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AMARANTHUS VIRIDIS L. A BEST HYPERACCUMULATOR FOR ARSENIC POLLUTANTS

Environmental Science

Selvaraj, K.* Department of Botany, G. Venkatasamy Naidu College (An Autonomous Institution affiliated to Manonmaniam Sundaranar University, Tirunelveli), Tamil Nadu, India. *Corresponding Author

Ramasubramanian, V. Principal SRV College of Arts and Science (Affiliated to Madurai Kamaraj University, Madurai).

Makesh Kumar, B. Department of Botany, G. Venkatasamy Naidu College (An Autonomous Institution affiliated to Manonmaniam Sundaranar University, Tirunelveli), Tamil Nadu, India.

ABSTRACT

Pollution is inevitable in the current world; finding new way to eradicate pollutants from the environment is a big challenge to the researchers. The new novel method is growing past that is used plant to mitigate toxins in the environment, this current work is aim to remove the arsenic pollutants from the environment by using the native hyperaccumulator plant *Amaratnhus virdis* L. The hyperaccumulator shows the high accumulation factor, translocation factor and mobility index, these factors are proves *Amaratnhus virdis* L. suitable to mobilize arsenic toxins from the environment and translocate it in various parts of plants. The accumulation factor and translocation factor is more than one that plant is consider to be a hyperaccumulator. Hence it is proves that *Amaratnhus virdis* L. is best suitable to eradicate arsenic pollutants from the environment and forms an environment with better ecosystem development.

KEYWORDS

Amaratnhus virdis L., hyperaccumulator, arsenic pollution, accumulation factor, translocation factor

INTRODUCTION

All plants have the ability to accumulate essential metal from the soil solution. Plants need different concentration for growth and development. This ability allows the plants to accumulate other non-essential metals (Al, As, Au, Cd, Cr, Hg, Pb, Pd, Pt, Sb, Te, Ti and U) which have no known biological function (1). The accumulation of toxic heavy metals in the environment and their impact on both public health and the natural environment were studied in detail (2). The capacity of plants to concentrate metals has usually been considered a detrimental trait since some plants are directly or indirectly responsible for a proportion of the dietary uptake of toxic heavy metals by humans (3, 4). The dietary intake of heavy metals through consumption of contaminated crop plants can have long-term effects on human health (5).

Plants often accumulate heavy metals to concentrations exceeding their levels in soil by several folds, wherefrom they enter the food chain. The capacity of plants to accumulate such metals and tolerate their high concentrations is a species-specific trait. Plants ideal for phytoremediation should grow fast, have high biomass and tolerate or accumulate a wide range of heavy metals in their harvestable parts. More than 400 plant species have been reported to hyperaccumulate heavy metals (7). Most of these species fall short of biomass, only recently some plants have been reported to be ideal an arsenic hyperaccumulator with a considerable biomass, fast growing and easy to propagate in nature (6).

The plant used in the phytoremediation technique must have a considerable capacity of metal absorption, its accumulation and strength to decrease the treatment time. Many families of vascular plants have been identified as metal hyperaccumulator (6). The hyperaccumulator is metal selective, having slow growth rate, produce small amounts of biomass and can be used in their natural habitats only (8).

METHODOLOGY

Seeds of *Amarantus viridis* L. was procured from local seed centre, Sivakasi. *Amarantus viridis* L. (Family; Amaranthaceae) was chosen as hyperaccumulator plants for this study. The effect of various concentrations of arsenic chloride and the accumulation factor, translocation factor and mobility index were analyzed on the plants.

PREPARATION OF THE EXPERIMENTAL SOIL

The experimental soil for raising the cultivars was prepared by mixing red soil, black soil and sandy soil in the ratio of 1 : 1 : 1. The prepared soil was sterilized by solar sterilization method (9) for 5 days. The analysed soil medium was taken in earthen pots of size 3033 cm and filled in about two-third of its height (5 kg of soil per pot).

