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Influence of Increasing Doses of Herbal Cellulose Bleaching Lye on Crop Yields

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Abstract

The team of Russian scientists has developed a new technology of pulp production from herbaceous vegetation, which can significantly reduce the negative impact of pulp and paper industry on the environment and become a very significant support for the development of agriculture. Laboratory-model and field experiments were carried out under conditions of grey forest soil. 2--12 l/m^2 single application of boring liquor increased the productivity of tested crops within two years, while higher doses (16--48 l/m^2) showed a reliable decrease in the yield of both crops, however, in the second year the negative impact of increased doses significantly decreased.

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1. Introduction

The most important condition for the sustainable development of rural areas is the diversification of the rural economy, i.e. the expansion of the range of products produced with a view to obtaining economic benefits, ensuring employment and raising the living standards of the rural population. Another equally important condition for the sustainable development of rural areas is the ecologization of production and expanded reproduction of soil fertility.

At the same time, both of these tasks can be solved by mastering the new innovative technology of pulp production from herbaceous vegetation (herbal cellulose), namely from by-products of crop production -- hay.

As it is known, cellulose finds the widest application in all branches of national economy. Now the basic quantity of cellulose receives from wood of coniferous breeds as deciduous breeds for this purpose are unsuitable.

Depletion of coniferous wood and the need for constant growth in the production of cellulose make it necessary to use herbaceous vegetation as raw material for deciduous species. For many countries and regions, the most promising is the production of cellulose from herbaceous vegetation, as the rate of reproduction of herbal mass significantly exceeds the reproduction of wood mass [1, 7--9, 11].

Unfortunately, all methods of wood pulp production applied nowadays are ecologically unfavorable, create difficult to solve problems at treatment facilities, and adversely affect the environment and human health. Against this background, a new technology for obtaining herbal cellulose, developed by a team of scientists from OAO NIIneftepromkhim (Russian Federation, Republic of Tatarstan, Kazan) under the leadership of O.K. Nugmanov and N.A. Lebedev [2--6], looks very tempting.

The new technology for obtaining herbal semi-cellulose (shortened technological cycle) and cellulose (full technological cycle) is devoid of the disadvantages inherent in the existing technologies. "The technology is based on a multifunctional reactor of continuous operation, which allows simultaneous "cooking" of hay, removal of the wood part of the stem bonfire (delignification) and crushing of cellulose fibers. Pulp mass from herbaceous plants is obtained without a accelerator, at atmospheric pressure and temperature of 1000C. At the stages of pumping, washing and squeezing it is provided the use of continuously operating centrifuges, for bleaching it is used ecologically safe hydrogen peroxide, and for drying the fiber mass --microwave equipment" [2, 3].

The new technology, according to its developers, significantly reduces the negative impact of the pulp and paper industry, opens up new opportunities for its development and can be a very significant support for the development of agriculture.

From an environmental point of view, the most important advantages of this technology are "Preservation of the country's forest fund, reduction of industrial effluents by 6 times; reduction of water turnover by 5 times; refusal from environmentally harmful chlorine derivatives and buffer catalysts containing sulfur; absence of gas emissions and formation of less toxic industrial effluents" [2, 4]. Proceeding from the latter, we can assume that the sewage from herbal pulp can be disposed of in a relatively simple and cheap way, namely in agriculture for irrigation and fertilizer irrigation. However, to date, there is no information about the effect and consequences of waste technology of obtaining herbal cellulose (bleaching alkalis) on crop productivity, which caused the need for our research.

In the initial stage of research, in laboratory-model experiments, we found out that there is a close negative correlation between the concentration of solutions of boring alkalis and germination of seeds of tested crops (spring rape, oilseed radish, oats) (r=--0.67...0.94). At the same time, strongly diluted lye solutions slightly increased seed germination and weight of seedlings. The nature of changes in seed germination at their direct contact with boring alkalis showed that the studied alkalis contain substances, both depressing and stimulating seed germination [10].

