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Effect of Foliar Application of Cytokinin, Active Dry Yeast and Potassium on Fruit Size, Yield, Fruit Quality and Leaf Mineral Composition of Valencia Orange Trees

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A FIELD experiment was conducted during two successive seasons of 2013/2014 and 2014/2015 in a private orchard located at Sharnoob village, El-Behera governorate, Egypt, this study aim to evaluate the effect of foliar application of benzyladenine, yeast extract and potassium solution on yield, fruit quality and leaf mineral content of Valencia orange trees (Citrus sinensis, osbeck) about 50 years old budded on sour orange (C. aurantium, L) rootstock planted in clay soil. The obtained results proved that spraying trees with a mixture of (BA 40 ppm+ yeast 0.4% + K 0.4%) resulted in a higher number of fruit set/branch, although it caused an increase of fruit juice acidity compared with the control and the differences were significant during both seasons of the study. Also, this treatment, significantly increased fruit length and diameter, only in one season. Moreover, benzyladenine spray treatment at 40 ppm, in both seasons, produced the highest number of fruits/tree, an average fruit weight and yield and participated with potassium at either 0.2 or 0.4% to improve fruit shape (fruits were more circular in shape). In most cases, BA 40ppm spraying treatment markedly increased fruit length, and fruit growth rate comparing to control treatment. The data also revealed that Valencia orange trees sprayed with a combination of (BA 20ppm + yeast 0.2% +K 0.2%), in both seasons, gave significantly higher fruit diameter and fruit growth rate in most measuring dates, increased vitamin C content in the fruit juice. Trees sprayed with dry yeast extract at 0.2%, in both seasons, markedly increased total soluble solid percentages in fruit juice. In addition, potassium spray treatment at 0.4% markedly increased fruit diameter, only in one season and participated with benzyladenine at 40ppm and dry yeast extract at 0.2% to improve fruit physical properties (length, diameter, pulp and rind weights, fruit weight and juice volume). Different foliar application increased total nitrogen, phosphorus and potassium in the leaves. Trees sprayed with a mixture of (BA 20ppm+ yeast 0.2%+ K 0.2%) and 0.4% potassium solution treatment, in both seasons, significantly increased leaf total nitrogen content as well as potassium spray treatments at either 0.2% or 0.4%, markedly increased leaf phosphorus and potassium content.

Keywords: Washington Navel orange, Benzyladenine, Dry Yeast Extract, Potassium.

Citrus occupies the largest fruit trees area in Egypt. Nowadays, Valencia orange is considered the most widespread variety planted, especially in the new reclaimed soils followed in descending order by Washington Navel orange in this respect. The total area occupied by citrus in 2014 was 530415 Feddan and produced 4402180 tons of fruits. From such area, 146407 Feddan are cultivated by Valencia orange trees, representing about 27.60% of the total area of citrus and produced 1182667 tons of fruits, representing about 26.86% of total citrus production (Annual Book of Agricultural Statistics, 2014). Valencia orange is considered the most desirable fruits for both local consumption and exportation. Efforts have been intensified to improve the cultural practices in order to raise citrus yield per acre and improving fruit size, particularly Valencia orange trees which produce fruits with small size specially when budded on sour orange rootstock. So, for improving Valencia orange fruit size, applied agricultural practice is easy, economical, safety and promising through foliar application of benzyladenine, active dry yeast extract and potassium solution treatments at proper time of flower ovaries cell division.

Plant growth regulators have been applied to improve fruit size such as synthetic cytokinin CPPU (N-2-chloro-4-pyridyl)-N-phenyl urea) which was tested in Kiwifruit, it has been shown to increase fruit size, fruit weight and yield significantly (Lawes *et al*., 1992 and Patterson *et al*., 1993). This effect has also been observed in citrus, specially on Valencia orange trees to increase fruit size, weight and yield through foliar sprays with benzyladenine (BA)_(6-benzylaminopurine) alone or combined with yeast and potassium. Benzyladenine (BA) is one of the most active cytokinins which regulate various growth processes in plant and improve fruit growth, yield and constituents of many crops and recently, BA has been identified as a natural cytokinin in a number of plants. Nevertheless, physiological responses to BA application may be associated with increased endogenous cytokinin concentrations (Van Staden and Crouch, 1996). BA has act on different fruit tissue through main stages, firstly most of the growth is in the ovary wall, which became the fruit peel and whose cells, in the exocarp and the endocarp, divided continuously, which explain its different effect on final fruit growth (Guardiola *et al*., 1993).

Dry yeast (natural stimulator) is characterized by its richness in proteins, large amount of vitamin B (Thiamin, riboflavin and pyridoxines), and amino acids. Also yeasts are prolific producers of vitamins, hormones, mineral elements and natural plant growth regulators namely cytokinin (Mahmoud, 2001).

Potassium is one of the most important macro elements which highly mobile in the plants at all levels, from individual cell to xylem and phloem transport. This cation plays a major role in enzyme activation, protein synthesis, stomatal function, stabilization of internal PH, photosynthesis, turgor related processes and transport of metabolities. Potassium improves fruit quality by enhancing fruit size, juice content, color and juice flavour (Tiwari, 2005 and Ashraf *et al*., 2010). In contrast, K deficiency produces small fruits with thin peel. Application

of potassium increased fruit yield and improve crop quality, including fruit weight and size (Ali *et al*., 2015 and Wei *et al*., 2002).

Therefore, this experiment was carried out in a trial to improve productivity and fruit quality, especially, the size of Valencia orange fruits on sour orange rootstock through evaluation the effect of foliar application withbenzyladenine, yeast extract and potassiumsolution on fruit size, yield fruit quality and leaf mineral composition of Valencia orange trees.

Materials and Methods

The present investigation was conducted in a private orchard located at Sharnoob village, El-Behera governorate, Egypt during 2013/2014 and 2014/ 2015 growing seasons. The main target of this study was to evaluate the influences of foliar spray with Benzyl adenine, dry yeast and potassium on fruit size, fruit quality and leaf mineral composition of Valencia orange trees (Citrus sinensis, L., osbeck).

Thirty sex trees (50-year old) of Valencia orange budded on sour orange (C. aurantum, L.) rootstock were used in this study. The selected trees were nearly uniform in vigor and size and spaced at 5 × 5 m apart (160trees/ Fed.) and received the same cultural practices. The trees were surface irrigated with Nile water every 12-15 days during the growing season, from February to November. Trees received 5000 m^3 of water per feddan per year distributed through 14-17 irrigations times / feddan / year. Soil analysis of the experiment orchard is shown in Table 1.

TABLE 1. Soil analysis of the experiment orchard.

Soil depth (cm)	Texture	P H %	E C (mhos/cm)	Soil content of cations (meq / L.)				Soil content of anions (meq / L.)		
				K	Na	Ca	Mg	HCO_3	CL	SO_4
0 – 30	Clay	7.78	1.13	0.45	5.99	2.5	1.5	2.32	2.25	2.78
30 – 60	Clay	7.57	0.97	0.33	3.70	5.00	1.20	2.90	5.25	5.50
60 - 90	Clay	7.48	1.00	0.29	3.90	4.50	2.10	2.90	5.60	1.79

The following experimental treatments were applied:

- Control (sprayed with water only)
- Trees sprayed with 20 ppm 6- benzyl amino purine (BA)
- Trees sprayed with 40 ppm 6- benzyl amino purine (BA)
- Trees sprayed with 0.2 % active dry yeast extract (ADYE)
- Trees sprayed with 0.4 % active dry yeast extract (ADYE)
- Trees sprayed with 0.2 % potassium solution (KS)
- Trees sprayed with 0.4 % potassium solution (KS)

- Trees sprayed with a mixture of BA at 20 ppm plus ADYE at 0.2% plus KS at 0.2%
- Trees sprayed with a mixture of BA at 40 ppm plus ADYE at 0.4% plus KS at 0.4%

For preparation of active yeast extract and Benzyladenine (BA), the dry pure yeast powder was activated by using source of carbon and nitrogen with the ratio of 6:1 according to Barnett *et al*. (1990). This ratio is suitable to get the highest vegetative production of yeast (each ml yeast contained about 12000 of yeast cells), and then the media was frozen and thawed directly before using.

Benzyl adenine (BA) was dissolved in 25 ml of 95% ethanol, heated and mixed with distilled water. Thecytokinin stock solution was diluted into 10L aliquots of 20 and 40 ppm BA, all mixtures were formulated 1 day before being applied according to Gene and Clenton (1983). Tween-20 was added as spreading agent.