SEED TREATMENT

Healthy seeds of *Amarantus viridis,* L. was surface sterilized with 0.1% mercuric chloride (w/v) for one minute and washed with running tap water followed by distilled water.

EXPERIMENTAL DESIGN

HEAVY METALS STRESS ON *AMARANTUS.*

The heavy metal arsenic was treated separately in the experimental plants with different concentrations *viz.,* 2 mM, 4 mM, 6 mM, 8 mM and 10 mM (w/v) in five replicates. The aqueous solutions of heavy metals were applied to the soil after the development of first leaves in the seedlings. Then the plants were watered with the respective concentration of metals on every alternate days. A set of plants without arsenic treatment was maintained as control. The metal concentration in plants such as accumulation, translocation factor and mobility index were analysed on the 35^{th} day after planting (DAP).

ANALYSIS OF ARSENIC IN PLANT MATERIAL

The heavy metals accumulated in experimental plants were assayed at the end of the plant life. Arsenic concentrations in plants was analysed using the method of Baker *et al*. (10). The plant sample as a whole was washed, dried in oven at 160°C for 40 minutes and digested in a mixture of nitric acid and perchloric acid (10:1). Then the solution was centrifuged at 5000 rpm for 5 minutes and double filtered with whatmann filter paper no.4 and the filtrate was used for analysing As concentration by Atomic Absorption Spectrometry (Shimadzu Model AA – 6300).

ACCUMULATION FACTOR (AF)

The Accumulation Factor (AF) was considered to determine the quantity of heavy metals absorbed by the plant from soil. This is an index of the plant to accumulate a particular metal with respect to its concentration in the soil and is calculated using the formula (11;12).

$$\text{Accumulation Factor (AF)} = \frac{\textit{Metal concentraiton in tissue of whole plant}}{\textit{(Initial concentraion of metal in the substrate (Soil)}}$$

Translocation Factor (TF)

To evaluate the potential of plant species for phytoextraction, the Translocation Factor (TF) was considered. This ratio is an indication of the ability of the plant to translocate metals from the roots to the aerial parts of the plant (13). It is represented by the ratio:

$$\text{Translocation Factor (TF)} = \frac{\text{Metal concentration in stem+leaves}}{\text{(Metal concentration in root)}}$$

Mobility Index (MI)

Mobility Index (MI) was considered to determine the biomobility and transport of heavy metals in different plant parts. The whole experiment was divided into three categories: Level 1 (Soil – Roots), Level 2 (Roots – Stems) and Level 3 (Stems – leaves). It was calculated by the methods of Kumar *et al*. (14)

$$\text{Mobility Index(MI)} = \frac{\text{Concentration of metal in the receiving level}}{\text{Concentration of metal in the source level}}$$

RESULT AND DISCUSSION

To evaluate the heavy metal accumulation in the plant tissue, the accumulation factor (AF) was calculated on the effect of arsenic chloride on *Amarantus viridis L*. and tabulated in table 1

Table 1: Metal arsenic chloride concentration in *Amarantus viridis L.*

Parameters	Control	2mM	4mM	6mM	8mM	10mM
Accumulation Factor (AF) ($\mu g\ g^{-1}$)	BDL	1.924 ± 0.0048	2.012 ± 0.0019a*	2.071 ± 0.0075a*	2.207 ± 0.0090a*	2.266 ± 0.0037a*
Translocation Factor (TF) ($\mu g\ g^{-1}$)	BDL	1.287 ± 0.0029	1.397 ± 0.0064a*	1.43 ± 0.0033a*	1.518 ± 0.0074a*	1.626 ± 0.0026a*
Mobility Index (MI) Level 1(S–R) ($\mu g\ g^{-1}$)	BDL	0.733 ± 0.0046	0.827 ± 0.0032a*	0.864 ± 0.0046a*	0.900 ± 0.0017a*	0.965 ± 0.0091a*
Level 2 (R–S) ($\mu g\ g^{-1}$)	BDL	0.439 ± 0.0040	0.555 ± 0.0059a*	0.592 ± 0.0041a*	0.643 ± 0.0055a*	0.668 ± 0.0043a*
Level 3 (S–L) ($\mu g\ g^{-1}$)	BDL	1.274 ± 0.0029	1.417 ± 0.0016a*	1.515 ± 0.0033a*	1.527 ± 0.0097a*	1.934 ± 0.0022a*

Values are an average of three observations. Mean ± SE, a – refers to value compared with control in various concentrations of metals, a* – refers to significant ($P \leq 0.05$ – Turkey test).