The purpose of this study was to assess the effects and implications of the increasing herbal pulp doses produced by the new technology on crop yields, which may be a basis for justifying the potential for the disposal of boring liquors by application to soil.

2. Materials and Methods

The object of the study was a bleaching alkali, which is a drain after hot washing of the cellulose mass of rape, the effect of which on plants was studied in the laboratory-model and field experiments.

The study was conducted in the Predkamsk agro-production zone (Predkamye) of the Republic of Tatarstan, located in the central part of the Volga Federal District of the Russian Federation. The Predkamye River occupies the northern part of the Republic of Tatarstan: the Predkamye River is limited to the southwest of the country. Volga, Kama River from the south. The relief is a low, dumpy plain, the highest altitude of which reaches 240...280 m. Its area is 21.8 thousand km^2, which is 32.2 % of the total area of the Republic of Tajikistan. The main part (67 %) of the agricultural lands of the Predkamsk zone is located on various subtypes of grey forest soils.

In terms of thermal resources, the Predkamye region belongs to the temperate-cool zone of the republic: the average annual air temperature is 2.5 °C, the sum of temperatures above 10 °C is 2150. Annual precipitation is 440 mm. The amount of precipitation during the growing season varies within the limits of 245...265 mm, the hydrothermal coefficient (HTC) is slightly higher than one. Average duration of vegetation period is 160 days, average thickness of snow cover is 39...44 cm.

The grey forest soil, which is prevailing in the study area, was used for laboratory-model and field experiments.

Grey forest medium loamy soil used in laboratory-model experiment was characterized by low humus content (2.6 %), medium acid reaction (pHsol.=5.The laboratory-model experience on the estimation of the effect of butter liquor on the initial growth of oil-bearing radish (Brassicarapa) was carried out in accordance with GOST R ISO 22030-2009. Oilseed radish seeds were sown after monthly composting of gray forest soil with increasing doses (from 6.7 to 267 ml/kg of soil) of bleaching lye (Table 1). Soil moisture content of 60 % of the total soil moisture content was maintained by weight irrigation, both during composting and after sowing the sample crop. The number and total weight of seedlings were taken into account 2 weeks after sowing.

The field experiment was also carried out on grey forest medium loamy soil. The arable layer of the plot was characterized by low humus content (2.7 %), high mobile phosphorus content (156 mg/kg), high mobile potassium content (138 mg/kg) and weakly acidic reaction of the environment (pHsol.=5.2).

A single application of bleaching liquor was carried out three days before sowing the radish (Brassicarapa) according to the experiment scheme (Table 2). The lye doses ranged from 2 to 48 l/m^2, which per hectare were 20 and 480 m^3/ha, respectively. Repetition of the experiment is 4-fold, the area of the plots is 0.5 m^2, the plots are placed systematically in 4 tiers, the norm of oilseed radish sowing is 3 million pieces/ha of germinated seeds, the depth of seed depositing is 2 cm. During the vegetation period, a complex of agricultural practices was carried out to protect plants from weeds, pests and diseases. All works in the experience were performed manually. Weather conditions of vegetation period for growth and development of oil-bearing radish were quite favorable.

Seeds were treated with Kinto Duo at the rate of 2.5 kg/t before sowing to protect against root rot, dust and coated head. Seeding rate -- 5 million pcs/ha of germinated seeds, seed depositing depth - 4 cm. During the oat vegetation period, the crops were sprayed twice with Timus fungicide (against powdery dew and crowned rust) and Tagore insecticide (against cereal flies, aphids).

In general, meteorological conditions of the growing season for growth and development of oats were satisfactory.

Soil analyses were carried out in the laboratories of FSBI CAC "Tatarskiy" and the Department of Agrochemistry and Soil Science of Kazan State University.Agrochemical parameters of soil are determined by conventional methods: the content of soil moisture in accordance with GOST 28268-89, the content of humus in accordance with GOST 26213-91, the content of mobile compounds of phosphorus and potassium in the modification of CINAO in accordance with GOST 26207-91, the preparation of salt extract determination of its pH in accordance with the method of CINAO in accordance with GOST 26483-85.Statistical processing of digital data was performed by the method of dispersion analysis with the help of MicrosoftOfficeExcel 2007 software. Correlation and regression analysis was performed using Statisticaver software. 5.5 AforWindows.

