Lignohumate AM – prospects for use in floriculture and reproduction

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Abstract. Improving agricultural technology and supporting plant reproduction in the collections of botanical gardens remain relevant. Using the example of species and varieties of the genus *Iris* L., the effectiveness of using the preparation Lignohumate AM was studied. Root watering and foliar treatment of varieties with the preparation stimulated leaf growth. However, the preparation was ineffective for improving the decorativeness of plants. Treatment of plants with Lignohumate had a positive effect on the water regime of irises. Water deficit decreased by 2,8%−5,3% as a result of root treatment, water-holding capacity increased by 5,7% during irrigation and mixed treatment. The preparation had no effect on the germination of seeds of *I. sibirica* and *I. pseudacorus*, but was highly effective in long-term experience. Lignohumate contributed to a reduction in the loss of one-year-old *I. sibirica* plants by 20,8%, as well as the growth of surviving *I. pseudacorus* plants by 39,7%. The stimulator also showed a significant prolonged growth-stimulating effect, which contributed to improving the quality of seedlings. The length of leaves under the influence of the preparation increased by 64% for *I. sibirica* and 17% for *I. pseudacorus*, the width of leaves of *I. sibirica* increased by 14%. Based on the results of the study, the growth stimulator Lignohumate AM can be considered an effective promising preparation for use in floriculture and the reproduction of decorative, rare species of iris.

1 Introduction

Humic substances are included in many new preparations intended for agriculture [1]. Traditional agricultural technology, which includes watering plants using growth stimulants, is complemented by the technique of leaf spraying with further cuticular transport of humates [2]. Humic acids are characterized by hormone-like activity and are used as stimulators of shoot and root growth [3], increasing the content of chlorophyll, sugars, protein, as well as enzyme activity [4]. It is especially important that humic substances have a positive effect on plants under unfavorable conditions: during drought, during recurrent frosts, excess nitrogen or pesticides in the soil, oxygen starvation and various diseases [5], mitigate salt stress [6], increase productivity and product quality [7−8]. The qualities of humates have traditionally been studied on agricultural crops. At the

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same time, the biological activity of humic preparations in the field of floriculture has been studied much less well.

Botanical gardens contain extensive collections of floral and ornamental plants. Improving agricultural technology and searching for opportunities to maintain and reproduce collections in often unfavorable conditions remain relevant. In particular, this applies to modern garden iris varieties introduced into cultivation in climatic conditions different from the place of selection. Not only varieties, but also species of irises, including those with rare or protected status, have found application in floriculture. Thus, *I. sibirica* and *I. pseudacorus*, promoted as ornamental plants [9], are listed in the Red Books [10−11] and are prohibited from being removed from nature. In this regard, the reproduction of species in artificial conditions becomes relevant.

The purpose of the research is to study the effectiveness of using the preparation Lignohumate AM in floriculture and reproduction using the example of species and varieties of the genus *Iris* L.

2 Materials and research methods

The field experiment was launched in the growing season of 2022 on several varieties of garden iris (Fig. 1). The soil in the experimental plot is gray forest with a humus content of 5,7−6,2% (SUST 26424-85), mobile phosphorus − 141−200 mg/kg of soil, mobile potassium − 132−145 mg/kg (SUST 26204-91), nitrate nitrogen – 9,3 mg/kg (SUST 26951-86), pH of saline soil solution – 6,3−6,5 units.

