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# Ecological aspects in use of new polimeric fertilizers as a tool of environmental safety management

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**Abstract.** Pollution of a significant territory of the Baltic Sea is largely determined by the levels of man-made emissions of significant quantities of mineral fertilizers, which are used in intensive agriculture practices in the Baltic region.

We developed and propose a new method of application of fertilizers from the "Zelenit" family, which allows for effective plant metabolic processes in an up-to-date manner. This method involves liquid mineral polymeric fertilizers, which lack the drawbacks of their predecessors and are fundamentally different from traditional varieties used for spray feeding due to containment of feeding elements in the polymeric matrix of fertilizers.

The use of the above-mentioned fertilizers allows us to solve the environmental problem of water polution by elements of plant feeding, particularly by decreasing waste in the Baltic Sea. It can also raise profitability of agricultural production due to decreased input of main fertilizers into the soil and help to create rational systems for mineral feeding, significantly decrease the influence of meteofactors, and raise the quality and quantity of a crop.

**Key words:** pollution of Baltic Sea, environmental problem, polymer fertilizers of «Zelenit» family

## INTRODUCTION

Pollution of a significant territory of the Baltic Sea is largely determined by the levels of man-made emissions of significant quantities of mineral fertilizers which are used in intensive agriculture practices in the Baltic region.

Improvement of agricultural practices aimed at decreasing the amount of fertilizers applied and maintaining or even increasing crop yield at the same time is an immediate problem. These new agricultural practices include effective and economical methods of farming, which comprise differential positioning of the needed stages of plant cultivation during the vegetation period. Such systems allow application of the necessary amounts of fertilizers at estimated areas of the crop field, taking into account nutrient levels there.

It is well-known that mineral fertilizers which are applied to the soil are only partly used by plants for creating productive biomass; the rest is permanently lost and adversely affects the environment. For example, losses of nitrogen from fertilizers under field conditions are estimated to be around 50–60%. Significant quantities of nitrogen are incorporated into humic substances that are stable to hydrolysis, certain amounts are lost as a gas phase, and the rest is washed away. In non-chernozemic areas 10–15 kg of nitrogen is washed away from 1 hectare, 20–25 kg is lost from sabulous soils. Loss of phosphorus is related more to soil erosion, however, losses from run off processes are also great. Up to 10 kg of phosphorus are removed from soil due to run-off which is transported to rivers and lakes. Losses of potassium which result from improper agricultural practices are also significant and comprise up to 10 kg per hectare of arable land. Typically, the means of transporting feeding elements changes according to the season (Burwell et al., 1975).

## MATERIALS AND METHODS

As an attempt to solve the above-mentioned problems a new kind of mineral polymeric fertilizer was developed and put into practice. The subject of the current research is the polymeric fertilizer «Zelenit», from a "family" of fertilizers. We have researched two types: Zelenit-1 and Zelenit-2. These fertilizers have significant quantities of nitrogen (up to 25%), phosphorus (up to 25%), and potassium (up to 15%) in the form of organo-mineral complexes fixed in a polymer matrix rather than present in a water solution alone. Organic polymers, which are the key feature of these fertilizers, have surfactant and adhesive properties towards leaf, stem and sprout surfaces and are capable of holding nutrients and then releasing them onto a vegetating plant (Komarov & Petropavlovskii, 2009).

A polymeric fertilizer is a water solution of polymer complexes of carbamide and microelements that are easily available to plants without intermediate conversion of nitrogen to ammonium.

«Zelenit-1» is used for spray feeding of vegetating plants during the entire plant life cycle or as necessary. It normalizes nitrogen feeding and allows significant reduction (by 1.5–2 times) of nitrogen fertilizer application during root feeding. Nitrogen content – 19–22%, dry matter – no less than 50%, pH = 6.0–8.0, microelements – iron, copper, molybdenum, zinc, boron, manganese, cobalt. As a nitric mineral fertilizer we used the carbamide (urea) $CO(NH_2)$ and the same carbamide was used in «Zelenit-1», however it was included in the structure of a polymeric matrix.

«Zelenit-2» is a liquid potassium-phosphorus fertilizer based on potassium phosphates; it is a water solution of polymer complexes of potassium phosphates and microelements, making potassium and phosphates easily available to plants. «Zelenit-2» is used for spray feeding of vegetating plants throughout the plant's life cycle. «Zelenit-2» normalizes potassium and phosphorus feeding and allows significant reduction (by 1.5–2 times) of potassium and phosphorus fertilizer application during root feeding. Content of $P_2O_5$ – 12–16%, $K_2O$ – 17–20%, dry matter – no less than 40%, pH = 6.5–8.0, microelements – iron, copper, molybdenum, zinc, boron, manganese, cobalt.

