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## EVALUATION OF BIOLOGICAL ACTIVITY OF MICROELEMENT COMPLEX AVATAR-2 FOR ITS APPLICATION FOR PRE-TREATMENT OF WHEAT SEEDS

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The effectiveness for pre-treatment of winter wheat seeds by 16-component microelement complex avatar-2, which contains biogenic microelements in the form of citratochelates was determined in pot experiments. Growthstimulation and antioxidant properties of this complex for wheat growing both the optimum and deficit the NPK-content of agrochemical background, and improve the ability of wheat plants for using phosphorus of soil hardsoluble phosphates were identified.

In recent years, Ukraine has a tendency to instability and a significant reduction in yield and profitability of grain production. For example, in farms of the steppe zone, where it is concentrated about half the grain crops, the average level of profitability declined from 39.9% in 2001 to 5.0% in 2009 and in 2012 in some areas of the region realization of grain was even unprofitable [8].

It was mainly as a result of a significant reduction in yield and grain quality. Among the whole variety of measures, which are essential for solution of branch program "Grain of Ukraine", it is important to optimize the mineral nutrition of plants. To implement this requirement, given the decline in the last 15 years the use in Ukraine of fertilizers doses for grains by 4-6 times or more, very important is the development and application of new environmentally safety, technological and low-cost preparations that are thanks to the effects on plants could provide improve the

efficiency of their removal of nutrient elements of fertilizers and soil – especially of nitrogen and phosphorus of hardsoluble soil phosphates This should promote to enhance of corn productivity, grain quality and, consequently, to the profitability of production.

In Institute of bioorganic chemistry and petrochemistry of the National Academy of Sciences of Ukraine jointly with the Scientific Production Company "Avatar" conducting research aiming to develop new effective preparations with anti-stress and growthstimulation action for many crops, including cereals by growing them on different – the optimum and deficit agrochemical background.

Developed preparations contains micro- and ultramicroelements, which chelated by three- and twokarboic organic acids, which are natural to plants and quickly involved in their metabolism [1,5].



Organochelates of biogenic elements derived from colloidal solutions by chelation of nanoparticles (30-70 nm) organic acids to complete the transition elements in ionic form. The resulting aqueous organochelates solutions have an extremely high degree of purity. One of the latest developments – a microelement complex with the working title "Avatar-2", which contains Zn, Mn, Cu, Fe, Mo, Co, Mg, Ge, V, La, Ni, Ti, Ag, Se, I-citratochelates and boron in the form of boric acid. The presence of silver, copper and iron ions provide to preparation additional antimicrobial properties.

The aim of the research covered in this article was to determine the efficacy of microelement complex avatar-2 for pre-treatment of winter wheat seeds varieties Smuglyanka for its cultivation on various agrochemical backgrounds, including – for the acute shortage of phosphorus in the feed.

**Materials and research methodology.** Pot experiments were conducted in Smuglyanka soft winter wheat. Complex avatar-2 was used for seeds pre-treatment in doses of 50, 100 and 200 ml/ton of seeds. Experiments were laid in vessels with capacity of 3 liters. Number of versions in experiments – 10, repetition – the seven-time, duration of the experiment – 26 days. The number of plants in a container – 15 pcs. Mass of dry quarts sand carefully washed sand (fraction – 1.5-2.5 mm) in the vessel – 2.4 kg. Sand humidity – 60% AH.

Plants versions 1-4 (see table) were grown in medium Hoagland–Arnon [4], which contained 1.0 norm NPK (g/kg of dry sand – N – 0,15; P<sub>2</sub>O<sub>5</sub> – 0,1, K<sub>2</sub>O – 0,1 (optimal agrochemical background), plants ver. 5-8 – with 0,5 of this dose, 9-10 versions – with 1,0 norm NK (in culture medium-Hoagland – Arnon without phosphorus) with carried dry tricalcium phosphate (0,15 g P<sub>2</sub>O<sub>5</sub>/kh) in the substrate, with carefully washing from the possible available of accessible to plant phosphorus. Illumination – 6 thousand luxes, light time – 12,5 hours per day. temperature – 18–20° C.

