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**SHORT COMMUNICATION**

# PHYTOREMEDIATION OF CADMIUM CONTAMINATED SOILS BY TUBEROSE

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**The potential of three varieties of tuberose (Prajwal, Shringar and Mexican single) for phytoremediation of soil contaminated with cadmium was evaluated by subjecting the plants to five levels of Cd (0, 25, 50, 75 and 100 mg kg$^{-1}$ soil). Applied Cd did not produce any toxic symptoms in all the three varieties of tuberose except marginal reduction in the photosynthesis rate and total dry weight beyond 50 mg Cd kg$^{-1}$ soil. The study showed that tuberose possessed the typical ability of Cd hyper accumulator characterized by (1) accumulation of Cd in the shoots of the plant exceeding the critical judging standard i.e., 100 µg g$^{-1}$ DW and (2) ratio of Cd in the shoots to bulbs >1. It was concluded that tuberose may be an effective accumulator plant for phytoremediation of cadmium polluted soils.**

***Key words*: Cadmium, phytoremediation, photosynthesis, tuberose**

The irrigation of crop fields with sewage water is being increasingly adopted by vegetable growers and marginal farmers due to scarcity of irrigation water. It inadvertently leads to addition of a large quantity of heavy metals to the agro ecosystem (Kumar and Dhingra 2005). Therefore, agricultural practices in peri-urban areas are under the scanner due to potential threat of entry of heavy metals into food chain (Purakayastha 2007). Among various heavy metals, cadmium (Cd), in particular, has attracted an increasing international concern and is considered as one of the most important metal contaminants since the *Itai-itai* disease out break in Japan (Cai and Braids 2002). Nriagu and Pacyna (1988) reported that about 22,000 MT of Cd is globally discharged into the soil annually. Identification of non-edible plant species for phytoremediation of heavy metals is ideal, as this reduces the chance of its entry into the food chain (Susselan *et al.* 2006). Ornamental plants are quite crucial if they have hyper accumulation properties and can be used for remediation of contaminated soils (Liu *et al.* 2006). So far, there is no systematic identification of ornamental plants amenable to remediation of contaminated soils. Very few studies have been conducted to identify ornamentals for remediation of contaminated soils (Lal *et al.* 2008, Ramana *et al.* 2008 a,b, Ramana *et al.* 2009). Therefore, in the present study, we have compared the tolerance ability and accumulation of Cd in three varieties of tuberose and their suitability for remediation of soils contaminated with Cd.

The experiment was conducted in plastic pots filled with 5 kg of black soil which was treated with aqueous solution of $CdCl_2$ so as to obtain 0, 25, 50, 75 and 100 mg Cd kg$^{-1}$ soil. After Cd treatments, pots were subjected to alternate wetting and drying cycles for about 15 days and the soil was then spread on a plastic sheet and was mixed thoroughly. Subsequently, the pots were

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filled with treated soil and moisture content was maintained at field capacity. The experimental soil was analyzed for DTPA extractable Cd content ($Cd_0$- traces, $Cd_{25}$-7.86, $Cd_{50}$-16.26, $Cd_{75}$- 24.44, $Cd_{100}$- 47.69 mg $kg^{-1}$ soil). The bulbs of three tuberose varieties (Prajwal, Shringar and Mexican single) were procured from the Division of Floriculture, Indian Agricultural Research Institute, New Delhi and two bulbs were sown in each pot. The rate of photosynthesis was determined at flowering stage (80 days after sowing) using portable photosynthesis system (CID Model CI-340). The plants were harvested at flowering stage and separated in to roots plus bulbs, shoots and spike. The samples were dried in an oven at 80°C till constant weight and the dry weight of each component was recorded. The dried samples were ground, digested with 10 ml of di-acid mixture (9 $HNO_3$ : 4 $HClO_4$) and concentration of Cd was determined using Fast Sequential Atomic Absorption Spectrometer (Varian, AA240 FS) (Wang and Zhou 2003). The experiment was conducted in a completely randomised block design with five replications. The data were analyzed statistically and treatment means were compared using LSD at 5% probability (Gomez and Gomez 1984).

