The management of microbiological regime of the irrigated light chestnut soils in the Nizhnee Povolzhye under drip irrigation

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Abstract. There is a certain relation between soil fertility and its microorganism content. The article considers the microbiological characteristics of irrigated light chestnut soils in the Nizhnee Povolzhye on various media. The soil samples were taken in the plow horizon (0-20 cm) in five replications for each experimental variant. To determine and account for the microorganism groups in the studied soil, the following nutrient media were used: MPA (meat-and-peptone agar), Wort – Agar and Czapek's, Waksman's. The studies also included the determination of the nutrient content in the soil in order to adjust the fertilizer application system for drip irrigation, since the soil arable layer on the experimental plot was poorly provided with easily hydrolyzed nitrogen and exchangeable potassium, and in medium way with mobile phosphorus. On the irrigated area one selected the plots with onion and cucumber crops with different mineral nutrition and the levels of maintaining pre-irrigation soil moisture, as well as a variant with a virgin (non-irrigated) plot. The development features of microbial communities on irrigated and non-irrigated lands were revealed. In the arable layer of the irrigated light chestnut soil of the Volgograd region, a fungus of the genus Fusarium, bacteria Bacillus subtilis, bacteria of the genus Erwinia were found, which can make it difficult to grow and store agricultural products. The options for maintaining pre-irrigation soil moisture during drip irrigation of vegetable crops did not have any significant effect on the quantitative and qualitative composition of microorganisms. The studied soil, according to agro-chemical analysis, is fertile and can be used for crop growing. Crop cultivation on non-irrigated areas should be carried out with the application of appropriate fertilizers.

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1 Introduction·

There is a certain relation between soil fertility and its microorganism content. Soils rich in bacteria are biologically more active. The greatest number of microorganisms is at a depth of 5-15 cm, less at a depth of 20-30 and even less at a depth of 30-40 cm. Calculations showed that for each hectare of poorly fertile soil there are 2.5-3.0 tons of microbial mass, highly fertile – up to 16 tons. The number of microorganisms in 1 g of soil can vary from 1-3x106 to 20-25x109 [1-4].

All biochemical processes in the soil are associated with microorganisms. Under aerobic conditions, reproduction reaches complete mineralization of residues with the formation of oxidized compounds of a simple composition; under anaerobic conditions gaseous substances and intermediate products in the form of organic acids are formed [3-6, 11,12].

2 Methods and materials

In 2018, studies on the dynamics of basic nutrients and humus content on the irrigated lands of K (F) H "V.V. Vybornov" in the Volgograd region were carried out. The object of the study was the experimental production plots with the onion and the cucumber.

The experimental research program included the study of the soil microbiological activity, as well as the nutrient content in the soil in order to optimize the regulation of the mineral nutrition level for agricultural crops based on the adjustment of the fertilizer application system for drip irrigation.

The experimental irrigated plot is located in the subzone of light chestnut soils. The soil granulo-metric composition is medium and light loamy. The average density of the solid soil phase in a layer with the thickness of 1.0 m varies from 2.34 to 2.58 g/cm3. Soil moisture at the lowest moisture capacity varied from 26.2–24.4% in the plow layer to 21.6% of the dry soil mass at the depth of 1.0 m. The wilting moisture of plants in the arable layer of 0-20 cm is 14.6% of the dry soil. The soils are characterized by a low humus content with fluctuation within the arable layer of 2.10-2.50%. Soil pH is close to neutral, with a tendency towards an increase in pH with an increase in the sampling depth. The soil arable layer on the experimental plot is poorly provided with easily hydrolysable nitrogen and exchangeable potassium (39.1 mg/kg and 89.4 mg/kg of dry soil, respectively), and in medium way with mobile phosphorus (29.5 mg/kg of dry soil).

On the irrigated project, one selected the plots with the onion and the cucumber with different mineral nutrition and the levels of maintaining pre-irrigation soil moisture (Table 1).

Table 1. Variants of the experiments by cultures

Variants by the level of mineral nutrition	Crop			
	Onion		Cucumber	
	Pre-irrigation soil moisture		Pre-irrigation soil moisture	
	Variant A	Variant B	Variant C	Variant D
1 ($N_{170}P_{85}K_{190}$)	80-90% HB in the level of 0,3-0,5 m	90-90% HB in the level of 0,3-0,5 m	X	X
2 ($N_{110}P_{60}K_{100}$)	80-90% HB in the level of 0,3-0,5 m	90-90% HB in the level of 0,3-0,5 m	X	X

Variants by the level of mineral nutrition	Crop			
	Onion		Cucumber	
	Pre-irrigation soil moisture		Pre-irrigation soil moisture	
	Variant A	Variant B	Variant C	Variant D
3 ($N_{165}P_{65}K_{65}$)	X	X	90-90% HB in the level of 0,3-0,5 m	80-90% HB in the level of 0,3-0,5 m
4 ($N_{130}P_{50}K_{20}$)	X	X	90-90% HB in the level of 0,3-0,5 m	80-90% HB in the level of 0,3-0,5 m

Experimental studies were carried out in accordance with generally accepted and specific methods [2, 3].

