

(Original Article)



## Effect of Potassium, Microelements and Seaweed Extract Spraying on Yield and Fruit Quality of Balady Mandarin (*Citrus reticulata* Blanco)

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### Abstract

This study was carried out during three successive seasons of 2019, 2020 and 2021 on 25 years old Balady mandarin trees budded on sour orange root stock and planted at 5 x 5 m apart.

The selected trees grown at the experimental orchard of Faculty of Agriculture, Assiut University Egypt. Where the soil has a clay texture and well-draining, surface irrigation was used. Therefore, this study aimed to investigate the effect of seaweed extract, potassium and micronutrients on yield and fruit quality of Balady Mandarin trees.

Forty-eight healthy trees, uniform in vigor as possible were chosen. The chosen trees were divided into eight different treatments including the control. The selected trees received four sprays from each treatment at full bloom, just after fruit setting, first week of July and September.

Treatments were arranged in a randomized complete block design with three replications per treatment, two trees each. All the studied treatments significantly increased yield, fruit physical and chemical properties and decreased total acidity %. The best treatments during the three study seasons were spraying with potassium at 2% + micronutrients at 3% + seaweed extracts at 2%. According to the previous results, it could be concluded that spraying Balady mandarin trees with liquid potassium 2% + micronutrients 3% + seaweed extracts 2% four sprays at full bloom, just after fruit set, first week of July and September to measure yield and improve fruit quality.

**Keywords:** *Citrus, Balady Mandarin, Seaweed extract, Potassium, Micronutrients*

### Introduction

Balady mandarin (*Citrus reticulata* Blanco) is the most important edible citrus cultivar after Balady orange.

It has a good flavor and aroma and it can be exported to the European markets. For commercial exploitation, mandarins have several disorders for instance; the tree has a tendency toward alternate or irregular bearing. Additionally, the mandarin fruit harvested too late in January and February or later loses

moisture and become shriveled and unmarketable. Accordingly, the fruit quality of mandarins must be maintained to increase the exportation and net income.

Nutrition management is one of the most important factors in improving the plant growth and yield through increasing photosynthetic efficiency. Micronutrients deficiency in soil and plants is a worldwide nutritional problem and very severe in many countries (Alloway, 2008; Mousavi *et al.*, 2007). Plants vary in their demand for micronutrients, as these are involved in almost all physiological functions. Some of these elements are redox-active and are cofactors in many enzymes. They have enzymes-activating functions and play structural role in stabilizing proteins (Hansch & Mendel, 2009). The nutrient deficiencies particularly micronutrients are common due to low organic matter, alkaline pH and calcareous nature of soil (Rashid *et al.*, 1997). By choosing appropriate fertilizer rates, the grower can drive a crop toward earlier and heavier fruit setting (Alva *et al.*, 2006). Micronutrients like zinc (Zn), copper (Cu) and boron (B) are very important for optimal plant growth, physiological and biochemical pathways in citrus cultivation under agro-climatic conditions.

Potassium (K) is one of the most important nutrients applied as fertilizer. It is necessary for several basic physiological functions like the formation of sugars and starch, synthesis of proteins, normal cell division and growth, and neutralization of organic acids. It improves the efficiency of plant water and sugar use in maintaining normal growth functions (Liu *et al.*, 2000). Potassium is important in fruit formation and enhancing fruit size, flavor, and color (Tiwari, 2005). It helps to reduce the influence of adverse weather conditions like drought, cold, and flooding (Cakmak, 1995). It is known to influence many enzymatic reactions and is associated with almost every major plant function.

Potassium helps to regulate the carbon dioxide supply to plants by controlling stomatal opening and closing. It moves sugar from the site of photosynthesis to other storage sites (Imas and Bansal, 1999). Potassium and P are necessary to stimulate and maintain the rapid root growth. It stimulates the synthesis of protein from amino acids (Rodriguez *et al.*, 2005). Potassium improves plant health and resistance to diseases and tolerance to nematodes and insects. The rate of photosynthesis drops sharply when plants are K deficient.

The chemical constituents of seaweed extract include complex polysaccharide, fatty acids, vitamins, phytohormones and mineral nutrients. Recent researches have shed light on the possible molecular mechanisms activated by seaweed extracts.

