Intensity of spring wheat transpiration due to weather factors and methods of basic tillage

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Abstract. The paper presents the study of daily course transpiration of the three upper leaves of cultivars of spring hard wheat of different origin, grown against the background of two methods of primary tillage in different conditions of the vegetation period according to weather factors. The studies were carried out according to the method of rapid weighing using the torsion scales VT-500 three times during the day (9:00, 12:00 and 15:00 hours) in the phases of stem elongation and wheat earing. The paper identifies cultivar specificity of the course of daytime transpiration, the influence of soil tillage methods on the amount of transpiration, as well as a significant dependence on weather factors over the years of study. The results can be used in practical breeding with the perspective assessment of varieties according to the transpiration activity of the leaves in the most important phases of the spring wheat growing season. In connection with changes in the climatic factor in the direction of increasing aridity, it is important to know the patterns of the response of the plant organism to the extreme conditions and the possibility of its use in breeding practice. The results obtained can substantiate the needs to use various methods of basic processing to reduce negative weather factors.

1. Introduction

Climate changes caused by global warming create extreme conditions for the physiological functions of the plant organism, in particular, spring wheat.

In dry conditions, plants suffer from water scarcity; therefore it is important to understand the process of water metabolism and the possible influence on this process both by measures of agricultural practices and by the creation of cultivars.

Transpiration is the main item of water consumption in a plant, therefore, to assess the water regime, it is important to know its dependence on various factors. In drought conditions, the ratio between absorption and water loss is important [1].

With increasing aridity, the degree of adaptation of plants varies from increasing the ability of the root system to provide water for sprouting [2] to the sheet's ability to hold water with the accumulation of osmotically active substances, particularly sugars [3]. The production of abscisic acid (ABA) is possible to reduce water loss with increasing conductivity of the roots and leaves [4].

It is assumed that under the action of high temperature in order to maintain the adaptation potential by increasing the efficiency of the water exchange of the top leaf, the sign “rolled sheet” appeared. At the same time this feature has cultivar specificity [5].

Inhibition of growth with increasing temperature occurs due to a decrease in tissue hydration, contributing to a twofold increase in the rate of transpiration [6].
In the experiments of E. A. Ivanov and others [7], the difference in transpiration intensity was established: in cultivars bred under conditions of high moisture in the first 20 minutes of exposure to elevated temperature, there was a sharp and then gradual increase in transpiration intensity. In cultivars bred under dry conditions, there were not abrupt changes in the intensity of transpiration with increasing air temperature.

The transpiration cultivars of the Volga steppe and forest-steppe West-Siberian ecotypes under the conditions of the Orenburg Urals differed by less depression of transpiration in research of Samuilov F. D. and Mukhitov L. A. [8].

According to I.A. Shulgin [9], under optimal conditions, more than 90% of the photosynthetic activity of radiation (PAR) is spent on transpiration and to obtain the maximum possible productivity of spring grain crops it is necessary to use about 180 mm of moisture in the transpiration of soil meter layer. At the same time, the maximum possible yield for the Samara and Saratov regions can be about 28 centners per hectare.

According to A. B. Safaralikhonov and others [10], the transpiration intensity of wheat plants is suppressed when short-wave UV rays irradiate presowing seeds and increased when using medium-wave irradiation, the application of mineral fertilizers in the range of available soil moisture increases the transpiration of grain crops [11].

The transpiration of spring wheat plants has many aspects and depends on weather conditions as well as techniques and has a specific cultivar character. Our study touches on one of the issues in this area, in particular, the cultivar response against the background of various methods of basic tillage.

2. Problem statement
The study of water regime on the example of leaf transpiration, with the assessment of cultivar characteristics and the role of agrotechnical methods, makes it possible to assess drought tolerance against the background of water deficit and high temperature.