Soil samples were taken in the plow horizon (0-20 cm) in five replications for each experimental variant. To determine and account for microorganism groups in the studied soil, the following nutrient media were used:

MPA medium

Microorganisms that use organic forms of nitrogen are detected on this medium.

To account for spore-forming bacteria, it is recommended to use mixed agar: MPA + wort in a ratio of 1:1. MPA is prepared in the usual way, wort – agar – from 7-balling wort and 2% agar. Next one mixes MPA and the wort – agar before sowing and pours the mixture into Petri dishes. [1, 2, 4, 10].

Wort – Agar and Czapek's Medium

Microscopic fungi are more often found on these media.

To prepare the wort – agar one takes a seven-balling wort, dilutes it 3 times with water and adds 2% agar.

Waksman's medium:

This medium is used to detect actinomycetes.

Preparation of soil suspension and sowing

To determine soil moisture (for MPA, Waksman's, Wort – Agar, Czapek's media), a 5-gram soil sample was used, which was placed in a weighing bottle and weighed (for conversion into dry soil), the empty bottle was preliminarily weighed.

To obtain dilutions with different soil concentrations, a 10-gram soil sample was used, placed in a 250 ml flask with sterile water, and shaken on a mechanical shaker for 5 minutes.

After shaking, dilutions containing various soil concentrations were prepared.

From the flask (dilution 10-1), 1 ml of the solution was taken with a sterile pipette out of the resulting suspension, placed in test tube No. 2 (dilution 10-2) and shaken. 1 ml of the solution was taken from test tube No. 2 with a new sterile pipette and placed into test tube No. 3 (dilution 10-3). From test tube No. 3, 1 ml of the solution was transferred with a new pipette into test tube No. 4 (dilution 10-4); with the same pipette from tube No. 3 the solution was transferred into 4 sterile Petri dishes, 1 ml of each solution (for Waksman's and Wort – Agar media).

From test tube No. 4, 1 ml of the solution was transferred with a new sterile pipette into test tube No. 5 (dilution 10-5); from test tube No. 4 with the pipette (which was used to pour the solution from test tube No. 4 into test tube No. 5), it was transferred into 6 sterile Petri dishes, 1 ml each (for MPA, Wort – Agar, Czapek's, Waksman's media). From test tube No. 5, with a clean pipette 1 ml of the solution was transferred into 2 Petri dishes (for MPA medium).

After preparing the dilutions, they are poured with preliminarily prepared nutrient media.

As a result of the research, the microorganisms in the light chestnut soil of the Volgograd region were studied and identified.

To compile the final table of the quantitative microorganism composition in the experimental plots (Table 2) and the chart for the quantitative microorganism accounting on different media (the figure), the average number of microorganisms was calculated from two dilutions of each experimental plot.

3 Discussion

In the light chestnut soil of the Volgograd region, on the MPA medium, mainly bacteria of the genus Bacillus of various species were found. For example, Bacillus subtilis, better known as Hay bacterium, was identified, which leads to spoilage of some food products [7,8]. Actinomycete hyphae and conidia were found on Waksman's medium. White, blue and black mold were found on Wort – Agar. Upon examination, it turned out to be Pénicillium, Mucor and Aspergillus. On Czapek's medium, a mold with a reddish shade was found. Microscopic examination revealed that this is Fusarium – a white-pink mold, this fungus causes Fusarium disease in solanaceous.

Table 2. Quantitative microorganism composition of all experimental plots, CFU/g abs. dry soil

Medium used	**The Volgograd region**		
	Non-irrigated plot	**Irrigated plot**	
		Onion	**Cucumber**
MPA medium	$2{,}4 \times 10^4$	$4{,}3 \times 10^4$	$3{,}7 \times 10^4$
Waksman’s medium	$1{,}2 \times 10^4$	$3{,}2 \times 10^4$	$7{,}4 \times 10^4$
Wort – Agar medium	$2{,}4 \times 10^3$	$3{,}2 \times 10^3$	$3{,}7 \times 10^3$

According to the data obtained during the study, one can conclude that this soil is suitable for agriculture, and according to agrochemical analysis, it is fertile and can also be used for crop growing.

