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Soil Solarization and Sideration in Cotton Wilt Control in Uzbekistan

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Abstract
Due to the high temperature formed when the wheat-free field was covered with the polyethylene film for 70 days in the summer and solariated, wilt fungi and some beneficial fungi were killed in the soil. Then mustard plants planted until September 5 and crushed them until the first frost in autumn (November 15-20), it was found that the microbiological activity of the soil increases and its fungi static properties are elevated. In early spring, it was observed that the thickness of the field strength was maintained and the incidence of wilt disease of plants was sharply reduced, resulting in increased yields.

INTRODUCTION

Protection of cotton crops from disease epiphytoties is an important problem preserving the yield and fiber quality of this most valuable industrial crop. Under the conditions of global climate change on plants, genetic changes occur, which lead to the emergence of new more aggressive species and races of pathogenic microorganisms (Tarr, 1975; Marupov, 2003; 2013).
For example, the new F. oxysporum race, which appeared in Australia during the 1992-1993 growing season, can be attributed. It spread very quickly in this country, causing extensive damage to the cotton crop.

In 2000, farmers in the state of California imported industrial cotton seeds from Australia for livestock feed. Due to untimely analysis and detection of the pathogen on imported seeds, the most dangerous fourth race of the pathogen Fusarium wilt of cotton was introduced. Cotton growing in the states of California and Louisiana, USA, is currently severely affected by this disease.

According to R. Stipanovic (2002), A. Bell (2003) the economic harm to California alone from the disease in 2002 was more than US $ 100 million.

In Uzbekistan, in the middle of the twentieth century, medium-fiber varieties of cotton were affected by wilt, only caused by the pathogenic fungus Verticillumdahliae Klebahn, and fine-fiber varieties Fusariumoxysporumf. sp. Vasinfectum (Atk.), And by the end of the same century, medium fiber varieties of cotton began to be affected by both the first and the second pathogen (Mirpulatova, 1973; Marupov, 1993).

It should be especially noted that in recent years in Bukhara and neighboring regions, during the period of appearance of 2-4 true cotton leaves, plants are strongly infected with the new pathogen of Fusarium wilt, the fungus Fusariumverticillioides (Sacc.) Nirenberg (Syn: F. moniliforme), which leads not to wilting (as usual), but to drying out (death) of young cotton plants, causing great economic harm to farms (Marupov, 2008; 2013).

Thus, currently under the conditions of Uzbekistan cultivated varieties of cotton of the species Gossypiumhirsutum L. are affected by three types of the causative agent of wilt by the pathogenic fungi Verticillumdahliae Klebahn, Fusariumoxysporumf. sp. Vasinfectum (Atk.) Snyderet. Hansen and Fusarium verticillioides (Sacc.) Nirenberg (Marupov, 2013).
The possibility of a repetition of wilt epiphytoties on cotton, which arose in the 60s and 70s of the last century, is not excluded.

The causative agent of wilt is constantly accumulating in the soil, and not the use of scientifically grounded anti-wilt crop rotation in farms only contributes to the defeat of new varieties of cotton, due to the high adaptive ability of pathogens to new zoned varieties. The spread

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of highly virulent and aggressive forms of pathogens, which constantly accumulate in the soil during the continuous cultivation of the same cotton variety, also contributes to the growth of wilt damage to varieties.

Therefore, along with the development of new lines and varieties of cotton that are highly tolerant to this disease, the destruction of infectious primordia of the causative agent of wilt in the soil by means of new agrotechnical anti-wilt measures has been and remains the main deterrent method of harmfulness of wilt.

The high efficiency of soil solarization in the fight against soil pathogens of cotton, vegetables and other crops has been proven by Israeli and American scientists (Kenneth N. and J. Katan (eds.), 1972; Grinstein, A. and J. Katan, 1979; Katan, J. and J. E. DeVay (eds.), 1991; Gamliel, A. and Katan, J. (eds.), 2012). As the authors point out, when using films with a size of 0.038-0.050 mm, the soil temperature at a depth of 5-10 cm reaches 42-550C and at a depth of 45 cm 32-370C. When using black and double layers of white films, the soil temperature rises.

As pointed out by N.S. Mirpulatov (1973), mainly soil pathogens are found in the rhizosphere of cotton roots at a depth of 5-25 cm. The favorable soil temperature for the development of wilt pathogens is 24-280C, over 300C is destructive.

In Uzbekistan, soil solarization in the fight against cotton wilt has not been studied before.

