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Effect of No-Till Technology on The Available Moisture Content and Soil Density in The Crop Rotation.

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ABSTRACT

On the chernozem of the ordinary zone of unstable moistening of the Stavropol Territory, the influence of No-till technology on the soil density and the moisture content of plants in the crop rotation was studied. The studies were carried out in a stationary experiment, where crop rotation (soybean - winter wheat - sunflower - corn) with traditional crop cultivation technology and the same crop rotation with cultivation of crops using No-till technology are deployed in space by all fields. In the traditional technology, the main soil cultivation for spring crops included stubble plowing in 2 tracks and autumn plowing to a depth of 20-22 cm, winter wheat was subjected to a double treatment with a disc harrow (8-10 cm) and pre-sowing cultivation. In No-till technology, no treatments were performed. Before leaving for winter, the soil density with traditional treatments for spring crops in the 0-10 cm layer was 0.82-0.83, in the 10-20 cm layer 0.83-0.87 g / cm^3, according to No-till the density was, respectively, 1.05-1.12 and 1.12-1.17 g / cm^3. During the growing season, the density of soil in both crop rotations is within the optimal values for chernozem soils. In the spring of available moisture, in a meter layer of untreated soil, cultures contained 14.5-20.4% more than in the treated soil. During the growing season, the moisture content decreased under all crops, however, in the winter wheat and spring flowering period, the difference increased on average in the rotation up to 23.3% in favor of No-till technology.

Keywords: No-till technology, traditional technology, soil density, available moisture, plant residues, snow cover.

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INTRODUCTION

When cultivating agricultural crops using traditional technology, agrarian scientific institutions of the Stavropol Territory are recommended to carry out basic, presowing and other soil cultivation that are adapted for each soil and climatic zone of the region and provide effective control of weeds and create conditions for the accumulation of moisture and soil content in the optimal for growth density plants.

In No-till technology, no soil treatments are carried out. To control weeds, we use herbicides of different spectrum of action. Soil fertility, which ensures high yields of cultivated crops, is supported by the introduction of mineral [1, 2] and bacterial [3] fertilizers.

At the same time, there is a danger of soil reconsolidation in this technology, which can lead to a decrease in its water and physical properties and, as a result, deterioration of the supply of plants with moisture and a decrease in the yield of cultivated crops. Therefore, the purpose of our research is to study the effect of No-till technology on soil density and the moisture content available in plants.

MATERIALS AND METHODS

The investigations were carried out on the experimental field of the North Caucasus Federal Scientific Agrarian Center located in the zone of unstable moistening of the Stavropol Territory. The annual sum of effective temperatures here is 3000-3200 °C. The duration of the frost-free period is 180 days. The annual amount of precipitation varies from 540 to 570 mm, during the vegetation period 350-400 mm, GTK = 0.9-1.1 [4].

The soil of the experimental site is chernozem ordinary medium-thick weakly humus heavy loam, with an average supply of phosphorus, potassium and a low content of humus. The years of research varied in the amount of precipitation. More favorable for wetting were 2013 and 2014, when 652 and 626 mm of precipitation fell, which is 98 and 72 mm higher than the climatic norm, the more arid were 2015 and 2016 - the precipitation was 26 and 53 mm lower than the mean multiyear values.

The studies were carried out in a stationary experiment, where crop rotation (soybean - winter wheat - sunflower - corn) with traditional crop cultivation technology and the same crop rotation with cultivation of crops using No-till technology are deployed in space by all fields. The main soil cultivation in the traditional technology of spring crop cultivation included stubbling in 2 tracks and autumn plowing to a depth of 20-22 cm. Winter wheat was treated twice with a disc harrow (8-10 cm) and pre-sowing cultivation.

In No-till technology, no soil treatments were conducted. Doses of mineral fertilizers recommended by scientific institutions were applied to all cultures. Repetition of the experiment is 3-fold, the plot area is 300 m^2, accounting is 90 m^2. Accounting and observations were conducted by methods common in the Russian Federation [5, 6].

RESULTS AND DISCUSSION

In both studied technologies, during harvesting, the plant residues of all cultures studied were crushed by a combine and distributed evenly over the surface of the plots. On an average, annually per 1 hectare of crop rotation area, according to the traditional technology, 5.62 were supplied, according to the technology without tillage - 6.36 tons of plant residues. However, according to the traditional technology, during the basic dumping of soil, plant residues were embedded in the soil, and in No-till technology they remained on the soil surface, thus ensuring its reliable protection against wind and water erosion [7].

Soil cultivation and plant residues influenced soil density throughout the warm season. The density of the soil till the winter leaves in the 0-10 cm layer is 0.82-0.83, 0.83-0.87 g / cm^3 in the 10-20 cm layer, which indicates its excessive looseness and inability to store and retain moisture (Table 1).

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Table 1: Influence of traditional and No-till technologies on soil density before leaving in winter, g / cm^3 (average for 2012-2016)

Technology	Layer of soil, cm	Cultivated crop			
		soybean	wheat	sunflower	corn
Traditional	0-10	0,83	0,99	0,82	0,82
	10-20	0,87	1,14	0,85	0,83
	20-30	1,09	1,21	1,08	1,08
No-till	0-10	1,10	1,05	1,11	1,12
	10-20	1,12	1,14	1,17	1,17
	20-30	1,15	1,21	1,22	1,22
HCP $_{0,95}$	-	0,06	0,08	0,09	0,08

According to No-till technology, where the soil was not processed, its density in the upper layers is from 1.05-1.12 and 1.12-1.17 g / cm^3. This state of the soil is optimal for the accumulation and preservation of moisture in the soil.

