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PREHARVEST APPLIED TREATMENTS ON ENHANCEMENT VEGETATIVE GROWTH AND FRUIT QUALITY OF TWO MANDARIN CULTIVARS

A- THE EFFECT OF SEVERAL PREHARVEST APPLIED TREATMENTS ON ENHANCEMENT VEGETATIVE GROWTH, YIELD AND SOME PHYSICAL PROPERTIES OF MANDARIN

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ABSTRACT: Citrus growers always aim to improve vegetative growth and increase productivity, while maintaining fruit quality to achieve a high economic return. Thus, the present study was carried out throughout the two successive seasons of 2018 and 2019 on the two important cultivars of mandarin (genetically convergent), namely Santra and Satsuma. Trees were sprayed with water (control), CPPU at 30 &60 ppm, yeast extract at 100&200 ppm, promalin at 75 &100 ppm and CPPU 30 ppm + yeast extract at 100 ppm + promalin at 75 ppm. The data revealed that the combination of CPPU (30 ppm), yeast extract (100 ppm) plus promalin (75 ppm) and yeast extract at 200 ppm treatments were the most effective treatment in enhancing vegetative growth, yield index and physical fruit quality in addition, these components are environmentally safe organic substances and costless.

Key words: Mandarin, cytokinins, yeast extract, promalin, yield, quality.

INTRODUCTION

Citrus are the most important fruits types in Egypt due to the great economic importance compared to the other types of fruit and it took the first rank in terms of cultivated area as well as the first export crop and a source of foreign currency. It is the largest horticultural industry during the last few years and the cultivated area reached 479656 feddan produced 4323030 tons **(according to the annual report of the Ministry of Agriculture and Land Reclamation, 2018).** Moreover, it is considered the first popular fruit in Egypt and has a high nutritional value.

Citrus growers always aim to improve vegetative growth and increase productivity, while maintaining fruit quality to achieve a high economic return.

Plant growth promoters play an important role in vegetative and reproductive growth according to **Hasan and Jumaa (2013)**. Cytokinins are one of the most important plant hormones and can significantly improve the growth of crop plants (**Hasan and Jumaa, 2013; Al-Taey and Majid, 2018**). Moreover, cytokinins can also increase yield, cell division and plant development (**Gan and Amasion,1995; Ashikari et al., 2005**). CPPU (KT-30) or forchlorfenuron (a synthetic cytokinin) that is more active comparing with benzyl adenine by about 10–100 times. In the same trend, **Lawes *et al*. (1992) and Patterson *et al.* (1993)** found that CPPU (N-2-chloro-4-pyridyl)-N-phenyl urea) significantly increased fruit size, fruit weight and yield in kiwi fruits. Furthermore, this effect has also been observed in citrus, especially on "Valencia" orange trees to increase fruit size, weight and yield by foliar sprays with cytokinins alone or combined with yeast

and potassium. **Abd-Alwahab and Al-Mashari (2017)** mentioned that CPPU treatment at 8 mg l^{-1} led to significant increase in number of branches and leaves area in navel orange. Cytokinins are one of the most important plant hormones and can significantly improve leaves enlargement and the growth of "navel" orange **(Hasan *et al.*, 2020**).

Dawood *et al.* (2001) stated that in recent time, the world condensed his attention to minimize the environmental pollution by decreasing the use of synthetic fertilizers and chemicals in plant crops production. Thus, several researchers tended to utilize environmentally safe organic substances and costless to encourage the productivity and quality of plant.

Yeast extract (bio-stimulant, can improve the yield and fruit quality in several fruit trees **(El-Sayed, 2013).** Foliar spray of yeast extract increased growth behavior in "Navel" orange trees **(Abd El-Motty and Orabi , 2013; El-Shazly and Mustafa , 2013 and Ahmed *et al.*,2013*)*. El-Boray *et al.* (2015)** recommended that yeast extract treatment increased yield and improved fruit quality of Washington Navel sweet orange cultivar. Using dry yeast increased number of fruit set per branch and fruit yield in "Valencia" orange tree (**El-Tanany and Mohamed, 2016).** Spraying "Washington navel" orange trees with a combination of urea plus yeast on 15 Jan., achieved the highest number of vegetative buds per branch (**El-Tanany, 2018)**. The foliar application with yeast extract has the ability to promote vegetative growth parameter in *Citrus lemon* **(Mustafa *et al.*, 2019)**.

Richard (1992) indicated that cell division during the early stage of fruit development has a major effect on final fruit size. **Kiang (1985)** showed that spraying orange seedlings with promalin (BA + GA_{4+7}) increased shoot length**.** Furthermore**, Ibrahim *et al*. (1994)** reported that spraying promalin (BA + GA_{4+7}) significantly increased the number and weight of fruits /tree as well as fruit TSS, TSS/acid ratio and peel thickness in "Washington navel" orange trees. **Burak and Büyükyilmaz (1997)** mentioned that using promalin as a foliar spray just after full bloom, with the second application one week later increased fruit size and length in apple. **Kumar *et al.* (2003)** revealed that in apple cv. Starking delicious, promalin spraying up to 15 ppm led to increase fruit set up and fruit yield increased. Promalin applications resulted in better bud break ratio, fruit set, fruit quality and earlier harvesting compared with the control in apricot (*Prunus armeniaca*) and plum (*Prunus domestica*) cultivars (**Son &Kuden, 2005).**

Leite *et al.* (2005) found that promalin had thinning effect, reducing fruit set on 'Imperial Gala' and 'Fuji' apple trees. Fruit weight increased from 5% to 15% due to promalin applications. Promalin promoted fruit elongation in 'Imperial gala', apple improving its marketable form. **Bakry (2007)** revealed that all cropping and fruit quality measurements positively responded to all applied yeast extract, promalin and their combination treatments comparing with the control, except acidity percentage which was reduced by the treatments them. Promalin is a mixture of two naturally occurring plant growth regulators: gibberellic acids (GA_{4+7}), which cause cell enlargement and elongation, and 6-benzyladenine (6-BA) which promotes cell division. Promalin has been reported very effective especially in temperate fruit.

