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B ABSORPTION BY PEANUT ON ULTISOL AS AFFECTED BY BORIC ACID AND ORGANIC MATTER APPLICATIONS

Eko Hanudin, Astika Rusmayani, Nasih Widya Yuwono
Soil Chemistry and Fertility Laboratory, Department of Soil Sciences, Faculty of Agriculture, University Gadjah Mada, Yogyakarta, Indonesia. E-mail: ekohanudin@ugm.ac.id or ekohanuddin@gmail.com, Phone/Fax: +62 274 548814

ABSTRACT

A greenhouse pot experiment was conducted to investigate the effect of organic matter and boric acid applications on the absorption of B by two varieties of peanut on ultisol Banyumas. The treatments consisted of 5 levels of organic matter (0, 5, 10, 15, 20 ton ha⁻¹) and 2 levels of boric acid (0, dan 14.2 kg ha⁻¹) arranged in a factorial combination with 2 varieties of peanut (Kancil dan Lokal Purworejo). The results indicated that the soil physico-chemical properties of the ultisol as follow: pH = 4.5, Al₂O₃, 0.74 cmol(+), kg⁻¹; OM = 2.26 %, CEC 16.38 cmol(+), kg⁻¹, Ca²⁺ 4.16 cmol(+), kg⁻¹, Mg²⁺ 0.45 cmol(+), kg⁻¹, K⁺ 0.03 cmol(+), kg⁻¹, Fe₂⁺ 1.41 %, Fe⁺₂ 0.054 %, Fe⁺₃ 0.029 %, Al₂O₃ 0.025 %, Al₂O₃ 0.0017 %, Al₂O₃ 0.0102 %, hot water extracted B 0.16 ppm, total N 0.18 %, sand 12.16 %, silt 63.7% and clay 81.46 %. Application of 20 ton OM ha⁻¹ and 14.2 kg boric acid ha⁻¹ increased significantly the soil B availability, plant growth, and B absorption by both varieties of peanut tested. Kancil variety is able to absorb B better than Purworejo indigenously variety.

Key word: boric acid, organic matter, peanut, and ultisol.

INTRODUCTION

Ground peanut (Arachis hypogea L.) is a type of plant that has been cultivated for long time by farmers in Indonesia. Peanuts grow well when it is planted in a light soils (loamy sand, sandy, or loam) that contains enough nutrients (Ca, N, P, and K). These plants require crumb structure in order for the roots to develop well. The gynofores easily penetrate into the soil to form deleted pods, and the pods are easily harvested (not many pods are left in the ground). The range of optimal soil pH for peanut growth is at 5.0 to 6.3 (Sumarno, 1993; Suprapto, 2001). Besides macronutrients, micronutrients also play an important role for peanut growth including Boron. Boron deficiency can cause abnormalities in peanut seeds which is called hollow heart (the inside of the bean seeds nacked) (Bell et al., 1990). In acid soils with coarse-texture there is critical limit of B deficiency around 0.05 ppm. The B critical value for the plant at the age of 30-60 days after planting is 26 ppm (Gupta and Load, 1977; Jones, 2003).

Acid soil area in Indonesia is quite large, it is Ultisol which has a poor fertility due to a high in acidity, Al, Fe, Mn content, P fixation, and very low in organic matter content, CEC, and base saturation. Improvement of Ultisol fertility could be done by adding organic matter as the source of C, N, P and micronutrients including Boron (B) (Sarief, 1989). Borax is frequently used as Boron fertilizer, it contains 11.3% B. Boron in soil solution is found in some species such as H₂BO₃⁻, B₂O₅²⁻, H₂BO₃⁻, H₂BO₂⁻. Boric acid is predominant form in soil solution at pH around 5-9 (Gupta, 2007; Tisdale et al., 1990).

Boron has a function that is essential for plant growth and development. Boron has an important role such as transport of sugar by forming a sugar-borate complex that can be utilized; directly involved in the enzymatic reaction of sucrose and starch synthesis and the synthesis of uridine diphosphate glucose; cell division and elongation; metabolism and
hormone auxin transport in root cells; contributing plants in P absorption and ATPase activity (Gupta, 2007).