Research methodology. Experiments on this problem were carried out in 2015-2017 on meadow-alluvial soils, on a naturally heavily contaminated field of a farm named after I. "Kulkhatib" of the Vobkent district of the Bukhara region.

Fig.1. Solarization of the experimental site

Figure 2. Vegetating mustard after solarization

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After harvesting wheat for grain, the experimental plot was prepared for sowing according to the generally accepted method on the farm (July 11). Then, according to the variants of the experiment, the plots were covered with a polyethylene film of 0.05 microseconds in size (July 17). After 48 days, i.e. On September 4, the film was removed from the experimental plots. According to the variants of the experiment, the sowing of mustard was carried out (September 5) according to the recommendation of A. Marupov (1988).

The experiment was carried out in 4-fold repetition.

Microbiological analyzes of the soil were carried out after harvesting wheat (July 11) before solarization and after solarization of the soil (September 4) before sowing mustard in 2015 and 2016 in the period before sowing and during the ripening of cotton, according to the generally accepted method of limiting dilutions according to S.F. Lazarev (1963).

The growing mustard was fed with nitrogen at a rate of 50 kg / ha. During the growing season, the plants were watered 3 times. When the plant height reached 1.0 m, their phytomass was crushed and plowed into the soil to a depth of 40 cm (November 10). When plowing the mustard phytomass, 70% of phosphorus and 50% of potassium were added from the annual rate of cotton fertilization (Marupov, 1988).

Fig.-3. Shredding mustard with KIR-1,5.

Fig-4. Flavoring the chopped mustard mass.

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In 2016, the cotton variety Bukhara-10 was sown at the optimal time for the farmer.

Discussion of research results. Table 1 shows the data of microbiological soil analysis after wheat harvesting and after soil solarization (2015). From the data in Table 1, it can be seen that after harvesting wheat (July 11), the total number of fungi is 9.0 thousand pieces, bacteria - 42.0 thousand pieces and actinomycetes - 100.0 thousand pieces per 1 g abs. dry soil.

In the same variant (September 4), an increase in the total number of microorganisms is noted, due to the enrichment of the arable soil layer with root and harvest residues of wheat. The total number of fungi is 11.7 thousand pieces, bacteria - 116.0 thousand pieces and actinomycetes - 92.7 thousand pieces per 1 g abs. dry soil.

Under cotton, these indicators were, respectively, by the types of microorganisms 10.0; 76.0 and 92.5 thousand pieces in 1g abs. dry soil.

In the variant where soil solarization was carried out, the total number of microorganisms sharply declined and their number was: fungus - 2.0 thousand pieces, bacteria - 50.5 thousand pieces and actinomycetes - 71.5 thousand pieces per 1 g abs. dry soil.

Isolation of fungi of the genus Fusarium from the soil was not observed. Thermophilic fungi of the genus Aspergillus predominated.

As A.S. Letov (1934); P.N. Golovin (1953); A.I. Solovyov (1955); N.S. Mirpulatova (1973) and A. Marupov (1975; 1993) wrot, mainly wilted pathogens are found at a depth of 10-25 cm. At temperatures above 300 C, they die.

Table 1
Results of microbiological soil analysis. 2015

П/П	Wholesale options	Fungi on Czapek	Bacteria on MPA	Actenomycitis on CAS
	After harvesting wheat (11 July)			
	Wheat	9,0	42,0	100,0
	After solarization of the soil (September 4)			
1	Cotton plant over cotton plant	10,0	76,0	92,5
2	Wheat	11,7	116,0	92,7
3	Wheat,solarization	2,0	50,5	71,5

Our research showed that the temperature of the soil at a depth of 10-30 cm with solarization averages 42.410C to 61.750C, which is fatal for the causative agent of wilt. This explains the absence of Fusariumsp wilt pathogen isolation from the soil in pure culture against the background of solarization.

Despite a significant decrease in the number of bacteria from 116.0 to 50.5 thousand pieces per 1 g of abs. dry soil, among them there are many colonies with antagonistic activity against the fungus Fusarium. There was also a decrease in the total number of actinomycetes.

Apparently, the high temperature and humidity of the soil, created under the film, inhibit the total number of microorganisms, especially fungi.

This pattern shows the need to replenish the arable soil horizon with the necessary organic materials to restore the useful natural microbiological potential of the soil after solarization.

For this purpose, we sowed mustard on September 5, after harvesting the film used to solarize the soil.

Harvest of phytomass of mustard before plowing under the plow.

