Cd ACCUMULATION IN ROOTS AND NITROGEN-FIXING ACTIVITY OF ROOT NODULES IN LEGUMINOUS PLANTS

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ABSTRACT

The Cd content in roots and the nitrogen-fixing activity (NFA) of root nodules were determined under soil and soilless culture conditions in species of leguminous plants depending on Cd concentration in the medium. The possibility of NFA stimulation by low Cd concentration was shown.

KEYWORDS: Cd, leguminous plants, accumulation, roots, nodules, nitrogen-fixing

INTRODUCTION

Plant root systems are the first which are subjected to unfavourable impact of heavy metals, particularly those that are accumulated predominantly in roots due to physico-chemical features. For leguminous plants, Cd is characterized by such a distinction. It is a high toxic element having primarily an inhibiting effect on root nodules (Huang et al.,1974; Porter,Sheridan,1981). There is information, however, that NFA can increase with certain Cd concentrations (Chen et al., 2003). The goal of the present work was to study the relationship between the NFA of root nodules and Cd concentration in root systems in some leguminous plants grown on media containing Cd.

METHODS

Plants were grown in soil culture (*Pisum sativum* L., *Medicago sativa* L., *Lotus corniculatus* L.) and under conditions of liquid soilless culture (*Medicago trancatula* Gaertn., *Lotus japonicus*). Cd was applied to substrates in the form of $CdCl_2$. Concentrations of 5,10,15 mg of Cd per kg of dry soil mass were used in soil culture and those of 1,10,100 and 1000 μM of $CdCl_2$ were used in soilless culture. The Cd content in roots and nodules of plants was determined by the method of atom-emission spectrometry and NFA – by acetylene method.

RESULTS AND DISCUSSIONS

The ability to accumulation Cd in roots is sharply pronounced in *Lotus corniculatus* and *Pisum sativum* (Table). With an increase in Cd ingress into roots under conditions of its excess content in soil, a barrier function of roots in these crops for Cd intensifies. The relationship between the Cd content in roots of leguminous plants and its concentration in soil manifests itself species-specifically. Both under conditions of the background Cd content in soil and at additional application, *Medicago sativa* roots (without nodules) accumulated Cd to a lesser degree than roots of other crops. Cd accumulation in nitrogen-fixing nodules was, vice versa, the highest in *Medicago sativa*, and the lowest in *Pisum sativum* (Table 1). It can be assumed that Cd transport paths into nodules are also species-specific.

Table 1. Cd content in roots and NFA of nodules in different species of leguminous plants depending on Cd concentration in soil

Cd in soil, mg · kg^{-1}	Cd, mg · kg^{-1} of dry mass		NFA, μmol C_2H_4· h^{-1}· g^{-1} of frash nodules	
	roots	nodules	min - max	means ± S.E.
Pisum sativum L.				
0.5	0.75 ± 0.13	0.36 ± 0.03	3.2 – 13.3	8.7 ± 3.3
5.0	19.13 ± 1.19	2.80 ± 0,14	4.8 – 18.8	12.7 ± 5.1
10.0	38.65 ± 1.58	5.10 ± 0.85	6.5 – 19.4	12.2 ± 3.6
15.0	46.83 ± 2.18	6.44 ± 0.16	5.7 – 22.5	15.7 ± 5.3
Medicago sativa L.				
0.5	0.15 ± 0.02	0.31 ± 0.02	18.0 – 56.3	33.2 ± 10.2
5.0	2.84 ± 0.14	4.94 ± 0.81	18.2 – 46.8	33.5 ± 13.7
10.0	4.19 ± 0.22	11.56 ± 1.02	17.7 – 49.6	30.7 ± 9.5
15.0	8.01 ± 0.60	12.68 ± 1.38	17.6 – 38.7	29.0 ± 6.8
Lotus corniculatus L.				
0.5	1.06 ± 0.19	0.75 ± 0.13	4.6 – 13.1	7.9 ± 3.2
5.0	13.71 ± 0.68	4.66 ± 0.05	1.0 – 4.1	2.5 ± 1.0
10.0	25.56 ± 2.05	5.58 ± 0.18	1.6 – 5.8	3.2 ± 1.4
15.0	37.99 ± 3.04	9.73 ± 0.29	1.0 – 5.5	2.7 ± 1.4

At the flowering stage, NFA of root nodules in *Medicago sativa* showed a tendency to a decrease with an increase in the Cd concentration in roots from 4.2 to 8 mg · kg^{-1} and in nodules from 11.6 to 12.7 mg · kg^{-1}. In the experiment with the soilless culture, certain stimulation was observed in *Medicago trancatula* at application of 10 μM of $CdCl_2$ and sharp NFA reduction in nodules was noted at 100 μM. Under soil culture conditions, NFA of nodules in *Lotus corniculatus* proved unstable towards the Cd effect and decreased sharply already at its concentration of 13.7 mg · kg^{-1} in roots and 4.7 mg · kg^{-1} in nodules. A lower threshold of sensitivity to Cd was observed in *Lotus japonicus* in soilless culture. So, at 1-10 μM of $CdCl_2$ in the medium, NFA of nodules in *Lotus japonicus* increased by a factor of 1.5 with respect to the control and decreased sharply at the concentration of 100 μM.

Pisum sativum nodules proved the most resistant to a high Cd content in roots. At the Cd concentration of 41.6 mg · kg^{-1} in roots and 6.4 mg · kg^{-1} in nodules, NFA of *Pisum sativum* increased to 15.69±5.29 μmol C_2H_4· h^{-1}· g^{-1} of fresh mass of nodules with the control parameters of 8.74±3.26 μmol C_2H_4. Thus, stimulation of the root nodule NFA, which can supposedly be regarded as an adaptive response of a symbiotic apparatus of roots to the presence of Cd in the medium, is possible for each of the studied leguminous species under a certain Cd concentration in the medium.

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