Nano and Mineral Selenium Foliar Application Effect on Pea Plants (*Pisum sativum* L.)

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The present study was conducted to observe the response of selenium application as a foliar spray on growth, some chemical composition, yield and quality of pea plants in Nubaria farm El-Behira Governorate, Egypt. This experimental study was done using split plot design in three replications in 2016/2017. Four levels of selenium foliar applications in "Nano and Mineral-Se (10, 20, 30 and 40 ppm)" were used, in addition to the control treatment sprayed with water. Achieved results about some parameters of pea plants in this study showed that the Mineral-Se (chemical) and Nano-Se (biological) selenium spraying treatments had a significant positive effect on all studied characteristics such as plant height, no. of leaves, no. of branches, fresh weight of leaves and stems, dry weight of leaves and stems, chlorophyll (SPAD) as well as yield quantity and quality which represented in pod weight, plant yield and total yield of pea plant. It could be concluded that, foliar spray of selenium "Nano or Mineral-Se" at rates of 10 and 20 ppm increased vegetative growth, yield and quality as well as mineral contents in leaves and seeds of pea plants. Moreover, the best use of selenium as a foliar spray was the Nano type because it is more safety and friendly environmental application compared with the chemical type.

Keywords: Selenium, Nano-Se, Mineral-Se, Foliar application, Pea (*Pisum sativum* L.).

INTRODUCTION

*Pisum sativum* L.) is one of the major winter crops grown in Egypt for local and export markets. Pea seeds dry or fresh had high nutritional values due to their high contents of proteins and carbohydrates as well as vitamins and minerals (Smart, 1990). *P. sativum* is an annual plant, in Egypt, early finds date from ca. 3800–3600 BC in Upper Egypt and from ca. 4800–4400 BC in the Nile delta area, (Bianchini and Corbetta, 1976).

Selenium is one of important trace element about health of human. Moreover, it is contributory in biosynthesis and protection mechanisms of hormones in human. Furthermore, selenium element implicated in the membrane protection and has anticancer action. It is a cofactor of glutathione peroxidase and plays a considerable part against oxidative damage of tissues (Ferrarese et al., 2012). The lack of selenium can cause many diseases such as many types of cancers and heart disease (Rayman, 2002). Selenium is absorbed and created within the plant in the same assimilation pathway as sulfur, which is present in selenium amino acids such as selenomethionine and selenocysteine (Sors et al., 2005). Moreover, the use effect of Se-laden plant materials as bio Se fertilizers acts an individual environmentally-friendly strategy to carry out the goal of Se bio fortification.

Selenium fertilizer application can be used in four major techniques: seed soaking, seed dressing, foliar application and soil application. Nowadays technology to apply Se fertilizer as a
foliar application or base fertilizer has been used to boost Se content in the portion rate of crops (Pezzarossa et al., 2012). Plants obtain selenium predominantly as selenite and also able to take up selenite and selenium containing amino acids (Zhao et al., 2005). An essential part of a resource efficient and sustainable agronomic fortification strategy includes proper use of Se fertilizers that takes the spatial soil variability, cropping systems into consideration and climatic conditions. Inorganic fertilization is the most common practice to increase Se levels in crops (Lyons et al., 2005 and Broadley et al., 2006). Spraying plants with selenium element solution may enhance the utilisable parts of plant with Se compounds in concentrations of importance nutritional (Germ et al., 2007, Ozbolt et al., 2008). Wang et al., (2013) demonstrated that Both soil and foliar Se applications had a positive effect in increasing the Se content in some plants without negatively effect on the N, P, K, Ca, Mg, Fe, Mn, Cu and Zn contents. Furthermore, foliar application is effective than soil application.