3. Materials and methods
The research method is a two-factor field experiment. As the first factor, the methods of basic tillage were studied — plowing wastage (by 25-27 cm) and chiseling by SibIME counters (by 25-27 cm). The second factor was the cultivars of spring hard wheat Orenburgskaya 10 and Bezenchukskaya 210. The field experiment was using the method of B. A. Dospekhov [12].

The study of transpiration was carried out using torsion scales VT-500 three times during the day (9.00; 12.00; 15.00) in the phases of stem elongation and wheat earing by the method of rapid weighing [13].

4. Discussion of the results
The conditions of the growing season of spring grain crops in the conditions of the Orenburg Urals are marked by significant aridity. Over the past decades, 2010, 2012, 2014, 2015, 2018 years were particularly arid, when the yield was from 6-7 to 1 c per 1 hectare. The most favorable was 2017, with yields of up to 20-30 centners per hectare.

The extremes of weather factors in the research area served as the motive for studying the water balance of plants through leaf transpiration.

The vegetation conditions of 2017, despite the formation of high crop yields for many years, did not differ favorably in terms of weather characteristics. The first half of the growing season was at low values of average air temperature. In May, it was below the multiyear average at 1.0 °C, including the second or third decade at 2.1-2.3 °C. In June it was below the normal at 2.3 °C on average per month with decrease in the first decade by 4.7 °C, in the second decade by 2.2 °C. In July, the air temperature was within the normal range. Most of the precipitation of the growing season (83.8%) fell in the first half (May-June), including 26 mm in May (97% of the norm), 36 mm in June (98% of the norm). But precipitation was insignificant in intensity: out of 15 days with precipitation as a whole over the growing season, 9 days were with an insignificant amount (5 mm or less).
The amount of productive moisture during the sowing period was insignificantly (8 mm) higher in plowing, practically the difference (10.5 mm) remained the earing phase mainly in horizons below 60 cm.

The weather conditions of 2018 during the growing season of spring wheat were extremely unfavorable. The increase in average daily air temperature occurred immediately after germination (in May, an excess of the norm by 1.4 °C, including in 1-2 decades by 2.5-2.2 °C). The maximum temperature was within 31 °C and higher. In June, the average temperature abruptly decreased with a consequent increase (to 3.1-3.9 °C in the early to mid-month).

The maximum temperatures were still high. In May-June 41.5 mm of precipitation fell (64% of the norm), with more falling in May (31mm). In June precipitation was unimportant.

The amount of productive moisture during the period of sowing was insignificant in the background of the chiseling (108 mm) and very little in the background of plowing – 76 mm. The main part of it (on chiseling (77%) was contained in the soil layer 0-60 cm; on plowing 80% – in a layer 0-50 cm).

By the earing phase, in the meter layer, 7–10 mm of productive moisture was found, with its total absence in the horizon of 0–50 cm.

Such weather indicators of the growing season determined the different crop yields of spring hard wheat. In 2017 it amounted to 10.1 centners from 1 hectare on plowing in the cultivar Orenburgskaya 10, 20.6 centners from 1 hectare on chiseling. The cultivar Bezenchukskaya 210 had a yield of 21.6 and 22.7 centners per hectare correspondingly.

In 2018, the yield of cultivar Orenburgskaya 10 was 2.4 centners per hectare on plowing and 3.4 centners per hectare on chiseling. The cultivar Bezenchukskaya 210 had the yield of 2.1 and 3.7 centners per hectare, respectively, in the tillage options.

The main difference between the meteorological conditions of the growing season in 2017 and 2018 is the temperature regime of the air with little difference in the amount of productive moisture in the soil during the main phases of the growing season – the phases of stem elongation and earing. As already noted, transpiration of a plant is determined by the course of air temperature, its values. In this regard, you should pay attention to the air temperature from germination to earing in 2017 and notice radical differences. In our opinion, this year the reduced temperature background of the first growing season through the regulation of the water regime of plants determined the productivity of crops. In 2018, it was the opposite situation when the high temperature of the air from the beginning of the growing season inhibited the processes of water flow in plants, led to their actual dehydration by the beginning of the second half of the growing season and the death of the crop. In both cases (2017 and 2018) transpiration, more precisely, its intensity played a decisive role.

