Effect of Cobalt Fertilizer on Growth, Yield and Nutrients Status of Faba Bean (Vicia faba L.) Plants.

Hala, Kandil


Abstract: Two field experiment were carried out to study the effect of cobalt on growth, yield, nodules formation and nutrients content of faba bean grown in El-Nobaria farm using four levels of cobalt 0, 5, 10, 15 and 20 ppm. Dry weights of roots, shoots, stem, pod, grain and nodules formation significantly increased by increase percentage cobalt levels in all treatments compared with control. The highest increases were obtained by using 20 ppm cobalt. The increasing % in grain yield by using 5, 10, 15 and 20 ppm cobalt were 73.68, 130.68, 204.66 and 217.74 % respectively. Supplying the faba bean with 20 ppm cobalt increased the total protein by 47.82 % and 44.54 % in the first and the second seasons as compared with control. The content of macro (N, P and K) and micro (Fe, Mn, Zn and Cu) nutrients in faba bean plants increased application cobalt, except iron which was decreased.

Key words: Faba bean, cobalt, nutrients and nodules formation.

INTRODUCTION

Faba bean (vicia faba L.) is one of the principal winter food legume crop in Egypt as source of vegetable protein. It serves as an important source of protein in the human diet, especially for those with low income. In addition, faba bean plants improve the fertility of the soil via providing a substantial input of N₂ through fixation.

Cobalt is important in the plant world. Bacteria on root nodules of legumes (beans, alfalfa and clover) require cobalt (and other trace elements) to synthesize B₁₂ and fix nitrogen from air. Soybeans grown without cobalt are severely retorted in growth and exhibit severe nitrogen deficiency, leading to death in about one of four plants. Adding only a few ounces of cobalt per acre can resolve deficiency symptoms in ten to 21 days.

Cobalt is an essential element for the synthesis of vitamin B₁₂, which is required for human and animal nutrition [1, 2]. Unlike other heavy metals, cobalt is safe for human consumption and up to 8 mg can be consumed on a daily basis without health hazard [1]. In higher plants cobalt is an essential element for legumes because of its use by microorganisms in fixing atmospheric nitrogen Evans and Kliwer [3] and Young [1]. In plants other than legumes. Cobalt also promotes many developmental processes including stem and coleoptiles elongation, opening of hypocotyls hooks, leaf disc expansion and feet development [4].

Cobalt is also required in low levels for maintaining high yields of cucumber Scott and William [5] and for increasing the growth of wheat Wilson and Nicholas [6], tomato El-Kobbia and Osman [7] and Nadia Gad [8] squash plants Atta Aly [9], parsley Layla and Nadia Gad [10] and groundnut [11, 12].

The aim of the present experiment is to evaluate the effect of cobalt levels on growth, yield and nutrients status of faba bean plants.

MATERIALS AND METHODS

Two field experiments were carried out at the experimental farm of National Research Centre at El-Nobaria during the two successive seasons 2005/2006 and 2006/2007 to study the effect of cobalt levels on growth, yield and nutrients status of faba bean plants. Physical and chemical properties of the used soil are given in Table (1).

The experimental unit consist of five ridges, 3.5 meter in length and 60 cm width (10.5 m² = 1/400 fed.). Calcium super phosphate (15.5%) was applied during seed-bed preparation at the rate of 31 kg P₂O₅/ fed. Nitrogen was applied at the level 120 kg N/fed. as urea (46%N) at the beginning of growth, while potassium was added as potassium sulfate (48 % K₂O) at rate of 50 kg K₂O/ fed. During growth, cobalt sulfate was used as a source of cobalt at the rate of 0, 5, 10, 15 and 20 ppm cobalt. Seeds of faba bean (Giza-3) were inoculated prior to sowing with the specific strain of rhizobium leguminosarum and were sown at the rate of 75 kg/ fed., on October in the two seasons.