Finally, research objective could be summarized as follows: to investigate the effect of yeast extract, CPPU (as cytokinins), promalin and their combination on vegetative growth, yield index, physical quality in two genetically- convergent mandarin cultivars namely, Santra and Satsuma.

MATERIALS AND METHODS

The present investigation was carried out throughout the two successive seasons of 2018 and 2019 at the citrus orchard at Moshtohor, Benha,Qalyubia Governorate on the two important cultivars of mandarin (genetically convergent), namely: Santra mandarin (*Citrus reticulata*, Blanco) and Satsuma mandarin (*Citrus unshiu* L.).

The trees were sixteen years old, budded on Sour orange rootstock (*Citrus aurantium* L Osbeck), planted in clay loam soil, spaced 5 × 5 meters in mixed blocks of different citrus varieties. The trees have been receiving standard agricultural practices as well as free from physiological disorders and visible pathological diseases as possible. Twenty- four healthy and nearly uniform in vigor and size trees of each cultivar were randomly selected and exposed to the following treatments. The investigated bio-stimulants treatments were: water (control), CPPU at 30 & 60 ppm, yeast extract at 100 & 200 ppm, Promalin at 75 & 100 ppm and CPPU 30 ppm + yeast extract at 100 ppm + promalin at 75 ppm. The non- ionic surfactant Top film at 0.05% was added to all treatments. The trees were sprayed three times on the following dates:

1- At the beginning of flowering (28 February).

2- After setting (28 March).

3- Before June drop (28 June).

Each treatment was represented by three replicates and each replicate included one tree. The response of the two tested cultivars to yeast extract and growth regulator treatments was handled as follows:

Vegetative growth measurements

Shoot length (cm), No. of leaves/shoot and leaf area (cm^2) by plainmeter, were determined.

Fruit set and fruit drop percentages

The fruit set percentage was measured 30 days after treatments according to the following equation:

$$\text{Fruit set percentage} = \frac{\text{No. of set fruitlets}}{\text{No. of treated flowers}} \times 100$$

Moreover, fruit drop percentage after June drop was calculated as follows:

$$\text{Fruit drop percentage} = \frac{\text{No of treated fruitlets - No of remaining in July}}{\text{No of treated fruitlets}} \times 100$$

Yield measurements

At harvest, fruits per tree were counted and the yield per tree was determined.

Ten mature mandarin fruits of each tree (replicate) for each treatment were collected in the middle of November for the two seasons of study. Samples were taken from all treatments to the laboratory in Hort. Dept., Fac. Agric., Moshtohor, Benha University and subjected to the following physical quality determinations:

Fruit weight (g), fruit size (cm3) and fruit shape (length/diameter) as well as juice weight (g) were determined.

Statistical analysis

The investigation was planned out as a factorial experiment consisted of two mandarin cultivars and eight treatments arranged in a complete randomized blocks design. All data obtained during both seasons of study of every experiment were subjected to statistical analysis according to **Snedecor and Cochran (1972)** using Costat program version 6.4 **(Costat, 2008).** Means values represented the various investigated treatments were compared using the Duncan's multiple range test (**Duncan, 1955**) at 5% level of significance. Letters were used for distinguishing various values, representing means of differential investigated treatments, whereas values followed by the same letter/s were not significantly different.

RESULTS AND DISCUSSION

Shoot length

Concerning the response of shoot length to some preharvest applied treatments, the data in Table 1 showed that shoots sprayed with yeast extract at 200 ppm recorded the highest length as compared with shoots sprayed with other applied treatments. Moreover, were able to increase shoot length as compared with the control during both seasons.

With regard to the cultivar effect on shoot length in mandarin, regardless the used treatments, the data in Table 1 indicated that Satsuma mandarin had higher shoot length than Santra cultivar in consistent trend in both seasons.

The data in the same Table presented that the greatest shoot length was obtained in Satsuma cultivar sprayed with yeast extract at 200 ppm in both seasons. Furthermore, spraying "Satsuma" mandarin with the combination of CPPU (30 ppm), yeast extract (100 ppm) and promalin at 75 ppm caused higher shoot length relative to spraying "Santra" mandarin sprayed with yeast extract alone at 200 ppm. On the contrary, unsprayed "Satsuma" and "Santra" shoots gave the least length during two seasons of study.

Table 1. Effect of some preharvest applied treatments, mandarin cultivars and their interaction on shoot length during 2018 and 2019 seasons

Parameter	Shoot length (cm)					
Cultivars / Treatments	Satsuma	Santra	Mean	Satsuma	Santra	Mean
	First season (2018)			Second season (2019)		
T1- Control (Water)	32.15o***	28.40p	**30.28H***	32.30n	29.10o	**30.70G**
T2- CPPU at 30 ppm.	34.55j	32.40n	**33.48G**	34.60k	32.60m	**33.60F**
T3- CPPU at 60 ppm.	37.15e	33.90l	**35.53E**	37.90g	35.60j	**36.75D**
T4- Yeast extract at 100 ppm.	39.76e	38.46f	**39.16C**	39.91e	38.70f	**39.31C**
T5- Yeast extract at 200 ppm.	42.24a	40.64c	**41.44A**	42.64a	40.70c	**41.67A**
T6- Promalin at 75 ppm.	33.70h	34.19k	**33.95F**	33.85l	34.45k	**34.15E**
T7- Promalin at 100 ppm.	36.80h	35.18i	**35.99D**	37.05h	36.38i	**36.72D**
T8- The combination of T2+T4+T6 treatments.	41.60b	39.95d	**40.78B**	41.88b	40.30d	**41.09B**
Mean	**37.24A****	**35.39B**	-	**37.52A**	**35.98B**	-

*, **, *** Values, within the column or the row or the table, of similar letter are not significantly different according to Duncan's Multiple Rang at 0.05 levels.

