Effect of Foliar Spray of Sitofex, Moringa Leaves Extract and Some Nutrients on Productivity and Fruit Quality of "Thompson seedless" Grapevine

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ABSTRACT: This experiment was achieved out during 2015 and 2016 seasons on 15 years old "Thompson seedless" grapevine grown in loamy clay soil under flood irrigation system at a private farm in Gharbia government, Egypt. The vines were planted 1.5 meter in row and 3 meters between rows. The vines were cane trained with three wires trellis supporting system. Five treatments; calcium nitrate at 1%, potassium sulfate at 2.5%, Sitofex (CPPU) at 6 mg/ L and Moringa leaves extract (MLE) at 2.5% and 3.5% were used as a spray application either single or in combinations on the vines at two times (at 20 cm of shoot length, and 4 mm of berry diameter). The results appeared that single applications of Ca at 1%, K at 2.5%, CPPU at 6 mg/ L as well as MLE at 2.5 and 3.5% or in combination of them were effective in improving the quality and total yield per feddan. The application of potassium sulfate at 2.5% + CPPU at 6 mg/ L as well as potassium sulfate at 2.5% + MLE at 3.5% were the superior treatments since they reached the best berry characters (berry firmness, berry diameter, weight and volume of 100 berries), cluster parameters (cluster weight, cluster length and cluster width), berry juice quality (total soluble solids (TSS%), acidity (%) and TSS/ Acid ratio) and yield per feddan as compared to control in both seasons. This suggested that Moringa leaves extract could be used as an alternative treatment for enhancing yield and quality of "Thompson seedless" grapevine.

Keywords: Sitofex, Moringa leaf extract, Potassium, Calcium and Grapevine.

INTRODUCTION

Grape (*Vitis vinifera*, L.) is an important fruit crop worldwide. It's the second major fruit after citrus in Egypt. Seedless grape as Thompson is a popular grape grown in Egypt. It is sweet, refreshing and natural source of minerals, and vitamins (B1, B2 and C). It is generally consumed fresh as table fruit, raisin and fresh juice. Because of its high total soluble solids, thin skin and desired shape, Thompson seedless is gaining more popularity as a table purpose and raisin making.

There are several horticultural practices were conducted for obtaining the maximum yield and fruit quality such fertilization and growth regulators applications. Potassium fertilizer is an important element as for plants, since stimulator of 60 enzymes, water and nutrient transport, root development, flowering, increase yield and fruit quality improvement. Moreover, enhances plant resistance to dryness, salinity, biosynthesis, sugar translocation, regulates the stomata necessary for photosynthesis and improves plant tolerance to infection disorders (Nijjar, 1985).

In addition, Calcium is an important component of plant tissues, where it plays a vital role in the preservation and regulation of different cell functions

(Elad and Kirshner, 1992). Physiologically, in many fruits and vines, it is essential element. Several studies cleared the advantages of calcium applications for grapevines. Foliar spraying of calcium chloride ($CaCl_2$) on Thompson Seedless grapevines increased berry firmness and decreased the percentage of unmarketable berries after seven days of harvest at ambient temperature (Marzouk and Kassem, 2011) and decreased the storage of *B. cinerea* rots (Ciccarese *et al.,* 2013). Calcium chloride treatment decreased weight loss, shattered percentage and delayed changes in firmness, titratable acidity, total soluble solids, vitamin C, anthocyanin content and respiration rate during storage periods (Wafaa *et al.,* 2014).

Growth regulators as like GA_3 and Cytokinin play an effective role in plant production. Cytokinin (N-(2-Chloro-4-pyridyl)-N0-phenylurea) is a plant hormone that distinguished by their ability to induce cell division (Davies, 2004). Cytokinin is naturally synthesis in all plants, some mosses, fungi, and bacteria. They are involved for controlling the process of cell division. There are many natural and synthetic forms of conjugates of cytokinin which used by horticulturists in a wide range of plant to increase plant production and enhances fruit quality. The synthetic cytokinin (Forchlorfenuron) namely Sitofex (CPPU) is a highly active plant growth regulator similar to natural cytokinin that promotes chlorophyll biosynthesis, cell division, and cell expansion. Moreover, improves fruit setting and enhances fruit enlargement (Zeng *et al.,* 2016). CPPU works in combination with natural auxins and its primary effects in fruit set control, berry growth and development (Wang *et al.,* 2013). Brassino steroids (BR) have also demonstrated their involvement in various plant processes such as cell division promotion, cell wall regeneration, cell expansion and cell elongation, auxin synergy and grape vascular differentiation promotion (Senthilkumar *et al.,* 2018). The artificial CPPU is toxic, unhealthy and damage to living organisms (Gong *et al.,* 2019). So, it could be using some organic extracts that have almost the same effect on plants but are safer on human health than artificial compounds.

Moringa (*Moringa oleifera*) is considered one of the most useful trees in the world, because nearly every part of the tree has an amazing impact of food, medicine and industrial purposes (Nunthanawanich *et al.,* 2016; and Vergara-Jimenez *et al.,* 2017). Moreover, in Agriculture production (George *et al.,* 2016; Latif and Mohamed, 2016 and Maishanu *et al.,* 2017). Moringa leaves are possible sources of vitamin A and C, iron, calcium, riboflavin, b-carotene, phenolics (Nambiar *et al.,* 2005) and active natural antioxidants (Njoku and Adikwu, 1997). Nowadays, moringa plant has attained tremendous attention because it leaves has cytokinin, antioxidants, macro and micronutrients (Abdalla and El-Khoshiban, 2012; and Abdalla, 2013). Foliar application of moringa leaf extract is a low-cost and environmentally friendly, organic technology that increases the growth of most vegetable crops such as potato, and tomato, and field crops like maize and common beans. Moringa leaf extract can therefore be used as an organic fertilizer. The effect of moringa leaf extract is similar to synthetic hormonal activity because the extract contains zeatin, a purine adenine derivative of plant hormone group cytokinin (Makkar *et al.,* 2007), which improves the antioxidant properties of many enzymes and protects cells from the aging effects of reactive oxygen species (Zhang and Ervin, 2004). Moreover, Cryptochlorogenic acid, isocercetin, and astragaline are the main antioxidant components in Moringa leaves (Vongsak *et al.,* 2012). Also, leaves of *Moringa oleifera* leaves are possible source of natural antibacterial and antioxidants (Kumar *et al.,* 2012).

