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^{137}Cs and ^{90}Sr uptake by sunflower cultivated under hydroponic conditions

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Abstract

The ^{90}Sr and ^{137}Cs uptake by the plant *Helianthus annuus* L. was studied during cultivation in a hydroponic medium. The accumulation of radioactivity in plants was measured after 2, 4, 8, 16 and 32 days of cultivation. About 12% of ^{137}Cs and 20% of ^{90}Sr accumulated during the experiments. We did not find any differences between the uptake of radioactive and stable caesium and strontium isotopes. Radioactivity distribution within the plant was determined by autoradiography. ^{137}Cs was present mainly in nodal segments, leaf veins and young leaves. High activity of ^{90}Sr was localized in leaf veins, stem, central root and stomata. The influence of stable elements or analogues on the transfer behaviour was investigated. The percentage of non-active caesium and strontium concentration in plants decreased with the increasing initial concentration of Cs or Sr in the medium. The percentage of ^{90}Sr activity in plants decreased with increasing initial activity of the nuclide in the medium, but the activity of ^{137}Cs in plants increased. The influence of K^+ and NH_4^+ on the uptake of ^{137}Cs and the influence of Ca^{2+} on the uptake of ^{90}Sr was tested. The highest accumulation of ^{137}Cs (24–27% of the initial activity of ^{137}Cs) was found in the presence of 10 mM potassium and 12 mM ammonium ions. Accumulation of about 22% of initial activity of ^{90}Sr was determined in plants grown on the medium with 8 mM calcium ions.
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1. Introduction

Radionuclide contamination is the result of nuclear power testing (Mahara, 1993), nuclear waste disposal (Gauthier-Lafaye, 2002), weapons production (Whicker et al., 1990; Sanzharova and Aleksakhin, 1982) and accidents resulting from nuclear power generation (Clark and Smith, 1988; Konshin, 1992). An accident of this nature occurred at the Chernobyl Nuclear Power Station on April 26, 1986 (Anspaugh et al., 1988). ^{137}Cs and ^{90}Sr are the most widespread radionuclides with estimated fallout of 671 TBq ^{137}Cs in the Czech Republic (EU publication, 1998). The deposition levels of ^{90}Sr in the Czech Republic have not been established. Because of their lower volatility and the forms in which they were released during the accident, nuclides of strontium and plutonium were deposited more rapidly from the atmosphere than those of caesium and their significance was limited to relatively small areas (EU publication, 1998).

The uptake and distribution of ^{137}Cs and ^{90}Sr by *Salix viminalis* were studied by von Fircks et al. (2002). The activity concentration of ^{137}Cs in the plants was significantly affected by the supply of potassium. Seedlings of *Eucalyptus tereticornis* were used by Entry et al. (1995) for the accumulation test. Entry et al. (1993) also tested the accumulation of ^{137}Cs and ^{90}Sr by seedlings of *Pinus ponderosa* and *Pinus radiata*. The potential accumulation of caesium and strontium from the medium was tested on *Panicum virginatum* by Entry and Watrud (1998) and on *Paspalum notatum*, *Sorghum halpense* and *Panicum viginatum* by Entry et al. (1999, 2001). Anguissola Scotti (1996) (*Phaseolus vulgaris* cv. Wotter) and Zehnder et al. (1995) (*Vitis vinifera* v. ‘‘Riesling × Sylvaner’’) studied the uptake of nuclides by crop plants.

Similar experiments on real contaminated soil were mainly carried out on a site near the Chernobyl Nuclear Power Plant. Krouglov et al. (1997) grew *Triticum aestivum*, *Secale cereale*, *Hordeum distichum* and *Avena sativa* there, Korobova (1998) tested nuclide accumulation in naturally growing vegetation and Malek et al. (2002) compared *Brassica oleracea* v. *capitata* and *Brassica olerace* v. *caulorapa* which were planted on two different contaminated sites. Nifontova et al. (1989) reported, on the basis of prospecting of twelve forest and five meadow phytocoenoses from the surroundings of Bjelojarsk nuclear power plant in Russia, accumulation from 530 to 1500 Bq of ^{137}Cs and from 300 to 1100 Bq of ^{90}Sr. Studying between organic matter and mineral phase of soils in ^{137}Cs partition (Vidal et al., 1995; Rigol et al., 1998), modelling to identify regions affected by residues of the Chernobyl accident (van der Perk et al., 1998), laboratory experiments to predict ^{137}Cs root uptake after flooding (Camps et al., 2003) and field studies on the flooded areas real contaminated by ^{137}Cs in the Pripyat catchment (Burrough and van der Perk, 1999) were performed.

It is well known that the uptake of caesium and strontium from soil to plant depends on a range of different factors and that the soil and plant relationships of ^{137}Cs and ^{90}Sr are rather complex. The influence of the potassium supply on the uptake of ^{137}Cs was tested (Robinson and Stone, 1992). Zhu (2001) published data on caesium uptake by *Triticum aestivum* cv. Tonic. The effects of the application of potassium and nitrogen fertilizers on legume and grass species were studied by Belli et al. (1995). The results of this study indicate: the effect of K fertilizer on reducing ^{137}Cs plant absorption; the effect of N fertilizer on favouring grass growth and ^{137}Cs absorption; for all fertilizer combinations, a higher ^{137}Cs storage in the root system of legumes and a lower ^{137}Cs absorption in the plants. Fertilizing the soil with nutrients such as K or Ca that compete with radionuclides for cation exchange sites and thus competing for uptake by the plant root should not increase the uptake of ^{90}Sr or ^{137}Cs (Entry et al., 1996).

In our work, we studied the uptake, translocation and distribution of ^{137}Cs and ^{90}Sr by sunflower. Attention has been focused not only on different time courses of the ^{137}Cs and ^{90}Sr

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