The main objectives of this research are (a) to find out the effect of boric acid and organic matter application on the changes of soil chemical properties and B availability in the Ultisol (b) to find out interaction of boric acid and organic matter in influencing the growth of ground peanut, (c) to compare B absorption between two varieties of ground peanut.

MATERIALS AND METHODS

The pot experiments used Ultisols (7.5 kg per bag) from Banyumas, Central Java and arranged in Completely Randomized Design (CRD) with 5 replications. The treatments consisted of 5 levels of organic matter (0, 5, 10, 15, 20 ton ha\(^{-1}\)) and 2 levels of boric acid (0, dan 14.2 kg ha\(^{-1}\)) arranged in a factorial combination with 2 varieties of peanut (Kancil dan Lokal Purworejo). Basal fertilizers such ZA (300 kg ha\(^{-1}\)), TSP (200 kg ha\(^{-1}\)) dan KCI (150 kg ha\(^{-1}\)) were also applied to avoid insufficiency N, P and K supply from the soil. Soil physical-chemical analysis was conducted for texture (pipette method), pH-H\(_2\)O and pH-KCl (pH-meter), C\(_{\text{org}}\), M\(_{\text{org}}\), K\(_{\text{org}}\) (NH\(_4\)Cl, AAS), N-total (Kjeldal), B-available, C-org (Walkley and Black), Fe-Al oxide (DCB), NH\(_4\)-Ox1 pH 3 and Na-pyrophosphate, Al\(^{3+}\) (KCI 1N, titration) and CEC (NH\(_4\) saturation) (Pansu and Gauheitrou, 2006; ISRI, 2005; Tan, 1996; Lambert et al., 1993). Chemical analysis of organic matter (Cow Manure) was also done for pH-H\(_2\)O, B-available, C-org, and CEC. Agronomic parameters were also measured for plant height, shoot fresh weight (shoot-FW), root fresh weight (roots-FW), total biomass weight (TBW), shoot-DW to root-DW ratio, B concentration in shoots and roots. Statistical analysis was done for analysing of variance (ANOVA) and Duncan’s Multiple Range Test (DMRT) at 5 % level of confidence.

RESULTS AND DISCUSSION

Soil chemical-physical analyses results were presented at Table 1. The Ultisols taken from Banyumas district posses soil-reactivity in the category of avery acid. Ultisols as an ultimate weathered contains a low concentration in macro-nutrients (N, Ca, Mg and K) and also micro-nutrient such as B. The content of B-hot water extracted in the soil was very low (0.16 ppm). The occurrence of sesquioxide in Ultisol resulted in pH-H\(_2\)O and pH-KCl was very acid (4.5 and 4.2, respectively). Source of soil acidity is Al\(^{3+}\) and H\(^{+}\). Organic matter content was observed around 2.26% (medium). The organic matter derived from vegetation growing on it or fertilization applied by the farmer.

<table>
<thead>
<tr>
<th>Chemical-physical properties</th>
<th>Value</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH-H(_2)O</td>
<td>4.5</td>
<td>Very acid*</td>
</tr>
<tr>
<td>pH-KCl</td>
<td>4.2</td>
<td>Very acid*</td>
</tr>
<tr>
<td>Organic Matter (%)</td>
<td>2.26</td>
<td>Medium</td>
</tr>
<tr>
<td>CEC (cmol(+).kg(^{-1}))</td>
<td>16.38</td>
<td>Low*</td>
</tr>
<tr>
<td>Al(_{\text{exch}}) (cmol(+).kg(^{-1}))</td>
<td>0.74</td>
<td>Very low*</td>
</tr>
<tr>
<td>Fe-Al oxide:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe-DCB (%)</td>
<td>1.413</td>
<td>Tinggi</td>
</tr>
<tr>
<td>Fe-NH(_4)-Ox1 pH 3 (%)</td>
<td>0.054</td>
<td>Very low**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------</td>
<td>--------</td>
<td>------------</td>
</tr>
<tr>
<td>Fe-Na Pyrophosphate (%)</td>
<td>0.029</td>
<td>Very low</td>
</tr>
<tr>
<td>Al-DCB (%)</td>
<td>0.0025</td>
<td>Very low</td>
</tr>
<tr>
<td>Al-NH₄OH pH ³ (%)</td>
<td>0.0017</td>
<td>Very low</td>
</tr>
<tr>
<td>Al-Na Pyrophosphate (%)</td>
<td>0.0012</td>
<td>Very low</td>
</tr>
<tr>
<td>Ca₉₀⁻ (cmol(+).kg⁻¹)</td>
<td>4.15</td>
<td>Low</td>
</tr>
<tr>
<td>Mg₉₀⁻ (cmol(+).kg⁻¹)</td>
<td>0.45</td>
<td>Low</td>
</tr>
<tr>
<td>K₉₀⁻ (cmol(+).kg⁻¹)</td>
<td>0.03</td>
<td>Very low</td>
</tr>
<tr>
<td>B-hum water extracted (ppm)</td>
<td>0.16</td>
<td>Very low</td>
</tr>
<tr>
<td>N-total (%)</td>
<td>0.18</td>
<td>Low</td>
</tr>
<tr>
<td>Texture:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand (%)</td>
<td>12.16</td>
<td></td>
</tr>
<tr>
<td>Silt (%)</td>
<td>6.37</td>
<td></td>
</tr>
<tr>
<td>Clay (%)</td>
<td>81.46</td>
<td></td>
</tr>
</tbody>
</table>


