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# Fertilization by Nano-powder Potassium Sulfate enhancing Production of Grapevines cv. Crimson Seedless

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## ABSTRACT

A field experiment was conducted in a randomized complete design with three doses of Nano-powder potassium sulfate (100, 150 and 200 g per vine) and one dose of traditional potassium sulfate (200 g per vine), which applied as soil applications to compare the effect of potassium at nano or traditional form on the performance of Crimson seedless grapevines during 2018 and 2019 seasons. Results revealed that the Nano-powder potassium sulfate at 150 and 200 g per vine was better than the traditional form in enhancing vegetative growth, nutrient uptake, cluster quality and yield of Crimson seedless grapevines. In summary, it can be concluded that utilizing a nano form of potassium sulfate at an equal dose of traditional form or by less than fifty gram lead to an increase in the productivity of Crimson seedless grapevines.

**Keywords:** Nano fertilizers – Crimson – Potassium sulfate - Grape – Vines – Fertilization.

## INTRODUCTION

Crimson grapes have become a popular variety in Egypt because of its desirable qualities to the consumer due to its extraordinary shelf life, pale pink berries and high sugar content, with half as glucose and half as fructose (Perfection, 2007). In addition, it ripens late at the end of the season (mid-September) in conjunction with a decrease in the air temperature, which allows storing it on trees and prolonging the period of its display in the markets until mid-November (Rio-Segade *et al.*, 2013).

Furthermore, it is one of the red seedless varieties; so, the potassium element has great importance in fertilization of Crimson grapevines. Hence, it has an important role in fruit trees which can be concise in transferring the products of plant metabolism (Salisburg and Ross, 1992), stimulating enzymes (Walker *et al.*, 1998), transfusions during the cell membrane and neutralization of anion which is indispensable in retaining membrane (Leigh, 2001) and controlling plant water relations (Davies and Zhang, 1991). Indeed, potassium is the most cation which participates to achieve balance and transport sugar in grape berries (Spayd *et al.*, 1993). On the other side, insufficient potassium affects negatively on growth and yield of vines and delaying the ripening of berries (Schreiner *et al.*, 2013).

The grape producers have become suffering from traditional potassium fertilizers because of its many disadvantages, including the difficulty of melting and a large number of impurities with a device; hence, plants uptake 30–50% of the applied potassium and lost the residual quantity. So, the urgent need to use effective alternatives to supply grapevines with their needs of potassium like the application of nanotechnology.

The nanomaterial has a small size (1 and 100 nm) characterized by high surface area, conductivity, reactivity and tunable pore size (Rai and Ingle, 2012). Nano fertilizers can enhance uptake of nutrients for program fertilization (Manjunatha *et al.*, 2016) due to their small size which leads to the more effective delivery of nutrients in plant surfaces and transport channels (Liu *et al.*, 2009); hence, plant cell walls have pore diameters ranging from 5 to 20 nm (Fleischer *et al.*, 1999).

This can be accomplished by encapsulating the nutrients by nanomaterials, coated with a thin protective film, or delivered as emulsions or nanoparticles (De Rosa *et al.* 2010).

Dependence on more efficient use of potassium fertilizers to increase the yield of Crimson vines, this investigation was done to compare the effect of Nano- powder potassium sulfate at different doses versus confidential potassium sulfate fertilizers on the behavior of Crimson seedless grapevines.

## MATERIALS AND METHODS

### Vines materials and experimental execution

This study was accomplished during both successive seasons 2018 and 2019 on Crimson seedless cultivar for evaluating vegetative growth characteristics, yield and cluster quality of Crimson seedless table grapes under different levels of Nano-powder potassium sulfate comparing with traditional potassium sulfate form.

Crimson grapevines were 4-years-old, spaced at 2.5 × 3.5 m between vines and 3.5 m between rows and grown in clay soil according to Table (1) under drip irrigation system and trained two lateral cordons with mixed pruning under modified supporting of "Y" trellis system at El-Esseily orchards at Donoshar village near El-Mahalla El-Kobra, Gharbia Governorate.

