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Efficiency of Nanopolymer Preparation on the Growth, Development and Yield of Varieties Wheat

Amanturdiev Shavkat Balkibaevich[1], Rashidova Dilbar Karimovna[1], Yakubov Muzaffar Matyakubovich[1], Sharipov Shukhrat Tulkinovich[1], Nazarov Khudoyberdi Kuydimurodovich[2], Zaripov Habib Salimovich[3]

[1]Cotton Breeding, Seed Production and Agrotechnologies Research Institute, Tashkent, Uzbekistan.
[2]Tashkent state agrarian university, Tashkent, Uzbekistan.
[3]Scientific experimental station of Navain region of the Cotton breeding, seed production and agritechnologies research institute, Tashkent, Uzbekistan.

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ABSTRACT:

The article presents the results of analyses of nanopolymer preparations effect on laboratory germination, development phases, yield components as well as resistance to leaf yellow rust disease of pre-sowing treatment of seeds of released wheat varieties Dustlik and Semurug on irrigated land. For encapsulation of wheat seeds the nanopolymer Nanoascorbate chitosan, Nanochitosan, Polymermetal complex of copper ion + silver in different ratios and polymer Chitosan (original), Ascorbate chitosan, Cuprumchit and as a standard UZHITAN preparations based on Chitosan Bombyx mori and its derivatives were used. Laboratory germination of wheat seeds was determined by Cotton Breeding, Seed Production and Agrotechnologies Research Institute in the Laboratory of Biochemistry and Plant Physiology. High germination rate was observed for Nanoascorbate chitosan in both varieties studied, which was 4.0 % and 4.25 % higher than control, respectively. The field studies were carried out at the experimental plot of the Research Institute of Bogary Farming in 2018-2020. The data obtained by biometric analyses are shown: average plant length, ear length, number of spikelets on one ear, number of grains on one ear, weight of grains in one ear and weight of 1000 pieces of grains. Nanopolymer preparations Nanoascorbate chitosan, Nanochitosan, PMC Cu^{2+}: Ag7:3 and PMC Cu^{2+}: Ag8:2 outperformed other preparations and control by biometric counts and observations. In terms of grain weight per ear and other indicators in the studied varieties, nanopolymers outperformed their counterparts of polymeric preparations. In terms of grain yield the nanopreparations exceeded in the variety Dustlik from 5.4 to 9.6 centners/ha, and in the variety Semurug from 0.5 to 5.5 centners/ha the control variant. The highest yielding variant was Nanoascorbate chitosan with yield of 57.6 centners/ha and 55.3 centners/ha respectively. In our research we also studied the suppression of yellow rust disease of wheat leaf rust by nanopreparations of pre-sowing seed treatment. From the results obtained it can be concluded that nanopolymeric preparations to some extent positively influence the suppression of this disease. Nanoascorbate chitosan was highly effective against fungal disease in the variety Dustlik, in which on May 25 defeat was 52.1% while the control variant was 83.4%. Since cultivar Semurug is resistant, there was almost no infestation of the disease.

Keywords: wheat, seeds, germination, growth, development, yield, variant, control, standard, chitosan, nanopolymer preparation, yellow rust.

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1. Introduction

Scientists in many countries of the world, such as USA, Japan, India, China, Vietnam, Germany, Russia and Uzbekistan conduct research on influence of nanopolymer preparations based on chitosan on seed quality, growth, development and yield of agricultural crops to increase crop yield. The conducted researches on influence of nanopreparations on seeds, plants, yield and receiving production, on metabolic processes in plants, development of methods, and also the mechanism of action is one of the actual problems.

In the Republic of Uzbekistan, the study of domestic nanopolymer preparations based on chitosan Bombyx mori and its derivatives obtained from mulberry silkworm pupae plays an important role in identifying the biological effects of nanoparticles, as well as their beneficial and harmful effects on plants.

Many years of research results made it possible to opt for chitosan, a polyfunctional polymer, especially since chitosan derived from crab shell (crab) is widely used in foreign agricultural practice [24]. Chitosan (CS) is a polymer derived from chitin, which is the second biopolymer in nature after cellulose. Chitosan is known for its unique features of microbial degradability, biocompatibility and non-toxicity [22;23]. In Uzbekistan, wastes of natural silk production in the form of mulberry silkworm pupae are a source of chitin and chitosan production [18].

Chitin, chitosan and their derivatives possess a number of valuable physico-chemical and medicobiological properties. The solubility in aqueous media of chitosan and its derivatives have opened new opportunities for the creation of unique polymeric systems applied in the field of agriculture. Chitosan samples have fungicidal [9;25] virucidal [10] bactericidal [18] immunomodulatory [16;32] properties.

