product. Dev., 14 (2): 391-410.
Hegab, M.M.Y. & Hegab, M.Y. (2011). Response of Valencia orange trees for spraying some vitamins. Minia J. of Agric. Res. & Develop, 31(1): 103-116.
Abd El- Rahman, M.M.A. & S.M.A. El-Masry (2012). Response of Valencia orange trees to foliar application of some vitamins, salicylic acid and Turmeric extract. Minia J. of Agric. Res. & Develop, 32 (5): 851–867.
Merwad, M.A. & Eisa, R.A. & Mostafa, E.A.M. (2015). Effect of some growth regulators and antioxidants sprays on productivity of some fruit quality of Zaghloul date palm. International J. of ChemTech Res., 8 (4): 1430-1437.
Abdel Aziz, F.H. & El-Sayed, M.A. & Aly, H.A. (2017). Response of Manfalouty pomegranate trees to foliar application of salicylic acid. Assiut J. Agric. Sci., 48 (2): 59-74.
McKersie, B.D. & Bowley, S.R. & Harjanto, E. & Leprince, O. (1996). Water-Deficit Tolerance and Field Performance of Transgenic Alfalfa Overexpressing Superoxide Dismutase, Plant Physiology, 111 (4): 1177–1181, https://doi.org/10.1104/pp.111.4.1177
Zhu, D., & Scandalios, J. G. (1994). Differential Accumulation of Manganese-Superoxide Dismutase Transcripts in Maize in Response to Abscisic Acid and High Osmoticum. Plant physiology, 106(1), 173–178. https://doi.org/10.1104/pp.106.1.173
Mullineaux, P.M. & Cressen, G.P. (1997). Glutathione reductase regulation and role in oxidative stress. In: Oxidative stress and the molecular biology of antioxidant defenses (Scandalios, J.G., Ed.). Cold Spring Harbor. Laboratory Press, NY.
Mallhi, A.I. & Chatha, S.A.S. & Hussain, A.I. & Rizwan, M. & Bukhar, S.A.H. & Hussain, A. & Mallhi, Z.I. & Ali, S. & Hashem, A. & Abd_Allah, E.F. & Alyemeni, M.N. & Ahmad, P. (2020). Citric Acid Assisted Phytoremediation of Chromium through Sunflower Plants Irrigated with Tannery Wastewater. Plants, 9(3), 380. https://doi.org/10.3390/plants9030380
Tahjib-Ul-Arif, M. & Zahan, M.I. & Karim, M.M. & Imran, S. & Hunter, C.T. & Islam, M.S. & Mia, M.A. & Hannan, M.A. & Rhaman, M.S. & Hossain, M.A. & Brestic, M. & Skalicky, M., & Murata, Y. (2021). Citric Acid-Mediated Abiotic Stress Tolerance in Plants. International Journal of Molecular Sciences, 22(13), 7235. https://doi.org/10.3390/ijms22137235
Shalata, A. & Neumann, P.M. (2001). Exogenous ascorbic acid (vitamin C) increases resistance to stress and reduces lipid peroxidation. J. Exp. Bot., 52 (364): 2207-2211.
Foyer, C.H. & Noctor, G. (2005). Redox homeostasis and antioxidant signaling: A metabolic interface between stress perception and physiological responses. Plant Cell, 17 (7): 1866-1875.
Sagi, M. & Fluhr, R. (2006). Production of reactive oxygen species by plant NAPDH oxidases. Plant Physiol., 141 (2): 336-340.
Rio, L.A. & Sandalio, L.M. & Corpas, F.J. (2006). Reactive oxygen species and reactive nitrogen species in peroxisomes. Production, scavenging and role in cell signaling. Plant Physiol., 141 (2): 330-335.
Gupta, S.D. & Datta, S. (2004). Antioxidant enzyme activities during in vitro morphogenesis of gladiolus and the effect of application of antioxidants on plant regeneration. Biol. Plant., 47: 179-183.
Rao, M.V. & Koch, R. & Davis, K.R. (2000). Ozone: a tool for probing programmed cell death in plants. Plant Molecular Biology, 44 (3): 345–358.
Shah J. (2003). The salicylic acid loop in plant defense. Current opinion in plant biology, 6(4), 365–371. https://doi.org/10.1016/s1369-5266(03)00058-x
Badran, M.A.F.M. & Ahmed, F.F. (2009). The promotive effect of some antioxidants on the productivity of Timour mango trees. Minia J. of Agric. Res. & Develop, 29 (2):333-348.
Eshmawy, E.M.Sh. (2010). Effect of some antioxidants and different pollination methods on fruiting of Sewy date palms. M. Sc. Thesis Fac. of Agric. Minia Univ., Egypt.
Ahmed, E.F.S. (2011). Response of Sakkoti date palms to foliar application of salicylic acid. Minia J. of Agric. Res. & Develop, 31 (2): 305-315.
Saied, H.H.M. (2011). Insight on the effect of salicylic acid on fruiting of Williams banana. Minia J. of Agric. Res. & Develop, 31 (2): 317-326.
AOAC (2000). Official Methods of Analysis of the Association of Official Analytical Chemists. 17th Ed., Association of Official Analytical Chemists, Washington, DC. USA. 234.
Chapmann, H.D. & Pratt, P.E. (1961). Methods of Analysis for Soils, Plants and Waters. Univ. Sci. pp. 30-45.
Mead, R. & Currow, R.N. & Harted, A.M. (1993). Statistical Methods in Agricultural and Experimental Biology. 2nd Ed. Chapman & Hall, London. Pp 10-44.
Gad El-Kareem, M.R. & Abdel Aal, A.M.K & Mohamed, A.Y. (2014). The synergistic effects of using silicon and selenium on fruiting of Zaghloul date palm (*Phoenix dectylifera* L.). Inter. J. of Agric. & Bios. Eng., 8 (3): 959-964.
Osman, M.M. (2014). Response of Superior grapevines grown under hot climates to rest breakages. M.Sc. Thesis, Fac. Agric., Minia Univ., Egypt.
Mohamed Attiat, A.M. (2016). Trials for alleviating the adverse effects of salinity on some grapevine cv. transplants. M.Sc. Thesis, Fac. Agric., Minia Univ., Egypt.
Hathout, T.A. & Shetawi, S.A. & Khallal, S.M. (1993). Effect of mode of application of some growth regulators on the physiology of tomatoes (2): Effect of nicotinamide on morphology growth, metabolism and productivity. Egypt. J. Physiol. Sci., 17 (2): 183-200.
Hassanein, R.A. & Bassuony, F.M. & Baraka, D.M. & Khalil, R.R. (2009). Physiological effects of nicotinamide and ascorbic acid on Zea mays plant grown under salinity stress. 1- Change in growth, some relevant metabolic activities and oxidative defense systems. Res. J. Agric. Biol. Sci., 5 (1): 72-81.
Deyab, M.A. (1989). Studies on some enzymic and hormonal activities in germination grains and seeds of some graminaceous and leguminous plants. Ph.D. Thesis, Fac. Sci., Tanta Univ., Egypt, pp: 121-123.
Reda, Fatma & Karima Gamal El-Din (2005). Effect of thiamine and ascorbic acid on growth, flowering and some biochemical constituents of chamomile (Chamomilla recutita L.) Rausch). Egypt. J. Appl. Sci., 20 (3): 74-85.
Ayad Hasnaa, S. (2006). Biochemical and physiological studies on Thymus vulgaris L. Ph. D. Thesis, Fac. Agric., Cairo Univ., Egypt, pp: 108-110.
Gharib, F.A. (2001). Morphological and biochemical responses of Tagetes minuta L. plant to foliar application of nicotinamide and micronutrients. Egypt. J. Bot., 41 (2): 227-240.
Sahu, M.P. & Solanki, N.S. & Dashora, L.N. (1993). Effects of thiourea, thiamin and ascorbic acid on growth and yield of maize (Zea mays L.). J. Agric. Crop Sci., 17; 65-69.
Mohamed, Y.A.H. & Sharf El-Din, A. & Foda, E. (1989). Role of nicotinamide and salicylaldehyde on some growth parameters in wheat. Phyton (Austria), 29: 33-41.
El-Bassiouny, H.M.S. & Gobarah M.E. & Ramadan, A.A. (2005). Effect of antioxidants on growth, yield and favism causative agents in seeds of Vicia faba L. grown under reclaimed sandy soil. J. Agron., 4 (4): 281-287.
Robinson, F.A. (1973). Vitamins In: Phytochemistry, Vol. 111: 195-220. Lawrence P. Miller (Ed.) Van-Nostrand Reinhold Co., New York.
Noctor, G. & Foyer, C.H. (1998). Ascorbate and glutathione of keeping active oxygen under control. Ann. Rev. Plant Physiol., 49: 249-279.

