

Effect of organic fertilizers on buckwheat yield

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Abstract. The paper discusses the effect of pre-sowing treatment of buckwheat with organic fertilizers on its structural indicators, yield and susceptibility to root rot. It was found that fertilizing has a positive effect on growth, development and yield of buckwheat in comparison with the control. Potassium humate was revealed to be particularly effective and showed the yield range from 3.2 t/ha in Chishminskaya and Barynya varieties and to 4.0 t/ha in Devyatka variety.

1 Introduction

In agriculture, soil depletion that entails decreased productivity is one of the most important problems. Organic mineral fertilizers, the most effective fertilizers for crops, should be currently used to replenish nutrients in the soil and plants. Organic mineral fertilizers help prevent soil degradation, increase productivity and the quality of the resulting product during growing of agricultural, horticultural and garden crops.

Organic mineral fertilizers are a complex mixture that consists of organic and mineral components. Humic acids, amino acids and others can be used as an organic component. Such fertilizers improve the soil structure and eliminate nutrient deficiency in plants. The mineral component is micronutrients, meso- and macronutrients (NPK), which are absorbed by plants in the shortest time.

Potassium humate is a fertilizer with a large content of humic acids (above 80%); it accelerates growth and development of various plant species. Humate decreases acidity of soil and increases general indicators of its effect on plants. In addition to humic acids, potassium humate includes peptides, natural growth stimulants, antibiotics, enzymes and amino acids.

Humates stimulate metabolic and biochemical processes in the soil, they are components of peat, coal, silt, and some types of the soil. Humates are produced from the soil, peat, sapropel, and brown coal.

Zdorovy Urozhay is one of the best stimulant fertilizers for plants and microorganisms, a natural catalyst of biochemical processes. It exhibits active properties, promotes growth of plants and development of soil microflora, and stimulates nitrogen, phosphorus, potassium and carbohydrate metabolism in plants. The main components are humates (not less than 80%) and various macro- and micronutrients. This fertilizer belongs to hazard class 4 in all indicators, which means it is safe for humans and the environment.

Biostim is a new generation organo-mineral fertilizer for weakened plants to

stimulate their vitality. It differs from other fertilizers, as it is a natural product prepared from plant raw materials. *Biostim* provides plants with a balanced composition of amino acids of plant origin and nutrients. It stimulates plant vitality and shows a powerful anti-stress effect. It contains macronutrients (NPK), mesonutrients (S; Mg), and (Fe, Cu, B, Mn, Zn, Mo), and biologically active organic substances and amino acids.

Humic acids, or humates, are produced from peat, brown coal or sapropel through treatment of the basic substance with weak alkaline solution. In fact, humic acids are a concentrate of soil humus, the compound that stimulates the activity of soil microorganisms, and plant development. Humic fertilizers do not increase the volume of humus in the soil; however, they effectively relieve stressful effects on plants caused by deficiency of organic matter.

Humates are referred to as fertilizer, but they are natural growth stimulators. Humates stimulate maximum germination, improve establishment and protect against adverse weather conditions.

One of the effective methods to increase germination and survival of plants is pre-sowing treatment of seeds with humic fertilizers.

The aim of the study was to reveal the effect of pre-sowing seed treatment with organic mineral fertilizers on the yield of buckwheat (*Fagopyrum esculentum*).

This crop plant was chosen not only because it is of high nutritional value but

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also due to a wide range of its useful healing properties (Table 1).

Buckwheat grain proteins are characterized by high tryptophan amino acid content (2.16), and threonine (0.80) is a limiting amino acid. It is close to unity in other essential amino acids, and at the same time, it surpasses barley, rice, corn and wheat in isoleucine, lysine, methionine and cystine. One more feature of the protein composition of buckwheat is to note. Unlike most cereals, buckwheat does not contain gluten and therefore can fully replace wheat, barley, rye and oat products in the diet of people suffering from celiac disease (disease associated with gluten intolerance) [1].

During flowering, the green mass of seed buckwheat accumulates a large amount of rutin and other flavonoids: quercetin, vitexin, orientin, isovitexin, isoorientin. It also contains phagopyrine, tannins, procathechin, chlorogenic, gallic, caffeic, toxic, menolenic, oxalic, malic and citric acids. Rutin and isovitexin in the buckwheat seed are inactive; however, all flavonoids are active in the seedlings and in the grass.

