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Effect of anti-stressors spraying to alleviate abiotic stress on productivity of Tommy mango trees grown under Qena conditions, Egypt

Salama Asmaa A., El-Wasfy M. M.*, El-Khawaga A. S., Abdel- Rahman M. M.

Horticulture Department, Faculty of Agriculture, South Valley University, Qena, Egypt

Abstract

This study was conducted during two successive seasons 2022 and 2023 at a private orchard located in El-Marashda region, Qena governorate, Egypt. The aim of this investigation is to evaluate the impact of amino acids, potassium silicate and citric acid spray on productivity and the fruits physicochemical characteristics of mango cv. Tommy. Mango trees were sprayed with potassium silicate or amino acids at 1.5 cm^3/L and citric acid at 1 g/L thrice at the end of October, 15th February and 15th May. The results showed that yield as well as physical and chemical fruit characters was all markedly enhanced by application these treatments compared non application. Amino acids spray surpassed on the rest of the other treatments in improvement crop quantity and fruit physical characters, while spraying potassium silicate surpassed in improving fruit chemical characters with no significant differences between them. Citric acid spray ranked the last order in this respect. It is that amino acids should be spraying at 1.5 cm^3/L three times in the end of October and middle of February and May to improve the yield quantity and quality of Tommy mango fruits and lessen the negative effects of heat stress.

Keywords: Potassium silicate, amino acids, anti-stressors, mango fruiting, heat stress.

*Corresponding author: El-Wasfy M. M.,
E-mail address: m.baghdady@agr.svu.edu.eg

1. Introduction

Mango (*Mangifera indica* L.) belong Anacardiaceae family, it is considered one of the most important fruits grown in tropics and subtropics region. In Egypt, it ranks the second after citrus in Egypt. Whereas its grown area reached 328284 fed. and fruit area 309488 fed produced 1429552 tons fruits (M.A.L.R., 2023). Mango production faces many problems, especially abiotic stresses such as climatic variables which can affect mango growth at every stage, from vegetative growth, flowering, fruit set and fruit growth until harvest (Bibi *et al*., 2019; Kumar and Kumar, 2016; Normand *et al.,* 2013). Some mongo cultivars dominate the global export market, among them Tommy mango cultivar because of its long shelf life. (Gálan-Saúco, 2017). The large variation in temperature or humidity because of climate changes during buds' formation stage, flowering, pollination, fruit set and fruit maturation have been considered the major causes for low productivity of many fruit crops (Abo Batta, 2019; Kai and Koh, 2014; Sing and Takhur, 2018) can be decreased the effect of abiotic stresses through enhancing the plant nutrient status (Kai and Koh, 2014; Sharma and Manjeet, 2020). Currently, many studies are being conducted to improve the productivity of fruit crops under changing climatic conditions through enhancing the tolerance of trees to abiotic stresses, by spraying the trees with anti-stressors *i.e*. amino acids, potassium silicate and antioxidants. Many studies have shown the beneficial role of amino acids in improving flowering, fruit set and increasing yield and improving fruit quality traits under stressful conditions through resistance cell aging, stimulation of cell growth and regulation pH, impacted on the physiological processes in plant and development, fosters the photosynthesis efficiency, organization opening and closing stomatal. In addition, their properties as antioxidants play an important role in plant defense against oxidative stress. (Ashraf and Foolad, 2007; El- Kady *et al*., 2022; El-Salhy *et al.*, 2021; Khan *et al.,* 2020; Sadak *et al.,* 2015). Potassium silicate (K_2SiO_3) is used in agriculture as the main source of silicon as well as containing potassium. Potassium is considered one of vital nutrients required for growth of plant and physiological functions, many physiological processes depended on it like regulation of stomatal movement, enzyme activation, cell division, protein synthesis, provide abiotic stress tolerance (Hasanuzzaman *et al.*, 2018). Meanwhile, silicon is beneficial on promoting the plants to biotic and a biotic stress it increased cell rigidity and enhancing uptake of water and nutrients, photosynthesis and leaf gas exchange. (Aziz *et al.*, 2002; Guntzer *et al.*, 2012; Liang *et al*., 2007). Hence, it is used to reduce the harmful effect of biotic and abiotic stress in plants, which positively affects growth and yield as well as fruit quality. (Rodrigues *et al.,* 2009, Jeong *et al*., 2012 and Gomaa *et al*., 2021). Antioxidants such as citric acid has a very important role plant tolerance for abiotic stress and improving flowering, fruit setting, productivity and fruit quality through promoting uptake the water and nutrients, enhancing photosynthesis and biosynthesis of proteins and plant hormones such as GA3, IAA and

