The influence of the preceding crops on the soil moisture content under the spring soft wheat fields

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Abstract. The paper presents data on the influence of the preceding crops on the soil moisture content under the spring soft wheat fields in the conditions of the moderately dry steppe in Altai Krai. The wheat was sown after three different predecessors: legumes, row crops and fallows. The total soil moisture content in the one-meter layer had been decreased from the beginning to the end of the vegetation period. The preceding crops have a significant influence on this indicator. This must be taken into account for the development of technology for environmentally sustainable and efficient spring soft wheat production.

1. Introduction
Modern conditions of agricultural development require finding new reserves for increasing the efficiency of the grain crops production. Due to the global climate change, it is strictly necessary to monitor the dynamics of the main yield forming factors, especially, for spring soft wheat, a widespread grain crop [1-4]. These factors include the total soil moisture content. It changes depending on the natural climatic conditions, which we are not able to directly influence, and on the elements of the wheat cultivation technology, the most important of which is the preceding crops. The result of the scientific research in this area will be an increase in the use of available reserves and, consequently, an increase in environmental sustainability and efficiency of the spring soft wheat production [5-6].

This paper presents the evaluation of the preceding crops influence on the soil moisture content under spring soft wheat fields in the conditions of moderately dry steppe in Altai Krai.

2. Materials and methods
The study was carried out in 2005-2010 on the fields of “Kiprinskoye” farm in the Shelabolikhinsky district of Altai Krai. The farm is located in the zone of moderately dry steppe on the right bank of the Ob river. The climate is continental, the average rainfall of the vegetation period is 193 mm, the average temperature of the May-August is 16.4 °C. The soils are chernozems.

The spring soft wheat was sown after three different preceding crops. The total number of the fields observed during the study was 41: 14 after legumes, 15 after row crops and 12 after fallows. The seeding rate averaged 180 kg/ha. On the observed fields, autumn tillage was carried out using КПГ and КПШ-9, as well as pre-sowing tillage using АПК-7, sowing was carried out with СЗП-3.6 seeder in mid-late May.

Meteorological data were provided by the hydrometeorological station of the Shelabolikha village.
Determination of the soil moisture to the depth of one meter was carried out by the HH-2 device in the triple repetition for each field in late April – early May, then in mid-June and before harvesting in late August – early September. Statistical evaluation of meteorological data and the total soil water content was carried out in accordance with the standard methods. Based on the statistical analysis of the data, a conclusion was drawn on the effect of various preceding crops on the accumulation of moisture in the soil under the spring soft wheat fields during the growing season.

3. Results and Discussion
The weather conditions for the 2005-2010 period were as follows (Table 1). The amount of the vegetation period precipitation over the years ranged from 111 mm (2010) to 226 mm (2009). Analysis of the distribution of the rainfalls by months showed that the maximum was noted in July, the minimum – in May. The comparison with the long-term averages shows that in the noted period there was a significant decrease in rainfall in May and August, while in June and July it remained at the same level (Figure 1). The fluctuations in the average monthly air temperature during the May-August period were in the range of 10.3-21.7 °C. The comparison with the long-term averages showed an increase in the average temperatures of May, July and August (Figure 2). Thus, we can say that in 2005-2010 the vegetation period was warmer and drier than usual.

| Precipitation, mm | Temperature, °C |
|-------------------|-----------------|
| May       | June | July | August | Sum  | May       | June | July | August | Average |
| x         | 24.6 | 45.2 | 63.1   | 28.8 | 161.5 | 12.5 | 17.9 | 20.1   | 17.2   | 16.9   |
| σ         | 12.5 | 17.4 | 20.6   | 12.6 | 42.5  | 1.3  | 2.3  | 1.6    | 1.2    | 0.9    |
| SEM      | 5.1  | 7.1  | 8.4    | 5.1  | 17.3  | 0.5  | 1.0  | 0.7    | 0.5    | 0.4    |
| Cv, %    | 51.1 | 38.5 | 32.7   | 43.7 | 26.3  | 10.8 | 13.1 | 8.2    | 6.7    | 5.4    |

