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Investigation of the effect of sodium humate fodder additive on sterlet in cage farming

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Abstract. Humic preparations are used as microfertilisers in crop production and growth stimulants in animal husbandry, in aquaculture there is a positive effect of these compounds on individual objects of cultivation, but their use in fish farming has not yet been understudied. The purpose of the work was to present the results of an experiment to evaluate the effect of fodder additive humates on the growth rate and survival of different age groups of sterlet (*Acipenser ruthenus* L., 1758) and the conversion of fodder by fish in aquaculture. A series of experiments were conducted on feeding sterlet with fodder with the addition of sodium humate. The research was conducted in 2018, 2020 and 2021 in the production conditions of the cage fish farm located at the Kaniv reservoir. The effect of various concentrations of sodium humate fodder additive on yearling and two-year-old sterlet was evaluated. Sodium humate was applied to the fodder for the respective groups of sterlet by spraying its aqueous solution in defined proportions with subsequent drying. It was established that the addition of sodium humate to fish fodder at concentrations of 60, 100, 120 and 200 mg/kg of fodder did not significantly affect the growth rate of sterlet. Thus, the advantage of the experimental variants over the control for this indicator was insignificant, within 1.0-1.6%. No effect of sodium humate on the survival of sterlet juveniles reared in cages was established. Therewith, the conversion of fodder with the addition of humates by juvenile and two-year-old sterlet was better by 6.7-17.4%. According to the experimental results, the best result was obtained in the variant using fodder additive humates at a concentration of 200 mg/kg of fodder. Based on the results of the research, it was established that in aquaculture conditions it is advisable to use sodium humate as a fodder additive for yearlings and two-year-old sterlet, designed to increase fodder conversion

Keywords: biologically active substances, fish farming, sturgeon, survival, growth rate, fodder conversion

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Relevance

Improving the fish fodder formula is one of the most effective ways to increase the profitability of commercial fish farming. The main purpose that the researchers set themselves is to achieve a reduction in fodder costs per unit of marketable products both in quantitative and in value terms.

To improve the productive properties of artificial fodder, additives of biologically active substances are frequently used, which, with a slight increase in the cost of fodder, significantly improve its conversion. Such substances include easily soluble salts of humic acids – humates. These substances have the properties of immunostimulants, probiotics, toxin adsorbers, and digestive and growth stimulants (Horovaya *et al*, 1995). According to Kovalenko & Polishhuk (2018), the effect of humates on fish, under the conditions of their cultivation in different aquaculture systems, has not yet been understudied, which determines the relevance of conducting appropriate research on various fish farming facilities, in particular on sturgeon.

Analysis of Recent Studies and Publications

The interest in the search for fodder additives with biologically active properties that can improve the conversion of artificial fodder for farm animals has existed for a long time. Fodder additives of different origins, both made from natural raw materials and synthetic, are widely used (Polishhuk & Bulavkina, 2010). An essential place among the latter is occupied by humates – water-soluble salts of humic and fulvic acids (Popov, 2004).

Humates are mainly used in crop production as growth stimulants and microfertilisers (Luchnyk *et al.*; Semenyuk *et al.*, 2016).

Significant positive experience has been accumulated in using these substances as micro-additives in animal and poultry fodder (Druzhynyna, 2002; Islam, 2005; Bezuhlova & Zynchenko, 2016), including for the treatment and prevention of diseases (Stepchenko & Hryban, 1997; Belyaev *et al.*, 2012; Hrybanova & Karymova, 2015).

Information on using humates in aquaculture is limited and fragmentary. Thus, it is known about the positive effect of fodder supplementation of humic substances on the fish farming performance of channel catfish (Neronin *et al.*, 1990), carp (Abdel-Wahab, El-Refaae & Ammar, 2012) and tilapia (Ahmed El-Ashram & Maaly Mohammed, 2012). There is no information on using humates in the sturgeon fodder.

The first investigation of the effect of humates on the growth rate and survival of sterlet (*Acipenser ruthenus Linnaeus*), a valuable object of commercial sturgeon farming, was conducted in 2017 (Kovalenko & Polishhuk, 2018). It was established that feeding fodder with the addition of humates to three-year-old sterlet, using the cage method of rearing this fish, had a positive effect on fish breeding performance. Thus, the average daily weight gain of fish in the experimental variant with the addition of humates in the amount of 30 mg/kg of fish fodder was 0.695 g/day, and in the control – 0.59 g/day. The survival rate of fish during the experiment in experimental cages was 92.7%, and in control cages – 82.5%. The obtained result of the experiment was the foundation for continuing research in this area.