A number of seaweeds are reported to possess plant-growth promoting activity and thus they have found one of their more universal and continuing relevancies in agriculture and horticulture as organic manures and fertilizers (Craigie, 2011).

Seaweed extracts have now gained much wider acceptance as "plant biostimulants". In general, seaweed extracts, even at low concentrations, are

capable of inducing an array of physiological, plant responses, such as promotion of plant growth, improvement of flowering and yield, and also enhanced quality of products, improved nutritional content of edible product as well as shelf life. Furthermore, applications of different extract types have been reported to enhance plants' tolerance to a wide range of abiotic stresses, i.e., salinity, drought and temperature extremes.

This study aimed to investigate the effect of seaweed extract, potassium and micronutrients on yield and fruit quality of Balady Mandarin trees.

### **Materials and Method**

This study was carried out during three successive seasons of 2018/ 2019, 2019/ 2020 and 2020/ 2021 on 25 years old Balady mandarin trees budded on sour orange root stock and planted at 5 x 5 m apart.

The selected trees grown on the experimental orchard of Faculty of Agriculture, Assiut University Egypt. Where the soil has a clay texture and well draining, surface irrigation was used, therefore, this study aimed to examine the effect of spraying potassium, micronutrient and seaweed extracts on yield and fruit quality of Balady mandarin.

Fourty eight healthy trees, uniform in vigor as possible were chosen. The chosen trees were divided into eight different treatments including the control, the treatments were as follows:

- 1- Control (spraying water only).
- 2- Liquid potassium 2%.
- 3- Micronutrients 3%.
- 4- Seaweed extracts 2%.
- 5- Potassium 2% + Micronutrients 3%.
- 6- Potassium 2% + seaweed extracts 2%.
- 7- Micronutrients 3% + seaweed 2%.
- 8- Potassium 2% + Micronutrients 3% + seaweed extracts 2%.

The selected trees received four sprays from each treatment at full bloom, just after fruit setting, first week of July and September.

Treatments were arranged in a randomized complete block design with three replications per treatment, two trees each.

The following parameters were measured during the three seasons.

### **Yield and its Components**

The fruits were harvested at maturity stage and directly transferred to the laboratory of pomology Department.

At harvesting time (last week of December) the number of fruit/tree was counted and then yield (Kg) / tree was calculated.

## **Fruit quality**

Ten fruits from each tree were randomly taken to estimate fruit quality.

- Fruit physical properties:

1- Fruit weight (g), pulp weight (g) and peel weight were recorded.

2- Fruit volume (cm<sup>3</sup>) was measured by water displacement using graduate cylinder.

3- Fruit juice volume (cm<sup>3</sup>) was measured using gradual cylinder.

4- Fruit length and fruit diameter were measured by vernier caliper in (cm) then shape index was estimated.

- Fruit chemical properties:

1- Total soluble solids % (TSS) was determined by using a hand refractometer.

2- Total acidity in the juice (as citric acid) by titration with 0.1 NaOH using phenolphthalein as an indicator (A.O.A.C. 1995).

3- TSS/Acid ratio was calculated by dividing T.S.S. on total acidity.

4- Total sugars were determined by using lane and Eynon volumetric method (A.O.A.C. 1995)

5- Vitamin C content (as mg ascorbic acid/100 ml juice) by titration against 2,6-dichlorophenol indo phenol dye according to (A.O.A.C. 1995).

## **Statistical analysis**

The obtained data were statistically analyzed according to Gomez and Gomez (1984) and Mead *et al.* (1993) using the L.S.D test 5% to define the significance of the differences between various treatments means. The combined analysis over the three seasons of study was done according to Gomez and Gomez (1984).

## **Results and Discussion**

### **1. Yield components**

The effect of different treatments on yield components (weight as kg/tree) and fruit number/tree is shown in Table 1

Table 1 revealed that, all the studied treatments significantly increased yield weight during the three studied seasons. The best treatments concerning yield weight during the three seasons of study were spraying with potassium at 2% + micronutrients at 3% + seaweed extracts at 2%, micronutrients at 3% + seaweed at 2% followed by potassium at 2% + micronutrients at 3% and then potassium at 2% + seaweed at 2%. Combined analysis of the three seasons of study also came on line with that of the individual seasons. Yield weight of the best treatments

recorded 35.07, 30.24, 29.02 and 28.36 kg/tree as an average of the three seasons of study for such previous treatments, respectively.