Number of leaves

The effect of various applied treatments, regardless cultivars, on number of leaves per shoot was reported in Table 2. The data revealed that the combination of CPPU (30 ppm), yeast extract (100 ppm) and promalin (75 ppm) had significantly the highest number of leaves per shoot. Furthermore, spraying yeast extract alone either at 100 or 200 ppm achieved higher number of leaves per shoot relative to other used treatments. Spraying CPPU at 30 or 60 ppm resulted in lower number of leaves per shoot as compared with other applications. The control treatment gave significantly the lowest number of leaves per shoot.

With regard to mandarin cultivars factor, the data in Table 2 also indicated that Satsuma mandarin cultivar had significantly higher leaves number per shoot than Santra one in both seasons.

Furthermore, the interaction between various used treatments and mandarin cultivars (Table 2), data showed that the highest numbers of leaves per shoot were obtained with "Satsuma" mandarin treated with CPPU, yeast extract plus promalin (at used concentrations) combinations and yeast extract treatment at 200 ppm, respectively relative to other applied treatments in the two seasons. It was also obvious in both seasons that the same trend was found in Santra mandarin cultivar sprayed with those treatments. On the other side, "Satsuma" and "Santra" mandarin shoots sprayed with water (control) gave significantly the least numbers of leaves in both seasons of investigation.

Leaf area

Leaf area in relation to preharvest applied treatments was reported in Table 3. The data showed that the greatest leaf area was found with the spraying combination of CPPU (30 ppm), yeast extract (100 ppm) and promalin (75 ppm) in the two seasons of study. Moreover, spraying yeast extract alone either at 100 or 200 ppm caused a significant increase in leaf area comparing with other used treatments. In contrast, the least leaf area was recorded with the control in a consistent manner.

The mandarin cultivar factor proved the significant increase in leaf area of "Satsuma" relative to "Santra" in both seasons (Table 3).

Meanwhile, the interaction between treatments and cultivars was illustrated in Table 3. The combination of CPPU, yeast extract and promalin gave the highest leaf area of "Satsuma" mandarin relative to other treatments in the two seasons. "Satsuma" mandarin sprayed with yeast extract alone either at 100 or 200 ppm also had significantly higher leaf area than other applications. Spraying "Satsuma" mandarin with promalin at 75 ppm caused similar leaf area to that of Santra cultivar sprayed with yeast extract at the both used concentrations. The control treatments (water) recorded the least leaf area of Satsuma and Santra cultivars in a consistent manner during both seasons.

Table 2. Effect of some preharvest applied treatments, mandarin cultivars and their interaction on number of leaves per shoot during 2018 and 2019 seasons

Parameter	No. leaves/shoot					
Treatments \ Cultivars	Satsuma	Santra	Mean	Satsuma	Santra	Mean
	First season (2018)			Second season (2019)		
T1- Control (Water)	17.00l***	16.00m	**16.50H***	18.00m	17.00n	**17.50H**
T2- CPPU at 30 ppm.	21.00j	18.00k	**19.50G**	23.00j	19.00l	**21.00G**
T3- CPPU at 60 ppm.	24.00i	21.00j	**22.50F**	25.00i	22.00k	**23.50F**
T4- Yeast extract at 100 ppm.	32.00c	29.00e	**30.50B**	33.00d	30.00e	**31.50C**
T5- Yeast extract at 200 ppm.	36.00b	32.00c	**34.00B**	38.00b	33.00d	**35.50B**
T6- Promalin at 75 ppm.	25.00h	24.00i	**24.50E**	26.00h	25.00i	**25.50E**
T7- Promalin at 100 ppm.	27.00f	26.00g	**26.50D**	28.00f	27.00g	**27.50D**
T8- The combination of T2+T4+T6 treatments.	38.00a	31.00d	**34.50A**	40.00a	34.00c	**37.00A**
Mean	**27.50A****	**24.63B**	-	**28.88A**	**25.88B**	-

*, **, *** Values, within the column or the row or the table, of similar letter are not significantly different according to Duncan's Multiple Rang at 0.05 levels.

Table 3. Effect of some preharvest applied treatments, mandarin cultivars and their interaction on leaf area during 2018 and 2019 seasons

Parameter	Leaf area (cm^2)					
Treatments \ Cultivars	Satsuma	Santra	Mean	Satsuma	Santra	Mean
	First season (2018)			Second season (2019)		
T1- Control (Water)	6.11hi***	5.23j	**5.67G***	6.17f	5.35g	**5.76F**
T2- CPPU at 30 ppm.	6.85f	6.10i	**6.48F**	6.91d	6.19f	**6.55E**
T3- CPPU at 60 ppm.	6.98de	6.47g	**6.73D**	6.99d	6.61e	**6.80D**
T4- Yeast extract at 100 ppm.	7.23c	6.88ef	**7.06C**	7.25c	6.93d	**7.09C**
T5- Yeast extract at 200 ppm.	7.39b	6.96ef	**7.18B**	7.42a	7.01d	**7.22B**
T6- Promalin at 75 ppm.	6.99de	6.19hi	**6.59E**	7.03d	6.24f	**6.64E**
T7- Promalin at 100 ppm.	7.10d	6.23h	**6.67DE**	7.21c	6.29f	**6.75D**
T8- The combination of T2+T4+T6 treatments.	7.69a	7.10d	**7.40A**	7.73a	7.19c	**7.46A**
Mean	**7.04A****	**6.40B**	-	**7.09A**	**6.48B**	-

*, **, *** Values, within the column or the row or the table, of similar letter are not significantly different according to Duncan's Multiple Rang at 0.05 levels.