By physiological and biochemical methods were defined: the intensity of organic acids root exudation – Korenman method [6]; malondialdehyde content in leaves – by the method of according to methodology [9]; chlorophyll and carotenoids content in leaves – in the extract of dimethyl-sulfoxide (DMSO) by the method of Wellburn [10].

Dry matter content in plant material was determined thermogravimetric method [3]. Acidification activity of the root system (AARS), which characterizes the intensity of the operation of root plasmolemma H<sup>+</sup> – ATPase pump is the most informative indicator of root system absorption capacity was determined by measuring the pH of the medium (0.1 mM KCl), in which were incubated roots of 7-daily shoots [2,7].

**Research results.** The results of the experiment are shown in Tables 1–3. Data of Table 1 shows that the avatar-2, used for pre-treatment of wheat varieties Smuglyanka seeds at doses of 50 and 100 ml/t, increases by 15,4 % acidification activity of the root system 7-days wheat shoots, for a dose of 200 ml/t – by 12 5%. Some researchers considers that increased activity of the proton pumps of the root system of wheat plants is positively correlated with the increasing of grain productivity. This index is the most informative regarding absorption capacity of the root system of wheat. For the optimum level of provision plants on main macroelements (var. 1–4) when using avatar-2 marked only trend upward in the relative weight of the dry matter relative to control plants – in 2,2–4,5 %. Removal of nitrogen by 26 -day plants exceeded the control at 5,3–6,5 %, phosphorus at avatar doses 50 and 100 ml/t – at 8,4–9,0 %, at a dose of 200 ml/t – 19,5%. Preparation virtually no impacted to removal of potassium by plants. Using an avatar-2 increases the intensity of secretion by root system of organic acids, mainly malic. It can enhance the solubility and thus availability

to plants of phosphorus of hardsoluble rhizosphere phosphates.

Growing plants for scarce NPK-background (0,5 normal) led to the weight of dry matter of control plants (ver. 5) at 6 % (relative ver. 1), the removal of nitrogen by plants – at 5 %, phosphorus – at 17 %, potassium – at 11%. The use of avatar-2 under these conditions was more effective: the preparation helped to increase the mass of dry matter in plants at 4,6–6,0 %. For doses of 100 and 200 ml/t nitrogen removal by plants increased (relative to control 2, ver.5) by 10,2–15,7 %, phosphorus – by 19,4–28,7 %. Removal of potassium by plants was significantly increased only at doses of 100 ml avatar-2 to 1 ton of seeds.

It should be noted that use of the preparation in versions with double reduced provision of plants on main macroelements led to higher removal by plants compared to the control 1 (without avatar-2, but with the full software NPK): nitrogen – at 4,8–10,1%, phosphorus (at doses avatar 100 and 200 ml/t of seeds) – at 6,7–7,1%). Preparation helped to intensification (relative control 2) acid secretion by roots at 45–64%.

In conditions of phosphorus shortage in the nutrition of plants (ver.9.10—lack of phosphorus in the nutrient solution, the substrate – dry tricalcium phosphate at a dose of 0.15 g of  $P_2O_5$  per 1 kg of dry sand ) the use of avatar -2 at a dose of 100 ml/t provided increasing of root acid secretion at 90 %, which helped boost by wheat plants using of hardsoluble mineral phosphate phosphorus –  $Ca_3(PO_4)_2$ . Removal of phosphorus by plants of ver. 10 was higher than control 3 to 26 % (ver. 9). Preparation slightly affected on removal of nitrogen and potassium by plants in this version, increased it according to 5,4 and 7.4 %.

In Table. 2 shows the effect of avatar -2 for chlorophyll content (a and b), total carotenoids and malondialdehyde in a leaves of 26-day plants. The data table shows that for optimal NPK in a leaves contains more chlorophyll and total carotenoids than for

depleted agrochemical background. Application avatar-2 with full dose of NPK provided a slight (in 2,2–4,4 % ) increase in chlorophyll content and 3,7–8,3 % – of total carotenoids, in the variant of depleted agrochemical background (0,5 n NPK) positive effect of the preparation was much more significant. Thus, the chlorophyll content of wheat leaves increased – by 4,5–17,0 %, of total carotenoids –by 4,6–19,8 %. With depleted agrochemical background preparation significantly increases the activity of the photosynthetic apparatus of plants, increasing of endogenous antioxidants content – total carotenoids reduces the intensity of the oxidation and destruction of chlorophyll. Under these conditions, the positive effect of the preparation on the intensity of photosynthetic processes increases with the dose applied microelement complex.

