SOLUBILITY OF PHOSPHORUS AND SULPHUR IN TWO CALCAREOUS SOILS

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Solubility relationship of sulphur (S) and phosphorus (P) were evaluated in two calcareous soils. Balkasar (Udic Haplustall) and Shahdara (Typic Torrifluvent) soils amended with 0, 25, 50 and 75 mg/kg each of Sand P in all possible combination in triplicate according to completely randomized design were incubated at 25 ± 2°C. After four weeks of incubation period the amended soils were extracted with CaCl2 and NaHCO3 for Sand P estimation. Application of Sand P had a significant (P < 0.01) main and interactive affect on CaCl2 as well as NaHCO3 extractable Sand P in the two soils. Influence of P application was more prominent than S on their extractable quantities in the two soils. Significant (P < 0.01) relationship between NaHCO3-S(Y) and applied S(X1) and P(X2) was given by the equation: Y = 14.85 + 0.5X1 + 0.8X2 (R = 0.7) in Balkasar soil and was Y = 15.95 + 0.53X1 + 0.073X2 (R = 0.8) in Shahdara soil, Significant (P < 0.05) relationship (R = 0.70) between NaHCO3-S(Y) and CaCl2-SeX) was given by the equation: Y = -5.7 + 2.11X. Significant relationship between NaHCO3-P(Y) and applied P(X1) and S(X2) was Y=O.17 + 0.97X1 + 0.17X2 (R=0.98) in Balkasar soil and was Y=0.17 + 0.93X1 + 0.14X2 (R=0.98) in Shahdara soil, Applied P mainly precipitated as Ca-phosphates in the two soils, Significant (P<0.01) relationship (r=0.47) between NaHCO3-P(Y) and CaCl2-P(X) was given by the equation: Y=0.13 + 1.41X.

INTRODUCTION

For their growth, plants absorb sulphur and phosphorus from soil solution. They exist in an anionic from in soils and are absorbed in this form by plants (Tisdale 1985). Synergistic as well as antagonistic interaction between Sand P has been reported in different soil and plant situations (Singh, 1988). They are involved in protein synthesis and are components of vital amino acids methionine, cystine and cysteine (Thompson et al., 1986). Synergistic relationship among Sand P applied to fodder sorghum also reduced a substance in plants fatal to livestock, hydrocyanic acid (Singh et al. 1988).

Deficiency of P is more frequent than S in alkaline calcareous soils of arid and semi-arid regions. Phosphorus is, therefore, commonly applied to alleviate its deficiency. In acidic soils applied P can desorb S from soil colloids and is held more strongly by soils than sulphate (Tisdall et al. 1985). However, interactive effect of Sand P on their availability in alkaline calcareous soils has rarely been reported. Sulphur application is not common for crop production on arid soils. But application of S to an alkaline calcareous soil increased P availability by lowering soil pH (Clement, 1978). Tisdale et al., (1985) have discussed a co-precipitation of Sand P by CaCO3 in some temperate region soils. Major reserves
of Sand P in arid region calcareous soils are organic sulphur and insoluble calcium phosphates, respectively (Nabi et al., 1990; Rahmatullah, 1992). In light of the studies conducted on acid soils of temperate region it is difficult, to extrapolate the interactive effect of Sand P application on their availability in calcareous soils. It has also not been studied extensively in arid region soils. For the present investigation two calcareous soils were, therefore, amended with different levels of Sand P to study their level in soil solution in relation to their NaHCO₃ extractable status and solubility relationships of P.

MATERIALS AND METHODS

Bulk surface (0.15 cm) samples collected for Balkasar series (Udic Hapludalf) and Shahdara series (Typic Torrifluvent) were air dried and ground to pass through a 2 mm sieve. They were characterized for some pertinent properties reported in Table 1. Twenty g portion of each of the two soils taken in conical flasks received 0, 25, 50 and 75 mg of Sand P in all possible combinations. Sulphur and P were added in solution as K₂S₀₄ and KH₂P₀₄, respectively. The treatments were imposed in triplicate according to completely randomized design (Steel and Torril, 1980). After Sand P application soil in each flask was shaken for one hour and incubated at 25 ± 2°C. Alternate wetting and drying cycles were repeated twice for the treated soils. After three weeks incubation four g of soil sampled from each container was extracted with 40 ml of 0.01 M CaCl₂ by shaking for two hours on a reciprocating shaker. Clear filtrate from CaCl₂ extraction was analyzed for pH, EC, Ca, Mg, P and S. Ion activities of P in CaCl₂ extracts were calculated using Davies equation for estimating activity coefficients (Davies, 1972). Electrical conductivity was used as an estimate of ionic strength (Griffin and Jurinak, 1973). The phosphate solubility lines for different forms were used as shown by Lindsay (1979). Sample from each container was also analyzed for 0.5 M NaHCO₃-extractable (Watanabe and Olsan, 1965) P and S. Sulphur in the two type of extracts was estimated by BaCl₂ turbidimetric method (Verma et al., 1977). Phosphorus was determined by vanadomolybdate blue color method.