In addition, some studies have shown that CS chitosan positively affects seed germination and can accelerate chlorophyll (Chl) a, b, total chlorophyll and soluble protein content of barley Hulless Barley L. [6]. Chitosan CS can accelerate corn seed germination rate and improve seedling growth advantage under low temperature stress, can mitigate salt stress injury and improve salt tolerance of wheat seeds and seedlings [8;31] .In addition, CS chitosan can attenuate abiotic stress responses of plants that cause multifaceted disease resistance [29], rice, coffee [12;21]wheat [30].

Chitosan nanoparticles (ChNPs) are natural materials with excellent physicochemical, antibacterial and biological features, which makes them excellent environmentally friendly materials, and they have biological activity that has no adverse effects on humans [4;11;27].

Chitosan nanoparticles are widely used in agriculture especially for plant protection due to their size-dependent quality, high surface-to-volume ratio and unique optical properties [20;23;24] chitosan nanoparticles (NPs) have the ability to increase chlorophyll content and nutrient uptake by plants, effect of chitosan nanoparticles on germination, seedling growth as well as yield of wheat [5]. Chitosan nanoparticles can promote growth at lower concentration than chitosan. Researchers concluded that chitosan nanoparticles could be used as new nanoparticles to promote wheat growth and reduce the use of agricultural fertilizer [19].

In the Republic of Uzbekistan, for the first time, the role of polymers in the creation and application of polymeric preparative forms of chemical crop protection and crop yield improvement has been revealed in the works of Rashidova S.S. and her students [14;16]. The role of polymer in crop seed encapsulation technology has been scientifically substantiated by formulating the principles of targeted selection and synthesis of polymers based on theoretically sound and experimentally validated approaches [13].

ZengD.F. and ZhangL. [32] used a new preparation for soybean seed treatment based on carboxymethyl chitosan as the main component supplemented with micronutrients, growth regulators to stimulate germination and growth of soybean seedlings. Test results showed that

the yield of soybean seeds treated with the new preparation increased by 17.95%. Antifeedant testing of the new preparation showed that it had an excellent antifeeding effect. The authors claim that the homemade preparation 55-F-1 has unique efficacy in pest control and provides fundamental protection to crops against pest damage.

The growth regulator, Agrostimul, is based on low molecular weight chitosan. The preparation is used to stimulate growth, plant development and increase the yield of tomato, a traditional vegetable crop for the Astrakhan region, grown in the open field (previously the effect of the preparation for pre-sowing treatment of watermelon seeds was studied) [3].

Chitosan polymermetallo complexes with cobalt and copper ions are water-soluble natural biopolymers with active growth-stimulating and antifungal properties [2]. The samples of CMCh (carboxyl methyl chitosan) and polymer metal complexes with cobalt and copper ions were also obtained [26].

The effect of different CMCh samples on germination energy and germination ability of cotton seeds was studied. Research showed that germination energy of seeds treated with BVM-1 was higher than BVM-2 by 1.75 % and 4.75 % higher than BVM-3. Seeds treated with CMCh -1, 2, 3 samples at a concentration of 0.3% differ in germination energy from control by 4.85-9.5% and in germination rate by 5.5% [14].

Treatment of oilseeds of safflower, flax and sesame with biopolymers can increase their oil content. When using Ascorbate chitosan preparation to treat sesame seeds, oiliness increased by 2.88%, for safflower seeds treatment with carboxylmethyl chitosan by 2.9%, flax seeds treated with UZHITAN by 1.88%. At the same time, a significant change in the composition of fatty acids, with the exception of the appearance of minor amounts of high-molecular weight saturated acids 24:0 and 24:1 in safflower seeds treated with Ascorbate chitosan, acid 20: 1 in flax seeds treated with four polymers, acid 24:0 in flax seeds treated with PMC Cu^{2+}: Ag (chitosan polymer-metal complex) and UZHITAN, and acids 20:1, 22:0, 24:0 in sesame seeds treated with UZHITAN [17].

Chitosan stabilized nanoparticles of silver, copper and cobalt were obtained under in vitro conditions and the possibility of regulating the nanoparticle size was shown [2;28]. It should be noted that silver is an active metal, due to rapid oxidation and aggregation it is difficult to obtain nanoparticles based on it and adjust their size.

In studies by Rashidova etal. [13] it was found that nanopolymer preparations Nanoascorbate chitasan 0.5% (4:1) and Nanochitasan 0.5% (90 kda) have positive effect on increasing laboratory germination of soybean seeds, have high biological activity that allows increasing the length of aboveground and underground part of seedlings and also increase the activity of peroxidase and polyphenol oxidase enzymes. Nanopolymer preparations have stimulating and fungicidal properties, soybean seeds treated with Nanoascorbate chitasan preparation were not found Fusarium wilt disease on the roots and slight affection was observed on the leaves.