Fruit set

Results in Table 4 showed that the highest percentage of fruit set was achieved by spraying with CPPU, yeast extract and promalin combination relative to other used treatments. Spraying yeast extract alone at 100 and 200 ppm respectively caused also higher fruit set percentage than the remaining treatments in both seasons. The treatments of CPPU at 60 ppm and promalin at 100 ppm recorded higher fruit set percentage than CPPU at 30 ppm and promalin at 75 ppm in both seasons. On the contrary, the control treatment gave the least fruit set percentage in a consistent manner during the two seasons (Table 4).

As for the effect of mandarin cultivars factor, the data in Table 4 revealed that the fruit set percentage of Santra mandarin cultivar was greater relative to Satsuma cultivar in a consistent trend in both seasons.

With regard to the interaction between the preharvest applied treatments and mandarin cultivars, the data in Table 4 reported that Santra and Satsuma mandarin cultivars sprayed with the combination of CPPU (30 ppm), yeast extract (100 ppm) and promalin (75 ppm) had significantly the highest fruit set percentage comparing with other used treatments in both seasons. Furthermore, there were other increases of fruit set percentage of Santra and Satsuma mandarin cultivars sprayed yeast extract at either 200 or 100 ppm, respectively. On the contrary, Satsuma and Santra mandarin cultivars had significantly the least fruit set percentage when sprayed with water in the two seasons of investigation.

Table 4. Effect of some preharvest applied treatments, mandarin cultivars and their interaction on the percentage of fruit set during 2018 and 2019 seasons

Parameter	Fruit set (%)					
Treatments \ Cultivars	Satsuma	Santra	Mean	Satsuma	Santra	Mean
	First season (2018)			Second season (2019)		
T1- Control (Water)	14.25m***	16.42l	**15.34H***	14.71o	16.95m	**15.83H**
T2- CPPU at 30 ppm.	17.33k	20.15f	**18.74F**	17.65l	20.69h	**19.17F**
T3- CPPU at 60 ppm.	19.07h	21.84cd	**20.46D**	19.65j	22.32e	**20.99D**
T4- Yeast extract at 100 ppm.	20.84e	21.93c	**21.39C**	20.88g	22.95d	**21.92C**
T5- Yeast extract at 200 ppm.	21.69d	23.74b	**22.72B**	21.96f	23.85c	**22.91B**
T6- Promalin at 75 ppm.	16.44l	18.45j	**17.45G**	16.74n	18.94k	**17.84G**
T7- Promalin at 100 ppm.	18.72i	19.57g	**19.15E**	18.84k	20.15i	**19.50E**
T8- The combination of T2+T4+T6 treatments.	23.86b	25.91a	**24.89A**	24.15b	26.07a	**25.11A**
Mean	**19.03B****	**21.00A**	**-**	**19.32B**	**21.49A**	**-**

*, **, *** Values, within the column or the row or the table, of similar letter are not significantly different according to Duncan's Multiple Rang at 0.05 levels.

Number of fruits per tree

Data of number of fruits per tree as influenced by spraying preharvest applied treatments was presented in Table 5. The data revealed that spraying yeast extract at 200 ppm followed by spraying with CPPU, yeast extract and promalin (at used concentrations) combination, respectively caused significant increases of fruits number per tree relative to other used treatments. Meanwhile, the treatments of yeast extract and promalin (both at 100 ppm) recorded higher number of fruits per tree as compared with treatments of CPPU at both used concentrations. On the other side, the control treatments gave significantly the least number of fruits per tree comparing with other ones.

With regard to the effect of mandarin cultivars factor on fruits number per tree, it was resulted that Satsuma mandarin cultivar had significantly higher fruit number per tree than Santra one during the two seasons.

The interaction effect between preharvest applied treatments and mandarin cultivars during the two seasons was displayed in Table 5. The tabulated data indicated that "Satsuma" mandarin sprayed with yeast extract at 200 ppm gave the greatest increase of fruits number per tree comparing with other used treatments. Furthermore, "Satsuma" mandarin sprayed either with yeast extract and promalin or yeast extract alone at 100 ppm recorded higher number of fruits per tree as compared with other applications in both seasons. On the contrary, "Santra" and "Satsuma" mandarin sprayed with water had the lowest number of fruits per tree.

Table 5. Effect of some preharvest applied treatments, mandarin cultivars and their interaction on number of fruits per tree during 2018 and 2019 seasons

Parameter	No. of fruits/tree					
Cultivars / Treatments	Satsuma	Santra	Mean	Satsuma	Santra	Mean
	First season (2018)			Second season (2019)		
T1- Control (Water)	202.0j***	199.0k	**200.5H***	197.0l	189.0m	**193.0G**
T2- CPPU at 30 ppm.	215.0g	198.0k	**206.5G**	218.0h	200.0k	**209.0F**
T3- CPPU at 60 ppm.	225.0d	202.0j	**213.5E**	229.0d	205.0j	**217.0E**
T4- Yeast extract at 100 ppm.	237.0c	219.0f	**228.0C**	241.0c	226.0e	**233.5C**
T5- Yeast extract at 200 ppm.	249.0a	223.0e	**236.0A**	258.0a	229.0d	**243.5A**
T6- Promalin at 75 ppm.	216.0g	207.0i	**211.5F**	221.0g	214.0i	**217.5E**
T7- Promalin at 100 ppm.	219.0f	211.0h	**215.0D**	224.0f	217.0h	**220.5D**
T8- The combination of T2+T4+T6 treatments.	243.0b	222.0e	**232.5B**	255.0b	228.0d	**241.5B**
Mean	**225.8A****	**210.1B**	-	**230.4A**	**213.5B**	-

*, **, *** Values, within the column or the row or the table, of similar letter are not significantly different according to Duncan's Multiple Rang at 0.05 levels.

Fruit drop

Results in Table 6 showed that control treatments caused the greatest increase of fruit drop percentage relative to other used treatments. Moreover, spraying CPPU either at 30 or 60 ppm caused higher fruit drop than promalin at 75 or 100 ppm in both seasons. On other side, spraying yeast extract at 100 or 200 ppm was more effective in reducing fruit drop percentage. The combination of CPPU (30 ppm), yeast extract (100 ppm) and promalin (75 ppm) succeeded in decreasing fruit drop percentage where it recorded 11.11 and 11.17%, respectively during both seasons of study.