On the other side, the control tree produced the least value of yield weight during the three studied seasons with an average of 19.29 kg/tree.

## 2. Fruit number/tree

Data presented in Table 1 also shown the treatment effects on fruit number/tree of mandarin. The results took the same trend of yield weight (kg/tree). Hence, spraying with potassium at 2% + micronutrients at 3% + seaweed extracts at 2%, micronutrients at 2% + seaweed extracts at 2%, potassium at 2% + micronutrients and the potassium at 2% + seaweed extracts at 2% recorded the highest number of fruit/tree. Such treatments significantly increased the number of fruits within each season of study or as an average of the three studied seasons. The number of fruits associated with the previous treatments was 209.83, 188.50, 186.58 and 179.50 fruits/tree, respectively. Meanwhile, the control trees presented the lowest value of 137.92 fruits/tree. Potassium (K) is required as a cofactor for many enzymes. Potassium also is required for many physiological functions in the plant such as cell division and growth. Accordingly, it has a key role in the productivity. Investigators agreed upon the effectiveness and role of potassium on enhancing the tree productivity. Erner *et al.* (2005), Boman (2001), Quggio *et al.* (2011), El-Tanany *et al.* (2011), Sarrwy *et al.* (2012), Shen *et al.* (2016), Vijay *et al.* (2016 and 2017), Tariq *et al.* (2007), Vijay *et al.* (2019) and Reetike *et al.* (2020). They found that potassium fertilization increased yield and/or fruit No/tree of citrus species.

**Table 1. Effect of different spraying treatments on yield weight and fruit number of mandarin**

Treatments	Yield Weight (kg)				Fruit Number			
	Season 1	Season 2	Season 3	Mean	Season 1	Season 2	Season 3	Mean
Potassium 2%	19.96	25.06	21.98	22.33 F	133.75	169.50	147.00	150.08 F
Micronutrients 3%	22.93	28.26	25.38	25.52 D	153.75	193.50	168.75	172.00 D
Seaweed extracts 2%	21.72	26.55	24.13	24.13 E	142.50	177.00	155.00	158.17 E
Potassium 2% + Micronutrients 3%	26.89	30.86	29.30	29.02 C	170.00	203.00	186.75	186.58 B
Potassium 2% + Seaweed 2%	25.62	31.53	27.93	28.36 C	161.25	201.00	176.25	179.50 C
Micronutrients 3% + Seaweed 2%	27.03	33.78	29.91	30.24 B	166.25	210.50	188.75	188.50 B
Potassium 2% + Micronutrients 3% + Seaweed 2%	31.56	38.68	34.96	35.07 A	185.00	234.50	210.00	209.83 A
Control	16.70	21.90	19.26	19.29 G	120.00	159.00	134.75	137.92 G
LSD	1.172	1.32	1.92		7.10	8.22	6.23	

Means marked by the same letter are not significantly different at 5% level.

Micronutrients are essential elements in plants growth and development. They play an important role in various enzymatic activities and synthesis Yadav

and Solanki (2015). Use of micronutrients treats the deficiency and improving growth and yield. Foliar application of micronutrients increases the photosynthetic compounds inside the plant tissue which leads to reduces the leaf drop and reflects on the productivity (Suresh *et al.*, 2018). A balanced supply between macro and micronutrients is required for optimum tree growth and fruit yield (Macedo *et al.*, 2017). Spraying citrus trees with micronutrients was found to be effective on increasing the yield (Karim *et al.*, 1996; Rahman and Haq, 2006; Tariq *et al.*, 2007; Mohamed *et al.*, 2009; Kumari *et al.*, 2009; Razzaq *et al.*, 2013; Kaur *et al.*, 2015; Meena *et al.*, 2017; Noor *et al.*, 2019; Rakhonde and Zope, 2020 and Reetika *et al.*, 2020). Seaweed extracts are a bio-stimulant containing different extracts are a bio-stimulant containing different macro and micronutrients, some growth regulators and vitamins. The application of seaweed extracts was found to improve nutritional status, vegetative growth and yield (Koo and Mayo, 1994; Fornes *et al.*, 1993; Fornes *et al.*, 2002; El-Badawy, 2017 and Al-Sabbagh *et al.*, 2020). These findings came on line with the results of the current study.