In addition to the positive impact on total carotenoid biosynthesis, preparation found significant antioxidant properties under both optimal and on scarce agrochemical background. This is evidenced by reduction in the leaves of plants content of malondialdehyde by avatar-2 doses of 50 and 100 ml/t – by 25–30, at doses of 200 ml/t – by 40–55 %. Reducing the intensity of lipid peroxidation of biological membranes in plants indicates the effect of anti-stress and increase plant adaptation to stress conditions, particularly in our experiment – phosphorus deficiency in the plants nutrition.

In Table 3 shows the effect of avatar-2 on morphological parameters of root system 26-day plants. The table shows that at both agrochemical background avatar-2 at a dose of 100 ml/t boosted by 10–20 % increase of the number of germinating roots of plants, by 15–18 % – of their total length, on the formation of 12–18% more lateral roots and 2.0–2.5 times – the number of roots of 3-rd level. The length of the main germinating root, which determines the depth of the root system, higher than the control at 10% of full NPK and 18% – by 0,5 n NPK.



**Table 1. Influence of application of microelement complex avatar-2 for pre-seeding treatment of winter wheat seeds Smuhlyanka variety on accumulation of dry matter by 26-day plants, bearing of nitrogen, phosphorus and potassium, on acid secretion and acidification activity of root system. \$ 1,0 n NPK, g/kg of sand: N – 0,15; P<sub>2</sub>O<sub>5</sub> – 0,1; K<sub>2</sub>O – 0,1**

Number of version	Research version	NPK dozes	Mass of a.d.m. of 100 plants, g	Nutrition elements bearing by 100 plants, mg			Root acid secretion, mcg. acid malate/plant/h	Root system acidification activity, mcM H <sup>+</sup> / 1 plant /24 h
				N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O		
1.	Water, control 1	1,0 n NPK	5,52 ± 0,28	248 ± 9	47,7 ± 2,6	386 ± 21	36 ± 3	1,04 ± 0,05
2.	Avatar-2, 50 ml/t	1,0 n NPK	5,77 ± 0,25	264 ± 11	52,0 ± 1,9	397 ± 17	39 ± 3	1,20 ± 0,06
3.	Avatar-2, 100 ml/t	1,0 n NPK	5,77 ± 0,20	261 ± 13	51,7 ± 1,7	377 ± 20	46 ± 5	1,20 ± 0,03
4.	Avatar-2, 200 ml/t	1,0 n NPK	5,64 ± 0,30	264 ± 13	57,0 ± 2,4	387 ± 16	53 ± 4	1,17 ± 0,05
5.	Water, control 2	0,5 n NPK	5,19 ± 0,23	236 ± 8	39,7 ± 1,4	342 ± 18	44 ± 4	1,04 ± 0,04
6.	Avatar-2, 50 ml/t	0,5 n NPK	5,33 ± 0,29	273 ± 14	47,4 ± 2,0	338 ± 14	72 ± 6	1,20 ± 0,06
7.	Avatar-2, 100 ml/t	0,5 n NPK	5,43 ± 0,22	266 ± 12	51,1 ± 2,4	408 ± 23	70 ± 5	1,20 ± 0,04
8.	Avatar-2, 200 ml/t	0,5 n NPK	5,50 ± 0,27	260 ± 10	50,9 ± 1,7	357 ± 19	64 ± 4	1,17 ± 0,05
9.	Water, control 3	1,0 n NK, in substrate	5,04 ± 0,21	239 ± 12	39,1 ± 1,8	338 ± 15	40 ± 3	1,04 ± 0,03
10.	Avatar-2, 100 ml/t	Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> , 0,15 g P <sub>2</sub> O <sub>5</sub> on 1 kg of sand	5,31 ± 0,24	242 ± 8	49,3 ± 2,2	363 ± 19	76 ± 5	1,20 ± 0,05

