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PHYTOMELIORATION OF SECONDARY SALINE IRRIGATED LANDS OF THE SOUTHEAST OF KAZAKHSTAN

Abstract. The article describes phytomeliorative methods for increasing the productivity of saline irrigated lands by sowing phytomeliorants and treating seeds and spraying the above-ground part of crops with PA-2,1 (adaptogen) preparation. The results of observations of the growth and development of phytoemeliorants showed that phytoemeliorants intensively grew, developed and accumulated aboveground masses, especially on variants treated with adaptogen. The intensive growth and development of phytomeliorants contributed, at the end of the growing season, to a decrease in the salt content in the soil and an increase in the yield of soybeans, sorghum, and Sudan grass. The conducted economic calculations to determine the effectiveness of cultivation of phytomeliorants on degraded irrigated lands showed that cultivation of phytomeliorants on saline soils, along with a decrease in the content of salts in the soil, makes it possible to obtain net incomes with high profitability. The article presents the results of field research on the cultivation of basic and intermediate crops and the economic justification for obtaining two crops per year.

Key words: phytomelioration, drip irrigation, fodder units, Sudan grass, sorghum, soy, adaptogen (PA-2.1).

Introduction. The current condition of secondary saline irrigated lands in the southeast of Kazakhstan requires a new approach to the problem of melioration of saline soils. Due to the lack of a collector-drainage systems, improperly using of the irrigation systems and crop rotation in agriculture, irrigated lands were salinized and the area of irrigated land decreased from 2.3 million hectares to 1.3-1.4 million hectares. Therefore, in the message to the people of Kazakhstan on January 31, 2017, the President of the Republic of Kazakhstan Nazarbayev N.A. noted that within 5 years, it is necessary to increase the area of irrigated land by 40%, and reach to 2 million hectares [1].

According to the Concept on the transition to the "green" economy by 2030, 15% of the agricultural lands will be transferred to water-saving technologies. It is also necessary to develop agrarian science and create experimental agro- innovative clusters [2].

In connection with the above-mentioned programs for the development of the agriculture in the country, especially in irrigated systems, the development and introduction of new methods to improve the productivity of saline irrigated land is an actual challenge. Therefore, there exists a solution which is the introduction of phytomeliorative crop rotations, where salt-tolerant phytomeliorants are cultivated to promote the reduction of salts in the soil and increase its fertility.

The research results show that the agribiological methods for improving degraded irrigated lands are a resource-saving and inexpensive method for the restoration of saline lands [3-5].

Materials and methods. The phytomeliorative role of the safflower and sweet clover that contributed to a decrease of salt content in saline soils by 6-8% has been revealed by experiments carried out earlier [6, 7]. The field research on developing techniques for increasing the productivity of saline irrigated lands by cultivating phytomeliorants was carried out on gray-brown soils of Akdalinsk in Almaty oblast.

The climate of the Akdalinsk is sharply continental with a wide temperature difference between day and night, summer and winter, with a cold little snowy winter and a hot and dry summer. The sum of temperatures above 10 °C is 3400-3500 °C. The annual amount of precipitation is 250 mm, 64% of which fall in the spring-summer period. The soil of the experimental land is characterized by a low content of humus (0.54 to 1.16%) and other elements.

The subject of the research was gray-brown soils, phytomeliorants, sudangrass, sorghum, soybeans, drip irrigation and preparation PA-2,1 (adaptogen). The total area of the experiment was 0.3 hectares. The area of the plots was 120 m^2, and the repetition was threefold. Records, observations, and analyses were performed by conventional methods in the experiments. The content of humus and other elements was low in the soil. Irrigation was carried out by a drip irrigation methods by maintaining soil moisture not less than 70% of the lowest moisture capacity of the soil.