The treatments were arranged in a complete randomized block design with three replications. Normal practices were followed as usual in faba bean fields. Plants were thinned to two plants per hill after three weeks from sowing. At maturity, ten guarded plants were hand pulled randomly from each plot to determine, plant height, number of branches, pods/plant, number of
seeds/plant, number of nodules/plant and dry weight of shoots and roots/plants. Seed and straw yields/fed were also recorded.

All the soil and plant analysis were determined using the standard method described by Jackson [13], Lindsay and Norvell [14] and Cottenie et al. [15]. Total protein content of faba bean seed was calculated.

All data were subjected to statistical analysis according to procedure outlined by Snedecor and Cochran [16].

RESULTS AND DISCUSSIONS

The available cobalt levels in most of Egyptian soils did not exceed 40 ppm [17]. The used soil in this work from El- Nobaria region contained total cobalt of 7.66 ppm (Table 1). The recommended cobalt level to be used in the selected soil range between 5 and 20 ppm cobalt as reported by Laila and Nadia Gad [18].

Data presented in Table (2) reveal that all the used levels of cobalt (5, 10, 15 and 20 ppm) significantly increased the growth and yield parameters as well as number of nodules per plant as compared with control treatment. These results are true for the two growing seasons, except, plant high and No. of branches/plant in the first season which did not reach the level of significance at 5 % when 5 ppm cobalt was applied.

The highest levels of growth and yield parameters of faba bean plants i.e plant height, No. of branches/plant, No. of nodules/plant, No. of pods/plant, No. of seed/plant, seed yield/fed. and dry weights of shoots and roots were obtained when 20 ppm cobalt was used followed by 15, 10 and 5 ppm in decreasing order.

The positive effect of may be due to cobalt application promotion of many developmental processes such as stem and coleoptiles elongation, opening of hypostyle hooks, leaf disc expansion and bud development as reported by Ibrahim et al. [19]. Also, the proper doses of cobalt may help in better nodulation and consequently a better growth and yield, but at high level cobalt reduced the bacterial population in the rhizosphere and as a result nodulation was hampered which led to a lower growth and yield of crop [20]. In other words, cobalt addition increased the nodules formation of root and atmospheric nitrogen fixation by microorganisms which increase the nitrogen content in faba bean plants. This was confirmed by Abdel-Moez and Nadia Gad [21]. Moreover, cobalt application increases the formation of loghaemoglobin required for nitrogen fixation, thereby improves the nodules activity [22]. Das [23] stated that there are three specific cobalaline dependent enzyme systems in rhizobium which may account for influence of cobalt on nodulation ribonucleotide reductase and methylmalonyl coenzyme A mutase.

In general, the obtained results in this work are in good agreement with those found by many investigators through their work on numerous plant species and varieties, as reported by Scott and William [24] on cucumber, Sowicki [25] on fodder hay, Laila and Nadia Gad [26] on parsley, Abdel-Moez and Nadia Gad [27] on cowpea and Basu et al. [28] on groundnut, who stated that growth, fresh and dry materials, yield components as well as nodules formation of roots of the previous crops, were significantly affected by cobalt application.

