Potentially toxic element hyperaccumulator plants: preliminary evaluation of the phytoextraction duration to remediate a contaminated agricultural soil by Brassica juncea successive croppings

Luigi Giuseppe Duri[12], Diana Agrelli[12], Eugenio Cozzolino[3], Massimo Fagnano[12], Paola Adamo[1]

[1]Department of Agricultural Sciences, University of Naples Federico II, Italy - [2]CIRAM, University of Naples Federico II, Italy - [3]CREA-Research centre for cereals and industrial crops, Italy

INTRODUCTION

Phytoextraction by hyperaccumulator plants is an in situ eco-friendly and cost-effective method to remediate soil by potentially toxic elements (PTEs). The plants uptake PTEs in the bioavailable forms, and the progressive reduction of the soil bioavailable pools until safety levels could be a remediation objective. However, during phytoextraction some changes may occur in PTEs repartition among soil geochemical fractions and in their equilibriums with soil solution, and these changes can influence phytoextraction duration.

OBJECTIVES

In this work we report the preliminary results of an ongoing pot experiment of PTEs phytoextraction with the aim to estimate time-span of remediation and changes in the PTEs repartition between the total, potentially bioavailable and readily bioavailable pool in soil, that may occur during the phytoextraction cycles.

METHODOLOGY

Brassica juncea was sowed in pot (4 replicates) on 3 soils from a contaminated site (Table 1). At flowering, plants were uprooted and analyzed for PTEs concentration. After *B. juncea*, in each pot Rocket salad (*Eruca vesicaria*) was sowed as worst-case bioindicator for verifying the risk of PTEs accumulation in food crops, since it is known as a metallophyte plant. Rocket salad was harvested 4 times in each pot, and PTEs concentration in the edible part was analyzed.

		A7 %	F4 %	C13 %
Cr	EDTA	- 8	+ 1	+ 5
	NH_4NO_3	+ 6	+ 6	+ 5
Zn	EDTA	- 26	- 2	- 8
	NH_4NO_3	+ 141	+ 118	+ 15
Pb	EDTA	- 9	- 8	- 20
	NH_4NO_3	nd	nd	nd
Cd	EDTA	- 2	+ 4	- 2
	NH_4NO_3	- 9	+ 48	- 8

Table 2: Variation (% of the initial amount) of the PTEs amount extracted by EDTA and NH_4NO_3 from the studied soils after *Brassica juncea* cycle.

	Cr	Zn	Pb	Cd
A7	123	147	68.0	0.23
F4	549	305	79.8	14
C13	555	617	161	0.50

Table 1: PTEs total concentration (mg/kg) in the three soil samples collected for pot experiment.

Amounts of readily and potentially bioavailable elements in soils before and after *B. juncea* cycle were evaluated by NH4NO3 1 M and EDTA 0.05 M pH 7 extractions (DIN 19730, 2008; Rauret et al. 2001).

