# Plant availability of As and Cd as influenced by biochar application to soil


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## INTRODUCTION

Biochar is a product of thermal decomposition of biomass produced by the process called pyrolysis. It is biochemically recalcitrant as compared to un-charred organic matter and has a considerable potential to enhance long term soil carbon pool. Biochar also improves soil structure and water retention, enhances nutrient availability and retention, ameliorates acidity and reduces aluminium toxicity to plant roots and soil microbiota. Research has shown that the application of biochar to the soil can substantially raise the productivity of field crops. Biochar possesses organic functional groups on its surfaces and the negatively charged organic functional groups increase over time during its oxidation in soil. The formation of surface functional groups and adsorption sites on biochar could influence its cation exchange capacity and therefore, the capacity of amended soils to form complexes with ions of trace elements.

## OBJECTIVES

To investigate the influence of an activated wood biochar (550°C) on bioavailability, plant growth and uptake of As and Cd by maize.

## EXPERIMENTAL METHODOLOGIES

### Glasshouse Experiments

- A glasshouse experiment was conducted using three levels of biochar (0, 5 and 15 g/kg) combined factorially with three rates (0, 10, 50 mg/kg) each of As and Cd separately.
- Maize was grown in polythene lined pots for 10 weeks and nutrient elements were applied at recommended rates (Fig. 1).
- After 10 months of growth, the aboveground biomass of the plants was harvested, the dry matter yield was recorded, plants were analysed for As and Cd.
- Available As and Cd in soil were extracted by phosphate and DTPA extraction methods, and were analysed by hydride generation AAS and flame AAS, respectively.

### Sorption Experiments

Batch experiments were conducted by equilibrating 1 g biochar with 25 ml of 0.01 M $Ca(NO_3)_2$ containing As or Cd $2\times10^{-3}$–$4\times10^{-1}$ M overnight at pH 7. After equilibration, the samples were centrifuged /filtered and the supernatants were analysed for As and Cd.

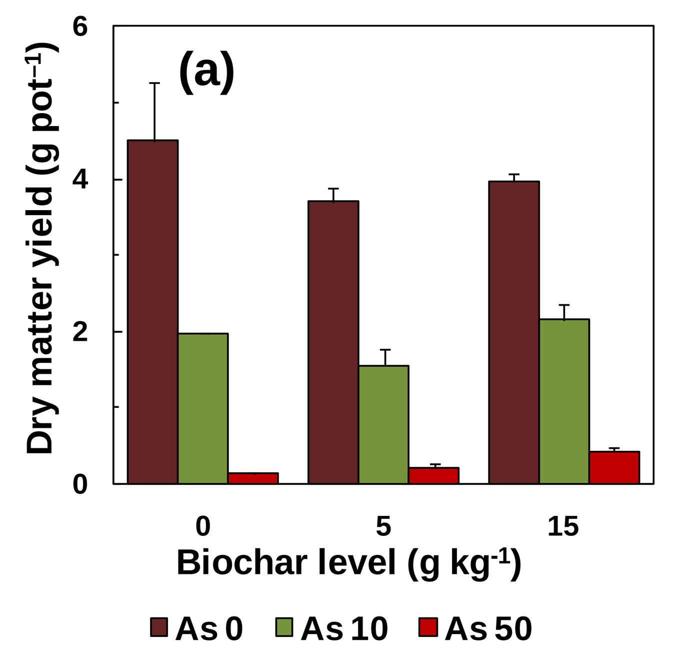



Fig. 3. Maize shoot dry matter yield as influenced by biochar application to soil in combination with (a) As and (b) Cd.