### 3. Fruit Physical characteristics

#### 3.1. Fruit weight

Data presented in Table 2 revealed that all the treatments significantly increased the average fruit weight. The best treatments in this respect were potassium at 2% + micronutrients at 3% + seaweed extracts at 2%, micronutrients at 3% + seaweed extracts at 2%, potassium + seaweed and then potassium + micronutrients. These results were true during the three seasons of study. The combined analysis of the three seasons of study suggested that there were significant differences between the treatments and the control. The best previous treatments recorded 167.38, 160.55, 158.08 and 155.78 (g), respectively. On the other side, the control gave the least fruit weight (110.03).

#### 3.2. Pulp weight (g)

Table 2 showed that the results of pulp weight (g) took the same trend of fruit weight where the same superior treatments recorded the best results. As an average of the three seasons of study, the abovementioned treatments gave 139.64, 132.46%, 131.60 and 122.25 (g) while the control had the least value (109.13).

#### 3.3. Peel weight

Table 2 showing the peel weight (g) of mandarin fruits as affected by various treatments. During the 1<sup>st</sup> and 2<sup>nd</sup> seasons of study, there were no significant differences between all the treatments. During the 3<sup>rd</sup> season, micronutrients, potassium, micronutrients + seaweed and seaweed recorded the highest values while the rest of treatments had not significant differences. The mean of the three seasons of study suggested that all the treatments had not any significant differences comparing with the control trees.

**Table 2. Potassium, micronutrients and seaweed extracts effects on fruit, pulp and peel weight of mandarin**

Treatments	Fruit Weight (g)				Pulp Weight (g)				Peel weight (g)			
	Season 1	Season 2	Season 3	Mean	Season 1	Season 2	Season 3	Mean	Season 1	Season 2	Season 3	Mean
Potassium 2%	149.25	146.88	149.63	148.58 D	126.18	125.65	106.75	119.53CD	23.05	21.23	42.88	29.05AB
Micronutrients 3%	149.15	145.90	150.00	148.35 D	126.88	125.50	105.50	119.29CD	22.28	21.15	44.50	29.31A
Seaweed extracts 2%	152.45	150.03	149.25	150.58 D	130.30	127.60	90.50	116.13D	22.13	22.43	38.75	27.77ABC
Potassium 2% + Micronutrients 3%	158.23	152.10	157.00	155.78 C	135.28	129.85	101.63	122.25C	22.95	22.25	35.38	26.86BC
Potassium 2% + Seaweed 2%	158.88	156.88	158.50	158.08BC	135.63	133.05	126.13	131.60B	23.25	23.83	32.38	26.48C
Micronutrients 3% + Seaweed 2%	162.65	160.50	158.50	160.55 B	140.38	137.63	119.38	132.46B	22.28	22.88	39.13	28.09ABC
Potassium 2%+ Micronutrients 3% + Seaweed 2%	170.65	164.98	166.50	167.38 A	146.90	142.03	130.00	139.64A	23.75	22.95	36.50	27.73ABC
Control	139.25	137.85	143.00	140.03E	126.48	111.93	89.00	109.13E	22.68	24.68	34.00	27.12ABC
LSD	2.357	2.44	7.03		11.23	5.45	8.15		N.S.	N.S.	N.S.	

Means marked by the same letter are not significantly different at 5% level.

### 3.4. Fruit volume (cm<sup>3</sup>)

Data presented in Table 3 showed that the treatments significantly increased fruit volume (cm<sup>3</sup>) comparing with the control. The best treatments in this respect were potassium + micronutrients + seaweed extracts, micronutrients + seaweed extracts, potassium + micronutrients and potassium + seaweed extracts. These results were true during the three seasons of study. As an average of the three seasons of study the previous treatments recorded 195.00, 183.42, 176.42 and 176.25 cm<sup>3</sup>, respectively, while the control gave the least value (160.67 cm<sup>3</sup>).