Four trees pear replicate were selected to represent each treatment. Different treatments were applied using a 20liters motor hand sprayer on the foliage until drip point of solution. Each tree received 6.5 liters of spraying solution containing from (0.02 to 0.04 gm/L 6- benzyl amino purine (BA), 2.0 to 4.0 g/L dry yeast and from 2.0 to 4.0 g/L. Potassium solution. Potassium used in this experiment was under the name Milagro **[**potassium mono hydrogen phosphate, containing potassium 40%w/w(K_20)+ phosphours 40% w/w P_20_5**]**, *i.e.* the addition rate were 0.13 to 0.26 gm 6- benzyl amino purine (BA), 13 to 26 gm active dry yeast and 13 to 26 gm potassium solution per tree. The benzyladenine and active dry yeast were sprayed twice, at 80% of full bloom on 11 April and two weeks after full bloom (after setting) on 26 April of both seasons. Potassium solution was also sprayed twice, two week after full bloom with BA and dry yeast on April, 26 and alone on 5 June and 5 July of both experimental seasons. Different treatments were repeated on the same trees for two successive experimental seasons.

Leaf analysis

Leaf samples of 30-40 full- expanded mature leaves were taken from non-fruiting shoots of the previous spring growth flushes. The leaves were collected from all over the circumference of each tree. Leaf samples were taken at random in August of each season. These samples were washed with tap water, rinsed three times in distilled water, oven dried at 65- 70 C^0 to a constant weight and grounded to 20 mesh size. Leaf samples were used for total nitrogen, phosphorus and potassium determination. As for total nitrogen, phosphorus and potassium determination, 0.3 gm ground dry material was digested with sulphuric acid and hydrogen peroxide as outlined by Evenhunis and DeWaard (1980). In digested solution of each sample, total nitrogen and phosphorus was calorimetrically determined according to Evenhunis (1976), Murphy and Riky (1962). Potassium was measured against a standard using Carlzesis Jena Flame Photometer.

Fruit set number

During April, May and June of 2013 and 2014 seasons, two branches located in two different directions (in north east and south west) were tagged from each tree. The circumference of chosen branches was 4.5-5.0 cm. The number of set fruits was recorded in three different counting dates *i.e.* 19^{th} of both April and May, 30^{th} June of both seasons.

Fruit length and diameter

During both experimental seasons, four fruits were randomly selected and tagged on each tree, fruit length and diameter were measured and recorded monthly on 10^{th} of July, August, September, October, November, December and January of each season. Fruit growth rates (length & diameter) were then calculated for during July - August, September - October, November - December - January, and July - January of both experimental seasons using the equation as follow:

- Final fruit growth (either length or diameter)- Initial fruit length growth X100
- Initial fruit growth (either length or diameter)
- Besides, fruit shape was also calculated by using this equation:
- Fruit shape = Fruit length (L)/ Fruit diameter (D).

Fruit number and yield

In November of 2013 and 2014 seasons, fruit number of each tree was recorded on 7 February, of 2014 and 2015 seasons. Average fruit weight for 10 randomly selected mature fruits was estimated for each tree. Fruit yield of each experimental tree was then calculated as kg per tree or ton/Fedd.

Fruit quality

At harvest time (on 7 February,) of both seasons, fruit length, diameter, plup and rind weight and fruit weight of seven fruits, randomly taken from each experimental trees, were estimated. Fruit juice volume was also recorded, total soluble solids (TSS) was also determined by hand refractometer according to Chen and Mellenthin (1981). Acidity as citric acid percent and vitamine C was determined according to (A.O.A.C., 1995).

Generally, all previous treatments were arranged in Complete Randomized Block Design (C.R.B.D) with four replicates for each treatment. The obtained data was statistically analyzed according to Snedecor and Cochran (1990). Means were separate dusing LSD method at 0.05 level by Gomez and Gomez (1984).

Results and Discussion

Effect of foliar spray of benzyladenine, dry yeast extract and potassiumsolution on fruit set number per branch

Data presented in Table 2 clearly indicated that, in both seasons, trees sprayed with combination of BA at 40 ppm plus yeast 0.4% plus K 0.4% gave significantly the highest number of fruit set per branch, compared with other treatments including control. This result hold valid through the three dates used for fruit set counts, on 19th of both April and May on 30 June, during both seasons of study. Meanwhile, Valencia orange trees sprayed with dry yeast extract at 0.2%, as well as sprayed with combination of BA20 ppm + yeast 0.2%+ K 0.2%, also increased number of set fruit per branch during both April and May months in both seasons of study and statistically followed in descending order a superior treatment of (BA 40 ppm + yeast 0.4%+ K 0.4%).

TABLE 2. Effect of foliar application of benzyladenine, dry yeast extract and potassium solution on fruit set number/ branch of Valencia orange trees during 2013/2014 and 2014/2015 of both experimental seasons.

Treatments	First season (2013/2014)			Second season (2014/2015)		
	Number of fruit set / branch			Number of fruit set /branch		
	April, 19	May, 19	June, 30	April, 19	May, 19	June, 30
Control (water spray)	52.50 ^{c}	15.80 ^{e}	4.00 ^{e}	65.63 ^{d}	21.13 ^{ef}	6.38 ^{g}
Benzyladenine at 20 ppm	57.25 ^{c}	15.00 ^{e}	6.00 ^{d}	82.88 ^{c}	22.63 ^{de}	11.00 ^{c}
Benzyladenine at 40 ppm	56.13 ^{c}	35.25 ^{d}	8.00 ^{c}	96.88 ^{b}	26.00 ^{cd}	10.75 ^{c}
Dry yeast at 0.2 %	98.50 ^{b}	47.80 ^{b}	4.50 ^{de}	99.25 ^{b}	38.38 ^{b}	6.88 ^{fg}
Dry yeast at 0.4 %	87.00 ^{b}	16.50 ^{e}	5.50 ^{de}	66.25 ^{d}	23.75 ^{de}	8.00 ^{ef}
Potassium at 0.2 %	54.38 ^{c}	48.00 ^{b}	10.50 ^{b}	64.88 ^{d}	17.38 ^{f}	9.00 ^{de}
Potassium at 0.4 %	42.88 ^{c}	40.00 ^{c}	9.00 ^{bc}	64.38 ^{d}	28.25 ^{cd}	13.00 ^{ab}
BA 20 ppm + yeast 0.2% + K0.2%	87.00 ^{b}	45.00 ^{b}	5.50 ^{de}	88.00 ^{bc}	36.25 ^{b}	11.63 ^{bc}
BA 40 ppm + yeast 0.4% + K0.4%	162.63 ^{a}	61.80 ^{a}	18.00 ^{a}	125.38 ^{a}	45.38 ^{a}	14.25 ^{a}
L. S. D at 0.05	22.96	11.57	1.55	11.57	4.85	1.46

* Means within each column with the same letter are not significantly different .

The differences were big enough to be significant. In most cases, if not all, spraying with benzyladenine at 20 ppm, in both seasons, produced the lowest number of fruit set / branch and this treatment was almost similar with that of the control (Table 2). This result was valid through three fruit set counting dates, in both experimental seasons. The results are in agreement with the finding of Khafagy *et al*. (2010) on Navel orange tree, who found that tree sprayed with

combination of 0.5% zinc sulfate +0.4% yeast extract, in both seasons, gave significantly the highest number of setting fruits and highest number of fruits per tree. Moreover, Thanaa *et al.* (2015) on Manzanillo olive trees, they reported that foliar application with dry yeast extract at 40g/L + benzyladenine at 60 ppm /tree recorded the highest significant values of percentage of fruit set (11.49 and 14.25) in both seasons, respectively, followed by dry yeast extract at 40g/L/ tree (9.14 and 11.37). Whereas, control treatment recorded the lowest percentage of fruit set in this respect, since it gave (4.75 and 5.06%) in the first and second seasons, respectively. In addition, Sanz *et al.* (1987) stated that fruit set has been correlated to some extent with mineral levels in the leaves during the time of fruit set especially potassium represented a limiting factor for fruit set. Hafez *et al.* (2007) studied the influence of foliar spray with (Zinc at 0.4% in the form of Chelate, Potassium at 1% in the form of Salent liquid, Zinc + potassium and control which sprayed with tap water).They found that the number of fruit set and number of fruits/ tree were increased with foliar application of potassium. On the contrary, Guardiola *et al.* (1993) working on Citrus unshiu to study effect of hormone treatments (both GA and BA) they reported that the hormone treatments had no effect on fruit set, which ranged between 80 and 84%, irrespective the time of application.

Effect of foliar spray with benzyladenine, dry yeast extract and potassium solution on average fruit length

The obtained data in Table 3 revealed that, most of treatments achieved significantly increased in an average fruit length during both experimental seasons as compared with water spray control treatment, except, in the first season, potassium solution treatment at 0.2% in September, as well as, a combination of (BA 20 ppm+ yeast 0.2% +K 0.2%) during September and October, gave significantly the lowest values of average fruit length as compared with control treatment. Similarly, in the second one, tree sprayed with benzyladenine at 40 ppm, dry yeast extract at 0.2%, on November,10^{th} and the combination of (BA 40 ppm + yeast 0.4% + K 0.4%), on 10^{th} September, caused a significant lowest values of fruit length compared with other treatments and the control. Besides, benzyladenine treatments at 40 ppm, as well as, dry yeast extract at 0.2% through September, October and December, in the second season, have almost similar average fruit length as those of the control treatment and the differences were not statistically significant (Table 3).

