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THE EFFICIENCY OF BENTONITE CLAY USE IN WINTER WHEAT CULTIVATION

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Abstract. The article presents the results of a field experiment conducted under the conditions of the Navoiy region to study the effect of bentonite clay powder on seed germination, overwintering, plant density at the end of the growing season, and grain yield of winter wheat. In the field experiments, bentonite clays were used for pre-sowing seed encapsulation and for foliar application in combination with organomineral fertilizers.

Keywords: winter wheat, seed encapsulation, germination, overwintering, yield, bentonite clay, suspension, plant density.

Аннотация. В статье представлены результаты полевого опыта, проведенного в условиях Навоийской области, по изучению влияния использования порошка бентонитовой глины на всхожесть, зимовку, количество растений в конце вегетационного периода и на урожайность. В полевых опытах бентонитовые глины использовались для предпосевной капсулировании семян и при листовой подкормке в сочетании с органоминеральными удобрениями.

Ключевые слова: озимая пшеница, капсулирование семян, прорастание, зимовка, урожайность, бентонитовая глина, суспензия, количество растений.

In Uzbekistan, one of the important tasks facing specialists in the agricultural sector is the improvement of the reclamation status of irrigated lands, the creation of favorable conditions for plant growth and development through various methods of utilizing inexpensive and environmentally friendly natural agrominerals, maintaining their economic efficiency and ecological sustainability at an appropriate level, and ensuring their rational conservation and management.

On the areas of farms cultivated with winter wheat, from seedling emergence until the end of the growing season, the leaf surface area is significantly influenced by light intensity, temperature, irrigation, fertilizer application, plant density, and the agronomic practices employed.

Therefore, under conditions of an arid climate and soils with varying degrees of salinity, it is a relevant scientific task to substantiate the effect of bentonite clay powder application in winter wheat cultivation – both for pre-sowing seed encapsulation and for foliar feeding in combination

with mineral fertilizers – on stress-free seed germination, plant stand preservation, growth and development, yield performance, and grain quality.

The long-term continuous cultivation of cereal crops, the highly inefficient use of organic and mineral fertilizers, and the sharp reduction in the areas devoted to grain legumes and alfalfa grown under clean and occupied fallow systems have led to severe soil degradation. As a result of these and other natural and anthropogenic factors, crop productivity has become directly dependent on the amount of atmospheric precipitation. In years with sufficient rainfall, grain crop yields on rainfed lands reach 6-8 centners/ha, whereas in drought years they decline to only 3-4 centners/ha.

An increase in the productivity of cereal crops grown on rainfed lands can be achieved through the adoption of no-till farming technologies, the retention of crop residues in the upper soil layers, crop diversification, and the implementation of other agronomic practices. In the long term, these measures will contribute to a more complete satisfaction of the demand for agricultural production.

Many years of experience and observations indicate that, as a result of the prolonged cultivation of cereal crops and the insufficient application of organic and mineral fertilizers, crops are often affected by various diseases and pests during years with increased precipitation. However, the necessary preventive and control measures are frequently not implemented.

The introduction into agriculture of new types of agrochemical raw materials containing insufficient concentrations of macro- and micronutrients for industrial processing may contribute to improving soil fertility and increasing the productivity of agricultural crops.

Natural minerals can serve as a viable alternative to mineral and organic fertilizers, as they contain a wide range of essential nutrients, while their extraction and application in nearby regions do not require substantial financial investments.

Existing unconventional mineral raw materials are of considerable importance to agriculture due to their abundant reserves and low cost. They can compensate for deficiencies of specific mineral nutrients required by plants or be used as supplementary nutrient sources, thereby ensuring high efficiency in their application.

The positive effect of bentonite clays on the water-physical and physicochemical properties of soils is attributed to their high sorption capacity, as well as to the presence of 20-60% or more of the magnesium-rich mineral montmorillonite in their composition.

In addition, bentonites serve as a source of nutrients for plants, as they contain 0,3-4,7% carbon, 0,4-3,0% potassium, and 0,3-1,0% phosphorus.