Prior to executing the experiment, the soil's physical and chemical properties of the experimental site were determined according to Jones (2001) as showed in Table (1).

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**Table 1. Physical and chemical analysis of the experimental soil.**

| Soil depth (cm) | Particle size distribution | | | | | Soil depth (cm) | PH % | Available nutrient (ppm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coarse sand % | Find sand % | Clay % | Silt % | Texture | | | N | P | K | Zn | Mn |
| 0-30 | 1.94 | 17.06 | 57 | 24 | Clay | 0-30 | 8.75 | 72.31 | 47.8 | 470 | 1.9 | 9.5 |
| 30-60 | 2.0 | 17.02 | 57 | 24.5 | Clay | 30-60 | 8.76 | 68.53 | 44.92 | 435 | 1.7 | 8.8 |
| 60-90 | 2.1 | 17.01 | 57 | 24.7 | Clay | 60-90 | 8.82 | 59.70 | 41.75 | 403 | 1.4 | 7.9 |

Sixty grapevines, almost uniform in growth, vigor and good physical condition were selected for the purpose of this experiment which was designed as a completely randomized design with three replicates (five grapevines for each replicate) to represent treatments during both seasons as follows:

**$T_1$ 100 g Nano-powder potassium sulfate/vine.**

**$T_2$ 150 g Nano-powder potassium sulfate/vine.**

**$T_3$ 200 g Nano-powder potassium sulfate/vine.**

**$T_4$ 200 g potassium sulfate/vine (control).**

These quantities were divided into three equal parts and added in the soil as follows:

1) The first part was divided into two equal quantities, the first one add at first bloom stage (15/3/2018 and 18/3/2019) and the second at full bloom stage (27/3/2018 and 30/3/2019) during both seasons.
2) The second part was divided into two equal quantities, the first one add at buckshot berries stage (16/4/2018 and 19/4/2019) and the second at berry touch/bunch closure stage (22/4/2018 and 25/4/2019) during both seasons.
3) The third part was divided into four equal quantities, the first one add at the first week of the véraison stage (12/5/2018 and 15/5/2019) and the remaining quantities were added successively 10 days intervals.

It is clear from the above-mentioned treatments that there are two sources of potassium sulfate the first is Nano-powder potassium sulfate and the second is the traditional potassium sulfate (Solo-potassium®). Both of them had 50% of $K_2O$ but Nano-potassium powder sulfate was produced under the license of Neufarm GmbH/Germany.

**Vegetative growth**

When the vines achieved full bloom stage, the third basal Internode length and thickness were measured in cm; furthermore, the average of leaf area was estimated as $cm^2$ according to Montero *et al.* (2000) by collecting 20 leaves /replicate from the top of the growing shoot ($6^{th}$ or $7^{th}$ leaf) and chlorophyll % was measured in the same leaves by using portable CCM-200 plus Chlorophyll Content Meter.

**Leaf mineral content**

It estimated by collecting 24 leaf petioles from the opposite side of the clusters at full bloom and cleaned then dried at 70°C to constant weight to determine its content of Ca and Mg as percentages, and Zn, Mn and Cu as ppm according to Jones (2001).

**Clusters and berries properties**

Five clusters from each replicate were collected when SSC % ranged 19-20% and SSC / acid ratio was about 72:1 (Abd El-Razek *et al.,* 2011) then transferred to Pomology Dept. for determining cluster characteristics {average of cluster weight (g), length and width (cm)}. And 100 berries from each replicate were collected at random to determine average berry weight (g) and berry diameter (mm). Then berries were squeezed to get juice and then filtered to measure SSC % using a refractometer and titratable acidity as a percentage of tartaric acid (AOAC, 1980); finally, SSC/acid ratio was calculated as a ratio of SSC % to titratable acidity.

Regarding total anthocyanin (mg/100g fresh weight) in berry skin, it was determined according to the method of Mazumadar and Majumder (2003) and the extract was measured at 535 nm by a spectrophotometer.

Referring to berry total sugar percentage, it was determined according to Sadasivam and Manickam (1996) and the extract was measured at 490 nm by a spectrophotometer.