The mandarin cultivar factor assessment also proved the significant increase in fruit drop percentage of Santra mandarin relative to Satsuma cultivar in the two seasons of study.

As for the interaction effect between the preharvest applied treatments and mandarin cultivars during 2018 and 2019 seasons, the data in Table 6 indicated that the highest fruit drop percentage were achieved in Santra cultivar treated with water in both seasons. Moreover, "Santra" mandarin sprayed with CPPU at both concentrations had higher fruit drop comparing with other treatments. Meanwhile, untreated "Satsuma" mandarin gave also high fruit drop during the two seasons. The greatest reduction of fruit drop percentage was achieved in "Satsuma" mandarin sprayed with the combination of CPPU, yeast extract and promalin. Spraying Satsuma and Santra mandarin cultivars with 200 ppm yeast extract led to lower fruit drop percentage in a consistent manner in the two seasons.

Table 6. Effect of some preharvest applied treatments, mandarin cultivars and their interaction on fruit drop percentage during 2018 and 2019 seasons

Parameter	Fruit drop (%)					
Treatments \ Cultivars	Satsuma	Santra	Mean	Satsuma	Santra	Mean
	First season (2018)			Second season (2019)		
T1- Control (Water)	18.45d***	20.39a	**19.42A***	18.66c	20.42a	**19.54A**
T2- CPPU at 30 ppm.	16.22g	18.74c	**17.48C**	16.29f	18.80c	**17.55C**
T3- CPPU at 60 ppm.	17.35e	19.13b	**18.24B**	17.63d	19.28b	**18.46B**
T4- Yeast extract at 100 ppm.	12.83k	13.02j	**12.93F**	12.97j	13.49i	**13.23F**
T5- Yeast extract at 200 ppm.	10.96n	11.65m	**11.31G**	10.92m	11.77l	**11.35G**
T6- Promalin at 75 ppm.	14.71i	15.59h	**15.15E**	14.87h	15.86g	**15.37E**
T7- Promalin at 100 ppm.	16.78f	16.82f	**16.80D**	16.93e	16.92e	**16.93D**
T8- The combination of T2+T4+T6 treatments.	10.27o	11.95l	**11.11H**	10.31n	12.02k	**11.17H**
Mean	**14.70B****	**15.91A**	**-**	**14.82B**	**16.07A**	**-**

*, **, *** Values, within the column or the row or the table, of similar letter are not significantly different according to Duncan's Multiple Rang at 0.05 levels.

Yield per tree

Yield per tree as influenced by some preharvest applied treatments was tabulated in Table 7. The data showed that the greatest value of tree yield was obtained by yeast extract treatment at 200 ppm. Moreover, the combination of CPPU, yeast extract and promalin achieved the highest yield per tree when compared with the individual spraying of each component at the low concentration. Otherwise, the biggest reduction of tree yield was recorded by the control treatment. The trend of results was consistent during both seasons.

With regard to tree yield as affected by mandarin cultivars, it was evident that Satsuma mandarin cultivar recorded higher yield than Santra one (Table 7). Data shown also indicated that the greatest increase of "Satsuma" yield/ tree was found by yeast extract treatment at 200 ppm relative to the lowest tree yield was recorded by the control of "Santra".

Moreover, spraying "Satsuma" tree with yeast extract at 100 ppm alone or mixed with CPPU and promalin resulted in higher yield comparing with other used treatments, except yeast extract at 200 ppm. "Santra" mandarin followed by "Satsuma" mandarin sprayed with water had the lowest yield per tree in the two seasons. In general, the response of Satsuma mandarin cultivar to all used treatments followed similar trend to that of Santra cultivar in increasing tree yield in a consistent manner in both seasons.

Fruit weight

Concerning the response of fruit weight to preharvest applied treatments, the data in Table 8 indicated that spraying yeast extract at 200 ppm resulted in the highest fruits weight during the two seasons (199.60 and 201.6, respectively) relative to other treatments. Moreover, the combination of CPPU at 30 ppm, yeast extract at 100 ppm plus promalin at 75 ppm and promalin (100 ppm) treatments caused higher fruit weight comparing with promalin at 75 ppm and CPPU at 60 ppm treatments in both seasons. Spraying CPPU at 30 ppm also recorded an increase of fruit weight as compared with the control which recorded the lowest fruits weight where it gave 151.40 and 153.10 g, respectively during 2018 and 2019 seasons.

With regard to the effect of mandarin cultivars on fruit weight, regardless the used treatments, the data in Table 8 showed that Satsuma mandarin cultivar had higher fruit weight than Santra in a consistent manner during both seasons.

The data in Table 8 also illustrated that the greatest fruit weight was achieved with "Satsuma" mandarin when sprayed with yeast extract 200 ppm. Furthermore, spraying "Satsuma" mandarin with

yeast extract at 100 alone or mixed with CPPU and promalin at the used concentrations resulted in significant increases of fruit weight during the two seasons relative to other applied treatments. In general, the response of Santra cultivar to all used treatments was similar to "Satsuma" in fruit weight as itl had bigger fruit weight values than the control. On the contrary, untreated Santra and Satsuma cultivars recorded the lowest values of fruit weight during 2018 and 2019 seasons.

