Morphology Reaction of Pea Root to the Source and Applied Amount of Manganese

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ABSTRACT

To study the effect of source and applied amount of manganese on the root morphology of pea varieties, a greenhouse-test in the form of factorial and completely randomized block design with three replicates was performed. Investigating factors were two pea varieties, Arman and Hashem. Manganese source was two levels of manganese sulfate and manganese chloride and applied amount of manganese was four levels of 0 (as control), 5, 10 and 15 kg manganese per hectare. The results showed that the difference between pea varieties regarding plant height, root volume, sum of the root surface and root dry weight was not significant. Despite of this, Hashem line had more sum of root length and medium root diagonal and more root dry weight in comparison to Arman line. Maximum rate of root volume, sum of root surface, sum of root length and root dry weight were observed after using manganese sulfate. Manganese source did not impress plant height, root diagonal intermediate and shoot dry weight. Pea root system was high sensitive to manganese consumption. Using 5 kg manganese per hectare, improved root characteristics, but using manganese more than this rate lead to decrease root system growth. Among pea lines Arman was more reactive to manganese consumption.

INTRODUCTION

Due to high protein amount (approximately twice as much amount to cereals) and the capacity of biological nitrogen fixation, cereals have considerable importance in agriculture and human nutrition [11]. In Iran that is one of origin of this plant, pea, either from the viewpoint of under- planted area and/or production has the maximum degree of importance as, except humid north areas it is planted in the most regions of Iran [1]. Today, fertilizers are used as tools to provide maximum production in surface unit. Unfortunately using chemical fertilizers in Iran is imbalance and disproportionate to real requirement of plant. Consumption rate of microelements in countries with modern agriculture, is 2 to 4 percent of total consumption rate of fertilizers. This rate is paltry in Iran and is about 2 grams per tone consumption fertilizer [8]. Manganese is one of essential micro elements for plant metabolism that is required as cofactor or activator for a group of enzymes. Manganese involves in electron transferring reactions in plant. It plays role in chlorophyll production and its existence is essential in photo system-II [15] With respect to the metabolic role of manganese in activity of reductase enzyme and activating enzymes that involve in carbonate metabolism, consuming fertilizers containing manganese, increase photosynthesis and synthesis of carbohydrates such as starch. Manganese involves in division and development of root cells. Manganese deficiency in plants prevents root growth that is due to carbohydrate deficiency and direct requirement of plant to that for growth. In manganese-deficient plants, lateral roots formation are stopped completely.

The results of different experiments showed that manganese deficiency cause to form additional hair roots in root system of Arabidopsis and lettuce. Although, there is not any information about understanding procedure of manganese deficiency and changing in root epidermal pattern [9,7].

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According to the report of Yang et al [15], manganese deficiency created complete change in arrangement and root epidermal cells characteristics of Arabidopsis and lettuce. In presence of manganese, the enhancement of hair roots was prevented, whereas in manganese deficient plantlets, development of root hair was improved.

 Characteristics such as root weight, root length, root diagonal, and root density or root amount in soil volume unit, play important role in water and nutrition element absorption from the soil and consequently yield production. There are many evidences about existence of genetic variation regarding plant species rooting system [4].

 Ganjeali & Kafi [3], reported significant differences among 20 genotypes of Iranian pea about root characteristics including, sum of the root length, number of lateral (side) roots, root surface and root dry weight. Also Singh et al, [14] in the study of 30 pea genotypes at flowering stage, observed high genetic variation from the viewpoint of root dry weight and root distribution in 30cm layer from soil surface.

 In current research the effect of manganese source and its rate of consumption on root morphology of two pea varieties are studied.