Berry content of calcium (mg/100g) is estimated according to Mazumdar and Majumder (2003) by titrating against a standard potassium permanganate.

**Specific leaf weight (SLW) (mg/$cm^2$)**

It was determined by dividing leaf dry weight to leaf area of selected leaves (6th or 7th leaf of growing shoots) according to Nelson (1988).

**Yield (kg/vines)**

It determined by multiplying the average weight of the cluster by the number of clusters per vine for each replicate.

***Statistical analysis***

Data were statistically analyzed as a randomized complete design by analysis of variance (ANOVA) as outlined by Snedecor and Cochran (1994), using the statistical package software SAS (SAS Institute Inc. Cary, NC, USA). Comparisons between means were made by using the Least Significant Differences Test (LSD) at 5% level of probability as referenced by Waller and Duncan (1969).

## RESULTS AND DISCUSSION

**Vegetative growth and chlorophyll**

The presented data in Table 2 show that the leaf area, internode length, internode thickness, and chlorophyll increased with increasing the levels of potassium fertilizers. The highest increase was recorded at 200 g Nano-potassium powder sulfate/vine (T3) followed by 150 g Nano-potassium powder sulfate/vine (T2) which showed a preference for these parameters over the traditional potassium sulfate fertilizer at 200 g /vine (T4). But 100 g Nano-potassium powder sulfate/vine (T1) showed the lowest effect for these parameters during both seasons.

The obtained results may be due to nano potassium fertilizer has a higher physical and chemical activity than traditional fertilizers because of the high surface area of the Nano fertilizer which improved the metabolic activities and accelerates the activity of photosynthesis enzymes as well as the chlorophyll (Morteza *et al.,* 2013) which positively reflected on increase the leaves area, Internode length, Internode thickness, and Chlorophyll (%). Furthermore, Subbaiya *et al.* (2012) pointed to previous studies that mentioned that nano-potassium fertilizer enhances the root system by increasing root growth which reflects an increment in plant growth. Also, Meena *et al.* (2017) reported that Nano fertilizers enhance growth parameters of crop plants and that was confirmed by Mustafa *et al.* (2018) on Sultani Fig cultivar. An Increase in the photosynthetic and other physiological activities associated with increasing K levels might have been responsible for the leaf expansion and resultant higher leaf area.

**Table 2. Effect of Nano and traditional form of potassium sulfate on vegetative growth and chlorophyll of Crimson grapevines during the 2018 and 2019 seasons.**

| Treatment | Leaf area ($cm^2$) | | Internode length (cm) | | Internode thickness (cm) | | Chlorophyll (%) | |
|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 |
| 1 | 115.47 | 116.95 | 7.17 | 7.66 | 0.80 | 0.81 | 11.83 | 12.53 |
| 2 | 121.66 | 122.36 | 9.16 | 9.33 | 1.07 | 1.42 | 15.40 | 16.40 |
| 3 | 141.87 | 156.17 | 9.41 | 9.67 | 1.45 | 1.50 | 16.43 | 16.66 |
| 4 | 119.32 | 119.69 | 8.83 | 8.85 | 1.06 | 1.08 | 14.73 | 14.93 |
| LSD at 5% | 2.76 | 1.80 | 0.45 | 0.37 | 0.24 | 0.15 | 0.28 | 0.29 |

**leaf mineral content**

The illustrated data in Table 3 cite an inverse relationship between the leaf petioles content of Ca, Mg, Zn and Cu and the levels of potassium sulfate fertilizers unless manganese which showed a positive relationship either at nano form levels or the utilized level of traditional form in the two seasons. It is evident that 100 g Nano-potassium powder sulfate/vine (T1) augmented the leaf petioles content of Ca, Mg, Zn, and Cu significantly while the treatment of 200 g Nano-potassium powder sulfate/vine (T3) diminished these nutrients than the other treatments, except manganese which showed the lowest value at 100 g Nano-potassium powder sulfate/vine (T1) and the highest value at 200 g Nano-potassium powder sulfate/vine (T3) in the two seasons.