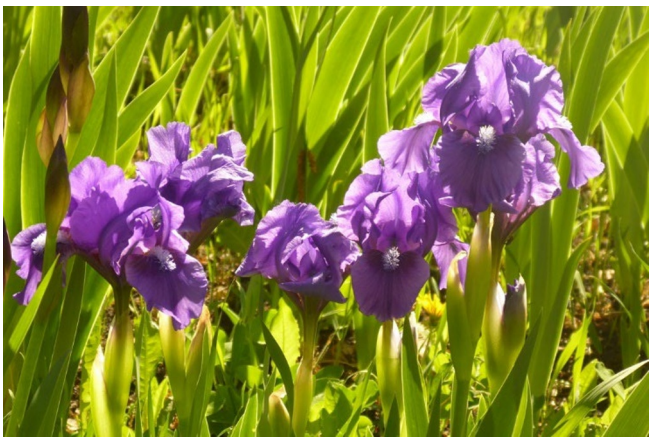
The average annual temperature in 2022 was 0,7°C above normal. The spring was cool, the average temperature in April reached 1,6°C, which is below the long-term average of 5,2°C. May was normal in terms of temperature and precipitation. The weather conditions in the summer of 2022 were characterized by significant polarity. In June, there was an excess of moisture − 132 mm of precipitation fell against 67 mm as normal. In July, August and September, on the contrary, there was a drought − the amount of precipitation was 17%, 22,4% and 43,8% of the norm. During the same period, hot weather was recorded with temperatures exceeding the average by 0,7°C, 2,5°C and 0,4°C, respectively.

The experiments were carried out as follows. During the growth, budding and flowering phases, the leaves were sprayed with a working solution (5 g/l), experimental plants were watered (1 l per individual plant), and both options were combined − foliar feeding with root feeding. Plants treated with water served as control.

The influence of the growth regulator on iris varieties was assessed using several parameters. Morphometric parameters of above-ground organs were measured during the phase of maximum development of each of them: peduncle during flowering, flowers during the period of full opening, leaf blades during the season of secondary growth. Physiological parameters (total water content, water-holding capacity and leaf water deficit) were determined using generally accepted methods [12].

‘Before The Storm’

‘Edith Wolford’



‘Banbury Ruffles’

Fig. 1. Objects of study − garden iris varieties

The studied preparation Lignohumate AM is a complex of humic (80−90%) and fulvic (15%) acids, enriched with microelements in chelate form (K − 9%, S − 3%, Fe – 0,2%, Zn, Cu, Co, Mn – 0,12% each, B – 0,15%, Mo – 0,015%, Se – 0,005%). The concentration of hydrogen ions (pH 6%) is 7−10%.

In a one-year laboratory experiment (2022−2023), the effect of the preparation on seed germination, survival and morphometric parameters of plant seedlings was determined (Fig. 2). Seed germination was calculated by counting germinated seeds to the number of sown seeds in % on 29, 43 and 62 days. Plant survival was determined one year after the start of the experiment. Taking into account the biometric parameters of seedlings included measuring the length and width of the largest leaf in the blade of one-year-old plants.

I. pseudacorus *I. sibirica*

Fig. 2. Objects of research − seeds of iris species

Seeds of 100 pieces were placed in gauze bags and soaked before sowing for 12 hours in a 1% working solution (0,1 kg of the preparation per 10 liters of water). Seeds soaked in water served as control. Seeds were sown in boxes filled with a mixture of soil and sand (in a ratio of 2:1). The experiment was repeated three times.

Statistical processing of the results was carried out using descriptive statistics using the Student coefficient.

3 Results and its discussion

Table 1 shows the results of morphometric measurements of experimental plants, taking into account treatment options. For a partial bush, leaf size is of great importance, since this organ takes on the main functions of photosynthesis. It was found that root treatment contributed to the growth of leaf parameters of the varieties ‘Banbury Ruffles’ (by 8,6% and 5,6% respectively) and ‘Before The Storm’ (by 6,5% and 3,7% respectively). In the case of leaf treatment, a significant increase in the length (‘Before The Storm’ – by 7,8%) and width of vegetative shoots (‘Banbury Ruffles’, ‘Before The Storm’ – by 5,6% and 3,7% respectively) was revealed. There were no differences between the indicators of control and joint treatment (root + non-root).

