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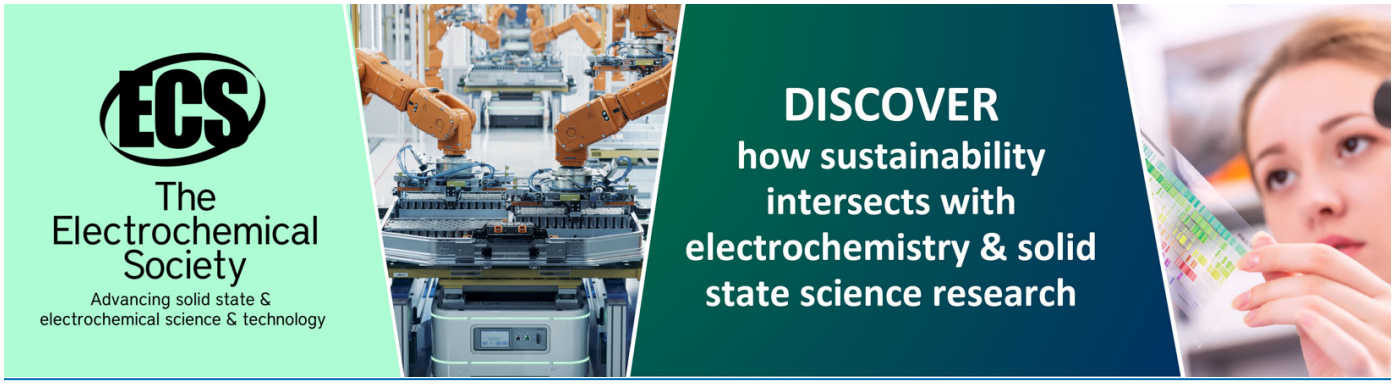

Influence of technology without tillage on indicators of soil fertility in arid conditions of the South of Russia

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Abstract. Winter wheat is the main crop in the Stavropol Territory. Today, the grain crops cover an area of more than 1.9 million hectares. However, the cost of grain production is constantly growing. This leads to a decrease in the profitability of its cultivation. Agricultural field cultivation enterprises are moving from traditional to more resource-saving technologies - technology without tillage. This technology involves growing crops without tillage. In the Stavropol Territory and its arid zone, the technology has not been sufficiently studied for its widespread introduction into production. In this regard, the cultivation of winter wheat using new technology is of scientific and practical interest to research its influence on the germination of fields and the productivity of the main cash crop. Therefore, special attention is paid to the influence of No-till on the agrophysical and agrochemical parameters of dark chestnut soils and crop rotation links in an arid climate. Research was conducted on the territory of the Agrokhleboprodukt Company, located within the borders of the Stavropol Territory. Sowing winter wheat is carried out using John Deere 1890, which allows sowing crops with the simultaneous supply of seed fertilizer. Agrochemical monitoring of the soil was carried out on the basis of the Stavropol Agrochemical Center. Monitoring of meteorological parameters was stationary in the field. Thus, the use of the No-till technology for 2017-2019 ensured the formation of winter wheat productivity in the range of 40.7-49.8 kg/ha. In order to stabilize the productivity of winter wheat attention should be paid to the dynamics of changes in agrochemical parameters: the content of humus and macronutrients in the soil. Regression analysis showed a close relationship between productivity and these values. The use of such precursors as chickpeas and sunflowers in grain rotations contributes to the softening and improvement of the agrophysical properties of dark chestnut soils.

1. Introduction

The concepts of the applied technologies (traditional, minimal, zero) for growing winter wheat in the South of Russia are the optimization of technological processes based on the use of scientific knowledge about the patterns of crop growth, the formation of crop productivity, the biological response of new varieties to the action of biotic, abiotic and production factors. As a result of their implementation, models and areas of resource and energy conservation in technologies for growing winter crops are being formed. Special attention among technologies is paid to zero tillage [1, 2].

The main criterion for the growth and development of winter wheat in the arid zone of southern Russia is the agrophysical and agrochemical properties of the soil, the variability of which is carried out

under the influence of precursors, varieties and tillage. They determine the distribution of the root system in soil layers and the productivity level of the cultivated crop [3, 4, 5].

