Manganese and cadmium accumulated in tomato under greenhouse conditions

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Greenhouse cultivation not only promotes vegetable production, but also alters soil pH, soil aeration, and even root microorganisms in the greenhouse, which affects heavy metal transport in vegetables. Field experiments were conducted. Soils and tomato plants were sampled at harvest and analyzed for concentrations of Mn and Cd as well as other properties.

As compared with open field, greenhouse cultivation significantly decreased soil pH, soil organic matter, and oxidation-reduction potential (ORP) ($p<0.01$). Total chlorophyll in greenhouse tomato laminae also decreased ($p<0.01$).

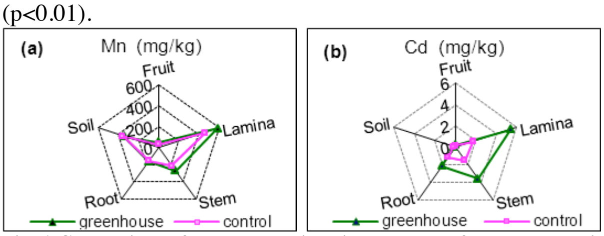

Fig. 1 Comparison of total metals in soil and parts of tomato plant in two cultivations

Mn and Cd concentrations in soil and parts of tomato plant were shown in Fig. 1. Mn and Cd concentrations in two cultivation soils had no significant difference. However, an obvious increase of metal concentrations in greenhouse tomato plant was clearly seen. Specifically, Mn concentrations in tomato root, stem, lamina and fruit increased with greenhouse cultivation by 5%, 27%, 28%, and 50%, respectively; the differences in two parts reached the significant levels ($p=0.009$ in lamina and $p=0.029$ in fruit). Cd concentrations in greenhouse cultivation increased in tomato root, stem, lamina, and fruit by 88%, 143%, 216%, and 27%, respectively, with all the differences being significant ($p=0.001$, $p=0.000$, $p=0.000$ and $p=0.049$, respectively). Lower pH and ORP in greenhouse soil were responsible for enhanced metal accumulation (Wang *et al*.. 2006). Correlation analysis showed that total chlorophyll in lamina was negatively correlated with Cd content, which was in accord with the report of a Cd inhibitory effect on chlorophyll formation (Stobart *et al*.. 1985). Mn and Cd concentrations in tomato fruit were below the limit for safe human consumption.

Greenhouse cultivation promoted heavy metal accumulation in vegetables. In other words, greenhouse cultivation may be a potential remediation of metal pollution.

[1] Stobart A K, *et al*.. (1985). "The effect of Cd^{2+} on the biosynthesis of chlorophyll in leaves of barley." Physiol Plant **63**: 293-298. [2] Wang A S, *et al*.. (2006). "Soil pH effects on uptake of Cd and Zn by Thlaspi caerulescens." Plant Soil **281**: 325-337.

Seesaw balance of Cenozoic carbon cycle

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It is generally accepted that decreasing partial pressure of atmospheric CO_2 (pCO_2) has caused the progressive cooling of Cenozoic climate. However, the reason behind the decline of pCO_2 is still unclear. BLAG model (Berner *et al*.., 1983, Am. J. Sci. 283, 641-683) proposes that the decrease of volcanic degassing is the primary driver for the long-term decline of pCO_2 through the negative feedbacks between pCO_2 and silicate weathering. However, the spreading rate of seafloor, which is believed as the major control of CO_2 degassing, seems to have remained relatively constant. The hypothesis of 'uplift driven climate change' proposes that tectonic uplift may have enhanced the sink of atmospheric CO_2 by silicate weathering, and thus produced the decline of pCO_2 (Raymo *et al*.., 1998, Geology 16, 649-653). However, increasing weathering sink of CO_2 could deplete atmosphere all of its CO_2 within several million years while holding volcanic outgassing constant (Berner and Caldeira, Geology 25, 955-956).

The fundamental difference between BLAG carbon model and the 'uplift driven climate change' hypothesis is related to the two extreme mechanisms that control the rate of silicate weathering, i.e., the weathering limited regime in BLAG model and the supply limited regime in 'uplift driven climate change' hypothesis respectively. Since both of the weatering regimes exist on earth, here based on reverse caclulation on the major carbon cycle fluxes, a seesaw balance of Cenozoic carbon cycle is proposed by combining the BLAG carbon model and the 'uplift driven climate change' hypothesis following the weatherability idea of Kump and Arthur (1997, Ruddiman, W. (Ed.), Tectonics Uplift and Climate Change. Plenum Publishing Co., 399-426). The seesaw balance model could solve both of the driver problem in BLAG model and balance problem in 'uplift driven climate change' hypothesis. Tectonic uplift will enhance the supply limited weathering consumption of atmospheric CO_2 in continents, which initialize the drawdown of pCO_2. The decline of pCO_2 will decrease the weathering consumption of atmospheric CO_2 in weathering limited regions (mainly basaltic islands) until the decrease of weathering limited weathering could compensate the increase of supply limited weathering, then reaches a new steady state.

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