Table 1. Morphometric parameters of plants depending on treatment with Lignohumate AM (average ± standard deviation)

Variety	Plant organs	Parameters, cm	Treatment options			
			root	non-root	root + non-root	control
‘Banbury Ruffles’	leaves	length	41.5±2.3*	36.8±3.1	35.3±2.1	38.2±1.8
		width	1.9±0.1*	1.9±0.1*	1.8±0.3	1.8±0.2
	shoots	length	19.2±2.4	21.4±2.2	20.8±3.4	22.9±2.6
		width	0.6±0.1	0.6±0.1	0.7±0.1	0.6±0.1
	flower	diameter	10.1±0.3	10.1±0.7	10.3±0.3	10.1±0.6
		height	3.9±0.5	4.4±0.7	4.1±0.4	4.4±0.2
	foul	length	6.1±0.2	6.2±0.2	6.1±0.1	6.0±0.3
		width	3.6±0.2	3.8±0.4	3.7±0.1	3.8±0.1
	standard	length	5.8±0.2	6.1±0.2	5.9±0.3	6.1±0.3
		width	4.1±0.1	4.1±0.1	4.1±0.2	4.1±0.2
‘Before	leaves	length	52.8±3.7*	53.5±4.1*	48.7±3.7	49.6±3.7

The Storm'		width	2.8±0.4*	2.8±0.2*	2.5±0.4	2.7±0.3
	shoots	length	68.5±4.1	73.0±3.9	71.4±4.4	73.1±5.2
		width	1.0±0.1	1.2±0.1	1.0±0.1	1.1±0.1
	flower	diameter	11.5±1.4	11.0±0.8	10.8±0.8	11.1±1.2
		height	6.0±0.5	6.2±0.5	6.0±0.6	6.1±0.4
	foul	length	11.0±0.5	11.1±0.6	11.0±0.8	11.0±0.6
		width	7.8±0.2	8.0±0.3	8.0±0.2	8.1±0.3
	standard	length	7.9±0.3	8.0±0.3	7.9±0.4	7.9±0.4
		width	6.5±0.2	6.4±0.1	6.5±0.3	6.5±0.1
'Edith Wolford'	leaves	length	43.8±7.3	39.1±6.3	44.7±6.6	47.3±7.0
		width	3.4±0.7	2.9±0.5	3.1±0.5	3.1±0.3
	shoots	length	69.0±3.8*	62.0±3.0	56.5±6.1	63.0±4.1
		width	0.9±0.1	1.0±0.2	1.0±0.1	1.2±0.1
	flower	diameter	15.3±0.9	15.1±1.0	14.8±1.1	15.3±1.2
		height	11.0±1.0	11.2±1.0	10.9±0.8	11.0±0.9
	foul	length	9.0±0.5	9.0±0.3	9.1±0.4	9.0±0.4
		width	7.6±0.3	7.7±0.5	7.4±0.4	7.7±0.3
	standard	length	8.5±0.3	8.6±0.5	8.4±0.4	8.6±0.5
		width	7.3±0.2	7.4±0.1	7.3±0.1	7.3±0.2

Note: * − differences between control and experimental indicators are significant at $p \leq 0,05$

The parameters of the flower, which are important for the formation of the decorative qualities of the plant, were surprisingly uniform. There were no significant differences between the control and experimental variants. The parameters of generative shoots were also close to the control. Only in the 'Edith Wolford' variety did the shoot length significantly increase by 9,5% in the case of root treatment. Thus, the preparation had virtually no effect on the decorative properties of irises.

The state of the water regime of plants significantly affects their growth, development and productivity. The higher the water content and water-holding capacity and the lower the water deficit, the more the plant is adapted to stress factors. Figure 3 shows the results of the preparation's influence on the water regime of irises. During the experiment, it was found that the water content in the tissues of experimental plants did not differ from the control. The water-holding capacity of leaves ('Before The Storm') increased by 5,7% in the case of root and mixed treatments. Water deficit decreased by 2,8–5,3% during plant irrigation with Lignohumate, but other experimental options did not affect the indicator values.