Table 1. Amino acid composition of protein

Indispensable amino acid	Cereals				
	Buckwheat	Barley	Rice	Corn	Wheat
Valine	0.95	1.12	1.02	0.84	0.82
Leucine	0.89	1.20	1.43	1.86	0.91
Isoleucine	1.17	0.88	–	0.75	0.88
Lysine	1.15	0.58	0.50	0.40	0.55
Methionine + cystine	1.06	0.39	0.96	0.96	–
Threonine	0.80	0.92	0.99	0.70	0.67
Tryptophan	2.16	1.45	1.29	0.70	1.07
Phenylalanine + tyrosine	1.13	1.67	1.30	1.22	1.15
EAA index*	1.11	0.93	1.02	0.85	0.86

Table 2. Laboratory germination

Experiment Options	Devyatka		Chimshinskaya		Barynya	
	Germination energy, %	Laboratory germination, %	Germination energy, %	Laboratory germination, %	Germination energy, %	Laboratory germination, %
Control	63	95	52	94	52	95
treatment with Humate Potassium fertilizer	76	98	56	96	58	97
treatment with Zdorovy Urozhay fertilizer	73	98	55	96	59	99
treatment with Biostim fertilizer	73	97	60	94	60	97

* Essential amino acid index

Green buckwheat is superior to other cereals in PP vitamin, folic acid, riboflavin, and vitamins of group B. It exhibits a significant content of potassium (380 mg), phosphorus (298 mg), magnesium (200 mg), calcium (20 mg), iron (6.7 mg), sulfur (88 mg), copper, cobalt, manganese and zinc [2–4].

The studies conducted by scientists in Korea, Poland and China have proved a powerful anti-inflammatory and antitumor effect of all organs of this plant: roots, seeds, stem, leaves, and flowers.

However, the extract from green buckwheat seedlings is most effective, since buckwheat contains substances that inhibit protein breakdown and make it effective against malignant diseases. Moreover, flavonoids and a unique complex of proteins contribute to anti-cancer properties of the plant.

Buckwheat contains a great amount of folic acid, which stimulates the production of blood cells, and similar to rutin it increases the resistance to damaging effects of ionizing, radioactive and X-rays. In addition, potassium and iron, which are found in buckwheat in sufficient amount, impede absorption of radioactive isotopes.

2 Materials and Methods

Three weeks before sowing, buckwheat seeds were planted to determine the germination energy and laboratory germinating capacity according to the following scheme (Table 2).

Buckwheat varieties: Devyatka, Chishminskaya, Barynya

- 1 Control (without treatment);
- 2 Seed treatment with *Potassium Humate* fertilizer;
- 3 Seed treatment with *Zdorovy Urozhay* fertilizer.
4. Treatment with *Biostim* fertilizer.

In germinators, where seeds were treated with the fertilizer, the germination energy and laboratory germinating capacity increased sharply, and the germination rate also changed. Under normal conditions, germination can be observed on day 7; however, complete germination after treatment was observed on day 5 [5]. The height of the seedlings (shilts) ranged from 4 cm (in the control) to 101 cm (after treatment) (Fig. 1).

Treatment of buckwheat seeds with *Potassium Humate*, *Biostim* and *Zdorovy Urozhay* fertilizers was performed at the rate of 0.3 l/t 18 hours before sowing.

Buckwheat is a thermophilic crop of a short vegetative period. The main species and varieties of buckwheat are relatively sensitive to heat and moisture. For its full ripening, an active temperature range of 1300–1600 °C (above 10 °C) is required.



Fig. 1. Seed germination on day 3

Buckwheat seeds start to germinate at 8–9 °C, while seedlings appear sparsely long time after seed sowing. At 6–8 °C, seeds only appear, but do not sprout. Long-term exposure to these conditions causes decay of seeds and death of the embryo. The optimum temperature for seed germination is 20 °C, in this case seeds germinate after 6–7 days.

The optimal temperature for buckwheat during sprouting is 15–18 °C, during the period of intensive growth of plants it is 16–20 °C, and at the final stage of fruiting and ripening it is 17–21 °C. Buckwheat is sensitive to frost in all growth periods. Temperature decrease to –1 °C for 4–6 hours causes significant damage of the plant, and the temperature of –2 °C leads to the death of leaves and flowers. Buckwheat is sensitive to high temperatures. When air becomes warm and attains 25 °C, especially at low soil moisture, the conditions for pollination and fertilization sharply worsen. At 30 °C, plant growth is inhibited, fertilized flowers and emerging fruits dry out [6–8].