**Table 3. The effect of spraying treatments on fruit and juice volume of mandarin**

Treatments	Yield Weight (kg)				Fruit Number			
	Season 1	Season 2	Season 3	Mean	Season 1	Season 2	Season 3	Mean
Potassium 2%	167.50	165.00	172.00	168.17 D	61.25	66.25	68.75	65.42 DE
Micronutrients 3%	173.75	147.75	165.00	162.17 E	68.75	77.00	75.75	73.83 A
Seaweed extracts 2%	163.75	162.50	168.00	164.75DE	73.75	73.75	70.00	72.50 AB
Potassium 2% + Micronutrients 3%	179.25	182.50	167.50	176.42 C	57.50	67.00	74.00	66.17CDE
Potassium 2% + Seaweed 2%	186.25	167.50	175.00	176.25 C	63.75	72.50	65.25	67.17 CD
Micronutrients 3% + Seaweed 2%	187.25	184.00	179.00	183.42 B	62.50	76.75	71.00	70.08ABC
Potassium 2% + Micronutrients 3% + Seaweed 2%	200.50	196.50	188.00	195.00 A	53.75	81.75	70.00	68.50BCD
Control	158.25	158.75	165.00	160.67 E	63.75	67.25	57.75	62.92 E
LSD	9.33	12.6	9.31		8.45	6.18	7.27	

Means marked by the same letter are not significantly different at 5% level.

### 3.5. Juice volume

Concerning juice volume/fruit, the results (Table 3) revealed that the best results obtained from the trees sprayed with micronutrients followed by seaweed extracts and then micronutrients + seaweed extracts. Such previous treatments significantly exceed the control trees. They recorded 73.83, 72.50 and 70.08 (cm<sup>3</sup>), respectively. The differences between these three treatments were not significant. On the other side, the control recorded the lowest value (62.92 cm<sup>3</sup>).

### 3.6. Fruit dimensions

Data found in Table 4 represented the treatments effect on fruit length, diameter and fruit shape parameter (length/diameter ratio).

#### 3.6.1. Fruit length (L.) (cm)

Table 4 showed that most of the treatment significantly increased the average fruit length during the three seasons of study. The superior treatments this respect were potassium + micronutrients + seaweed extracts followed by micronutrients, and then seaweed micronutrients + seaweed. The values of fruit length associated with the previous treatments were 5.99, 5.81 and 5.73 (cm), respectively. The differences between such treatments were not significant (Three seasons average).

**Table 4. Effect of potassium, micronutrients, seaweed extracts and their combinations on fruit length, fruit diameter and fruit shape parameter of Balady mandarin**

Treatments	Fruit length				Fruit diameter				Fruit shape parameter			
	Season 1	Season 2	Season 3	Mean	Season 1	Season 2	Season 3	Mean	Season 1	Season 2	Season 3	Mean
Potassium 2%	5.83	5.35	5.78	5.65BC	7.05	6.55	6.68	6.76ABC	0.82	0.81	0.86	0.83AB
Micronutrients 3%	5.93	5.60	5.90	5.81 AB	7.05	6.55	6.53	6.71 BC	0.84	0.85	0.90	0.86AB
Seaweed extracts 2%	6.08	5.53	5.58	5.73AB	7.00	7.18	6.40	6.86A	0.86	0.77	0.87	0.83B
Potassium 2% + Micronutrients 3%	5.95	5.28	5.88	5.70AB	6.65	6.73	6.38	6.58BC	0.89	0.78	0.92	0.86AB
Potassium 2% + Seaweed 2%	6.53	5.10	5.45	5.69AB	7.18	7.10	5.88	6.72ABC	0.91	0.72	0.93	0.85AB
Micronutrients 3% + Seaweed 2%	5.90	5.30	6.00	5.73AB	6.70	6.60	6.20	6.50 CD	0.88	0.81	0.97	0.89A
Potassium 2% + Micronutrients 3% + Seaweed 2%	6.30	5.58	6.08	5.99A	6.68	7.30	6.58	6.85 AB	0.94	0.77	0.92	0.88 AB
Control	5.43	4.98	5.60	5.34C	6.38	6.38	6.13	6.29 D	0.91	0.84	0.91	0.84 AB
LSD	0.626	0.442	0.696		0.440	0.487	0.522		N.S.	N.S.	N.S.	

