Tillage influence of on the qualitative composition of soil structure

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Abstract. The research has been carried out on the change in the structural composition of leached chernozem of the Krasnoyarsk forest steppe under the influence of plowing with turnover soil and without it in “Acha” barley crops. It was found out that the content of agronomically valuable aggregates ranging from 0.25 mm to 10 mm in size corresponds to the structural state of the soil according to the Williams V. R. gradation. The sample without tillage proved to be the highest structurally coefficient. The content of structural elements larger than 0.25 mm ranges from 78.3 % to 92.5 % and indicates a high wind resistance of the soil. The water resistance of the soil structure of the studied variants in the spring corresponds to an excellent condition. By autumn it is reduced to good condition. Evaluation of the role of individual structural aggregates larger than 10 mm, 5 mm and less than 0.25 mm in the formation of barley yield in laboratory conditions showed that the maximum amount of moisture evaporated from the vessels filled with the smallest aggregates (less than 0.25 mm). In these same vessels, the maximum yield of phytomass of barley was obtained.

1. Introduction

Soil is a complex heterogeneous system with a number of properties. One of these properties of the soil is its physical condition, which plays a very important role in shaping the level of crop yield.

The soil structure is one of the most important indicators of the physical state of the soil. The role and value of this indicator has been repeatedly studied in the works of a number of scientists [1], [2], [3], [4], etc.

Such close attention to this indicator is due to the fact that the structural soil creates optimal conditions for water, air and food regimes, which in turn provide the most favorable conditions for the growth and development of plants.

Nowadays with the application of energy-saving technologies in the process of soil cultivation, the role and value of this indicator is significantly increasing. As not only does the tillage of structural soil require less traction, and the quality of processing proves to be much higher. At the same time from an environmental point of view the strong structure prevents the impact of water and wind erosion on the soil. In addition such soil is less compacted under the action of tillage and harvesting machines.
Chernozems are the national wealth. Therefore, many scientists pay close attention to chernozems. It is known [2] that chernozem of the Krasnoyarsk forest-steppe has good water-physical properties. In this regard the purpose of the research was to study the influence of various methods of tillage on the structural state of leached chernozem in the Krasnoyarsk forest steppe.

The objectives of the research were:

• to determine the structural composition of leached chernozem and the structural coefficient;
• to consider the influence of tillage techniques on the changes in the structural composition of the soil;
• to determine the effect of soil aggregates of various sizes (more than 10 mm, 5 mm and less than 0.25 mm) on the yield of green mass of barley.

The subject of the research is the structural state of leached chernozem. The object of the study was leached chernozem of the Krasnoyarsk forest-steppe, which is characterized by an increased content of humus (6.1-8.0 %), a neutral reaction of the soil solution (pHKCl-6.1-7.0). Granulometric composition of leached chernozem – heavy loam. The research was carried out for two years (2018, 2019) in barley crops in the grain-crop rotation: sideral steam – spring wheat – barley – corn – spring wheat. “Acha” barley was sown in the experiment.

2. Methods and Results
The study of the influence of various methods of tillage on the structure of the soil was carried out on variants with a 20-22 cm plowing with turn soil and no-till. Repeatability in the experience – 4 times. The barley sowing period is the 3rd decade of may. Agrotechnics of barley cultivation – generally accepted for this agricultural zone [5]. Soil samples for determining the structure were taken in spring during the sowing period and in autumn after harvesting.

The macroaggregate composition of the soil was determined by dry sifting according to N.I. Savvinov. The water resistance of the soil structure was determined by the method of "wet" sifting on the Baksheev device.

The results of the research on the influence of various systems of tillage on the content of agronomically valuable aggregates at the beginning and end of the growing season of barley are shown in figure 1.

![Figure 1](image-url)
From the presented data (figure 1), it follows that the content of structural separations of 0.25 – 10 mm in the studied variants is a significant amount and ranges from 69.2 % to 79.7 %. Assessing the structural state of leached chernozem by the content of air-dry aggregates of size from 0.25 mm to 10 mm in accordance with the Williams V. R. gradation [6], it should be noted that in all studied variants it proves to be good. Moreover, during the entire growing season, from sowing to harvesting of barley, the indicators of the structural state remained within the limits. Although by the harvest time, there was a tendency to reduce the content of air-dry soil aggregates in the studied variants compared to the sowing period. The structural coefficient is higher for the option without tillage (3.5 and 3.2), compared to the turnover ploughing (2.7 and 2.4), both in 2018 and 2019.

One of the most important characteristics of wind resistance of the soil is the content of aggregates larger than 0.25 mm (figure 2).