Therefore, this investigation was conducted to determine the impact of foliar applications with Moringa extract, Sitofex, and some nutrients such as Potassium and Calcium solutions on yield and performance of "Thompson seedless" grapevines grown under Egyptian condition.

MATERIALS AND METHODS

This experiment was conducted during successive seasons of 2015 and 2016 on 15 years old, "Thompson seedless" grapevine grown at a private farm in Gharbia government, Egypt. The vines were planted in loamy clay soil at 1.5 meter in row and 3 meters between rows. The vines were cane trained with three wires trellis supporting system. The total number of eyes per vine was adjusted to 48 buds/ vine (4 cans *12 buds/ can) in addition to 6 renewal spurs (2 buds/ spur). Normal cultural practices as recommended by the Ministry of Agriculture and Land Reclamation for grapevines were done. The vines were well established healthy and uniform as possible in both vigor and crop load. Five foliar treatments: water, potassium sulfate at 2.5%, calcium nitrate at 1%, Sitofex at 6 mg/ L (Forchlorfenuron 0.1%, Alz chem company, German) (CPPU), Moringa leaf extract at 2.5% and 3.5% as well as the interaction among all of them were conducted. This study was arranged as randomize complete block design.

Foliar spray of potassium sulfate at 2.5% and calcium nitrate at 1% were conducted at veraison stage (changing berry color from green to yellowish green- berries became nearly soft) with covering of all vegetative growth of vines. However, application of Sitofex at 6 mg/ L was done at 4 mm of berry diameter through foliar spray on clusters only. Foliar spray of Moringa leaves extracts were applied on all vegetative growth of vine at two times (at 20 cm of shoot length, and 4 mm of berry diameter).

The treatments arranged as follow:
1-Control (spraying with water)
2-Foliar spray by Sitofex at 6 mg/ L.
3-Foliar spray by Moringa leaf extract at 2.5%
4-Foliar spray by Moringa leaf extract at 3.5%.
5- Foliar spray by potassium sulfate at 2.5% + Sitofex at 6 mg/ L.
6- Foliar spray by potassium sulfate at 2.5% + Moringa leaf extract at 2.5%
7- Foliar spray by potassium sulfate at 2.5%+ Moringa leaf extract at 3.5%.
8- Foliar spray by calcium nitrate at 1%+ Sitofex at 6 mg/ L.
9- Foliar spray by calcium nitrate at 1%+ Moringa leaf extract at 2.5%
10- Foliar spray by calcium nitrate at 1%+ Moringa leaf extract at 3.5%.
11- Foliar spray by potassium sulfate at 2.5%.
12- Foliar spray by calcium nitrate at 1%.

Preparation of Moringa leaves extract (MLE):

Moringa (Moringa oleifera) leaves were brought from Sakha research station, Agriculture Research Center, Egypt. 1kg of moringa leaves were air-dried under shade for two weeks and subsequently grounded to reach powder case then mixed with 1liter 80% ethyl alcohol using a blender as suggested by (Makkar and Becker, 1996). The suspension was stirred using a homogenizer to help maximize the amount of the extract. The extract was purified by filtering twice through (Whatman No. 2) filter paper. After purification the extract was subjected to a rotary evaporator to fully evaporate the alcohol and get the crude extract. The MLE was used within 5h from extracting (if not ready to be used, the extract was stored at 0°C and only taken out when needed for use). The concentrations were prepared from the crude extract. 25 and 35 ml from the crude extract were taken and diluted with 975 ml and 965 ml distilled water for reaching the concentration to 2.5% and 3.5% respectively, according to (Bashir *et al.,* 2014).

The following parameters were recorded during both seasons of study.

1- Berries characteristics:

Berry firmness:

Samples of 3 clusters from each replicate were picked randomly at harvesting time (when TSS reached 16-17%) according to Sabry *et al.* (2009), berry firmness was determinate in three clusters/ replicate by using ten berries per cluster with the help of hand dynamometer apparatus model FDP1000 with a thump 1mm. The collected data were transformed into Newton units by using standard factor (1gram-force = 0.00980665 Newton).

Berry Length, diameter and shape index:
Berry length and diameter were measured with the help of Vernier calipers in centimeter up to two decimal points. Also, berry shape index was estimated by dividing berry length by its diameter.

Weight and volume of 100 berries:
Weight of randomly selected 100 berries/ cluster from each replicate was determined using the sensitive balance and expressed in gram. Moreover, the volume of 100 berries were determined by using water displacement method.

2-Cluster characteristics:

Cluster weight, length and width:
At the harvesting time, six clusters per replicate were weighed in gram. In addition, cluster length and width were estimated in cm.

3-Yield per feddan:
At harvesting time (TSS 16-17%), number of clusters per vine was counted, six clusters/ vine were weighed and the average of cluster weight was multiplied by number of clusters/ vine to calculate the average yield/ vine and then yield per feddan was calculate by using the following equation:
Yield per feddan (tons)= yield per vine * number of vines per feddan.