The plant density before plowing was 310.0 thousand / unit per hectare. The average height of the stems was 95.0-100.0 cm. In total, 532.0 centners / ha were plowed under the fall of the green mass of mustard together with the roots.

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In 2016, against the background prepared in 2015, cotton of the Bukhara-10 variety was sown.

Microbiological soil analysis data

Data from microbiological analyses of soil in 2016 and 2017 at the time before sowing and during the ripening period of cotton are presented in Table 2. From the data in the table it can be seen that in 2016, with a monoculture of cotton, the total number of mushrooms before sowing cotton amounted to 7.75 thousand pieces, and growing during the growing season of plants, it reached 15 , 0 thousand pieces in 1 gr. abs. dry soil. The number of bacteria was 65.0 and 14.3 actinomycetes in 1 g of abs. dry soil.

The data obtained in 2017 in this variant show that there is no big difference in the development of the total number of microorganisms in comparison with 2016.

In the variant wheat + cotton, it is noted that in 2017 the development of the total number of microorganisms is somewhat more active in comparison with 2016. We believe that this is due to the timing of decomposition of plant residues of wheat.

In the variant wheat + solarization + cotton, the amount of mushrooms did not exceed 2.0 pcs per 1 g. abs. dry soil. Apparently solarization had a detrimental effect on the development of fungi. In 2017, there was an increase in the total number of microorganisms, which recovered during the growing season of cotton.

In the variant wheat + solarization + mustard for green manure + cotton, the rapid development of fungi was noted in the period before the sowing of cotton and decreased by almost 50.0% during the period of cotton ripening. In our opinion, this is due to the active participation of the soil microflora in the decomposition of the phytomass of mustard plowed under the plow in the spring, and by the maturation of cotton, due to the absence of easily mobilized organic material, the activity of microorganisms slightly decreased.

Table 2

The total number of microorganisms in 1 g of abs. dry soil. Bukhara region, Vobkent district, farm "Kulkhatib".

Bukhara-10 th variety.

№ / №	Research options	Years	Fungi on Czapek, thous.		Bacteria on PA, thous.		Actinomycetes per CAS, mln.	
			before sowing	into ripening	before sowing	into ripening	before sowing	into ripening
1.	Cotton plant over cotton plant	2016	7,75	15,0	65,0	30,0	14,3	84,0
		2017	8,0	3,75	94,0	16,25	15,0	150,2
2.	**Wheat + cotton**	2016	6,75	14,0	57,5	70,0	14,9	11,1
		2017	18,0	3,75	99,7	10,75	9,2	139,0
3.	Wheat, solarization + cotton	2016	2,0	2,0	60,0	20,0	10,8	7,0
		2017	14,25	10,25	188,5	8,25	9,75	191,5
4.	Wheat, solarization, green manure mustard + cotton	2016	13,25	7,0	265,0	260,0	19,1	96,0
		2017	10,75	16,25	204,0	8,75	5,25	130,0

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The development of bacteria and actinomycetes also intensively took place in the variant where a large amount of organic material was plowed in, where bacteria amounted to 265.0 thousand pieces, and actinomycetes - 19.125 million pieces per 1 g abs. dry soil. Antagonistic forms predominated among bacteria, which strongly suppressed the growth of the pathogen in pure culture.

Table 3. presents the data for 2016 and 2017 on the isolation of various types of dominant soil fungi into a pure culture. The tabular data show that with a monoculture of cotton, the total number of mushrooms is 7.75 thousand pieces in 1 g of abs. dry soil. Among the isolated fungi were dominated by such fungi as Aspergillus, Penicillium and Fusarium. Isolation of fungi from the genus Trichoderma is not observed. In the variant wheat + cotton with a total amount of fungi in 1gr abs. dry soil 7.75 thousand units, Aspergillus was 3.0 thousand units, Penicillium 0.25 and Fusarium 0.75 thousand units. in 1g abs. dry soil.

In 2016, in the variant wheat, solarization, mustard for green manure + cotton before sowing cotton, there is a rapid development of fungi, especially from the genus Aspergillus 8.25 thousand pcs. 1 g abs. dry soil. Fungi from the genus Penicillium amounted to 1.75 thousand pieces 1 g abs. dry soil. This variant had a disastrous effect on the development of fungi from the genus Fusarium. It was noted that the isolation of fungi from the genus Trichoderma in the amount of 0.25 thousand pieces in 1 g of abs. dry soil. Almost the same consistency is observed in 2017.