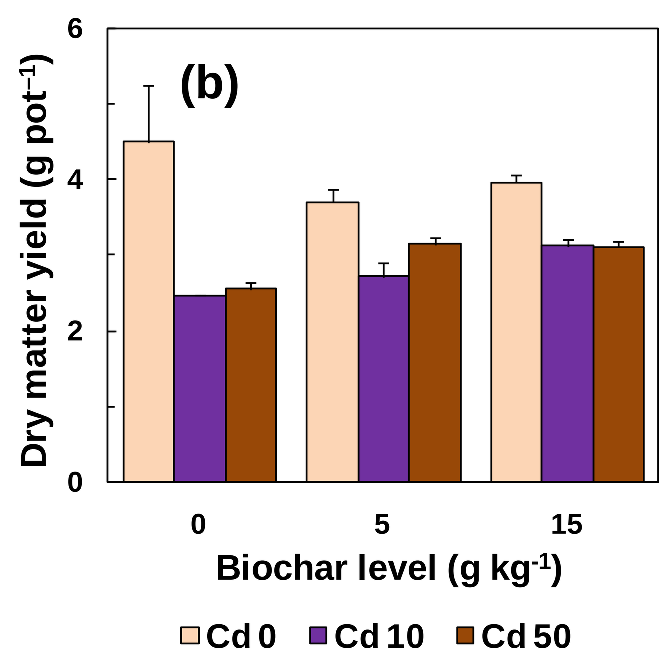



Table 1. As concentration in maize shoot in response to biochar and As treatments.

| As (mg/kg) | Biochar (mg/kg) | | | Mean |
|---|---|---|---|---|
| | 0 | 5 | 15 | |
| 0 | 0.15 | 0.11 | 0.24 | 0.17 |
| 10 | 4.38 | 6.48 | 3.36 | 4.74 |
| 50 | 29.11 | 26.47 | 18.87 | 24.81 |
| $LSD_{0.05}$: Bio, As = 2.4, Bio × As = 4.1 | | | | |

Table 2. Cd concentration in maize shoot in response to biochar and Cd treatments.

| Cd (mg/kg) | Biochar (mg/kg) | | | Mean |
|---|---|---|---|---|
| | 0 | 5 | 15 | |
| 0 | 0.20 | 0.22 | 0.22 | 0.21 |
| 10 | 6.78 | 5.00 | 4.59 | 5.46 |
| 50 | 31.26 | 23.24 | 12.80 | 22.43 |
| $LSD_{0.05}$: Bio, Cd = 1.0, Bio × Cd = 1.7 | | | | |