Nano-Se defined as Nano-elemental selenium and/or Nano-Se manufactured for use in developed in medical therapy and nutritional supplements (Gao et al., 2002) as well as Se-fertilization. More applications for nanoparticles of Se are represented the development of safer selenium vitamins and additives of food (Wang et al., 2007). Using of Nano-Se in Se fertilization sector can be used for increasing crop yield and productivity of agricultural soils. Thus, it was recorded that there are a good opportunities for the intervention of Se nanotechnology in the area of plant nutrition and fertilizers (Mastronardi et al., 2015).

Therefore, the main objectives of this study were to cognition the effect of selenium “Nano and/or Mineral-Se” as a foliar application on growth, yield and quality as well as some mineral composition of pea plants.

**MATERIALS AND METHODS**

**Site and Soil Description:**
The Field experiment was conducted under natural conditions in the Nubaria farm – Experimental Farm of the National Research Centre during the winter season of 2016/2017 (from November 2016 to April 2017). The research field is situated in an arid climate region at an altitude of 27 m above mean sea level and is intersected by latitude of 30°30N and longitude of 30°20E. The soil of the experimental site was deep, well-drained sandy profile which was classified as an (Entisol-Typic Torripsamments) composing of 85.5% sand (2.0–0.02 mm), 11.7% silt (0.02–0.002) 2.8% clay (less than 0.002 mm) and 0.4% organic matter in the topsoil (0-80 cm depth) with an alkaline pH of 8.2, EC of 0.85 dS m⁻¹, CaCO₃ 1.5%. The average soil water content at field capacity from surface soil layer down to 80 cm depth at 20 cm intervals was 0.18 (v/v) and the permanent wilting point for the corresponding depths was 0.08 (v/v), respectively. Average available N, P and K from surface soil layer down to 60 cm depth at 20 cm intervals was 12, 4 and 35 mg kg⁻¹ soil, respectively before the initiation of the experiment.

**Experimental Design and Treatments:**
This experiment was split plot design represented the treatments with three replicates for each. The experiment is of nine treatments as following:

1) Control treatment “water spraying”.
2) Mineral selenium 10 ppm.
3) Mineral selenium 20 ppm.
4) Mineral selenium 30 ppm.
5) Mineral selenium 40 ppm.
6) Nano selenium 10 ppm.
7) Nano selenium 20 ppm.
8) Nano selenium 30 ppm.
9) Nano selenium 40 ppm.

The foliar spray treatments were performed twice after 45 days of planting between the two sprayed 10 days.

**Selenium Solution Preparation:**

**Mineral-Se:**

It was prepared using sodium selenite (NaSeO₃). This source of selenium was imported from Hungary (Institute of Bio and Environmental Energetics, University of Debrecen).

**Nano-Se:**

It was prepared biologically in the Soils, Water and Environment Research Institute (SWERI), Soil Microbiology Department according to Eszenyi et al., (2011). The size of selenium nanoparticles and other properties were measured using TEM and X-ray in Nanotechnology Lab in Agricultural Research Center, in Giza.
Plant Samples and Analysis:
At harvesting stage, a random sample of five plants were chosen from each plot and subjected for analysis.

Parameter Measured:

Growth Parameters:
The following plant growth parameters were measured: plant height (cm); no. of leaves and branches/ plant; fresh and dry weight of plant leaves and stem (g plant⁻¹). The chlorophyll (SPAD) content was determined as described by Schepers et al., (2006).

Chemical Composition:
The plant samples were dried at 70 °C; ground using stainless steel equipment's to analyze N, P, K and Se content of leaves and seeds of pea. From each sample 0.5 g was digested by the mixture of sulfuric (H₂SO₄) and per chloric (HClO₄) acids (1:1) for N, P and K determination and nitric (HNO₃) and per chloric (HClO₄) acids for Se determination. N was determined by Kjeldahl method, K was determined by Flame photometer and P with Spectrophotometer as described by Cottenie et al., (1982). While, Se content was determined by atomic absorption spectroscopy as described by (Levesque and Vendette, 1971).

Yield Parameters:
The following yield parameters were measured: pod weight (g), shelling percentage, yield (g/plant) and total yield (ton/fed).

