Mass transport of micro- and macro-molecule compounds of phosphorous base fertilizer fortified with protein in soil matrix

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Abstract - Microgranule phosphorous soil fertilizer based on a post-production waste was developed. Diffusion of micromolecule components of the granule in soil matrixes was measured. Degradation and diffusion of protein components in soilmatrix was determined.

Keywords - Phosphorous fertilizers, fertilizers fortified with protein, protein diffusion in soil, mass transport, protein degradation in soil,

Introduction

In recent years there has been a significant increase in the prices of phosphorous fertilizers, which made it necessary to seek alternative, more cost-effective solutions in the field of plant fertilization. Much cheaper fertilizers containing partially decomposed phosphorite, have become an alternative to the existing phosphorus sources, such as superphosphate [1-2].

Raw material for the production of such fertilizers can also be obtained from animal bones containing natural hydroxyapatite. Therefore, we developed a mineral phosphate fertilizer based on ash obtained by incinerating the meat industry wastes. The fertilizer in the form of a microgranule was supplemented with additives sourced from natural raw materials, i.e., protein preparations based on post-production waste (milk serum, soy paste, eggs).

In this project we measured the mass transport of the microgranule components in two different model solid matrixes composed of sand and standardized soil. The mechanism of protein decomposition during the fertilization process was proposed.

Methods

Microgranules were prepared using a laboratory pan granulator. The granule was composed of incinerated and grounded bones, lake chalk and protein isolates from milk serum, soy and chicken egg proteins. A microgranule (0.5 g mass) was placed on the bottom of a 15-ML cylinder with piston and a matric scale on the side-wall. Seven identical cylinders were used for the experiments. The cylinders were filled with wet sand or wet standardized soil (both with a predefined moisture content) with the height of 4.5 cm. The samples of the solid matrixes (sand and soil) were withdrawn at different time intervals; 5 mL slices of matrixes were acquired at different distances from the microgranule (from the bottom of the cylinder). Next, the samples were mixed with 5 mL of 0.1 M NaCl solution and vortex-homogenized. The supernatants obtained were subjected to HPLC, HPLC-SEC and Lowry method analyses, to determine the mass transport of ions and proteins through the matrix.

Results and discussion

Typical results of the concentration analysis of a protein from milk serum isolate and micromolecule components of microgranules in the matrix samples that were acquired at different distances from microgranule and different time intervals are presented in Fig.1 and Table 1. It can be observed that the maximum of the protein concentration is reached after 48 h at the distance of 1.5 cm from the microgranule. The concentration of the protein drops rapidly with increasing the distance, and practically vanishes at 4.5 cm away from the microgranule. Moreover, the concentration of the protein decreases in time, which is caused by its degradation. The latter is confirmed by increasing ammonia ion concentration with increase in time (Table 1). The concentration of other ions reaches quickly its maximum due to fast diffusivity of small ions in the solid matrix. The results obtained for other protein isolates were similar to those reported above.

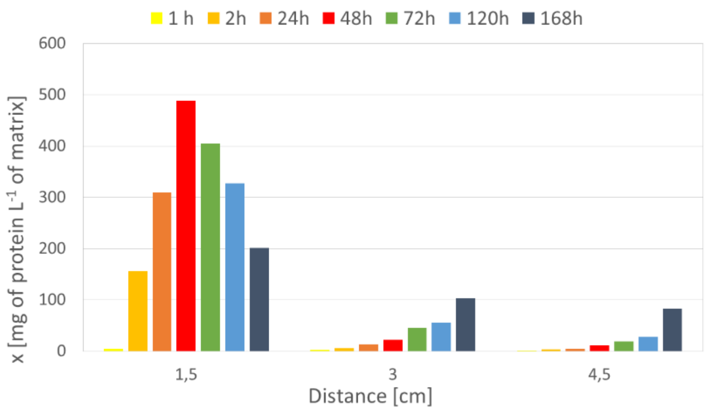

Fig.1. Protein concentration at different distances from microgranule containing milk serum isolate.

Table 1 Concentration of ions at the distance of 1.5 cm away from the microgranule measured at different time intervals.

Time	ammonium	potassium	magnesium	calcium	nitrate	phosphate	sulphate
[h]	μg of ion mL^{-1} of matrix						
6	0.376	52.05	6.27	29.96	1.67	1.19	374
24	0.360	66.02	9.62	16.35	1.22	8.61	303
48	1.96	59.97	7.84	22.83	0.68	3.36	278
72	3.59	57.10	8.96	20.58	0.79	3.18	296
120	33.5	58.56	8.09	27.93	0.62	2.67	321
168	34.1	55.27	11.33	36.16	1.58	3.02	449

Conclusion

The macromolecule components of the microgranule fertilizer diffuse through the solid matrix very slowly. The transport of the proteins is accompanied with their degradation, which induces formation of ammonium ions. The maximum of the protein concentration and ammonia ions is reached at very close distance from the microgranule, therefore, the fertilizer granule should be placed in vicinity to the plant grain.

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