Table 1. Average precipitation and average air temperature for May-August 2005-2010

The results of the statistical analysis of the total soil water content in dependence on the preceding crops during the vegetation period 2005-2010 under the spring soft wheat fields are presented in Table 2. It can be noted that the coefficient of variation of this indicator was minimal in late April–early May.
and achieved the maximum in late August–early September. We can also see that in time before sowing the coefficient of variation was almost the same in all studied soil layers and averaged at 27.7%, while at the end of the vegetation period, the coefficient of variation of the total soil moisture content in the upper 50 cm of the soil was already at 40.9%, and in the arable layer it reached 49.2%.

**Table 1.** Dependence of the average soil moisture on the preceding crops, mm (2005-2010)

| Forecrops | Soil layer, cm | 0-10 | 0-20 | 0-30 | 0-40 | 0-50 | 0-60 | 0-70 | 0-80 | 0-90 | 0-100 |
|-----------|----------------|------|------|------|------|------|------|------|------|------|-------|
| Legumes   | W1*            | 17.7 | 39.4 | 61.4 | 82.4 | 102.4| 121.1| 138.3| 154.1| 169.1| 183.5 |
| Row crops |                | 20.8 | 45.5 | 71.6 | 96.4 | 119.0| 140.4| 160.8| 180.3| 198.7| 216.6 |
| Fallow    |                | 21.6 | 47.7 | 76.1 | 102.5| 128.5| 154.2| 178.5| 200.5| 220.3| 238.8 |
| x         |                | 20.0 | 44.2 | 69.7 | 93.8 | 116.6| 138.6| 159.2| 178.3| 196.0| 213.0 |
| σ         |                | 5.5  | 10.9 | 16.9 | 22.7 | 28.5 | 34.3 | 39.9 | 45.2 | 50.1 | 54.7  |
| SEM       |                | 0.9  | 1.7  | 2.6  | 3.5  | 4.5  | 5.4  | 6.2  | 7.1  | 7.8  | 8.5   |
| Cv, %     |                | 26.7 | 24.1 | 23.7 | 23.6 | 24.0 | 24.4 | 24.8 | 25.1 | 25.2 | 25.3  |

| Forecrops | Soil layer, cm | 0-10 | 0-20 | 0-30 | 0-40 | 0-50 | 0-60 | 0-70 | 0-80 | 0-90 | 0-100 |
|-----------|----------------|------|------|------|------|------|------|------|------|------|-------|
| Legumes   | W2**           | 14.0 | 32.2 | 51.1 | 70.8 | 90.5 | 110.6| 129.9| 147.8| 164.7| 181.1 |
| Row crops |                | 14.3 | 33.3 | 53.1 | 73.6 | 94.6 | 115.3| 136.0| 156.7| 176.8| 196.0 |
| Fallow    |                | 15.3 | 34.6 | 53.8 | 73.9 | 94.1 | 114.4| 134.3| 153.6| 172.3| 190.2 |
| x         |                | 7.0  | 11.2 | 13.3 | 15.4 | 17.0 | 18.7 | 20.4 | 22.3 | 24.5 | 26.7  |
| σ         |                | 1.1  | 1.8  | 2.1  | 2.4  | 2.6  | 2.9  | 3.2  | 3.5  | 3.8  | 4.2   |
| SEM       |                | 50.1 | 34.8 | 26.0 | 21.8 | 18.7 | 16.9 | 15.7 | 15.1 | 14.9 | 14.8  |
| Cv, %     |                | 11.5 | 22.7 | 35.0 | 48.0 | 60.9 | 73.3 | 85.6 | 97.6 | 110.1| 122.7 |