3. Results and Discussion

The influence of increasing doses of bleaching lye on the weight of oilseed germline seedlings in the conditions of laboratory-model experiment is demonstrated by the data of Table 1.

Table 1: Influence of increasing doses of bleaching lye on the weight of oilseed germline seedlings in the conditions of laboratory-model experiment.

Grinding liquor dose, ml/kg soil	Weight of seedlings	
	g/beverage container	%
0 (control)	1.275	100
6.7	1.398	110
13.4	1.475	116
40.2	1.238	97
80.3	1.288	101
160.5	1.175	92
214.0	1.275	100
267.0	1.298	102
MED_{05}	0.102	8

The results of the accounting of the above-ground mass of oil-bearing radish seedlings showed that the tested sufficiently high doses of bleaching lye (up to 267 ml/kg of soil, which approximately corresponds to the dose of 80 l/m^2) did not lead to statistically significant reduction of the total weight of seedlings. relatively small doses of alkali application (6.7 and 13.4 ml/kg of soil) had a stimulating effect on the initial growth of seedlings.

However, the study of the response of seedlings to the increasing doses of bleaching lye cannot give a complete picture of the actual phytotoxicity of the lye for a long period of time, due to the fact that the seedlings mainly use seed nutrients. This is confirmed by the significant difference in the response of oil-bearing radish to the same doses of bleaching lye in the conditions of laboratory-model and field experiments.

The effect of increasing doses of bleaching lye in the first year of application to the productivity of oil-bearing radish in the field experiment is illustrated by the data of Table 2.

Introduction of boring liquor into grey forest soil in doses from 2 to 12 l/m2 did not lead to decrease in productivity of oil-bearing radish. On the contrary, there was a statistically significant increase in the dry above-ground mass yield of the radish. At application of boring liquor in doses of 2, 6 and 8 l/m2 the accumulation of above-ground mass increased by 18, 9 and 15 %, respectively. Introduction of boring liquor in the dose of 16 l/m2 resulted in the reduction of above-ground mass yield by 40 %. Further increase of alkali dose up to 32 and 48 l/m2 resulted in adequate decrease of yield. Only a few plants survived at the plots with the maximum dose of bleaching lye and the accumulation of above-ground mass decreased by 10 times.

The effect of increasing bleaching lye doses on the yield of radish oilseed is generally similar to that of above-ground mass accumulation. The main conclusion is that the bleaching lye dose from 2 to 12 l/m^2 provided a reliable increase in seed yield by 10--18 %. The maximum increase in yield (18 % to the control level) gave a dose of 8 l/m^2. A significant decrease in radish seed yield (by 24 % to the control level) was detected with the addition of 16 l/m^2 of lye. More than threefold decrease of seed productivity and almost complete absence of seeds was noted at application of 32 and 48 l/m^2 of lye respectively.

The dependence of oil-bearing radish productivity on increasing doses of lye is most clearly demonstrated by the graphs in Fig. 1. As can be seen, the dependence of yield of both above-ground mass and seeds on the lye dose was very close, as evidenced by the values of determination coefficients (R^2).

Table 2: Influence of increasing doses of bleaching lye in the first year of application on productivity of oil-bearing radish in conditions of grey forest soil (action).

Lye dose, l/m^2	Dry matter from the aboveground mass		Grain yield	
	g/m^2	% to control	g/m^2	% to control
0 (control)	917	100	223	100
2	1082	118	256	115
4	982	107	245	110
6	998	109	241	108
8	1054	115	263	118
12	963	105	245	110
16	553	60	173	76
32	318	35	70	31
48	90	10	8	4
MED_{05}	70	8	21	9

Close correlation of radish seed yield with the doses of lye was higher (R^2 = 0.9114) than the dependence of the yield of the whole above-ground mass (R^2 = 0.8923).