The studies on the growth and development of phytomeliorants were made according to the generally accepted Rudnev's method [8]; soil moisture was determined by the thermostatic-weight method [9]; observation of the dynamics of accumulation of biomass of phytomeliorants was made according to the generally accepted method [10]. The selection of soil samples before sowing and harvesting along the soil horizons was carried out by soil drill to determine the salt content. The analyses were carried out in an accredited soil analysis laboratory of the Kazakh Research Institute of Agriculture and Plant Growing. The norms of vegetative irrigation were determined by the moisture deficiency in the soil according to the Kostyakov's formula [11]; the processing of harvest data was made according to Dospekhov's method [12]. The water-physical qualities of the soil were determined by conventional methods [13-18].

There was studied the dynamics of the content of salts in the soil before sowing and harvesting. Also, there was experimented the effect of adaptogen on the growth and development of phytomeliorants. Seeds were treated with a two percent solution of adaptogen and sprinkled with vegetative plants with 0.03-0.05 percent of aqueous solutions.

Adaptogen increases bioenergetics and ecological resistance of plants to soil salinity. Also, the preparation increases plant's germination energy with pre-sowing seed treatment. Spraying after germination of plants gives them additional energy for vegetation [19].

The preparation increases germination energy of seeds, promotes the increased growth of roots and the other parts of plant. This also influences the on growth of the utilization rate of nutrients from the soil of introduced fertilizers and affects the ripening of cereals for 7-9 days [20].

Results and discussion. The field experiments conducted on saline soils of the Akdalinsk irrigation massive where there were studied the effects of various phytomeliorants on the content of salts in soil and adaptogen for growth and development and yield of phytomeliorants.

The results of the conducted field experiments showed that the treatment of planting seeds of phytomeliorants promotes the emergence of crop germination two days earlier in comparison with the variants of seeds that were not treated with adaptogen solutions.

There was an observation of the growth and development of phytomeliorants in the main phases of their development. The results of analysis before harvesting showed that the accumulation of raw mass on an area of 0.3 m^2 in sudangrass, sorghum and soybean was 1043, 769, 690 grams with adaptogen, respectively, while without the adaptogen it was 982, 742, 681 grams (table 1).

Table 1 – Results of experiments of the growth and accumulation of biomass phytomeliorants. 24.08.2016, 0.30 m^2, average data

Variants of experience, phytomeliorants	Seed treatment with preparation PA-2,1 (adaptogen)	Plant height, cm	Weight, gram	
			raw mass	dry weight
Sudangrass (ejection of panicle, 2 slopes)	with treatment	270	1043	688
	without treatment	262	982	648
Sorghum (grain filling)	with treatment	190	769	501
	without treatment	183	742	490
Soybean (wax ripeness)	with treatment	103	690	414
	without treatment	94	681	409

The intensive growth and development were observed in phytomeliorants of sudangrass, where the plant height averaged up to 270 cm, and on the variant without adaptogen treatment was 262 cm. Also, there was an intensive accumulation of raw and dry above-ground mass (table 1). The intensive growth and development were observed in soybean. Soybean at the expense of active growth and development has suppressed weed plants. The crop also showed a good seed formation. There were selected soil samples at the beginning of the year, during the sowing and before harvesting, to determine the primary and residual salt content in the soil. This experiment was done to study and determine the influence of phytomeliorants on the dynamics of changes in the content of salts in the soil.

Comparative data on the content of a dense residue of salts before the sowing of phytomeliorants (May 23, 2016) and residual salts before harvesting (August 25, 2016) showed that phytomeliorants contributed to the reduction of salts in the upper horizon 0-20 cm from 0.06% in sudangrass, 0.10% in sorghum and 0.27% in soybean. On the lower layer of soil with 20-40 cm, the reduction of salts was in the range of 0.04-0.05%. There was a decrease in salts by 0.27% in field of soybean (table 2).