The application of 100 mg Cd $kg^{-1}$ soil did not produce any toxic symptoms in any tuberose varieties. However, there was a significant reduction in photosynthesis rate at higher levels (>50 mg Cd $kg^{-1}$ soil) in Prajwal and Mexican single. The variety Prajwal recorded the highest photosynthesis rate and was followed by Shringar and Mexican single (Table 1). At higher levels of Cd, there was no significant effect on total dry weight in all the three varieties (Table 1). The reduction in growth and biomass yield with increasing levels of Cd has been primarily attributed to perturbed photosynthesis (Chugh and Sawhney 1999). A similar inhibitory effect of Cd on flower production has also been reported in marigold and chrysanthemum (Ramana *et al.* 2009) and gladiolus (Ramana *et al.* 2008a).

Cd is not an essential element for plants and is effectively absorbed by roots and transported to various parts of plants. The mechanisms of internal Cd translocation are still not well understood. McLaughlin *et al.* (2000) ascertained that a large amount of Cd was retained in roots of peanuts and a small amount was translocated to stem. It has been suggested that binding of Cd to the specific root-cell proteins, which form metabolically inactive complexes, results in Cd accumulation in roots (Cieslinski *et al.* 1996). Among different plant species and genotypes of the same species, uptake and translocation of Cd from roots to shoots may vary considerably (Guo *et al.* 1995, Ramana *et al.* 2009). In the present study, Cd concentration in tissues of all the three varieties increased significantly with increasing Cd concentration in soil. Most of the Cd absorbed by the plants accumulated in the shoot (Fig. 1) and slightly lower concentration was found in the bulbs and spikes. Higher accumulation of Cd in leaf tissue as compared to seed, fruit and tuber tissues has earlier been reported in several crops (Qadir *et al.* 2000,

**Table 1.** Photosynthetic rate, total dry weight (TDW) and plant height in three varieties of tuberose grown at different levels of Cd in soil. Values are mean of five replicates

| Levels of Cd (mg $kg^{-1}$ soil) | Photosynthetic rate ($\mu mol\ CO_2\ m^{-2}\ s^{-1}$) | | | TDW (g $pot^{-1}$) | | | Plant height (cm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Prajwal | Shringar | Mexican single | Prajwal | Shringar | Mexican single | Prajwal | Shringar | Mexican single |
| 0 | 14.45 | 14.45 | 13.80 | 69.19 | 61.91 | 64.11 | 103 | 79 | 143 |
| 25 | 14.35 | 13.90 | 12.95 | 68.59 | 58.91 | 61.81 | 93 | 68 | 122 |
| 50 | 14.45 | 13.90 | 11.50 | 66.49 | 58.36 | 56.23 | 82 | 65 | 100 |
| 75 | 12.70 | 12.95 | 11.40 | 66.19 | 56.16 | 56.16 | 78 | 62 | 88 |
| 100 | 11.95 | 12.10 | 9.90 | 65.64 | 55.93 | 56.14 | 65 | 54 | 72 |
| CD (0.05) | 1.92 | NS | 2.35 | NS | NS | NS | 20 | 10 | 16 |