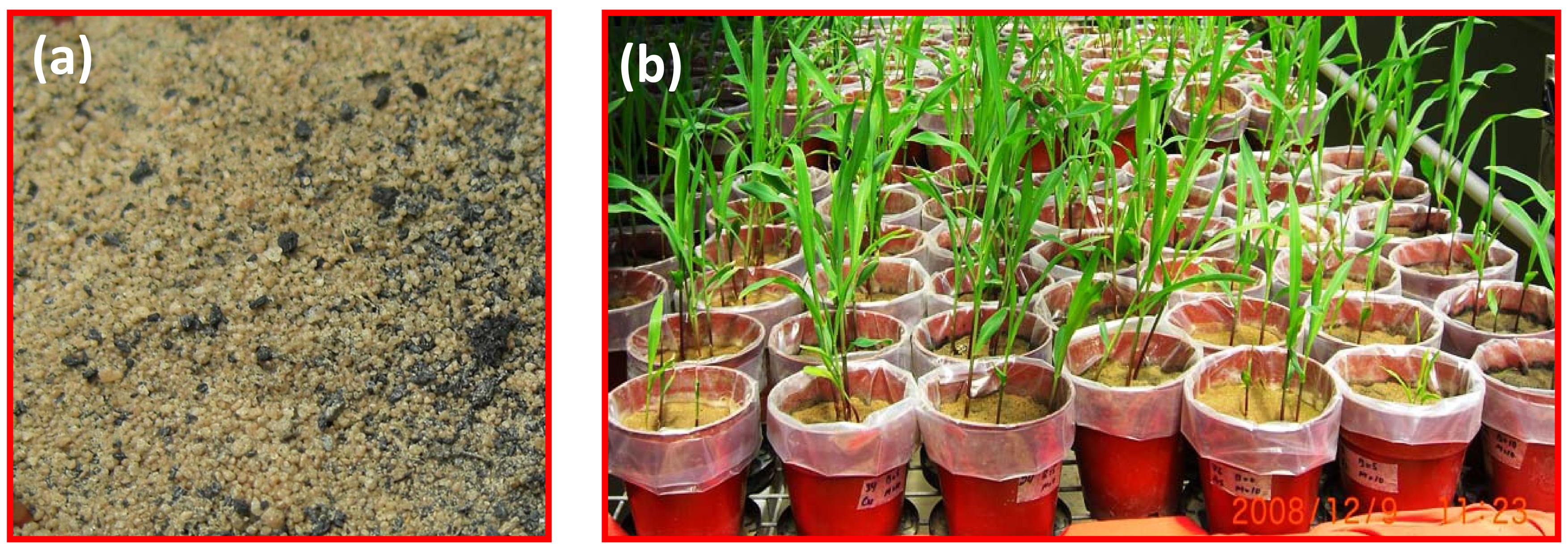



Fig. 1. Photographs showing (a) biochar treated soil (b) maize plants grown in biochar amended soil combined with the application of trace elements at different levels.

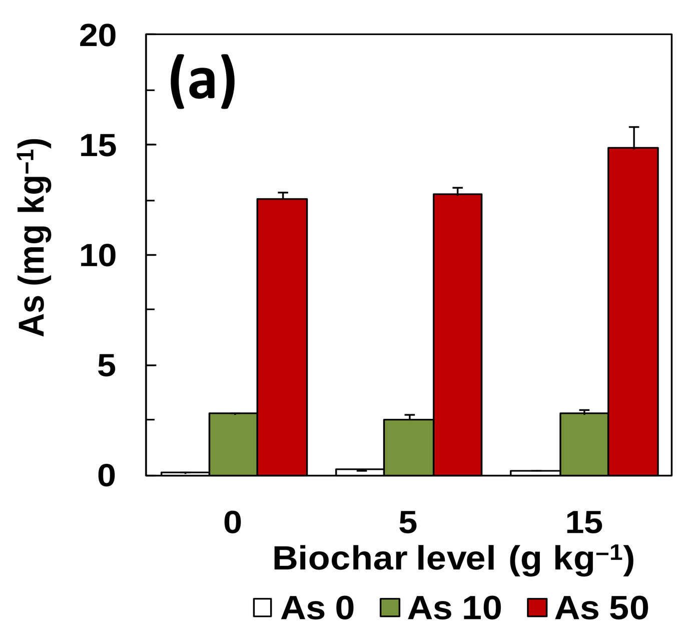
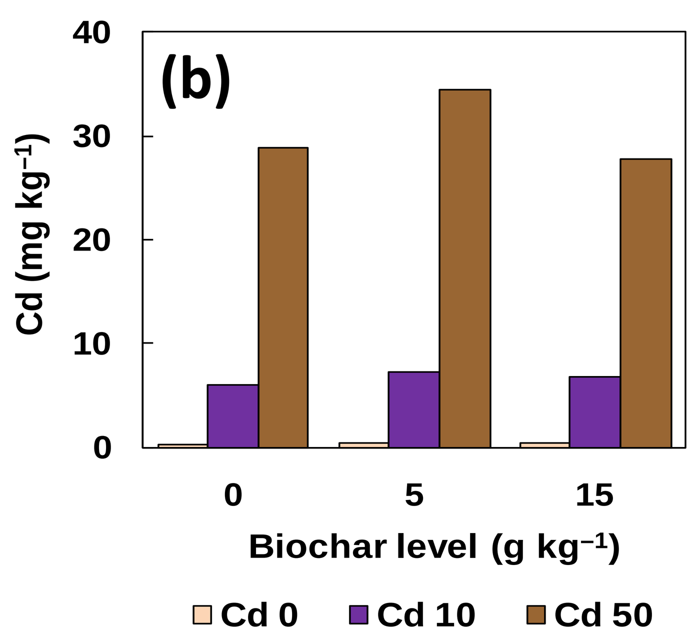



Fig. 4. Effect of biochar application on the availability of (a) phosphate extractable As and (b) DTPA extractable Cd in soil.