The Purpose of the Research

The purpose of the research was to investigate the effect of different concentrations of humate additives in fish fodder on sterlets of different

ages when grown in the production conditions of cage fish farming.

The object of research – the fish-breeding effect of adding sodium humate to fish fodder.

The subject of the research – growth and survival rates of various age groups of sterlet, the efficiency of conversion of fish fodder with the addition of sodium humate.

Objectives of the research:

- to test the effect of feed additive sodium humate at different concentrations on the growth rate and survival of sterlet juveniles, and on the efficiency of fodder use;

- to collect biological material for laboratory tests on the content of heavy metals in fish.

Materials and Methods of Research

The research was conducted in 2018, 2020 and 2021 at the production facility of the private fish farm of industrial type “Research and Production Agricultural Enterprise” Bester”. The gardens of the enterprise are located in the

waters of the Kaniv reservoir, in the coastal zone near the village of Trypillya, Obukhov district, Kyiv region.

The material for the research was this yearling (in 2018 and 2020) and two-year-old sterlet (2021), for their cultivation in fish cages with intensive feeding with the product feed “INICIO 917” of the Danish company BioMar, one of the world leaders in fodder production in the field of aquaculture.

The source of sodium humate – the drug “Reasil Humic Health” in powder form, produced by the international company UAB “Life Force Baltic” (Lithuania). The content of humic compounds in dry matter – not less than 80%. The product corresponds to the generally accepted requirements for bacteriological indicators and sanitary and hygienic standards for the permissible content of radionuclides and heavy metals (Feed material Reasil® Humic Health, 2021). The research was conducted using different concentrations of sodium humate additive to fodder according to the scheme (Table 1).

Table 1. The scheme of research

Year	Age group of fish	Concentration of sodium humate in fish fodder, mg/kg		
		Control	Experiment 1	Experiment 2
2018	Yearlings	0	60	120
2020	Yearlings	0	100	200
2021	Two-year-olds	0	200*	-

Notes: * – one pilot variant was established in 2021

The research was performed with double replication. For each variant of the experiment, 2 specifically made rectangular frame cages with side dimensions of 1x1x1 m and a mesh size of 5 mm were allocated.

The planting density of the experimental material in all orchards was the same and

generally corresponded to the technological requirements (Sudakova *et al.*, 2006).

The preparation of sodium humate in the form of an aqueous solution was applied to the fodder in the required proportion using a household sprayer, after which the fodder was dried before feeding to the fish. To balance the conditions

of the experiment, the fish fodder in the control variant was sprinkled with distilled water.

Fish feeding was performed with the frequency and according to the provisions proposed by BioMar, based on the actual weight of sterlet in the cages, obtained from the data of periodic control catches and the schedule of planned fish growth.

The duration of the research period, excluding landing and fishing days, was: 70 days in 2018 (from July 27 to October 4), 90 days in 2020 (from August 2 to October 30) and 35 days in 2021 (from September 15 to October 20).

Fish growth was monitored during control catches, every 8-10 days. All fish from each cage were inspected, counted and weighed.

Assessment of the growth rate and survival of fish and fodder conversion efficiency was

performed according to the methods generally accepted in fish farming. Thus, the growth rate was determined by the values of average absolute and relative body weight gain and specific growth rate (Shherbyna & Hamihyn, 2006), and survival rate – by the percentage of fish that survived to the end of the experiment among the planted ones (Marcenyuk & Marcenyuk, 2020).

The fodder conversion efficiency was estimated by the feed coefficient, which was defined as the ratio of the amount of consumed fodder to the body weight gain of fish (Marcenyuk & Marcenyuk, 2020).

Research results

The evaluation indicators of the experiment conducted in 2018 are presented in the table (Table 2).