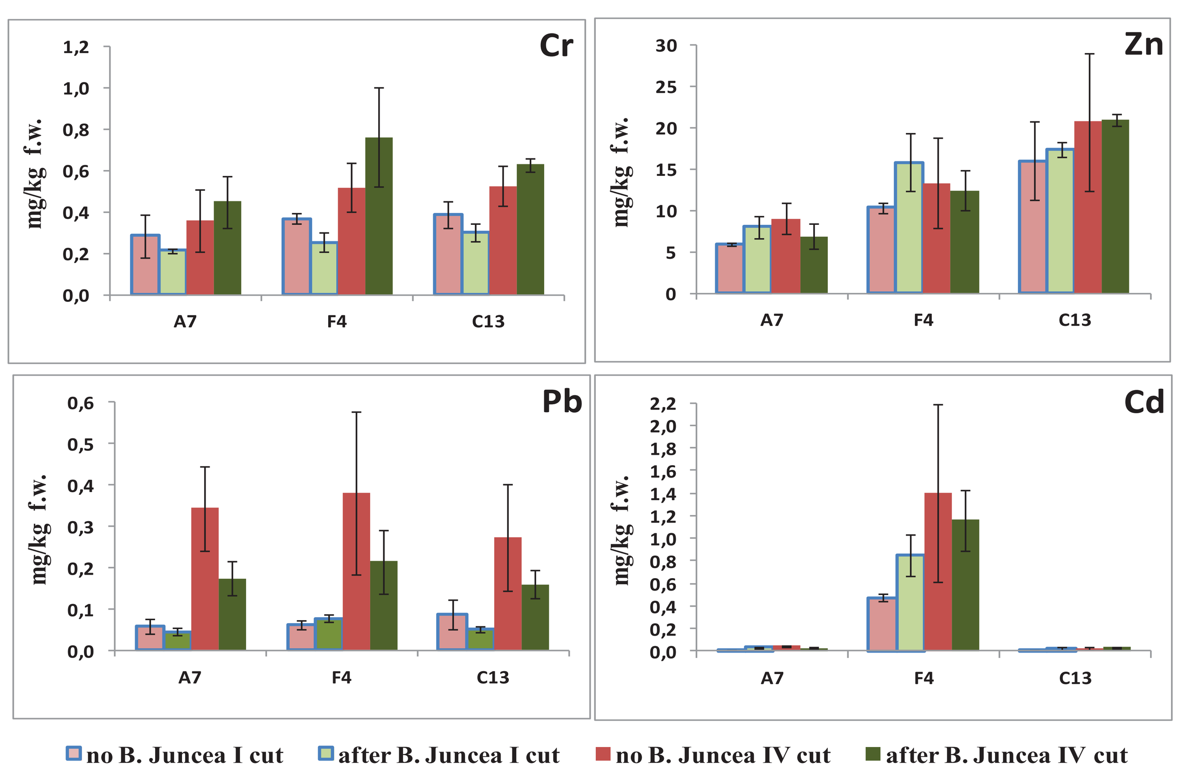

Figure 1: Concentration of PTEs in the leaves of Rocket salad (I and IV cut) grown in the studied soils with and without *Brassica juncea* in precession.

MAIN RESULTS

After the 1st *B. juncea* cycle, a general depletion of the potentially bioavailable and an increase of the readily bioavailable pools was observed (Table 2), in particular for Cd and Zn. The increased bioavailability enhanced Cd and Zn accumulation in leaves of Rocket salad grown after *B. juncea* (Figure 1); an opposite behavior was observed for Cr and Pb. According to the amounts of PTEs removed by *B. juncea*, the number of crop cycles needed to remove the amounts of potentially bioavailable Cd, Cr and Zn at pot scale ranged from 15 and 112 (acceptable); the time-span was extremely long for lead (981-2416 cycles) (Table 3). The scale-up at field level must be evaluated.

The phytoextraction times might be underestimated because plant uptake decreases as the PTEs amount in soil goes down. Furthermore, changes in the equilibrium between PTEs soil pools during phytoextraction should be deeply investigated; in our case, an increase of PTEs readily bioavailable amounts and a decrement of PTEs potentially bioavailable amounts were measured after *B. juncea* cycle.

At the same time PTEs accumulation in Rocket salad in some cases was enhanced after *B. juncea*, but the amount removed by plants were always lower than the decrement of the potentially bioavailable amounts.

CONCLUSIONS

To evaluate phytoremediation duration in site-specific conditions it is crucial to monitor successive phytoextraction cycles to become aware of the potential changes in PTEs repartition among soil fractions. These changes, indeed, can modify pollutant amounts extracted over time both by plants used for reclamation, but also by food crops in a scenario of a possible return of the site to agricultural use. This latter use will became feasible only when bioindicator plants (e.g. Rocket) will not uptake PTEs in amounts dangerous for human health.

		Cr	Zn	Pb	Cd
PTEs extracted in EDTA before *B. Juncea* (mg/pot)	A7	10.1	220	76.1	1.60
	F4	18.3	917	147	61.1
	C13	42.6	2401	508	3.56
PTEs removed by *B. Juncea* (mg/pot)	A7	0.266	14.7	0.0776	0.0371
	F4	0.632	30.2	0.146	1.79
	C13	1.08	37.9	0.210	0.0317
n° of *B. juncea* cycles needed to remove the potentially bioavailable PTEs in pots	A7	38	15	981	43
	F4	29	30	1011	34
	C13	40	63	2416	112

Table 3: Estimation of the number of *Brassica juncea* cycles needed to remove the potentially bioavailable PTEs

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