Means marked by the same letter are not significantly different at 5% level.

#### 3.6.2. Fruit diameter (D) (cm)

Table 4 suggested that seaweed extracts, potassium + micronutrients + seaweed, potassium and then potassium + seaweed represented the highest values with no significant differences between them. Their values were 6.86, 6.85, 6.76 and 6.72 (cm) as an average of the three seasons of study, respectively. While the control produced the lowest value (6.2 g).

### 3.6.3. Fruit shape parameter

Data presented in Table 4 demonstrated that during the three seasons of study and the combined analysis of the three seasons there were no significant differences between the treatments concerning the fruit shape parameter (L/D ratio).

Potassium has a key role in the synthesis of proteins, normal cell division and growth. Thus, the trees with optimum potassium level characterized by a normal fruit weight, volume and size (Tiwari, 2005). The beneficial effect of potassium on increasing fruit weight, size and/or volume has been demonstrated by many workers. Erner *et al.* (2005), Boman (2001), Alva *et al.* (2006), El-Tanany *et al.* (2011), Sarrwy *et al.* (2012), Hebasy (2016), Vijay *et al.* (2016, 2017, 2019) and Reetika (2020) suggested that potassium treatments were effective on increasing fruit weight, size, volume and juice content of citrus fruits. The effects of micronutrients on enhancing fruit weight and size have been demonstrated by Mohamed *et al.* (2009), Kumari *et al.* (2009), Razzaq *et al.* (2013), Zhang *et al.* (2014), Ilyas *et al.* (2015), Davinder *et al.* (2017), Meena *et al.* (2017), Nithin Kumar *et al.* (2017), Reetika *et al.* (2018), Suleiman *et al.* (2019), Helal *et al.* (2019) and Rakhonde and Zope (2020). They found that application of micronutrients enhanced fruit growth, weight, size and volume. Seaweed extracts are vital source of nutrition because they

containing various nutrients, some growth regulators and vitamins. Thus, using then in fruit orchards was found to be a useful impact on fruit growth and development. Koo and Mayo (1994), Fornes *et al.* (2002), El-Badawy (2017), Al-Musawi (2018) and Al-Sabbagh *et al.* (2020) revealed that seaweed extracts spraying on citrus trees caused an increase in fruit weight, volume or size. The later was accord onto with the results of the present study.

**Table 5. Effect of potassium, micronutrients, seaweed extracts and their combinations on TSS and total acidity of mandarin**

Treatments	TSS%				Total acidity %			
	Season 1	Season 2	Season 3	Mean	Season 1	Season 2	Season 3	Mean
<b>Potassium 2%</b>	13.33	12.90	13.50	13.24B	1.17	1.30	1.16	1.21 B
<b>Micronutrients 3%</b>	12.45	12.33	13.05	12.61DE	1.17	1.17	1.30	1.21AB
<b>Seaweed extracts 2%</b>	12.58	12.40	12.35	12.44E	1.32	1.16	1.22	1.23AB
<b>Potassium 2% + Micronutrients 3%</b>	12.78	13.00	13.40	13.06BC	1.28	1.26	1.15	1.23AB
<b>Potassium 2% + Seaweed 2%</b>	12.85	12.83	12.65	12.78CD	1.31	1.16	1.12	1.20 B
<b>Micronutrients 3% + Seaweed 2%</b>	12.70	12.65	12.25	12.53DE	1.34	1.16	1.26	1.26 A
<b>Potassium 2% + Micronutrients 3% + Seaweed 2%</b>	13.38	13.38	14.05	13.60 A	1.24	1.15	1.51	1.30 A
<b>Control</b>	11.55	11.45	12.45	11.82 F	1.16	1.18	1.43	1.26 B
<b>LSD</b>	0.436	0.542	0.665		0.216	0.169	0.152	

Means marked by the same letter are not significantly different at 5% level. TSS: Total Soluble Solids.