During the autumn-winter period and at the beginning of the growing season of all crops, the density of the soil, especially in the upper horizons, increases in all the variants studied, and the differences between technologies become mathematically indecisive during the flowering phase (Table 2).

Table 2: Effect of cultivation technology on soil density in the flowering phase of field crops, g / cm^3 (average for 2013-2016)

Technology	Layer of soil, cm	Cultivated crop				Average
		soybean	wheat	sunflower	corn	
Traditional	0-10	1,24	1,11	1,27	1,18	1,20
	10-20	1,34	1,25	1,32	1,26	1,29
	20-30	1,38	1,27	1,36	1,30	1,33
No-till	0-10	1,28	1,16	1,23	1,18	1,21
	10-20	1,37	1,25	1,28	1,26	1,29
	20-30	1,36	1,28	1,32	1,30	1,32
HCP $_{0,95}$	-	0,09	0,08	0,10	0,09	-

At the same time, the soil density under the studied crops differs significantly, which is due to the peculiarities of the development of the root system of different plants. Under soybean and sunflower crops with a rod root system, the upper horizons of the soil are denser than under wheat and maize with a fibrous root system. Nevertheless, under all crops the soil density was within the optimal values for chernozem soils.

The processing and, accordingly, the density of the soil had a significant effect on the moisture content in it. So before leaving for the winter in the dump-treated soil in the 0-30 cm layer contained 18-20 mm of available moisture, while in the untreated - 38-40 mm, or 2 times more. This is explained by excessive soil emptying into the depth of its processing, which leads to loss of moisture from physical evaporation, whereas in the optimal soil density in the untreated soil, favorable conditions for its accumulation and conservation are added.

In winter, plant residues that remain on the soil surface when cultivating field crops using No-till technology play an important role in the accumulation of snow. On average, for four winters for all crops of the crop rotation, the snow layer according to this technology was 31.2 cm with fluctuations between cultures from 20.8 after low-cut soybean to 40.0 cm after sunflower harvested at an altitude of 80-85 cm, while on The treated soil accumulated only 15.6 cm of snow (from 14.8 to 17.0 cm), or 2 times less.

The snow cover is caused not only by the amount of plant residues (r = 0.444), but also by their height above the soil surface (r = 0.611). The regression equation that we calculated allows us to predict the height of the snow cover, depending on the height of plant remains:

$$Y = 0,36x+15,57$$

where:

Y – depth of snow cover, cm
x – height of plant residues, cm
0,36 и 15,57 – regression coefficients.

But the amount and height of plant residues also determines the rate of snow cover in spring. Snow on untreated soil with a large amount of plant residues melted for 8-12 days longer than on the treated soil. All this positively affected the accumulation and the presence of moisture in the untreated soil, where in the spring in the meter layer available for plants moisture under cultivated crops was from 159 to 167 mm, which is reliably 20-27 mm, or 14.5-20.4% more, than in the soil processed by traditional technology.

During the growing season, the growing plants used the moisture in the soil, so its content under all crops was reduced. However, in the phase of winter wheat earing and flowering of spring crops, the difference in the content of available moisture in the soil increased on average in the crop rotation to 23.3% in favor of crops without tillage. Under winter wheat, it an average of 32.9% over the years of research (Table 3).

Table 3: Effect of cultivation technology on the maintenance of productive moisture during vegetation in a meter layer of soil, mm (average for 2013-2016)

Technology	Cultivated crop				Average
	soybean	wheat	sunflower	corn	
Traditional	64	70	64	92	73
No-till	78	93	78	110	90
Addition: mm	14	23	14	18	17
%	21,9	32,9	21,9	19,6	23,3
$HCP_{0,95}$	5,1	5,8	4,8	6,5	-

A mathematically more reliable amount of available moisture for the plants by No-till technology at this time is also due to the presence of plant residues on the soil surface, which reduce the wind speed at the surface, which affects the evaporation of moisture from the soil surface. Our observations showed that in the presence of plant residues, the wind speed at an altitude of 10 to 25 cm decreases by a factor of 1.5-1.6, and in the surface layer it is 1.9-2.0 times greater than on the surface of the soil, not having plant residues. Therefore, with traditional technology, where there are no plant residues, unproductive losses of soil moisture due to physical evaporation from the surface increase.

That is, plant residues on the surface during the cultivation of crops using No-till technology, on the one hand, contribute to greater accumulation, on the other hand, better preservation of moisture in the soil, which plants use to form the crop at a critical period and in the absence of precipitation . This is evidenced by the same content of productive moisture in the full ripeness of cultivated crops for both technologies.

CONCLUSION

Thus, when cultivating crops using No-till technology, the soil density is within optimal values for plant growth on chernozem soil, which contributes better than in sowing in traditional technology with basic and presowing treatments, the accumulation and conservation of moisture that plants use to form a crop. This is also facilitated by the remaining plant remains of the preceding crops remaining on the surface of the field.

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