4- Berry juice attributes:
Total soluble solids (TSS%), Acidity and TSS/ Acid ratio:
Berries juice TSS% was measured with the help of hand refractometer apparatus and expressed in °Brix. Also, berry juice acidity was assayed using 10 ml of juice titrated against 0.1N NaOH in the presence of an indicator (phenolphthalein) as described by A.O.A.C. (1985). The data were expressed as mg of tartaric acid per 100 of berry juice. TSS/ Acid ratio was calculated depending on TSS% and titratable acidity data.

5- Fruit quality score:
At harvesting date. Evaluation system for calculating the total score of fruit quality for each treatment was done according to Mansour *et al.* (1981) using the ranking system in which, the highest TSS% treatment received 7 points, the second best 6 points and so on. The same was done for TSS/ Acid ratio, and berry firmness. With acidity percent, the lowest value received 7 points, the second best 6 points and so on. The treatment that recorded the highest score was considered as the optimum one.

6- Statistical analysis:
This study was arranged as a randomized complete block design. The collected data were subjected to analysis of variance (ANOVA) as factorial experiment according to (Snedecor and Cochran, 1980) with the help of MSTAT-C statistical package (M-STAT, 1993). The differences among mean of treatments were compared by using Duncan's multiple range tests (DMRT) at 0.05 probability level according to (Duncan, 1955).

RESULTS AND DISCUSSION

Berry characteristics:

Berry firmness

Data of Table (1) cleared that, foliar application of all treatments were enhanced berry firmness and berry diameter. Foliar spray of potassium sulfate (K 2.5%) recorded the highest values of berry firmness 2.41 and 2.33 Newton and berry diameter 1.52 and 1.58 cm in both seasons, respectively. Moreover, the application of Sitofex (CPPU) at 6 mg/ L as well as Moringa leaves extract (MLE at 3.5%) regardless potassium and calcium applications, showed the highest values of berry firmness 2.31 and 2.29 Newton in the first season and 2.29 and 2.28 Newton in the second one. As for berry diameter, they recorded 1.52 and 1.48 cm in the first season and 1.57 and 1.55 cm in the second season. The interaction between potassium sulfate (K 2.5%) application and Sitofex (CPPU) at 6 mg/ L as well as in combined with Moringa leaves extract (MLE at 3.5%) reached the highest values of berry firmness 2.55 and 2.52 Newton and 2.45 and 2.44 Newton in both seasons, respectively. The same results were recorded as for berry diameter in both seasons. The lowest values of both berry firmness and berry diameter were recorded in vines of control in both seasons.

Berry length was clearly affected by the treatments as showed in Table (1). Application of potassium sulfate (K 2.5%) recorded the highest berry length 1.65 cm as compared to both calcium (Ca 1%) and control (Cont.) treatments in the first season. However, the differences among (K 2.5%), (Ca 1%) and control were not significant in the second one. Concerning foliar application of control, CPPU at 6 mg/ L, MLE at 2.5% and MLE at 3.5%, CPPU at 6 mg/ L treatment showed the lowest berry length 1.48 cm in the first season, but by the second one the vines that treated by CPPU at 6 mg/ L and MLE at 3.5% resulted the lowest values. However, control vines showed the highest values in both seasons of the study. These results could be explained according to the known effect of Ca on cell wall, plasma membrane formation and plays a major role in plant growth, increasing fruit firmness and shelf life (Madani *et al.,* 2015) also, potassium applications that cleared an enhancement effect on apple fruits (Anjum *et al.,* 2008). Also, several workers cleared the positve effect of potassium on both fruit firmness (Gill *et al.,* 2012) on pear, and (Mosa *et al.,* 2015) on apple, and fruit size (Ebeed and Abd El-Migeed, 2005) on mango, (Al-Atrushy and Abdul-Qader, 2016) on olive, and (Strydom, 2014) on grape. Moreover, several workers cleared the positve effect of CPPU on both fruit firmness and fruit size which may be due to enhancing cell division, cell enlargement and elongation (Lowes and Woolley, 1992) on Kiwi and (Guirguis *et al.,* 2010) on persimmon trees. Moringa leaves extract showed nearly effects as like CPPU, where it has cytokinin, antioxidants, macro and micronutrients (Abdalla and El-Khoshiban, 2012)

Table (1). Effect of foliar application of Ca, K, CPPU and Moringa leaves extract on berry firmness, diameter and length of 'Thompson seedless' grape during 2015 and 2016 seasons

Treatments	Berry firmness (Newton)							
	2015				2016			
	Cont.	K 2.5%	Ca 1%	Average	Cont.	K 2.5%	Ca 1%	Average
Tap water	1.71d	2.26b	2.10c	**2.02b**	1.62e	2.15c	2.07c	**1.95c**
CPPU at 6 mg/L	2.12c	2.55a	2.28b	**2.31a**	2.14c	2.45a	2.27b	**2.29a**
MLE at 2.5%	1.77d	2.32b	2.15c	**2.08b**	1.84d	2.30b	2.12c	**2.09b**
MLE at 3.5%	2.08c	2.52a	2.26b	**2.29a**	2.12c	2.44a	2.28b	**2.28a**
Average	**1.92c**	**2.41a**	**2.10b**		**1.93c**	**2.33a**	**2.18b**	
	Berry diameter (cm)							
Tap water	1.17e	1.37d	1.34d	**1.29b**	1.13f	1.42d	1.36e	**1.30c**
CPPU at 6 mg/L	1.48b	1.64a	1.44bc	**1.52a**	1.49cd	1.69a	1.54b	**1.57a**
MLE at 2.5%	1.39cd	1.44bc	1.40cd	**1.41ab**	1.36e	1.50b	1.43cd	**1.43b**
MLE at 3.5%	1.40cd	1.61a	1.44bc	**1.48a**	1.43cd	1.71a	1.51b	**1.55a**
Average	**1.36c**	**1.52a**	**1.41bc**		**1.35c**	**1.58a**	**1.46b**	
	Berry length (cm)							
Tap water	1.80a	1.72b	1.7b	**1.74 a**	1.77a	1.79a	1.76a	**1.77a**
CPPU at 6 mg/L	1.40f	1.61c	1.44f	**1.48c**	1.51d	1.6bcd	1.59c	**1.57c**
MLE at 2.5%	1.57cd	1.62c	1.52be	**1.57bc**	1.61bc	1.50d	1.58c	**1.56d**
MLE at 3.5%	1.44f	1.63c	1.47ef	**1.51bc**	1.52d	1.58bcd	1.66b	**1.59c**
Average	**1.55b**	**1.65a**	**1.53b**		**1.60a**	**1.62a**	**1.65a**	