Buckwheat is classified as a crop of narrow temperature range. V.E. Pisarev reported (1957) that summer temperatures above +25 °C inhibit its growth and development.

One of the important periods in the life of a buckwheat plant is formation of inflorescences up to the flowering period, since the formation of generative organs terminates at this time. Warm (+16–+18 °C) and normally humid weather favor abundant flowering. In case of light

rains during flowering and relatively low temperature (+15–+18 °C), its productivity increases. Buckwheat blooms for a long time until harvesting, although most of the flowers form seeds by this time.

The period from the beginning of plant flowering to ripening is critical for buckwheat. When ripening, the number of branches with underdeveloped seeds, buds and flowers depends on weather conditions. At least several days of hot, dry and windy weather during buckwheat flowering cause ‘seizure’, when flowers and fruit ovaries dry out [9].

The indicators above provide a general idea of the thermal needs of the plant. They vary greatly depending on the variety biology.

Thus, a comparison of the thermal needs of buckwheat with thermal conditions in Kurgan region allows us to conclude that the region is suitable for growing the most early ripening buckwheat varieties.

The sooner the crop is sown, the better it ripens that ensures the opportunity to produce quality products. The optimal sowing conditions are as follows: warm soil and sufficient moisture, but the hydrothermic factor in May 2019 was 0.3, which is not sufficient for germination of buckwheat seeds (Table 3).

Table 3. Weather conditions, May–September 2019

Month	Temperature		Total precipitation	Hydrothermic factor
	for a month, °C	average for several years, °C		
May	14.0	12.6	23	0.3
June	16.9	18.4	43	0.8
July	21.1	19.8	36	0.6
August	17.3	17.2	101	1.7
September	9.9	10.9	30	0.4

Buckwheat is a hydrophilic crop. Its increased demand for moisture is caused by high consumption of water for formation of a unit of dry matter. The transpiration coefficient is 500. Buckwheat seeds begin to germinate when absorbed water amounts to 45–50 % of their mass.

Demand of the plant for soil moisture varies depending on the growth phase. In the period from seedlings to flowering, water consumption is up to 11 % of the total demand. The largest amount of water (up to 50 %) is consumed from the beginning of flowering to ripening and about 30% of water is required for ripening.

3 Results and Discussion

Buckwheat sowing was carried out on May 26, the temperature was 10.6 °C. Due to insufficient moisture, seedlings appeared not on day 10–11, but after two weeks.

Flowering began in July–August when the temperature and moisture indicators were optimal and the hydrothermic factor attained 0.6–1.7, which affected the structural indicators and crop yield.

The yield level in the growing season largely depends on weather conditions, and temperature and water regime in the experimental plot. Based on the indicators of active temperatures and moisture, it is possible to determine the

value of the factors for formation of the productivity of cereals and grain crops.

Buckwheat has many features of growth and development, for example, it has a long flowering period during which the crop can be exposed to various adverse factors typical of a continental climate. Therefore, when analyzing the structure of the crop yield, it is necessary to take into account a large amount of data. In the Vegetable section of Kurgan State Agricultural Academy, the indicators to estimate its development and fruiting characteristics are as follows: plant height, number of inflorescences, number of plants per square meter, weight per plant and weight of 1000 seeds.

The formed organic mass of plants is the main source of nutrients for seeds. A high buckwheat yield can be expected only when the leaf surface is well developed, stems are high and there are many flowers [2].

Plants are treated with fertilizers to obtain high yields; in our experiments, fertilizers had a significant effect on buckwheat yield (Table 4).

By the time of harvesting, Devyatka variety had the largest number of plants (280–273 pcs.). The weight of 1000 seeds was also high. Variety Barynya was distinguished by the height of its stem, which ranged from 0.91 cm to 1.02 cm when treated with *Zdorovy Urozhay* fertilizer. There is a relationship between structural indicators and biological crop yields.

When treated with *Potassium Humate* fertilizer, high yields were observed for Devyatka variety – 4.0 t/ha, and the yields of Chishminskaya and Barynya varieties were similar – 3.2 t/ha. When treated with *Zdorovy Urozhay* fertilizer, Devyatka variety showed the best results – 3.8 t/ha, and the biological yield of Chishminskaya and Barynya varieties was 3.1 t/ha. When treated with *Biostim*, Devyatka variety showed the highest yield, and the lowest result was observed for Chishminskaya variety – 3.0 t/ha.