It should be especially noted that during the period of cotton ripening, a decrease in the total number of fungi is observed, however, the number of fungi from the genus Trichoderma increases sharply and reaches 3.0 thousand pieces per 1 g abs. dry soil. As you know, among the fungi of the genus Trichoderma, there are many strains that are antagonists of soil pathogens.

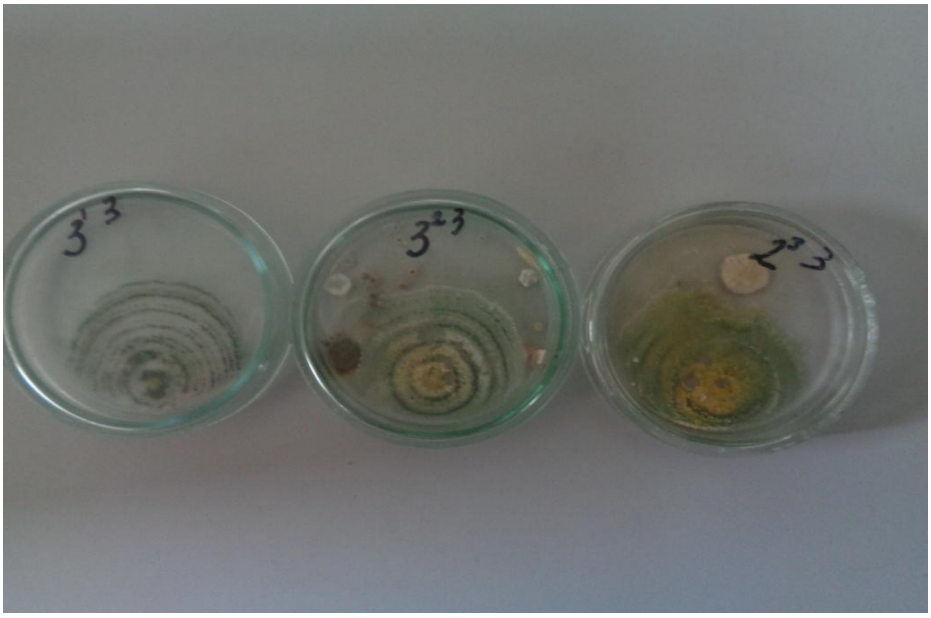

Fig. 5. Fungal strains of the genus Trichoderma isolated from the variant solarization + soil sideration.

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Table 3
The amount of fungi in 1 g of abs. dry soil, thous.
Bukhara region, Vobkent district, farm "Kulkhatib", Bukhara-10variety

№	Research options	Years	All of fungi	among them					
				Asper gillus	Penicillium	Fusarium	Trichoderma	Mucor	Прочие
		before sowing							
1.	Cotton plant over cotton plant	2016	7,75	2,25	1,75	2,0	0,0	0,0	0,75
		2017	8,0	6,5	1,25	0,0	0,0	0,0	0,25
2.	Wheat + cotton	2016	6,75	3,0	0,25	0,75	0,0	0,25	0,5
		2017	18,0	17,25	0,75	0,0	0,0	0,0	0,0
3.	Wheat, solarization + cotton	2016	2,0	1,25	0,0	0,0	0,0	0,5	0,25
		2017	14,25	13,5	0,75	0,0	0,0	0,0	0,0
4.	Wheat, solarization, green manure mustard + cotton	2016	13,25	8,25	1,75	0,0	0,25	0,25	2,75
		2017	10,75	7,0	3,5	0,25	0,0	0,0	0,0
into ripening									
1.	Cotton plant over cotton plant	2016	15,0	6,0	3,0	5,0*	0,0	0,0	1,0
		2017	3,75	3,75	0,0	0,0	0,0	0,0	0,0
2.	**Wheat + cotton**	2016	14,0	5,0	3,0	4,0*	0,0	1,0	1,0
		2017	3,75	3,75	0,0	0,0	0,0	0,0	0,0
3.	Wheat, solarization + cotton	2016	2,0	0,0	1,0	0,0	1,0	0,0	0,0
		2017	10,25	0,5	0,0	0,0	9,75	0,0	0,0
4.	Wheat, solarization, green manure mustard + cotton	2016	7,0	2,0	2,0	0,0	3,0	0,0	0,0
		2017	16,25	15,25	0,25	0,0	0,75	0,0	0,0

In the variant wheat + cotton + solarization, the suppressing effect of solarization is observed for all fungi, except for thermophilic fungi of the genus Aspergillus.