## **4. Fruit chemical characteristics**

### **4.1. Total Soluble Solids % (TSS%)**

Data presented in Table 5 suggested that all the treatments during the 1<sup>st</sup> and 2<sup>nd</sup> season of study significantly increased the percentage of total soluble solids while in the 3<sup>rd</sup> season most of the treatments did not significantly affect the TSS% comparing with the control. Three seasons average data revealed that all the treatments had a significant increase of TSS% comparing with the control. The highest percentage of TSS was obtained from the trees sprayed with potassium + micronutrients + seaweed extracts followed by potassium and then potassium + micronutrients. The percentages of the total soluble solids of such treatments were 13.60, 13.24 and 13.06, respectively. The control trees recorded the lowest TSS% (11.82%).

### **4.2. Total acidity percentage**

Table 5 revealed that the beset treatments on decreasing the percentage of acidity were potassium + seaweed extracts and potassium and micronutrients. The percentages of these treatments were 1.20 and 1.21, respectively, as an average of the three seasons of study.

### **4.3. TSS/Acid ratio**

The presented data Table 6 demonstrated that, during the 1<sup>st</sup> season of study the differences between the treatments were not significant while during the 2<sup>nd</sup> and 3<sup>rd</sup> seasons most of the treatments had a significant effect on TSS/acid ratio. On the other side, three seasons average data suggested that most of the treatments significantly increased the ratio of TSS and acidity. The best ratio obtained from potassium spraying, potassium + micronutrients, potassium + seaweed extracts and then potassium + micronutrients + seaweed extracts. The values of abovementioned treatments are 11.09, 11.85, 11.67 and 11.62, as an average of the three seasons of study, respectively. The control trees gave the least ratio (9.52).

### **4.4. Vitamins C (mg/100 ml)**

During the three seasons of study most of the treatments significantly led to an increase of V.C content in mandarin fruits (Table 6). While three seasons average data showed that all applied treatments significantly increased V.C comparing with the control. The best treatment in this respect was potassium + micronutrients + seaweed extracts which it recorded 5.63 (mg/100 ml). While the control gave only 4.63 (mg/100 ml).

### **4.5. Total sugars**

Table 6 revealed that all the treatments, with an exception of some treatments in the 3<sup>rd</sup> season, significantly increased the percentage of total sugars. Three seasons average data suggested that all the treatments significantly increased the percentage of total sugars. The best treatments in this respect were potassium + micronutrients + seaweed and potassium then potassium + micronutrients. The

percentage of total sugars associated with the previous treatments were 10.99, 10.65 and 10.41%, respectively. Total sugars percentage of the control recorded the lowest value (8.80%).

**Table 6. Effect of potassium, micronutrients, seaweed extracts and their combinations on TSS/acid ratio, V.C. (mg/100 ml) and total sugars % of mandarin**

Treatments	TSS/Acid ratio				Vitamin C (mg/100ml)				Total sugars %			
	Season 1	Season 2	Season 3	Mean	Season 1	Season 2	Season 3	Mean	Season 1	Season 2	Season 3	Mean
Potassium 2%	11.47	10.00	11.79	11.09A	38.95	46.30	48.48	44.58CD	10.30	10.40	11.25	10.65B
Micronutrients 3%	10.71	10.59	10.09	10.46AB	41.45	43.53	45.70	43.56D	9.60	9.03	10.93	9.85FE
Seaweed extracts 2%	9.76	10.75	10.13	10.21BC	40.90	46.40	48.57	45.29BC	9.38	9.33	10.40	9.70F
Potassium 2% + Micronutrients 3%	10.13	10.60	11.82	10.85AB	42.10	47.30	50.05	46.48 B	10.45	10.33	10.45	10.41BC
Potassium 2% + Seaweed 2%	10.08	11.05	10.88	10.67AB	38.50	45.78	51.03	45.10BCD	10.15	10.23	10.60	10.33CD
Micronutrients 3% + Seaweed 2%	9.58	10.93	9.72	10.08BC	43.83	47.80	48.58	46.73B	9.68	10.33	10.35	10.12DE
Potassium 2% + Micronutrients 3% + Seaweed 2%	10.87	11.65	9.34	10.62AB	46.18	51.83	53.89	50.63A	10.63	10.73	11.63	10.99 A
Control	10.09	9.73	8.74	9.52C	35.73	41.95	44.23	40.63E	8.60	8.23	9.58	8.80G
LSD	N.S.	1.26	1.65		2.94	2.65	3.75		0.362	0.442	0.665	

Means marked by the same letter are not significantly different at 5% level. TSS: Total Soluble Solids.