Valencia orange trees sprayed with a mixture of (BA40ppm + yeast 0.4% + K0.4%), in the first season, gave the highest values in average fruit length compared with other treatments including control trees and the differences were enough to be significant. Likewise, spraying trees with 20ppm benzyladenine, in the second one, during July, August and September, as well as, 0.4% active dry yeast extract treatment in November, December and January, as well as, spraying with 0.2% potassium solution through October, November and January, addition trees sprayed with a mixture of (BA20ppm + yeast 0.2% + K 0.2%), in the second season, gave the highest values of average fruit length compared with the

other treatments and control. This result was valid during July, November, December and January and data supported with significant differences.

TABLE 3. Effect of foliar application of benzyladenine, dry yeast extract and potassium solution on fruit length of valencia orange trees during 2013/2014 and 2014/2015 experimental seasons.

Treatments	First season (2013/2014)							Second season (2014/2015)						
	Fruit length (cm)							Fruit length (cm)						
	July, 10	August, 10	Sept., 10	Oct., 10	Nov., 10	Dec., 10	Jan., 10	July, 10	August, 10	Sept., 10	Oct., 10	Nov., 10	Dec., 10	Jan., 10
Control (water spray)	3.29 g	4.49 e	5.61 c	5.87 de	6.12 d	6.46 e	6.56 g	3.93 f	4.40 e	5.15 d	5.53 d	5.98 d	6.03 e	6.22 e
Benzyladenine	3.82 b	5.10	5.69	6.04	7.06 a	7.31 a	7.58 b	4.32 a	5.34 a	5.84 a	6.11 b	6.31 c	6.31 d	6.60 cd
Benzyladenine	3.51 de	5.05	5.83 a	6.31 a	6.97 a	7.34 a	7.72 a	4.05 de	4.66 d	5.04 de	5.37 d	5.65 e	6.07 e	6.49 d
Dry yeast at 0.2	3.43 ef	5.06	5.71	6.13 bc	6.78 b	7.17 b	7.38 c	4.04 e	4.63 d	5.04 de	5.40 d	5.76 e	6.04 e	6.47 d
Dry yeast at 0.4	3.59 c	5.24 ab	5.81 ab	5.95 de	6.51 c	6.80 c	7.00 e	4.17 c	4.86 c	5.41 c	6.05 b	6.59 ab	6.74 a	6.91 a
Potassium at 0.2	3.65 c	4.92 cd	5.16 e	6.02 cd	6.67 b	6.65 d	7.15 d	4.08 d	4.86 c	5.32 c	6.31 a	6.64 a	6.47 cd	6.84 a
Potassium at 0.4	3.50 de	4.89 d	5.65 bc	6.14	6.52 c	6.77 cd	7.12 d	4.22 b	5.15 b	5.65 b	5.90 c	6.46 bc	6.38 cd	6.83 ab
BA 20 ppm + yeast 0.2% +	3.33 fg	5.07 bcd	5.40 d	5.80 e	6.22 d	6.49 e	6.82 f	4.30 a	4.88 c	5.14 d	6.15 b	6.54 ab	6.68 ab	6.83 ab
BA 40 ppm + yeast 0.4% +	3.95 a	5.27 a	5.86 a	6.20 ab	6.67 b	6.88 c	7.18 d	3.94 f	4.68 d	4.98 e	5.88 c	6.34 c	6.55 bc	6.67 bc
L. S. D at 0.05	0.12	0.19	0.18	0.17	0.13	0.13	0.10	0.03	0.15	0.13	0.15	0.18	0.18	0.16

* Means within each column with the same letter are not significantly different.

These results are in agreement with the finding of Khafagy *et al*. (2010) working on Washington Navel orange trees, who found that foliar spray with a combination of Zinc sulphate (Zn So_4) with yeast extract at either 0.2% or 0.4% proved to be the most efficient combination in improving fruit length, in both seasons of study. Moreover, Bakry (2007) reported that spray Jafa orange trees with yeast extract improved fruit physical properties including fruit length. Likewise, Thanaa *et al.* (2015) on olive trees found that fruit length character was significantly affected by all applications (foliar application with dry yeast extract at 40g/L+ benzyladenine at 60 ppm/tree) gave highest fruit length. On the other hand, control treatment gave the lowest values in the respect. Lorenzo *et al.* (2007) in Spain, working on Kiwifruit found that the combination of three growth regulators (2, 4-D, CPPU (ascytokinin) and GA_3) applied 43 day after full bloom (25, 50 and 10mg/kg, respectively), increase fruit size but fruit shape did not change. While application of CPPU alone produced smaller fruit size They added that the combination of CPPU + 2, 4-D were the treatment which most increased fruit length and diameter. Furthermore, Guardiola *et al*. (1993) discussed the effect of exogenous growth regulators on fruit development of

citrus Unshiu, they stated that gibberellin and /or cytokinin requirements for cell division may decrease as the fruit grows and it required higher GA or BA concentrations at flowering than several weeks later. They concluded that auxins on one hand, and cytokinins and gibberellins on the other hand, act on different fruit tissues, which explains their different effect on final fruit size. Finally, Ali *et al*. (2015) in Egypt, working on Washington Navel orange trees, reported that foliar spray with potassium sulfate (K_2SO_4) at 3% gave the highest values of average fruit length and average fruit volume, and these values were significant as compared with the control.

The surge in fruit length and fruit size due to potassium application to citrus trees was reported by Rattanpal *et al.* (2008) on Kinnow mandarin, Quaggio *et al. (*2002) in Brazil on Sicilian lemon and Boman, (2001) in Florida on Valencia orange as well as Boman, (2002) on "Sunburst" Tangarin.

Effect of foliar sprays with benzyladenine, dry yeast extract and potassiumsolution on average fruit diameter

The effect of different foliar sprays with benzyladenine, dry yeast and potassium solution on the fruit diameter of Valencia orange seemed to be significantly differed from one season to another, as shown in Table 4. In general, all foliar spray treatments increased average fruit diameter as compared with control treatment through seven dates recorded fruit diameter (July, August, September, October, November, December and January) in both experimental seasons. The only exceptional cases were dry yeast extract treatment at 0.2%, in the second season, which gave the lowest values of fruit diameter and similar to that of the control but the differences were not big enough to be significant. Similarly, the combination treatment of (BA 20ppm + yeast 0.2% + K 0.2%) during September, October in the first season, as well as, spraying trees with 0.2% or 0.4 of active dry yeast extract, through Sept., Oct., Nov. and Dec., in the second one, additional, foliar spray treatment with a mixture of (BA 40ppm + yeast 0.4% + K 0.4%) during July, October and November. Also, in the second season, fruit diameter was almost similar with that of the control and the differences were not statistically significant (Table 4).

Noteworthy, trees sprayed with a combination of (BA 40 ppm + yeast 0.4% + K 0.4%) produced fruits with the highest diameter compared with water spray control treatment, particularly in the first season, and the difference was high enough to be significant. This result was valid on all seven measuring dates. While, in the second one, trees sprayed with potassium solution alone at 0.4% gave the highest fruit diameter on all measuring dates when compared with the control treatment and the differences were significant. As well as, benzyladenine treatment at 20ppm in August and September and dry yeast extract treatment at 0.4% on 10 Decemberand 10 January, also, in the second season, markedly increased fruit diameter when compared with the control and the differences were high enough to be statistically significant (Table 4).

TABLE 4. Effect of foliar application with benzyladenine, dry yeast extract and potassium solution on fruit diameter of valencia orange trees during 2013/2014 and 2014/2015 of both experimental seasons.

Treatments	First season (2013/2014)							Second season (2014/2015)						
	Fruit diameter (cm)							Fruit diameter (cm)						
	July, 10	Aug., 10	Sept., 10	Oct., 10	Nov., 10	Dec., 10	Jan., 10	July, 10	Aug., 10	Sept., 10	Oct., 10	Nov., 10	Dec., 10	Jan., 10
Control (water spray)	3.46 e	4.15 f	5.18 e	5.63 f	6.15 e	6.43 g	6.59 f	3.80 cd	4.12 g	4.72 f	5.33 e	5.74 ef	5.85 e	6.12 d
Benzyladenine at 20 ppm	4.19 b	4.77 de	5.35 bcd	5.85 cde	6.50 ab	6.99 b	7.19 ab	4.02 b	4.91 ab	5.34 ab	5.88 b	6.21 b	6.34 bc	6.53 b
Benzyladenine at 40 ppm	3.92 c	4.72 e	5.43 ab	5.88 bcd	6.45 b	6.80 c	7.21 a	3.93 bc	4.64 de	5.04 cd	5.53 d	5.91 cd	6.09 d	6.28 c
Dry yeast at 0.2 %	3.90 c	4.92 bc	5.41 abc	5.75 def	6.45 b	6.72 cd	7.06 c	3.73 d	4.47 f	4.84 ef	5.30 e	5.66 f	5.91 e	6.31 c
Dry yeast at 0.4 %	3.87 cd	4.88 bcd	5.50 ab	5.92 bc	6.32 cd	6.57 ef	6.77 e	3.77 d	4.56 ef	5.01 d	5.58 cd	6.16 b	6.62 a	6.83 a
Potassium at 0.2 %	3.74 d	4.68 e	5.26 cde	5.74 def	6.02 f	6.47 fg	6.96 cd	3.92 bc	4.74 cd	5.19 bc	5.82 b	5.97 c	6.23 c	6.32 c
Potassium at 0.4 %	3.89 c	4.82 cde	5.46 ab	6.00 ab	6.40 bc	6.64 de	6.85 de	4.12 a	5.01 a	5.39 a	6.12 a	6.53 a	6.65 a	6.75 a
BA 20 ppm + yeast 0.2% + K0.2%	4.06 b	4.97 ab	5.21 de	5.73 ef	6.28 d	6.51 fg	7.08 bc	3.82 cd	4.83 bc	5.00 de	5.73 bc	6.12 b	6.35 b	6.60 b
BA 40 ppm + yeast 0.4% + K0.4%	4.39 a	5.07 a	5.56 a	6.07 a	6.56 a	7.20 a	7.28 a	3.80 cd	4.58 ef	4.92 de	5.34 e	5.85 de	6.41 b	6.54 b
L. S. D at 0.05	0.14	0.15	0.15	0.14	0.10	0.12	0.12	0.15	0.15	0.16	0.15	0.11	0.10	0.12

