THE USE OF CROP BRASSICAS IN PHYTOEXTRACTION : A SUBSET OF PHYTOREMEDIATION TO REMOVE TOXIC METALS FROM SOILS

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ABSTRACT

Phytoextraction is a subset of phytoremediation in which metal-accumulating plants are used to transport and concentrate metals from soils into the harvestable parts. Phytoextraction of Pb by *B. juncea* and other members of Brassicaceae has been investigated. Screening of different cultivars of *B. carinata* and *B. napus* for Pb uptake and accumulation in roots and shoots has shown lower levels of Pb compared to *B. juncea* cv 426308. Comparison of different cultivars of *B. nigra* with *B. juncea* cv 426308 has demonstrated that some of the *B. nigra* cultivars contained even higher Pb levels and biomass than *B. juncea*. *Sinapis pubescens* contained 3 fold more Pb in its shoot tissue but only half as much biomass as that of *B. juncea*.

INTRODUCTION

Of late, the use of metal-accumulating plants for plant-based remediation method called "Phytoremediation" is emerging to be an attractive environmental remediation approach (Cunningham and Berti 1993; Raskin et al. 1994; Baker et al. 1994; Brown et al 1994, 1995; Nanda Kumar et al. 1995; Dushenkov et al. 1995). Phytoextraction is one of the three subsets of phytoremediation (Raskin et al. 1994; Nanda Kumar et al. 1995) in which metal-accumulating plants are used to transport and concentrate metals from the soil into the harvestable parts of roots and above ground shoots. Essentially, phytoextraction involves planting of successive croppings of metal accumulating plants which extract the toxic metals from the soil into the above ground shoots. We have previously reported the higher phytoextraction abilities of *B. juncea* (Brassicaceae) compared to several high-biomass crop species (Nanda Kumar et al. 1995). Here, we compare the phytoextraction abilities of *B. juncea* and different members of Brassicaceae for accumulation of Pb.

EXPERIMENTAL

Brassica species and cultivars were obtained from USDA/ARS Plant Introduction Station of Iowa State University. Seeds of *Sinapis* were obtained from Dr. Gomez-Campo, Universidad Politechnica, Madrid, Spain. Experimental design and metal salts used were same as described before (Nanda Kumar et al. 1995).

Metal uptake by different cultivars

Lead accumulation by different cultivars of *B. carinata* and *B. napus* in roots and shoots was studied and compared to that of *B. juncea* cultivar 426308 that was identified as the best cultivar for Pb accumulation in the shoot tissue (Nanda Kumar et al. 1995). As shown in Figure 1, none of the cultivars of *B. carinata* and *B. napus* treated with 625 µg Pb/g DW sand-Perlite mixture were as efficient as *B. juncea* cv 426308 for Pb accumulation. In general, *B. carinata* cultivars showed higher levels of Pb compared to *B. napus*. The most efficient *B. carinata* accumulator (cv 194900) contained 1.9 mg Pb/g DW in shoots and 50.8 mg Pb/g DW in roots while the least efficient cultivar contained 1.1 and 32.8 mg Pb/g DW in shoots and roots respectively. Cultivars of *B. napus*, Midas and Westar, contained less than 0.5 mg Pb/g DW in shoots and about 30mg Pb/g DW in roots. We have also compared 35 different cultivars of *B. nigra* with *B. juncea* cv 426308 for Pb accumulation. For this experiment, the seedlings were fertilized for 17 days without transplanting to nutrient-free sand-Perlite substrate to reduce the precipitation of Pb. Before Pb treatments at a concentration of 625 µg Pb/g DW sand-Perlite mixture, the pots containing 17-day-old seedlings were flushed with water. The shoot phytoextraction coefficients (the ratios between µg of metal/g DW shoot tissue and µg of metal/g DW soil) of some of the *B. nigra* cultivars were observed to be even more than that of *B. juncea* cv 426308 (Figure 2). For example, *B. nigra* cv 175073 showed a phytoextraction coefficient of 33 with a biomass of 0.07g while *B. juncea* cv 426308 showed a phytoextraction coefficient of 21 with a biomass of only half as much as that of *B. nigra* cv 175073. Although *B. nigra* cv 183020 contained only half as much Pb in its shoots as that of the cv 175073, the biomass of this cultivar was twice as much and thus the total Pb removal remained the same in both the cultivars.