2. Materials and methods

In the current study seeds of wheat varieties Dustlik and Semurug were used, these are included in the State Register of Agricultural Crops and recommended for sowing in the Republic of Uzbekistan. Before the showing, these seeds were encapsulated treated with various active nanopolymer andpolymer preparations such as nanoascorbate chitosan, nanochitosan, polymermetallo complexes of copper and silver ions at various ratios. Further, UZHITAN, ascorbate chitosan, cuprumchit and based on chitosan and its derivatives are synthesized in the Laboratory of Advanced Polymers Synthesis, Institute of Chemistry and Physics Polymers Republic of Uzbekistan. As a standard reference treatment, wheat seeds were dressings with Daltebu, which is approved agro-industrial complex by the State Chemical Commission of the Republic of Uzbekistan for use agriculturewhile untreated seeds

were used as a control.The germination of wheat seeds was determined according to GOST 12038-86 "germination determination methods for crops Under laboratory conditions. The obtained results were analyzed using the SPSS program.

3. Results and Discussion

One of the actual problems in the research is the study of nanopreparations effect on morpho-physiological indices, seed sowing qualities, growth, development and yield of wheat, their behavior in interaction with biological materials, influence on the metabolic processes in plants. In obtaining the high and guaranteed yields of wheat the important place is given to the use of advanced technologies of seed preparation, which involve the use of a wide range of environmentally friendly plant protection agents.

The effect of nanopolymer preparations on laboratory germination of wheat seeds was studied in the laboratory of biochemistry and plant physiology of Research Institute of Plant Breeding, Seed Production and Agrotechnology of Cotton during three years. Wheat seeds were treated with polymermetallo complex Cu^2+:Ag 7:3, polymermetallo complex Cu^2+: Ag 8:2, chitosan source, ascorbate chitosan 0.5% (90 kda), nanoascorbate chitosan 0.5% (4:1), UZHITAN and Daltebu used as standards and as control seeds without treatment. Laboratory germination of wheat seeds at 3 and 7 days was studied.

Table 1 shows the germination of wheat seeds sown in the irrigated area of Dustlik and Semurug wheat varieties of the Research Institute of Rainfed Agriculture. Seeds of Dustlik variety treated with Nanoascorbatechitosan 0.5% (4:1) had the highest germination rate of 98.0%, which is higher than the control by 4.0% and the Daltebu reference by 3.5% and the UZHITAN reference by 3.0%.

Table 1 Determination of laboratory seed germination of wheat varieties (average data 2018-2020) Compiled by the authors.

№	Preparation	Germination, %					
		After 3 days	On 7th day	±relative to the control	After 3 days	On 7th day	±relative to the control
		Dustlik			Semurug		
1	Control	91,2±0,4	94,0±0,4	0	92,25±0,2	94,75±0,4	0
2	Daltebu (Standard)	91,5±0,2	94,5±0,5	+0,5	91,5±0,2	95,2±0,2	+0,45
3	UZHITAN (Standard)	92,0±0,2	95,0±0,4	+1,0	89,25±0,3	95,25±0,3	+0,5
4	PMC Cu^{2+}: Ag 7:3	92,0±0,3	95,2±0,3	+1,2	91,75±0,4	95,25±0,2	+0,5
5	PMCCu^{2+}: Ag 8:2	93,6±0,4	94,7±0,2	+0,7	88,75±0,2	95,75±0,3	+1,0
6	Nanochitosan	93,0±0,5	97,2±0,4	+2,7	91,5±0,1	98,25±0,4	+3,5
7	Nanoascorbate chitosan	94,2±0,4	98,0±0,2	+4,0	92,0±0,1	99,0±0,2	+4,25
8	Ascorbate chitosan	94,7±0,5	97,2±0,3	+3,2	90,0±0,2	95,5±0,3	+0,75
9	Chitosansource	93,4±0,4	95,7±0,2	+1,7	89,75±0,2	96,75±0,3	+2,0
10	Cuprumchit 0,5%	93,0±0,4	97,0±0,5	+3,0	90,25±0,3	95,25±0,4	+0,5
		LSD_{05}=2,04 %			LSD_{05}=1,92 %		

In the variety Semurug obtained similar results, respectively, by 4.25%, 3.8% and 3.7% higher than the variants of control and standards.

In recent years, traditional salt and chelate compounds of trace elements are intensively replaced by more efficient and less toxic preparations of a new generation based on

nanoparticles of trace elements, providing high yields in crop production. Nanoparticles in the form of neutral insoluble compounds of elements or reduced metals with zero valency do not require the services of ionic transport mechanism and due to their small size they penetrate easily and quickly into plant and animal cells. The stabilising shell of nanoparticles based on biogenic polymers ensures a gradual utilisation of trace elements in the process of enzyme complex synthesis. This allows nanoparticle-based preparations to exhibit high biological efficacy at lower concentrations of trace elements compared with salts and chelates.

