Influence of subwinter sowing period of spring wheat on efficiency of using water component in arid conditions of Orenburg Cis-Urals

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Abstract. In the arid conditions of agriculture in the Orenburg Cis-Urals, the level of development of crop production and the state of agriculture as a whole largely depend on the water component. The applied technologies and methods of soil cultivation do not ensure the most efficient use of water resources and the natural potential of the region. In order to develop and improve technologies for the effective use of the water component in arid agricultural landscapes, the article studies the use of available water resources by spring wheat sown in the traditional spring and subwinter way.

1. Introduction
In the arid conditions of agriculture in the Orenburg Cis-Urals, with a relatively high provision of the region with heat resources, the level of development of crop production and the state of agriculture in general depend to a large extent on the water component. The applied technologies and methods of soil cultivation do not ensure the most efficient use of water resources and the natural potential of the region.

Water in the emerging temperature conditions characterizing the region creates conditions for the interaction of life factors of plants on the ground, which determine the level of effective fertility and agriculture in general throughout the history of crop cultivation.

A soil solution containing nutrients and various compounds, in accordance with the prevailing temperature regime, determines the degree of direct impact on the reactions occurring in the soil, while exerting a significant effect on its agrophysical properties and the direction of biological processes, which ultimately affects productivity agricultural crops [1-2].

The low efficiency of using the entire annual amount of precipitation in the arid steppe conditions of the Orenburg region blocks the influence of other conditions and factors that are in an optimal amount and a favorable combination.

The results of long-term agricultural activity, along with many other anthropogenic impacts, have significantly influenced the current state of natural systems, their vegetation, soil cover and the water system of the region, significantly disrupting the natural balance of ongoing biological processes [3-4].

The maximum use of the annual amount of precipitation even under the conditions of the sharply continental climate of the region, accompanied by dry winds against the background of high air temperatures coming from Central Asia and Kazakhstan, which can reach +40 ... +43 °C, could allow obtaining high and sustainable crop yields. However, a large amount of incoming water resources are
of charge. Of particular interest in the structure of the water balance are moisture losses in different periods of the year. The extremely low efficiency of using autumn and winter moisture reserves, as well as high losses in spring and summer, significantly affect the development of plants, especially during the period of critical development phases, limiting their potential productivity. And the precipitation of the growing season in most cases does not have time to seep into the soil and quickly evaporate due to high air temperatures [2-3; 5-6].

The above features of crop cultivation in the conditions of the region are of great importance, therefore, studies aimed at maximizing the reduction of unproductive losses of precipitation in the cold period and increasing the efficiency of their use are relevant.

The applied modern technologies do not ensure maximum and efficient use of water resources in the region, which is a consequence of the loss of a significant amount of precipitation in the winter-spring period.

In connection with the above, research aimed at improving the technologies and methods of cultivating spring crops for the sub-winter sowing period in frozen soil is of great importance, both for agricultural producers and in scientific terms.

2. Materials and methods
The studies were carried out in laboratory conditions, as well as by winter sowing of spring wheat in frozen soil at negative air temperatures, to a depth of 1-4 cm, in the experimental fields of the Orenburg, Perevolsky and Sakmarsky districts of the Orenburg region. Sowing of spring wheat was carried out in the spring, when the physical maturity of the soil, after pre-sowing treatment. In field crops, the soil moisture and its temperature, the height of the snow cover were measured according to the methods of Roshydromet [7].

3. Results
The research results indicate that the conditions for the development of spring wheat under the winter sowing period starting from the germination period, as well as tillering and plant emergence into the tube, in comparison with spring sowing in physically ripe soil, are the most optimal and have a number of fundamental differences.

Spring wheat of the near-winter sowing period, at the beginning of the growing season, using the most favorable moisture conditions and temperature conditions in comparison with its spring sowing, actively used the provided natural advantages. Spring sowing of wheat was carried out during the period of physical ripeness of the soil with the use of pre-sowing treatment, when a large amount of precipitation of the cold period has already been lost and cannot be used productively by plants. The difference between the seedlings of wheat in the winter and spring sowing period varied on average from 12 to 16 days, the moisture loss during this period was from 40 to 67 mm. Changes in moisture reserves in the soil under the sowing of spring wheat of the subwinter and spring sowing dates are shown in Table 1.

By the tillering phase of spring wheat of the winter sowing period, the reserves of productive moisture per meter decreased by 35 mm compared with the period after snowmelt and amounted to 232 mm. The amount of atmospheric precipitation for this period was 36 mm. By the tillering phase of spring wheat of the spring sowing period, the reserves of productive moisture per meter decreased by 55 mm compared to the period after snowmelt and amounted to 210 mm. The amount of atmospheric precipitation for this period was 79 mm.