Data presented in Table (2) show that application of cobalt particularly 20 ppm, significantly increased not only the growth and yield parameters but also balanced this increases with larger root size. In this concern, Shehata [29] stated that cobalt application affected adventitious root formation and growth inducing or inhibiting ethylene production (which is an essential hormone for the formation and growth of adventitious root) based on its concentration in the growing media.
Table 2: Effect of cobalt fertilization on growth and yield parameters of faba bean plants grown for two seasons.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Length of plant (cm)</th>
<th>No. of stem</th>
<th>No. of nodules</th>
<th>No. of pod/plant</th>
<th>Dry weight (gm)/plants</th>
<th>No. of seed/plant</th>
<th>Seed yield/fed. (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>shoots</td>
<td>roots</td>
<td>Total</td>
</tr>
<tr>
<td>First season</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>49.5</td>
<td>1.33</td>
<td>107</td>
<td>6</td>
<td>10.25</td>
<td>4.7</td>
<td>14.95</td>
</tr>
<tr>
<td>5 ppm cobalt</td>
<td>51</td>
<td>1.66</td>
<td>126</td>
<td>10</td>
<td>14.5</td>
<td>5.55</td>
<td>20.05</td>
</tr>
<tr>
<td>10 ppm cobalt</td>
<td>56.2</td>
<td>2.33</td>
<td>138</td>
<td>14</td>
<td>18.97</td>
<td>6.25</td>
<td>25.22</td>
</tr>
<tr>
<td>15 ppm cobalt</td>
<td>64.7</td>
<td>3.33</td>
<td>154</td>
<td>18</td>
<td>25.3</td>
<td>7.55</td>
<td>32.85</td>
</tr>
<tr>
<td>20 ppm cobalt</td>
<td>65.1</td>
<td>3.66</td>
<td>195</td>
<td>22</td>
<td>26.25</td>
<td>8.01</td>
<td>34.26</td>
</tr>
<tr>
<td>LSD</td>
<td>2.84</td>
<td>0.51</td>
<td>8</td>
<td>3</td>
<td>0.82</td>
<td>0.55</td>
<td>1.46</td>
</tr>
<tr>
<td>Second season</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>49.1</td>
<td>1.33</td>
<td>102</td>
<td>7</td>
<td>10.12</td>
<td>4.5</td>
<td>14.62</td>
</tr>
<tr>
<td>5 ppm cobalt</td>
<td>51.4</td>
<td>2</td>
<td>134</td>
<td>11</td>
<td>14.81</td>
<td>5.85</td>
<td>20.67</td>
</tr>
<tr>
<td>10 ppm cobalt</td>
<td>55.9</td>
<td>2.66</td>
<td>145</td>
<td>13</td>
<td>19.72</td>
<td>6.48</td>
<td>26.22</td>
</tr>
<tr>
<td>15 ppm cobalt</td>
<td>65.2</td>
<td>3.66</td>
<td>162</td>
<td>19</td>
<td>26.15</td>
<td>7.95</td>
<td>34.74</td>
</tr>
<tr>
<td>20 ppm cobalt</td>
<td>66.1</td>
<td>4</td>
<td>203</td>
<td>21</td>
<td>27.24</td>
<td>8.5</td>
<td>35.74</td>
</tr>
<tr>
<td>LSD</td>
<td>1.89</td>
<td>0.62</td>
<td>9</td>
<td>2</td>
<td>0.75</td>
<td>0.51</td>
<td>1.38</td>
</tr>
</tbody>
</table>

Table 3: Effect of cobalt fertilization on macronutrients content in shoots and roots of faba bean plants grown for two seasons.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Shoots (%)</th>
<th>Roots (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
</tr>
<tr>
<td>First season</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.81</td>
<td>0.11</td>
</tr>
<tr>
<td>5 ppm cobalt</td>
<td>1.86</td>
<td>0.13</td>
</tr>
<tr>
<td>10 ppm cobalt</td>
<td>2.25</td>
<td>0.16</td>
</tr>
<tr>
<td>15 ppm cobalt</td>
<td>3.41</td>
<td>0.18</td>
</tr>
<tr>
<td>20 ppm cobalt</td>
<td>4.96</td>
<td>0.21</td>
</tr>
<tr>
<td>LSD</td>
<td>0.11</td>
<td>0.04</td>
</tr>
<tr>
<td>Second season</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.82</td>
<td>0.12</td>
</tr>
<tr>
<td>5 ppm cobalt</td>
<td>1.91</td>
<td>0.15</td>
</tr>
<tr>
<td>10 ppm cobalt</td>
<td>2.3</td>
<td>0.17</td>
</tr>
<tr>
<td>15 ppm cobalt</td>
<td>3.86</td>
<td>0.2</td>
</tr>
<tr>
<td>20 ppm cobalt</td>
<td>5.07</td>
<td>0.24</td>
</tr>
<tr>
<td>LSD</td>
<td>0.12</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Effect of Cobalt on Nutrient Status:

Macronutrients: Data presented in Table (3) show that, addition of different levels of cobalt namely 5, 10, 15 and 20 ppm had a significant beneficial effect on the status of studied macro-elements (nitrogen, phosphorus and potassium) in both shoots and roots of faba bean plants, the highest content values of N, P and K in shoots and roots were obtained at the treatment of 20 ppm cobalt followed by 15, 10 and 5 ppm in decreasing order. However, the content of P in shoots and roots in both seasons did not show any significant difference when the level of 5 ppm cobalt was compared with control treatment. The results of the two seasons showed the same trend. These results are in good agreement with those found by Jana et al. [11], Castro et al. [23], Abdel-Moez and Nadia Gad [18]...
and Basu et al.\(^\text{[12]}\) who stated that cobalt levels had a promotion effect for better status of N, P and K in groundnut, tomato and cowpea plants. Generally, data show that the content of shoots from N, P and K values were higher than those obtained by roots of faba bean plants.

**Micronutrients:** The effect of cobalt levels on the content of micronutrients (Co, Fe, Mn, Zn and Cu) in shoot and roots of faba bean plants are shown in Table (4). Increasing cobalt levels from 5 to 20 ppm significantly increased the content of all the studied except Fe micronutrients. The highest values of Co, Mn, Zn and Cu in shoots and roots were found when the cobalt treatment of 20 ppm was used, then followed by 15, 10, 5 ppm in decreasing order. On the other hand, such treatments of cobalt resulted in progressive depression effect on iron content in the shoots and roots of faba bean plants (Table, 4). The highest contents of Fe were found under the cobalt level of 5 ppm followed by 10, 15 and 20 ppm in decreasing order. The obtained results of iron are in accordance with those found by Bisht\(^\text{[24]}\) and Blaylock et al.\(^\text{[25]}\), who showed certain antagonistic relationship between Co and Fe. Also, Atta Aly et al.\(^\text{[26]}\) found that cobalt and iron were competitive elements in the nutrition of tomato plants. Moreover, data show that cobalt contents in shoots and roots of faba bean were significantly increased by increasing cobalt levels from 5 up to 20 ppm. These results were confirmed by Hussein\(^\text{[27]}\), Atta Aly et al.\(^\text{[26]}\) and Abdel-Moez and Nadia Gad\(^\text{[18]}\) who stated that Co content in tomato plants increased by increasing cobalt additions.

Data presented in Table (4) show that the content of all the studied micronutrient in roots of faba bean were higher than those obtained in shoots under all the cobalt treatments.

**Grain Nutrients Content:** Table (5) show the data concerning the effect of cobalt addition on macro and micronutrients as well as protein content in grains of faba bean plants grown for two seasons. It is clear from these data, that all cobalt levels (5, 10, 15 and 20 ppm) significantly increased the content of macro and micronutrients (except Fe content) as well as protein percentage in the grains of faba bean as compared with control treatments. These results are true during the two seasons. The highest values of all the studied nutrients were found when cobalt treatment of 20 ppm was used and followed by 15, 10 and 5 ppm in decreasing order. Only, the content of N and P did not affect with cobalt treatment of 5 ppm when compared with control in the two seasons. Concerning iron content in faba bean grains, it took a contrary trend, where their values were significantly decreased by increased cobalt levels from 5 ppm up to 20 ppm. All these data took the same trend of the content of macro and micronutrients in straw and roots of faba bean during the two seasons (Table 3 & 4). Data also reveal that supplying the faba bean with 20 ppm