BDL – Below Detectable Level, S – R: Soil to Root, R – S: Root to Stem, S – L: Stem to Leaf

The accumulation factor and translocation factors were significantly increased with the increasing concentrations of arsenic chloride

The mobility index of arsenic chloride treated Amarantus viridis L. was divided into three parts; Level 1- Soil to Root; Level 2- Root to Stem and level 3- Stem to Leaf.

There are important characteristics (15;16) used in defining a plant as a hyperaccumulator. The first characteristics is the translocation factor (TF) which refers to the concentration of heavy metal in shoots divided by that in roots, which should be higher than 1 (the concentration of contaminants in shoots should be higher than in roots). The second characteristics is the accumulation factor (AF), that is, the concentration of heavy metal in roots divided by that in soil which should be higher than 1. Mobility is the third criterion, which is the translocation of metals from soil to leaf through root and stem.

Bioaccumulation pattern of heavy metal can also be interpreted in terms of Accumulation Factor (AF) and Translocation Factor (TF) following the method suggested by Yoon et al., (12). Amarantus the accumulation factor (AF) and translocation factor (TF) of both metals seems to be gradually increasing with increasing concentrations of heavy metals. Similar results have been reported in the accumulation pattern of heavy metals in Bidens tripartita (17). These authors suggested that accumulation potential of plants towards arsenic chloride depends on the availability of the metals in the soil/ growth media. When the accumulation is expressed as percentage of available metal content in the growth medium, in spite of significant differences in the molar concentrations of each metals, almost similar quantities of all metals are accumulated in the roots, whereas this pattern is not followed by accumulation pattern of stem and leaf tissue presumably due to significant difference in the TF values as a result of differences in translocation flux. This observation is in conformity with the views of Zeng *et al*., (18).

The mobility index (MI) was studied in Amarantus, the mobility is higher than one for level 3, whereas the mobility index in level 1 and level 2 were more than 0.6. which indicated the low rate of mobility of metals form stem to leaves, moderate rate of mobility of metals form soil to roots and higher mobility rate in stem to leaves. As the mobility index is higher in level 3, it clearly indicates that these two plants had removed metals by the phytoextraction process. Thus, the present results were well-corroborated with the observations of Hunter et al., (19;20;21) in copper, cadmium contaminated grassland ecosystem.

The plants having TF factor more than 1 is considered to have significant phytoremediation potential (7;13;17). The present study clearly indicates that Amarantus are suitable for phytoremediation through phytoextraction method for mitigation of heavy metals especially arsenic as a biological detoxification system. According to Yoon *et al*., (12) and Zhelyjazkove et al. (17), if the accumulation factor (AF) and translocation factor (TF) values are above 1, the plant is suitable for phytoremediation. All hyperaccumulator plants species are known to have AF and TF values more than one (22). Values of both AF and TF shown by *Amarantus viridis* L. towards arsenic chloride and nickel chloride treatments come above one and hence these plants could be considered as potential hyperaccumulators and phytoremediation through phytoextraction by *Amaranthus* plants could be a viable option.

CONCLUSION

Thus, from the above findings, it is clear that the plant *Amarantus viridis* L. chosen for this study, are acting as hyperaccumulators. This is proved by the results obtained on accumulation factor (AF), translocation factor (TF) and mobility index (MI) studies. based on the result obtained on accumulation factor (AF), translocation factor (TF) and mobility index (MI), it is suggested that *Amarantus viridis* L. is best suited for remediating arsenic.

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