![Figure 2](image2.png)

**Figure 2.** The content of aggregates larger than 0.25 mm in the soil at the time of barley sowing and barley harvesting.

From the presented data (figure 2), it follows that the content of structural fragments larger than 0.25 mm in the studied variants is a significant amount and ranges from 78.3 % to 92.5 %.

Among aggregates larger than 0.25 mm, a significant share is made up of aggregates from 1 mm to 3 mm, the most valuable in agronomic terms (figure 3).

![Figure 3](image3.png)

**Figure 3.** The content of aggregates from 1 mm to 3 mm in the soil at the time of barley sowing and barley harvesting.
Taking into account the fact that the number of aggregates with a size of 1 mm and up to 3 mm is not less than 30.0 % according to the studied variants, we can make a clear conclusion about the high structurality of this soil.

If we talk about the influence of different methods of tillage on the content of fractions larger than 1 mm (the most erosive resistant particles), it can be noted that the largest number of them falls on the option without tillage – from 60.0% (in the 0-10 cm layer of soil) to 69.0 % (in the 20-30 cm layer of soil) and the least on the turnover plowing – from 45 % (in the 0-10 cm layer of soil) to 48.8 % (in the 10-20 cm layer of soil).

The most objective and qualitative indicator of the structural state of the soil is the presence of water-resistant aggregates larger than 0.25 mm [7]. As a rule, such an assessment of the water quality of the soil structure is carried out based on the results of determining the aggregate composition after "wet" sifting. It is believed that the more aggregates >0.25 mm in size obtained by sifting the soil in water, the higher the waterproofness of the structure against the eroding effect of precipitation is. The results of evaluating the water resistance of the structure in the studied variants are shown in figure 4.

Figure 4. The content of water-bearing aggregates larger than 0.25 mm in the soil at the time of barley sowing and barley harvesting in 2018.

Evaluating the water resistance of the structure of leached chernozem in the studied variants [8], it can be noted that in spring before sowing it corresponds to an excellent state.

Thus, the refusal to carry out turnover plowing increases the stability of the structure of leached chernozem. If we evaluate the structural state of the soil according to the gradation of V. R. Williams, we can evaluate it as good on plowing (20-22 cm) and excellent in the variant without tillage (during the sowing period of barley).

It is known that in agronomic science, it is customary to assess the structural state of the soil with the total content of aggregates ranging from 0.25 to 10.00 mm in size. However, the role of individual structural aggregates in the formation of crop yields is not taken into account. We have studied the influence of the smallest (less than 0.25 mm), medium (5.0 mm) and largest (more than 10 mm) aggregates in laboratory conditions. For this purpose “Acha” barley plants were grown in vessels under optimal conditions. After the emergence of seedlings in 10 days the plants were cut and weighed.

The conducted research has shown that during the period of the laboratory experiment, the largest amount of moisture evaporated from the vessels filled with the smallest soil fraction – less than 0.25 mm. Less moisture evaporated from vessels filled with aggregates larger than 10 mm and 5 mm. The highest yield of green mass of barley was obtained in vessels filled with aggregates less than 0.25 mm in size.
According to I. V. Kuznetsova [9], the highest yield of barley and buckwheat plants was obtained in the vessels with structural separations of 1-0.5 and <0.5 mm in diameter.

Research of V. K. Ivchenko, V. A. Polosina and A. A. Steele [10] found that leached chernozems of the Krasnoyarsk forest-steppe with the content of water-resistance aggregates from 49.3 to 63.8 % (plowing in barley crops) and from 60.1 to 71.5 % (without tillage) provide a relatively stable addition of soil with a density of 1.09 to 1.15 g / cm$^3$, porosity within 55-56 %.

The refusal to carry out turnover plowing of leached chernozem does not lead to a deterioration of the structural condition of leached chernozem in the Krasnoyarsk forest-steppe, the same as turnover plowing does not reduce the quality indicators of the structural condition of the soil to a satisfactory level.

3. Conclusion
The structural coefficient is higher for the option without tillage (3.5 and 3.2), compared to plowing (2.7 and 2.4), both in 2018 and 2019.

The number of agronomically valuable aggregates from 1 to 3 mm does not decrease below 30% both on the background without tillage, and on plowing, carried out as the tillage.

The largest number of erosion resistant soil particles larger than 1 mm is noted in the variant without tillage. In the case of the turnover ploughing option, their quantity is reduced by 15 % in the upper 0-10 cm layer of soil.

The content of water-resistance aggregates is reduced from sowing to harvesting of barley, but nevertheless the structural condition of the soil remains good both on the variant with turnover plowing (20-22 cm), and without tillage.

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