It has been established that agrominerals exert a broad influence on the physiological and biochemical processes of plants. In particular, they increase seed germination energy by 10-12%, raise chlorophyll content by 2,5-3,0 times, and enhance photosynthetic productivity.

When bentonite clays are used as soil-ameliorating fertilizers, cotton yield increases by 2,5-9,3 centners/ha, alfalfa green biomass yield by 78,4-98,7 centners/ha, wheat yield by 4,4-5,1 centners/ha, barley yield by 5,5-7,1 centners/ha, mung bean grain yield by 1,9-3,5 centners/ha, and sugar beet root yield by 18%.

In winter wheat cultivation, the application of foliar fertilization is considered advisable. Even under conditions of high grain productivity, foliar feeding of winter wheat is regarded as an effective agronomic practice that contributes to improved plant nutrition and crop performance.

An increase in the amount of organic substances synthesized in plant leaves promotes faster growth and development. Therefore, positive results can be achieved through fertilization with complex fertilizers containing not only the macronutrients nitrogen, phosphorus, and potassium, but also micronutrients such as boron, molybdenum, copper, and iron, which are readily absorbed

through the leaf surface. Foliar fertilization is recommended to be carried out using specialized spraying equipment twice in March and once in April.

Taking these considerations into account, field experiments were conducted at the Navoi Experimental Station of the Research Institute of Cotton Selection, Seed Breeding and Cultivation Agrotechnologies during 2020-2023 to evaluate the effectiveness of bentonite clay powder in enhancing the growth, development, and productivity of winter wheat. The experiments were established in 12 treatment variants with four replications, depending on the types of suspensions used for seed encapsulation and foliar feeding of plants. The replications were arranged in a single tier according to a systematic experimental design.

The experimental field was located in the Karmana District of Navoi Region, and its soils are classified as typical sierozems (gray desert soils). The groundwater table was situated at a depth of 2,5-3,0 m and fluctuated throughout the growing season.

Preliminary soil analyses of the experimental site revealed that, in the 0-30 cm soil layer, the humus content was 1,18%, total nitrogen 0,12%, total phosphorus 0,26%, nitrate nitrogen 12,4 mg/kg, available phosphorus 23,1 mg/kg, and exchangeable potassium 192 mg/kg. In the 30-50 cm layer, the corresponding values were 0,81%, 0,04%, 0,18%, 7,1 mg/kg, 16,3 mg/kg, and 171 mg/kg, respectively.

The analytical results indicated that these concentrations of soil nutrients and ions, when combined with appropriate agronomic practices, do not exert any adverse effects on the cultivation of winter wheat.

The field experiments investigated the effect of pre-sowing encapsulation of winter wheat seeds of the “Asr” variety with bentonite clay powder on seed germination, as well as the effect of three-time foliar application of mineral fertilizers and bentonite suspension during the tillering, stem elongation, and heading stages on the final plant stand density and the duration of the growing season.

In the long-term experiments, winter wheat seeds were encapsulated with bentonite clay powder at the optimal rate previously established – 40 kg/t. During the growing season, foliar treatments were applied using urea and the complex fertilizer “Gektar” with the addition of bentonite clay at a rate of 1 kg/ha.

In the field experiments, although winter wheat seeds on all plots were sown simultaneously, it was observed that seedlings emerged 2 days earlier in the plots where seeds had been treated with bentonite clay powder compared with untreated seeds.

In the plots with bentonite clay-encapsulated seeds, the average number of seedlings per 1 m² was 450 plants, whereas in the untreated plots this indicator was lower by 39-40 plants (Fig. 1).