Table 2 – The content of salts in the soil horizontally before sowing and harvesting phytomeliorants

Phytomeliorants	Depth, cm	Solid residue, %		Ions HCO_3, %		Sulfate ions, %		Sodium, %	
		before sowing	before harvesting	before sowing	before harvesting	before sowing	before harvesting	before sowing	before harvesting
Soybean	0-20	0,78	0,51	0,13	0,06	0,21	0,18	0,18	0,01
	20-40	0,94	0,67	0,06	0,03	0,40	0,09	0,22	0,01
Sorghum	0-20	0,31	0,21	0,02	0,05	0,19	0,16	0,09	0,06
	20-40	0,20	0,16	0,05	0,05	0,09	0,12	0,09	0,07
Sudangrass	0-20	0,19	0,13	0,03	0,05	0,16	0,16	0,01	0,06
	20-40	0,21	0,16	0,03	0,05	0,19	0,08	0,01	0,07

The intensive growth and development of phytomeliorants which seeds were treated with adaptogen promoted the reduction of salts in soil. In addition, irrigation was carried out by drip irrigation system where water was supplied by small norms and the upper layer of the soil was moistened. Ground (saline) water does not rise to the root zone of plants with such soil moistening. The intensive growth and development of phytomeliorants have had an impact on their yields (table 3).

In the given data in table 3, the formation of a high above ground mass of phytomeliorants of sorghum and sudangrass without treatment with adaptogen formed a high yield of green mass where average yield was 947.0 t/ha in sudangrass and 740.4 c/ha in sorghum. The processing of seeds and the above-ground mass of the crops contributed to an increase in the yield of sudangrass to 990.3 c/ha and sorghum to 777.6 c/ha. Also, a high yield was obtained in soybeans where varieties without treatment were on average 54.7 c/ha on, and with treatment increased to 56.6 c/ha.

Table 3 – The yield of green mass and grain of phytomeliorants in drip irrigation (average data for 2015-2017)

Variants of experience, phytomeliorants	Seed treatment with preparation PA-2,1 (adaptogen)	Productivity, green mass, grain, centner / ha	Gathering of fodder units, centners / hectare
Sorghum (green mass)	With treatment	777,6	176,6
	Without treatment	740,4	168,2
Sudangrass (two slopes per green mass)	With treatment	990,3	219,0
	Without treatment	947,0	210,0
Soybean (grain)	With treatment	56,6	73,0
	Without treatment	54,70	70,2
SSD_{05} 5,87			
Note: The fodder units from the soybean stems are not taken into account when calculating the collection of feed units.			

The most important indicators of the final results and the overall efficiency of production in a market are the profitability of the products.

The calculations showed that along with improving the meliorative condition of saline soils, it is possible to obtain additional cost-effective crops (table 4).

Table 4 – Economic efficiency of phytomeliorants cultivation with the use of adaptogen

Variants of experience, phytomeliorants	Seed treatment with preparation PA-2,1 (adaptogen)	Average yield for 2015-2017. c/ha	Total cost of production, thousand tenge / ha	Total costs, thousand tenge / ha	Income, thousand tenge / ha	Level of profitability, %
Sorghum (green mass)	With treatment	777,6	31,1	19,10	12,0	62,8
	Without treatment	740,4	29,6	18,8	10,8	60,0
Sudangrass (two slopes per green mass)	With treatment	990,3	39,6	23,2	16,4	71,0
	Without treatment	947,0	37,8	22,3	15,5	69,5
Soybean (grain)	With treatment	56,6	448	205	243	118,5
	Without treatment	54,7	437	201	237	117,0

Calculations of economic efficiency of cultivation of phytomeliorants on degraded soils have shown that further effective use of irrigated lands and improvement of meliorative condition, it is necessary to introduce inexpensive agrobiological and agromeliorative methods of land restoration, which have come out of order.

The highest net income was received from soybeans with 237-243 thousand tenge per hectare, and the crop showed accordingly a high level of profitability with 117.0 % and 118.5% out of all the cultivated phytomeliorants (table 4). These economic indicators show that among the researched phytomeliorants, the highest number was given in soybean for seeds. Also, the highest for green mass was given in sudangrass.

Conclusion.

1. The results of cultivation of phytomeliorants on soils which susceptible to salinization have shown that sorghum, sudangrass, and soybean are intensively growing and accumulate above ground masses. Moreover, the intensive growth and development were observed on the variant where the seeds of phytomeliorants were treated with the preparation of adaptogen. Increasing the energy of germination of seeds, the preparation PA-2.1 promoted the emergence of seedlings two days earlier than in the untreated variants.