Indeed, potassium has direct synergistic relationships with iron and manganese which leads to lower zinc and copper values and higher manganese value in the plant at elevated potassium levels; on the other hand, potassium has direct antagonistic relationships with calcium and magnesium; hence, their ions are quite similar in size and charge and hence, exchange sites cannot distinguish the difference between the ions. Reiterating, calcium, magnesium, and potassium compete with each other and the addition of any one of them will reduce the uptake rate of the other two (Ujwala, 2011). Similar results were also reported by Dev *et al.* (1995) and Dias and Flore (2002) for apple vegetation.

**Table 3. Effect of Nano and traditional form of potassium sulfate on leaf mineral content of Crimson grapevines during the 2018 and 2019 seasons.**

| Treatment | Ca (%) | | Mg (%) | | Zn (ppm) | | Mn (ppm) | | Cu (ppm) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 |
| 1 | 0.396 | 0.391 | 0.143 | 0.142 | 15.9 | 15.9 | 39.3 | 39.2 | 10.2 | 10.0 |
| 2 | 0.357 | 0.357 | 0.112 | 0.111 | 14.8 | 14.8 | 40.8 | 40.6 | 8.7 | 8.6 |
| 3 | 0.351 | 0.351 | 0.097 | 0.097 | 14.0 | 14.1 | 41.3 | 41.1 | 8.15 | 8.1 |
| 4 | 0.375 | 0.374 | 0.128 | 0.127 | 15.3 | 15.3 | 39.8 | 39.7 | 9.28 | 9.2 |
| LSD at 5% | 0.003 | 0.010 | 0.002 | 0.006 | 0.11 | 0.25 | 0.11 | 0.32 | 0.09 | 0.24 |

**Clusters and berries characteristics**

Cluster weight, length, and width were significantly influenced either by using different doses of Nano-potassium powder sulfate or the level of traditional potassium sulfate in the two seasons; particularly, Nano-potassium powder sulfate at 200 g /vine (T3) which presented the highest values in this concept than the other doses; hence, it recorded 415.3 & 416.25 g for cluster weight, 19.8 & 20.3cm for cluster length and 16.5 & 16.8cm for cluster width in the two seasons, respectively. In contrast, 100 g Nano-potassium powder sulfate/vine (T1) presented the lowest values in this concept than the other doses; consequently, it recorded 271.73 & 277.1 g for cluster weight, 17.0 & 17.4 cm for cluster length and 13.0 & 13.4 cm for cluster width in the two seasons, respectively (Table 4).

Different levels of potassium sulfate fertilizers either in form of Nano or traditional influenced significantly the weight and diameter of Crimson berry. The highest values in this concept were gained from vines fertilized with 200 g Nano-potassium powder sulfate/vine (T3) followed by the vines fertilized with 150 g Nano-potassium powder sulfate/vine (T2) and 200 g potassium sulfate/vine (T4), respectively. Conversely, vines fertilized with 100 g Nano-potassium powder sulfate/vine (T1) gave lower values in this concept in the two seasons (Table 4).

**Table 4. Effect of Nano and traditional form of potassium sulfate on clusters and berries characteristics of Crimson grapevines during the 2018 and 2019 seasons.**

| Treatment | Cluster weight (g) | | Cluster length (cm) | | Cluster width (cm) | | Berry weight (g) | | Berry diameter (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 |
| 1 | 271.73 | 277.10 | 17.0 | 17.4 | 13.0 | 13.4 | 3.04 | 3.20 | 14.20 | 14.25 |
| 2 | 317.15 | 336.90 | 18.0 | 18.3 | 15.0 | 15.2 | 3.52 | 3.61 | 15.30 | 15.83 |
| 3 | 415.30 | 416.25 | 19.8 | 20.3 | 16.5 | 16.8 | 3.75 | 3.79 | 16.33 | 16.35 |
| 4 | 299.50 | 315.75 | 17.4 | 17.5 | 14.5 | 14.8 | 3.47 | 3.50 | 14.55 | 14.58 |
| LSD at 5% | 4.44 | 5.19 | 1.33 | 0.39 | 0.73 | 0.98 | 0.23 | 0.05 | 0.28 | 0.41 |