However, the cultivation of agricultural crops in “non-irrigated areas” should be carried out with the application of appropriate fertilizers, so the cultivation will be most effective [9]. The quantitative and qualitative microorganism composition satisfies the soil ability to grow crops, but in the soil in the Volgograd region, a fungus of the genus Fusarium, bacteria Bacillus subtilis, bacteria of the genus Erwinia were found, which can complicate both the cultivation of agricultural products and its storage.

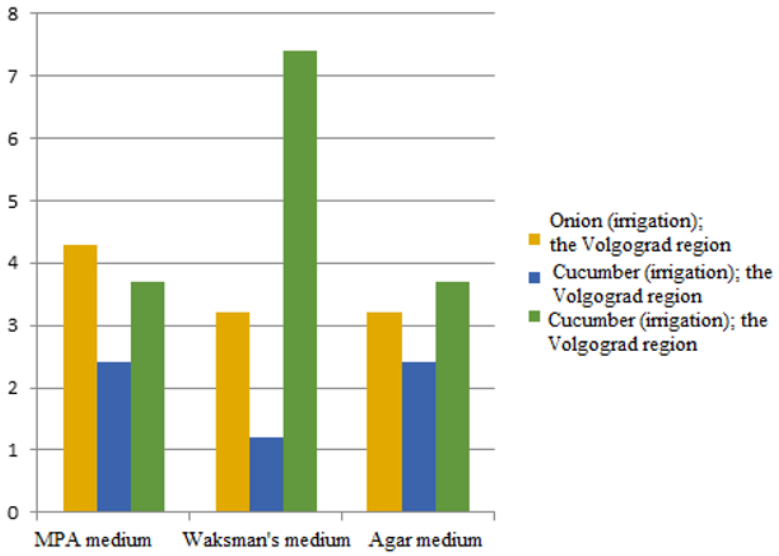

Fig. 1. Quantitative accounting of microorganisms on different media in light chestnut soil of the Volgograd region

4 Conclusion

The microorganism quantity and quality in light chestnut soils of the Leninsky district in the Volgograd region was studied during the onion and cucumber cultivation on irrigated plots with different moisture content in the arable soil layer, as well as on a variant with a virgin (non-irrigated) plot. The number of microorganisms in the light chestnut soil, accounted on the nutrient media MPA, Waksman's, Wort – Agar, showed that the non-irrigated soil contained the lowest number of microorganisms. The reason for this, apparently, was both the low moisture content of this soil, and its lower humus content, compared with irrigated soils.

Quantitative analysis of microorganisms in the light chestnut soil of the Volgograd region on the MPA medium No. 1 ("onion-irrigation" variants) showed that the bacteria of the genus Bacillus subtilis predominate in this soil sample (4.3 × 104 CFU/g abs. dry soil); No. 2 (non-irrigated plot variant), a large number of the bacteria of the genus Bacillus sp. (2.4×104 CFU/g abs. dry soil); No. 3 (variants "cucumber-irrigation"), a large number of the bacteria of the genus Bacillus sp. were also detected, which were the dominant forms (3.7 × 104 CFU/g abs. dry soil). The analysis of the light chestnut soil in the Volgograd region on the Wort – Agar medium showed a large number of fungi of the genus Pénicillium, the variants "onion-irrigation" (3.2 × 103 CFU/g of abs. dry soil), a large number of fungi of the genus Mucor, the variant non-irrigated plot (2.4×103 CFU/g abs. dry soil) and fungi of the genus Fusarium, the variant "cucumber-irrigation" (3.7×103 CFU/g abs. dry soil). Quantitative analysis of microorganisms in the light chestnut soil in the Volgograd region on Waksman's medium showed the bacteria of the genus Actinomyces in all the variants; the variants "onion-irrigation" (3.2×104 CFU/g abs. dry soil); the non-irrigated plot variant (1.2×104 CFU/g abs. dry soil); the variants "cucumber-irrigation" (7.4×104 CFU/g abs. dry soil).

In light chestnut soils, among the microorganisms grown on the Waksman's medium, the genus Actinomyces prevailed, while the number of microorganisms in these soils was approximately half as much as the number of microorganisms in the soddy-podzolic soils of the Moscow region (comparing the results of similar studies on the soddy-podzolic soil of the Moscow region). Apparently, this is due to better moistening conditions in the taiga-forest zone compared to the dry steppe zone. Various maintaining of pre-irrigation soil moisture during drip irrigation of vegetable crops did not have any significant effect on the quantitative and qualitative composition of microorganisms and showed unidirectional dynamics in the total mass.

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