Potassium has an important role on many physiological functions such as formation of sugars, synthesis of protein and improving efficiency of sugar use. It has a great role on fruit quality. Many investigators suggested that potassium improved various quality parameters of citrus fruits, e.g., decreasing acidity, improving, TSS%, TSS/acid ratio, sugars and various chemical characteristics. Boman (2001), Alva *et al.* (2006), El-Tanany *et al.* (2011), Sarrwy *et al.* (2012), Shen *et al.* (2016), Hebasy (2016), Vijay *et al.* (2016, 2017 and 2019), Dalal *et al.* (2017) and Alikani *et al.* (2020) found that potassium increased fruit quality of citrus species in terms of TSS, TSS/acid ratio, sugars and other chemical contents. These findings came online with the results of the current study. The beneficial effects of micronutrients on improving the fruit quality of citrus have been reported by Vitti *et al.* (1993), Mohamed *et al.* (2009), Kumari *et al.* (2009), Razzaq *et al.* (2013), Zhang *et al.* (2014), Kaur *et al.* (2015), Davinder *et al.* (2017), Meena *et al.* (2017), Suleiman *et al.* (2019), Helal *et al.* (2019) and Peetika *et al.* (2020).

Seaweed extracts was also reported to enhance the fruit quality of citrus fruits. For instance, Fornes *et al.* (1995), El-Badawy (2017), Al-Musawi (2018) and Razaei *et al.* (2019). Suggested that seaweed spraying on citrus trees improved various fruit quality parameters. The later came on line with the results of the present study.

## Conclusion

According to previous results it could be concluded that spraying Balady mandarin trees with liquid potassium 2% + micronutrients 3% + seaweed extracts 2% four sprays at full bloom, just after fruit set, first week of July and September to improve yield and fruit quality.

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## تأثير رش البوتاسيوم والعناصر الصغرى ومستخلص الطحالب على محصول وجودة ثمار اليوسفي البلدي (يوسفي البحر الابيض المتوسط)

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### الملخص

أجريت هذه التجربة خلال ثلاث مواسم متتالية 2019، 2020، 2021 على أشجار اليوسفي البلدي عمر 25 سنة مزروعة علي مسافه  $5 \times 5$  ومطعمه علي اصل النارنج. الاشجار المختارة مزروعة في المزرعة البحثية لقسم الفاكهة لكلية الزراعة جامعه اسيوط حيث التربة الطينية ومتبع بها الري السطحي. وتهدف الى دراسة تأثير الرش بمستخلص الطحالب البحرية والبوتاسيوم السائل والعناصر الصغرى على محصول وجوده ثمار اليوسفي البلدي. تم اختيار 48 شجره متماتله وتم رش هذه الاشجار أربع رشات لكل معاملة في الأزهار الكامل، بعد العقد مباشرة، الأسبوع الاول من يوليو وسبتمبر.

جميع المعاملات كان لها تأثير ايجابي علي زيادة وزن المحصول والصفات الطبيعية والكيميائية للثمار وخفض النسبة المئوية للحموضة الكلية وكانت أفضل المعاملات خلال الثلاث مواسم الرش بالبوتاسيوم السائل 2% + العناصر الصغرى 3% + مستخلص الطحالب البحرية 2%.

وطبقا لنتائج الدراسة يمكن التوصية برش أشجار اليوسفي البلدي بالبوتاسيوم السائل 2% + العناصر الصغرى 3% + مستخلص الطحالب البحرية 2% أربع رشات في الأزهار الكامل، بعد العقد مباشرة وفي الأسبوع الأول من يوليو وسبتمبر لتحسين المحصول وجوده الثمار.