Zero technology provides for direct sowing of seeds in soil previously treated with herbicides. The decisive factor determining the success of the No-till application is the needs to take into account the main features and properties of soils (compaction resistance, drainage, humus content and mobile forms of nutrients) [6, 7].

In the No-till technology it is important to control and regulate the level of coverage of the soil surface with crop residues, which reduces the effects of drought and water erosion, soil crust formation, soil degumification, soil compaction, and also preserves soil moisture, forms a natural snow retention and nutrient medium for soil fauna. When applying the No-till technology the combination of strip sowing, fertilizing and rolling in one pass is carried out, yield increases, fuel consumption is reduced by up to 60%, labor costs are minimized, costs of equipment acquisition and forest and irrigation improvement are reduced to 50% in the arid zone [8].

However, without a scientifically based assessment of the suitability of soils for zero tillage, its use may pose a certain risk and give negative agronomic, economic and environmental results. Along with the positive aspects of the application of the technology, there are disadvantages: deterioration of the phytosanitary situation (including an increase in mouse-like rodents), a decrease in the content of humus, weediness of crops, etc. [9].

2. Problem statement

Soil fertility is the basis for food stability because 95 % of production is directly or indirectly related to the soil. The use of resource-saving technologies allows to stabilize soil indicators and sometimes leads to its increase [10, 11].

The use of traditional technology has led to the formation of eroded (2.2 %) and deflated (13.3 %) lands. The balance of nutrients in the arable land was again negative and returned to the level of the 1960s.

In order to create a rational system for using the land Fund in domestic science and production, there is a contradictory attitude to replacing the traditional technology with a new one – the technology without tillage [12]. A number of authors give examples of its effective development and impact on soil fertility and productivity of cultivated crops. The presence of a large number of crop residues reduces the effectiveness of nitrogen fertilization by the scattered method and creates a danger of waterlogging the arable layer. The disadvantage of the technology is the high purchase price of the main technical means-direct seeding drills. In addition, the application of technology requires a high level of qualification of agronomic and technical personnel, etc. [13, 14].

3. Research questions

The research was conducted from 2017 to 2019. The field experiments were carried out in the arid climatic conditions of the Stavropol Territory. The average annual rainfall was 506 mm; the average annual air temperature was 10.1 °C [15]. The soil cover of land use "Agrokhleboproduct" is represented mainly by dark chestnut soils, which are characterized by low humus content (2.61-2.70 %), high content of mobile phosphorus (33.2-37.0 mg/kg), exchange potassium (364.5-420.3 mg/kg). The reaction of the soil solution in the upper horizons of the soil is alkaline in the range from 7.7 to 7.9.

The experiment is placed in 3-fold repetition, the area of one plot is 500 m^2. Studied links of crop rotation are sunflower – winter wheat, chickpeas-winter wheat.

4. Purpose of the study

The purpose of the research was to research the effect of the technology without tillage on the agrophysical and agrochemical parameters of dark chestnut soils during the cultivation of winter wheat in the arid zone.

5. Research methods

The object of research is the dynamics of the parameters of soil fertility. The subject of the research is the elements of the technology without tillage with the help of which various technological operations are carried out. They are presented in table 1.

Table 1. Technological operations of the technology without tillage when cultivating winter wheat.

Technological operation	Application rate	Composition of the agricultural equipment
Presowing treatment with herbicides (Sprut Extra)	2 l/ha	Self-propelled sprayer Caffini
Sowing winter wheat	210 kg/ha	Buhler John Deere 1890
Entering sowing fertilizer (ammonium nitrate)	100 kg/ha	Buhler John Deere 1890
Early spring top dressing (ammonium nitrate)	100 kg/ha	MTZ 1221 + Amazone
Application of foliar application (carbamide-ammonia mixture)	100 kg/ha	MTZ 80+ Trailed sprayer 2000
Herbicidal treatment (Ballerina)	0,4 l/ha	MTZ 80+ Trailed sprayer 2000
First fungicidal treatment (Altosuper)	0,5 l/ha	MTZ 80+ Trailed sprayer 2000
Second fungicidal treatment (Kolosal Pro)	0,4 l/ha	MTZ 80+ Trailed sprayer 2000
Insecticidal treatment (Borey)	0,1 l/ha	MTZ 80+ Trailed sprayer 2000
Harvesting winter wheat		Harvester CLAAS

