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SYNTHETIC ZEOLITES AND ACCUMULATION OF STRONTIUM AND CAESIUM BY PEA, CABBAGE AND CARROT

E. Nalborczyk,
S. Pietkiewicz,
T. Loboda,
O. Horodecki,
B.Janowska

Poland, Plant Physiology Department, Warsaw Agricultural University, Warsaw
Poland, Department of Agriculture Development and Menagement,
Technical University of Bialystok

Наведено результати застосування гранульованих синтетичних цеолітів та їх вплив на вміст стронцію в урожаї пасльонових культур.

One of the symptoms of environmental degradation is accumulation of heavy metals in the soils. The change in chemical composition of the soil induces essential changes in the chemical composition of plants. In consequence, the accumulation of heavy metals is transfer from soil to :

plants-animal-man. The augmented accumulation of Cs and Sr by plants means the problem of contamination of animal and human food. Such process can be prevented by the immobilization of heavy metals during plants' growth by added zeolites minerals. The application of synthetic zeolites gives the chance of elimination of Cs and Sr pollution directly from the soil (indirectly from plants) because these ions are easily adsorbed by zeolites.

The aim of the experiment was to examine the accumulation of strontium and caesium in different plants and their organs and to estimate the possibility of applying synthetic zeoiltes as those ions' absorbents in polluted soils. An attempt to use granulated zeolites for the clearing soils of the strontium and caesium ions as well reducing their absorption by the plants has been undertaken.

Materials and methods

The pot experiment was carried out in 2000 in greenhouse of Warsaw Agricultural University with the soil artificially contaminated with stable strontium and caesium. Soil samples were taken from the upper layer (0-20 cm) of the field in Chylice. The experiment was conducted with the Wagner pots fulfilled with 9 kg of soil combined with sand in 7:2 v/v.

The mixture of natural soil with sand was supplemented with strontium and caesium ions in the following amount and form: Sr 79 mg kg soil as $SrCl_2$ x $6H_20$ and Cs 79 mg kg soil as $CsNO_3$. Three experimental treatment were established: 1. Soil with strontium and caesium as a control, 2. Soil with strontium, caesium and zeolites and 3. Soil neither contaminated nor with zeolites. There were 5 replicates of the treatment. There were used 3 zeolites (Z2 sodium – calcium 180 g) per an appropriate pot. The analyzed plant species were: white cabbage, carrot and pea as common cultivars. All experimental treatments were applied for each studied plant species. The seeds were sown on 26.04.99, carrot and pea directly into the pots, while the cabbage firstly into the boxes, and then transplanted to the pots. Presowing fertilization rates were: cabbage - 0.7 g N as NH_4NO_3, 0,25 g P_2O_5 as NaH_2PO_4 x H_20, 0.9 g K_20 as K_2SO_4, 0.09 g CaO as $CaCl_2$ and 0.06 g MgO as $MgSO_4$ x 7 H_20, while for carrot and pea they were: 0.5 g, 0.2 g 0.65 g 0.4 g 0.08 g and 0.2 g, 0.15 g, 0.5 g, 0.3 g and 0.06, respectively. Also full micronutrient solution for each plant species was added. During the vegetation the plants were watered with distilled water up to 70 % of water capillary capacity. At the harvest the plants were divided into individual organs, washed both in tap and redistilled water. Then dried at 60°C, weighed and thereafter grounded. Plant material was burned on dry at 450°C and kept on to finish burning under concentrated HNO_3 with addition of perchloric acid and then dissolved in 20% HCl. Soil samples for each treatment were taken using Egner equipement, dried at 20°C, then they were sieved using mesh 1 mm, grounded and burned at 450-500°C. So prepared samples underwent mineralization in 20 % HCl by boiling them for 30 min. The obtained extracts were hotty filtered. The mineralizates were analyzed for individual elements' content using Atomic Adsorption Spectrometry for caesium and Atomic Emission Spectrometry methods for strontium content determination. Photosynthetic rate was measured using Li-Cor 6200 gas analyzer. Original ANOVA program (J. Górczyński) was used for testing statistical hypothesis.

Results and discussion

Content of both studied metals was much lower in studied parts of pea, cabbage and carrot when zeolites were used than when plants were grown with these metals but without zeolites (Fig. 1). Sometimes these differences were very big eg. content of strontium in cabbage shoot was about seven times lower when zeolites were added. Usually strontium was much higher absorbed by zeolites than caesium.