 MATERIALS AND METHODS

 This research was performed in 2001-2001 farming year in the greenhouse of agricultural faculty of Azad university of Sabzevar. The experiment was performed in the form of factorial and completely randomized block design figure with four replication. Under-studying factors were two lines of pea namely Arman and Hashem, manganese supply source were at two levels of manganese sulfate and manganese chloride and consumption amount of soil-manganese were as four levels of zero (control), 5, 10, 15 kg pure manganese per hectare. In order to do experiment, polyethylene pots (lid diagonal and height of 25 cm) containing farming soil were used. Before planting seeds 150 kg per hectare super triple-phosphate and 150 kg per hectare potassium sulfate by manganese fertilizer treatments were added to the pots and mixed with the soil. After propagation of the pots 20 numbers of pea line seeds were planted in the said pots. After emergence, density of the pea was decreased to three plants in each pot. At two steps of emergence and one month after that, 50 kg nitrogen- fertilizer in the form of top dressing fertilizer was applied in all pots. When the pea plants reached to reproductive stage, shoot growth characteristics were studied. Steam height was measured with ruler in all plants. After measuring plant height in greenhouse, root morphological characters were investigated. At first, pea bushes were exited completely from pots and were segregated in two parts of root and shoot. Roots were washed carefully to remove soil particles and then were transferred to the laboratory to study the root traits. In laboratory, roots were colored by placing in purple methyl and then were scanned to measure properties such as root volume, sum of root surface, medium root diagonal and sum of root length. After investigation of the root characteristics, the root and shoot samples were transferred in a heater with temperature of 75°C for 48 hours and then root and shoot dry weight were measured by digital scale with accuracy rate of 0.001 g. After collecting data, analysis of variation was performed by SAS software and Duncan test was used to comparison of data means. Tables and graphs were drawn by Excel and Word software.

 RESULTS AND DISCUSSION

 Results of the experiment showed that differences between pea lines about sum of root length, average diagonal of the root, and shoot dry weight were not significant. Spite of this, Hashem variety has more sum of root length and average root diagonal in comparison with Arman variety. In contrast, Arman allocated the maximum shoot dry weight to itself. Shoot dry weight of Arman variety was 7.4 percent superior to Hashem variety.

 Above-mentioned result is expressing the competition between shoot and root of pea lines, as line with longer and thicker root system (Hashem), had less dry shoot weight in relation to the other line (Arman).

 There are many evidences on existence of genetic variation from the viewpoint of rooting traits of plant species [4]. Ganjeali & Kafi [3], reported significant differences between 20 genotypes of Iranian pea from viewpoint of the root traits, such as root length, number of lateral roots, root surface and root dry weight.

| Table 1: comparison between shoot dry weight, sum of the length and root diagonal medium in pea lines |
| variety | mean | Sum of root length (m plant⁻¹) | Root diagonal average (mm) | Shoot dry weight (g plant⁻¹) |
| Hashem | a² | 12.51 | a 1.75 | b 0.528 |
| Arman | b 11.01 | b 1.67 | a 0.567 |

*means that at least have one common letter, aren’t significant in Duncan multi-side test(P≤0.05)

Using manganese fertilizer type (manganese-sulfate and manganese chloride), plant height, root diagonal average and shoot dry weight didn’t influence pea plants but their effect on root volume, sum of root surface, sum of root length and root dry weight was significant.
Appling manganese chloride lead to decrease in root volume, sum of root surface sum of root length and root dry weight in comparison with manganese sulfate. This decreasing rate was 31.7, 16.1, 10.8, 18.3 percent respectively (table 2).

Improvement of developmental (growth) characters of the root, can be attributed to the positive role of sulfur in soil PH decreasing and consequently increase absorption of the other nutrition element, specially micronutrients and also macro elements such as phosphorus [2]. On the other hand, using manganese chloride by increasing chloride ion to the soil and through salinity increasing can lead to decrease root growth of salinity- susceptible plants [6]. With respect to decrease of root growth traits, such as volume, sum of the surface, sum of the length and root dry weight in manganese chloride treatments and being ineffective of manganese fertilizer on shoot characters like plant height and shoot dry weight, it can be expressed that the root system with respect to its spreading in soil is more susceptible to the type of nutritional element carriers.