Cytocynins, in addition to protecting the plants from stress because of their protective qualities it works on preventing cell senescence (Abd El Rahman, 2005; Abo El-Komsan *et al*., 2003; Ahmed *et al*., 2003; Hayat and Ahmed, 2007; Samiullah *et al*., 1988). Previous studies showed that using antioxidants can improve development, yield, nutritional status, and fruit quality in several fruit crops, which can help solve the problem of low yielding under unfavourable conditions (Abd El-Rahman, 2005; Abd El-Rahman, 2021; Abd El-Rahman and El-Masry, 2012; Ahmed *et al*., 2007; Gabara, 2004; Gamal, 2006). The aimed of this research to examine the effect of spraying antistressors for reduction the negative effects of heat stress under adverse climate conditions and improving the yield and fruit quality of tommy mango trees growing under Upper Egypt conditions.

2. Materials and methods

This study was conducted during two seasons 2022 and 2023 on twelve-year-old Tommy Atkins mango cv. grown in a private mango orchard located in El-Marashda region, Qena governorate, Egypt, the soil is sandy loam. Mango trees budded on seedling rootstock. The selected trees were planted at three by four meters. Surface irrigation system was followed using Nile water. All trees received the same horticultural practices. Foliar spraying treatments were used as follows:

1. Control (sprayed trees with water only).
2. Spraying amino acids at 1.5 cm^3/L (0.15%).
3. Spraying potassium silicate at 1.5 cm^3/L (0.15%).
4. Spraying citric acid at 1.0 g/L (1000 ppm).

The experiment was implemented in a randomized complete block design (RCBD) with three replicates, one tree per replicate. Antistressors were sprayed three times at the end of October, 15th February and 15th May. The following measurements were recorded during every season.

2.1 Yield and its component

The fruit retention at harvest was calculated as a percentage of fruitlets using the following equation according to Masroor *et al.* (2016):

$$Fruit\ retention\ \% = \frac{Total\ number\ of\ fruits\ retained}{Total\ number\ initial\ fruit\ set} \times 100$$

At harvesting time at the end of June in both seasons the remained fruits on trees were picked and the average number of fruits per tree and yield were determined as (kg/tree).

2.2 Fruit physical characteristics

Ten fruits were randomly selected from each tree for the purpose of determining the physical and chemical parameters: The average fruit weight (g), average fruit length (cm), percentage of pulp and stone weight (%).

2.3 Fruit Chemical characteristics

Samples fruits juice filtered to determine the chemical characteristics represented by the percentage of total soluble solids (TSS) by using hand Refractometer, total and reducing sugars (%), total acidity as citric acid content according to (A.O.A.C., 2000) and vitamin C (mg/100 ml juice) was determined according to A.O.A.C. (2000).

2.4 Statistical analysis

Statistical analysis was done using the new L.S.D. at 5% according to Snedecor and Cochran (1980).

3. Results and Discussion

3.1 Yield and its component

It is evident from the data in Table (1) that spraying tommy mango trees with amino acids or potassium silicate at 0.15% or citric acid at 1000 ppm significantly promotion percentages of fruit retention, number of fruits/tree and yield/tree comparing with the check treatment, similar trend was noticed during both seasons. it can be arranged the effect of treatments in ascending order in improving Yield and its component as follows, spray citric acid, potassium silicate and amino acids. The best results regarding the percentage of fruit retention, number of fruits/tree and yield/tree were obtained by spraying the trees with amino acids at 0.15%. Under such promise treatment, percentage of fruit retention, number of fruits/tree and yield/tree reached (2.67 %, 92 and 27.23 kg) and (2.75 %, 95.67 and 29.74 kg) during both seasons, respectively. While, the lowest percentage of fruit retention, number of fruits/tree and yield/tree was recorded on untreated trees (2.16 %, 68.67 and 20.37 kg) and (2.38 %, 71 and 19.27 kg) during both seasons, respectively. The increment percentage on the yield above the control attained (33.68, 8.98 and 3.17%) and (54.32, 24.98 and 20.37%) due to spraying amino acids, potassium silicate and citric acid during the two studied seasons, respectively.