Table 2. Results of research conducted in 2018

Indicators	Experiment variant						
	Control		Experiment 1		Experiment 2		
	cage 1	cage 2	cage 3	cage 4	cage 5	cage 6	
Small fry planted	units	50	50	50	50	50	50
		total 100		total 100		total 100	
	average weight, g/units	13.3	12.3	13.2	12.6	11.8	11.2
		average 12.8		average 12.9		average 11.5	
Caught yearlings	units	48	49	47	49	49	47
		total 97		total 96		total 96	
	average weight, g/units	80.2	56.5	89.4	57.1	63.3	60.6
		average 68.4		average 73.3		average 62.0	
Absolute growth, g/units		66.9	44.2	76.2	44.5	51.5	49.4
		average 55.6		average 60.4		average 50.5	
Relative growth, %		143.10	128.49	148.54	127.69	137.15	137.60
		average 135.79		average 138.11		average 137.37	
Specific growth rate, %		2.04	1.84	2.12	1.82	1.96	1.97
		average 1.94		average 1.97		average 1.96	

Table 2. Continued

Indicators	Experiment variant					
	Control		Experiment 1		Experiment 2	
	cage 1	cage 2	cage 3	cage 4	cage 5	cage 6
Fish survival, %	96.00	98.00	94.00	98.00	98.00	94.00
	average 97.00		average 96.00		average 96.00	
Fodder coefficient	0.99	1.11	0.87	1.12	1.03	1.06
	average 1.04		average 0.97		average 1.04	

As evident from the table, in terms of relative body weight gain, the best result (138.11%) was obtained in experimental variant 1, the average (137.37%) – in experimental variant 2, the worst (135.79%) – in the control group. Experimental variant 1 was the best in terms of absolute body weight gain and specific growth rate (60.4 g/unit and 1.97%, respectively), the control variant had the second result (55.6 g/unit) in terms of growth and the third – in terms of specific growth rate (1.94%). Experimental variant 2 is the second in terms of specific growth rate (1.96%) and the third in terms of absolute growth (50.5 g/unit). In general, the advantage of the experimental variants over the control in terms of growth rate was insignificant and was in the range of 1.2-1.7%.

Thus, there is a close correlation between the starting weight of fry and the absolute weight gain of sterlet yearlings. A significantly smaller difference in the values of relative growth and specific growth rate of fish between experimental variants 1 and 2 than between the control and each of the experimental variants can be perceived as an additional confirmation of the positive effect of sodium humate fodder additive on fish. According to the survival rate of sterlet from fry to juveniles,

there was no significant advantage of any variant of the experiment, as the absolute difference between the control and experimental variants in the number of fish at the end of the experiment was only 1 fish.

The best result of fodder conversion was recorded in experimental variant 1, with an average value of fodder coefficient of 0.97. In the variants, Experiment 2 and Control the same values of this indicator were obtained (1.04).

Based on the analysis of the results of the experiment conducted in 2018, it can be concluded that the addition of sodium humate at the rate of 60 mg per 1 kg of fish fodder had a positive effect on the growth of yearling sterlet and the efficiency of their use of fodder.

In 2020, a repeated experiment was conducted on yearling sterlet to assess the effect of the fodder additive sodium humate on the growth and survival of fish and their absorption of fodder. The number of fish in each variant of the experiment doubled compared to the previous year. In addition, the concentration of sodium humate in the fodder for the experimental variants was increased: in Experiment 1 – up to 100 and in Experiment 2 – up to 200 mg/kg of fodder. The results of the experiment are presented in Table 3.

Table 3. Results of research conducted in 2020

Indicators	Experiment variant						
	Control		Experiment 1		Experiment 2		
	cage 1	cage 2	cage 3	cage 4	cage 5	cage 6	
Small fry planted	units	100	100	100	100	100	100
		total 200		total 200		total 200	
	average weight, g/units	15.2	23.3	17.5	24.5	29.4	21.3
		average 19.3		average 21.0		average 25.4	
Caught yearlings	units	99	99	100	100	100	100
		total 198		total 200		total 200	
	average weight, g/units	96.3	123.1	129.2	124.2	155.2	121.4
		average 109.8		average 126.7		average 138.4	
Absolute growth, g/units		81.1	99.8	111.7	99.7	123.8	100.1
		average 90.5		average 105.7		average 112.0	
Relative growth, %		143.48	134.98	152.28	132.76	143.74	140.30
		average 140.24		average 142.52		average 142.02	
Specific growth rate, %		1.59	1.50	1.69	1.48	1.60	1.56
		average 1.55		average 1.59		average 1.58	
Fish survival, %		99.00	99.00	100.00	100.00	100.00	100.00
		average 99.0		average 100.00		average 100.00	
Fodder coefficient		1.39	1.24	0.93	1.50	1.15	1.02
		average 1.32		average 1.22		average 1.09	