Thus, under the conditions of field experience, single application of lye up to 12 l/m^2 inclusively increased the yield of radish oilseed by 10--18 %, but the dose of 16 l/m^2 led to a significant decrease in both the accumulation of above-ground mass and seed productivity.

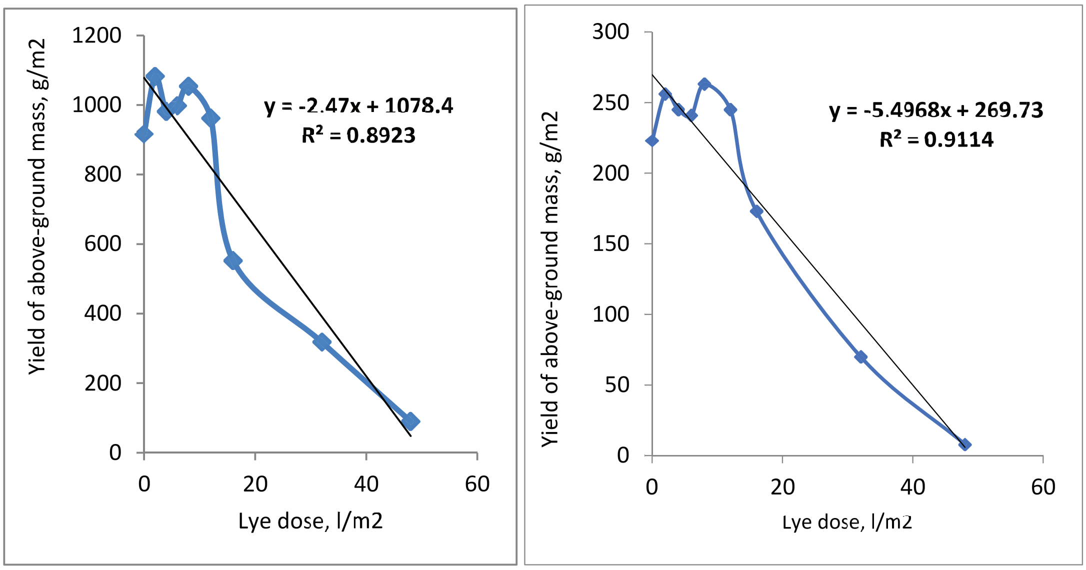

Figure 1: Correlation of oil-bearing radish yield from increasing doses of boring liquor in the conditions of field experience in the first year of application (effect).

Accounting for the above-ground mass of sowing oats sown one year after the introduction of alkali showed that statistically significant decrease in the marketable part of the crop (grain) was detected by the doses of lye, introduced in the previous year in doses of 16 l/m^2 and more (Table 3, Fig. 2).

Table 3: Influence of increasing doses of bleaching lye on productivity of oats under conditions of grey forest soil on the second year after application (effect).

Lye dose, l/m^2	Dry matter from the aboveground mass		Grain yield	
	g/m^2	% to control	g/m^2	% to control
0 (control)	679	100	289	100
2	665	98	295	102
4	758	112	336	116
6	692	102	312	108
8	666	98	318	110
12	631	93	279	97
16	579	85	277	96
32	548	81	202	70
48	337	50	134	46
MED$_{05}$	54	8	25	9

From the maximum dose of lye (48 l/m^2) the yield of above-ground mass and grain decreased by 50 and 54 %, respectively. According to the other variants of the experiment, the yield of dry above-ground mass was close enough to the control level.

Statistically reliable increase of above-ground mass yield by 12 % was found from the lye dose of 4 l/m^2.

Positive effect of lye was more pronounced on commodity part of yield. Stimulating influence of lye on sowing oats grain yield manifested itself at its application in doses of 4 and 8 l/m^2.