---

**Table 4:** Effect of cobalt fertilization on micronutrient content in shoots and roots of faba bean plants grown for two seasons.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Shoots (%)</th>
<th>Roots (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Co</td>
<td>Fe</td>
</tr>
<tr>
<td>First season</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.87</td>
<td>40.6</td>
</tr>
<tr>
<td>5 ppm cobalt</td>
<td>1.17</td>
<td>68.4</td>
</tr>
<tr>
<td>10 ppm cobalt</td>
<td>1.53</td>
<td>62.1</td>
</tr>
<tr>
<td>15 ppm cobalt</td>
<td>2.39</td>
<td>55.2</td>
</tr>
<tr>
<td>20 ppm cobalt</td>
<td>4.5</td>
<td>48</td>
</tr>
<tr>
<td>LSD</td>
<td>0.17</td>
<td>0.98</td>
</tr>
<tr>
<td>Second season</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>0.89</td>
<td>41.2</td>
</tr>
<tr>
<td>5 ppm cobalt</td>
<td>1.22</td>
<td>77.3</td>
</tr>
<tr>
<td>10 ppm cobalt</td>
<td>1.67</td>
<td>68.7</td>
</tr>
<tr>
<td>15 ppm cobalt</td>
<td>2.56</td>
<td>63</td>
</tr>
<tr>
<td>20 ppm cobalt</td>
<td>4.86</td>
<td>56.3</td>
</tr>
<tr>
<td>LSD</td>
<td>0.11</td>
<td>2.12</td>
</tr>
</tbody>
</table>

---

Table 5: Effect of cobalt fertilization on macro and micronutrient as well as protein % in grain of faba bean plants grown for two seasons.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Macronutrients (%)</th>
<th>Micronutrients (%)</th>
<th>Protein%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
<td>K</td>
</tr>
<tr>
<td><strong>First season</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>1.8</td>
<td>0.06</td>
<td>0.56</td>
</tr>
<tr>
<td>5 ppm cobalt</td>
<td>1.86</td>
<td>0.09</td>
<td>0.69</td>
</tr>
<tr>
<td>10 ppm cobalt</td>
<td>1.99</td>
<td>0.15</td>
<td>0.75</td>
</tr>
<tr>
<td>15 ppm cobalt</td>
<td>2.32</td>
<td>0.18</td>
<td>0.83</td>
</tr>
<tr>
<td>20 ppm cobalt</td>
<td>2.66</td>
<td>0.22</td>
<td>0.88</td>
</tr>
<tr>
<td><strong>Second season</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>1.86</td>
<td>0.08</td>
<td>0.61</td>
</tr>
<tr>
<td>5 ppm cobalt</td>
<td>1.9</td>
<td>0.12</td>
<td>0.67</td>
</tr>
<tr>
<td>10 ppm cobalt</td>
<td>2.2</td>
<td>0.19</td>
<td>0.73</td>
</tr>
<tr>
<td>15 ppm cobalt</td>
<td>2.43</td>
<td>0.22</td>
<td>0.77</td>
</tr>
<tr>
<td>20 ppm cobalt</td>
<td>2.69</td>
<td>0.25</td>
<td>0.84</td>
</tr>
<tr>
<td>LSD</td>
<td>0.11</td>
<td>0.08</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Cobalt increased the total protein, 47.82 and 44.54 % in the first and the second seasons as compared with control respectively.

From the obtained results it could be concluded that in higher plants, cobalt may be an essential element, the appropriate supply might be necessary to maintain a high yield production 28.

Addition proper levels of cobalt to the nutrient media caused a significant increases in the dry weight yields of non- nodulated clover Hallsworth et al. 29, legumes and wheat plants 30.

Application of CaSO₄ to the soil increased Lupinus engustifolia dry matter yield by 50% 30.

In conclusion, it is suggested that addition of 20 ppm cobalt fertilization, improved all the growth and yield parameters as well as macro and micronutrients content of faba bean plants without human health hazard.

REFERENCES