The No-till system in the agricultural enterprise Agrokhleboproduct JSC was introduced in 2014. In the first three years of applying the technology, it cannot be considered zero technology (direct sowing). Only in the fourth year technology began to show itself as the technology without tillage. Before mastering the technology, loosening was carried out below the depth of the compacted soil layer (23-25 cm) and surface leveling.

Soil monitoring was carried out on the basis of the agrochemical center "Stavropol" and the laboratory of agrochemical analysis of the Stavropol state agrarian University. Determination of the soil density and the reserve of productive moisture was carried out according to the method of B. A. Dospekhov, organic matter - according to the method of Tyurin, mobile compounds of phosphorus and potassium - according to Machigin, nitrogen content-GOST 26951-86.

6. Findings

This technology becomes a farming system only taking into account the selection of crops and their placement in the crop rotation, since the issues of preserving and increasing the fertility of dark chestnut soils, protecting them from wind and water erosion, moisture accumulation, etc. are resolved. Preservation of atmospheric precipitation in the soil allowed the agricultural enterprise to abandon pure steam and expand the range of cultivated crops (table 2). When developing grain-cultivated crop rotation, the precursors were selected: sunflower and chickpeas, taking into account climatic conditions, the market and the price of cultivation.

Table 2. The effect of the No-till technology and the precursor on the productive moisture content in winter wheat crops in a meter soil layer, mm (average for 2017-2019).

Technology	Predecessor	Growth phases		
		before sowing	exit to a tube	full ripeness
No-till	Chickpea	64.7	114.5	49.2
	Sunflower	56.4	93.7	44.0

On average, the supply of productive moisture for the research period in the meter-long soil layer before sowing winter wheat after chickpea was 64.7 mm and sunflower - 56.4 mm. By the phase of full ripeness a decrease in the content of productive moisture is observed respectively to 49.2 mm and 44.0 mm. On average, for 3 years the supply of productive moisture ensured the appearance of timely seedlings due to plant residues remaining on the surface of the fields after harvesting cultivated crops. Therefore, a prerequisite for increasing the productivity of winter wheat is the grinding of crop residues and their uniform distribution over the field surface.

In the arid zone before sowing winter wheat the soil density in the top layer (0-10 cm) after chickpea is 1.17 g/cm^3 and sunflower - 1.08 g/cm^3 (table 3). During the spring resumption of the growing season of winter wheat the soil density increases and by the phase of full ripeness - even more compacted.

Table 3. The effect of the No-till technology and precursors on soil density in winter wheat crops, g/cm^3 (average for 2017-2019).

Technology	Predecessor	Soil layer, cm	Growth phases		
			before sowing	exit to a tube	full ripeness
No-till	Chickpea	0-10	1.17	1.19	1.14
		10-20	1.24	1.18	1.21
		20-30	1.21	124	1.29
	Sunflower	0-10	1.25	1.27	1.29
		10-20	1.24	1.29	1.22
		20-30	1.27	1.35	1.33

Particular attention in the agricultural enterprise was paid to the use of mineral fertilizers. To develop the fertilizer system agrochemical parameters were determined: mobile phosphorus, nitrogen and potassium exchange (table 4).

Table 4. The effect of the No-till technology and precursors on the agrochemical condition of the soil (0-20 cm) and yield of winter wheat (average for 2017-2019).