Metal uptake by wild species

To further understand the potential use of crop-related and wild Brassicaceae members for phytoextraction, *B. juncea* was compared with the species of *Sinapis*, the genus known to include relatively high biomass species. Figure 3 shows the shoot phytoextraction coefficients and dry weights of *Sinapis* and *Brassica* treated with 625 µg Pb/g DW. *Sinapis pubescens* has shown the highest phytoextraction coefficient of 30 followed by *B. junea* and *S. flexuosa*. On the other hand, *B. juncea* had shown the highest biomass of 0.14g followed by *S. flexuosa* (0.08g) and *S. pubescens* (0.035 g).

All the tested cultivars of amphidiploids *B. carinata* and *B. napus* displayed significantly lower levels of Pb in shoots compared to *B. juncea*. Some of the cultivars of *B. nigra* had higher levels of shoot Pb than *B. juncea*. Thus these results further support the hypothesis that the presence of both AA and BB genomes together as in *B. juncea* or BB genome alone as in *B. nigra* are responsible for high Pb accumulation in shoots. In addition to being efficient Pb accumulators, both *B. juncea* and *B. nigra* are high biomass producers (Bhargawa 1991) and are thus good candidates for phytoremediation. There may also be non-crop members of the tribe Brassiceae with rapid biomass production that are able to accumulate metals to high levels in their above ground parts. Some of the species of *Sinapis* are known to produce a high above ground biomass. Comparison of *B. juncea* and

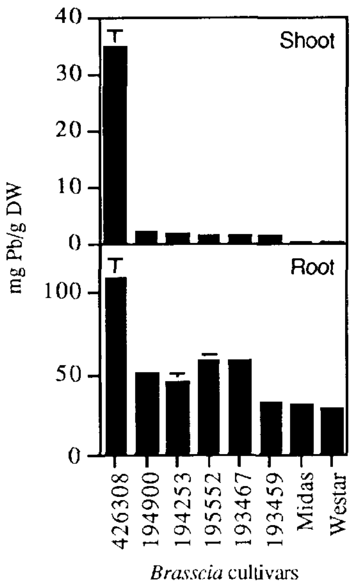

Fig 1. Pb content in roots and shoots of *Brasscia* cultivars. 426308 is *B. juncea* cultivar. Midas and Westar are *B. napus* and the rest are *B. carinata* cultivars. Vertical bars denote S.E. (n=4).

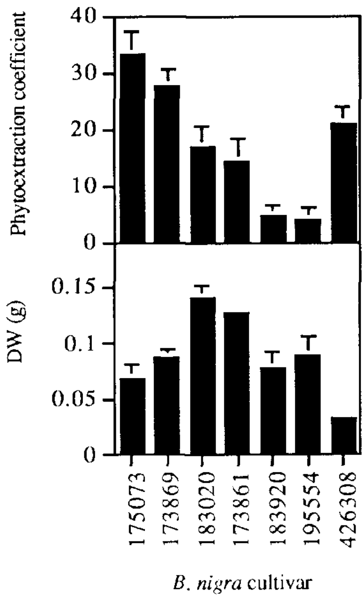

Fig 2. Shoot Pb phytoextraction coefficents and dry weights of *B. nigra* cultivars compared to *B.juncea* cv 426308. Vertical bars denote S.E. (n=4).

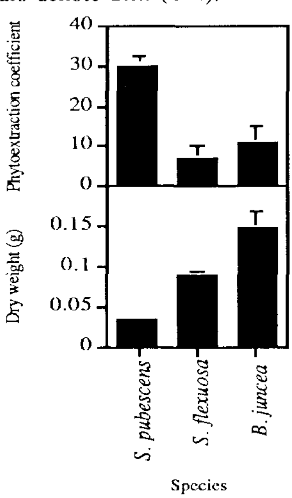

Figure 3. Shoot Pb Phytoextraction coefficients and dry weights of *Sinapis* species and *B. juncea*.. Vertical bars denote SE (n=4).

Sinapis spp has shown that *S. pubescens*, a wild species of the tribe Brassiceae, has shown even higher levels of Pb in shoots than *B. juncea* although the shoot biomass was considerably lower than that of *B. juncea*. *B. nigra* is closely related to *Sinapis* than it is to other crop brassicas (Pradhan et al. 1991). It is clear from these results that some of the crop brassicas and their wild allies have different phytoextracting abilities. Thus, it may be possible to produce improved cultivars of crop brassicas for phytoremediation through genetic hybridizations within Brassicaceae.

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