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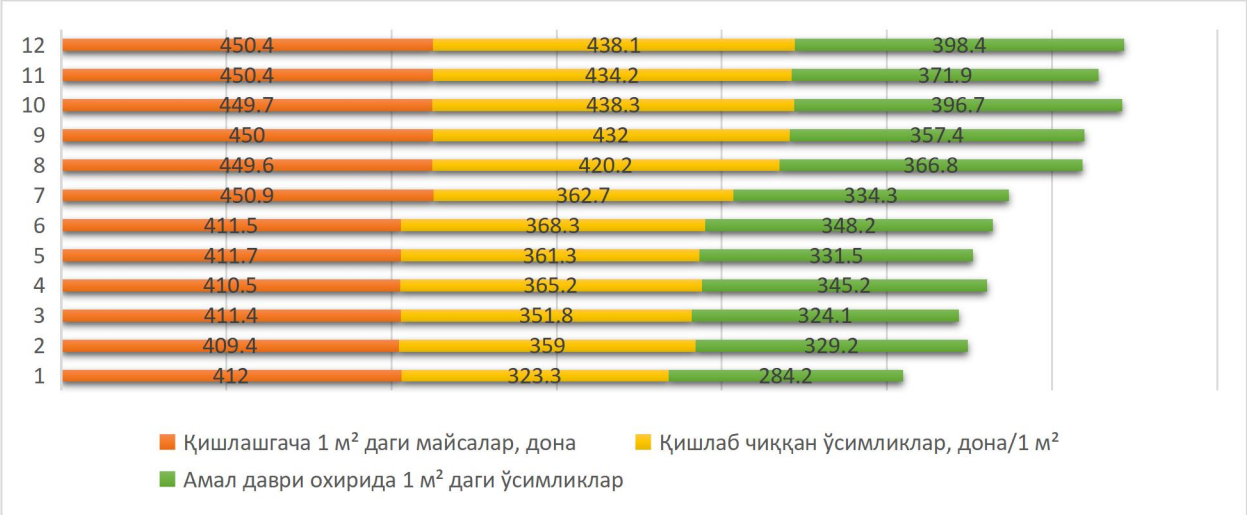


Figure 1. Influence of bentonite clays on winter wheat seed germination, winter survival, and final plant stand density at the end of the growing season (2020–2023).

In the experimental plots, foliar application carried out once during the tillering stage before winter dormancy, using a fertilizer suspension supplemented with bentonite clay powder, had a positive effect on plant overwintering.

For example, in the plots where seeds were not encapsulated and only foliar feeding with a urea suspension was applied, 87,7% of seedlings survived the winter, whereas in the plots where bentonite clay powder was added to the urea suspension, this value reached 89,0%. This indicates that, compared with the control treatment, the number of overwintered plants increased by 9,3 and 10,6%, respectively.

In the treatments involving bentonite clay-encapsulated seeds combined with foliar application of a suspension containing the “Gektar” complex fertilizer and bentonite, the number of overwintered plants was the highest, reaching 438,1 plants. In comparison, under foliar feeding only with the “Gektar” complex fertilizer suspension, this value was 434,2 plants. In both treatments, the number of surviving plants exceeded the control by 114,8 and 110,9 plants, respectively.

It was established that in the treatments involving seed encapsulation and foliar feeding only with a suspension containing bentonite clay, these indicators were slightly lower compared with those observed in other plots (Fig. 1).

Similarly, foliar feeding of winter wheat during the growing season with suspensions of different compositions had varying effects on the number of plants at the ripening stage. According to the obtained results, the highest values were observed in the plots with encapsulated seeds combined with foliar application of urea and bentonite suspension, as well as the “Gektar” complex fertilizer suspension supplemented with bentonite, where the number of surviving plants reached 396,7 and 398,4 plants, respectively.

It should be particularly noted that although the plots where bentonite clay powder was used for both seed encapsulation and foliar feeding did not demonstrate results as high as those obtained with the combined treatments, it was nevertheless established that even in crops grown from non-encapsulated seeds, three-time foliar fertilization with fertilizers supplemented with bentonite clay had a positive effect on plant overwintering and the final plant stand density.

The sorption properties of bentonite clays and their rich micronutrient composition provide a positive effect during seed encapsulation, promoting stress-free seed germination. These properties

are further enhanced when bentonite is applied foliarly in combination with fertilizers, contributing to the preservation of winter wheat plant density and achieving higher productivity indicators.

According to the results of observations conducted during the growing season of winter wheat in the experimental plots, plant height at the tillering, stem elongation, heading, and full maturity stages in the control treatment was 10,9; 70,2; 87,4; and 88,5 cm, respectively. In the treatments with seed encapsulation, where the application rate of bentonite clay was 40 t/ha, combined with foliar feeding using a urea+bentonite suspension, the corresponding values were 18,2; 82,3; 100,1; and 100,5 cm.