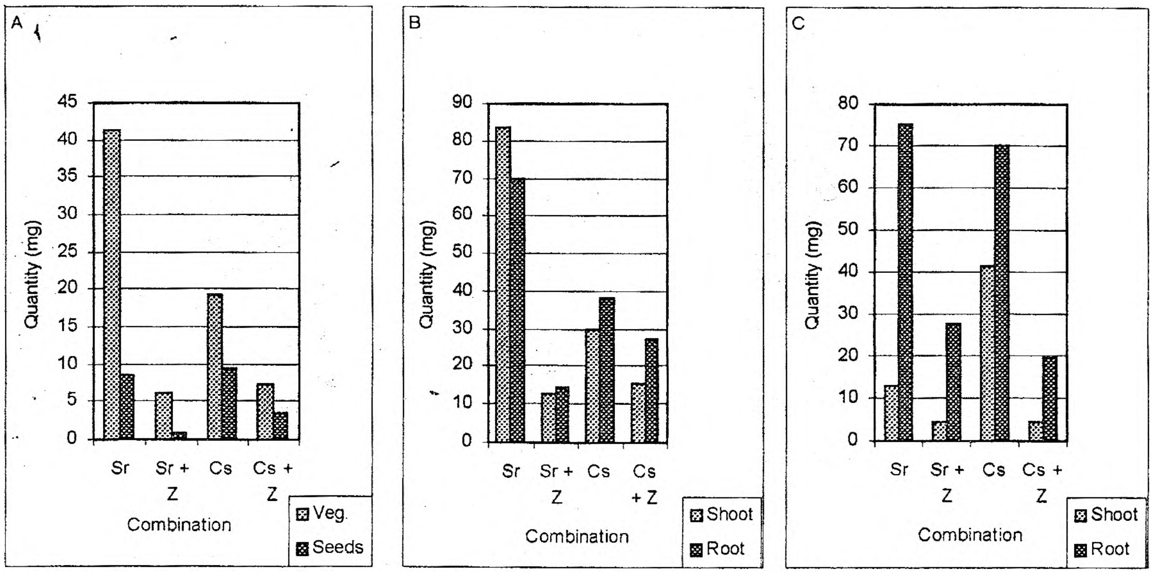

Fig. 1. Content of Sr and Cs in vegetative part and seeds of pea (A), in shoot and root of cabbage (B) and in shoot and root of carrot (C) in mg in presence and absence of zeolite.

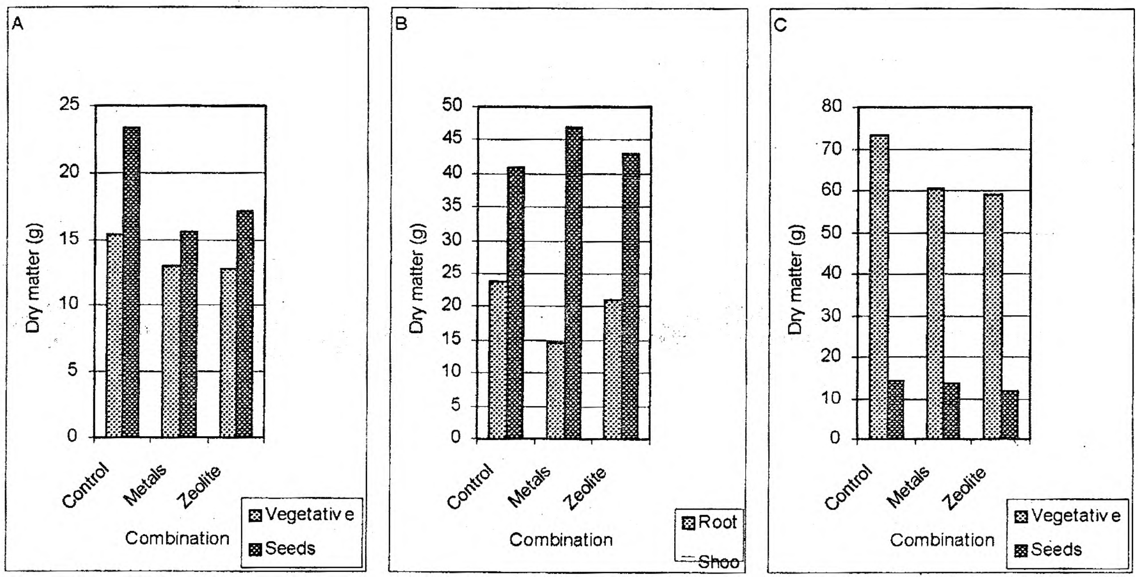

Fig. 2. Average dry matter of vegetative part and seeds of pea (A), root and shoot of cabbage (B) and root and shoot of carrot (C) in control, in presence of metals and in presence of zeolite.