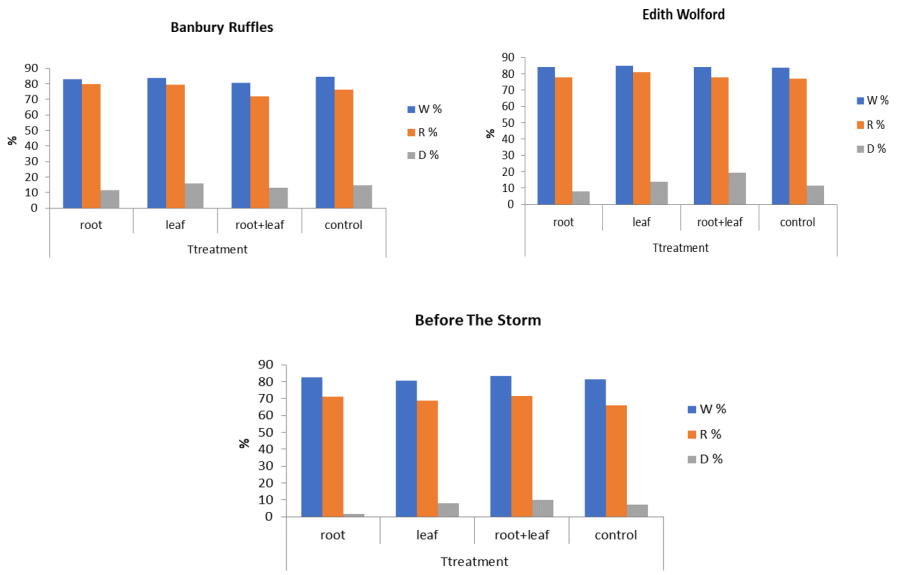
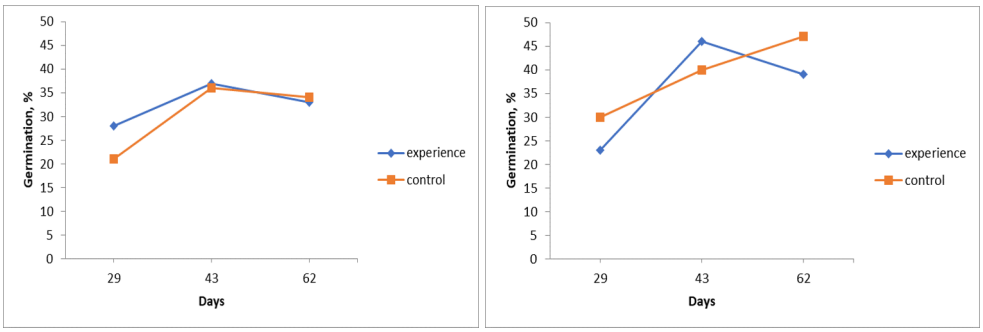


Fig. 3. Effect of the growth regulator Lignohumate AM on the water regime of irises
W – total water content, R – water holding capacity, D – water deficit, %

The results of studies of the germination of seeds of species irises are shown in Figure 4. Treatment of *I. pseudacorus* seeds with the preparation increased the germination energy by 7%, however, further accounting of laboratory germination showed no differences between the indicators of the experiment and control. By the end of the second month, it was 33−34%, having decreased slightly by 2−4% due to the loss of seedlings compared to the germination results on the 43rd day.

There was also no significant difference between the germination values of *I. sibirica* seeds. The positive effect of the preparation is noted on the 43rd day − germination increased by 6%. However, by the end of the second month, the loss of seedlings in the experiment was 7%, which neutralized the previous result.