Table (1): Effect of anti-stressors foliar spraying on yield and its component of Tommy mango trees during 2022 and 2023 seasons.

Treatment	Fruit retention (%)		Number of fruits/tree		Yield/tree (Kg)	
	2022	2023	2022	2023	2022	2023
Water spray	2.16	2.38	68.67	71.00	20.37	19.27
Amino acids at 0.15%	2.67	2.75	92.00	95.67	27.23	29.74
Potassium silicate at 0.15%	2.52	2.60	79.33	84.33	22.20	24.09
Citric acid at 1000 ppm	2.45	2.53	76.67	82.00	21.02	23.20
L.S.D at 0.5%	0.05	0.06	6.89	7.40	1.99	2.15

3.2 Physical characteristics of fruit

Data in Table (2) cleared that physical characteristics of mango fruits cv. tommy were significantly affected by anti-stressors spraying namely amino acids, potassium silicate and citric acid as compared with the control. The results showed that all spraying treatments were significantly very effective in improving physical fruit quality in terms of increasing fruit weight, length of fruit, pulp % and reducing the percentages of seed weight relative to the check treatment. Amino acids spraying were favourable than using potassium silicate or citric acid in this respect was gave the highest fruit weight (296.3 and 311.0 g), fruit length (11.45 and 11.70 cm) and pulp percentage (78.10 and 77.86%) as well as the lowest stone percentage (9.26 and 9.77%) compared the control treatment which recorded the lowest fruit weight (253.3 and 271.7 g), fruit length (9.07 and 19.87 cm) and pulp percentage (70.33 and 71.67%) as well as the highest stone percentage (12.20 and 12.89%) in the two seasons of study, respectively.

Table (2): Effect of anti-stressors foliar spraying on physical characters of the fruits of Tommy mango trees during 2022 and 2023 seasons.

Treatment	Fruit weight (g)		Fruit length (cm)		Pulp (%)		Stone (%)	
	2022	2023	2022	2023	2022	2023	2022	2023
Water spray	253.3	271.7	9.07	9.87	70.33	71.67	12.20	12.89
Amino acids at 0.15%	296.3	311.0	11.45	11.70	78.10	77.86	9.26	9.77
Potassium silicate at 0.15%	280.0	286.0	10.82	10.87	74.65	75.25	10.83	11.08
Citric acid at 1000 ppm	274.3	283.0	10.08	10.27	73.65	74.87	11.73	12.42
L.S.D at 0.5%	8.68	9.21	0.32	0.41	1.22	1.13	0.59	0.48

Hence, the increment percentage of the fruit weight, length of fruit, pulp % above the control were attend (16.97 and 14.48), (26.29 and 18.58) and (11.04 and 8.65%) meanwhile, decrement the percentages of seed weight against (24.07 and 24.23%) in two studied seasons of study, respectively.

3.3 Fruit chemical properties

The data in Table (3) indicate that the chemical quality characteristics of tommy mango fruits *i.e*. T.S.S.%, total sugars, reducing sugars, vitamin C and total acidity % were positively affected by spraying amino acids, potassium silicate and citric acid three times compared to un-spraying. Using potassium silicate superiority than other spraying treatments in promoted characteristics chemical of fruits increasing total soluble solids, total sugars, reducing sugars, vitamin C and reduce the percentages of total acidity. The increment percentage of total soluble solids, total sugars, reducing sugars and vitamin C attained (16.83 and 15.68), (8.06 and 9.68), (13.27 and 13.83) and (15.91 and 16.88%) meanwhile, percentage of total acidity decrement by (17.67 and 19.62%) due to spraying potassium silicate

over than the control treatment during the two studied seasons, respectively.