It also perniciously influenced the development of pathogenic fungi from the genus Fusarium, simultaneously with solarization and green manure with the phytomass of mustard.
We have identified three fungi of the genus Trichoderma, different in terms of cultural and morphological characteristics, from the variant solarization, green manure + cotton, which are of great theoretical and practical interest in the development of a biological method for combating soil pathogens (Fig. 5).

Thus, solarization of the arable horizon of a cotton field, followed by green manure under the plow, completely inhibits the development of the causative agent of wilt, the fungus Fusarium.
Enrichment of the soil with easily mobilized phytomass of mustard increases the fungistatic activity of the soil, due to an increase in the number of mycolytic bacteria and natural antagonist fungi, especially from the genus Trichoderma. As a result, there is a sharp decrease in the incidence of cotton wilt, a decrease in harmful toxic substances of pathogens that negatively affect young plants and the preservation of the number of plants.

Harmfulness of the wilt on the density of plant standing.
Our long-term research in the Bukhara region has shown that when cotton is sick with wilt at an early stage of its development, the plants die, while the number of plants in the field is lost. This leads to the obsolescence of crops and, ultimately, the yield of cotton sharply decreases.

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Fig. 6. Sick cotton wilt in the early stage of development.

Table 4 shows data on the harmfulness of wilt on the density of standing of cotton crops. From the data in Table 4, it can be seen that with a monoculture of cotton in 2016, the plant density per 1 hectare was 57.0 thousand pieces / ha and in 2017 - 67.3 thousand pieces / ha. Almost similar results were obtained in the wheat + cotton variant.

In the variant wheat, solarization + cotton, the saved number of plants was 28.5 thousand pieces / ha in 2016 and 8.7 thousand pieces / ha in 2017.

The inclusion of mustard for green manure in this option dramatically increased the preserved number of plants, and in 2016 and 2017 it amounted to 29.5 and 23.1 thousand units / ha, respectively. The preservation of a large number of plants in this variant in the year of action and aftereffect is due to the high anti-vilt efficiency of the joint application of soil solarization with green manure under the plow.

Table 4
Harmfulness of wilt on the number of plants, pcs.
Bukhara region, Vobkent district, farm "Kulkhatib", Bukhara-10 variety.

№ / №	Research option	Years	Number of plants, thousand/hectare	Preserved number of plants, thous./ha
			10 july	10 july
1.	Cotton plant over cotton plant	2016	57,0	-
		2017	67,3	-
2.	Wheat + cotton	2016	56,5	-0,5
		2017	70,2	2,9
3.	Wheat, solarization + cotton	2016	85,5	28,5
		2017	76,0	8,7
4.	Wheat, solarization, green manure mustard + cotton	2016	86,5	29,5
		2017	90,4	23,1

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Dynamics of development of wilt in cotton. Data for 2016 and 2017 of the dynamics of the development of wilt on cotton plants of the Bukhara-10 variety are presented in Table 5. Tabular data show that in 2016, in the variant of cotton monoculture with 2-4 true plant leaves, plants affected by wilt make up 35.0% (the number plants 57.0 thousand pieces / ha).

It should be noted that precise sowing was carried out at the rate of 90-100 thousand pcs / ha. The loss of the number of plants from wilt is almost 50.0%. In budding and maturation, the percentage of diseased plants increased by 8.0% and 15.0%, respectively. During the period of cotton ripening (September 17), diseased plants accounted for 58.0% in terms of external symptoms and 61.0% in terms of wood tissue necrosis. Dried plants from the disease were not noted.

Almost similar results were obtained in the wheat + cotton variant, where as of July 17 the number of plants was 56.5 thousand pcs / ha. Plants with wilt during the period of cotton ripening accounted for 42.7% in terms of external symptoms and 44.2% in terms of wood tissue necrosis.

In 2017, in all variants, there was a decrease in the number of plants affected by wilt and an increase in the number of plants per hectare. In the variants of solarization, plants affected by wilt during the period of cotton ripening accounted for 8.5% in 2016 for external symptoms, 9.0% for wood tissue necrosis, 17.5% and 22.5% in 2017, respectively.