Statistical Analysis:
Data of the experiment were subjected to statistical analysis of least-significant-differences test (LSD) at the confidence level of 5% conducted on means of treatments to measure the considered significantly different according to the procedures of the procedure outlined by Gomez and Gomez (1984).

RESULTS

Nano and Mineral-Se effect on vegetative growth characteristics of pea plants
Data in Table (1) show clearly that, foliar applications of selenium Mineral or Nano-Se increased significantly all vegetative growth characteristics " plant height, number of leaves, fresh weight of leaves and total chlorophyll" except for number of branches and stem fresh weight as well as dry weights of leaves and branches. However, the highest mean amount of no. of leaves (19.48), no. of branches (3.38) and fresh weight of leaves (23.35 g) was found by Mineral-Se. While, the highest amount of plant height (49.18 cm), fresh weight of stems (12.18 g) as well as leaves dry weight (6.67 g) and total chlorophyll (SPAD) (40.68) was recorded by using Nano-Se. On the contrary, the lowest amount of plant height (cm), fresh weight of stems (g) as well as total chlorophyll (SPAD) was recorded by Mineral-Se. Moreover, the lowest amount of number of leaves, number of branches, fresh weight of leaves (g) and dry weight of stems (g) was recorded by using Nano-Se.

Different rates of selenium foliar spray effect on growth characteristics of pea plants
As illustrated in Table (1) show that, the foliar spraying of selenium at rates of "0, 10, 30 and 40 ppm" increased significantly all vegetative growth characteristics except for no. of branches of pea plants. Furthermore, the highest amount of vegetative growth characteristics "plant height (54.96 cm), no. of branches (3.63), no. of leaves (22.76), fresh weight of leaves (27.72 g) and dry weights of leaves (7.78 g) and stems (4.64 g)" were found by foliar application of selenium at a rate of 20 ppm and the highest amount of fresh weight of stems (13.9 g) and total chlorophyll (SPAD) (43.25) were found by foliar application of selenium at a rate of 30 ppm. On the other hand, the lowest amount of all vegetative growth characteristics was recorded by control treatment.

Interaction effect of different sources and rates of selenium foliar application on growth parameters of pea plants
Table (1) shows that the Mineral and Nano-Se spraying treatments had a significant effect on all vegetative growth characteristics except for no. of branches. Moreover, the highest amount of plant height (58.45 cm) was recorded by foliar application of Nano-Se at a rate of 20 ppm. However, the highest amount of no. of branches (4.63), no. of leaves (28.38), fresh weight of leaves (28.66 g) and dry weight of stems (4.81 g) were found by foliar spray of Mineral-Se at rate of 20 ppm. Moreover, the highest amount of fresh weight of stems (15.38 g) was recorded by foliar application of Mineral-Se at rate of 30 ppm and the highest value of total chlorophyll (SPAD) (43.90) was found by foliar application of Nano-Se at rate of 30 ppm. Furthermore, the highest value of dry weight of leaves (8.11g) was found by foliar spray of Nano-Se at a rate of 10 ppm.
On the other hand, the lowest amount of all vegetative growth characteristics was recorded by control treatment "foliar spray of water".

The previous obtained results of studying and evaluating the effect of different Se-supplemental sources and rates on some growth parameters of pea plants may be due to increase in starch content in chloroplast (Pennanen et al., 2002). Also Se can protect the plant cell from oxidative damage by antioxidant defenses (Seppanen et al., 2002), also has a beneficial role in plants subjected to various abiotic stresses (Abul-Soud and Abd-Elrahman, 2016), high temperature (Balal et al., 2016), chilling injury (Akladious, 2012), metals accumulation (Li et al., 2016) and drought stress (Nawaz et al., 2015 a,b). This is due to Se positive role in several physiological and biochemical mechanisms (Djanaguiraman et al., 2005). However, the total dry matter of plants was observed in Se sprayed plants as compared with controls for cultivar. So that, Se effect on plant growth depends on rate and crop variety (Germ et al., 2007). Hasauzzaman et al., (2010) stated that Se foliar application increased the activity of many enzymes. Malik et al., (2011) were observed that low concentration of spraying Se enhanced shoot growth in mug bean plants by 24 and 27%. Similarly, Germ et al., (2005) found that non-accumulator species respond metabolically to low dosage of Se fertilization. It is well documented that some plant species, need Se for development and normal growth or strongly promotes it (Price et al., 1987).