* Means within each column with the same letter are not significantly different.

The results agree with those obtained by Lorenzo *et al*. (2007), Lema *et al*. (2003) and Augusuti and Almela (1993), worked on Kiwifruit and citrus, they stated fruit cell division and expansion , therefore growth are controlled by endogenous hormones, so plant growth regulators have been applied to improve fruit size. They found that foliar application with CPPU (N-(2-chloro-4-pyridyl)-N-phenyl urea) as a cytokinin, 2, 4-D or GA_3 (as auxin) applied alone or in combination at 43 days after full bloom(at 50, 25and 10 mg/ kg), respectively, increased fruit size, but the combination of CPPU + 2,4D was efficient treatment to increase fruit length and diameter. They also added that this effect has also been observed in citrus. Moreover, Khafagy *et al*. (2010) using Navel orangetrees, found that spraying trees with 0.4% yeast extract alone or combined with 1.0% zinc sulfate was more effective in improving total yield besides increasing fruit volume (length and diameter) as compared with the control. In

addition, Thanaa *et al*. (2015) working on olive trees, found that trees sprayed twice at full bloom stage and two weeks later with dry yeast extract at 40g/L and benzyladenine at 60ppm, each alone or in combination besides control (spraying with water only) are recommended for improving fruit length and diameter as well as other fruit quality properties.

The increment in fruit size, particularly, fruit diameter due to potassium foliar application to citrus trees was reported by many investigators such as, Miller *et al*. (1998), Boman (2001), Ali and Gobran (2002), El-Fangary (2004), Gill *et al*. (2005), Abd-Alla (2006), Sangwan *et al.* (2008) and Rattanpal *et al*. (2008) and Ali *et al*. (2015).

Effect of foliar spray with benzyladenine, dry yeast extract and potassium solution on the length fruit growth rates

The results shown in Table 5, generally revealed that, no clear trend regarding length growth rate of fruits seemed to be differed significantly, differed from one month to another during measuring dates. Nevertheless, in most cases, all foliar sprays experimenting here participated to raise length growth rates, except those of Valencia orange trees sprayed with 20ppm benzyladenine and a mixture of (BA 40 ppm+ yeast 0.4%+ K 0.4%) during July -August, Nov.-Dec. and July - Jan. which gave the lowest value in length fruit growth rates, and almost similar with of the control, particularly in the first season. Besides, dry yeast extract treatment either 0.2% or 0.4% on during Dec. and Jan., produced fruits were smallest in length rate when compared with water spray control treatment, and the difference was statistically significant. While, in the second one, trees sprayed with 40 ppm benzyladenine and 0.2% yeast extract on July and Aug. as well as on Sept. - Oct., gave the least values in this respect and were almost similar with of the control, and the differences was not significant. Similar trend was also noticed when trees sprayed with a mixture of (BA20 ppm + yeast 0.2% + K 0.2%) on July - Aug. and Dec. and Jan. in the second one and the difference between this treatment and the control was not high enough to be significant (Table 5).

On the other hand, Valencia orange trees sprayed with benzyladenine at 40ppm on July - Aug., Nov. - Dec., Dec. - Jan. and July - January, in the first season, and on Nov- Dec. and Dec.- Jan. in the second one, gave the highest significantly in their fruit length growth rate when compared with the control. Likewise, yeast extract treatment at 0.2% on July -August, July- Jan. in the first season and Nov. - Dec., in the second one was the most efficient treatment for increasing length growth rate of fruits when compared with the control. Moreover, potassium spray treatment at 0.2%, also, gave the same trend as that of the yeast treatment at 0.2%, this was clear during Sept.-Oct. and Dec.-Jan. in 2013/ 2014 season, and Sept.-Oct. in 2014/2015 season. Highly significant differences were noticed among these foregoing treatments and the control as shown in Table 5.

TABLE 5. Effect of foliar application with benzyladenine, dry yeast extract and potassium solution on the length fruit growth rates of valencia orange trees during 2013/2014 and 2014/2015 of both experimental seasons.

Treatments	First season (2013/2014)					Second season (2014/2015)				
	Length fruit growth rates (%)					Length fruit growth rates (%)				
	During July-Aug	During Sept.-Oct	During Nov.-Dec.	During Dec.-Jan.	During July-Jan.	During July-Aug	During Sept.-Oct	During Nov.-Dec.	During Dec.-Jan.	During July-Jan.
Control (water spray)	36.73^{cd}	3.53 ^{d}	3.54 ^{cd}	4.33 ^{abc}	97.93 ^{cd}	15.42 ^{cd}	6.42 ^{de}	0.85 ^{d}	1.90 ^{e}	52.74 ^{c}
Benzyladenine at 20 ppm	33.28 ^{d}	6.34 ^{c}	3.62 ^{cd}	3.75 ^{bcd}	95.00 ^{d}	23.81 ^{a}	9.44 ^{c}	2.08 ^{c}	4.94 ^{b}	58.58 ^{b}
Benzyladenine at 40 ppm	44.10 ^{ab}	8.34 ^{b}	7.42 ^{a}	4.52 ^{ab}	110.46^{ab}	15.47 ^{cd}	6.55 ^{d}	5.06 ^{a}	7.32 ^{a}	60.95 ^{b}
Dry yeast at 0.2 %	48.63 ^{a}	7.42 ^{bc}	5.85 ^{b}	3.00 ^{d}	116.54^{a}	15.32 ^{cd}	7.10 ^{d}	4.77 ^{a}	5.30 ^{b}	60.89 ^{b}
Dry yeast at 0.4 %	46.65 ^{a}	2.48 ^{d}	4.62 ^{c}	3.09 ^{cd}	96.73 ^{cd}	16.51 ^{bc}	12.21 ^{b}	2.32 ^{c}	2.61 ^{de}	66.15 ^{a}
Potassium at 0.2 %	35.00 ^{d}	11.92 ^{a}	1.36 ^{e}	5.27 ^{a}	108.08^{b}	19.28 ^{b}	18.80 ^{a}	0.82 ^{d}	3.88 ^{bcd}	67.79 ^{a}
Potassium at 0.4 %	40.19 ^{bc}	8.62 ^{b}	3.96 ^{cd}	5.19 ^{a}	81.90 ^{e}	24.08 ^{a}	4.25 ^{e}	2.61 ^{bc}	3.10 ^{cde}	61.88 ^{b}
BA 20 ppm + yeast 0.2% + K0.2%	44.77 ^{ab}	7.42 ^{bc}	4.34 ^{c}	4.40 ^{ab}	92.38 ^{d}	13.68 ^{d}	20.08 ^{a}	2.16 ^{c}	2.42 ^{de}	59.18 ^{b}
BA 40 ppm + yeast 0.4% + K0.4%	33.61 ^{d}	6.75 ^{c}	3.08 ^{d}	4.37 ^{ab}	104.32 ^{bc}	18.64 ^{b}	18.83 ^{a}	3.54 ^{b}	4.39 ^{bc}	69.13 ^{a}
L. S. D at 0.05	4.78	1.26	1.09	1.24	7.60	2.77	2.25	0.89	1.62	4.09

* Means within each column with the same letter are not significantly different .

Foliar application with a combination of (BA 20PPm + yeast 0.2% + K 0.2%) as well as (BA 40ppm + yeast 0.4% + K 0.4%) gave significantly higher length fruit growth rates than that of the control. This was valid during Dec. - Jan. measuring date, in the first season, and also, on Sept.-Oct. and July- Jan. in the second season. The results from Table 5 generally indicated that both benzyladenine at 40 ppm and dry yeast extract treatments at 0.2% during July – August and July- January, in the first season, produced the highest in the length growth rates of their fruits and were as much as 1.13 and 1.19 fold as compared to the control treatment. However, in the second one, 0.4% dry yeast extract, Potassium solution at 0.2% and the combination of (BA 40 ppm + yeast 0.4% + K 0.4%) treatments, gave the highest in length growth rates and were as high as 1.25, 1.29 and 1.31 folds, respectively, when compared with the control during July and January.