Table5
Dynamics of development of wilt in cotton.
Bukhara region, Vobkent district, farm "Kulkhatib", Bukhara-10 variety.

ions	Years	Plants sick with wilt,%.					Biological effectiveness of the way to combat wilt (by external signs).
		2-4 present Leaves	budding	flowering-fruiting	Maturation		
					outwardly	by necrosis of wood tissue	
		30.05	10.07	14.08	17.09	17.09	17.09
over cotton	2016	35,0	8,0	15,0	58,0	61,0	-
	2017	11,1	13,2	9,1	33.4	41.2	-
on	2016	28,0	6,8	7,9	42.7	44.2	26.4
	2017	10,6	12,5	8,1	31,0	33,0	7.2
ırization, +	2016	4,0	2,5	2,0	8,5	9,0	85.3
	2017	6,2	5,16	6,1	17.5	22.5	47.6
solarization, e mustard +	2016	2,0	0,5	0,75	3,25	4.25	94.4
	2017	4,5	3,5	4,3	12.3	17.7	63.2

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Fig. 7. Condition of cotton after wheat (control).Fig. 8. Condition of cotton after wheat + solarization + green manure.

The biological efficiency of solarization in the fight against wilt was 85.3% in the year of action and 47.6% in the year of aftereffect.

The best results were obtained in suppressing wilt and preserving the number of plants per 1 hectare in the option of solarization, mustard for green manure.

In 2016, during the period of 2-4 true leaves of cotton, diseased plants accounted for 2.0%, during the ripening of cotton, by external symptoms, they were 3.25% and by necrosis of wood tissues, 4.25%, with a plant density of 86.5%.

In 2017, these indicators were 4.5%, 12.3% and 17.7%, respectively.

The plant density per 1 hectare was 90.4 thousand units.

In this variant, the highest biological efficiency was obtained from the use of anti-force measures, 94.4% in the year of action and 63.2% in the year of aftereffect.

Thus, the artificially created high temperature in the arable horizon during solarization destroyed the causative agent of wilt.

The combined effect of solarization and green manure with the phytomass of mustard increased the fungistatic activity of the soil, activated the action of mycological bacteria and the role of natural forms (Bukhara population) of antagonistic fungi of the genus Trichoderma on the pathogen Fusarium. All this combined led to a decrease in the incidence of cotton wilt and contributed to the conservation of the number of plants. The cotton plant, almost in a healthy state, has accumulated the elements of the fruit and has matured.

5.7. Biological yield of raw cotton.

Table 6 presents data on the biological yield of the Bukhara-10 variety. These tables show that in 2016, in a monoculture of cotton (control) with a plant density of 57.0 thousand pcs / ha, the yield of raw cotton was 28.0 c / ha. In 2017, these indicators were 67.3% and 28.7 c / ha, respectively.

Almost similar results were obtained in the cultivation of cotton after wheat in terms of plant density and yield.

In 2016, with the cultivation of cotton after solarization with a plant density of 85.5 thousand pcs / ha, the biological yield amounted to 47.4 c / ha. In 2017, there was a decrease in plant density, and it was 77.5 thousand units / ha, the biological yield was 46.1 c / ha.

In 2016 and 2017, the largest amount of plant density was preserved in the variant solarization + mustard for green manure 96.5 and 90.4 thousand pcs / ha. and the biological yield was 66.8 and 55.7 c / ha, respectively.

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Table 6
Biological cotton crop
Bukhara region, Vobkent district, farm "Kulkhatib", Bukhara-10 variety

№/№	Research options	Years	Number of plants, thousand pcs / ha .	Number of preserved plants, thousand hectares	Biological yield, c / ha	Saved biological yield, c / ha
1.	Cotton plant over cotton plant	2016	57,0	-	28,0	-
		2017	67,3	-	28.7	-
2.	Wheat + cotton	2016	56,5	-0,5	28,8	+0,8
		2017	75,7	+8,4	34,4	+5,7
3.	Wheat, solarization + cotton	2016	85,5	+28,5	47,4	+19,4
		2017	77,5	+10,2	46.1	+17,4
4.	Wheat, solarization, green manure mustard + cotton	2016	86,5	+29,5	66,8	+38,8
		2017	79,5	+12,2	55,7	+27,0

CONCLUSION.
Thus, it was found that during soil solarization, the causative agent of wilt, the fungus Fusariumsp, is eradicated in the arable horizon, along with it, other beneficial soil microorganisms are destroyed. Sideration of the soil after solarization restores the natural microbiological potential of the soil and increases its fungistatic activity. All this together reduces the incidence of wilt plants at an early stage of their development, preserves the number of plants and increases the cotton yield.

PRACTICAL OFFER FOR FARMERS.
We recommend to carry out solarization on the fields infected with wilt with a coating of the soil with a polyethylene film of 0.05 μm after harvesting wheat grown after cotton, then cultivating mustard for green manure in the fall, followed by plowing its phytomass under the plow.

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