In the same treatments with seed encapsulation and foliar application of the complex fertilizer "Gektar" combined with bentonite suspension, plant heights at the respective growth stages were 18,8; 82,6; 100,6; and 101,4 cm.

Based on the analysis of the effect of bentonite clay on the number of spikelets and grains per spike, as well as the 1000-grain weight of winter wheat, it was established that in the control treatment without seed encapsulation, the number of spikelets per spike was 17,6; the number of grains per spike was 43,4; and the 1000-grain weight was 41,2 g.

Under the treatment involving three-time foliar application of the "Gektar"+bentonite suspension under the same sowing conditions, these indicators were 10,6 spikelets, 51,7 grains per spike, and 50,1 g per 1000 grains, respectively.

Under field conditions, the treatment involving pre-sowing seed encapsulation with bentonite clay powder at a rate of 40 kg/t combined with foliar application of the "Gektar" preparation supplemented with bentonite clay had a more pronounced effect on the formation of winter wheat grain.

In this treatment, compared with the control, the number of spikelets per spike increased by 3,7; the number of grains per spike increased by 5,0; and the 1000-grain weight increased by 12,0 g.

In our studies, winter wheat grain yield was also significantly influenced by seed encapsulation with bentonite clay powder and foliar application of bentonite suspension.

According to the average three-year data, grain yield in the untreated control treatment was 41,8 centners/ha. In the plots without seed encapsulation, where foliar feeding was carried out only with urea, this indicator reached 50,6 centners/ha, while the application of only the "Gektar" complex fertilizer resulted in a yield of 51,2 centners/ha.

In the treatments involving seed encapsulation combined with foliar application of urea and the "Gektar" complex fertilizer supplemented with bentonite, the additional yield increase compared with the control was 12,8 and 14,5 centners/ha, respectively.

The treatments with seed encapsulation (40 kg/t) demonstrated higher yield indicators compared with crops grown from non-encapsulated seeds. With foliar application of bentonite in combination with urea and the "Gektar" fertilizer, the additional yield increase compared with the control reached 22,0 and 22,4 centners/ha, respectively (Table 1).

Table 1

Effect of bentonite clays on winter wheat yield under irrigated conditions

Exp. №	Bentonite clay	Type of foliar application	Yield, centners/ha	Average yield, centners/ha	Yield increase, centners/ha

	powder encapsulation rate		2020	2021	2022	2023		Compared with the control, centners/ha	Compared with the control, %
1	-	Control (water)	0,6	1,4	1,9	3,2	1,8	-	-
2		Urea	8,9	0,2	1,1	2,3	0,6	8,8	21,0
3		Bentonite	5,3	5,9	5,8	7,1	6,0	4,2	10,0
4		Urea + bentonite	3,1	4,8	4,9	5,6	4,6	12,8	30,6
5		"Gektar" complex fertilizer	0,8	1,3	0,9	1,9	1,2	9,4	22,5
6		"Gektar" complex fertilizer + bentonite	5,2	6,4	6,1	7,5	6,3	14,5	34,7
7	40 kg/t	Control (water)	6,4	8,6	9,1	9,1	8,3	6,5	15,5
8		Urea	7,7	8,9	9,4	11,6	9,4	17,6	42,1
9		Bentonite	1,6	3,0	3,4	4,7	3,2	11,4	27,2
10		Urea + bentonite	1,7	3,9	4,5	5,3	3,8	22,0	52,6
11		"Gektar" complex fertilizer	,4	0,7	1,2	2,2	0,9	19,1	45,7
12		"Gektar" complex fertilizer + bentonite	2,4	4,1	5,8	5,8	4,2	22,4	53,5

In conclusion, it can be stated that the field experiments conducted have demonstrated that seed encapsulation with bentonite clay powder and foliar application with the addition of bentonite clay at a rate of 1 kg per hectare to urea or "Gektar" complex fertilizer solutions represent the most optimal agronomic practice for winter wheat cultivation on irrigated lands of the Navoi Region.

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