**Table 2. Influence of application of microelement complex avatar-2 for pre-seeding treatment of winter wheat seeds Smuhlyanka variety on content of chlorophyll, total carotenoids and malondialdehyde in leaves of 26-day plants; 1,0 n NPK, g/kg of sand: N – 0,15; P<sub>2</sub>O<sub>5</sub> – 0,1; K<sub>2</sub>O – 0,1**

Number of version	Research version	NPK dozes	Content of chlorophyll, mg in a.d.m. of 100 plants			Content of total carotenoids, mg/100 plants	Content of MDA in leaves, nmole/g of raw mass
			a	b	a+b		
1. <b>Water, control 1</b>		1,0 n NPK	42,1 ± 1,4	8,8 ± 0,3	50,9 ± 1,7	10,9 ± 0,4	66,0 ± 3,4
2.-2, 50 ml/t		1,0 n NPK	43,0 ± 1,3	9,0 ± 0,3	52,0 ± 1,6	11,4 ± 0,5	49,1 ± 2,1
3. Avatar-2, 100 ml/t		1,0 n NPK	44,0 ± 1,5	9,1 ± 0,4	53,1 ± 1,9	11,8 ± 0,4	48,6 ± 2,5
4. Avatar-2, 200 ml/t		1,0 n NPK	41,0 ± 1,1	9,5 ± 0,4	50,5 ± 1,5	11,3 ± 0,5	38,7 ± 1,8
5. <b>Water, control 2</b>		0,5 n NPK	34,1 ± 1,2	8,4 ± 0,3	42,5 ± 1,5	8,6 ± 0,3	67,4 ± 3,3
6. Avatar-2, 50 ml/t		0,5 n NPK	35,2 ± 1,2	9,2 ± 0,5	44,4 ± 1,7	9,0 ± 0,3	48,6 ± 2,0
7. Avatar-2, 100 ml/t		0,5 n NPK	37,4 ± 1,4	9,0 ± 0,4	46,4 ± 1,8	9,5 ± 0,4	49,1 ± 2,4
8. Avatar-2, 200 ml/t		0,5 n NPK	40,2 ± 1,4	9,5 ± 0,4	49,7 ± 1,8	10,3 ± 0,4	30,3 ± 1,4
9. <b>Water, control 3</b>		1,0 n NK, in substrate	31,9 ± 1,0	8,1 ± 0,3	40,0 ± 1,3	8,5 ± 0,3	69,4 ± 3,0
10. Avatar-2, 100 ml/t		Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> , 0,15 g P <sub>2</sub> O <sub>5</sub> on 1 kg of sand	34,8 ± 1,2	8,9 ± 0,3	43,7 ± 1,5	9,2 ± 0,3	48,9 ± 2,0

According to an acute shortage of phosphorus (var. 9.10) avatar-2 at a dose of 100 ml/t assisted to the number of germinal roots by 18%, of lateral roots – by 22%, the average length of one lateral root – by 20%, increase in the number of roots of 3-rd level – in 2,4 times. But the length of the main germination root was greater than control only by 4.4%.

**Conclusions.** 1) Microelement complex avatar-2 has growthstimulation and antioxidant effect that in the field conditions should enhance the corn productivity of plants and their resistance to various stress-factors; 2) The preparation increases the nitrogen utilization by plants of winter wheat (removal above the control at 6–15 %), increases bearing of phosphorus – by 9–19 % at full NPK, to 19–29 % at 0,5 n NPK and



Table 3. Influence of application of microelement complex avatar-2 for pre-seeding treatment of winter wheat seeds Smuhlyanka variety on content of chlorophyll, total carotenoids and malondialdehyde in leaves of 26-day plants; 1,0 n NPK, g/kg of sand: N – 0,15; P<sub>2</sub>O<sub>5</sub> – 0,1; K<sub>2</sub>O – 0,1