Ca = Calcium nitrate at 1%**, K =** Potassium sulfate at 2.5%, **CPPU =** Sitofex **(**Forchlorfenuron 0.1%), **MLE=** Moringa leaves extract.

Weight and volume of 100 berries, and berry shape index

Data presented in Table (2) cleared that, foliar application of all treatments were enhanced weight of 100 berry and volume of 100 berry. Foliar spray of potassium sulfate (K 2.5%) recorded the highest values of weight of 100 berry 196.25 and 223.89 g and volume of 100 berry 192.86 and 181.14 ml in both seasons, respectively. the Sitofex (CPPU) application at 6 mg/ L as well as Moringa leaves extract (MLE at 3.5%) regardless potassium and calcium applications, showed the highest values of weight of 100 berry 201.85 and 201.96 g in the first season and 226.67 and 226.67 g in the second one. As for the volume of 100 berry, they recorded 196.93 and 196.70 ml in the first season and 182.67 and 182.78 ml in the second season.

The interaction between potassium sulfate (K 2.5%) application and Sitofex (CPPU) at 6 mg/ L as well as in combined with Moringa leaves extract (MLE at 3.5%) reached the highest values of weight of 100 berry 225.56 and 225.00 g and 243.33 and 244.44 g in both seasons, respectively. The same results were recorded as for volume of 100 berry in both seasons. The lowest values of both weight of 100 berry and volume of 100 berry were recorded in vines of control in both seasons.

Berry shape index was clearly affected by the treatments as showed in Table (2). The differences among (K 2.5%), (Ca 1%) and control were not significant in both seasons. Concerning foliar application of control, CPPU at 6 mg/ L, MLE at 2.5% and MLE at 3.5%, CPPU at 6 mg/ L treatment showed the lowest berry shape index 0.98 in the first season, but by the second one, the vines that treated by CPPU at 6 mg/ L and MLE at 3.5% resulted the lowest values. However, control vines showed the highest values in both seasons of the study. These results could be explained according to the known effect of potassium applications that cleared an improved the size of the pear fruits compared to control (Gill *et al.,* 2012), (Omar *et al.,* 2017) on date palms, cv. Sukary. Moreover, improved the weight of "Costata" persimmon fruits compared to control (Kassem *et al.,* 2010), (El-Tanany *et al.,* 2011) on Washington navel orange trees, (Ashraf *et al.,* 2013) on Kinnow fruit (Mosa *et al.,* 2015) on apple trees called "Anna". Also, the results show the importance of K foliar spray in growing plum and peach fruits weight as it is dependent on the fruit cost (Ben Mimoun *et al.,* 2009). The foliar spray is an important fertilization method especially during fruit growth stage III in plum and peach. Some authors suggest the value of K during this time as there is an extreme mobilization of potassium from leaf to fruit, and tree root absorption of K may be insufficient to satisfy the tree's demand for this nutrient by (Weinbaum et al., 1994). Moreover, several workers cleared the positive effect of CPPU on weight and volume berries and cluster in grape (Marzouk and Kassem, 2011). Also, Moringa leaves extract showed nearly effects as like CPPU, cluster physical quality parameters are also increased in terms of weight, size, width, berry physical parameters such as weight and volume of 100 berries in grape (Bassiony and Ibrahim, 2016).

Table (2). Effect of foliar application of Ca, K, CPPU and Moringa leaves extract on weight of 100 berry, volume 100 berry and berry shape index of 'Thompson seedless' grape during 2015 and 2016 seasons

