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Original Research Article

Application of chitosan Bombyx mori and its derivatives in cotton-growing

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Abstract: It was found that the polymeric disinfectant Uzchitan is non-toxic, ecology-safe, easily utilized in soil, assists suppress of pathogenic organisms, stimulates germinating power, growth, plant development and cotton yield. The effect of the processing of seeds with the studied polymeric preparations on germinating power and growth of cotton root was investigated experimentally.
Keywords: seed, chitin, chitosan, Uzkhitan, germination, productivity

INTRODUCTION:

It is known that for the harvests to be guaranteed, the chemical substances of protection and regulation of plant growth (CSPR) are actively used in agricultural practice. They are phytohormones and their synthetic analogs, microelements, bactericides, fungicides, acaricides and other biologically active compounds. Such chemical substances are used to process plant seeds at different stages of ontogenesis. The use of CSPR-pesticides is connected with their effect on ecology of human being and environment, very frequently with serious consequences. An important aim is ecologization and optimization of the methods of seeds processing with biologically active compounds.

In the latest 30 years several effective technologies were revealed; among them most effective proved to be seed processing with biologically active polymers. One of the perspective technologies of presowing preparation of agricultural seeds is encapsulation, i.e. covering of the seed surface with water-soluble polymeric semi-functional films [1-7].

The multiyear-study results allowed chitosan – poly-functional polymer – to be selected especially because chitosan produced from crab testa is widely used in foreign agricultural practice [8]. In Uzbekistan the waste of natural silk production (silkworm chrysalis) can be a source of chitin and chitosan [6].

The use of chitin and chitosan for creation of biodegradable polymers is reasonable and perspective. The advantages of these compounds are their biocompatibility, biodegradation, lox toxicity and availability. They have no negative effect on ecology, can be easily modified with transformation into water-soluble forms, create films with high adhesion and have high sorption capacity.

The polymeric preparative forms with own biological activity have been created, as well as the systems where chitin and chitosan are matrixes – carriers of biologically active compounds determining prolongation of their action [6].
The collective of the scientists has developed under supervision of academician S.Sh. Rashidova the ecology-safe preparations on the basis of chitosan and its derivatives – carboxymethyl chitosan, chitosan ascorbate, polymer-polymeric mixtures of carboxymethylcellulose – chitosan, pectin-chitosan, polymer-metal complexes of chitosan with ions of cobalt, copper, iron, nickel, zinc. A technology of their production from the waste of silk-winding industry (silkworm chrysalis) was realized with a pilot installation.

The systematic studies in the field of application of water-soluble polymers on the basis of natural polysaccharides have led to creation of a preparation UZCHITAN that is a polymer-polymeric mixture of chitosan and carboxymethylcellulose (CS, CMC) [7].

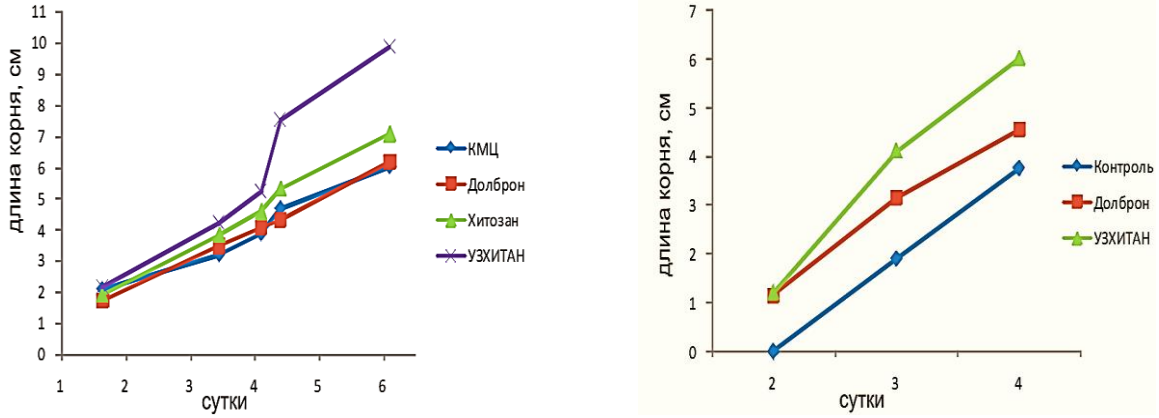
The complex hygiene-toxic studies of UZCHITAN preparations, derivatives of chitosan-ascorbarchitosan, carboxymethylchitosan, polymer-metal complex were carried on at Research institute of sanitary, hygiene and professional diseases of the Health Ministry of the Republic of Uzbekistan under

supervision of academician T. Iskandarov. The studies showed that all the studied preparations are related to class IV of danger in toxicity, have a weak annoyance on mucilaginous shells of eyes and have no local skin-irritating effect. The hygienic standards of preparations in objects of the environment were scientifically justified; the schedules of safe application in agriculture were developed [10-12].