This enhancement in clusters and berries characteristics due to Nano-potassium powder sulfate at 150 and 200 g per vine refer to the uptake of potassium in sufficient quantity for grapevines and that leads to higher cell division and elongation, and translocation of photosynthates to the fruit which becomes the strongest sink for available K during berry development and ripening (Mpelasoka *et al.*, 2003 and Neilsen and Neilson, 2006); hence, fruit requires more K than any other nutrient and its size is positively correlated with leaf K content (Stiles and Reid, 1991). Likewise, the same trend was found by Abd El-Razek *et al.* (2011) who tested the effect of potassium fertilization at different doses in Crimson grapevines.

**Soluble solids content (SSC %), titratable acidity, SSC/acid ratio and anthocyanin**

The gained results of SSC**%** reveled that vines fertilized with 200 g Nano-potassium powder sulfate/vine (T3) showed an increment of SSC significantly than the other treatments followed by vines fertilized with 150 g Nano-potassium powder sulfate/vine (T2) in the two seasons of this trial. On contrary, vines fertilized with 200 g potassium sulfate/vine (T4) decreased SSC % significantly followed by the vines fertilized with 100 g Nano-potassium powder sulfate/vine (T1) which recorded the lowest data in this concept (Table 5). The increment in SSC % by T2 and T3 is mainly due to these treatments increase the chlorophyll of Crimson grapevines as shown in table 2 which enhance photosynthesis process; besides, potassium has direct synergistic relationships with iron, manganese, and boron which have overlapping roles to play in plant physiology leading to increase SSC % in Crimson berry juice. For instance, iron plays a very important part in chlorophyll formation, manganese is a very important component of photosynthesis and boron enhances carbohydrate metabolism (Ujwala, 2011). Similar results were also reported by Rather *et al.* (2019) and Yousf *et al.* (2018) on apple trees.

Regarding the data of titratable acidity, it followed an opposite behavior to that observe by SSC %. Therefore, vines fertilized with a level of 200 g Nano-potassium powder sulfate/vine (T3) decreased titratable acidity in berry juice in compered to other applications; while, vines fertilized with a level of 100 g Nano-potassium powder sulfate/vine (T1) scored the highest titratable acidity in berry juice compared to the other treatments during both seasons. That might be due to potassium reduces acid levels in berries and interacts with tartaric acid to form potassium bitartrate that has limited solubility. The precipitation of potassium bitartrate significantly lowers tartaric acid levels, resulting in an increase in pH (Morris *et al.*, 1980 and Mullins *et al.*, 1992).

In the same way, SSC/acid ratio took the trend of SSC %; consequently, vines fertilized with 200 g Nano-potassium powder sulfate/vine (T3) gave a higher SSC/acid ratio than other treatments of Crimson seedless grapevines. While vines fertilized with a level of 100 g Nano-potassium powder sulfate/vine (T1) scored the lowest values in this concept compared to other treatments in the seasons of this trial (Table 5). Similar results were investigated since the SSC/acid ratio of 'Thompson Seedless' grapevines increased as K application-level increased (Davies and Robinson,1996).

Different potassium sulfate levels either Nano or traditional form influenced significantly anthocyanin values; for instance, vines fertilized with 200 g Nano-potassium powder sulfate/vine (T3) gave the highest values of anthocyanin in berry skin followed by the vines fertilized with 150 g Nano-potassium powder sulfate/vine (T2) and control (T4), respectively; on the contrary, vines fertilized with 100 g Nano-potassium powder sulfate/vine (T1) showed a sharp decline in anthocyanin of berry skin in the two seasons of this trial (Table 5). Certainly, adequate potassium nutrition helps to increase both coloring and polyphenolic content of berries and in this study high level of Nano-potassium powder sulfate/vine (200 g) increased values of anthocyanins during both seasons and that was in harmony with Omar (2000) and Reynolds *et al.* (2005) who mentioned that potassium improves berries color.