Year	The content of agrochemical indicators					Productivity, c/ha
	pH	humus, %	N, mg·kg^{-1}	P_2O_5, mg·kg^{-1}	K_2O, mg·kg^{-1}	
			Predecessor – chickpea			
2017	8.1	2.70	14.0	34.8	413.3	49.8
2018	7.8	2.69	13.9	38.7	402.3	46.8
2019	7.9	2.69	13.8	37.3	386.0	43.5
			Predecessor – sunflower			
2017	7.8	2.63	13.6	32.3	372.0	47.4
2018	7.8	2.62	13.4	34.2	361.0	45.0
2019	7.5	2.61	13.2	33.2	349.0	40.7
2017	7.8	2.63	13.6	32.3	372.0	47.4

The analysis showed that the soil has low humus content, while mobile phosphorus and metabolic potassium have high content due to the introduction of optimal doses of mineral fertilizers.

When using the No-till technology the fertilizers were applied to the stable moist soil layer to ensure their good accessibility to plants. It was found that nutrients in the soil are washed away and displaced as a result of diffusion. The nitrogen fertilizers are washed mainly in the form of nitrates. This process usually occurs in early spring and late autumn, so it is important to choose the right time and method of

applying the nitrogen fertilizers in order to bring it closer to the period of intensive assimilation of nitrogen by cultivated plants.

During the research period it was noted that the dynamics of productivity (40.7-49.8 kg/ha) was influenced by microorganisms that decompose plant residues of previous crops and the loss of active substance when granular nitrogen fertilizers are applied during feeding At the same time, every year this technology is used, there are more and more microorganisms and their activity increases. The statistical analysis showed that the trend models of the relationship of technology and precursor to the agrochemical state of the soil and the yield of winter wheat have different binding strengths (d) and the proportion of variance of the dependent variable (R^2) (table 5).

Table 5. Trend models of the relationship between the No-till technology and the precursor for the agrochemical state of the soil (0-20 cm) and winter wheat productivity (average for 2017-2019). [a]

Parameters	d	R^2	Different binding strengths	Regression equation
		Predecessor – chickpea		
pH	0.645	0.428	noticeable	$Y = 209.7333 – 0.1x_1$
humus, %	1.0	1.0	very high	$Y = 2.72 – 0.01x_1$
N, mg/kg	0.866	0.75	high	$Y = 417.433 – 0.2x_1$
P_2O_5, mg/kg	0.50	0.25	noticeable	$Y = -1981.0 +1.0x_1$
K_2O, mg/kg	0.999	0.998	very high	$Y = 26636.3 – 13.0x_1$
Productivity, c/ha	0,98	0,97	very high	$Y = 2030.9 – 0,29071\ x_1$
		Predecessor – sunflower		
pH	0.866	0.75	very high	$Y = 22.8 – 0.01x_1$
humus, %	1.0	1.0	very high	$Y = 310.4 – 0.15x_1$
N, mg/kg	0.944	0.893	very high	$Y = 517.9 – 0.25x_1$
P_2O_5, mg/kg	0.473	0.224	moderate	$Y = -874.87 + 0.45x_1$
K_2O, mg/kg	0.992	0.984	very high	$Y = 21351.7 – 10,4x_1$
Productivity, c/ha	0.99	0,99	very high	$Y =2032,81 -0,31722\ x_1$

[a] d is the Pearson coefficient; R^2 is the coefficient of determination.

Based on statistical analysis it is necessary to control the content of available nutrients in the soil: nitrate nitrogen, mobile phosphorus, and metabolic potassium in order to stabilize the production capacity of winter wheat.

7. Conclusion

The research has shown that the cultivation of winter wheat without soil treatment (No-till) on dark chestnut soils in the arid zone from 2017 to 2019 does not lead to its compaction. The change in soil density was within the optimal values for the growth of winter wheat. An increase in soil density is associated with plant growth phases.

A positive effect is provided by the No-till moisture storage technology. The presence of plant residues on the soil surface ensures the accumulation and more economical expenditure of productive moisture in the soil. This allowed expanding the range of cultivated crops in the agricultural enterprise.

When applying the No-till technology much attention should be paid to the stabilization of the agrochemical properties of the soil and to the content of nitrate nitrogen. To obtain the sustainable winter crop yields, it is advisable to control the content of available nutrients in the soil and increase the dose of nitrogen fertilizers, depending on weather and climate conditions and the development of soil microorganisms. When sowing the crop, it is recommended that the farm add 100 kg of ammophos to increase its yield, which is higher than traditional technology.

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