Treatments	Weight of 100 berry (g)							
	2015				2016			
	Cont.	K 2.5%	Ca 1%	Average	Cont.	K 2.5%	Ca 1%	Average
Tap water	136.67^{e}	161.11^{d}	160.00^{d}	**152.59^{c}**	126.67^{e}	181.11^{d}	175.00^{d}	**160.93^{c}**
CPPU at 6 mg/ L	180.00^{c}	225.56^{a}	200.00^{b}	**201.85^{a}**	207.78^{c}	243.33^{a}	228.89^{b}	**226.67^{a}**
MLE at 2.5%	160.00^{d}	173.33^{cd}	174.44^{cd}	**169.26^{b}**	171.11^{d}	226.67^{b}	180.56^{d}	**192.78^{b}**
MLE at 3.5%	178.11^{c}	225.00^{a}	202.78^{b}	**201.96^{a}**	205.56^{c}	244.44^{a}	230.00^{b}	**226.67^{a}**
Average	**163.70^{c}**	**196.25^{a}**	**184.31^{b}**		**177.78^{c}**	**223.89^{a}**	**203.61^{b}**	
	Volume of 100 berry (ml)							
Tap water	111.67^{e}	163.67^{d}	154.56^{d}	**143.30^{c}**	121.11^{h}	160.00^{de}	146.89^{f}	**142.67^{c}**
CPPU at 6 mg/ L	185.00^{bc}	212.78^{a}	193.00^{b}	**196.93^{a}**	169.44^{cd}	194.00^{a}	184.56^{ab}	**182.67^{a}**
MLE at 2.5%	155.67^{d}	180.00^{c}	162.33^{d}	**166.00^{b}**	132.44^{g}	176.67^{b}	156.11^{ef}	**155.07^{b}**
MLE at 3.5%	182.78^{bc}	215.00^{a}	192.33^{b}	**196.70^{a}**	171.11^{c}	193.89^{a}	183.33^{ab}	**182.78^{a}**
Average	**158.78^{c}**	**192.86^{a}**	**175.56^{b}**		**148.53^{c}**	**181.14^{a}**	**167.72^{b}**	
	Berry shape index							
Tap water	1.54^{a}	1.26^{b}	1.27^{b}	**1.36^{a}**	1.57^{a}	1.26^{b}	1.29^{b}	**1.37^{a}**
CPPU at 6 mg/ L	0.95^{d}	0.98^{d}	1.00^{d}	**0.98^{c}**	1.01^{c}	0.95^{c}	1.03^{c}	**1.00^{b}**
MLE at 2.5%	1.13^{c}	1.13^{c}	1.09^{d}	**1.12^{b}**	1.18^{bc}	1.00^{c}	1.11^{c}	**1.10^{b}**
MLE at 3.5%	1.03^{d}	1.01^{d}	1.02^{d}	**1.02^{c}**	1.06^{c}	0.92^{c}	1.10^{c}	**1.03^{b}**
Average	**1.16^{a}**	**1.10^{a}**	**1.10^{a}**		**1.21^{a}**	**1.03^{a}**	**1.13^{a}**	

Ca = Calcium nitrate at 1%**, K =** Potassium sulfate at 2.5%, **CPPU =** Sitofex **(**Forchlorfenuron 0.1%), **MLE=** Moringa leaves extract.

Cluster characteristics:

Weight, length and width of cluster:

Data of Table (3) cleared that, foliar application of all treatments were enhanced cluster weight and cluster length. Foliar spray of calcium nitrate (Ca 1%) recorded the highest values of cluster weight 305.57 g in the first season, while foliar spray of potassium sulfate (K 2.5%) recorded the highest values of cluster weight 348.67 g in the second season, respectively. On the other hand, found that control recorded the highest values of cluster length 19.47 cm in the first season, while foliar spray of potassium sulfate (K 2.5%) recorded the highest values of cluster length 21.06 cm in the second season, respectively. Also, the application of Sitofex (CPPU) at 6 mg/ L as well as Moringa leaves extract (MLE at 3.5%) regardless potassium and calcium applications, showed the highest values of cluster weight 310.51 and 308.37 g in the first season and 373.70 and 372.00 g in the second one. As for cluster length, they recorded 20.59 and 20.31 cm in the second season while Sitofex (CPPU) at 6 mg/ L recorded the highest values 19.54 cm in the first season. The interaction between calcium nitrate (Ca 1%) application and Sitofex (CPPU) at 6 mg/ L as well as in combined with Moringa leaves extract (MLE at 3.5%) reached the highest values of cluster weight 332.45 and 329.78 g in the first season, while the interaction between potassium sulfate (K 2.5%) application and Sitofex (CPPU) at 6 mg/ L as well as in combined with Moringa leaves extract (MLE at 3.5%) recorded the highest values of cluster weight 385.89 and 383.33 g in the second season. On the other hand, found that Sitofex (CPPU) at 6 mg/ L reached the highest values of cluster length 21.32 cm in the first season, while the interaction between potassium sulfate (K 2.5%) application and Sitofex (CPPU) at 6 mg/ L as well as in combined with Moringa leaves extract (MLE at 2.5% and 3.5%) reached the highest values of cluster length 21.33, 21.17 and 21.28 cm in the second season, respectively. The lowest values of both cluster weight and cluster length were recorded in vines of control in both seasons.

Cluster width was clearly affected by the treatments as showed in Table (3). Potassium sulfate (K 2.5%) and calcium nitrate (Ca 1%) recorded the highest cluster width 18.93 and 18.50 cm as compared to control treatment in the first season. However, the differences among (K 2.5%), (Ca 1%) and control were not significant in the second season. Concerning foliar application of control, CPPU at 6 mg/ L, MLE at 2.5% and MLE at 3.5%, CPPU at 6 mg/ L and Moringa leaves extract (MLE at 3.5%) treatments showed the highest values of cluster width 19.25 and 19.06 cm in the first season, but by the second one the vines that treated by MLE at 3.5% resulted the highest values. The interaction between potassium sulfate (K 2.5%) application and Sitofex (CPPU) at 6 mg/ L as well as in combined with Moringa leaves extract (MLE at 2.5% and 3.5%) recorded the highest values of cluster width 19.82 – 19.39 and 19.28 cm in addition to the interaction between calcium nitrate (Ca 1%) application and Moringa leaves extract (MLE at 3.5%) which recorded 19.82 cm, respectively, in the first season, while The interaction between potassium sulfate (K 2.5%) application and Moringa leaves extract (MLE at 3.5%) recorded the highest values of cluster width 17.83 cm in the second season, respectively, However, control vines showed the lowest values in both seasons of the study. These results could be explained according to the known effect of Ca on increasing fruit quality in pear (Haggag *et al.,* 2014), also, (Kassem *et al.,* 2010) found that potassium improved the weight of "Costata" persimmon fruits compared to control. Yadav (2013) found that K_2SO_4 was the most effective for physical characteristics to enhance fruit size and weight on ber, (Al-Atrushy and Abdul-Qader, 2016) on olive, (El-Tanany *et al.,* 2011) on Washington navel orange trees, (Ashraf *et al.,* 2013) on Kinnow fruit, and (Mosa *et al.,* 2015) on apple trees called "Anna". Moreover, several workers cleared the positive effect of CPPU on grape (Abdel-Fattah *et al.,* 2010), (Smith, 2008) and (Nilnond *et al.,* 2010). Moringa leaves extract showed nearly effects as like CPPU in enhanced cluster weight, cluster length and cluster width.