Table 7. Effect of some preharvest applied treatments, mandarin cultivars and their interaction on yield per tree during 2018 and 2019 seasons

Parameter / Cultivars / Treatments	Yield (kg)/tree					
	Satsuma	Santra	Mean	Satsuma	Santra	Mean
	First season (2018)			Second season (2019)		
T1- Control (Water)	31.14l***	29.58n	**30.36H***	30.91l	28.21n	**29.56H**
T2- CPPU at 30 ppm.	35.53j	28.78o	**32.16G**	36.35i	29.20m	**32.78G**
T3- CPPU at 60 ppm.	39.03h	30.54m	**34.78F**	39.98h	31.80k	**35.89F**
T4- Yeast extract at 100 ppm.	47.44c	38.47i	**42.95C**	49.02c	39.81h	**44.42C**
T5- Yeast extract at 200 ppm.	53.65a	40.99e	**47.32A**	56.22a	42.42e	**49.32A**
T6- Promalin at 75 ppm.	40.00f	33.17k	**36.58E**	41.61f	34.97j	**38.29E**
T7- Promalin at 100 ppm.	41.91d	35.53j	**38.72D**	43.37d	36.35i	**39.86D**
T8- The combination of T2+T4+T6 treatments.	47.94b	39.86g	**43.90B**	50.87b	41.13g	**46.00B**
Mean	**42.08A****	**34.62B**	-	**43.54A**	**35.49B**	-

*, **, *** Values, within the column or the row or the table, of similar letter are not significantly different according to Duncan's Multiple Rang at 0.05 levels.

Table 8. Effect of some preharvest applied treatments, mandarin cultivars and their interaction on fruit weight during 2018 and 2019 seasons

Parameter / Cultivars / Treatments	Fruit weight (g)					
	Satsuma	Santra	Mean	Satsuma	Santra	Mean
	First season (2018)			Second season (2019)		
T1- Control (Water)	154.2m***	148.7o	**151.4H***	156.9m	149.3o	**153.1G**
T2- CPPU at 30 ppm.	165.3k	145.4p	**155.3G**	166.8k	146.0p	**156.4F**
T3- CPPU at 60 ppm.	173.5i	151.2n	**162.3F**	174.6i	155.1n	**164.9E**
T4- Yeast extract at 100 ppm.	200.2b	175.6h	**187.9EC**	203.4b	176.2h	**189.8B**
T5- Yeast extract at 200 ppm.	215.5a	183.8f	**199.6A**	217.9a	185.2f	**201.6A**
T6- Promalin at 75 ppm.	185.2e	160.3l	**172.7E**	188.3e	163.4l	**175.8D**
T7- Promalin at 100 ppm.	191.4d	168.4j	**179.9D**	193.6d	167.5j	**180.6C**
T8- The combination of T2+T4+T6 treatments.	197.3c	179.6g	**188.4B**	199.5c	180.4g	**189.9B**
Mean	185.3A**	164.1B	-	187.6A	165.4B	-

*, **, *** Values, within the column or the row or the table, of similar letter are not significantly different according to Duncan's Multiple Rang at 0.05 levels.

Fruit volume

As for the effect of various used treatments on fruit volume, the data in Table 9 revealed a significant increase was occurred by spraying the combination of CPPU, yeast extract and promalin in both seasons as compared with other applied treatments. All treatments of promalin caused higher fruit weight comparing with yeast extract at both concentrations. Using CPPU at 60 ppm was more effective in increasing fruit volume than 30 ppm. The control treatment had significantly the lowest values of fruits weight in a consistent trend in the two seasons of investigation.

Table 9 also showed that Satsuma mandarin cultivar had greater fruit volume relative to Santra one in both seasons.

From the data presented in Table 9, it could be also noticed that spraying "Satsuma" mandarin with the combination consisted of CPPU, yeast extract and promalin recorded the highest values of fruit volume in both seasons. The both used concentrations of promalin caused significant increases of "Satsuma" mandarin fruit volume relative to the remaining treatments. Furthermore, there were significant increases appeared with "Santra" mandarin treated with the combination of CPPU, yeast extract plus promalin than the treatment of yeast extract at 100 ppm in Satsuma cultivar. Spraying Santra and Satsuma cultivars with water led to the lowest fruit volume during 2018 and 2019 seasons.

Table 9. Effect of some preharvest applied treatments, mandarin cultivars and their interaction on fruit volume during 2018 and 2019 seasons

Parameter	Fruit volume (cm^3)					
Cultivars / Treatments	Satsuma	Santra	Mean	Satsuma	Santra	Mean
	First season (2018)			Second season (2019)		
T1- Control (Water)	138.0m***	133.1n	**135.5H***	139.8m	135.7o	**137.8H**
T2- CPPU at 30 ppm.	146.3k	138.5m	**141.9G**	148.5k	139.0n	**143.8G**
T3- CPPU at 60 ppm.	151.3i	141.2l	**146.2F**	153.9i	141.2l	**147.5F**
T4- Yeast extract at 100 ppm.	159.2f	147.5j	**153.3E**	151.5f	148.4k	**154.9E**
T5- Yeast extract at 200 ppm.	163.0d	151.3i	**157.1D**	166.0d	152.3j	**159.1D**
T6- Promalin at 75 ppm.	166.3c	154.2h	**160.2C**	167.8c	156.6h	**162.2C**
T7- Promalin at 100 ppm.	169.6b	158.0g	**163.8B**	172.5b	159.7g	**166.1B**
T8- The combination of T2+T4+T6 treatments.	178.0a	162.1e	**170.1A**	181.2a	163.8e	**172.5A**
Mean	**158.9A****	**148.1B**	**-**	**161.4A**	**149.6B**	**-**

*, **, *** Values, within the column or the row or the table, of similar letter are not significantly different according to Duncan's Multiple Rang at 0.05 levels.

Fruit shape

Fruit shape index as influenced by various preharvest applied treatments, the data in Table 10 found that spraying promalin at 100 ppm recorded the highest fruit shape index as compared with other used treatments. Meanwhile, the combination of CPPU (30 ppm), yeast extract (100 ppm) and promalin (75 ppm) caused a considerable increase of fruit shape index relative to other treatments. Moreover, CPPU at 30 ppm and yeast extract either at 100 or 200 ppm had significantly the same effect on fruit shape index. The lowest values of fruit shape index were achieved by the control treatment (water) during 2018 and 2019 seasons.