(Bohdady et al., 2017) also found that, there values of plant height, no. of leaves, fresh and dry weight of faba bean shoots were obtained when used low concentration (10 ppm) of selenium.


<table>
<thead>
<tr>
<th>Selenium sources</th>
<th>Plant height (cm)</th>
<th>No. of leaves /plant</th>
<th>No. of branches /plant</th>
<th>Leaves fresh weight (g)</th>
<th>Stems Fresh weight (g)</th>
<th>Leaves dry weight (g)</th>
<th>Stems Dry weight (g)</th>
<th>Chlorophyl L (SPAD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral</td>
<td>44.59</td>
<td>19.48</td>
<td>3.38</td>
<td>23.35</td>
<td>11.58</td>
<td>6.29</td>
<td>4.32</td>
<td>38.24</td>
</tr>
<tr>
<td>Nano (Bio)</td>
<td>49.18</td>
<td>14.38</td>
<td>2.70</td>
<td>21.54</td>
<td>12.18</td>
<td>6.67</td>
<td>4.08</td>
<td>40.68</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>3.27</td>
<td>3.71</td>
<td>NS</td>
<td>1.17</td>
<td>NS</td>
<td>NS</td>
<td>1.09</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Selenium rates (ppm)</th>
<th>Plant height (cm)</th>
<th>No. of leaves /plant</th>
<th>No. of branches /plant</th>
<th>Leaves fresh weight (g)</th>
<th>Stems Fresh weight (g)</th>
<th>Leaves dry weight (g)</th>
<th>Stems Dry weight (g)</th>
<th>Chlorophyl L (SPAD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>39.31</td>
<td>11.07</td>
<td>2.38</td>
<td>13.05</td>
<td>8.99</td>
<td>4.75</td>
<td>3.52</td>
<td>35.20</td>
</tr>
<tr>
<td>10</td>
<td>51.13</td>
<td>18.07</td>
<td>3.38</td>
<td>27.17</td>
<td>12.96</td>
<td>7.48</td>
<td>4.63</td>
<td>37.75</td>
</tr>
<tr>
<td>20</td>
<td>54.96</td>
<td>22.76</td>
<td>3.63</td>
<td>27.72</td>
<td>12.79</td>
<td>7.78</td>
<td>4.64</td>
<td>39.40</td>
</tr>
<tr>
<td>30</td>
<td>48.01</td>
<td>19.57</td>
<td>3.25</td>
<td>23.24</td>
<td>13.90</td>
<td>6.92</td>
<td>4.20</td>
<td>43.25</td>
</tr>
<tr>
<td>40</td>
<td>41.00</td>
<td>13.19</td>
<td>2.57</td>
<td>21.05</td>
<td>10.75</td>
<td>5.46</td>
<td>4.03</td>
<td>41.70</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>5.87</td>
<td>3.14</td>
<td>NS</td>
<td>2.17</td>
<td>2.15</td>
<td>1.43</td>
<td>NS</td>
<td>2.07</td>
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<table>
<thead>
<tr>
<th>Selenium sources</th>
<th>Selenium Rates (ppm)</th>
<th>Plant height (cm)</th>
<th>No. of leaves /plant</th>
<th>No. of branches /plant</th>
<th>Leaves fresh weight (g)</th>
<th>Stems Fresh weight (g)</th>
<th>Leaves dry weight (g)</th>
<th>Stems Dry weight (g)</th>
<th>Chlorophyl L (SPAD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral</td>
<td>Control</td>
<td>36.39</td>
<td>10.88</td>
<td>2.50</td>
<td>12.46</td>
<td>9.12</td>
<td>4.58</td>
<td>3.54</td>
<td>35.10</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>43.92</td>
<td>19.50</td>
<td>3.25</td>
<td>27.94</td>
<td>11.47</td>
<td>6.85</td>
<td>4.58</td>
<td>36.30</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>51.47</td>
<td>28.38</td>
<td>4.63</td>
<td>28.66</td>
<td>12.06</td>
<td>7.97</td>
<td>4.81</td>
<td>37.30</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>52.51</td>
<td>24.88</td>
<td>3.63</td>
<td>25.83</td>
<td>15.38</td>
<td>7.57</td>
<td>4.48</td>
<td>42.60</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>38.64</td>
<td>13.75</td>
<td>2.88</td>
<td>21.87</td>
<td>9.85</td>
<td>4.47</td>
<td>4.18</td>
<td>39.90</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>5.14</td>
<td>3.68</td>
<td>NS</td>
<td>3.43</td>
<td>2.56</td>
<td>2.67</td>
<td>NS</td>
<td>3.12</td>
<td></td>
</tr>
</tbody>
</table>


