Description of project results

The aim of the research was to develop a method for producing hydrogel micronutrient fertilizers based on sodium alginate. Currently, society is facing the problem of "hidden hunger" associated with micronutrient deficiency, hence the main interest was focused on developing a structure enriched with micronutrients such as copper, zinc and manganese. It was hypothesized that a properly selected polymer matrix would be a suitable carrier of micronutrients and allow precise delivery of nutrients and plant growth stimulants. Fully biodegradable materials were used to prepare the matrices, making them environmentally friendly. Such formulations are a novel solution that can be proposed to the fertilizer industry and applied in agriculture. The research carried out under the project is interdisciplinary, combining research in materials engineering, chemical engineering, biotechnology, and agriculture.

In order to achieve the mentioned goals, a series of experiments have been carried out to (1) develop a method for producing complex micronutrient-carrying biocomposites, (2) test their physicochemical properties, (3) verify whether an additional hydrogel coating will slow the release of components, (4) check the rate of biodegradation of the material, and (5) verify the effect of hydrogel fertilizers in plant tests.

During the realization of the grant, biocomposites based on natural polymers (sodium alginate, carboxymethylcellulose, starch) and biosorbents (eggshells, peat and other biological materials) that can serve as carriers of fertilizer micronutrients (Cu, Zn, Mn) were studied. It has been proven that the presence of a biosorbent in the matrix has a beneficial effect on the sorption properties of such a system (binding and release of micronutrients). It has also been shown that the presence of an additional polymer in the matrix strengthens the structure of the hydrogel, increases the degree of swelling improves long-term stability and sorption properties. The results showed that CMC gives the hydrogels the desired property like high water absorption (about 96-140% more than for hydrogels with alginate alone), and starch increases their mechanical strength (Young's modulus higher by 3-13% than for alginate hydrogels). The germination tests showed that the slowed release of nutrients from the hydrogel matrix resulted in more than 70% higher sprout weight than in the reference group (where micronutrients were applied in salt solution form). In addition, it was observed that the presence of the polymer matrix itself had a stimulating effect on the root zone of the plants. It was noted that the group with hydrogel application without enrichment obtained more than 20% longer roots compared to the control group irrigated with water only.

Coated hydrogel fertilizers were prepared by applying a layer of another polymer (chitosan, alginate) to the biocomposites, resulting in a slower release of the nutrients into the environment. An attempt to prepare multilayer fertilizer compositions containing macronutrients (N, P, K) and micronutrients (Cu, Mn and Zn) yielded favorable results. The biocomposites were characterized by the limited release of most fertilizer ions (<10% within 100 h) and plant tests (germination and pot trials) demonstrated that the application of multicomponent hydrogel fertilizers increased cucumber root length by 20%, compared to the group fertilized with a commercial product.

An additional project outcome was the design of polymer matrices for the encapsulation of amino acid hydrolysates with plant growth-promoting effects. For this purpose, hydrolysates from high-protein material (mealworm larvae) were used. The hydrolysate matrices were additionally coated with a chitosan layer. These formulations also showed a beneficial effect on plant growth, allowing the biostimulant to be delivered at a slower rate.