Tari, I. & Simon, L.M. & Deér, K.A. & Csiszár, J. & Sz, B. & Gy, K. & Szepesi, Á. (2004) Influence of salicylic acid on salt stress acclimation of tomato plants: oxidative stress responses and osmotic adaptation. Acta Physiol. Plant., 26S:237.

Joseph, B. & Jini, D. & Sujatha, S. (2010). Biological and physiological perspectives of specificity in abiotic salt stress response from various rice plants. Asian J. Agric. Sci., 2 (3): 99-105.

Gamal El-Din, K.M. (2005). Physiological studies on the effect of some vitamins on growth and oil content in sunflower plant. Egypt. J. Appl. Sci., 20 (5B): 560-571.

Aml, R.M. Yousef & Hasnaa, S. Ayad & Saleh, M.M.S. (2009). The beneficial effect of spraying some antioxidant vitamins on fruit quality, oil composition and improving oil characteristics of Picual olive. World Journal of Agricultural Sciences, 5 (S): 871-880.

Hamad, A.S.A. (2004). Effect of some nutrients, gibberellic acid and vitamin C on growth and nutritional status of some mango Cv. Treatments. M.Sc. Thesis, Fac. of Agric., Minia Univ., Egypt.

Abd El-Rady, A.H.E. (2015). Response of Flame seedless grapevines to spraying salicylic acid. M.Sc. Thesis, Fac. Agric., Minia Univ., Egypt.