RESULTS AND DISCUSSION

Sulphur availability: Balkasar and Shahdara soils had initially NaHCO₃ extractable-S less than its critical level of 22 mg S/kg soil, reported for wheat cultivation on similar alluvial soils of Indian Punjab (Takkar, 1990). Application of Sand P, therefore, had a significant (P < 0.01) main and interactive effect on CaCl₂ as well as NaHCO₃ extractable S in the two soils. Relationship of S extracted by NaHCO₃ (Y) to S (X₁) and P (X₂) application depicted in (Fig. 1) in Balkasar soil was Y = 14.85 + 0.5X₁ + 0.8X₂ (R = 0.7) and was Y = 15.95 + 0.53X₁ + 0.73X₂ (R = 0.91) in Shahdara soil. The two soils responded similarly to initial application of 25 mg/kg of either S or P. But increase in NaHCO₃ extractable S with subsequent addition of Sand P had been more regular in Balkasar than in Shahdara soil. The two soils responded differently to Sand P amendments. Application of P had a more pronounced influence on NaHCO₃ extractable S in the two soils. While competing for the same reaction sites phosphate is held more strongly than sulphate and hence sulphate is desorbed easily from soil constituents (Barrow, 1970; Bohn et al. 1986). Influence of P application on NaHCO₃ extractable S was 23% higher in Balkasar than in
Shahdara soil, but Shahdara soil had a more NaHCO₃-extractable S than Balkasar soil (Fig. 2). While CaCl₂-extractable S was significantly (P<0.01) higher in Balkasar soil than in Shahdara soils. Shahdara soil has more CaCO₃ (Table 1). A co-precipitation of S with CaCO₃ in soils had been discussed (P.296) by Tisdale et al., (1985). Relatively coarser texture in Balkasar soil may also have allowed more S in soil solution (CaCl₂-extractable S) than in Shahdara soil. A significant (P<0.05) correlation between CaCl₂-extractable Sand NaHCO₃-extractable S was calculated using average values of S concentration found for the two soils and for four levels of each of Sand P application (Fig. 2).

Phosphorus availability: Balkasar and Shahdara soils, used in this study, were initially deficient in P (Table 1).

Table 1. Selected physical and chemical properties of the two soils.

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>Balkasar (Udic Hapludalf)</th>
<th>Shahdara (Typic TorriOvend)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>%</td>
<td>69.7</td>
<td>22.5</td>
</tr>
<tr>
<td>Silt</td>
<td>%</td>
<td>18.1</td>
<td>69.4</td>
</tr>
<tr>
<td>Clay</td>
<td>%</td>
<td>12.1</td>
<td>8.1</td>
</tr>
<tr>
<td>Texture</td>
<td></td>
<td>Sandy loam</td>
<td>Silt loam</td>
</tr>
<tr>
<td>pH (1:1)</td>
<td></td>
<td>7.6</td>
<td>8.0</td>
</tr>
<tr>
<td>EC (1:1)</td>
<td>dS/m</td>
<td>0.24</td>
<td>0.33</td>
</tr>
<tr>
<td>CaCO₃</td>
<td>%</td>
<td>2.9</td>
<td>4.6</td>
</tr>
<tr>
<td>Organic matter</td>
<td>%</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>NaHCO₃-P</td>
<td>mg/kg</td>
<td>0.53</td>
<td>0.90</td>
</tr>
<tr>
<td>NaHCO₃-S</td>
<td>mg/kg</td>
<td>16.43</td>
<td>21.97</td>
</tr>
</tbody>
</table>

Application of Sand P to these two soils, therefore, had a significant (P<0.01) main and interactive effect on CaCl₂ as well as NaHCO₃-extractable P in the two soils. Relationship of P extracted by NaHCO₃ to P(X₁) and S (X₂) application illustrated in Fig. 3 in Balkasar soil was Y = 0.17 + 0.97X₁ + 0.17X₂ (R=0.98) and was Y = 0.67 + 0.93 X₁ + 0.04X₂ (R=0.98) in Shahdara soil. Phosphorus application had a more prominent influence than S application on NaHCO₃-extractable P in the two soils. Influence of Sand P soil amendment was more prominent in Balkasar soil than in Shahdara soils. Nevertheless, a small fraction of added P was extractable P with NaHCO₃ or CaCl₂ in the two soils. Phosphorus precipitates predominantly as calcium phosphates in calcareous soils (Ruhmatullah et al. 1992, Tisdale, 1985). Solubility relationships of P according to Lindsay (1979) indicated differences in precipitation products in the two soils. Applied P precipitated probably as β-tricalcium phosphate and hydroxyapatite in Balkasar soil while in Shahdara soil it mainly precipitated as octo-calcium phosphate. Phosphorus extracted by CaCl₂ as well as by NaHCO₃ was maximum in Shahdara soil. A significant (P<0.01) linear correlation between CaCl₂-extractable P and NaHCO₃-extractable P was calculated using average values of P found for the two soils and for four levels of each of Sand P application (Fig. 4).

CONCLUSIONS

Application of Sand P significantly (P<0.01) increased their CaCl₂, as well as NaHCO₃-extractable P quantities in the two soils. Influence of P application was more prominent than S addition on Sand P extracted from the two soils. Applied P mainly precipitated as calcium phosphate in the two soils.
Fig. 1. Extraction of sulphur by 0.5M NaHC03 from Balkasar (A) and Shahdra (B) soils treated with Sand.

Fig. 2. Status and relationship among sulphur extracted by CaCl2.0 and NaHC03 from Balkasar and Shahdra soils treated with Sand P.
Fig. 3. Phosphorus extracted by 0.5M NaHCO₃ from Balkasar (A) and Shahdra (B) soils treated with S and P.

Fig. 4. Status and relationship among phosphorus extracted by CaCl₂ 0 and NaHCO₃ from Balkasar and Shahdra soils treated with Sand P.

Fig. 5. Phosphorus solubility in Balkasar (0) and Shahdra (6) soils treated with Sand P.

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ACKNOWLEDGEMENTS

Funds were provided by National Scientific Research and Development Board of University Grants Commission.

REFERENCES