Usually dry matter of studied plants was the highest in the control ie. without contamination with Sr and Cs (Fig. 2). When metals and/or zeolites were used dry matter was lower with exception of dry matter of cabbage shoot which was higher than that of control plants. One explanation could be that zeolites remove from the soil also other nutrients.

Photosynthetic rate of pea was the highest in control which was without zeolites and without metals (Fig. 3). Presence of Sr and Cs caused twice lower photosynthesis and presence of metals and zeolites lowered photosynthetic rate about 20%. The same was found for other studied species. Lower photosynthetic rate in combinations with metals and zeolites can influence lower dry matter production of plants grown with metals and with metals and zeolites.

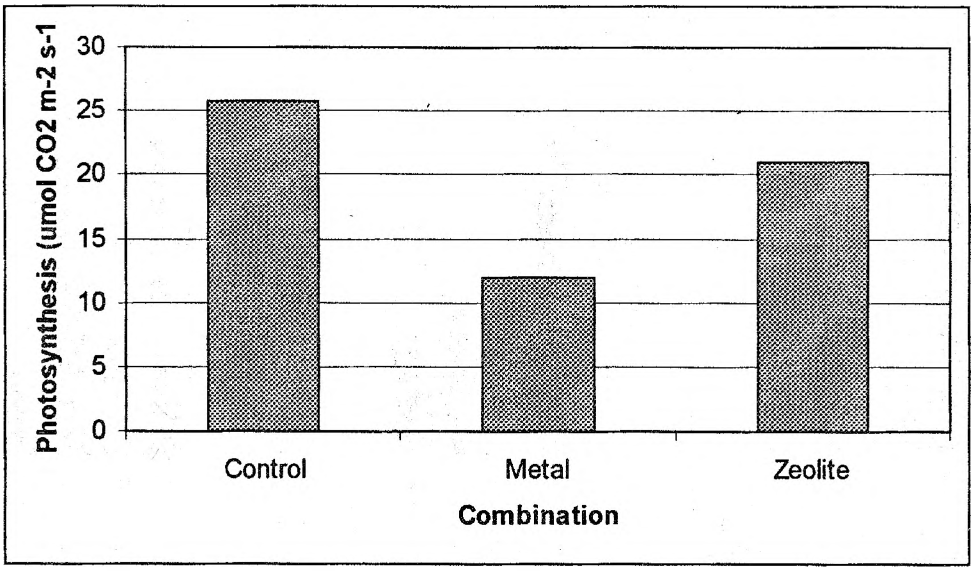

Fig. 3. Photosynthetic rate of pea in control, in presence of metals and in presence of zeolite.

More than a half of strontium and about one forth of caesium were accumulated in zeolites. There were small amount of these metals in plant and the rest was in the soil (Figs. 4-6).

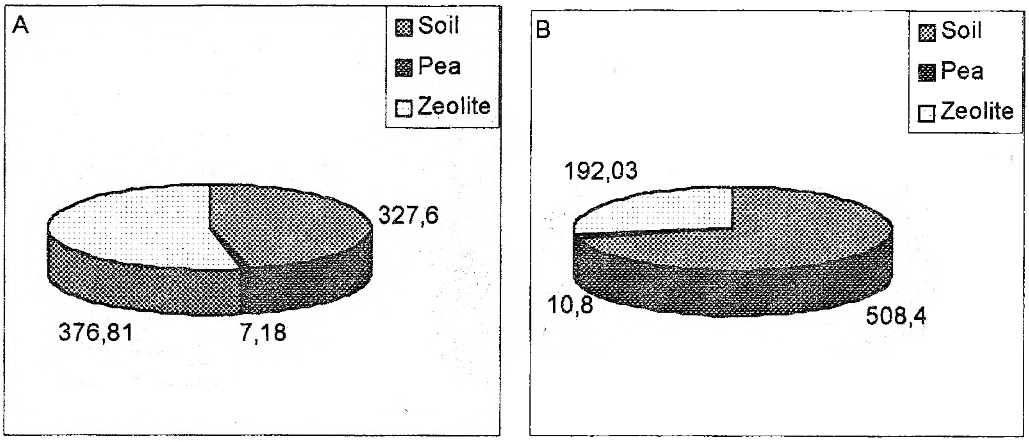

Fig. 4. Balance of strontium (A) and caesium (B) in soil, pea and zeolite in mg.