| Forecrops | Soil layer, cm | 0-10 | 0-20 | 0-30 | 0-40 | 0-50 | 0-60 | 0-70 | 0-80 | 0-90 | 0-100 |
|-----------|----------------|------|------|------|------|------|------|------|------|------|-------|
| Legumes   | W3***          | 11.8 | 23.4 | 35.6 | 48.5 | 61.5 | 74.2 | 87.0 | 99.8 | 112.6| 125.6 |
| Row crops |                | 11.0 | 22.1 | 34.0 | 46.6 | 59.4 | 72.4 | 85.2 | 98.1 | 110.8| 123.6 |
| Fallow    |                | 11.4 | 22.7 | 34.9 | 47.7 | 60.6 | 73.3 | 85.9 | 98.5 | 111.2| 124.0 |
| x         |                | 6.5  | 10.2 | 13.9 | 17.1 | 19.6 | 21.4 | 22.7 | 23.7 | 24.9 | 26.2  |
| σ         |                | 1.0  | 1.6  | 2.2  | 2.7  | 3.1  | 3.3  | 3.5  | 3.7  | 3.9  | 4.1   |
| SEM       |                | 54.8 | 43.6 | 39.0 | 35.3 | 31.8 | 28.8 | 26.0 | 23.7 | 22.1 | 20.9  |

*W1 – late April–early May
**W2 – mid-June
***W3 – late August–early September

Figure 3 illustrates the dynamics of the soil moisture during the vegetation period. It can be noted that in late April–early May the most amount of soil water was contained after the fellows, the second place was under the fields after the row crops, and the last place was under the fields after the legumes (Figure 3, W1). The difference between them in the meter soil layer was 22.2 mm and 33.1 mm, respectively, i.e. the soil after the fallsows contained 55.3 mm more water than after the legumes. The average total soil water content was 213 mm.

In mid-June, the situation changed, and we can see that the total soil water content under the fields after the row crops compared to other preceding crops has become minimal (Figure 3, W2). The average amount was lower than in late April–early May and was already 190.2 mm in the meter soil layer. The difference between the fields after the fallsows and the fields after the legumes was only 2.4 mm, i.e. was within the standard error of the mean.

In late August–early September, the average water content in the meter soil layer was already at 124.0 mm. The highest amount was found under the fields after the row crops, and the fields after the fallsows and after the legumes were again at the same level, taking second place with a difference in the average total soil water content within the standard error of the mean (Figure 3, W3).
Figure 3. The dynamics of the soil moisture during the vegetation period 2005-2010 in dependence on the preceding crops: W1 – late April–early May; W2 – mid-June; W3 – late August–early September.

The average moisture consumption from the one-meter soil layer in the first period between measurements was 22.8 mm, in the second - 64.8 mm, i.e. was almost 3 times larger than in the first. It should be noted that the moisture consumption from the soil in the first period was recorded from the fields after the fallows (42.8 mm) and after the row crops (35.5 mm), while moisture accumulation was observed in the fields after the legumes (+10.1 mm). In the second period between measurements, the moisture consumption from the one-meter soil layer was again maximum in the fields after the fallows (72.4 mm). Now, however, the fields after the legumes with the soil moisture consumption
70.9 mm were at the second position, and the fields after the row crops remained the most moisturized by autumn with only 55.6 mm soil moisture consumption.

4. Conclusion
The total soil moisture content in the one-meter layer had been decreased from the beginning to the end of the vegetation period 2005-2010 under the spring soft wheat fields in the conditions of the moderately dry steppe of Altai Krai. Soil moisture accumulation in late April–early May was maximum in the fields after the fallows and minimum in the fields after the legumes, the fields after the row crops occupied the middle position. In mid-June, the difference in this indicator between the fields after the fallows and after the legumes was within the standard error of the mean, and the minimum total soil water content was obtained under the fields with row crops as a forecrop. At the end of the vegetation period of spring soft wheat, the total soil water content in the one-meter soil layer was maximum under the fields after the row crops, the fields after the fallows and after the legumes were again at the same level. Thus, it can be concluded that the preceding crops have a significant influence on the total soil moisture content. This must be taken into account for the development of technology for environmentally sustainable and efficient spring soft wheat production.

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