648
Table (2): Response of selenium “Nano and Mineral-Se” on N, P, K (%) and Se (ug/Kg) content of pea plant” leaves and seeds” in 2016/2017 season.

<table>
<thead>
<tr>
<th>Selenium sources</th>
<th>Leaves</th>
<th></th>
<th></th>
<th>Seeds</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N (%)</td>
<td>P (%)</td>
<td>K (%)</td>
<td>Se (ug/Kg)</td>
<td>N (%)</td>
<td>P (%)</td>
</tr>
<tr>
<td>Mineral</td>
<td>2.79</td>
<td>0.52</td>
<td>2.47</td>
<td>11.3</td>
<td>3.17</td>
<td>0.43</td>
</tr>
<tr>
<td>Nano (Bio)</td>
<td>2.71</td>
<td>0.34</td>
<td>2.40</td>
<td>6.30</td>
<td>3.10</td>
<td>0.32</td>
</tr>
<tr>
<td>Nano (Bio) LSD (5%)</td>
<td>0.04</td>
<td>0.09</td>
<td>0.05</td>
<td>2.30</td>
<td>0.03</td>
<td>0.06</td>
</tr>
<tr>
<td>Selenium rates (ppm)</td>
<td>N(%)</td>
<td>P(%)</td>
<td>K(%)</td>
<td>Se (ug/Kg)</td>
<td>N(%)</td>
<td>P(%)</td>
</tr>
<tr>
<td>Control</td>
<td>2.49</td>
<td>0.38</td>
<td>2.44</td>
<td>1.30</td>
<td>3.12</td>
<td>0.45</td>
</tr>
<tr>
<td>10</td>
<td>2.93</td>
<td>0.42</td>
<td>2.44</td>
<td>5.30</td>
<td>3.27</td>
<td>0.38</td>
</tr>
<tr>
<td>20</td>
<td>2.82</td>
<td>0.45</td>
<td>2.47</td>
<td>9.10</td>
<td>3.10</td>
<td>0.37</td>
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<tr>
<td>30</td>
<td>2.98</td>
<td>0.43</td>
<td>2.41</td>
<td>12.7</td>
<td>3.32</td>
<td>0.33</td>
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<tr>
<td>40</td>
<td>2.54</td>
<td>0.47</td>
<td>2.41</td>
<td>15.8</td>
<td>2.86</td>
<td>0.36</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>0.04</td>
<td>0.20</td>
<td>NS</td>
<td>1.60</td>
<td>0.07</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Padmaja et al., (1989) and Aggarwal et al., (2011) reported that the higher concentration of Se inhibited porphobilinogen synthase activity and decreased the total chlorophyll content that is due to higher concentration of Se caused damage plant cell membranes, chlorophyll and respiration in bean plants. By contrast, under foliar spray with low concentration of Se enhanced photosynthesis, stimulated anti-oxidative system and primary metabolism that leads to significant effect on photosynthetic pigments (chl a, chl b, total chl and carotenoids) concentration in leaves of faba bean (Boghdady et al., 2017).