Table (3). Effect of foliar application of Ca, K, CPPU and Moringa leaves extract on cluster weight, length and width of 'Thompson seedless' grape during 2015 and 2016 seasons

Treatments	Cluster weight (g)							
	2015				2016			
	Cont.	K 2.5%	Ca 1%	Average	Cont.	K 2.5%	Ca 1%	Average
Tap water	233.25^{h}	244.27^{g}	252.76^{f}	**243.43^{c}**	241.44^{h}	265.89^{f}	258.67^{g}	**255.33^{c}**
CPPU at 6 mg/L	285.55^{c}	313.52^{b}	332.45^{a}	**310.51^{a}**	360.00^{c}	385.89^{a}	375.22^{b}	**373.70^{a}**
MLE at 2.5%	262.34^{e}	278.36^{d}	307.29^{bc}	**282.66^{b}**	333.56^{e}	359.56^{c}	355.78^{d}	**349.63^{b}**
MLE at 3.5%	283.95^{c}	311.37^{b}	329.78^{a}	**308.37^{a}**	359.67^{c}	383.33^{a}	373.00^{b}	**372.00^{a}**
Average	**266.27^{c}**	**286.88^{b}**	**305.57^{a}**		**323.67^{b}**	**348.67^{a}**	**340.67^{ab}**	
	Cluster length (cm)							
Tap water	17.43^{de}	16.43^{e}	18.10^{d}	**17.32^{c}**	18.11^{d}	20.44^{b}	20.28^{b}	**19.61^{b}**
CPPU at 6 mg/L	21.32^{a}	19.77^{b}	17.53^{de}	**19.54^{a}**	20.11^{b}	21.33^{a}	20.33^{b}	**20.59^{a}**
MLE at 2.5%	19.06^{c}	19.27^{bc}	17.83^{de}	**18.72^{b}**	18.44^{cd}	21.17^{a}	19.72^{bc}	**19.78^{b}**
MLE at 3.5%	20.06^{ab}	16.53^{e}	19.10^{c}	**18.56^{b}**	19.83^{bc}	21.28^{a}	19.83^{bc}	**20.31^{a}**
Average	**19.47^{a}**	**18.00^{b}**	**18.14^{b}**		**19.12^{c}**	**21.06^{a}**	**20.04^{b}**	
	Cluster width (cm)							
Tap water	15.00^{f}	17.21^{cd}	16.06^{e}	**16.09^{c}**	16.00^{c}	16.22^{ab}	16.22^{bc}	**16.15^{c}**
CPPU at 6 mg/L	18.83^{ab}	19.82^{a}	19.10^{ab}	**19.25^{a}**	16.28^{bc}	16.94^{abc}	16.44^{abc}	**16.55^{b}**
MLE at 2.5%	16.88^{de}	19.39^{a}	19.00^{ab}	**18.42^{b}**	16.50^{abc}	16.11^{c}	16.17^{bc}	**16.26^{bc}**
MLE at 3.5%	18.07^{bc}	19.28^{a}	19.82^{a}	**19.06^{a}**	16.33^{bc}	17.83^{a}	17.33^{abc}	**17.16^{a}**
Average	**17.20^{b}**	**18.93^{a}**	**18.50^{a}**		**16.28^{a}**	**16.78^{a}**	**16.54^{a}**	

Ca = Calcium nitrate at 1%**, K =** Potassium sulfate at 2.5%, **CPPU =** Sitofex **(**Forchlorfenuron 0.1%), **MLE=** Moringa leaves extract.

Data of Table (4) cleared that, foliar application of all treatments was enhanced yield per feddan (ton). Foliar spray of potassium sulfate (K 2.5%) recorded the highest values of yield per feddan 7.83 and 8.96 ton in both seasons, respectively. Also, the application of Sitofex (CPPU) at 6 mg/ L as well as Moringa leaves extract (MLE at 3.5%) regardless potassium and calcium applications, showed the highest values of yield per feddan 8.20 and 8.15 ton in the first season and 9.42 and 9.40 ton in the second one. The interaction between potassium sulfate (K 2.5%) application and Sitofex (CPPU) at 6 mg/ L as well as in combined with Moringa leaves extract (MLE at 3.5%) reached the highest values of yield per feddan 8.37 and 8.45 ton and 9.79 and 9.90 ton in both seasons, respectively. The lowest values of yield per feddan were recorded in vines of control in both seasons.

These results could be explained according to the known effect of Ca on cell wall, plasma membrane formation and plays a major role in plant growth, increasing Le-Conte pear trees yield (Haggag *et al.,* 2014), (Abd-Elall and Hussein, 2018) on Balady orange trees, and (Marzouk and Kassem, 2011) on grape, also, potassium sulfate applications that cleared an enhancement effect on Williams bananas yield (Roshdy, 2016), (Quaggio *et al.,* 2011) on orange trees and (Zlámalová *et al.,* 2015) on grape. Moreover, several workers cleared the positive effect of CPPU on grape (Marzouk and Kassem, 2011). Also, Moringa leaves extract showed nearly effects as like CPPU in enhanced yield on Mandarin trees (Sattar *et al.,* 2016).