Table 4. Structural indicators of buckwheat treated with humic fertilizers

Structural indicators	Buckwheat varieties								
	Devyatka			Chishminskaya			Barynya		
	Contr ol	<i>Zdorovy Urozhay</i>	<i>Potassium Humate</i>	<i>Biostim</i>	<i>Zdorovy Urozhay</i>	<i>Potassium Humate</i>	Contr ol	<i>Zdorovy Urozhay</i>	<i>Potassium Humate</i>
Number of plants per m ² , pcs	273	275	280	201	206	210	211	213	213
Number of inflorescence, pcs	15.0	15.5	15.2	15.2	16.2	17.7	13.6	18.0	16.3
Plant height, cm	0.93	0.88	1.12	0.80	0.98	0.82	0.92	1.02	0.98
Weight of 1 plant, g	1.3	1.3	1.4	1.3	1.4	1.4	1.4	1.5	1.5
Weight of 1000 seeds, g	30	31	32	28	28	28	31	30	32

Among buckwheat varieties treated with humic fertilizers with the control (without treatment), the yield of Devyatka variety attained 3.8 t/ha, that of Chishminskaya was 2.9 t/ha, and that of Barynya was 3.0 t/ha.

Weather conditions in 2019 were favorable for the growth and development of buckwheat, and pre-sowing treatment with humic fertilizers increased the protective functions of crops, accelerated phenological phases, improved crop viability by the time of harvesting, structural indicators and, accordingly, biological yield of buckwheat (Fig. 2).

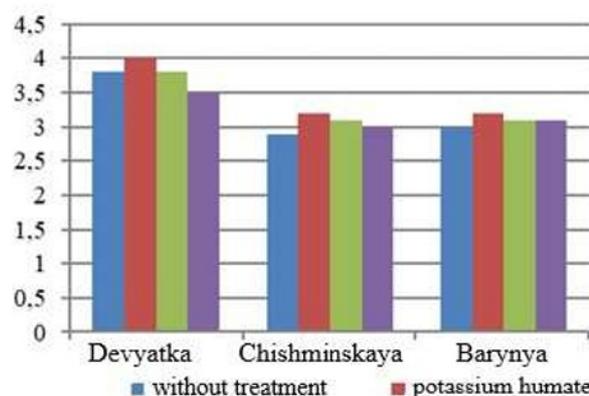


Fig. 2. Biological yield of buckwheat

Buckwheat is less affected by pests and diseases than other crops, however, root rot causes great damage to young seedlings and reduces crop yields [10].

The results of distribution of root rot in buckwheat varieties are presented in Table 5.

The data summarized in the table indicate that Devyatka variety was affected by rot 1.2 times higher than economic threshold of harmfulness (ETH = 15%). Thus, based on the data obtained in 2019, Chishminskaya and Barynya varieties showed relative resistance to root rot.

Mycological analysis showed that root rot was largely caused by fungi of the genus *Fusarium*, regardless of variety.

Table 5. Distribution of root rot in varieties

Variety	Roots	Stem base	Average by plants
Barynya	15.3	13.1	14.2
Devyatka	16.1	18.7	17.4
Chishminskaya	11.6	10.4	11.0
LSD ₀₅			4.5

Infection of the underground organs of buckwheat varieties with *Fusarium* fungi ranged from 80 to 100%. Among the fungi of the genus *Fusarium*, we noted *Fusarium heterosporum* Nees (the main causative agent of buckwheat rot), as well as *F. oxysporum* Schldtl., *F. solani* Koord., *F. poae* (Peck) Wollenw., *F. sporotrichioides* and others. In addition to *Fusarium* fungi, the roots were populated by fungi of the genus *Alternaria*, which are quite harmful to buckwheat (Table 6).

Table 6. Etiology of root rot of buckwheat varieties, %

Variety	<i>Alternaria</i> <i>spp.</i>	<i>Fusarium</i> <i>spp.</i>	<i>Aspergillus</i> <i>spp.</i>
Barynya	5	100	7
Devyatka	17	97	3
Chishminskaya	20	80	15

The contribution of *alternaria* fungi to the pathogenic complex of buckwheat root rot ranged from 5 to 30%. Due to the early death of the root system characteristic of buckwheat, mold fungi of the genus *Aspergillus* were isolated from the roots.

It should be noted that treatment of crops with fertilizers reduced the buckwheat susceptibility to rot by 30 %.

4 Conclusion

Thus, buckwheat is one of the crops that does not require a large number of chemicals against pests and diseases. This biological feature ensures production of environmentally friendly products.

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