

研究论文

生长在铅锌矿废水污灌区的长豇豆组织中Pb、Zn、Cd含量的品种间差异

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摘要 在经铅锌矿废水灌溉约50年的农田中种植24个长豇豆品种, 测定植物体内的Pb、Zn、Cd在根、茎、叶及果实中的含量。结果表明, Cd在长豇豆根、茎、叶及果实的平均含量分别为1.212、0.425、1.051mg•kg⁻¹和0.11mg•kg⁻¹; Pb则分别是92.53、97.9、33.08mg•kg⁻¹和0.120mg•kg⁻¹; Zn分别是130.14、59.40、99.94mg•kg⁻¹和6.320mg•kg⁻¹。果实中的Cd、Pb和Zn最大品种间差异分别达4.4倍、4.2倍和1.6倍; 各品种3种重金属含量ANOVA分析结果显示了品种间差异具有极显著意义。不同仁色(花仁、红仁及黑仁)长豇豆品种间的3种重金属含量在根部均有显著差异, 而Zn及Cd含量在茎组织中也有显著差异; 但各组在叶及果实中没有显著差异。尽管污灌区土壤Cd、Pb和Zn浓度均超出了国家土壤环境质量标准二级土壤的最高限值, 但绝大多数品种的果实中所含重金属均符合国家食品卫生标准。Pb较易在果实中积累, 有一个品种果实Pb浓度超过国家标准。根和茎中的3种重金属含量相互间均具有高度相关性, 且果实中的Cd和Pb含量间也有显著相关, 表明长豇豆对Cd、Pb和Zn的吸收和积累有协同性, 这一特性使得同时低量积累重金属的长豇豆品种的筛选更为容易, 特别是在可食部分同时低量积累Cd和Pb的品种。污灌区具有比对照区更高的产量, 说明长豇豆能耐受农田中Cd、Pb和Zn的复合污染, 因而生产者比较难以从长豇豆的中毒症状发现重金属的污染, 导致在污染土壤中生产长豇豆容易受重金属污染。可见, 筛选和培育低量积累重金属的长豇豆品种有利于降低人类通过食物链暴露于重金属的水平。

关键词 [长豇豆](#) [品种间差异](#) [污灌](#) [重金属](#) [土壤污染](#)

分类号 [S19](#)

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Abstract Heavy metal pollution has been a serious worldwide problem which is impacting on the ecosystem and human health. These toxic metals exist in agricultural soil in rather high concentrations in many areas all over the world and easily enter the human body mainly via the food chain. Reducing the risk of exposure to the metals is as important as remediation of the contaminated soils. As uptake and accumulation of heavy metals are indicated to be varied in different cultivars of crops, select and use of the cultivars accumulating fewer heavy metals in their edible parts shall be effective and facile strategy to reduce the influx of heavy metals to the human food chain. Vegetables are important sources of heavy metals transferred from the soil to the human body, consequently they are an excellent model system to explore the strategy. In this study, asparagus bean (*Vigna unguiculata* subsp. *sesquipedalis* L.), an important legume vegetable, and a farmland multi-contaminated by lead, zinc and cadmium were used for investigating the feasibility of the strategy under the condition contaminated by multiple heavy metals. Twenty four cultivars of asparagus bean were planted in a farmland that had been irrigated by Pb/Zn mining wastewater for over 50 years. Lead, zinc and cadmium concentrations in roots, stems, leaves and fruits of the cultivars were analyzed. Average Cd concentrations in roots, stems, leaves and fruits were, respectively, 1.212, 0.425, 1.051mg•kg⁻¹ and 0.11 mg•kg⁻¹; those of Pb were 92.53, 97.9, 33.08mg•kg⁻¹ and 0.120 mg•kg⁻¹; and those of Zn, were 130.14, 59.40, 99.94mg•kg⁻¹ and 6.32 mg•kg⁻¹. In the fruits of the tested cultivars, the maximal differences of Cd, Pb and Zn concentrations were 4.4, 4.2 and 1.6 fold, respectively. Analyses of variance showed that the variations among differ

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ent cultivars in concentrations of Cd, Pb and Zn in all tissues were significant ($p < 0.01$). The tested cultivars were divided into three types (striped, red and black) according to their seed capsule color. Cd concentration in root was significantly higher in striped than in the other types ($p < 0.01$), and that in stem was significantly higher in red than in the others ($p < 0.05$). Pb concentration in root was significantly higher in black than in the others ($p < 0.05$). Zn concentrations in root of black, in stem of red and in leaf of red and black were significantly higher than the others ($p < 0.05$). While no significant differences were found for the concentrations of all the tested metals in fruits between the three types each other. Although Cd, Pb and Zn concentrations in soil of the wastewater-irrigated farm exceeded the maximum limitation of the second grade soil according to the National Standard for Soil Environmental Quality of China, concentrations of the tested metals in the fruits of most tested cultivars were significantly lower than the National Food Hygiene Standard of China (NFHSC). Lead accumulation in the fruits is noticeable because Pb seems to be relatively easier to translocate to fruit, and there is one cultivar in which Pb concentration in fruit exceeded the maximum limitation of NFHSC. Correlations among the three tested metals in roots and stems were highly significant, and the correlation between Cd and Pb in fruits was also significant. This suggests that absorptions of Cd, Pb and Zn in asparagus bean might be tightly associated, which in turn may help the selection of cultivars that accumulate multiple heavy metals at lower levels in their edible tissues. The overall fruit yield of all tested varieties were not affected by the high Cd, Pb and Zn concentrations in the wastewater-irrigated soil. This places asparagus bean at extra risk of heavy metal contamination from polluted soils, because the farmers will not receive any warning about the toxic level in the soil by the appearance of yield. Therefore, the selection and breeding of cultivars that accumulate lower levels of heavy metals are believed to be important and much in need in reducing the exposure of human beings to heavy metal pollutions via the food chain.

Key words [asparagus bean](#) [variation in cultivars](#) [wastewater irrigation](#) [heavy metals](#) [soil contamination](#)

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