Cation exchange capacity (CEC) of Ultisol Banyumas was obtained at 16.38 cmol (+). kg⁻¹ (low category). The low value of the soil CEC is related to the ultimate development of the soil. Soil CEC was derived from organic materials (carboxylic functional groups) and clay minerals (isomorphic substitution and protonation-deprotonation process). Ultisol was dominated by kaolinite and sesquioxide (R₂O₃, R: Al, Fe) compounds. There are several forms of Al-Fe oxide compounds present in soil such as crystalline (free), amorphous and oxide-humic complexes forms. Normally, the three oxide forms are predicted by applying the three selective dissolutions, namely: dithionite citrate bicarbonate (DCB), oxalate-oxalate acid (NH₄-oxalate pH=3) and Na-pyrophosphate. The content of Fe extracted by the three selective dissolutions, respectively obtained by 1.413 % (high), 0.054% (low) and 0.029% (very low). While the content of the three Al forms are respectively obtained as follows 0.0025%, 0.0017% and 0.0012%, which are all categorized as very low rate.

The result of texture analysis is obtained three main fractions, namely: clay (81.46%), silt (6.37 %), and sand (12.16 %). Based on the USDA texture triangle, the texture of the soil could be categorized as clay. High levels of clay to 81, 46% will cause the soil has low permeability, sticky consistency and angular blocky structure, so the soil is difficult to plow.

**Chemical Characteristics of Organic Matter (Cow Manure)**

The results of chemical characterization of cow manure are presented in Table 2. Based on the table cow manure has a pH-H₂O 7.9 (lighty base), pH-KCl 7.5 (neutral), organic matter 69.49 % and boron-available 0.76 ppm (high). According to Minister of Agriculture Regulation No.28/Pert/HK.060/2/2009 of organic fertilizer, soil amendment, organic fertilizer minimum technical requirements must contain organic matter >12%, a maximum B-available of 0.25% (2500 ppm), and pH 4-8. Based on the Minister of Agriculture regulations, cow manure used in this study has met minimum technical requirements of organic fertilizer.
Tabel 2. Chemical characteristics of Cow Manure

<table>
<thead>
<tr>
<th>Chemical characteristics</th>
<th>Cow Manure</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH-H₂O</td>
<td>7.9</td>
<td>Slightly basic*</td>
</tr>
<tr>
<td>pH-KCl</td>
<td>7.5</td>
<td>Neutral*</td>
</tr>
<tr>
<td>Organic Matter (%)</td>
<td>69.5</td>
<td>High**</td>
</tr>
<tr>
<td>B-available (ppm)</td>
<td>0.76</td>
<td>High**</td>
</tr>
</tbody>
</table>

Source: * ISRI (1980)
** Minister of Agriculture Regulation No.28/Pert/HK.060/2/2009

Effect of Boric Acid and Organic Matter on Soil Chemical Properties.