Num-ber of version	Research version	NPK dozes	Morphological indices of 1 plant root system						
			germina-tion roots quantity, pieces	their sum-mary length, cm	lateral roots quantity, pieces	their sum-mary length, cm	average length of lateral root, cm	third level roots, quantity, pieces	mane germinating root length, cm
9.	Water, control 1	1,0 n NPK	4,4	57 ± 3	114 ± 9	82 ± 4	0,72	32 ± 4	17,4 ± 0,8
10.	Avatar-2, 50 ml/t	1,0 n NPK	4,8	59 ± 2	121 ± 6	84 ± 6	0,70	50 ± 6	17,9 ± 0,6
11.	Avatar-2, 100 ml/t	1,0 n NPK	5,2	67 ± 4	134 ± 11	100 ± 6	0,75	62 ± 11	19,2 ± 0,9
12.	Avatar-2, 200 ml/t	1,0 n NPK	4,8	60 ± 4	123 ± 7	112 ± 9	0,91	32 ± 3	20,7 ± 1,1
5.	Water, control 2	0,5 n NPK	4,2	60 ± 3	120 ± 7	69 ± 3	0,57	23 ± 6	21,4 ± 0,9
6.	Avatar-2, 50 ml/t	0,5 n NPK	5,0	69 ± 5	131 ± 12	92 ± 7	0,70	53 ± 5	22,4 ± 1,2
7.	Avatar-2, 100 ml/t	0,5 n NPK	5,0	69 ± 4	134 ± 9	90 ± 5	0,67	57 ± 7	25,3 ± 1,1
8.	Avatar-2, 200 ml/t	0,5 n NPK	4,8	62 ± 4	121 ± 5	86 ± 5	0,71	55 ± 4	21,8 ± 1,0
9.	Water, control 3	1,0 n NK, in substrate	4,4	60 ± 2	124 ± 8	77 ± 6	0,62	28 ± 4	18,0 ± 0,7
10.	Avatar-2, 100 ml/t	Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> , 0,15 g P <sub>2</sub> O <sub>5</sub> on 1 kg of sand	5,2	65 ± 5	152 ± 11	112 ± 8	0,74	67 ± 9	18,8 ± 0,9

26 % – for growing on the substrate with  $\text{Ca}_3(\text{PO}_4)_2$  and slightly – potassium. This indicates the possibility in a industrial conditions for the cultivation of winter wheat using avatar-2 reduced by 20–30 % norms of application of phosphate fertilizers and nearly half – preplant (autumn) of nitrogen fertilizers; 3) avatar-2 promotes acid secretion and acidofication

activity, as well as significant improvement in morphological parameters of wheat root system . This leads to improved mineral nutrition of plants, increased solubility and, therefore, the plants availability to phosphorus of hardsoluble mineral soil phosphates and perhaps hardsoluble mineral compounds that contain essential for plant biogenic micronutrients.

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*Давидова О.Є., Аксиленко М.Д., Максін В.І., Котенко С.І., Дерев'янка К.Ю., Николаєвська В.І. Оцінка біологічної активності мікроелементного комплексу «Аватар-2» за його застосування для передпосівної обробки насіння пшениці // Біоресурси і природокористування. – 2014. – 6, №5–6. – С. 72–78.*

Показано ефективність застосування для передпосівної обробки насіння озимої пшениці 16-компонентного мікроелементного комплексу «Аватар-2», який містить біогенні мікроелементи у формі цитратохелатів. Виявлено антиоксидантні та стимулюючі ріст властивості комплексу за вирощування пшениці як на оптимальному, так і на дефіцитному за вмістом НРК агрофоні та підвищення здатності рослин пшениці використовувати фосфор важкорозчинних мінеральних ґрунтових фосфатів.

## АННОТАЦИЯ

*Давыдова О.Е., Аксиленко М.Д., Максін В.І., Котенко С.І., Дерев'янка К.Ю., Николаєвська В.І. Оценка биологической активности микроэлементного комплекса «Аватар-2» при его использовании для предпосевной обработки семян пшеницы // Биоресурси и природопользование. – 2014. – 6, №5–6. – С. 72–78.*

Показана ефективність використання для предпосевной обработки семян озимой пшеницы 16-компонентного микроэлементного комплекса аватар-2, который содержит биогенные микроэлементы в форме цитратохелатов. Выявлены стимулирующие рост и антиоксидантные свойства комплекса при выращивании пшеницы как на оптимальном, так и на дефицитном по содержанию НРК агрофоне и повышение способности растений пшеницы использовать фосфор труднорастворимых минеральных почвенных фосфатов.