Differences in the intensity of transpiration in the experiments have already been found from the phase of stem elongation.

In more favorable conditions (2017), the intensity of transpiration is significantly higher (up to 3-5 times) than in 2018. In 2018, by this phase of the growing season, there was suppression of the growth functions of wheat plants, the loss of turgor by the morning. Crops of chiseling were in this sense, in more favorable conditions. However, the presence of residues of stubble created a more favorable regime for the passage of transpiration in comparison with plowing.

Cultivar differences in transpiration intensity are minor. We should note relatively higher transpiration of the cultivar Orenburgskaya 10 against the background of plowing, and the cultivar Bezenchukskaya 210 against the background of chiseling.

The intensity of transpiration decreases from the top (flag) leaf to the bottom most in a favorable year. In the arid year, the suppression of the water regime of the leaf is manifested regardless of their layering. More information is in table 1.

In the earing phase, the pattern of transpiration intensity in the manifestation of the influence of weather factors and agro-reception is the same with the phase of stem elongation. The degree of transpiration intensity decreases due to fall in the water content of plants, the advantage of stubble background remains. In this phase, the upper leaf is also transported more actively, although in the chiseling, the leaf activity of all tiers of cultivar Bezenchukskaya 210 is almost the same.
Table 1. The intensity of transpiration of spring hard wheat, depending on the method of tillage and conditions of years. Phase – earing

| Cultivar                  | Method of tillage | Year | 1-st leaf | 2-nd leaf | 3-d leaf |
|---------------------------|-------------------|------|-----------|-----------|----------|
|                           |                   |      | 9.00      | 12.00     | 15.00    | 9.00     | 12.00     | 15.00     |
| Orenburgskaya 10          | Plowing           | 2017 | 0.81      | 0.62      | 0.57     | 1.18     | 0.70      | 1.19      | 0.73      | 0.65     | 0.63     |
|                           |                   |      | 0.36      | 0.26      | 0.33     | 0.33     | 0.41      | 0.34      | 0.36      | 0.27     | 0.58     |
|                           | Chiseling         | 2018 | 1.56      | 1.44      | 0.96     | 0.79     | 0.82      | 0.89      | 0.93      | 0.90     | 0.79     |
|                           |                   |      | 1.20      | 1.34      | 0.96     | 0.76     | 0.75      | 0.55      | 0.51      | 0.49     | 0.75     |
| Bezenchukskaya 210        | Plowing           | 2017 | 0.83      | 0.65      | 0.52     | 0.98     | 0.89      | 0.90      | 0.68      | 0.99     | 0.52     |
|                           |                   |      | 0.40      | 0.35      | 0.43     | 0.32     | 0.33      | 0.44      | 0.53      | 0.53     | 0.57     |
|                           | Chiseling         | 2018 | 1.46      | 1.15      | 0.66     | 1.55     | 0.85      | 0.92      | 1.17      | 0.64     | 0.51     |
|                           |                   |      | 1.23      | 1.11      | 0.63     | 0.60     | 0.55      | 0.35      | 0.38      | 0.37     | 0.39     |

5. Conclusion
Problems of increasing drought tolerance and methods of its assessment are problems for the conditions of regions with extremely arid weather. In recent years, the degree of aridity in these regions, which includes Orenburg region, is increasing. A particular problem is the lack of water in the main phases of the growing season. The study of transpiration makes it possible to answer some questions of its course and ways of possible regulation. Our data have established that in dramatically dry conditions the water balance of plants is disturbed already in the early phases of the growing season (stem elongation), which leads to a practical loss of plant productivity. One of the possible ways to reduce the negative impact of drought is to leave stubble on the soil surface, which makes it possible to reduce water loss by the plant.

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