Table (4). Effect of foliar application of Ca, K, CPPU and Moringa leaves extract on yield per feddan of 'Thompson seedless' grape during 2015 and 2016 seasons

Treatments	Yield /feddan (ton)							
	2015				2016			
	Cont.	K2.5%	Ca1%	Average	Cont.	K2.5%	Ca1%	Average
Tap water	5.52^{d}	6.28^{c}	5.97^{cd}	**5.92^{c}**	6.11^{d}	6.87^{c}	6.46^{cd}	**6.48^{c}**
CPPU at 6 mg/L	7.83^{ab}	8.37^{a}	8.40^{a}	**8.20^{a}**	9.16^{ab}	9.79^{a}	9.31^{ab}	**9.42^{a}**
MLE at 2.5%	7.66^{b}	8.20^{ab}	7.63^{b}	**7.83^{b}**	8.65^{b}	9.29^{ab}	9.13^{ab}	**9.02^{b}**
MLE at 3.5%	8.02^{ab}	8.45^{a}	7.97^{ab}	**8.15^{a}**	8.95^{b}	9.90^{a}	9.35^{ab}	**9.40^{a}**
Average	**7.26^{c}**	**7.83^{a}**	**$7.49b^{c}$**		**8.22^{c}**	**8.96^{a}**	**8.56^{b}**	

Ca = Calcium nitrate at 1%**, K =** Potassium sulfate at 2.5%, **CPPU =** Sitofex **(**Forchlorfenuron 0.1%), **MLE=** Moringa leaves extract.

Data of Table (5) cleared that, foliar application of all treatments (potassium and calcium applications) was lowest of total soluble solids (TSS%) compared with control. Control recorded the highest values of total soluble solids (TSS%) 19.23 and 19.77% in both seasons, respectively. Also control regardless potassium and calcium applications, showed the highest values of total soluble solids (TSS%) 19.70 and 20.49% in both seasons, respectively. The interaction between all treatments showed that, control reached the highest values of total soluble solids (TSS%) 20.09 and 20.76% in both seasons, respectively. The lowest values of total soluble solids (TSS%) were recorded in vines of foliar application of (calcium nitrate 1% + CPPU at 6 mg/ L) 15.56 and 16.02% in both seasons.

Titratable acidity (%) was clearly affected by the treatments as showed in Table (5). the differences among (K 2.5%), (Ca 1%) and control were not significant in both seasons. Concerning foliar application of control, CPPU at 6 mg/ L, MLE at 2.5% and MLE at 3.5%, CPPU at 6 mg/ L and MLE at 3.5% treatments showed the highest of titratable acidity (%) 0.98 and 0.89% in the first season, and 0.71 and 0.72% in the second season, respectively. Also, found that (CPPU at 6 mg/ L alone, potassium sulfate (K 2.5%) + CPPU at 6 mg/ L, calcium nitrate (Ca 1%) + CPPU at 6 mg/ L, MLE at 3.5% alone, calcium nitrate (Ca 1%) + MLE at 3.5%, and potassium sulfate (K 2.5%) + MLE at (3.5%) were recorded a highest values of titratable acidity (%) in both seasons. However, control vines showed the lowest values in both seasons of the study.

Data of Table (5) cleared that, foliar application of all treatments (potassium and calcium applications) was lowest of (TSS/ Acid ratio) compared with control. Control recorded the highest values of (TSS/ Acid ratio) 26.03 and

35.07 in both seasons, respectively. Also control regardless potassium and calcium applications, showed the highest values of (TSS/ Acid ratio) 37.30 and 39.40 in both seasons, respectively. The interaction between all treatments showed that, control reached the highest values of (TSS/ Acid ratio) 37.91 and 44.17 in both seasons, respectively. The lowest values of (TSS/ Acid ratio) were recorded in vines of foliar application of (calcium nitrate 1% + CPPU at 6 mg/ L) 15.88 in the first season and (calcium nitrate 1% + MLE at 3.5%) 20.39 in the second season, respectively.

These results could be explained according to the known effect of potassium applications that cleared with increased K fertilization, the fruit mass also increased, which decreased total soluble solids in juice and associated with 'Valencia' leaf K concentrations (Quaggio *et al.,* 2011). Also, (Zlámalová *et al.,* 2015) found that the content of titrable acids in the must range insignificantly in grape. Moreover, several workers cleared effect of CPPU on decreases TSS and increases titrable acidity in grape (Zhang *et al.,* 2013), (EL-Abbasy *et al.,* 2016) and (Kok and Bal, 2016). Also, Moringa leaves extract showed nearly effects as like CPPU, where it has cytokinin, antioxidants, macro and micronutrients.

Table (5). Effect of foliar application of Ca, K, CPPU and Moringa leaves extract on total soluble solid (TSS) %, titratable acidity and TSS/ acid ratio of 'Thompson seedless' grape during 2015 and 2016 seasons