N, P, K and Se content in leaves and seeds of pea plant as affected by different sources of selenium foliar application

The results presented in the Table (2) clearly revealed that, foliar spray of Mineral or Nano-Se had a significant effect on N, P, K and Se in both leaves and seeds of pea plants. Moreover, the highest values of N, P, K and Se (2.79, 0.52, 2.47% and 11.3 ug/Kg), respectively, in leaves and (3.17, 0.43, 2.28% and 3.90ug/Kg), respectively, in stems were found by Mineral-Se as compared with Nano-Se and control.

Different rates of selenium foliar spray effect on N, P, K and Se content in leaves and seeds of pea plants

Data in Table (2) demonstrated that, using selenium as a foliar application at rates from 20 to 40 ppm gave the highest values of N, P and K (%) in leaves. At the same rates in case of Se (ug/Kg) content, the highest values were recorded in both leaves and seeds of pea plants. On the other hand, the highest values of P (0.45%) and K (2.27%) in seeds were recorded by control treatment. On the contrary, the lowest amount of N (2.49%), P (0.38%) and Se (1.30ug/Kg) in leaves of pea plant was recorded by control treatment. Furthermore, the lowest amount of N (2.86%) in seeds at a rate of 40 ppm and the lowest value of P (0.33%) in seeds was found at a
rate of 30 ppm treatment of selenium foliar spray. Moreover, the lowest value of K (2.22%) was recorded in seeds by using selenium as a foliar application at a rate of 10 ppm.

**Interaction effect of different sources and rates of selenium foliar application on N, P, K and Se content in leaves and seeds of pea plants**

The results in Table (2) revealed that the interaction between different types of selenium "Mineral or Nano" and different rates of selenium foliar application were significant effect on N (%) and Se (ug/Kg) contents. On the contrary, the treatments had a non-significant effect on P and K (%) contents. Moreover, the highest value of N (3.43%) in leaves was found by foliar application of Nano-Se at rate of 30 ppm. However, the highest value of N (3.70%) in seeds was found by foliar spraying of Mineral-Se at a rate of 10 ppm. Furthermore, the highest value of P (%) in leaves and seeds and K (%) in leaves of pea plants was found by foliar spray of mineral selenium at rates of 10 and 20 ppm. However, the highest value of Se in leaves and seeds (20.7 and 7.30 ug/Kg), respectively, as well as K (2.32%) in seeds was recorded by foliar application of mineral selenium at rate of 40 ppm. On the contrary, the lowest values of N, P, K and Se were recorded by control treatment.

The pervious results agreed with the finding of Yang et al., (2003) on soybean. Foliar application with Se at 10 and 20 ppm were twice increase intake of selenium in garlic, cabbage, radish and onion (Slejkovec and Goessler, 2005). Se addition to the medium growth increases the Se status in plants as found by Zhang et al., (2011) in chickpea sprouts, and in Zea mays (Longchamp et al., 2013). Other studies obtained the same results that Se contents increased in seeds and roots of brassica with high in the Se supplemented plants (Lyons et al., 2009). Se foliar application increased Se content in seeds of faba bean (Boghdady et al., 2017), and Se content in wheat grain (Ekanayake et al., 2015). There are many factors affecting the increase in Se efficiency in plants which include the time, rate, method of Se application, Se form, crop species and variety as well as soil and climatic conditions (Rengel et al., 1999). Foliar Se application had no negative effect on N, P, K, Ca, Mg, Fe, Mn, Cu and Zn contents in wheat (Wang et al., 2013). Rios et al., (2010) investigated that there was no significant effect of Se source and level on nitrogen content in lettuce plants.