**Table 5. Effect of Nano and traditional form of potassium sulfate on SSC, acidity, SSC/acid ratio of berry juice and anthocyanin of Crimson berries during the 2018 and 2019 seasons.**

| Treatment | SSC (%) | | Titratable acidity (%) | | SSC/ acid ratio | | Anthocyanin (mg/100g fresh weight) | |
|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 |
| 1 | 19.16 | 19.23 | 0.32 | 0.33 | 59.88 | 58.27 | 122.1 | 125.50 |
| 2 | 20.53 | 21.40 | 0.28 | 0.30 | 73.32 | 71.33 | 152.64 | 156.3 |
| 3 | 21.46 | 21.76 | 0.26 | 0.28 | 82.54 | 77.71 | 207.66 | 225.9 |
| 4 | 20.26 | 21.10 | 0.30 | 0.32 | 67.53 | 65.94 | 141.85 | 145.9 |
| LSD at 5% | 1.52 | 0.74 | 0.02 | 0.02 | 7.16 | 4.10 | 3.12 | 3.90 |

In the same way, all data mentioned in Table 5 are in harmony with Hafez *et al.* (2018) who reported that Nano-potassium nano-capsulated biodegradable polylactic acid (K-PLA) was better in stabilizing K than conventional potassium ($K_2O$) and significantly enhanced coloring percentage, SSC %, SSC/acid ratio but decreased acidity percentage in fruit juice.

**Total sugar and calcium content of Crimson berries**

The total sugar content of Crimson berries was significantly increased by increasing potassium sulfate levels at both utilized forms under this study. In this concern, the vines fertilized with 200 g Nano-potassium powder sulfate/vine (T3) appeared to assimilate higher berry sugar content than fertilized with 100 g Nano-potassium powder sulfate/vine (T1) which showed lower sugar berry content during both seasons of this trial. Moreover, vines fertilized with 150 g Nano-potassium powder sulfate/vine (T2) and 200 g potassium sulfate/vine (T4) presented the minimum level of berry sugar content, but vines fertilized with the level of 150 g Nano-potassium powder sulfate/vine (T2) was higher than the level of 200 g potassium sulfate/vine (T4) during both seasons of this trial (Table 6). This happened because potassium is implicated in preserving sugars into phloem which authorizes sugars translocation from source tissues to provide the requirements of growing organs like fruits and roots (Taiz and Zeiger, 2004). These results also corroborate the findings of Lacombe *et al.* (2000).

A negative relationship was found obviously between utilized potassium sulfate levels at nano or traditional form and calcium content of Crimson berries in the two seasons of this trial. Therefore, vines fertilized with 200 g Nano-potassium powder sulfate/vine (T3) diminished calcium content of Crimson berries significantly compared with other applications; it recorded 41.2 & 41.33 mg/100g during both seasons, respectively. On the other hand, vines fertilized with 100 g Nano-potassium powder sulfate/vine (T1) recorded the highest calcium content of Crimson berries; it scored 44.6 & 44.48 mg/100g in the two seasons, respectively (Table 6). In fact, these results may be due to that Ca content in the fruit sharply decreases with increase in the rate of K application and as Ca is an important constituent of the cell wall, very low Ca concentration adversely affects the cell wall formation, and by implications the fruit firmness (Naiema, 2003 and Wojcik, 2005).

**Table 6. Effect of Nano and traditional form of potassium sulfate on total sugar and calcium content of Crimson berries and SLW and yield of Crimson grape vines during the 2018 and 2019 seasons.**

| Treatment | Berry total sugar (%) | | Ca berry content (mg/100g) | | SLW ($mg/cm^2$) | | Yield /vine (Kg) | |
|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 | 2018 | 2019 |
| **1** | 14.5 | 14.61 | 44.6 | 44.48 | 0.039 | 0.037 | 5.54 | 6.00 |
| **2** | 15.82 | 15.9 | 42.7 | 42.55 | 0.029 | 0.027 | 7.93 | 9.66 |
| **3** | 16.5 | 16.65 | 41.2 | 41.33 | 0.026 | 0.024 | 12.32 | 15.81 |
| **4** | 15.29 | 15.4 | 44.1 | 43.80 | 0.033 | 0.029 | 6.29 | 6.33 |
| LSD at 5% | 1.88 | 1.89 | 0.16 | 0.19 | 0.006 | 0.008 | 1.09 | 0.74 |