In accordance with these results those reported by numerous other investigators. Khafagy *et al.* (2010) and Bakry (2007), using Navel orange and Jafa orange trees, respectively, who reported that trees sprayed with yeast extract at either 0.2 or 0.4% increased volume and improved other physical fruit properties. Thanaa *et al.* (2015) using olive trees, they concluded that spring trees with 40g/L yeast extract plus 60 ppm/ tree benzyladenine followed by spraying with yeast extract at 40g/L/tree alone lead to increase physical fruit properties, including fruit growth rates and final fruit size.

In addition some scientists explained on scientific basis, how phytohoromones caused an increment in fruit growth rate, length or diameter, in this concern, Badou and Lavania (1985), Rajput and Babu (1985), working on lemon trees, Lakso (1994), Emongor and Murr (2001) and Barbara and Matej (2010), on apple trees. They reported that fruit growth rates after bloom is dependent in large part on photosynthesis supplied by spur leaves in addition to increase of the sink ability in fruit through increasing the level of endogenous phytohoromones. They added that this could be interpreted on basis that increasing both mineral uptake and endogenous regulators in fruits act though mobilization of nutrient and other substances vitamins and phytohoromones from the source (leaves) to skin (fruit), leading to increase fruit size and fruit dry matter.

Effect of foliar sprays with benzyladenine, dry yeast extract and potassium solution on diameter fruit growth rates

Data given in Table 6 indicated that, in the both seasons, trees sprayed with a mixture of (BA 20ppm + dry yeast 0.2% + K0.2%) produced higher fruit growth rates in their diameter than the control. This was clear on all fruit diameter measuring dates and the differences were big enough to be significant. Potassium spray treatment at 0.4% gave the highest diameter fruit growth rate when compared with control, especially, on July - August and September and October in both experimental seasons. Meanwhile, trees sprayed with potassium solution at 0.2% during Nov. - Dec., in the first season, and July - August, in both seasons, showed almost similar trend as those of 0.4% potassium spray treatment. In addition, spraying trees with active dry yeast extract either 0.2% or 0.4% was also superiorin this respect July-Aug., in the first season, and Nov. -, Dec. -Jan. and July - Jan. in the second one when compared with that of the control, and the differences were statistically significant on these measuring dates. On the contrary, trees sprayed with either 20 ppm or 40 ppm benzyladenine or sprayed with a combination of (BA40 ppm + yeast 0.4% + K 0.4%) which produced fruits had a lower diameter growth rate than other treatments on most measuring dates, particularly in the second season (Table 6).

These results are in harmony with those obtained by Thanaa *et al.* (2015) who concluded that foliar application of dry yeast extract at 40g/L/tree plus benzyladenine at 60 ppm alone or combination gave the best treatments for improving fruit quality, including fruit growth rate (length and diameter) in olive trees. Moreover, Guardiolo *et al.* (1993) reported that there was direct effect of growth regulators, especially GA and BA effects on fruit tissue of *Citrus unshiu* as the primary cause of the differences in growth of fruit, and fits well with the observed effects of hormones on final fruit size. They added that juice sac enlargement makes the major contribution to fruit size at maturity. El-Tanany *et al.,* (2011) concluded that foliar sprays with potassium solution at either 0.3 or 0.6 g/L to Washington Navel orange trees during May, June and July increased fruit growth rates and leaves content of potassium.

TABLE 6. Effect of foliar application with benzyladenine, dry yeast extract and potassium solution on the diameter fruit growth rates of valencia orange trees during 2013/2014 and 2014/2015 of both experimental seasons.

Treatments	First season (2013/2014) diameter fruit growth rates					Second season (2014/2015) diameter fruit growth rates				
	During July-Aug	During Sept.-Oct	During Nov.-Dec.	During Dec.-Jan.	During July-Jan.	During July-Aug	During Sept.-Oct	During Nov.-Dec.	During Dec.-Jan.	During July-Jan.
Control (water spray)	19.94 ^{c}	3.94 ^{d}	3.10 ^{e}	3.58 ^{e}	58.02 ^{f}	12.89 ^{e}	6.65 ^{e}	1.99 ^{f}	2.20 ^{e}	61.25 ^{de}
Benzyladenine at 20 ppm	13.97 ^{d}	9.37 ^{b}	5.67 ^{c}	3.49 ^{e}	73.39 ^{d}	17.57 ^{c}	10.10 ^{cd}	2.10 ^{ef}	2.91 ^{d}	56.44 ^{e}
Benzyladenine at 40 ppm	20.77 ^{c}	8.38 ^{bc}	5.58 ^{c}	6.47 ^{bc}	85.04 ^{b}	18.81 ^{bc}	9.73 ^{d}	3.18 ^{de}	3.08 ^{cd}	63.50 ^{cd}
Dry yeast at 0.2 %	26.41 ^{a}	3.84 ^{d}	4.20 ^{d}	5.22 ^{cd}	81.55 ^{bc}	19.89 ^{bc}	9.62 ^{d}	5.25 ^{b}	5.85 ^{a}	69.45 ^{bc}
Dry yeast at 0.4 %	26.58 ^{a}	7.77 ^{c}	3.98 ^{de}	3.00 ^{e}	76.62 ^{cd}	20.97 ^{b}	11.60 ^{bc}	7.48 ^{a}	3.29 ^{c}	82.31 ^{a}
Potassium at 0.2 %	25.04 ^{ab}	9.18 ^{bc}	7.47 ^{a}	7.50 ^{b}	86.00 ^{b}	24.85 ^{a}	12.56 ^{b}	4.50 ^{bc}	1.33 ^{g}	62.08 ^{de}
Potassium at 0.4 %	24.03 ^{ab}	11.17 ^{a}	3.73 ^{de}	3.18 ^{e}	76.28 ^{cd}	24.86 ^{a}	15.78 ^{a}	1.91 ^{f}	1.49 ^{fg}	68.23 ^{bcd}
BA 20 ppm + yeast 0.2% + K0.2%	22.67 ^{bc}	9.90 ^{ab}	6.91 ^{ab}	8.86 ^{a}	108.98 ^{a}	27.04 ^{a}	14.60 ^{a}	8.76 ^{a}	4.05 ^{b}	74.95 ^{b}
BA 40 ppm + yeast 0.4% + K0.4%	15.49 ^{d}	9.16 ^{bc}	6.46 ^{bc}	4.12 ^{de}	66.01 ^{e}	20.91 ^{b}	8.57 ^{d}	3.76 ^{cd}	2.07 ^{ef}	72.94 ^{b}
L. S. D at 0.05	3.23	1.57	0.95	1.14	6.63	2.50	1.60	1.15	0.65	7.01

* Means within each column with the same letter are not significantly different.

The surgein fruit diameter growth and final fruit size due to potassium sprays was reported by Ali *et al.*, (2015), Yaseen and Ahmed (2010), Erner *et al.*, (1993) and Erner *et al.*, (2001) and Boman (2001) all found that foliar potassium sprays influence yield and fruit size of citrus trees, and improve physical properties including fruit growth rat and its size. Additional, Stern *et al.*, (2001) on "Spadona" pear, who found that synthetic cytokinin CPPU caused appreciable increases in fruit size when applied at 10- 20 ppm, two weeks after full bloom, whereas application four weeks after full bloom gave only small effect or none. Also, concluded that CPPU increased fruit size with no influence on fruit number and fruit shape.

Effect of foliar sprays with benzyladenine, dry yeast extract and potassium solution on average fruit weight, number of fruits/tree and yield of Valencia orange trees

The results shown in Table 7 revealed that, generally, in both seasons, most spraying treatments increased average fruit weight, fruit number/ tree and yield, expressed as either kilogram/tree or ton/Fedd. When compared with the control. Magnitude, that benzyladenine treatments at 40 ppm, in both seasons, gave the highest values in an average fruit weight, number of fruit/trees and fruit yield expressed as kilogram/tree or ton/Fedd. when compared with other treatments

and control (water spray only), and the differences were statistically significant. Moreover, the data concerning fruit yield (Kg/tree or ton/Feddan) obtained from the different foliar spray treatments could be arranged in the following descending order : benzyladenine spray treatment at 40 ppm, a mixture of (BA 20 ppm plus yeast extract 0.2% plus K 0.2%) and then benzyladenine at 20 ppm. This result was valid in both seasons. Meanwhile, in the first one, yeast extract spray treatment either at 0.2% or 0.4%, followed by potassium treatments at 0.2% and 0.4%.

TABLE 7. Effect of foliar application with benzyladenine, dry yeast extract and potassium solution on the number of fruits / tree, average fruit weight, fruit yield as kg/tree, fruit yield as ton/feddan and fruit shape of valencia orange trees during 2013/2014 and 2014/2015 of both experimental seasons.