2. The intensive growth, development, and accumulation of the above ground mass was observed in phytomeliorants of sudangrass, where the plant height averaged up to 262 cm, and on the variant with adaptogen treatment was 270 cm;

3. The intensive development of phytomeliorants contributed to a decrease in salts on the upper horizon of the soil (0-20 cm) from 0.06 to 0.27%. On the lower soil layer (20-40 cm) was from 0.04 to 0.27%.

4. The intensive growth and development of phytomeliorants contributed to the production of high yields. Thus, the average yield of green sorghum without treatment was within 740.4 c/ha, and with processing was 777.6 c/ha. The yield of sudangrass without treatment was 947.0 c/ha, and with treatment was 990.3 c/ha. The yield of soybean grain varied within the range of 54.7-56.6 c/ha.

5. Calculations of the economic efficiency of cultivation of phytomeliorants on saline soils showed that the highest net income was received from soybean grain where it was 237-243 thousand tenge per hectare. Also, there was accordingly a high level of profitability with 117 and 118.5%, and the green mass was highest in sudangrass.

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ФИТОМЕЛИОРАЦИЯ ВТОРИЧНО ЗАСОЛЕННЫХ ОРОШАЕМЫХ ЗЕМЕЛЬ ЮГО-ВОСТОКА КАЗАХСТАНА

Аннотация. Приводятся фитомелиоративные приемы повышения продуктивности засоленных орошаемых земель путем посева фитомелиорантов и обработкой посевных семян и опрыскиванием надземной части культур препаратом ПА-2,1 (адаптоген). Результаты наблюдений за ростом и развитием фитомелиорантов показали, что фитомелиоранты интенсивно росли, развивались и накапливали надземные массы, особенно на вариантах с обработкой адаптогеном. Интенсивный рост и развитие фитомелиорантов способствовали, в конце вегетации, уменьшению содержания солей в почве и увеличению урожайности сои, сорго и суданской травы. Проведенные экономические расчеты по определению эффективности возделывания фитомелиорантов на деградированных орошаемых землях показали, что возделывания фитомелиорантов на засоленных почвах, наряду с уменьшением содержания солей в почве, дают возможность получать чистые доходы с высокой рентабельностью.

Ключевые слова: фитомелиорация, капельное орошение, кормовые единицы, суданская трава, сорго, соя, адаптоген (ПА-2,1).

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ҚАЗАҚСТАННЫҢ ОҢТҮСТІК-ШЫҒЫСЫНДА ҚАЙТАДАН СОРТАҢДАНҒАН СУҒАРМАЛЫ ЖЕРЛЕРДІ ФИТОМЕЛИОРАЦИЯЛАУ

Аннотация. Мақалада, сортаңданған (тұзданған) суғармалы жерлерді пайдалануды фитомелиорация әдісі арқылы жоғарылату, әртүрлі фитомелиорант дақылдарын егіп, олардың егілетін тұқымдарын және өскіндерін адаптоген ПА-2,1 препаратымен өңдеп-өсіріп ол жерлердің өнімділігін арттыру жолдары қаралады. Жүргізілген зерттеулердің нәтижелері бойынша, адаптоген ПА-2,1 препаратымен өңделген нұсқаларда фитомелиоранттардың қарқынды өніп-өсуі байқалды. Фитомелиоранттардың қарқынды өніп-өсуі, вегетация соңында, топырақтағы тұздардың азаюына және майбұршақ, қонақ жүгері, судан шөбі дақылдарының өнімділігінің артуына себебін тигізді. Тозған (сортаңданған) суғармалы жерлерде фитомелиоранттарды егіп-өсіру, топырақ құрамындағы тұздарды азайту мен қатар, экономикалық жағынан тиімді екені дәлелденді, өйткені ол жерлерден алынған өнімнің таза пайдасы және рентабельдік деңгейі жоғары болды.

Түін сөздер: фитомелиорация, тамшылатып суғару, азықтық өлшем, судан шөбі, қонақ жүгері, майбұршақ, адаптоген (ПА-2,1).

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