Table (3): Effect of anti-stressors foliar spraying on chemical characters of the fruits of Tommy mango trees during 2022 and 2023 seasons.

Treatment	T.S.S (%)		Total sugars (%)		Reducing sugar (%)		Vitamin C (mg/100g)		Total acidity (%)	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
Water spray	13.87	14.03	11.29	11.37	4.12	4.22	22.83	23.20	0.479	0.442
Amino acids at 0.15%	16.03	16.10	11.70	12.17	4.30	4.63	26.30	26.80	0.407	0.392
Potassium silicate at 0.15%	16.20	16.23	12.20	12.47	4.67	4.80	26.47	27.12	0.394	0.355
Citric acid at 1000 ppm	14.93	15.07	11.57	11.87	4.17	4.47	24.97	25.27	0.435	0.415
L.S.D at 0.5%	0.39	0.36	0.17	0.18	0.10	0.12	0.41	0.36	0.021	0.019

4. Discussion

Amino acids play many roles in plants are basic ingredients for synthesizing the vitamins, nucleotides, and growth regulators thus they are essential components of the living matter and protoplasm in plant; as well as they contribute to the synthesizing enzymes and the enzymatic reactions inside the cells and contribute to increasing the cell ability to uptake water and nutrients where amino acids play an important role as a chelate material for each of iron, zinc, copper, magnesium, and calcium and then increasing the vegetative growth; moreover, they increase synthesizing proteins participating to the multiple functions of plant metabolism leading to increasing the yield (Sharma-Natu and Ghildiyal, 2005; Vernieri *et al.,* 2005). Additionally, amino acids is bio-stimulants which have positive effects on plant growth and yield and significantly mitigate the injuries caused by abiotic stresses (Kowalczyk *et al.,* 2008; Sadak *et al*., 2015). Amino acids play a great role in improving the plant yield and quality when they are sprayed at the different growth stages such as the tillering and flowering stages or under biotic and abiotic stress conditions, thus they contribute to reducing the stress effect of drought and salinity through the different physiological activities by changing the osmotic potential of plant tissue as well as they greatly reduce injuries caused by bio stresses. They stimulate physiological and biochemical processes and participate in protein and carbohydrate synthesis. It also believed that amino acids are accountable for cell division and producing some natural growth hormones such as IAA and GA3 and consequently increasing the yield and improving the quality (Ahmed *et al*., 2014; Baqir *et al*., 2019; Madian and Refaai, 2011). External implementation of amino acids has been appraised to improve the yield and fruit quality of mango trees (Abd-Elall, 2022; Aly *et al*. 2019; El-Kosary *et al*. 2011; Khattab *et al*. 2016; Pereira *et al*. 2009). Potassium is important element of the plant and plays a pivotal role in osmoregulation and enhancing physiological processes such

as chlorophyll pigments, stomata movement, and water status, formation of sugars and starch, protein synthesis, cell division and improves ionic balance and antioxidant enzymatic activity as well as increase fruit size and quality (Hasanuzzaman *et al*., 2018). Meanwhile, silicon is considered as one of the most important beneficial elements enhancing the tolerance of plants to biotic and abiotic stresses as well as enhancing root and plant growth, photosynthesis, and regulating water relations and enhancing growth, nutritional status of the trees, yield and fruit quality (Abdel Aal and Oraby, 2013; Hasanuzzaman *et al*., 2018; Liang *et al*., 2007), in addition to, strengthened the plant biomass under different stressed conditions (Ahmed *et al*., 2007). These results regarding the promoting effect of silicon on fruiting of mango trees are in harmony with those obtained by Gad El-Kareem (2012), Ahmed *et al*. (2013), Abdel Aal and Oraby Mona (2013), and Abd EL-Rahman (2015).

5. Conclusion

According to the results were obtained from this study under Qena conditions, Egypt and the resembling condition, it is advised to foliar spraying of tommy mango trees with amino acids 1.5 cm^3/L three times in the end of October and middle of February and May to increase the productivity and enhancement fruit quality and lessened the negative consequences of heat stress.

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