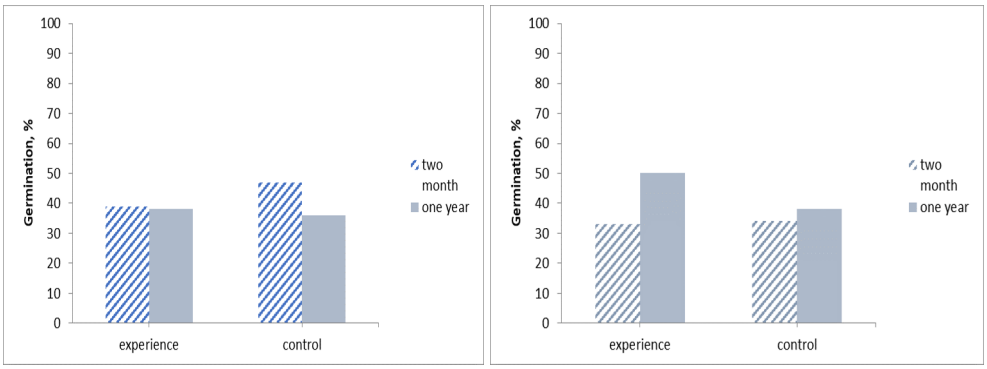


I. pseudacorus *I. sibirica*

Fig. 4. Laboratory germination of seeds of representatives of the genus *Iris* L.

Observations on one-year-old plants are reflected in Figure 5 and Table 2. Significant differences between germination rates in the control and experimental groups ($p \geq 0.05$) show that the preparation promotes the resistance and survival of plants, as well as an increase in the number of seedlings over a long period. In the case of *I. sibirica*, loss of one-

year-old seedlings was observed by 23,4% in the control and only 2,6% in the experiment. The decrease in the loss of experimental plants thus amounted to 20,8%.



I. sibirica *I. pseudacorus*

Fig. 5. Survival rate of one-year-old seedlings of representatives of the genus *Iris* L.

Table 2. Morphometric parameters of leaf length of one-year-old plants

I. sibirica				*I. pseudacorus*			
length, cm		width, cm		length, cm		width, cm	
experience	control	experience	control	experience	control	experience	control
23±2.3	14±1.9	0.4±0.2	0.35±0.2	35±4.1	30±3.8	0.4±0.1	0.38±0.2

Compared to two-month-old seedlings, the number of one-year-old *I. pseudacorus* plants increased by 51,5% in the experiment, which is 39,7% more than in the control. The number of surviving plants in the control increased by only 11,8%.

The preparation had an effect on the morphometric parameters of leaf length of one-year-old irises (Table 2). In both species, the experimental group of plants showed a significantly longer leaf length compared to the control (by 64% for *I. sibirica* and 17% for *I. pseudacorus*). The leaf width of *I. sibirica* also differed significantly from the control variant (by 14%). However, no differences in this parameter were found for *I. pseudacorus*.

4 Conclusions

Root irrigation and foliar treatment of garden iris varieties with Lignohumate AM stimulated plant growth in terms of leaf morphometric parameters. With the only exception (‘Edith Wolford’, root treatment), no effect of Lignohumate on the growth of generative organs – flowers and peduncles – was found.

Treatment of plants with Lignohumate had a positive effect on the water regime of irises. Water deficit was reduced by 2,8%−5,3% as a result of root treatment, and water holding capacity increased by 5,7% during irrigation and mixed treatment.

The preparation had no effect on the germination of seeds of *I. sibirica* and *I. pseudacorus*, but was highly effective in long-term experience. Lignohumate contributed to a reduction in the loss of one-year-old *I. sibirica* plants by 20,8%, as well as the growth of surviving *I. pseudacorus* plants by 39,7%. The stimulator also showed a significant prolonged growth-stimulating effect, which contributed to improving the quality of seedlings. The length of leaves under the influence of the preparation increased by 64% for *I. sibirica* and 17% for *I. pseudacorus*, the width of leaves of *I. sibirica* also increased by 14%.

Based on the results of the study, the growth stimulator Lignohumate AM can be considered an effective promising preparation for use in floriculture and the reproduction of decorative, rare species of iris.

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