Effect of Different Way of Bottom Ash and Compost Application on Phytoextractability of Cadmium in Contaminated Arable Soil

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Objective

Bottom ash (BA) contains considerable amounts of CaO and MgO, it could be a useful amendment to increase soil pH and to immobilize cadmium (Cd). Therefore, This study was conducted to determine the effect of application of BA and CP on Cd phytoextractability.

Materials & Methods

Cd immobilization (Incubation experiment)

- 500 g of soil was mixed in a plastic beaker
- Treatment
  - w/o BA and CP
  - w/ BA (3%, *wt/wt*) only
  - w/ CP (3%, *wt/wt*) only
  - w/ BA (3%, *wt/wt*) + CP (3%, *wt/wt*)

Cd phytoextractability (Field experiment)

- Lettuce (*Lactuca sativa*)
- Treatment
  - w/o BA and CP
  - w/ BA 30 Mg/ha only
  - w/ CP 30 Mg/ha only
  - w/ BA 30 + CP 30 Mg/ha

Results

Table 1. Concentration of Cd fractions in soil added with control, BA, CP, and BA+CP under incubation condition at 25℃ for 5 weeks

Treatment	Cd fraction[1)] (mg kg^{-1})				
	F1	F2	F3	F4	F5
Control	1.33$^{a2)}$	2.70^{a}	2.12^{c}	0.61^{b}	6.55^{a}
BA	0.98^{b}	2.33^{b}	2.26^{c}	0.63^{b}	6.05^{a}
CP	0.29^{c}	1.10^{c}	4.00^{a}	0.67^{b}	6.06^{a}
BA+CP	0.26^{c}	0.84^{d}	3.28^{b}	1.39^{a}	5.77^{a}

[1)]Fraction means F1: Exchangeable + acidic fraction, F2: Reducible fraction, F3: Oxidizable fraction, F4: Residual fraction.

[2)]values with same letter within a column are significantly different at p = 0.05.

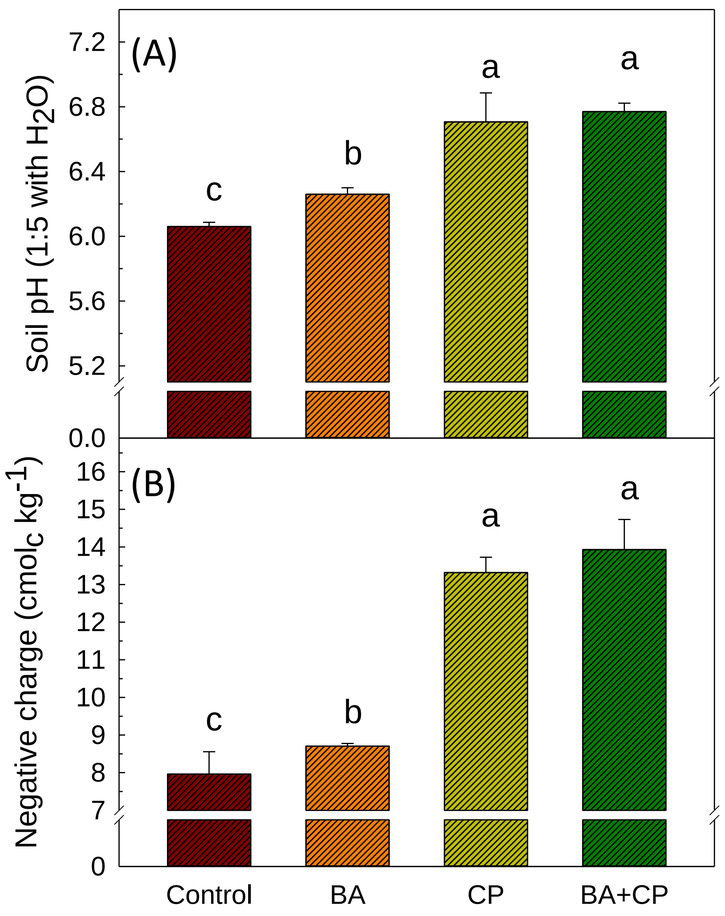

Fig. 1. Change of pH (A) and negative charge of soil (B) added with control, BA, CP, and BA+CP under incubation condition at 25℃ for 5 weeks.

Table 2. Correlation coefficients for relationship between Cd fractions and chemical properties of soil added with control, BA, CP, and BA+CP under incubation condition at 25℃ for 5 weeks

Soil property	Cd fraction			
	F1	F2	F3	F4
pH	-0.958$^{***1)}$	-0.975***	0.816**	0.504
Negative charge	-0.983***	-0.970***	0.888***	0.506

[1)]** and *** denote significance at 0.01 and 0.001 levels of probability, respectively.