Se supply enhanced significantly the uptake of K in wheat as well as Pazurkiewicz et al., (2008) noticed that there was an increase in K contents in maize grains. By using foliar Se application, regardless of the source, there was a negative effect in P content in wheat grains according to the inhibition of selenium in phosphorus absorption was observed (Li et al., 2008). Also (Boghdady et al., 2017) found that foliar spray with Se at low concentrations had a positive effect as there was a significant increase of N, P and K percentage in faba bean seeds.

**Nano and Mineral-Se effect on yield and quality of pea plants**

The recorded data in Table (3) showed that foliar applications of selenium Mineral or Nano-Se had a significant effect on all yield and quality of pea plants except for pod weight (g). Moreover, the highest pod weight (5.34 g) and shelling (63.83 %) was found by Nano-Se. On other hand, the highest amount of yield (252.49 g/plant) and total yield (13.68 ton/fed) were recorded by Mineral-Se.

**Different rates of selenium foliar spray effect on yield and quality of pea plants**

The results presented in the Table (3) clearly found that, foliar application of selenium at rates of 10, 20, 30 and 40 ppm had a significant effect on all yield and quality of pea plants. Furthermore, the highest amount of pod weight (5.90 g) and total yield (254.66 g/plant) and total yield (13.8 ton/fed) of pea was recorded by foliar application of selenium at rate of 20 ppm and the highest shelling (65 %) of pea was found by foliar spraying of selenium at rate of 40 ppm.
Table (3): Response of selenium "Nano and Mineral-Se" on yield and quality of pea plants

<table>
<thead>
<tr>
<th>Selenium sources</th>
<th>Pod weight (g)</th>
<th>Shelling (%)</th>
<th>Yield g/plant</th>
<th>Total yield ton/ fed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral</td>
<td>4.86</td>
<td>59.99</td>
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<td>22.65</td>
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<th>Shelling (%)</th>
<th>Yield g/plant</th>
<th>Total yield ton/ fed</th>
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Interaction effect of different sources and rates of selenium foliar application on yield and quality of pea plants

The results in Table (3) reported that the interaction between different types of selenium "Mineral or Nano" and different rates of selenium foliar application were significantly affected all yield and quality characteristics of pea plants. Moreover, the highest value of pod weight (6.68 g), yield (273.96 g/plant) and total yield (14.85 ton/fed) of pea plant were recorded by foliar application of Mineral-Se at a rate of 20 ppm. However, the highest value of shelling (68.71%) was found by foliar application of Nano-Se at rate of 10 ppm. On the contrary, the lowest value of all yield and quality of pea plants was found by control treatment.

Foliar Se-application promoted significantly an increase in carrot, garlic bulbs (Poldma et al., 2011), onion bulbs (Kapolna et al., 2009; 2012) as well as radish flowers (Hladun et al., 2013).

Interestingly, a field study showed that Se application increased wheat grain yield (Ekanayake et al., 2015), chicory (Germ et al., 2007), brassica seed production (Lyons et al., 2009), pumpkin yield (Germ et al., 2005), barley (Ducsay and lozek 2006), rice (Wang et al., 2013) and maize (Chilimba et al., 2012a). That may be attributed to Se behavior in increasing the respiratory activity in leaves and flowers, also chloroplast enzymes and its anti-oxidative level and activity in plants (Sajedi et al., 2011)

CONCLUSION

It could be summarized that, the best rates of selenium foliar spray "Nano or Mineral-Se" were 10 and 20 ppm which increased vegetative growth, yield and quality as well as mineral content in leaves and seeds of pea plants. Moreover, the authors recommend that it is better to use selenium as a Nano type because it is more safety and friendly environmental application compared with the chemical type.
CONFLICT OF INTEREST
The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS
All authors significantly contributed in all parts and aspects of paper.

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REFERENCES