Treatments	Total soluble solids (TSS) %							
	2015				2016			
	Cont.	K 2.5%	Ca 1%	Average	Cont.	K 2.5%	Ca 1%	Average
Tap water	20.09^{a}	19.00^{c}	19.00^{c}	**19.70^{a}**	20.76^{a}	20.60^{ab}	20.11^{b}	**20.49^{a}**
CPPU at 6 mg/ L	17.56^{d}	16.33^{e}	15.56^{f}	**16.48^{b}**	17.49^{cd}	18.00^{c}	16.02^{d}	**17.17^{d}**
MLE at 2.5%	20.64^{a}	18.02^{d}	19.87^{b}	**19.51^{ab}**	19.91^{bc}	20.11^{b}	19.71^{bc}	**19.91^{b}**
MLE at 3.5%	17.64^{d}	16.24^{e}	15.87^{f}	**16.58^{b}**	20.93^{a}	18.13^{c}	16.11^{d}	**18.39^{c}**
Average	**19.23^{a}**	**17.40^{b}**	**17.58^{b}**		**19.77^{a}**	**19.21^{b}**	**17.99^{c}**	
	Titratable acidity (%)							
Tap water	0.53^{bc}	0.54^{bc}	0.49^{c}	**0.52^{b}**	0.47^{c}	0.56^{ab}	0.54^{ab}	**0.52^{b}**
CPPU at 6 mg/ L	0.99^{a}	0.97^{a}	0.98^{a}	**0.98^{a}**	0.69^{a}	0.73^{a}	0.70^{a}	**0.71^{a}**
MLE at 2.5%	0.70^{b}	0.67^{b}	0.59^{bc}	**0.65^{b}**	0.51^{bc}	0.60^{ab}	0.58^{ab}	**0.56^{b}**
MLE at 3.5%	0.93^{a}	0.80^{ab}	0.93^{a}	**0.89^{a}**	0.66^{ab}	0.72^{a}	0.79^{a}	**0.72^{a}**
Average	**0.79^{a}**	**0.75^{a}**	**0.75^{a}**		**0.58^{a}**	**0.65^{a}**	**0.65^{a}**	
	TSS/ Acid ratio							
Tap water	37.91^{a}	35.19^{ab}	38.79^{a}	**37.30^{a}**	44.17^{a}	36.79^{bc}	37.24^{bc}	**39.40^{a}**
CPPU at 6 mg/ L	17.73^{f}	16.90^{g}	15.88^{g}	**16.84^{d}**	25.35^{e}	24.66^{e}	22.89^{f}	**24.30^{c}**
MLE at 2.5%	29.49^{c}	26.89^{d}	33.68^{b}	**30.02^{b}**	39.04^{b}	33.52^{c}	33.98^{c}	**35.51^{b}**
MLE at 3.5%	18.97^{ef}	20.30^{e}	17.06^{f}	**18.78^{c}**	31.71^{d}	25.18^{e}	20.39^{g}	**25.76^{c}**
Average	**26.03^{a}**	**24.82^{b}**	**26.35^{a}**		**35.07^{a}**	**30.04^{bc}**	**28.63^{c}**	

Ca = Calcium nitrate at 1%, **K =** Potassium sulfate at 2.5%, **CPPU =** Sitofex **(**Forchlorfenuron 0.1%), **MLE=** Moringa leaves extract.

CONCLUSION

The results of this applied experiment indicate that Moringa leaf extract (It contains high concentrations of naturally created cytokinin) can be used as a substitute for Sitofex (The creature is artificial, and it has many damages to human health). Where we found that using Moringa leaf extract with a concentration of 3.5% gives similar results to the effect of Sitofex in improving the physical and chemical properties of "Thompson seedless" grapevine fruits.

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الملخص العربي

تأثير الرش الورقى بالسيتوفكس ومستخلص أوراق المورينجا وبعض العناصر المعدنية على إنتاجية وجودة العنب الطومسون سيدلس

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تم اجراء هذه التجربة خلال مواسم عامي ٢٠١٥ و ٢٠١٦ على كرمات العنب "طومسون سيدلس" التي تبلغ من العمر ١٥ عامًا والمزروعة في التربة الطينية الطميية تحت نظام الري بالغمر في مزرعة خاصة في محافظة الغربية ، مصر. زرعت الكروم على بعد ١,٥ متر بين الكرمات داخل الصف الواحد و ٣ أمتار بين الصفوف. الكرمات مرباة بالطريقة القصبية مع التدعيم بثلاثة أسلاك دعم نظام تعريشة. واستخدمت أربعة معاملات وهى نترات الكالسيوم بتركيز ١٪، سلفات البوتاسيوم بتركيز ٢,٥٪، وسيتوفكس (CPPU) بتركيز ٦ ملجرام لكل لتر ومستخلص أوراق المورينجا (MLE) بتركيز ٢,٥% و ٣,٥% كتطبيق رذاذ إما مفردة أو في مجموعات على الكروم في وقتين (في ٢٠ سم من طول الأفرخ الخضرية الحديثة ، و ٤ مليمتر من قطر الحبة). أظهرت النتائج أن المعاملات المنفردة لـ Ca عند ١٪ و K عند ٢,٥٪ و CPPU عند ٦ ملجرام لكل لتر وكذلك MLE عند ٢,٥ و ٣,٥٪ أو مجتمعة كانت فعالة في تحسين الجودة وإجمالي العائد للفدان. إضافة سلفات البوتاسيوم بتركيز ٢,٥ ٪ + CPPU بتركيز ٦ ملجرام لكل لتر وكذلك سلفات البوتاسيوم بتركيز ٢,٥ ٪ + MLE بنسبة ٣,٥ ٪ كانت معاملات متفوقة لأنها وصلت إلى أفضل خصائص للحبة مثل (صلابة الحبة ، قطر الحبة ، وزن وحجم ١٠٠ حبة) ، وخصائص العنقود مثل (وزن العنقود ، طول العنقود وعرض العنقود) ، جودة عصير الثمار مثل (محتوى المواد الصلبة القابلة للذوبان (TSS٪) ، الحموضة (٪) ونسبة TSS / الحموضة) والعائد لكل فدان مقارنة بالكنترول في كلا الموسمين. هذا يشير إلى أنه يمكن استخدام مستخلص أوراق المورينجا كعلاج بديل لتحسين المحصول ونوعية كرمة العنب صنف "طومسون سيدلس".