It was found that the polymeric disinfectant UZCHITAN is non-toxic, ecology-safe, easily utilized in soil, assists suppress of pathogenic organisms, stimulates germinating power, growth, plant development and cotton yield.

Chitosan of some degree of deacetylation is used as a component of the UZCHITAN preparation (a disinfectant with stimulating effect) that was registered by the State Chemical Commission of the Republic of Uzbekistan for application in agriculture [9].

The UZCHITAN preparation has been used for presowing processing of cotton seeds with an encapsulation technology since 2004; the use was started with naked seeds of cotton. The effect of the processing of seeds with the studied polymeric preparations on germinating power and growth of cotton root was investigated experimentally. The dependence of root length on germination time is presented in Fig. 1.



a) **b)**

Fig 1: The effect of seed processing with different preparations on root growth for naked seeds (a) and tomentous ones (b) for growth C-6524.

RESULTS:

The experiments showed that the variants with the use of UZCHITAN and chitosan demonstrated the most absorption of water by seeds and acceleration of growth of cotton root for the time of observations [13].

The oscillations of the weather indicators were fixed yearly, especially for the sowing period. The studies of the UZCHITAN effect on sowing characteristics of encapsulated naked cotton seeds was started with the influence of low temperature on germination power of seeds processed with different preparations. In connection with that, the germinating power of encapsulated naked cotton seeds was defined under laboratory conditions. The germinating power was determined for T=+25°C and then compared with different modes of cotton storage: ±5°C for 3 days, +12°C for 2 days and +25°C for 4, 8 and 12 days.

The germinating power was over 34% for encapsulated seeds processed with UZCHITAN and over 28% for those processed with chitosan as compared with control. The results showed that the seeds processed with the polymeric preparation better undergo low temperatures, which allows higher germinating power and healthy sprouts.

The chitosan-based preparations are usually characterized as plant stability inductors of starting different protective reactions in plants [14-17]. The biological activity of the UZCHITAN preparation was studied for Sultan-growth cotton, particularly its effect on peroxidase activity. For comparative analysis, the preparations UZCHITAN, UZCHITAN-O, chitosan-1, chitosan-2 and Dalbron preparation were used (Table 1). The Sultan-growth seeds were naked and encapsulated in the solutions of the preparation UZCHITAN, UZCHITAN-O, chitosan-1, chitosan-2 and Dalbron (standard).

Table 1: Activity of ferments of 7-days gems of sultan growth cotton processed with preparations chitosan-1, chitosan-2, uzchitan, and uzchitan-o

Variants	Ferment activity, E/mg POX			Mean statistical values with standard deviation	Difference+
	Repetition				
	1	2	3		
Sultan					
Control	2.49	2.38	2.12	2.33	0
Dalbron	1.92	20.4	1.98	1.98	-0.35
UZCHITAN	5.60	5.42	5.38	5.47	+3.14
UZCHITAN-O	5.61	4.56	4.98	5.12	+2.79
Chitosan-1	3.42	3.48	3.35	3.42	+1.09
Chitosan-2	3.88	3.96	4.16	4.00	+1.67

The germs of Sultan-growth seeds processed with the polymeric preparations UZCHITAN, UZCHITAN-O, chitosan-1 and chitosan-2 demonstrated the peroxidase activity higher than 2.2, 2.3, 1.5 and 1.71 times, respectively, as compared with control while for the variant with Dalbron the peroxidase activity decreased by 0.15 times. The studies showed the positive effect of the polymeric preparative forms on the basis of chitosan both on germinating power of seeds and on oxidase system of cotton [18].

Among the water-soluble derivatives of chitosan a special place is occupied by carboxymethylchitosan, ascorbatchitosan and polymer-metal complexes to be used for wide practical application in the fields of medicine, agriculture, perfumery, building construction *etc* [19-21]. Producing these derivatives of chitosan extracted from the domestic silkworm chrysalis *Bombyx mori* is of great scientific and practical interest for production of new domestic products.