<table>
<thead>
<tr>
<th>Manganese source</th>
<th>Mean</th>
<th>Root volume (cm² plant⁻¹)</th>
<th>Sum of root surface (cm² plant⁻¹)</th>
<th>Sum of root length (m plant⁻¹)</th>
<th>Root dry weight (mg plant⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manganese sulfate</td>
<td>a*</td>
<td>38.74</td>
<td>a 120.25</td>
<td>a 12.43</td>
<td>a 0.398</td>
</tr>
<tr>
<td>Manganese chloride</td>
<td>b</td>
<td>26.46</td>
<td>b 100.85</td>
<td>b 11.09</td>
<td>b 0.323</td>
</tr>
</tbody>
</table>

*means that at least have one common letter, aren’t significant in Duncan multi-side test (P≤0.05)

Effect of manganese consumption rate on all of the studying traits, except plant root, were significant. All levels of manganese consumption, lead to considerable increase in root volume of the pea in comparison with the control treatment (without using manganese). The maximum increase of root volume (76.5 percent), was observed in treatment of 5 kg manganese per hectare. Using high rates of manganese consumption (10 and 15 kg manganese per hectare) resulted in root volume decreasing relative to the treatment of 5 kg manganese per hectare (table 3).

By using 5 kg manganese per hectare, sum of the surface and root dry weight increased 17.2 and 63.8 percent in comparison with control, respectively. Using much rate of manganese (10 and 15 kg manganese per hectare), resulted in considerable decrease in sum of the surface and root dry weight of the pea (table 3).

Sum of the pea root length didn’t show any positive reaction to manganese consumption and manganese consumption lead to decrease in sum of root length. Difference between treatment with 5 kg manganese per hectare and control wasn’t significant. The maximum decrease was observed in sum of root length (50.6 percent), in treatment with 15 kg manganese per hectare (table 3). Manganese is one of the essential micro element for all plants. Manganese deficiency in plant prevents from root growth that is due to carbohydrate deficiency and also direct requirement of plant to it in order to grow. Manganese plays role in division and development of root cells. In manganese-deficient plants lateral roots formation stops completely. Spite of this, manganese toxicity creates undesirable sings in plant [10]. In current research, manganese toxicity creation, is one of the reasons of root growth decreasing of pea bushes at high rate of manganese consumption. Marschner [10] reported that drying of leave tip and decrease of the root growth is one of symptoms for manganese toxicity in plants.

In study of arsenic and manganese effects on root growth and cell division in Vigna radiate, emergency percent and root length, increased gradually with increasing heavy metal associations. Association of arsenic and manganese, cause to prevent emergency and growth of Vigna radiate root [13].

Hashemi et al [5] showed that high concentrations of manganese consumption results in decreasing steam length, root length, reduction of zinc element absorption and catalase enzyme and increasing malondialdeid in plants.

<table>
<thead>
<tr>
<th>Root volume (cm² plant⁻¹)</th>
<th>Sum of root surface (cm² plant⁻¹)</th>
<th>Sum of root length (m plant⁻¹)</th>
<th>Root dry weight (mg plant⁻¹)</th>
<th>Root diagonal average (mm)</th>
<th>Shoot dry weight (g plant⁻¹)</th>
<th>Manganese consumption rate (kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>e* 24.65</td>
<td>b 119.64</td>
<td>a 1.25</td>
<td>b 0.36</td>
<td>b* 1.45</td>
<td>b 0.45</td>
<td>0</td>
</tr>
<tr>
<td>a 43.51</td>
<td>a 140.26</td>
<td>a 1.42</td>
<td>a 0.38</td>
<td>1.77a</td>
<td>a 0.61</td>
<td>5</td>
</tr>
<tr>
<td>b 29.81</td>
<td>c 96.56</td>
<td>b 10.22</td>
<td>c 0.24</td>
<td>c 1.84</td>
<td>c 0.56a</td>
<td>10</td>
</tr>
<tr>
<td>32.43b</td>
<td>c 85.76</td>
<td>c 7.54</td>
<td>c 0.26</td>
<td>a 1.84</td>
<td>a 0.57</td>
<td>15</td>
</tr>
</tbody>
</table>

*means that at least have one common letter, aren’t significant in Duncan multi-side test (P≤0.05)

By increasing manganese consumption, average of root diagonal, increased, as in treatment of 15 kg manganese per hectare, maximum average of root diagonal was achieved that had 21.3 percent increasing relative to control treatment (table 4). Decrease of the root length- growth by increasing manganese concentration (table 3) can be introduced as the factor of increasing lateral growth and consequently root diagonal increase of pea in much rate of manganese consumption. Application of all manganese levels leads to
significant increase of shoot dry weight in pea in comparison with control treatment. Maximum increasing of shoot dry weight (36.5 percent) was observed in treatment of 5 kg manganese per hectare (table 4).

