Journal of Integrative Agriculture 2015, 14(6): 1192–1201

Available online at www.sciencedirect.com

ScienceDirect

RESEARCH ARTICLE

Comparison of phytotoxicity of copper and nickel in soils with different Chinese plant species

LI Bo[1, 2], LIU Ji-fang[2], YANG Jun-xing[3], MA Yi-bing[2], CHEN Shi-bao[2]

[1] *Institute of Plant Nutrition and Environmental Resources, Liaoning Academy of Agricultural Sciences, Shenyang 110161, P.R.China*
[2] *National Soil Fertility and Fertilizer Effects Long-term Monitoring Network, Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081, P.R.China*
[3] *Centre for Environmental Remediation, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, P.R.China*

Abstract

Ecological risk assessment of metals in soils is important to develop the critical loads of metals in soils. Phytotoxicity is one of the endpoints for ecological risk assessment of soils contaminated with metals. The sensitivity of eight Chinese plant species (bok choy, mustard, tomato, green chilli, paddy rice, barley, spinach and celery) to copper (Cu) and nickel (Ni) toxicity in two Chinese soils was investigated to assess their potential use for ecological risk assessment in the region. The results showed that bok choy and mustard were the two most sensitive species to Cu and Ni toxicities. Assessment of metal accumulation by the plants demonstrated that bok choy shoot had the highest bioconcentration factor (BCF, the ratio of metal concentration in plant shoots to metal concentration in soil). Given the importance of bok choy to agricultural production in Asia, it is therefore important that these sensitive plant species are included in species sensitivity distributions for ecological risk assessment of Cu and Ni in soils.

Keywords: copper, nickel, plant species, sensitivity, risk assessment

1. Introduction

Phytotoxicity is one of the key endpoints for ecological risk assessment of soils contaminated with metals. To assess effects of contaminants on plant vegetative growth, more than 10 plant species, including monocotyledonsous and dicotyledons, have been suggested in biasaasy (EPA 1996; Stephenson *et al.* 1997; OECD 2003; ISO 2005). When examining phytotoxicity of metals to different plant species, it is important that the sensitivity of agronomically or ecologically important species is assessed, and effects data for these species are included in risk assessments. Most of the species currently recommended to use in phytotoxicity assays are species relevant for temperate agricultural systems in the Northern Hemisphere (EPA 1996; OECD 2003; ISO 2005). These are few data available for tropical and sub-tropical regions, and for species relevant to Asian agricultural or ecological systems.

There are lots of researches on sensitivity comparison for copper (Cu) and nickel (Ni) phytotoxicity across crop plants, nevertheless, few are focused on vegetable plants (EPA 2007a, b). Generally, vegetable plants are more sensitive for metal toxicity than crop plants with lower toxicity thresholds

Received 18 July, 2014 Accepted 27 October, 2014
LI Bo, E-mail: libocaas@163.com; Correspondence MA Yi-bing, Tel: +86-10-82106201, E-mail: ybma@caas.ac.cn

doi: 10.1016/S2095-3119(14)60906-0

(An 2006; EPA 2007a, b). For instance, alfalfa was found to be the most resistant species for Ni and cobalt toxicities among five plant species including three vegetables (Kapustka *et al.* 2006). Moreover, plant sensitivity for heavy metal is strongly metal-dependent and soil-dependent. For another gramineous plant, barley, was more sensitive for Cu in contrast to Ni in 17 Chinese soils, and toxicity thresholds (effective concentration of added metal causing 50% inhibition in root elongation, EC_{50}) were 2.43-fold higher for Ni than those for Cu in average; also, among a series of different soils, barley was much easier to suffer Cu and Ni toxicities in soils with lower organic matter and pH values (Li 2010; Li *et al.* 2011).

