THE EFFECTS OF PHOSPHORUS APPLICATION ON SHOOT DRY MATTER AND UPTAKE OF PHOSPHORUS, CALCIUM AND ZINC IN TWO WHEAT CULTIVARS GROWN IN A HIGH CLAY SOIL

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Abstract


Interactions of phosphorus (P) with calcium (Ca) and zinc (Zn) in different plant species have received a great deal of attention recently. A glasshouse pot experiment with different rates of P application (0, 30, 60, 90 and 120 mg P kg⁻¹ soil) was conducted to investigate these interactions in two wheat varieties (Ege-88 and Gun-91). Increased application of P reduced shoot Zn concentration significantly. Shoot Ca concentration was also reduced by P application but the reduction was disproportionate to P application rate. These results demonstrate that P application could be one of the reasons for Zn and Ca deficiency. Therefore, the level of P application should be determined carefully in order to maximize yield.

Key words: phosphorus, calcium, zinc, uptake, clay soil

Introduction

Phosphorus (P) is less abundant in soils than nitrogen (N) and potassium (K). Total P in soil surface soils varies from 50-1500 mg kg⁻¹ soil. Although prairie soils are often high in total P, many of them are characteristically low in plant available P. Therefore, understanding the relationships and interactions of the various forms of P in soils and the numerous factors that influence P availability is essential to efficient P management (Havlin et al., 2005). The P within the plant is taken up as an orthophosphate anion (H₂PO₄⁻ or HPO₄²⁻) and phosphate esters play an important role in energy metabolism (Kacar and Katkat, 2011). Recent studies have demonstrated antagonistic relationships of P with Zn (Kizilgoz and Sakin, 2010).

In acid soils, calcium carbonate-P interactions of positive nature were also reported (Friesen et al., 1980). Zn plays an important role in most of the enzymes (e.g. superoxide dismutase). Excessive use of phosphate fertilizers in soils imposes deficiency of micronutrients in the plants. Accordingly, concentration of micronutrients will decline in dry matter and crop

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Materials and Methods

Bread wheat cultivar (cv.) Gun-91 and durum wheat cultivar (cv.) Ege-88 were used in the present study. The soil was dried, sieved and placed into polyethylene pots of 2 kg capacity. To ensure maximum growth, N and K were also added to each pot (350 mg N as NH4NO3, and 250 mg K as K 2SO4 respectively). This could have been resulted from an antagonistic interaction between P and Zn (Brady and Weil, 2008). Compared to nill treatment, this reduction was 39% and 52% in durum wheat cv. Ege-88 and bread wheat cv. Gun-91, respectively. In general, Zn concentration was reduced by soil P supply over the entire range of soil P application. These results are in accordance with earlier reports (Havlin et al., 2005; Kizilgoz and Sakin, 2010). However, the increases in shoot P concentration over the soil P application range were not proportional with greater increases occurring up to 90 mg P kg\(^{-1}\) soil.

Shoot Zn concentrations of both cultivars varied depending on P application rate. In general, Zn concentration was reduced by soil P supply over the entire range of soil P application. Compared to nill treatment, this reduction was 39% and 52% in durum wheat cv. Ege-88 and bread wheat cv. Gun-91, respectively. This could have been resulted from an antagonistic interaction between P and Zn (Brady and Weil, 2008). In addition, it is well known that P application to calcareous

<table>
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<tr>
<th>Table 1</th>
<th>The physical and chemical properties of the soil used in the present study</th>
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<tbody>
<tr>
<td>Sand, %</td>
<td>21</td>
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<tr>
<td>Silt, %</td>
<td>26</td>
</tr>
<tr>
<td>Clay, %</td>
<td>53</td>
</tr>
<tr>
<td>pH, 1:2.5</td>
<td>7.6</td>
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<tr>
<td>EC, dS m(^{-1})</td>
<td>1.8</td>
</tr>
<tr>
<td>CEC, cmol kg(^{-1})</td>
<td>51.3</td>
</tr>
<tr>
<td>Organic matter, %</td>
<td>1</td>
</tr>
<tr>
<td>Av. P, mg/kg</td>
<td>6.8</td>
</tr>
<tr>
<td>Av. Zn, mg/kg</td>
<td>0.45</td>
</tr>
<tr>
<td>Av. Ca, mg/kg</td>
<td>1648</td>
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soils increases Zn adsorption (Sead, 2004) thus making Zn less plant-available. Our results are also supported by other studies (Kizilgoz and Sakin, 2010). It is interesting to note that cultivar by soil P application interaction was only significant for Zn. Bread wheat cv. Gun-91 maintained a higher shoot Zn concentration than durum wheat cv. Ege-88 when soil P application increased up to 30 mg kg\(^{-1}\) soil beyond which both cultivars showed a similar trend.

**Conclusion**

Similar to shoot Zn concentration, shoot Ca concentrations of both cultivars were also reduced by increased soil P application. The reduction in shoot Ca concentration was similar in both cultivars averaging 10.6%. This could be a result of P and Ca interaction (Porter and Sanchez, 1992; Cole et al., 1993; Kacar and Katkat, 2011). In addition, as negatively charged P anions are not adsorbed onto negatively charged clay particles, this could increase plant available P in soil solution (Ince, 1995). In this study, soil P application had significant effects on shoot P and Ca concentrations. These results suggest that given the negative effects of P application on Ca and Zn nutrition of wheat the optimum P application rate for wheat should be determined carefully in order to maximize yield.

**References**


Cole, C. V., S. R. Olsen and C. O. Scott, 1953. The nature of


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