The effect of nanopreparations on the yield of wheat and its components was studied at the experimental site of the Research Institute of Rainfed Agriculture. The varieties of soft wheat zoned in Uzbekistan Dustlik and Semurug on irrigated lands were used.

Before sowing seeds of selected wheat varieties were treated with a suspension of polymeric and nanopolymeric preparations Nanoascorbate chitosan, Nano Chitosan, PMC Cu^2+Ag 7:3, PMC Cu^2+Ag 8:2, Chitosan (initial), Ascorbate chitosan, Cuprumchit 0.5%, and UZHITAN at a rate of 15 l/t seed.

The seed rate was 200-220 kg/ha. Each repetition consisted of one plot of 25 m^2. Works on the experimental plot were carried out according to the requirements of the general agrotechnics. The repetition was four times.

As the previous studies show polymeric nanopreparations in the treatment of wheat seeds increase the germination energy of seeds by 5-10%, allow obtaining a friendly and complete seedlings, increase plant resistance to adverse weather conditions, including spring frosts and drought, and may have a stimulating and immunomodulatory effect [1].

Iron nanoforms stimulate the germination of wheat seeds, which resulted in an increase in morphometric parameters and germination compared to the control variant. Scientists note that Fe3O4 magnetite nanoparticles have a greater stimulating effect compared to Fe nanoiron particles [9].

Some studies have shown that chitosan CS has a positive effect on seed germination and can accelerate the content of chlorophyll (Chl) a, b, total chlorophyll and soluble protein of barley Hulless Barley L. Chitosan CS can accelerate the germination rate of corn seeds and improve the benefits of seedling growth under low temperature stress , is able to mitigate salt stress injuries and increase the salt tolerance of seeds and seedlings of wheat. [6;7;8;31].

In our studies, the treatment of seeds of common wheat varieties of various origins with nanopreparations showed a positive effect on the germination and growth of plants during the growing season. In Dustlik variety when seeds were treated with Nanoscarbate chitosan and Nanochitosan both germination and ear emergence were earlier by almost four days compared to the control variant.

The same trend was observed in another variety Semurug. Relatively weak effect on germination and earing was observed when seeds were treated with Cuprumchit and UZKHITAN (reference), but compared with the control variant they also showed acceleration of germination and earing of plants (Table 2).

Zeng D.F. and Zhang L. [32] used a new preparation for the treatment of soybean seeds based on carboxymethyl chitosan as the main component, supplemented with trace elements, growth regulators to stimulate the germination and growth of soybean seedlings. The test results showed that the yield of soybean seeds treated with the new drug increased by 17.95%. Anti-feeder testing of the new drug showed that it had an excellent anti-feeder effect. The authors state that the homemade preparation 55-F-1 has a unique effectiveness in pest control and provides fundamental protection of crops from pest infestation.

We considered the effect of nanopreparations on wheat yield components, the data are shown in Table 3. We considered the effect of nanopreparations on the length of the ear, the weight

of one ear, the number of spikelets and grains in one ear, the weight of grains from one ear and the weight of 1000 seeds, as well as the height of the main stalk.

Table 2 Effect of nanopreparations on the rate of developmental phases of wheat varieties (2019-2020) Compiled by the authors.

Preparation	Varieties			
	Dustlik		Semurug	
	In gathering	heading	In gathering	heading e
Control	9.11	03.05	7.11	29.04
UZHITAN (Standard)	7.11	02.05	5.11	28. 04
Nanochitosan	5.11	30.04	4.11	28. 04
Nanoascorbate chitosan	5.11	29.04	3.11	25. 04
PMC Cu^{2+}: Ag 7:3	6.11	29.04	5.11	26. 04
PMCCu^{2+}: Ag 8:2	7.11	01.05	6.11	25. 04
Ascorbate chitosan	7.11	01.05	6.11	26. 04
Chitosansource	8.11	01.05	5.11	26. 04
Cuprumchit 0,5%	7.11	01.05	6.11	28. 04

Our results of the study also confirm the use of nanopreparations cited by foreign scientists affects the increase in yield compared to untreated seeds. The greatest improvement in yield components were in Dustlik, whose seeds were treated with Nanoascorbate chitasan. The average length of the ear was 8.45±0.07cm, the number of spikelets in one ear 16.1±0.32pcs, the number of grains in one ear on the average 40.3±0.21 units, grain weight per ear 1.8±0.033 grams and weight of 1000 seed units 49.8±0.09 grams. Also high index for all yield components in comparison with other nanopreparations was revealed in this variety at treatment with Nanochitasan with ear length 8,2±0,06 cm; number of ears in one ear 15,9±0,30 pieces; number of grains in an ear 38,9±0,29 pieces; weight of grains from one ear 1,7±0,036 gram and weight of 1000 pieces of seeds 47,6±0,09 gram. In our research all studied nanopolymer and polymeric preparations surpassed the control variant in all indicators of yield components.