As the table demonstrates, in terms of relative body weight gain, experimental variants 1 and 2 demonstrated almost the same result (142.52% and 142.02%, respectively), which was higher than in the control (140.24%). The values of absolute body weight gain were higher in experimental variants 1 and 2, which was largely influenced by the superiority of these variants over the control planting material: 15.2 and 21.5 g, or 16.7 and 23.8%, respectively). However, in terms of relative growth and specific growth rate, which consider the difference in the starting weight of fish, the advantage of

experimental variants over the control was not that evident. Thus, the best results in terms of relative growth and specific growth rate in experimental variants 1 and 2 (142.52 and 1.59% and 142.02 and 1.58%, respectively) were only 1.3 and 1.6% higher than the corresponding figures in the control variant.

The survival of sterlet from fry to yearlings in the 2020 experiment was at a high level: from 99% in the control to 100% in both experimental variants. These indicators were significantly higher than the regulatory values (70-80%), due to the high level of the technological process

at the base fishery. A slight advantage for this indicator in the experimental variants over the control (only 1% or 1 fish per cage) does not give grounds for a conclusion about the presence of a positive effect of sodium humate on the survival of sterlet yearling in the first year of rearing under cage conditions.

The most effective use of artificial fodder by fish in terms of fodder coefficient was recorded in experimental variant 2 (1.09), the second result was observed in experimental variant 1 (1.22), and the third – in the control (1.32). The advantage of experimental variants 1 and 2 over the control for this indicator was 7.6 and 17.4%, respectively.

Thus, according to the results of the experiment conducted in 2020, it can be concluded that the addition of sodium humate in concentrations of 100 and 200 mg per 1 kg of fish fodder had a slight positive effect on the growth

of sterlet yearlings, but contributed to a much better fodder conversion.

The main objective of the experiment conducted in 2021 was to collect experimental material to assess by laboratory methods the protectionist effect of humates on protecting the fish organism from the accumulation of heavy metals in the second year of commercial sterlet rearing, to prevent fish diseases and ensure food safety of fish products. Therefore, and considering the fact that simultaneously research was started to assess the impact of humates on sterlet yearlings during their cultivation in a closed recirculating aquaculture system, the cage experiment was conducted in two variants: experimental (200 mg of sodium humate per 1 kg of fodder) and control. The duration of the experiment was significantly reduced compared to previous years of research. The results of the experiment are presented in Table 4.

Table 4. Results of research conducted in 2021

Indicators	Experiment variant				
	Control		Experiment		
	cage 1	cage 2	cage 3	cage 4	
Planted annuals	units	40	40	40	40
		total 80		total 80	
	average weight, g/units	53.7	54.5	53.8	54.0
		average 54.1		average 53.9	
Two-year-olds caught	units	36	32	34	35
		total 68		total 69	
	average weight, g/units	106.3	115.0	109.0	112.2
		average 110.4		average 110.6	
Absolute growth, g/units	52.6	60.5	55.2	58.2	
	average 56.3		average 56.7		
Relative growth, %	65.75	71.39	67.81	70.04	
	average 68.57		average 68.93		

Table 4. Continued

Indicators	Experiment variant			
	Control		Experiment	
	cage 1	cage 2	cage 3	cage 4
Specific growth rate, %	1.46	1.59	1.51	1.56
	average 1.53		average 1.54	
Fish survival, %	90.00	80.00	85.00	87.50
	average 85.00		average 86.26	
Fodder coefficient	1.55	1.71	1.49	1.45
	average 1.63		average 1.47	

As the table demonstrates, the experimental and control variants almost did not vary in terms of body weight gain and growth rate of fish. A slight advantage in these indicators (within 0.5-1.0%) was demonstrated by the experimental variant.