To date, there is little information regarding sensitivity of Chinese plant species to Cu and Ni addition in soils. Bok choy is an important agricultural food crop in Asia, especially in southern China, its sensitivity distribution in a series of vegetable species and crop species is extremely meaningful for risk assessment of heavy metals in soil. The present study was designed to investigate the difference in phytotoxicity of Cu and Ni to eight Chinese plant species grown on two representative Chinese soils (Ferrosol and Dark semi-hydromorphic soil) in order to find the sensitivity sequence of bok choy for Cu and Ni toxicities in eight representative plant species. The results will be integrated into sensitivity distribution database of most plant species in China and could contribute a lot to environmental risk assessment of Cu and Ni in soils.

2. Results

2.1. Copper toxicity thresholds and sensitivity comparison of different species

Copper concentration-dependent effects in all plant species were shown in Fig. 1, except for spinach and celery in Ferrosol and paddy rice in Dark semi-hydromorphic soil which data could not be fitted because plants failed to survive. Compared to the unamended control, the inhibition on all plant species shoot biomass by the maximum concentration of added Cu almost reached 100%. For most of plant species, the data fitted reasonably well to the log-logistic

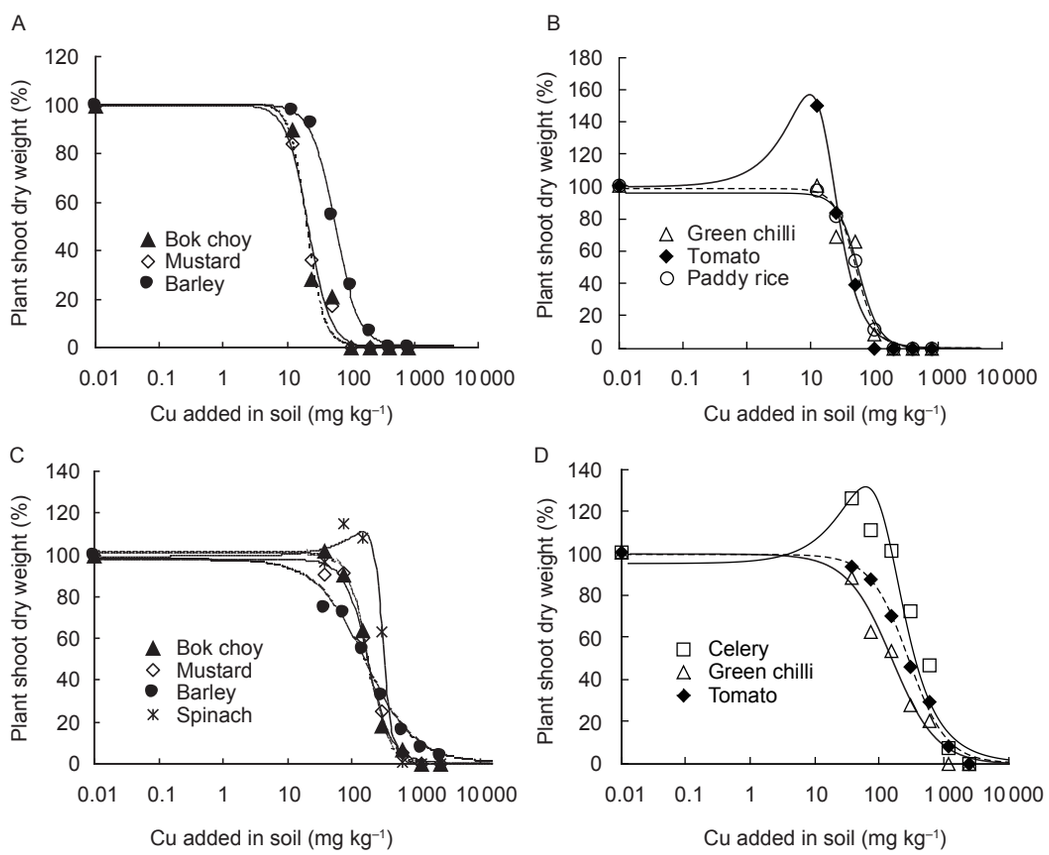

Fig. 1 The dose-response curves of measured added Cu concentrations (mg kg^{-1}) for plant shoot growths in Ferrosol (A, B) and Dark semi-hydromorphic soil (C, D). Symbols represented average values of all replicated data points, lines were fitted log-logistic curves. The same as below.