THE IMPACT OF BACTERIAL FERTILIZER AND HUMATE ON PLANTS ACCUMULATION OF ESSENTIAL MICROELEMENTS

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SUMMARY

Three kinds of vegetable crops have been studied, including Japanese cabbage, leek and garlic, grown on turf-podzol soils in Moscow Region. The influence of bacterial fertilizer Biostar containing produced in Belgium Bacillus sp., and sodium humate (Krasnoyarsk production) on plants accumulation of selenium, zinc and copper, was investigated. It was revealed that both fertilizers increased accumulated essential microelements in the quantities depending on the vegetable kind. The level of selenium accumulation was the lowest, and practically no distinctions were observed at humate and Biostar application. Changes of accumulation levels of zinc and copper were more considerable. Zinc and copper accumulation levels were considerably higher when applying Biostar compared to humate, especially for Japanese cabbage and garlic.

Key words: humate, Bacillus sp., cabbage, leek, garlic, selenium, zink, copper

INTRODUCTION

Improvement of plants nutritional value is considered to be extremely important in modern agriculture, one of the examples being the production of organic food. Attempts are made to decrease mineral fertilizers utilization via introduction of growth stimulators, natural complexons (humates, ceolites) [1], phytohormones [2] and soil microorganisms [3-5].

Vegetables are known to be the main source of vitamins and trace elements for human beings. Efficiency of plants nutrition directly affects the content of these components in integrated products. That is why increase in soil fertility, conditions of elevated bioavailability of trace elements to plants is extremely important.

Humic substances are most abundant natural complexons. Thanks to peculiarities of chemical composition these compounds improve soil structure, increase seeds germination, activate the development of microorganisms [6], improve soil fertility [7]. Humic acids are supposed to affect photosynthesis and respiration and demonstrate hormone-like activity [1].

Humus colonization by soil microorganisms both due to humic substances and microorganisms supplementation to soils lead to a formation of biologically available to plants forms of Ca, P, Fe and other essential elements decrease water evaporation, that is especially important for soils with low content of clay and high level of sandy components, unable to retain water.

Nevertheless, effect of gumic acids on plants growth is contradictory on virtue of their heterogeneity [8] while microorganisms utilization needs strict evaluation of the positive effect.

The aim of the present work was to evaluate the effect of sodium humate and bacterial fertilizer Biostar (product of Belgium, based on Bacillus sp.) on accumulation levels of selenium, copper and zink by Japanese cabbage *Brassica japonica L.*, leek *Allium porrum L.* and garlic *Allium sativum L.* with organic fertilizers as a background.

MATERIALS AND METHODS

Study of humate and bacterial fertilizer effect on soil-plant system was achieved on*: Brassica japonica L.*, varieties *Mizuna, Rusalochka* and *Mibuna*, leek *Allium porum L.*, Karantansky variety and garlic *Allium sativum L*., Petrovsky variety. Plants were grown on sod-podzol soil with supplementation of horse manure 0,5 kg/m^2. For each of the above plants the following scheme of the experiment was used: 1) control, 2) sodium humate 0,005%, (0,1 l / m^2, supplementation twice during the season), 3) Biostar (single supplementation of 1 kg/m^2).

Biostar is known to be a complex of selective microorganisms *Bacillus sp.*, 1% (5 x 10^6 KOE /g) immobilized on the surface of fine crushed straw (75%). The fertilizer contains 24% of N, 3,92% P_2O_5, and 4,61% K_2O. Element composition of humate is presented in Table 1.

Cabbage *Brassica japonica* was harvested in the middle of July, leek *Allium porum* and garlic *Allium sativum* – at the end of August. Concentration of elements were determined in fresh garlic bulbs, while other species were dried at room temperature before the analysis. Homogenized samples were used. Selenium was determined by fluorimetric method [9], zinc, copper and other elements – by atomic-absorption spectrometry.

Statistical analysis was achieved using Student criteria.

Table 1. Element composition of sodium humate preparation (Krasnoyarsk production)

Element	Content, mg /g	Element	Content, mg /g	Element	Content, mg /g
Al	3,52	B	0,02	Ti	0
Ca	11,11	Zn	0,05	Zr	0

K	0,049	Cu	0,02	Hg	0,00003
Mg	1,60	Ba	0,126	As	0,0005
Na	15,53	Fe	7,45	Cd	0
Sr	0,17	Co	0	Pb	0
Ba	0,126	Mo	0	Ni	0
Si	0,52	V	0		

RESULTS AND DISCUSSION

Agrochemical characteristic of soils shown in Table 2 demonstrate extremely high concentration of mobile phosphorous that is connected with utilization of organic fertilizer. Concentrations of Ca, Mg and Se were in the range of background values.