The survival rate of sterlet from yearlings to two-year-olds had no significant differences in the variants of the experiment and, in general, was slightly lower than the technological standard (90%). The latter can be explained by the abnormally intense and long-term development and death of planktonic algae (the so-called “water bloom”) in the Dnipro reservoirs during August-October this year, which caused a significant deterioration in the living conditions of aquatic organisms by reducing the oxygen concentration in the water below the optimum level and a high risk of fish poisoning by decay products of algae (particularly blue-green algae).

The values of the fodder coefficient for the variants of the experiment were significantly higher than those recommended by the fodder manufacturer (1.1-1.2): experiment – 1.43, control – 1.67. Presumably, this was caused by the above-mentioned “water bloom”, which resulted in the deterioration of the quality parameters of the aquatic environment for fish,

in particular – to reduce the concentration of oxygen dissolved in water. But, even under unfavourable growing conditions, the addition of sodium humate to fish fodder had a positive effect: using the fodder by fish in the experimental variant was 10.9% more effective than the control one.

After completion of the experiment, fish material was selected for testing for heavy metals and transferred to a certified laboratory for ecological and toxicological research.

Conclusions and Perspectives

According to the results of the research, the following was identified:

1. Using humates as a fodder additive is rather common in livestock farming. However, the influence of humates on the growth rate and survival of fish farming objects, in particular sturgeon, has been understudied.

2. The addition of sodium humate to fish fodder at a concentration of 60, 100, 120 and 200 mg/kg of fodder did not significantly affect the growth rate of sterlet yearlings in the cage method of rearing. The advantage of the experimental variants over the control for this indicator was within 1.0-1.6%.

3. There was no significant effect of fodder additive humates on the survival of sterlet

yearlings during their cultivation in experimental cages of a production enterprise with a high level of technological support of the production process.

4. The conversion of fish fodder with the addition of sodium humate was noted to be better by 6.7-17.4% when feeding to yearlings and two-year-old sterlet.

5. According to the results of the experiments, the greatest level of positive impact on the results of sterlet rearing in cages had to

feed fish with the addition of humates at a concentration of 200 mg/kg of fodder.

6. It is considered promising to explore the effect of fodder additives of humates on the growth and survival of valuable fish farming objects under different conditions of keeping, in particular – in closed recirculating aquaculture systems, and to continue the search for the optimal concentration of these additives in fish fodder for different age groups of fish.

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Дослідження впливу кормової добавки гумату натрію на стерлядь за садкового способу вирощування

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Анотація. Гумінові препарати використовують, як мікродобрива у рослинництві і стимулятори росту у тваринництві, в аквакультури також існує позитивна дія цих сполук на окремі об'єкти культивування, але їх застосування за вирощування риби ще недостатньо вивчене. Метою роботи було висвітлити результати експерименту з оцінки впливу кормової добавки гуматів на швидкість росту і виживаність різних вікових груп стерляді (*Acipenser ruthenus* L., 1758) та конверсію корму рибою за утримання в умовах аквакультури. Було проведено серію експериментів з годівлі стерляді кормами з добавкою гумату натрію. Дослідження проходили у 2018, 2020 і 2021 рр. у виробничих умовах садкового рибницького господарства, розташованого на Канівському водосховищі. Було оцінено вплив різних концентрацій кормової добавки гумату натрію на цьоголітків і дволітків стерляді. Гумат натрію наносили на комбікорм для відповідних груп стерляді шляхом розпилювання його водного розчину у визначених пропорціях з подальшим висушуванням. Встановлено, що додавання гумату натрію до рибного комбікорму в концентраціях 60, 100, 120 і 200 мг/кг корму суттєво не вплинуло на швидкість росту стерляді. Так, перевага дослідних варіантів над контрольним за цим показником була незначною, в межах 1,0-1,6 %. Не встановлено впливу гумату натрію на виживаність цьоголітків стерляді, за їх вирощування в садках. Разом із тим, відмічено кращу на 6,7-17,4 % конверсію кормів з добавкою гуматів цьоголітками і дволітками стерляді. За результатами експериментів найкращий результат отримано у варіанті з використанням кормової добавки гуматів у концентрації 200 мг/кг корму. Виходячи з результатів досліджень, встановлено, що в умовах аквакультури доцільно використання гумату натрію, як кормової добавки для цьоголіток і дволіток стерляді, призначеної для підвищення конверсії корму

Ключові слова: біологічно активні речовини, рибництво, осетрові риби, виживаність, швидкість росту, конверсія корму