Treatments	First season (2013/2014)					Second season (2014/2015)				
	Number of fruit/	Average fruit	Fruit yield	Fruit yield	Fruit shape	Number of fruit/	Average fruit	Fruit yield	Fruit yield	Fruit shape
Control (water spray)	161.50 ^{e}	209 ^{cd}	33.24^{e}	5.58 ^{e}	1.00 ^{c}	145.25 ^{d}	167 ^{cd}	24.27^{e}	4.08^{e}	1.03 ^{bc}
Benzyladenine at 20	216.25^{bcd}	224 ^{b}	48.08^{c}	5.08 ^{c}	1.06 ^{a}	247.75 ^{b}	172 ^{c}	42.73 ^{c}	7.18^{c}	1.01^{c}
Benzyladenine at 40	315.00 ^{a}	250^{a}	77.53^{a}	13.03 ^{a}	1.06 ^{a}	390.50 ^{a}	231 ^{a}	91.95 ^{a}	15.45^{a}	1.04 ^{b}
Dry yeast at 0.2 %	193.75^{de}	223 ^{b}	43.59 ^{c}	7.32 ^{cd}	1.05 ^{ab}	199.75 ^{c}	162 ^{d}	33.35^{cde}	5.60^{cde}	1.02 ^{bc}
Dry yeast at 0.4 %	231.25^{bc}	204 ^{d}	47.30 ^{c}	10.45^{b}	1.04 ^{ab}	188.50 ^{c}	191 ^{b}	35.63 ^{cd}	5.99^{cd}	1.03 ^{bc}
Potassium at 0.2 %	242.50 ^{b}	188 ^{e}	46.51 ^{c}	7.81 ^{c}	1.03 ^{b}	204.75 ^{c}	171 ^{c}	34.99 ^{cd}	5.71^{cd}	1.08 ^{a}
Potassium at 0.4 %	233.75 ^{b}	179 ^{e}	41.90 ^{cd}	7.04^{cde}	1.04 ^{ab}	187.50 ^{c}	167 ^{cd}	31.53 ^{de}	5.30^{de}	1.08 ^{a}
BA 20 ppm + yeast 0.2% + K0.2%	298.75 ^{a}	219 ^{bc}	64.06 ^{b}	10.76 ^{b}	0.96 ^{d}	271.50 ^{b}	255 ^{a}	61.17 ^{b}	10.28^{b}	1.04 ^{b}
BA 40 ppm + yeast 0.4% + K0.4%	196.25^{cde}	186 ^{e}	35.77 ^{de}	6.01 ^{de}	0.99 ^{c}	173.25^{cd}	186 ^{b}	32.28 ^{de}	5.43^{de}	1.02 ^{bc}
L. S. D at 0.05	35.42	11.68	7.01	1.51	0.02	40.87	6.97	9.63	1.61	0.02

* Means within each column with the same letter are not significantly different.

As for the effect of different foliar application on fruit shape the results in Table 7 indicated that, Valencia orange trees sprayed with benzyladenine at either 20 ppm or 40 ppm, followed yeast extract treatments at both 0.2% and 0.4% as well as potassium spray treatment at 0.4%, in the first season, gave significantly higher fruit shape when compared with other spray treatments, including the control. While, in the second, potassium spray treatment at either 0.2% or 0.4% was the best treatment in - fruit shape *i.e.* their fruits were more circularly in shape compared with that of the control in this respect, and the differences were highly significant. Besides, foliar spray with a mixture of (BA20 ppm + yeast 0.2% + K 0.2%) gave the highest number of fruit/trees, during the first season, and gave the heaviest fruits in the second one when compared with that of the control (Table 7).

The present results are in a general harmony with Thanaa *et al*. (2015) who studied the effect of foliar application with benzyladenine, dry yeast extract and their combination on yield and physical fruit properties of olive trees. They reported that, all treatments increased yield compared with the control treatment in the1st and 2nd seasons. Moreover, benzyladenine at 60 ppm/tree + dry yeast extract at 40g/L achieved the highest significant yield in the first and second season, respectively followed dry yeast extract at 40 gm/L/tree. Meanwhile, the control gave the lowest yield. They added that fruit weight and shape were significantly affected by all applications and foliar application of dry yeast extract at 40g/L + benzyladenine at 60 ppm/tree gave the highest fruit weight. Meanwhile, the lowest value of this respect was recorded by the control. Stern *et al*. (2001) using pear trees, they found that synthetic cytokinin (CPPU) when applied at 10-20 ppm, two weeks after full bloom caused appreciable increases in fruit size and its weight with no influence on fruit number and shape. They also concluded that a significant potential to improve cropping, without any negative aspects of pears.

Moreover, Khafagy *et al*. (2010), Bakry (2007) and Mohamed (2008), all working on Navel orange trees, Jafa oranges and Balady mandarin trees, respectively. They found that foliar spray with yeast extract at 0.4%significantly increased yields either as fruit number or weight per tree as compared with the control treatment and improved physical fruit properties. Additional, Abd-Elmotty *et al.* (2005) who found that spraying Keitte mango trees once at full bloom with alge at 2% combined with yeast extract at 0.2% was very effective in improving yield as number of fruits or weight (Kg) per tree compared with control. On the other hand, Stern *et al*. (2001) using pear trees, and Thanaa *et al.* (2015) working on olive trees, they stated that concerning fruit shape index (length/diameter) showed, there were no significant differences between benzyladenine or CPPU (as a cytokinin) spray treatments alone or with combination of active yeast extract and control treatment.

Effect of foliar sprays with benzyladenine, dry yeast extract and potassium solution on physical fruit properties of Valencia orange trees

The effect of foliar application with benzyladenine, dry yeast extract and potassium solution on fruit length, diameter, pulp weight, peel and fruit weights and fruit juice volume are presented in Table 8. The results indicated that, Valencia orange trees sprayed with potassium solution at 0.4%, in both seasons, gave significantly higher in all physical fruit properties mentioned above, except both pulp and fruit weights, in the first season which gave the lowest values in this respect, but the differences were not big enough to be statistically significant when compared with the control. Likewise, spraying trees with dry yeast extract at 0.2% followed by benzyladenine spraying treatment at 40 ppm , in first season, gave the highest values in all physical characteristics investigated herein compared with control treatment. These results were supported with significant differences. Moreover, potassium spray treatment at 0.4% and a mixture of (BA20 ppm + yeast 0.2% + K0.2%) spray treatment, in both seasons, caused

significantly increases in juice volume of Valencia orange fruits, as compared with the control (Table 8).

TABLE 8. Effect of foliar application with benzyladenine, dry yeast and extract potassium solution on physical fruit properties of valencia orange tree during 2013/2014 and 2014/2015.of both experimental seasons.

Treatments	First season (2013/2014)						Second season (2014/2015)					
	Fruit Length (cm.)	Fruit Diam-eter (cm.)	Pulp weight (gm.)	Peel weight (gm.)	Fruit Weight (gm.)	Fruit Juice volume (ml.)	Fruit Length (cm.)	Fruit Diam-eter (cm.)	Pulp weight (gm.)	Peel weight (gm.)	Fruit Weight (gm.)	Fruit Juice volume (ml.)
Control (water spray)	7.02 fg	6.30 c	134.71cd	56.67c	191.38c	68.44d	6.46 e	6.43 e	134.13f	38.06de	172.19e	69.69d
Benzyladenine at 20 ppm	7.62 b	7.32 ab	139.22bc	66.29b	205.51b	75.94cd	6.69 cd	6.70 cd	141.56e	41.25bc	182.81d	80.94b
Benzyladenine at 40 ppm	7.33 de	7.21 ab	158.48a	69.06ab	227.54a	75.94cd	6.37 e	6.66 d	140.00e	43.13b	183.13d	68.19d
Dry yeast at 0.2 %	7.82 a	7.35 a	167.85a	67.85ab	235.43a	92.50 a	6.72 cd	7.18 ab	141.13e	37.63e	178.75	66.88d
Dry yeast at 0.4 %	7.54 bc	7.01 ab	144.56bc	58.37c	202.93b	84.06 bc	7.11 b	6.81 c	165.94c	34.69f	200.63c	81.25b
Potassium at 0.2%	6.86 g	7.12 ab	144.22bc	57.37 c	201.59b	74.69 d	6.61 d	6.50 e	140.81e	38.19de	179.00	74.69c
Potassium at 0.4%	7.84 a	6.87 b	126.79 d	70.78 a	197.57b	85.31ab	7.32 a	7.27 a	190.69a	48.06a	238.75a	90.63a
BA 20 ppm + yeast 0.2% + K0.2%	7.42 cd	7.14 ab	147.09bc	58.95 c	206.04b	90.94 a	7.08 b	7.07 b	173.50b	40.56 bcd	214.06b	86.94a
BA 40 ppm + yeast 0.4% + K0.4%	7.20 ef	7.13 ab	127.21 d	66.95b	194.16bc	54.38 e	6.76 c	6.75 cd	156.25d	39.69 cde	195.94c	75.63c
L. S. D at 0.05	0.19	0.47	10.46	3.67	11.98	8.30	0.13	0.13	5.37	2.89	7.14	4.73

* Means within each column with the same letter are not significantly different.