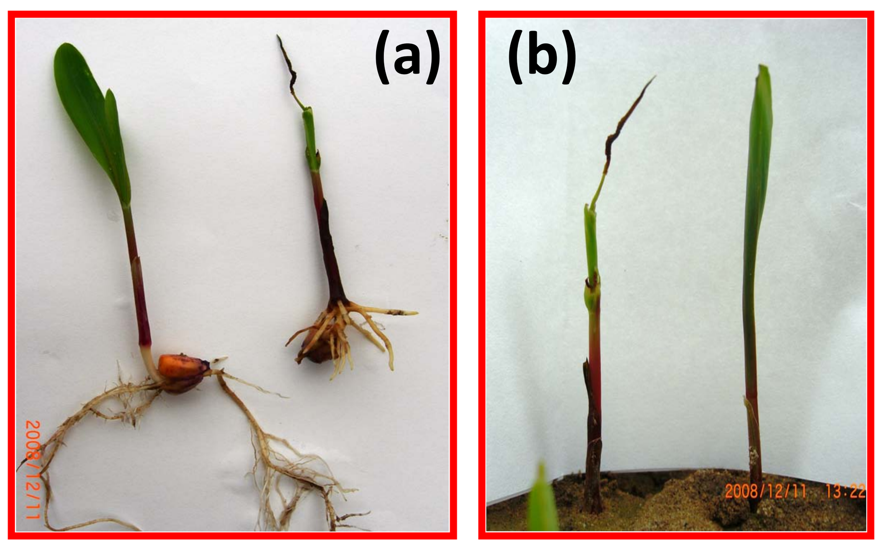




Fig. 2. Photographs showing (a) As and (b) Cd toxicity symptoms to maize plants.

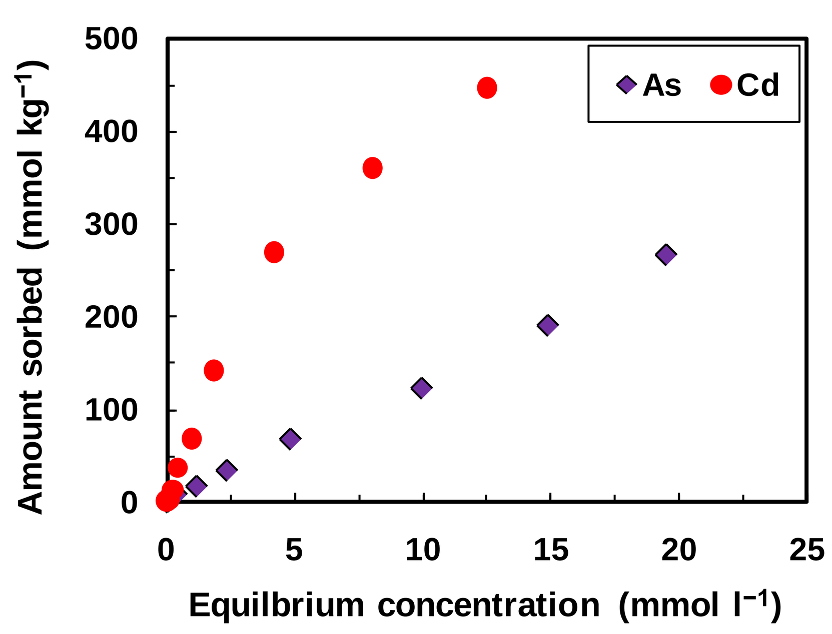



Fig. 5. As and Cd adsorption on biochar at pH 7.

## RESULTS AND DISCUSSION

- The shoot dry matter yield of maize was not significantly affected by biochar application in the absence of As and Cd.
- Arsenic was found to have more significant adverse effect than Cd on the dry matter yield of maize (Fig. 2 and 3).
- Biochar addition to the soil was found to reduce shoot concentration of As (Table 1) possibly due to the strong binding of As on the surface functional groups of biochar.
- Significant reduction in the shoot concentration of Cd in biochar amended soil was observed (Table 2) and can be attributed to the formation of metal-organic complexes and adsorption of Cd to biochar.
- An increase in extractable As in biochar amended soil at the highest biochar application rate was observed (Fig. 4a).
- The extractable Cd concentration in soil increased in 10 and 50 mg/kg Cd treatments combined with 5 g/kg biochar application (Fig. 4b).
- Cadmium adsorption on biochar was greater than As at pH 7 (Fig. 5).

## OUTCOMES

- In the absence of metals biochar did not have any significant effect on the dry matter yield of maize in a fertilized soil.
- Biochar application significantly reduced As and Cd toxicity to plants.
- The application of biochar to the soil decreased the availability of As and Cd to the plants.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