The same trend was observed in the Semurg wheat variety. The high indices of effect of nanopreparation on yield components compared to control variant and other preparations were observed in seed treatment with nanopolymeric preparation Nanoascorbate chitasan and polymeric Ascorbate chitosan, in which the earlength was 10.8±0.04c; 10.4±0.04cm, number of spikelets in one ear 19.8±0.30;19.8±0.31 pieces, number of grains in one ear 45.9±0.23;45.4±0.23 pieces, weight of grain per ear 3.2±0.039;3.0±0.037 grams and weight of 1000 seeds 53.4±0.19; 49.3±0.24 grams respectively. Low indices were detected at the treatment with Chitosan initial preparation. The results obtained suggest that nanopreparation Nanoascorbate chitosan and Nanochitosan have a positive effect on yield components in wheat varieties Dustlik and Semurug, which are biologically winterized. There was no strong difference in plant height between the varieties of Dustlik. The tallest varieties were those whose seeds were treated with UZHITAN, Chitosan initial and Nanoascorbate Chitosan. The lowest was the variantPMCCu2+: Ag7:3 (98.3 cm), the indicator on this trait was even 0.9 cm inferior to the control. In the variety Semurug, plant height varied from 108.6 cm to 127.8

cm. The high-growing varieties were Cuprumchit 0.5 % and Nanoascorbate chitosan, with plant heights of 127.8 cm and 127.5 cm, respectively.

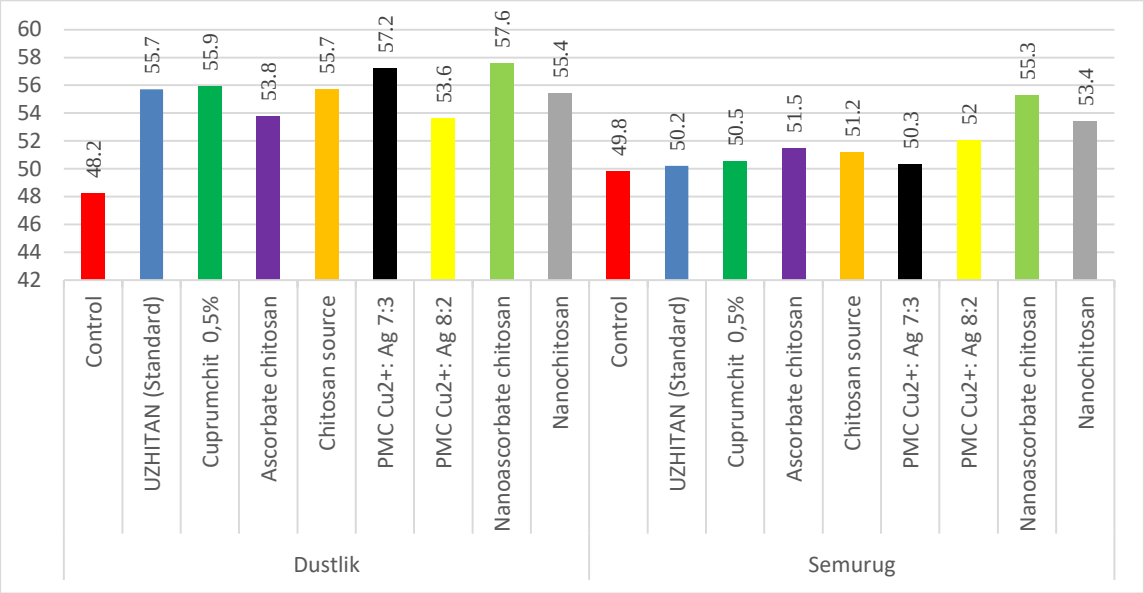
Table 3 Средние Average yield components of wheat varieties (averaged data 2018-2020) Compiled by the authors.