The results obtained herein seemed to be in general agreement with those reported by Mostafa *et al*. (2005) showed that the best results with regard to fruit weight of Balady mandarin trees were observed owing to spraying KNO_3 at 2% alone or combined with GA_3 at 10 ppm two times per year. Sangwan *et al*. (2008) reported that foliar sprays with potassium nitrate three times increased fruit size (length and diameter) of Kinnow mandarin, thereby enhancing the "A" grade fruits compared to the control. They added that 2% potassium nitrate treatment was most effective in this regard. Similarly, El-Tanany *et al*. (2011) who found that Washington Navel orange trees sprayed with either 0.3 or 0.6g/L. Potassium solution, gave the highest fruit length and diameter, especially in the second season, also, these treatments increased significantly juice volume of fruits. Moreover, Ali *et al*. (2015) reported that foliar application with K_2SO_4 at either 2% or 3% on Washington Navel orange tree, in both seasons, gave the

highest values of average fruit volume, average fruit diameter and average fruit length and these values were significant as compared with control. Beside, Abd El-Rahman *et al.* (2012) found that foliar spray with potassium nitrate on Washington Navel orange trees increased fruit size as compared with control especially with high concentration of KNO_3 in both seasons of study. Noteworthy, Thanaa *et al*., (2015) working on Manzanello olive trees, their results indicated that foliar application with yeast extract at 40g/L plus benzyladenine at 60 ppm/tree followed by dry yeast extract at 40g/L/tree leads to increase in fruit physical properties, (fruit weight, length, diameter and fruit flesh weight) compared to the control. They attributed this response to the role of these materials as a stimulate for dry mass production through enhancement of cell division.

Effect of foliar sprays with benzyladenine, dry yeast extract and potassium solution on chemical fruit properties of Valencia orange trees

Results concerning total soluble solids percentages of Valencia orange fruits are represented in Table 9 indicated that spraying trees with active dry yeast extract at 0.2%, in both seasons, significantly increased total soluble solids content in fruit juice, followed in descending order by a combination of (BA20 ppm + yeast 0.2% + K 0.2%) treatment as comparing with control. Besides, in the first season, trees sprayed with dry yeast extract at 0.4% and potassium solution spray treatment at 0.4%, exerted slight increase in total soluble solids content when compared with the control, but the difference was not high enough to be significant.

TABLE 9. Effect of foliar application with benzyladenine, dry yeast extract and potassium solution on chemical fruit properties of valencia orange trees during 2013/2014 and 2014/2015 of both experimental seasons.

Treatments	First season (2013/2014)			Second season (2014/2015)		
	Total soluble solids (TSS) (%)	Acidity (%)	Vitamin C (mg/100 ml juice)	Total soluble solids (TSS) (%)	Acidity (%)	Vitamin C (mg/100 ml juice)
Control (water spray)	11.13 bc	1.32 d	37.41 e	10.88 f	1.50 d	39.22 g
Benzyladenine at 20 ppm	10.88 cd	1.44 ab	39.96 cd	11.13 de	1.68 c	41.27 def
Benzyladenine at 40 ppm	11.13 bc	1.40 abc	40.03 cd	11.63 c	1.34 e	40.11 fg
Dry yeast at 0.2 %	11.50 a	1.44 ab	40.29 c	12.50 a	1.90 b	42.39 cd
Dry yeast at 0.4 %	11.25 ab	1.35 cd	41.37 b	11.30 d	1.69 c	44.36 ab
Potassium at 0.2 %	11.13 bc	1.19 e	34.34 g	11.13 de	1.89 b	40.56 efg
Potassium at 0.4 %	11.38 ab	1.15 e	35.22 f	11.00 ef	1.70 c	41.74 cd
BA 20 ppm + yeast 0.2% + K0.2%	11.25 ab	1.37 bcd	46.79 a	11.90 b	1.89 b	44.72 a
BA 40 ppm + yeast 0.4% + K0.4%	10.63 d	1.46 a	39.42 d	11.00 ef	2.05 a	42.85 bc
L. S. D at 0.05	0.26	0.07	0.70	0.24	0.07	1.51

* Means within each column with the same letter are not significantly different.

Increasing T.S.S. of citrus fruits due to active dry yeast extract and potassium foliar sprays was reported by Khafagy *et al.* (2010) who found that spraying trees with 0.4% or 0.2% yeast extract alone or combined with 1.0% zinc sulfate, recorded the highest values of fruit quality resembled by increasing total soluble solids and other chemical fruit properties of Washington Navel orange. Besides, Mohamed (2008) and Bakry (2007) who found that spraying yeast extract increased TSS and TSS/acid ratio of Balady mandarin and Jafa orange, respectively. Ali *et al.* (2015) working on Washington Navel orange, reported that spraying with potassium sulfate at 1,2 and 3% were very effective in improving total soluble solid content (TSS) of fruit juice rather than control. Meanwhile, Gill *et al*. (2005) using Kinnow mandarin, concluded that all foliar fertilizer treatments containing potassium (K), significantly increased total soluble solids content in fruit juice. Similarly, Boman (2001) on Valencia orange trees concluded that three foliar applications per year of KNO_3 were effective in increasing total solids and gave more fruits with larger size than control.

As for the effect of different foliar application treatments on juice acidity Results in Table 9 revealed that, in both seasons, trees sprayed with a combination of (BA 40ppm + yeast 0.4% + K 0.4%) significantly increased fruit juice acidity as compared with other treatments and the control. Noteworthy, both spraying treatments, benzyladenine at 20 and 40ppm as well as spraying trees with dry yeast extracted 0.2% in the first season, also raised juice acidity of Valencia orange fruits when compared with the control. The differences among these treatments and the control were big enough to be statistically significant (Table 9).

These results disagree with those reported by Khafagy *et al*. (2010), Mohamed (2008) and Bakry (2007), working on citrus trees, who found that spraying trees with 0.4% yeast extract alone or combined with zinc sulphate, in both seasons, recorded the lowest juice acidity contents compared with a high acid content of the control and improved fruit chemical properties. On the other hand , Ali *et al*. (2015) reported that foliar application with potassium sulphate with high concentrations led to significant decreases in the juice acidity percentage of Washington Navel orange fruits compared to the control treatment. On the contrary, Erner *et al*. (2001) stated that the most serious disadvantage of potassium is direct and strong link with juice acidity and concluded that it is not known how the K level affects the accumulation or degradation of acid in citrus fruits. Therefore some varieties (Star Ruby & Mineola tangelo) tend to have high acid levels consequently are not recommended to have high K level.

The results shown in Table 9 revealed that, in both seasons, vitamin C in fruits juice of trees sprayed with a mixture of (BA 20 ppm + yeast 0.2%+ K 0.2%) was significantly higher than that of other spraying treatments and the control, followed in descending order by 0.4% dry yeast extract spraying treatment and the differences between these treatments and the control were statistically significant. In accordance with this result those reported by numerous other investigators. Khafagy *et al*. (2010) reported that the highest significant values of fruit juice

ascorbic acid were obtained when Navel orange trees were sprayed with yeast (0.4%) + Zn SO_4 (1.0%) treatment as compared with other treatments and the control. Moreover, Mohamed (2008) and Bakry (2007) who found that spraying yeast extract increased vitamin C content in fruit juice of Balady mandarin and Jafa orange trees, respectively. Ali *et al*. (2015) concluded that Washington Navel orange trees sprayed with potassium sulphate at either 2% or 3% were very effective treatments in improving vitamin C content in fruit juice rather control. Similarly, Rattanpal *et al*. (2008) working on Kinnow mandarin, reported that foliar application of potassium increased vitamin C content.

Effect of foliar sprays with benzyladenine, dry yeast extract and potassium solution on leaf nitrogen, phosphorus and potassium of Valencia orange trees

The results of Table 10 showed that all foliar spraying treatments, generally resulted in increase leaf total nitrogen content compared with that of the controlin both seasons. However, leaf collected from trees sprayed with a mixture of (BA 20ppm + yeast 0.2% + K0.2%), as well as, sprayed with potassium solution at 0.4%, in both seasons, were markedly higher in leaf nitrogen content than that of other treatments including the control.

TABLE 10. Effect of foliar application with a combination of (benzyladenine plus yeast plus potassium) and potassium solution alone on leaf Nitrogen, phosphorus and potassium content of valencia orange trees during 2013/2014 and 2014/2015 of both experimental seasons .