To prove these assumptions we conducted experiments to determine the remaining amounts of nutrients on the leaf surface after spray feeding and subsequent rain treatments. Experiments were conducted with 30-day-old wheat of hard variety. The area of the experimental plot was 1 $m^2$. Wheat sprouts were treated in a traditional way by spray feeding with the solutions of carbamide (5%), pyrophosphate (1%), «Zelenit-1» (5%), «Zelenit-2» (1%).

The field experiments were conducted on potato and wheat in 2008–09. The experiments were repeated 3 times; the area of researched land was more than 100 $м^2$.

The aim of the first experiments was to identify the influence of not root feeding on the productivity of the potato if the amount of basic fertilizers is decreased two times. Experiments were done on well fed land on two regimes of mineral feeding: low ($N_{40}P_0K_0$) and average ($N_{60}P_{30}K_{40}$). Control areas were not processed with not root fertilizers.

«Zelenit-1» and «Zelenit-2» were tested in the fields on spring wheat (grade Leningrad-89, elite) in production crops of the Northwest region (Leningrad region) under the following scheme:

1. $N_{48}P_{60}K_{60}$ (full dose NPK - the control)
2. $N_{24}P_{30}K_{30}$ (1/2 of full dose NPK) + 5 l $ha^{-1}$ of «Zelenit-1»
3. $N_{48}P_{60}K_{60}$ (full dose NPK) + 5 l $ha^{-1}$ of «Zelenit-1»
4. $N_{24}P_{30}K_{30}$ (1/2 of full dose NPK) + 5 l $ha^{-1}$ of «Zelenit-2»
5. $N_{48}P_{60}K_{60}$ (full dose NPK) + 5 l $ha^{-1}$ of «Zelenit-2»

Mineral fertilizers were combined for use on spring wheat crops. Tests of fertilizer «Zelenit-1» and «Zelenit-2» twice-processed were done by application of not root feeding twice: in the phase of plant forming and in an exit phase on a stalk.

Experiments were done by definition of the residual quantity of nutrients on sheet plates of plants after not root top feeding and the subsequent influence of rain moisture. We took wheat of a firm grade at the age of 30 days on an area of 1$м^2$ each site. Wheat sprouts were processed according to the usual technology by means of drop irrigation by carbamide solutions (5%), pirophosphate (1%), «Zelenit-1» (5%) and «Zelenit-2» (1%). After two (2) hours, which is needed for total removal of moisture from the leaf surface, we began drop irrigation with 10 mm of water. After this operation, the residual quantity of nitrogen, potassium and phosphorus was identified. For a quantitative definition of feeding elements, the green mass of wheat sprouts was cut off and ashed, then the nitrogen level was identified according to the Kjeldahl method using the potassium-spectrofotometric method in a solution of tetrafenilborate mixed with ethane nitrile with a wave length of $\lambda$ 266 or 274 mmc. Identification of phosphates was made by using calorimetry with the help of phosphoric-vanado-molibdate complex with a wave length of $\lambda$ 315 mmc. The results are represented in Table 1.

## RESULTS AND DISCUSSION

After fixation of the solutions for two hours by full drying, water was sprayed on both experimental and control plants in equal volumes. After that the remaining amounts of fertilizers were estimated (Table 1).

As Table 1 illustrates, water spraying removed nutrients when traditional fertilizers were used for spray feeding. As soon as the first treatment was complete, almost all of the carbamide and pyrophosphate had run off. After the second treatment it was not possible to determine any measurable quantities of nutrients. The liquid polymer fertilizers behaved quite differently: despite the second treatment by significant water spraying, most fertilizers remained on the plants and would be assimilated under natural conditions.