Varieties	Preparation	Spike length, cm			Number of spikelets per ear, units			Weight of 1000 seeds, g.		
		X±Sx	δ	V %	X±Sx	δ	V %	X±Sx	δ	V %
Dustlik	Nanochitosan	8,2±0,06	0,21	2,66	15,9±0,30	0,94	6,04	47,6±0,09	0,54	1,21
	Nanoascorbate chitosan	8,4±0,07	0,23	2,79	16,1±0,82	0,98	6,41	49,8±0,26	0,83	1,69
	PMC Cu^{2+}: Ag 7:3	8,0±0,05	0,17	2,57	14,6±0,29	0,76	6,77	46,5±0,30	0,95	2,03
	PMCCu^{2+}: Ag 8:2	8,1±0,05	0,19	2,61	14,2±0,46	0,75	6,81	48,3±0,25	0,73	1,66
	Ascorbate chitosan	7,5±0,04	0,15	2,06	13,9±0,19	0,72	6,94	47,0±0,26	0,82	1,74
	Chitosansource	8,3±0,06	0,23	2,72	15,3±0,25	0,81	5,44	45,3±0,29	0,62	1,68
	Cuprumchit 0,5%	7,7±0,05	0,16	2,11	14,7±0,21	0,67	4,71	43,3±0,21	0,66	1,54
	UZHITAN (Standard)	7,9±0,05	0,17	2,44	15,7±0,29	0,91	6,01	47,4±0,25	0,81	1,71
	Control	6,8±0,04	0,13	1,95	11,9±0,24	0,78	7,04	39,7±0,31	1,00	2,52
Semurug	Nanochitosan	9,6±0,04	0,14	1,50	18,1±0,23	0,73	4,12	50,4±0,22	0,70	1,39
	Nanoascorbate chitosan	10,8±0,04	0,15	1,38	19,8±0,30	0,94	4,91	53,4±0,19	0,61	1,14
	PMC Cu^{2+}: Ag 7:3	8,9±0,05	1,16	1,86	16,9±0,26	0,84	5,15	49,5±0,17	0,91	1,78
	PMCCu^{2+}: Ag 8:2	9,6±0,04	0,13	1,47	17,8±0,26	0,83	4,79	51,2±0,19	0,70	1,24
	Ascorbate chitosan	10,4±0,04	0,16	1,41	19,8±0,31	0,96	4,89	49,3±0,24	0,81	1,72
	Chitosansource	8,3±0,06	0,22	2,69	14,8±0,42	0,77	6,69	48,7±0,22	0,79	1,67
	Cuprumchit 0,5%	9,6±0,04	0,14	1,49	18,3±0,26	0,87	5,08	48,3±0,21	0,76	1,77
	UZHITAN (Standard)	9,3±0,04	0,12	1,37	17,6±0,51	0,79	4,67	51,6±0,18	0,66	1,21
	Control	7,6±0,05	0,17	2,49	14,7±0,24	0,69	4,73	48,5±0,21	0,77	1,74

Continuation of table 3

Varieties	Preparation	Number of grains per ear, units			Grain weight per ear, g.			Stem height, cm		
		X±Sx	δ	V %	X±Sx	δ	V %	X±Sx	δ	V %
Dustlik	Nanochitosan	38,9 ±0,29	0,73	1,88	1,7±0,036	0,07	7,14	101,0±0,42	1,34	1,33
	Nanoascorbate chitosan	40,3 ±0,21	0,67	1,65	1,8±0,033	0,08	4,68	104,8±0,40	1,28	1,23
	PMC Cu^{2+}: Ag 7:3	38,9±0,24	0,72	1,82	1,9±0,031	0,09	5,54	98,3±0,38	1,20	1,22
	PMCCu^{2+}: Ag 8:2	38,9 ±0,25	0,72	1,84	1,7±0,032	0,07	4,02	99,3±0,69	1,18	2,20
	Ascorbate chitosan	37,3 ±0,24	0,78	2,14	1,6±0,033	0,07	4,19	101,1±0,40	1,31	1,29
	Chitosansource	38,8 ±0,23	0,71	1,79	1,8±0,035	0,07	4,39	105,3±0,45	1,45	1,38
	Cuprumchit 0,5%	39,1 ±0,21	0,66	1,71	2,0±0,031	0,07	4,94	99,9±0,61	2,12	2,01
	UZHITAN (Standard)	38,2 ±0,26	0,84	2,20	1,8±0,028	0,08	4,83	106,3±0,59	1,87	1,78
	Control	35,2±0,26	0,85	2,36	1,3±0,031	0,09	7,59	99,2±0,98	3,11	3,15
Semurug	Nanochitosan	42,0±0,25	0,82	1,94	2,8±0,033	0,10	3,76	122,3±0,72	2,29	1,88
	Nanoascorbate chitosan	45,9±0,23	0,73	1,60	3,2±0,039	0,11	3,29	127,5±0,85	2,71	2,13
	PMC Cu^{2+}: Ag 7:3	41,0±0,30	0,94	2,79	2,6±0,027	0,07	3,21	113,8±0,72	2,29	2,03
	PMCCu^{2+}: Ag 8:2	43,5±0,26	0,81	1,85	2,9±0,023	0,07	2,53	122,8±0,75	2,33	1,98
	Ascorbate chitosan	45,4±0,23	0,74	1,77	3,0±0,037	0,11	3,91	118,0±0,81	2,58	2,18
	Chitosansource	38,7 ±0,26	0,75	1,99	2,2±0,035	0,11	4,97	108,6±0,51	1,49	1,39
	Cuprumchit 0,5%	38,0±0,24	0,78	2,08	2,6±0,026	0,07	3,33	127,8±0,82	2,69	2,28
	UZHITAN (Standard)	41,5±0,25	0,82	1,94	2,6±0,024	0,07	3,41	114,5±0,80	2,79	2,16
	Control	35,5±0,31	0,96	2,63	1,9±0,032	0,09	5,61	109,5±0,49	1,48	1,27