Based on statistical analysis showed that a single treatment of organic materials or combination with boric acid had significant effect on pH-H₂O, whereas single treatment of boric acid did not significantly affect the pH-H₂O. There is a tendency of the higher doses used cow manure, the soil pH-H₂O also increased. Application of 5-15 tons OM/ha only able to increase the pH-H₂O at 0.1 units (from 4.4 to 4.5). This is probably due to the addition of organic matter has the pH categorized as lightly basic, that's why the soil pH also increased.

Applications of organic matter with the doses of 0, 5, 10, 15 and 20 tonnes/ha were able to increase the CEC and the soil B-available significantly. The soil CEC values, respectively obtained at 16.44, 17.74, 22.98, 23.74 and 27.61 cmol (+) kg⁻¹, while the B-available respectively obtained at 0.24, 0.57, 0.66, 0.84, and 0.96 ug/g. Application of 14.2 kg boric acid/ha did not significantly affect the soil CEC, but increased significantly the B-available concentration from 0.5 (without B) to 0.81 ug/g. Improvement of the soil CEC is likely a scribed to the contribution of carboxylic functional groups present in the OM. There was a positive correlation between the dose of organic materials with the available B content, this indicated that cow manure could be used as a source of B for plants.

Application of 14.2 kg boric acid/ha and organic matter (5, 10, 15 and 20 tonnes/ha) was able to significantly reduce the soil Al₃⁺ concentration. The higher dose of OM applied the lower contents of the soil Al₃⁺. This is likely to increasing the OM dosage resulted in a lot of Al₃⁺ that chelated by carboxylate functional groups in humic compounds derived from the OM. The same complexation process also occurred between boric acid and Al₃⁺, therefore the amount of Al₃⁺ decreased.

Effect of Boric Acid and Organic Matter on Growth and B Uptake by Peanut

Based on the analysis of variance (ANOVA) at the significance level of 5% indicated that a single treatment of organic materials, varieties, had significant effect on shoot-FW. Kancil variety produced shoot-FW (7.46 g) was significantly heavier than that of the local Purworejo variety (5.83 g). While single treatment of boric acid or a combination of boric acid-OM resulted in no significant effect on shoot-FW. The treatments also resulted in the same trend for roots-FW. However the greatest total weight of biomass obtained by the treatment of 20 tons of OM/ha and 14.2 kg boric acid/ha.

The treatment combination of boric acid, organic matter, and peanut varieties had significant effect on B uptake in the shoot. Boron absorption in the shoot of Kancil variety (3.26 g/pot) was higher than that of the Local Purworejo (2.46 g/pot). The combination
of boric acid and organic matter had no significant effect on the B absorption of the shoot. Single treatment of boric acid or organic matter also resulted in no significant effect on the B absorption in the shoot. There is a tendency that the higher dose of OM and boric acid the higher the B absorption of the shoot.

The treatment combination of boric acid, organic matter, and the varieties did not significantly affect on the B uptake of the roots, but the combination of boric acid and OM significantly affected the B absorption of the roots. Single treatment of boric acid or OM no significant effect on the B uptake of the root. Although statistically not significantly different, but there is a tendency of the absolute value of the higher dosage of OM and boric acid the higher the B uptake of the shoot.

Distribution of the amount of B that absorbed by the plants organs above ground and below ground could be found out based on the ratio of the B absorption in the shoot to the root. The combination of three treatments of boric acid, organic matter, and peanut varieties resulted in no significant effect on the ratio of the B uptake in the shoot to the root. The combination of boric acid and organic material significantly affected on the ratio of the B uptake in the shoot to the root. Single treatment of OM or boric acid did not significantly affect on the ratio of the B uptake in the shoot to the root. Based on the ratio of the B absorption in the shoot to the root it was able to be be summarized that the amount of B absorbed into the leaves more than that in the roots. The higher dosage of OM applied higher B translocated to the shoot. Therefore, the application of organic materials much as 20 ton/ha resulted in the most accelerated transportation of B from the root to shoot.

CONCLUSIONS

- Ultisol from Banyumas is an ultimate weathered soil having some constraints for plant growth such as a high acidity, toxic in Al monomeric, deficiency in macro and micro nutrients.
- Application of 20 ton OM, ha⁻¹ and 14.2 kg boric acid ha⁻¹ increased significantly the soil B availability, plant growth, and B absorption by both varieties of the peanut Kancil and local Purworejo.
- Kancil variety absorbed B more than local Purworejo variety.

REFERENCES