**Table 1.** The effect of treatments of vegetating plants by polymer fertilizers followed by water spraying.

| Composition of the treatment solutions | The remaining amounts of nutrients, % from initial amounts | | | | | |
|---|---|---|---|---|---|---|
| | First treatment | | | Second treatment | | |
| | N | K | P | N | K | P |
| Potassium pyrophosphate | – | 7.8 | – | – | – | – |
| Carbamide | 16.3 | – | – | 3.7 | – | – |
| «Zelenit-1» | 89.9 | – | – | 71.4 | – | – |
| «Zelenit-2» | – | 61.0 | 59.4 | – | 41.2 | 51.2 |
| «Zelenit-1» + «Zelenit-2» | 74.2 | 39.1 | 74.8 | 76.3 | 49.1 | 76.4 |

It can be proposed that the use of liquid polymer fertilizers for spray feeding will solve several problems facing farmers. Application of these fertilizers will help create rational systems of plant nutrition, increase resistance of plants to adverse weather conditions, significantly reduce the amount of fertilizers used, improve quality of crops and crop yields, and, certainly, greatly increase profitability of agriculture. At the same time, it will solve at least some environmental problems.

In field experiments with a potato variety (Table 2) it was well demonstrated that in the case of «Zelenit-1» use, the coefficient of biological productivity on a minimal mineral background has increased 10 times, compared to control. «Zelenit-1» helps to decrease the lack of nitrogen, doesn't increase the biomass accumulation and increases the productivity of tubers. On an average background the factor of biological efficiency has almost not changed.

In Table 2 it is possible to see the theoretical dependence between the change of parities of weight of the above ground parts of the vegetable and tubers during vegetation.The relative change of crude weight of a vegetable top and a tuber can be characterised in the resulting factor of biomass distribution – coefficient $K_b$:

$$K_b = \frac{|\Delta M|}{M*}100, \tag{1}$$

where – $\Delta M$ is a difference between the biomass of tubers and tops in absolute value, $M$* – total biomass (tubers + tops)

Field researches have shown that application of fertilizers «Zelenit-1» and «Zelenit-2» has given an authentic increase of a crop in variant $N_{24}P_{30}K_{30}$ (1/2 from full dose NPK) + 5 l ha$^{-1}$ of «Zelenit-1» in comparison with a control variant of 12%. The effect of the use of fertilizer «Zelenit-1» against a full dose of mineral fertilizers use provided an increase of 20%. Using «Zelenit-2» against $N_{24}P_{30}K_{30}$ (1/2 from full dose NPK) + 5 l ha$^{-1}$ of «Zelenit-2» the increase was 0.4 %, and at $N_{48}P_{60}K_{60}$ (full dose NPK) + 5 l ha$^{-1}$ of «Zelenit-2» - it amounted to 7 % (Table 3).

**Table 2.** Value of factor of biological efficiency $K_b$ after potato processing by liquid nitric polymeric fertilizers.

| | *Low background* | | *Average background* | |
|---|---|---|---|---|
| | Control | Zelenit-1 | Control | Zelenit-1 |
| $\boldsymbol{K_b}$ | 0.03 | 0.21 | 0.07 | 0.07 |

Thus the use of polymeric fertilizers of the «Zelenit» family allows reaching the same yield with a decrease of normal mineral fertilizer doses by 1.5–2 times.

**Table 3.** Influence of fertilizer «Zelenit-1» and «Zelenit-2» at various NPK on productivity of spring wheat.

| Variant | Productivityin case of 14% humidity | Decrease, comparing with control | |
|---|---|---|---|
| | t ha$^{-1}$ | t ha$^{-1}$ | % |
| 1. $N_{48}P_{60}K_{60}$ (full dose NPK - control) | 4.08 | 0 | 0 |
| 2. $N_{24}P_{30}K_{30}$ (1/2 of full dose NPK) + 5 l ha$^{-1}$ «Zelenit-1» | 4.57 | 0.49 | 12 |
| 3. $N_{48}P_{60}K_{60}$ (full dose NPK) + 5 l ha$^{-1}$ « Zelenit-1» | 4.85 | 0.72 | 20 |
| 4. $N_{24}P_{30}K_{30}$ (1/2 of full dose NPK) + 5 l ha$^{-1}$ « Zelenit-2» | 4.10 | 0.02 | 0.4 |
| 5. $N_{48}P_{60}K_{60}$ (full dose NPK) + 5 l ha$^{-1}$ « Zelenit-2» | 4.40 | 0.30 | 7 |
| $LSD_{05}$ | 0.32 | | |

## CONCLUSIONS

Use of the above mentioned fertilizers allows solving the environmental problem of water polution by elements of plant feeding and particularly by decreasing fertilizer run-off in the Baltic Sea. In addition, it raises profitability of agricultural production and helps to create rational systems of mineral feeding, significantly decreasing the influence of meteofactors, to greatly reduce the quantity of used mineral fertilizers, and increase both quality and quantity of a crop.

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