Table 2. Agrochemical characteristics of soil

Parametre	Found	Background value
pH	6,5 ± 0,1	4,5 - 6,5
$P_2 O_5$, mg /kg	918 ± 41	400-500
K_2O, mg / kg	449 ± 21	400-600
NO_3, mg / kg	6,3 ± 3,3	absent
Ca, mg-equivalent /100g	7,8 ± 1,6	5 - 10
Mg, mg-equivalent /100g	2,0 ± 0,4	2 - 3
Cu, mg / kg	29,1 ± 11,3	27
Zn, mg / kg	62,4 ± 22,7	50
Se, µg / kg	224 ± 32	210 - 270

Comparative effect of fertilizers on the harvest of *Brassica japonica*, *Allium porum* and *Allium sativum* reveals their high efficiency and species based peculiarities. Thus, humate and Biostar utilization resulted in the same increase of garlic harvest, where as a significant difference in harvest increase was demonstrated for *Brassica japonica* and *Allium porum* ($P < 0,001$**)** (Table 3). Biostar fertilizer resulted in 2,5 and 3,1 increase of *Brassica japonica* and *Allium porum* harvest respectively.

Table 3. Elements content in plants and their mass

Parametre	Fertilizer	*Brassica japonica Mizuna*	*Allium porum*	*Allium sativum*
Mass, g /one plant	-	208 ± 43	31 ± 8	23 ± 5
	Humate	367 ± 30	71 ± 7	40 ± 2
	Biostar	520 ± 48	95 ± 8	39 ± 2
Se**,** µg / kg of dry weight	-	168 ± 15	135 ± 10	173 ± 15
	Humate	179 ± 15	171 ± 14	237 ± 19
	Biostar	185 ± 16	181 ± 15	206 ± 18
Zn, mg/kg of dry weight	-	65 ± 5	182 ± 11	33 ± 4
	Humate	74 ± 6	183 ± 12	37 ± 4
	Biostar	160 ± 9	226 ± 17	61 ± 5
	-	19 ± 4	242 ± 17	11 ± 1

Cu, mg/kg of dry weight	Humate	25 ± 3	258 ± 18	19 ± 1
	Biostar	162 ± 8	436 ± 17	69 ± 3
1000 Se : Zn : Cu	-	9 : 3 : 1	2 : 3 : 4	16 : 3 : 1
	Humate	7 : 3 : 1	7 : 7 : 1	13 : 2 : 1
	Biostar	1 : 1 : 1	1: 1: 2	3 : 1 : 1

Both fertilizers increased the concentration of Se, Zn and Cu. In these conditions Se accumulation compared with Zn and Cu was the lowest – 1,07-1,37 times compared to the control plants. No differences were found between Se accumulation by *Brassica japonica* in humate and Biostar experiments ($P > 0,5$) while Biostar happened to be slightly more effective than humate in Se accumulation by *Allium porum* ($P < 0,5$). A positive effect of soil microorganisms is known to be efficient in phytoremediation of soils polluted by Se [10].

The same effect seems to be useful for the improvement of Se content in vegetables. As can be seem from Table 4, there are significant differences between varieties in Se accumulation. Thus among three varieties of *Brassica japonica* higher Se accumulation happened to be typical for *Rusalochka* ($P < 0,001$) compared to *Mibuna* and *Mizuna*. At the same time *Mibuna* is characterized by the highest positive effect of humate and Biostar utilization on Se accumulation level.

Table 4. Selenium accumulation by Brassica japonica in control plants and plants growth with humate and Biostar

Plants	Control, µg / kg	Humate, µg / kg	Biostar, µg / kg
Mizuna	167	211	160
Rusalochka	180	233	185
Mibuna	185	244	220

More significant were changes in Zn and Cu accumulation levels. Peculiarities in fertilizers effect are especially significant here. Thus humate did not change significantly Zn accumulation (1-1,2 fold concentration increase) while Biostar improved Zn accumulation by 1,24-2,46 times compared to control plants.

Cu accumulation was also lower in experiments with humate (1,07-1,73 times compared to control plants) than with Biostar (1,8-8,5 times) ($P < 0,001$).

One can also see that among species investigated *Allium porum* accumulated 2,7-22 times more Cu and 1,4-5,5 times more Zn than other species.

Differences in elements accumulation by different species attract special attention. In experiments with Biostar the highest changes in Se accumulation was found for *Allium porum* (1,34 times compared to control plans), in Zn – for *Brassica japonica* (2,46 times), in Cu – for *Brassica japonica* (8,52 times) and garlic (6,27 times) with only 1,8 times increase of Cu in *Allium porum.*

In a whole increase of plants mass as a result of humate and Biostar utilization is accompanied by changes both in elements content and their ratio (Table 3). Natural symmetry seems to be reflected here in values close to Fibonacci numbers for control plants and plants grown with humate and equal to Fibonacci numbers for plants grown with Biostar.

CONCLUSION

The research results confirmed the efficiency of humate and Biostar in improvement of yield and elements composition. The application of both fertilizers increased the accumulated levels of selenium, zinc and copper in all investigated plants (*Brassica japonica*, *Allium porum*, *Allium sativum*), but to different degree. The efficiency of Biostar was higher, than humate. The highest accumulation level was observed for copper when applying Biostar bacterial fertilizer for *Brassica japonica Mizuna* (in 8.52 times) and *Allium sativum* (in 6.27 times) compared to control group. Zinc accumulation by all crops was also higher when applying Biostar compared to humates. Selenium accumulation by all crops was observed at lower levels compared to copper and zinc, however, high level of selenium accumulation was revealed at humate application while growing *Allium sativum.*

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