The results showed a positive effect of nanopreparation on the overall grain yield of soft wheat varieties. The yield data of the wheat varieties is shown in Figure 1. Compiled by the authors.



The data show that among the nano-preparations affecting the overall grain yield the most effective was the preparation Nanoascorbate chitosan. The average yield of four replications, seeds treated with this preparation in variety Dustlik was 57.6 centners/ha, and in variety Semurug 55.3 centners/ha, which is by 9.4 centners/ha and 5.5 centners/ha more than in the control variant. The other nanopolymer preparations also surpassed, on this parameter the control. The high indicator on influence on grain yield in cultivar Dustlik was observed with nanopreparations PMC Cu2+Ag 7:3 57.2 c/ha, Nanochitosan 55.4 c/ha, and in cultivar Semurg nanohitosan 53.4 c/ha and PMC Cu2+Ag8:2 52.0 c/ha. The average grain yield of the studied nanopolymer and polymer preparations based on chitosan for both varieties exceeded the control variant.

Based on these results, we can conclude that the most effective nanopreparations for the treatment of wheat seeds in our experiments, showed the preparations Nanoascorbate chitosan and Nanochitosan,

Chitosan nanocleaners are widely used in agriculture, especially for plant protection, due to their size-dependent quality, high surface to volume ratio, and unique optical properties [20;23;24]. Chitosan nanoparticles (NPs) have the ability to increase the chlorophyll content and the absorption of nutrients by plants, the effect of chitosan NPs on germination, seedling growth, and wheat yield [5]. Chitosan NPs can promote growth at a lower concentration than chitosan. The researchers came to the following conclusion that chitosan NPs can be used as new nanoparticles to stimulate wheat growth and reduce the use of agricultural fertilizers [19].

The effect of nanopolymer preparations on suppression of yellow rust disease of winter wheat varieties Dustlik and Semurug was analyzed. The survey was carried out on 2 dates on May 15 and 25. The surveys were conducted in four replications of 20 plants in each, i.e. 80 leaves of plants in each variant on a 7-point scale. The variety Dustlik is susceptible to yellow rust by origin and the variety Semurug is resistant (Tables 4 and 5). From the results of the analyses in table 4 we can see that infected leaves of the test plants on the 15th of May ranged from 71 to 79, in percentages 88,8% to 98,8%. Yellow rust disease development on the leaves was most spread in the control variant - 74,3%, which exceeds Nanoascorbate

chitosan variant by 30,3%. In other variants the spread of disease development was from 50,5 % Cuprumchit to 66,4 % Nanoascorbate chitosan and RMSCu2+: Ag7:3. From the counts on May 25, it is clear that all 80 leaves of the plants in all variants were infected to varying degrees. The highest disease development was observed in the control variant 83.4 % and the lowest in plants treated with Nanoascorbate chitosan 52.1 % or 30.3 % less than in the control plants. Also low development of yellow rust disease in wheat cultivar Dustlik, were found in variants where the seeds were treated with Ascorbatechitosan-58.4% and Cuprumchit-60.7% of defeat. The data show that the application of chitosan-based Bombyx mori to Dustlik wheat seeds was observed to slightly reduce disease development.

A study of the effect of nano-preparations on the incidence of yellow rust in the variety Semurug showed that the variety itself is weakly sensitive to the disease. The highest percentage of infected leaves showed plants whose seeds are untreated (control) and treated with UZHITAN (standard). In these variants by May 25 the affected leaves were 42 and 32 or in percent 16,3 % and 11,3 % respectively, at that it is necessary to notice that leaves were affected to an insignificant extent. As can be seen from Table 5, in variants Nanoascorbate chitosan, Ascorbate chitosan and Cuprumchit 0.5 % of leaf damage was not found, while in Nanochitosan and Chitosan initial development of the disease was only 1.4 % and 1.3 %.Based on the obtained research results and literature sources it can be concluded that our results are in agreement with those obtained by foreign authors.