The effect of carboxymethylchitosan (CMCS) with different degree of substitution on germination energy and germinating power of cotton seeds was studied. The study results showed that the germination energy of seeds processed with CMCS-1 is 1.75% and 4.75% higher than those processed with CMCS-2 and CMCS-3, respectively. The seeds processed with CMCS-1, CMCS-2 and CMCS-3 of the concentration 0.3% differ by 4.85-9.5% in germination energy and by 5,5% in germinating power as compared with control (Table 2).

Table 2: The effect of CMCS with different degree of substitution on energy of germination of germinating power of cotton seeds

No	Preparation	N, %	W, %	Solubility %	Germination energy, %	Germinating power, %
1	Control	-	-	-	86.25	89
2	CMCS 1	2.60	12.8	97.51	95.75	96.75
3	CMCS 2	2.91	15.3	93.96	94	94.5
4	CMCS 3	4.03	16.4	93.98	91	94.5

N- Nitrogen content, %
W-humidityCMCS %
P- Solubility of CMCS in water, %

The effect of chitosan metal-complex with copper and cobalt ions on germinating power was studied for cotton seed encapsulation. The results are presented in Table 3.

Table 3: The effect of polymer-metal complex of chitosan on germinating power of cotton seeds

No	Variants	Germinating power, %	Quantity of ill germs, pcs.
1	Control	91.0	9
2	Chitosan	92.0	8
3	Chitosan - Co	94.0	6
4	Chitosan - Си	94.0	6

The studies showed that the polymer-metal complexes for the studied concentration influence positively on germination energy, germinating power and germination dynamics of cotton seeds, which leads to early growth and development of cotton.

The naked seeds processed with Dalbron, chitosan, UZCHITAN and without (control) were used in field experiments. The naked seeds processed with UZCHITAN and UZCHITAN containing copper ions and control without processing were used in the three variants.

Before the field experiments the germination energy and germinating power of seeds for all the three variants were defined under laboratory conditions. The laboratory data demonstrated that all the experimental variants surpass the control one both in germination energy and in germinating power.

The best data were obtained for the naked encapsulated seeds processed with UZCHITAN. The germination energy was by 8% higher and the germinating power by 5% higher than the control variant. The quantity of rotten germs was the least (1.7%), which is by 5.3% less than the control variant

.

For the tomentous seeds the best result of the germinating power was for seeds processed with UZCHITAN.

The field germinating power was almost by 8% higher, the phase of budding started 3 days earlier and the growth for June 1 was by 1.4 cm longer than the control variant.

The further observations of growth and development demonstrated that the sympodial branches in the variant with UZCHITAN were by 1.8 and 1.1 higher than the control one. The number of cotton bolls was 0.9 pcs more than the control variant. For all the variants the gummosis disease was not found; the plants were infected with wilt by 1% less than the control variant.

The yield of raw cotton was calculated. For October 10 the yield of raw cotton grown from the seeds processed with UZCHITAN was 1.6 c/he higher than the control and the total yield by 3.1 c/he higher. It should be noted that the plants grown from the seeds processed with UZCHITAN have a tendency to early boll opening, which allows more qualitative raw cotton.

The yield of fiber in per cents and the mass of raw cotton in one boll in grams were defined with the trial samples. The best results were obtained for the variants where the seeds were processed with UZCHITAN. After ginning the fiber mass (40 g of each repetition) was sent to the laboratory "Sifat" to determine the technological properties.

The results obtained demonstrated that Mic of cotton fiber of the plants grown from the encapsulated naked seeds processed with UZCHITAN was equal to that of the control and exceeded the control for the tomentous seeds. As a whole, the technological qualities of fiber defined with the HVI system corresponded to the authors' description of the Sultan growth (Table 4).