The yield of spring wheat crops on farms on an area of at least 10 hectares and a total area of more than 2000 hectares was determined based on the results of its continuous combine harvesting, and the biological yield at the registration sites with the analysis of sheaf material according to the method of B.A. Dospekho [8-10]. The yield of spring wheat in winter crops in 2019 on an area of 1020 hectares was 13.9 c/ ha, in spring 4.7 c/ha (table 1).
Table 1. Changes in moisture reserves in the soil under the sowing of spring wheat under winter and spring sowing dates.

| Soil layer | Moisture reserves in soil-vegetation layer, mm | sub-winter sowing period of spring wheat | spring sowing time for spring wheat |
|------------|---------------------------------------------|----------------------------------------|-----------------------------------|
|            | before snow melt (March 18) | after snow melt (April 110) | in tillering phase (May 15) | before snow melt (March 18) | after snow melt (April 110) | in earing phase (June 18) | before snow melt (March 18) | after snow melt (April 110) | in earing phase (July 15) | before snow melt (March 18) | after snow melt (April 110) | in earing phase (July 15) | before snow melt (March 18) | after snow melt (April 110) | in earing phase (July 15) |
| 0-30 cm    | 67                                      | 98                                      | 69                                      | 55                                      | 52                                      | 65                                      | 97                                      | 57                                      | 49                                      | 45                                      | 45                                      | 45                                      | 45                                      | 45                                      | 45                                      |
| 0-50 cm    | 125                                     | 164                                     | 145                                     | 115                                     | 110                                     | 123                                     | 166                                     | 104                                     | 95                                      | 93                                      | 93                                      | 93                                      | 93                                      | 93                                      | 93                                      |
| 0-100 cm   | 218                                     | 267                                     | 232                                     | 210                                     | 207                                     | 216                                     | 265                                     | 210                                     | 198                                     | 192                                     | 192                                     | 192                                     | 192                                     | 192                                     | 192                                     |
| 0-150 cm   | 332                                     | 379                                     | 340                                     | 318                                     | 312                                     | 330                                     | 372                                     | 300                                     | 291                                     | 285                                     | 285                                     | 285                                     | 285                                     | 285                                     | 285                                     |

In winter sowing of spring wheat, it is 9.7 c/ha higher in comparison with spring sowing with LSD$_{0.95}$ - 3.5 c/ha and with LSD$_{0.99}$ - 5.1 c/ha. Analysis of the sheaf material showed that spring wheat of the near-winter sowing period had a higher productive tillering, 2.2 times higher than wheat sown using traditional technology. The mass of grain in an ear, as well as the biological yield of spring wheat under the winter sowing period, was 1.8 times higher, and had high quality indicators. The plants had a strong root system with no signs of root rot infestation.

4. Discussion

The grain of spring wheat of the winter sowing period began to germinate at a temperature of 1-2 ºС, increasing the rate of plant development in parallel with an increase in the air and soil temperature. A crop, using productively the available moisture reserves, while covering the soil surface with vegetation, significantly affects the degree of physical evaporation of moisture from its surface, which is an important feature for the intensity of biological processes occurring in the soil and symbiosis with plants. It is also important that a crop sown in the autumn does not require additional mechanical processing in the spring at the beginning of the growing season, which makes it possible to form a sod layer on its surface using the technology of non-moldboard tillage, which not only reduces unproductive moisture loss, but protects against direct exposure to sunlight, provides optimal temperature conditions in the root layer of the soil, while creating favorable conditions for improving its agrophysical properties and the activity of biological processes.

Wheat seedlings, without serious consequences, are able to withstand short-term early spring frosts down to -6, -8 ºС, the vegetated soil is much less exposed to solar radiation, high air temperatures and dry winds, it overheats less and loses temperature more slowly with the onset of short-term frosts, remains high activity of biological processes and favorable conditions for the development of microorganisms. The lack of high air and soil temperatures, as well as a sufficient amount of moisture in the germination and especially tillering phase, influenced the development of the root system. The lowered soil temperature in the tillering phase of spring wheat of the subwinter term, in comparison with its summer sowing, promoted the formation and development of nodal roots, which significantly affects the growth of yield.

The passage of the critical phases of development of winter wheat crops, at earlier calendar dates, was accompanied by moderate temperature load and favorable conditions during the pollination period, which contributed to a decrease in the risk of pollen death, the negative consequences of which were not observed during the study period.
Sowings of spring wheat of the sub-winter period ripen two, and in some cases three weeks earlier, wheat of the spring sowing period, which contributes to a significant expansion of the possibilities of using and productivity of agrocenoses, in accordance with a favorable combination of moisture conditions and temperature regime. This made it possible to increase the efficiency of using the available reserves of moisture and precipitation. The amount of decrease in moisture and precipitation reserves for the period from snow melting to tillering of spring wheat under winter sowing was 71 mm, which is 63 mm less than when using the spring sowing period in the experimental field.

5. Conclusion
The maximum productivity of agricultural crops is possible only if all principles and conditions are fully balanced, ensuring the growth and development of plants in specific soil and climatic conditions. Their maximum balance was formed in the course of the evolution of the preserved natural, virgin, steppe biogeocenoses of the Orenburg region, where the existing moisture conditions are productively and most optimally used by plants, in full balance of hydrothermal conditions and biomass productivity. The steppe biogeocenoses of the Orenburg Cis-Urals, having a layer of sod on their surface, absorb and retain moisture as much as possible, protecting the soil and plants from the effects of high temperatures, while creating a favorable microclimate in the root layer of the soil. In addition, the vegetation of plants begins with the onset and establishment of positive temperatures, and not after sowing, carried out with preliminary presowing treatment on physically mature soil. Modern technologies for the cultivation of crops in agrocenoses should be built as close as possible to the natural conditions of the region, while maintaining a balance of features, principles and conditions for the effective use of the natural climatic features of the region, resources and plant productivity.

The use of winter wheat crops in agrocenoses of the Orenburg Cis-Urals, can significantly reduce unjustified losses of water resources, reducing anthropogenic impact in agroecosystems, improve the systems and technologies of crop cultivation, ensuring their maximum productivity and give a 1.5-2-fold increase in yield.

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