Thus, the analysis of the effect of the preparations on the disease incidence in wheat varieties Dustlik and Semurug allowed us to conclude that the development of yellow rust disease is influenced by the resistance of the variety to the disease. The non-tolerant variety Semurug can be used for breeding work to develop new varieties resistant to yellow rust disease.

Table 5Effect of nanopolymer preparations on yellow rust disease in Dustlik wheat variety (average data 2018-2020) Compiled by the authors.

№	Preparation	Record date	Disease prevalence,%	Number of recordable leaves, pieces	Including infested leaves		Expression in points of disease development on the leaves, pieces							Development of the disease
					шт ук	%	1	2	3	4	5	6	7	
1	Control	15 May	57,5	80	79	98,8			1	15	34	20	9	74,3
		25 May	62,5	80	80	100					29	34	17	83,4
2	UZHITAN (Standard)	15 May	42,5	80	76	95,0			10	26	33	7		60,9
		25 May	47,5	80	80	100			5	28	31	16		67,5
3	Ascorbate chitosan	15 May	32,5	80	71	88,8		1	14	31	24	1		52,5
		25 May	37,5	80	80	100		7	11	36	20	6		58,4
4	Nanoascorbate chitosan	15 May	35,0	80	72	92,5		7	33	27	5			44,0
		25 May	40,0	80	80	100		6	28	34	12			52,1
5	Chitosansource	15 May	32,5	80	74	92,5			10	28	30	6		58,6

		25 May	37,5	80	80	100			4	31	34	11		66,4
6	Nanochitosan	15 May	40,0	80	76	95,0			9	17	33	15	2	66,4
		25 May	42,5	80	80	100				21	37	20	2	72,0
7	PMC Cu^{2+}: Ag 7:3	15 May	40,0	80	76	95,0			3	17	42	13	1	66,4
		25 May	40,0	80	80	100			2	23	40	13	2	69,6
8	PMC Cu^{2+}: Ag 8:2	15 May	35,0	80	75	93,8		3	14	27	24	7		56,8
		25 May	40,0	80	80	100			4	31	33	12		66,6
9	Cuprumchit 0,5%	15 May	32,5	80	73	91,3		8	13	32	20			50,5
		25 May	35,0	80	80	100			15	34	27	4		60,7

Table 6 Effect of nanopolymer preparations on yellow rust disease in Wheat varietySemurug (average data 2018-2020) Compiled by the authors.

№	Preparation	Record date	Disease prevalence,%	Number of recordable leaves, pieces	Including infested leaves		Expression in points of disease development on the leaves, pieces							Development of the disease
					штук	%	1	2	3	4	5	6	7	
1	Control	15 May	7,5	80	23	28,8	6	12	5					8,0
		25 May	11,25	80	42	52,5	7	23	11	1				16,3
2	UZHITAN (Standard)	15 May	5,0	80	15	18,8	4	10	1					4,8
		25 May	10,0	80	32	40,0	8	17	7					11,3
3	Ascorbate chitosan	15 May	0,0	80	0	0,0								0,0
		25 May	0,0	80	0	0,0								0,0
4	Nanoascorbate chitosan	15 May	0,0	80	0	0,0								0,0
		25 May	0,0	80	0	0,0								0,0
5	Chitosansource	15 May	0,0	80	0	0,0								0,0
		25 May	0,0	80	4	5,0	1	3						1,3
6	Nanochitosan	15 May	0,0	80	0	0,0								0,0

		25 May	1,25	80	5	6,0	2	3						1,4
7	PMC Cu^{2+}: Ag 7:3	15 May	5,0	80	16	20,0	3	13						5,2
		25 May	6,25	80	23	28,8	6	12	5					8,0
8	PMCCu^{2+}: Ag 8:2	15 May	0,0	80	0	0,0								0,0
		25 May	6,25	80	22	27,5	8	13	1					6,6
9	Cuprumchit 0,5%	15 May	0,0	80	0	0,0								0,0
		25 May	0,0	80	0	0,0								0,0

4. Conclusion

From the obtained research results, the following conclusions can be drawn: nanopolymer preparations based on chitosan Bombyx mori Nanoascorbatchitsan 0.5% (4:1) and Nanochitosan 0.5% (90 kDa) have a positive effect on the germination energy and seed germination, as well as on yield components wheat varieties Dustlik and Semurug, which have a high biological activity, which made it possible to obtain an additional yield of 5.5 c/ha to 9.4 c/ha compared to the control variant. In our studies, it was found that the use of Nanoascorbatchitosan in the treatment of seeds of wheat varieties Dustlik and Semurug with a nanopolymer preparation Nanoascorbatchitosan suppresses the development of yellow rust disease by up to 50%. The most effective nanopreparation in our experiments turned out to be Nanoascorbatchitosan, which we recommend for pre-sowing treatment of wheat seeds.

5. List Used Literature

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