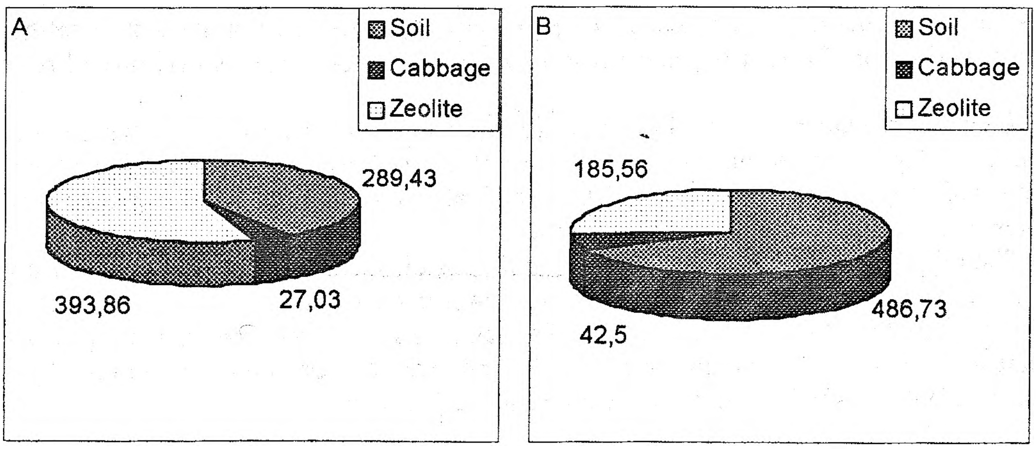

Fig. 5. Balance of strontium (A) and caesium (B) in soil, cabbage and zeolite in mg.

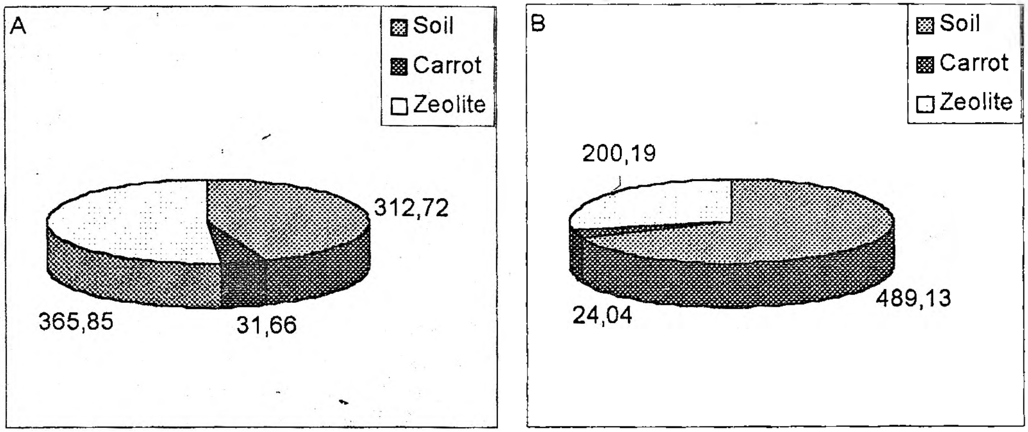

Fig. 6. Balance of strontium (A) and caesium (B) in soil, carrot and zeolite in mg.

Conclusions

An introduction of synthetic zeolites to the soils contaminated with strontium and caesium brought about significant reduction in uptake and accumulation of these elements for all investigated crops.

Synthetic zeolites added to the soil lowered its strontium and caesium ions contents, depending on the crop and kind of ions.

The very high absorption of strontium and caesium by the points to the possibilities of cultivation the crop all over the areas contaminated with the radionuclides of these elements thus leading to significant soil decontamination.

The introduction of synthetic zeolites into soil artificially polluted with Cs and Sr ions results in much lower accumulation of those ions in examined plant species in comparison with polluted control without zeolites.

The presence of zeolites in soil has not clearly influenced the percentage of distribution of the accumulated CS and Sr between plants' organs in the experiment

The level and the pattern of plants' organs contamination by Cs and Sr metals from polluted soils was different in examined crops. The significant concentration of those atoms (or their radioisotopes) in plants' organs used as animal or human foods, creates the higher health risk.