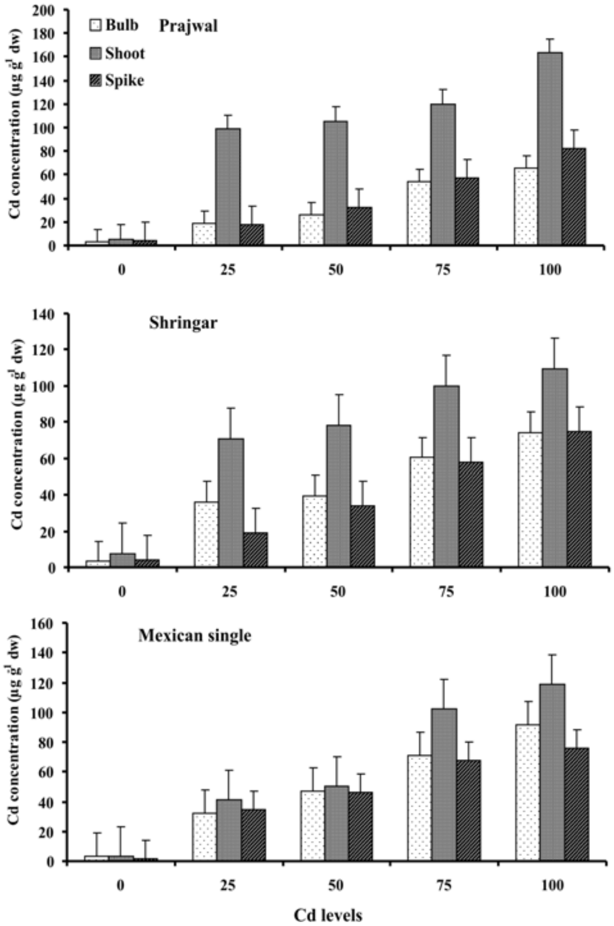


**Fig. 1. Partitioning of Cd in three varieties of tuberose treated with different levels of Cd. Bars represent the mean ±SE of five replicates (P≤0.05).**

Ramana *et al.* 2009). The variety Prajwal recorded the highest Cd content in shoot and was followed by Mexican single and Shringar (Fig. 1). This study clearly showed that all three varieties of tuberose possessed the typical ability of Cd hyper accumulation characterized by (1) accumulation of Cd in shoots of the plant exceeding the critical judging standard i.e., 100 µg $g^{-1}$ DW and (2) by possessing ratio of Cd in the shoots to bulbs >1 (Table 2). This is similar to our previous study in marigold (Ramana *et al*. 2009). Among the three varieties, Prajwal recorded the highest uptake of Cd followed by Mexican single and Shringar (Fig. 2). When the fraction of Cd removed from the total soil Cd was calculated, highest average fraction was observed in Prajwal (1.30%) and more or less similar trend was observed in Shringar (1.22%) and Mexican single (1.23%). These values are higher than reported for mustard (0.4%) which is a hyper accumulator of Cd (Wu *et al.* 2003).

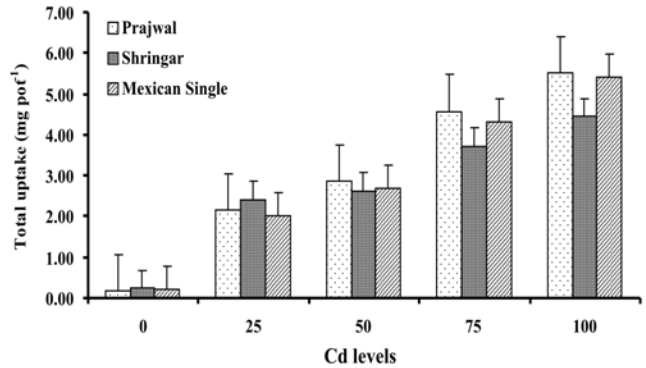


**Fig. 2. Total uptake of Cd by different varieties of tuberose. Bars represent the mean ±SE of five replicates (P≤0.05).**

Thus, it can be concluded that all three varieties of tuberose showed greater tolerance to Cd and exhibited strong ability to accumulate Cd and were more efficient in accumulating Cd and its partitioning from bulb to shoot. Therefore, this plant has got greater potential for remediation of Cd contaminated soils.

**Table 2.** Fraction of total Cd removal (%) and shoot/bulb ratio of Cd in three different varieties of tuberose

| Levels of Cd (mg $kg^{-1}$) | Fraction of total Cd removal (%) | | | Shoot/ bulb ratio of concentration of Cd | | |
|---|---|---|---|---|---|---|
| | Prajwal | Shringar | Mexican single | Prajwal | Shringar | Mexican single |
| 25 | 1.73 | 1.93 | 1.61 | 5.33 | 1.96 | 1.27 |
| 50 | 1.15 | 1.05 | 1.07 | 4.08 | 1.97 | 1.06 |
| 75 | 1.22 | 0.99 | 1.15 | 2.22 | 1.66 | 1.44 |
| 100 | 1.10 | 0.89 | 1.08 | 2.48 | 1.48 | 1.29 |
| CD (0.05) | 0.15 | 0.23 | 0.10 | 0.74 | 0.32 | 0.21 |

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