Treatments	First season (2013/2014)			Second season (2014/2015)		
	Total Nitrogen N (%)	Phosphorus P(%)	Potassium K (%)	Total Nitrogen N(%)	Phosphorus P(%)	Potassium K (%)
Control (water spray)	1.38 C	0.224c	0.650d	1.63c	0.203d	0.775b
BA 20 ppm + yeast 0.2% + K0.2%	2.50 a	0.270b	0.823b	2.84a	0.278c	0.950a
BA 40 ppm + yeast 0.4% + K0.4%	2.11 b	0.272b	0.710c	2.11b	0.292bc	0.778b
Potassium 0.2%	2.21 b	0.309a	0.873a	2.02b	0.300ab	0.885a
Potassium 0.4%	2.45 a	0.301ab	0.840b	2.42a	0.313a	0.930a
L. S . D at 0.05	0.23	0.033	0.032	0.26	0.017	0.065

*Means within each column with the same letter are not significantly different.

Concerning phosphorus content, the results in Table 10 indicated that, also, all spraying treatments markedly increased leaf phosphorus content compared with the control. Moreover, spraying trees with potassium solution at either 0.2% or 0.4%, in both seasons, significantly raised phosphorus content in their leaves compared with other treatments and the control.

As for leaf potassium content, in general all spraying treatments markedly increased leaf potassium content when compared to the control and the

differences were significant (Table 10). Noteworthy, potassium spray at 0.2%, in both seasons, resulted in increases in leaf potassium content compared with that of the control. In the second season, however, foliar spray with potassium liquid solution at either 0.2% or 0.4% and a combined treatment of (BA 20ppm + yeast 0.2% + K 0.2%) were markedly higher in leaf potassium content than that of other treatments including the control. Increased leaf potassium of citrus leaves when the trees sprayed with potassium solution was reported by Boman (2002 & 2001), Abd-Allah (2006) and El-Tanany *et al*. (2011).

Conclusion

From the results of the present study, it can be concluded that foliar application with benzyladenine at 40 ppm resulted in a high number of fruits/tree, average fruit weight and fruit yield and increased the length growth rate of Valencia orange fruits and contributed with dry yeast extract at 0.2% to improve physical fruit properties of Valencia orange. Moreover, spraying trees with a mixture of (BA 40 ppm + yeast 0.4% + K 0.4%) was the efficient treatment for increasing length and diameter growth rates of fruits and contributed to improve final fruit size of Valencia orange fruits, especially budded on sour orange rootstock. This treatment, also improved fruit chemical properties.

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تأثير الـــرش الورقـــى بالسيتوكينين والخميره الجافه النشطه والبوتاسيوم على حجم ومحصول وجودة الثمار والتركيب المعدنى لأوراق أشجار البرتقال الصيفى

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أجريت هذه التجربة خلال موسمي ٢٠١٣/ ٢٠١٤، ٢٠١٤/٢٠١٥ فى بستان خاص بمنطقة شرنوب - محافظة البحيره- مصر وذلك بهدف دراسه تأثير الرش الورقي بالبنزيل أدنين (ب أ) ومستخلص الخميرة الجافه ومحلول البوتاسيوم على حجم الثمار والمحصول وجودة الثمار والمحتوى المعدني لاوراق أشجار البرتقال الصيفى المطعم على أصل النارنج. وكانت المعاملات على النحو التالي :

- كنترول (رش بالماء فقط)
- المعاملتين أرقام ٢ ،٣ استخدام البنزايل ادنين رشا بتركيزين ٢٠، ٤٠ جزء فى المليون.
- المعاملتين ٤، ٥ وهى استخـدام مستخلص الخميره الجافـه رشا بتركيزين ٠.٢ ٪ أو ٠.٤٪ .
- المعاملتين ٦،٧ وهى أستخدام محلول البوتاسيوم بتركزين ٠.٢ ٪ و ٠.٤ ٪ .
- المعاملتين ارقام ٨،٩ وهى عباره عن اشجار تم رشها بمخلوط من (البنزيل ادنين عند ٢٠ جزء فى المليون + الخميره عند تركيز ٠.٢ ٪ + البوتاسيوم عند تركيز٠.٢ ٪) و (البنزيل ادنين عند ٤٠ جـزء فى المليون + الخميره عند ٠.٤ ٪ + البوتاسيوم عند تركيز ٠.٤ ٪).

أستخدمت اشجار عمرها ٥٠ سنه من البرتقال الصيفى المطعمة على أصل النارنج والمزروعه فى تربه طينيه وعلى مسافة ٥ × ٥ متر. استخدم تصميم القطاعات العشوائية الكاملة مع ٤ مكررات لكل معاملة وكان نظام الرى المتبع هو نظام الغمر.

(الرى السطحى) وكانت النتائج كالاتى:

- أدت معاملة الرش الورقى بمخلوط من (البنزيل ادنين ٤٠ جزء فى المليون + الخميره ٠.٤ ٪ + البوتاسيوم٠.٤ ٪) الى انتاج أعلى عدد من الثمار العاقده/

الفرع، بالرغم من انها تسببت فى تزايد الحموضه فى عصير الثمار مقارنة بالشاهد والفروق كانت معنوية خلال موسمي التجربه.

- ايضا المعامله السابقه أدت الي زيادة طول الثمار ، نمو الثمره الطولي فى الموسم الاول فقط. فضلا عن انه قد انتجت معامله الرش بالبنزيل ادنين عند تركيز ٤٠ جزء فى المليون اعلى عدد من الثمار / الشجرة وأعلى متوسط وزن للثمره واعلى محصول خلال موسمي التجربه، كما شاركت هذه المعامله مع محلول الرش بالبوتاسيوم عند كلا التركيزين ٠.٢٪ او ٠.٤٪ فى تحسين شكل الثمره (أعطت ثمارا كانت اكثر استداره فى الشكل).
- فى معظم الحالات التى تم قياس معدل النمو الطولى ، ادت معامله الرش البنزيل ادنين عند تركيز ٤٠ جزء فى المليون فى تزايد لمعدل نمو الثمره الطولى مقارنه بمعامله الشاهد.
- اوضحت النتائج ان اشجار البرتقال الصيفى المرشوشة بمخلوط من (البنزيل ادنين ٢٠ جزء فى المليون + الخميره ٠.٢٪ + البوتاسيوم ٠.٢٪) اعطت اعلى معدل للنمو القطري للثمار وذلك فى كل المواعيد التى تم فيها قياس اقطار الثمار. وايضا أدت الي زيادة محتوى العصير في الثمار من فيتامين ج.
- لقد شاركت المعامله بالمخلوط السابق مع معامله الرش بمستخلص الخميره عند تركيز٠.٢٪ فى تزايد طـول الثمار خاصـه فى الموسم الثانى من التجربه (٢٠١٤/٢٠١٥).
- أدت معامله الرش بمستخلص الخميره الجافه عند تركيز ٠.٢٪ فى زياده النسبه المئويه للمواد الصلبه الذائبه الكليه فى عصير الثمار وقللت من حموضة العصير فى موسمي الدراسه.
- أدت معامله الرش بالبوتاسيوم عند تركيز٠.٤٪ الى حدوث زياده كبيره فى أقطار الثمار خاصه فى موسم واحد فقط وشاركت مع معامله الرش بالسيتوكينين عند تركيز ٤٠ جزء فى المليون ومستخلص الخميرة الجافه عند التركيز ٠.٢٪ فى تحسين صفات الثمار الفيزيائيه (الطول ، القطر، وزن اللب والقشرة ، وزن الثمره وحجم العصير).
- ادت كل معاملات الرش الورقي فى حدوث زيادة مؤكده فى محتوى أوراق البرتقال الصيفى من النيتروجين والفسفور والبوتاسيوم. وجدير بالذكر ان معاملتي الرش الورقى بمخلوط (البنزيل ادنين ٢٠ جزء فى المليون + الخميره ٠.٢٪ + البوتاسيوم ٠.٢ ٪) والرش بالبوتاسيوم ٠.٤٪ نتج عنهما زياده محتوى الاوراق من النتروجين الكلي فى كلا الموسمين
- كما ادت معامله الرش الورقي بالبوتاسيوم عند كلا التركيزين ٠.٢٪ أو٠.٤٪ فى زيادة محتوى الاوراق من الفسفور والبوتاسيوم فى كلا موسمي التجربه.
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التوصيه :

نوصى بأن الرش بالبنزايل ادينين على أوراق أشجار البرتقال الصيفى مرتين عند مرحله تفتح ٨٠٪ من الأزهار (فى أبريل) و بعد اسبوعين من مرحله الأزهار الكامل تؤدى الى زياده المحصول الثمرى عددا ووزنا كما تؤدى هذه المعامله مع الرش بمستخلص الخميره الجافه بتركيز ٢٪ الى تحسين صفات جوده الثمار الطبيعيه وفضلا عن أن الرش الورقى بمخلوط من (البنزيل أدينين بتركيز ٤٠ جزئ فى المليون + الخميره الجافه بتركيز ٠.٤٪ + البوتاسيوم بتركيز ٠.٤٪ تؤدى الى زياده معدل النمو الطولى و القطرى للثمار و بالتالى تحسين الحجم النهائى لثمار البرتقال الصيفى المطعوم على أصل النارنج.