The data in the same Table presented that there was no significant difference between Satsuma and Santra mandarin cultivars in fruit shape index during the two seasons.

From the data displayed in Table 10, it could be also noticed the greatest value of fruit shape index was found by "Satsuma" mandarin treated with the combination of CPPU, yeast extract and promalin. In

the same trend, fruit shape index values of "Santra" mandarin treated with promalin alone at 75 or 100 ppm, mixed with CPPU, yeast extract plus promalin and "Satsuma" sprayed by the combination of CPPU, yeast extract plus promalin were higher than that of other used treatments, but the differences among the four treatments were not big enough to be significant. The response of "Satsuma" and "Santra" mandarins to the spraying with CPPU at 60 ppm or yeast extract was similar. Meanwhile, "Santra" mandarin sprayed with 200 ppm had significantly the same fruit shape index to that of "Satsuma" sprayed with the same treatments. On the other hand, untreated Santra and Satsuma mandarin cultivars, respectively had the lowest fruit shape index comparing with other used treatments. This trend was stable in the two seasons.

Table 10. Effect of some preharvest applied treatments, mandarin cultivars and their interaction on fruit shape during 2018 and 2019 seasons

Parameter	Fruit shape					
Cultivars / Treatments	Satsuma	Santra	Mean	Satsuma	Santra	Mean
	First season (2018)			Second season (2019)		
T1- Control (Water)	1.46cd**	1.32e	**1.39D***	1.49c-e	1.37e	**1.43CD**
T2- CPPU at 30 ppm.	1.51cd	1.43d	**1.47C**	1.29f	1.40de	**1.35E**
T3- CPPU at 60 ppm.	1.51cd	1.43d	**1.47C**	1.52cd	1.45c-e	**1.48CD**
T4- Yeast extract at 100 ppm.	1.42d	1.51cd	**1.46C**	1.40de	1.50cd	**1.45CD**
T5- Yeast extract at 200 ppm.	1.45cd	1.56c	**1.50C**	1.50cd	1.57c	**1.53C**
T6- Promalin at 75 ppm.	1.98a	1.83b	**1.90A**	1.79b	1.72b	**1.76B**
T7- Promalin at 100 ppm.	2.05a	1.81b	**1.93A**	2.05a	1.70b	**1.87A**
T8- The combination of T2+T4+T6 treatments.	1.79b	1.81b	**1.80B**	1.80b	1.76b	**1.78B**
Mean	**1.64^{Ns}**	**1.59**	**-**	**1.60**	**1.56**	**-**

*, **, Values, within the column or the row or the table, of similar letter are not significantly different according to Duncan's Multiple Rang at 0.05 levels.
Ns: Non-significant.

Juice weight

Data shown in Table 11 revealed to the effect of some preharvest applied treatments on juice weight during 2018 and 2019 seasons. During the two seasons of study, the combination of CPPU (30 ppm), yeast extract (100 ppm) plus promalin (75 ppm) had significantly the highest juice weight when compared with other used treatments. Moreover, yeast extract treatments at 100 or 200 ppm were better in increasing juice weight comparing with promalin treatments, and CPPU at the low concentration (30 ppm). The differences among the treatments of promalin at 75 or 100 ppm and CPPU at 30 ppm were not significant in both seasons. Control treatment caused the lowest juice weight relative to all applied treatments.

During 2018 and 2019 seasons, Satsuma mandarin cultivars recorded higher juice weight than Santra.

From results introduced in Table 11, it could be also observed that the highest juice weight was recorded in Satsuma mandarin cultivar treated with CPPU, yeast extract and promalin in a combination form. Moreover, yeast extract treatments at 200 ppm and 100 ppm, respectively resulted in increasing juice weight of "Satsuma" mandarin as compared with other treatments."Satsuma" mandarin sprayed with promalin at 75 ppm had similar juice weight to that of "Santra" mandarin during the two seasons of study. Meanwhile, the effect of CPPU at 30 ppm on juice weight of "Satsuma" mandarin did not differ from that of "Santra" mandarin treated with 60 ppm. The control treatment caused the lowest juice weight comparing with other applied treatments in both seasons. Untreated "Satsuma" mandarin was similar to "Santra" mandarin in juice weight. This trend was consistent in the two seasons of investigation.

Table 11. Effect of some preharvest applied treatments, mandarin cultivars and their interaction on juice weight during 2018 and 2019 seasons

Parameter	Juice weight (g)					
Cultivars / Treatments	Satsuma	Santra	Mean	Satsuma	Santra	Mean
	First season (2018)			Second season (2019)		
T1- Control (Water)	51.00fg***	50.00g	**50.50G***	52.00i	51.00i	**51.50F**
T2- CPPU at 30 ppm.	56.00e	53.00f	**54.50E**	57.00e	54.00h	**55.50E**
T3- CPPU at 60 ppm.	58.00d	55.00e	**56.50D**	59.00d	56.00e-g	**57.50D**
T4- Yeast extract at 100 ppm.	61.00c	56.00e	**58.50C**	63.00c	60.00d	**61.50C**
T5- Yeast extract at 200 ppm.	63.00b	58.00d	**60.50B**	65.00b	63.00c	**64.00B**
T6- Promalin at 75 ppm.	53.00f	51.00fg	**52.00F**	55.00f-h	56.50ef	**55.75E**
T7- Promalin at 100 ppm.	55.00e	53.00f	**54.00E**	57.00e	54.50gh	**55.75E**
T8- The combination of T2+T4+T6 treatments.	65.00a	59.00d	**62.00A**	67.00a	65.00b	**66.00A**
Mean	**57.75A****	**54.38B**	**-**	**59.38A**	**57.50B**	**-**

*, **, *** Values, within the column or the row or the table, of similar letter are not significantly different according to Duncan's Multiple Rang at 0.05 levels.