**Specific leaf weight (SLW) and yield per vine**

Data in Table 6 reveal that vines fertilized with 100 g Nano-potassium powder sulfate/vine (T1) showed a higher Specific leaf weight than those gained under the other nano potassium sulfate doses or control; it scored 0.039 & 0.037 $mg/cm^2$ in the two seasons, respectively. While vines fertilized with of 200 g Nano-potassium powder sulfate/vine (T3) gave a lower Specific leaf weight than the other treatments; hence, it recorded 0.026 & 0.024 $mg/cm^2$ in the two seasons, respectively. Furthermore, vines fertilized with 200 g potassium sulfate/vine (T4) was better than fertilized with 150 g Nano-potassium powder sulfate/vine (T2); hence, it recorded 0.033 & 0.029 $mg/cm^2$ in the two seasons, respectively. And that is mainly due to potassium cation is used as an osmotic agent in the opening and closing of stomata, an important mechanism of vine water relations (Mullins *et al.*, 1992).

The yield of Crimson grapevines was influenced significantly by utilizing different doses of Nano-potassium powder sulfate and control. Consequently, the vines fertilized with 200 g Nano-potassium powder sulfate/vine (T3) yielded the highest values in this concept (12.32 & 15.81 kg/vine in the two seasons, respectively) followed by T2, T4, and T1, respectively. Also, data showed a positive relationship between yield and Nano-potassium powder sulfate levels; nevertheless, 100 g Nano-potassium powder sulfate/vine level (T1) gave the lowest yield during both seasons (Table 6). The increase in yield parameters may be due to photosynthesis productions that transferred by potassium which contribute in transferring the outputs from the source (leaves) to the sink (vegetative growth, flowers, fruits), as well as the activation of potassium for many enzymes which responsible for the activities of vegetative growth may contribute to increasing the cellular activity and transfer of nutrients to the fruits and thus reflected on the yield (Patrick *et al.*, 2001), or it may be due to the effectiveness of Nano-fertilizer to improve the enzymatic and biological reactions and the regularity of hormones (Grover *et al.*, 2012), as well as its nutrition role in activating the nutrient movement, which is positively reflected on increasing the yield and its components (Al-Juthery *et al.*, 2018). The obtained results were corroborated with antecedent trials of Abd El-Razek *et al.* (2011) and Zlamalova *et al.* (2015) on several grapevines varieties.

In summary, Nano-potassium powder sulfate proofed that nano-fertilizer is better a traditional form of fertilizers for enhancing all estimated parameters in this study whether at an equal or lesser concentration of traditional form which leads to the production of an economic yield with high productive characteristics.

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## التسميد بواسطة مسحوق نانو سلفات البوتاسيوم حسن إنتاجية كروم العنب صنف الكريمسون عديم البذور

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أجريت تجربة حقلية بتصميم كامل العشوائية باستخدام ثلاث تركيزات من مسحوق نانو سلفات البوتاسيوم (١٠٠ و ١٥٠ و ٢٠٠ جم / كرمة) وتركيز واحد من سلفات البوتاسيوم التقليدية (٢٠٠ جم / كرمة) كإضافات للتربة لمقارنة تأثير البوتاسيوم في صورة النانو أو الصورة التقليدية على أداء كرمات العنب الكريمسون عديم البذور خلال موسمى ٢٠١٨ و ٢٠١٩. وكشفت النتائج أن مسحوق نانو سلفات البوتاسيوم عند ١٥٠ و ٢٠٠ جم / كرمة كان أفضل من الصورة التقليدية في تحسين النمو الخضري، امتصاص المغذيات، جودة عنقود ومحصول العنب الكريمسون عديم البذور. باختصار، يمكن استنتاج أن استخدام صورة النانو من سلفات البوتاسيوم بجرعة مساوية للصورة التقليدية أو أقل بخمسين جرام يؤدي إلى زيادة في إنتاجية كرمات العنب الكريمسون عديم البذور.