Manganese participation in chlorophyll production and its role in enzymes being active and carbohydrate metabolism are from factors that results in shoot dry weight increasing due to manganese consumption. It has been shown that using fertilizers containing manganese, increases effectiveness of photosynthesis and synthesis of carbohydrates such as starch. Therefore manganese - deficiency cause to decrease the effectiveness of photosynthesis, yield and crop quality [12].

Co-reaction of variety and manganese source on sum of root surface, sum of root length, root dry weight and shoot dry weight, was significant (table-1). In Hashem line, significant statistical difference between manganese- chloride and manganese-sulfate fertilizers wasn’t observed from the viewpoint of sum of the root surface, sum of the root length and root dry weight. But, using manganese chloride lead to considerable decrease of these traits in Arman line. Using manganese chloride lead to considerable decrease in shoot dry weight of Hashem variety, while the difference between shoot dry weight of Arman variety in treatment of manganese chloride and manganese sulfate wasn’t significant (table 4).

Table 4: Reaction of variety and manganese source to each other on sum of surface, sum of length and weight of root and shoot

<table>
<thead>
<tr>
<th>variety</th>
<th>Manganese source</th>
<th>mean</th>
<th>Sum of root surface (cm² plant⁻¹)</th>
<th>Sum of root length (m plant⁻¹)</th>
<th>Root dry weight (mg plant⁻¹)</th>
<th>Shoot dry weight (mg plant⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hashem</td>
<td>Manganese sulfate</td>
<td>115.79ab*</td>
<td>a 12.55</td>
<td>a 0.42</td>
<td>a 0.57</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manganese chloride</td>
<td>108.33b</td>
<td>12.46a</td>
<td>ab 0.38</td>
<td>b 0.49</td>
<td></td>
</tr>
<tr>
<td>Arman</td>
<td>Manganese sulfate</td>
<td>124.71a</td>
<td>a 12.30</td>
<td>ab 0.37</td>
<td>a 0.56</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Manganese chloride</td>
<td>93.37c</td>
<td>b 9.71</td>
<td>c 0.31</td>
<td>a 0.58</td>
<td></td>
</tr>
</tbody>
</table>

*means that at least have one common letter, aren’t significant in Duncan multi-side test(P≤0.05)

Co-reaction of variety and manganese consumption rate influenced sum of surface and sum of root length. In Hashem line, all consumption levels of manganese, cause to decrease sum of surface and sum of root length relative to control. Spite of this, in Arman line consuming 5 kg manganese per hectare resulted to increase sum of surface and sum of root length relative to control. But deference between higher levels of manganese consumption with the control treatment wasn’t significant (figures 1 and 2). Therefore it can be expressed that root system of Arman variety in comparison with Hashem variety to manganese fertilizers, co-reaction of manganese amount and source, had significant effect on sum of surface and sum of root length of pea lines.

Fig. 1: Co-reaction of variety and manganese consumption rate on sum of root surface
Using 5 kg manganese per hectare in the form of manganese sulfate created considerable increase in sum of surface and sum of root length relative to control treatment. While any levels of manganese consumption didn’t result to improve sum of surface and sum of root length in comparison with control treatment (figures 3 and 4).
Fig. 4: co-reaction of manganese source and consumption rate on sum of root length

Concluding:
Results of this research showed that there is difference between pea varieties from the viewpoint of root morphological traits that can influences varieties reaction to environmental factors and specially soil nutrition condition. Root growth traits of the pea, are influenced by the type of the consuming manganese fertilizer. With respect to being alkaline the soil of arid and semi arid regions where farming of pea is doing there, using manganese sulfate can be resulted to growth traits improvement in pea plant. Root system of pea crop is very sensitive to manganese consumption and as well as low amount of manganese results in improvement of root growth traits, consuming high rate of that can limits root system growth due to creating toxicity.

REFERENCES