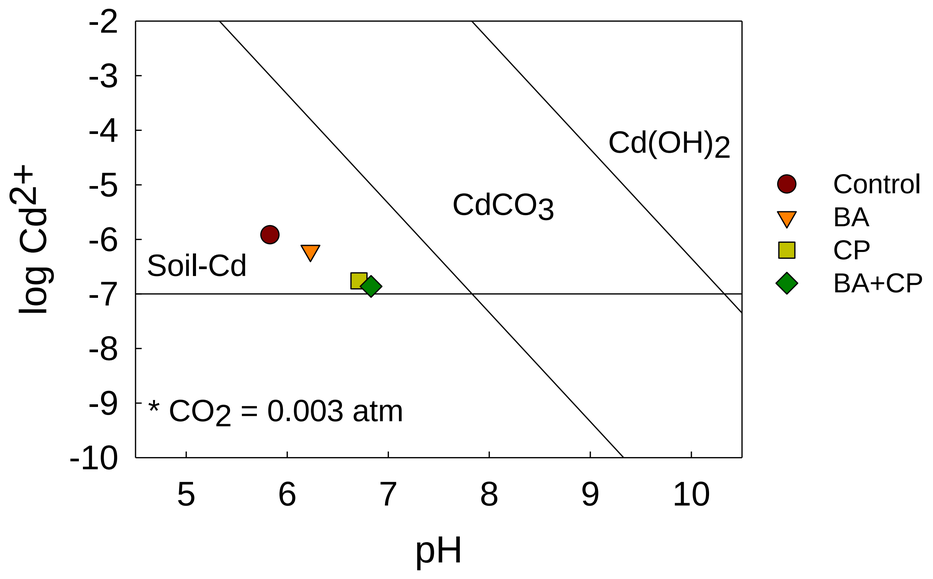

Fig. 2. Cadmium solubility diagram of soil solution added with control, BA, CP, and BA+CP under incubation condition at 25℃ for 5 weeks.

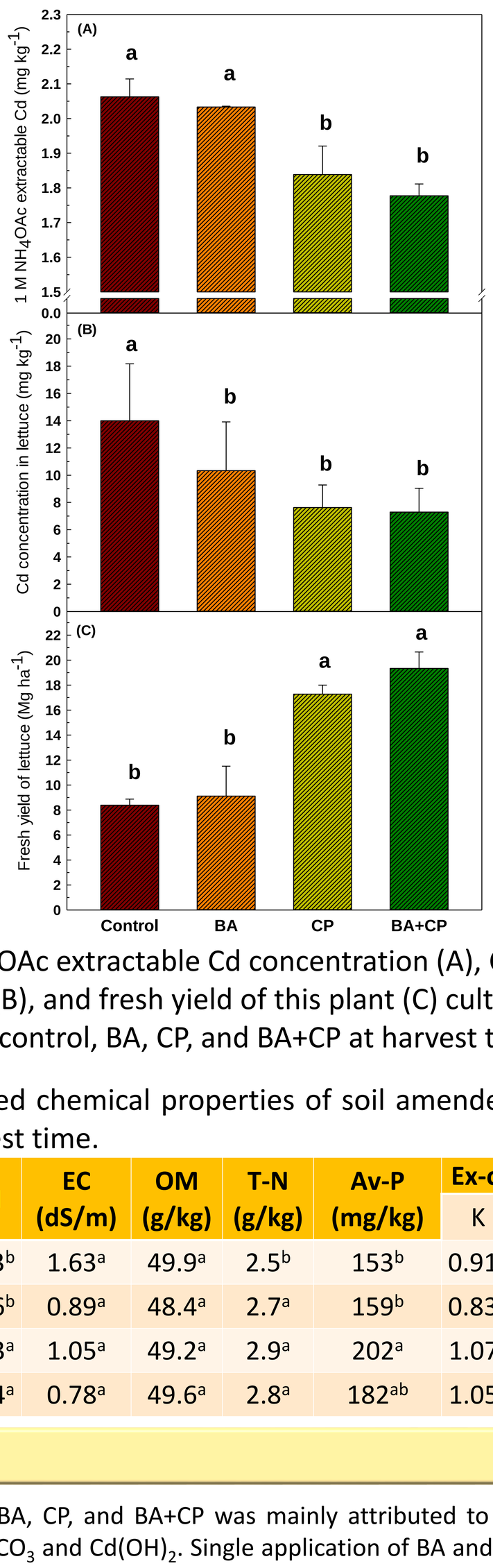

Fig. 3. 1 M NH_4OAc extractable Cd concentration (A), Cd concentration in lettuce (B), and fresh yield of this plant (C) cultivated in soils amended with control, BA, CP, and BA+CP at harvest time.

Table 3. Selected chemical properties of soil amended with BA, CP, BA+CP at harvest time.

Treatment	pH	EC (dS/m)	OM (g/kg)	T-N (g/kg)	Av-P (mg/kg)	Ex-cation (cmol$_c$/kg)		
						K	Ca	Mg
Control	6.03^{b}	1.63^{a}	49.9^{a}	2.5^{b}	153^{b}	0.91^{b}	3.96^{b}	1.41^{b}
BA	6.16^{b}	0.89^{a}	48.4^{a}	2.7^{a}	159^{b}	0.83^{b}	3.97^{b}	1.39^{b}
CP	6.23^{a}	1.05^{a}	49.2^{a}	2.9^{a}	202^{a}	1.07^{a}	4.15^{a}	1.50^{ab}
BA+CP	6.24^{a}	0.78^{a}	49.6^{a}	2.8^{a}	182^{ab}	1.05^{a}	4.17^{a}	1.62^{a}

Conclusions

Incubation experiment clearly demonstrated that reduced extractability of Cd with addition of BA, CP, and BA+CP was mainly attributed to Cd adsorption by increase in pH and negative charge of soil rather than precipitation of Cd as Cd minerals such as $CdCO_3$ and $Cd(OH)_2$. Single application of BA and CP and combined application BA and CP were effective to reduce Cd uptake by lettuce, but there was no additional benefit with combined application compared with single application. However, combined application of BA and CP was more effective to increase fresh yield of lettuce than single application of BA. Therefore, combined application of BA and CP might be a good management practice in Cd contaminated arable soil in the view point of Cd phytoavailabilty and crop productivity.