Discussion

1- Vegetative characteristics of Satsuma and Santra mandarin cultivars

According to the data in Tables 1- 3, Preharvest application of CPPU, yeast extract and promalin significantly increased shoot length, leaf area and number of leaves per shoot as compared with control treatment. The positive effect of different treatments could be due to their roles in increasing cell division, cell elongation, photosynthesis and nutritional status (**Antognozzi *et al.* 1992; Barnett *et al.*, 1990** and **Chauhan *et al.*, 2012).**

The positive role of yeast extract on increasing vegetative characteristics of mandarin cultivars might be attributed to the effect of yeast extract in increasing levels of endogenous hormones such as IAA, GA_3 and cytokinins in treated plants which could be interpreted by cell division and cell elongation (**Barnett *et al.*, 1990** and **Ferguson *et al.* 1995**). Moreover, **El-Tanany and Mohamed (2016)** showed that using dry yeast increased fruit set and fruit yield of "Valencia" orange trees as compared with control treatment.

According to the data in Tables 1- 3, both of CPPU and promalin compounds enhanced vegetative growth of both mandarin cultivars such as shoot length, leaf area and number of leaves per shoot. The increase in vegetative growth recorded in this investigation could be a reflection of the effect of CPPU and promalin (contains GA and benzyladenine) on growth and development (**Mackay *et al.* 2002** and **Westfall *et al.*, 2013**). Moreover, CPPU enhanced vegetative growth of "Navel" orange (**Abd-Alwahab and Al-Mashari, 2017**) and mandarin fruits (**Hasan and Jumaa, 2013**).

2- Effect of Preharvest treatments on fruit set, fruit drop, number of fruits and fruit yield

The data in Tables 4-7 illustrated the role of different chemical compounds on fruit set, fruit drop and yield. The data indicated that all Preharvest treatments increased fruit set and yield as compared with control treatments. On the other hand, it decreased fruit drop as compared with the control treatment. The positive effect of CPPU and promalin on increasing fruit set could be attributed to their effect on promoting fruit setting and reducing fruit drop of fruits (**Mostafa and El-Berry, 2020**). Furthermore, preharvest application of CPPU and promalin increased fruit set of "Washington" navel orange (**Paranjape, 2015**; **Kulkarni *et al.* 2017 and Mostafa and El-Berry, 2020**). The positive role of yeast extract on increasing fruit set might be attributed to its influence on improving net photosynthesis, growth and productivity of fruit crop (**Ferguson *et al.* 1995**). To explain the role of CPPU, promalin and yeast extract on fruit set, fruit drop and yield of mandarin cultivars, **Kulkarni *et al.* (2017)** sprayed CPPU (10 and 20 ppm) thrice

during mango fruit development stages *viz*. at mustard stage, pea stage and at marble stage. The treatment of CPPU at 10 ppm in pea stage produced maximum number of fruit per tree (362.33). Yield of fruit (107kg/tree and 10.7 t/ha) was maximum in the treatment of CPPU (10ppm) at marble + pea stages. Application of CPPU at mustard + pea stage was found effective in increasing fruit number and weight than single application at any stage. CPPU 10 ppm at mustard + pea stage recorded maximum yield. Moreover, **Bakry (2007)** mentioned that promalin treated "Jaffa" orange at 25 and 50 ppm were more effective in increasing fruit set, fruit remained and yield as well as decreasing fruit drop as compared with control treatment. Furthermore, **Abd El-Razek *et al.* (2017)** showed that preharvest foliar application of yeast extract on "Ewais" mango trees raised fruit set, minimized the percentage of fruit drop and increased tree yield of mango trees. The results of current study agreed with those obtained by **Ibrahim *et al.* (1994)** on "Washington navel" orange trees, **Subhadrabandhu and lamsbu (1996**) on mango, **Atawia and El-Desouky (1997**) on Navel orange, **Chen *et al*. (2002**) on citrus and **El-Kosary (2009**) on palm trees.

3- Effect of Preharvest treatments on physical characteristics of mandarin cultivars

The data in Tables 8-11 showed that there were significant alterations in physical characteristics of mandarin cultivars such as fruit weight, size, fruit shape by Preharvest treatments as compared with control treatment. The significant effect of yeast extract, CPPU and promalin could be attributed to enhancing production and transport of plant sugars which cause an increase in cell size and stimulate cell division as well as cell elongation (**Notodimedjo, 1999**). The results of the present study are in agreement with those obtained by **Antognozzi *et al.* (1992**) on olive fruit trees, **Farag and Nagy (2012**) on "Nova" tangerines, **Mostafa and El-Berry (2020**) on avocado, Atawia **and El-Desouky (1997**) on "Washington navel" orange trees, **Hegab *et al.* (2005**) on "Valencia" orange trees and **Ali *et al.* (2019**) on olive fruit trees. To explain the role of different treatments on physical properties of two mandarin cultivars, **Kumar *et al*. (2003)** reported that the fruit weight, fruit length and fruit breadth were gradually increased with increasing the concentration of CPPU. The greatest values of fruit weight (88.6 and 93.5 g), between thinning and CPPU concentrations, were significant. The heaviest and largest fruits were recorded by the application of CPPU at 10 ppm. Moreover, **El-Boray *et al.* (2015)** mentioned that using yeast extract treatment during full bloom stage and one month later increased fruit volume, length and diameter as well as juice volume in Washington navel sweet orange cultivar. Furthermore, **Bakry (2007)** illustrated that promalin treatments (25 and 50 ppm) were more effective in increasing fruit weight, volume, length, diameter and juice of "Jaffa" orange. **Giacobbo *et al.* (2010)** also showed that the effect of promalin either alone or in combination with boron and branches girdling on "Navelina" orange fruit height, diameter and weight was non-significant.

Conclusion

This investigation recommended that the combination of CPPU (30 ppm), yeast extract (100 ppm) plus promalin (75 ppm) and yeast extract at 200 ppm treatments were the most effective treatments in enhancing vegetative growth, yield and physical quality in the two genetically convergent mandarin cultivars namely Satsuma and Santra.

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