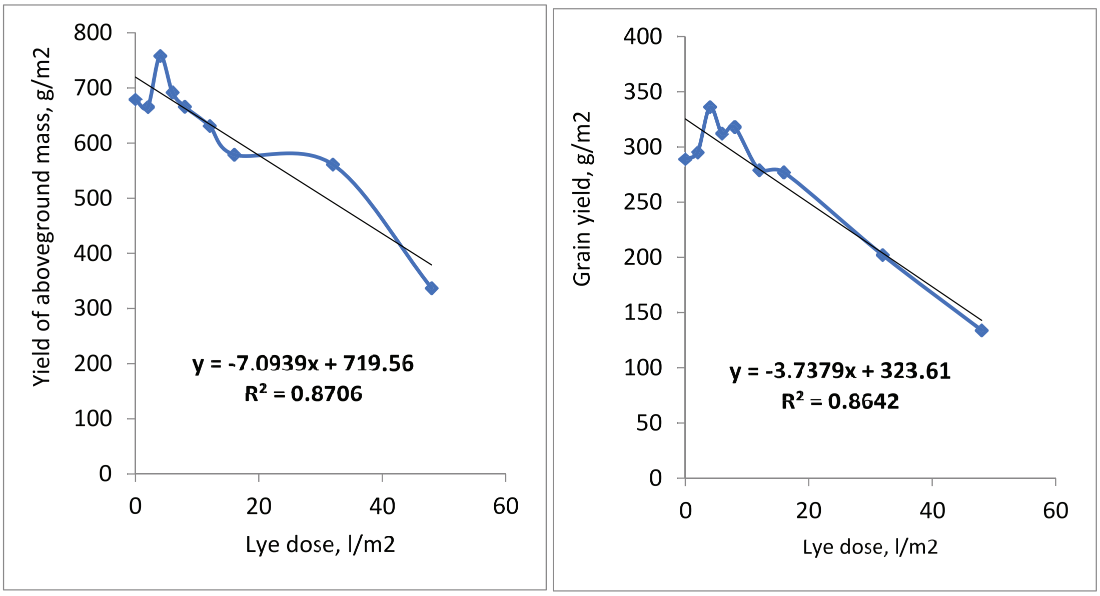

Figure 2: Correlation of sowing oats yield from increasing doses of bleaching lye in the conditions of field experience for the second year after application (effect).

Comparison of the yielding data of oil-bearing radish and oats shows that on the plots that received increased doses of lye last year, there is a significant decrease in soil phytotoxicity and increase in plant productivity. Thus, if from doses of 16, 32 and 48 l/m^2 per year of application (action) dry above-ground mass yield decreased by 40, 65 and 90 %, respectively, to the control level, for the second year after application (action) the reduction of this indicator was only 15, 19 and 50 %.

The effect of increasing doses of bleaching lye on the productivity of the marketable part of the crop was approximately the same. A year after the application of lye, the negative impact of its increased doses (16--48 l/m^2) on the growth and development of oat grain significantly decreased. For example, if from the doses of 16, 32 and 48 l/m^2 oilseed yield of radish seeds decreased by 24, 69 and 96 %, the mentioned doses reduced the yield of oat grain accordingly only by 4, 30 and 54 %. Graphs of Fig. 2 show close negative correlation between dry above-ground mass (R^2=0.8706) and grain (R^2=0.8642) yield from increasing doses of lye.

4. Conclusion

In the conditions of field experience, the single application of bleaching lye on weakly acidic grey forest soil with the dose of 16 l/m2 in the first year led to a significant decrease (24 %) in the yield of oilseed radish seeds. However, the negative influence of the mentioned lye dose on the sowing oats yield for the next year has not appeared any more. Decrease of reproductive organs yield within two years within the range from 30 to 69 % was observed at single application of 32 l/m^2 of lye. The maximum tested dose (48 l/m^2) in the year of application practically resulted in the death of oil-bearing radish, and in the second year reduced the yield of oat grain by more than 2 times. At the same time, a single application of butter liquor on slightly acidic grey forest soil up to 12 l/m^2 not only did not have a negative effect on the generative productivity of tested crops (oil-bearing radish, oats), but even increased the yield of seeds by 10--18 %. This fact, in our opinion, may be the basis for substantiation of the possibility of utilization of bleaching lye through the introduction of acidic grey forest soils.

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