Table 4: data on yield and agriculturally valuable properties of raw cotton

Variants	For 10 September		For 1 October		For 15 October		For 1 November		Total			Agriculturally valuable properties of raw cotton	
	Gathered, g	Converting into c/he	Gathered, g	Converting into c/he	Gathered, g	Converting into c/he	Gathered, g	Converting into c/he	Gathered, g	Converting into c/he	+ to control	Fiber yield, %	Mass of raw cotton in 1 boll, g
Control naked	8680	24.1	3420	9.5	1070	3.0	618	1.7	13788	38.3	0	36.0	5.66
Dalbron	8450	23.5	3690	10.3	1540	4.3	504	1.4	14184	39.4	+1.1	35.8	5.72
Chitosan	8862	24.6	3525	9.8	1482	4.1	387	1.1	14256	39.6	+1.3	36.5	5.86
UZCHITAN	9010	25.0	3650	10.1	1426	4.0	350	1.0	14436	40.1	+1.8	36.4	5.91
Control tomentous	8198	22.8	3415	9.5	1517	4.2	802	2.2	13932	38.7	0	35.8	5.72
UZCHITAN	8986	25.0	3740	10.4	1123	3.1	659	1.8	14508	40.3	+1.6	36.5	5.88
UZCHITAN + copper ion	8720	24.2	3600	10.0	1218	3.4	682	1.9	14220	39.5	+0.8	36.2	5.80

These studies demonstrated that the UZCHITAN preparation is very perspective for encapsulation of naked cotton seeds. That is connected with the fact that firstly the amount of seeds per hectare significantly decreases and a preset quantity of seeds can be sown in one hole. Secondly, the seeds processed with the polymeric preparation better endure low temperatures. Under favorable conditions their field germinating power increases. Thirdly, the encapsulated naked seeds left behind the control in growth and development of plants and the rate of root rot sickness was significantly lower than that of the control.

According to the positive results obtained for the laboratory and field tests, the seeds processed with encapsulated UZCHITAN were sown in the Andijan, Namangan and Kashkadariya regions of the Republic of Uzbekistan and in the Amudariya one of the Republic of Karakalpakstan (Table 5).

Table 5: Application of Encapsulated Seeds Processed With Uzchitan in the Regions of the Republic Of Uzbekistan (2010-2014)

Region	Years	Number of farms	Consumption of encapsulated seeds for one hectare	Sown area, he/kg	Gross yield of raw cotton, centner	Mean yield, c/he		
						Under plan	In fact	+to plan
Amudarinskiy rayon, Republic of Karakalpakstan	2010	10	30.3	528.0	17054	26.0	32.3	+6.3
	2011	24	39.6	1010.0	29795	26.0	29.5	+3.5
	2012	23	31.9	1458.0	43594	26.2	29.9	+3.7
	2013	25	34.9	1109.0	34046	26.2	30.7	+4.5
	2014	11	30.0	730.0	23433	26.2	32.1	+5.9
Total	***2010-14***	***93***	***33.3***	***4835.0***	***147922***	***26.1***	***31.2***	***+4.8***
Andijan region	2010	4	48.1	201.6	6814	30.0	33.8	+3.8
	2011	13	44.4	579.2	17064	30.0	33.2	+3.2
	2012	14	45.7	608.6	20022	30.0	32.9	+2.9
	2013	68	43.8	2282.0	76218	31.3	32.1	+0.8
	2014	178	48.5	6134.5	196917	31.3	305	-0.8
Total	***2010-14***	***277***	***44.1***	***9805.9***	***317035***	***30.5***	***32.3***	***+1,8***
Namanganregion	2010	1	42.0	20	682	30.5	34.1	+3.6
	2011	22	42.8	467.4	14636	30.0	31.4	+1.4
	2012	102	44.4	3428.1	103186	29.0	30.1	+1.1
	2013	130	48.3	5150.0	151925	28.6	29.5	+0.9
	2014	130	45.0	3549.0	109309	29.6	30.1	+0.6
Total	***2010-14***	***385***	***44.5***	***12614.5***	***379738***	***29.3***	***30.1***	***+0.8***
Kashkadariya region	2012	31	36.0	1200	33960	28.0	28.3	+0.3
	2013	265	35.0	5475.7	138518	25.9	26.3	+0.4
	2014	277	30.1	6504.9	167175	25.3	25.7	+0.4
Total	***2013-14***	***573***	***33.7***	***13180.6***	***339653***	***26.4***	***26.8***	***+0.4***

CONCLUSION:

The over-10-years studies of biologically active polymers to be used in agriculture were directed to apply the domestic ecology-safe polymeric compounds of plant protection on the basis of chitosan. The study results demonstrated that the processing of seeds with biologically active polymeric preparation on the basis of chitosan and its derivatives can suppress pathogenic organisms, stimulate the germinating power, growth and development of plants, and increase the cotton yield, which is confirmed by application in agriculture and farms.

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