Characteristics of the cultivated area and its structure under conditions of increasing average annual temperatures

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Abstract. The climatic characteristics, the area and structure of arable land occupied by agricultural crops, including cereals and legumes, the area of agricultural land, including arable land in the Tyumen region without autonomous regions, as well as the content of mobile forms of heavy metals in the arable horizon. It was revealed that the climate is becoming more favorable for growing crops in the Northern Trans-Urals, thus, from the zone of risky farming, the region can move to a more favorable area for growing grain and leguminous crops. The content of mobile forms of Cu, Zn, Ni, Cd and Pb in the arable horizon does not exceed the MPC. Nevertheless, in recent years, the area and structure of arable land sown with agricultural crops, including cereals and legumes, the area of agricultural land, including arable land, has practically not changed.

1. Introduction

In recent years, there has been a global change in temperature\textsuperscript{[1 - 5]}, modern technogenesis leads to an increase in the intensity of pollution of land resources\textsuperscript{[6 - 8]}, including the soils of agricultural landscapes of the Northern Trans-Urals. As a result, the study of the patterns of spatio-temporal changes in arable soils, the development of recommendations for the formation of sustainable agricultural landscapes in the Northern Trans-Urals and the optimization of land use in this area is an urgent task. In this regard, it is necessary to carry out comprehensive work aimed at an interdisciplinary analysis of climatic and ecological trends and forecasting further changes in the state of arable soils over time. Therefore, monitoring the content and reserves of organic matter in soils of agricultural landscapes requires the introduction of new approaches, including a detailed and large-scale agrochemical study of the content of heavy metals in soils of agricultural landscapes. The insufficient level of such studies in land management design significantly complicates the consideration of the conditions for the formation of sustainable agricultural landscapes.

According to the Office of the Federal Service for State Registration, Cadastre and Cartography in the Tyumen Region, the land fund as of 01.01.2020 within the administrative boundaries of the region amounted to 16012.2 thousand hectares, of which 24.3% falls on agricultural land with a decrease in their area by 673.1 thousand hectares. At the same time, the land intended for agricultural work occupied 3379.4 thousand hectares (21.1%), and arable land - 1289.1 thousand hectares (38.1%). A feature of the lands of the Northern Trans-Urals is the presence of arable land with a low humus content (24.7%) and acidity (62.3%) with a gradual increase in their share in recent years, which can contribute to the transition of heavy metals to mobile forms and their accumulation in agricultural products\textsuperscript{[9]}. 

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The purpose of the work was a spatial-temporal study of the climatic characteristics of the Tyumen region, the sown area of agricultural crops and the structure of sown areas, as well as the content of mobile forms of Cu, Zn, Ni, Cd and Pb in the arable horizon.

2. Materials and methods

Sown area of agricultural crops for the 2006 and 2016 harvest in the Tyumen region (excluding autonomous regions), including grain and leguminous crops, as well as the structure of sown areas for the considered types of crops was obtained according to the Results of the All-Russian Agricultural Census for 2006 and 2016 [10, 11]. Used area of agricultural land, including arable land for 2006 - 2018 given according to the Report on the ecological situation in the Tyumen region in 2018 [12]. Climate data for 2006 and 2016 were obtained from the site https://rp5.ru/Pogoda [13] from the Tyumen weather station. To study climatic conditions, air temperature, atmospheric pressure, relative humidity, wind speed, horizontal visibility range, dew point temperature are considered. Content of mobile forms of heavy metals in the arable horizon for 2011 - 2019 obtained according to the Reports on the ecological situation in the Tyumen region [9, 12, 14 - 20].

For statistical processing of the obtained material, the integrated software package Excel and "IBM SPSS Statistics 21" were used (mean value (arithmetic mean), standard error of the arithmetic mean, variance and its derivative (standard deviation) with plotting a trend line and finding the confidence value approximation (R²)). The Student's criterion was used to assess the reliability of differences between the statistical characteristics obtained in the study.

3. Results and discussion

Sown area of agricultural crops for the 2006 and 2016 harvest in the Tyumen region (without autonomous regions), including grain and leguminous crops, as well as the structure of sown areas for the considered types of agricultural crops is presented in Table 1.

Table 1. Sown area of agricultural crops and its structure.

| №  | Name                              | Farms of all categories | including agricultural organizations |
|----|----------------------------------|-------------------------|--------------------------------------|
|    |                                  | 2006 | 2016 | 2006 | 2016 |
| 1. | Sown area of agricultural crops (ha), including: | 998756 | 1055173.7 | 835652 | 854307.4 |
| 1.1| Cereals and legumes, of them:     | 696216 | 700610.4 | 578780 | 558011.3 |
| 1.1.1| Wheat                         | 432665 | 430113.6 | 351366 | 326408.1 |
| 1.1.2| Rye                            | 4199 | 2143.0 | 3284 | 1686.0 |
| 1.1.3| Barley                         | 97293 | 144403.0 | 84274 | 130249.6 |
| 1.1.4| Buckwheat                      | 229 | 229 |
| 1.1.5| Oats                           | 143750 | 91959.6 | 122197 | 71585.4 |
| 1.1.6| Maize                          | 65.6 | 65.6 | 60.0 |
| 1.1.7| Leguminous crops of them:       | 18012 | 26713.9 | 17429 | 23140.4 |
| 1.1.7.1| Peas                          | 26165.8 | 22592.4 |
| 2.  | Structure of sown areas by grain and leguminous crops (% of the total sown area) | 67 | 66.4 | 65.3 |

It was found that the used area of agricultural land, including arable land for 2006 - 2018 remained practically unchanged (2340.24 + 14.74 and 1112.89 + 5.36 thousand hectares, respectively) and according to the trend line with finding the approximation reliability value it is not expected to increase (\( y = 10.486 x + 2266.8; R^2 = 0.59 \) and \( y = -0.3143x + 1115.1; R^2 = 0.004 \), respectively).

As for agricultural indicators, in 2016, compared to 2006, the sown area of barley and leguminous crops increased by about 1.5 times in farms of all categories, while the sown area of rye decreased by about 2 times and the sown area of oats by 1.6 times.

Climatic characteristics of Tyumen in 2006 and 2016 are presented in Table 2.
Table 2. Climatic characteristics of the area in 2006 and 2016 (average values).

| Name                        | Year   |       |       |
|-----------------------------|--------|-------|-------|
| Air temperature, ºС         | 2006   | 1.88±0.27 | 2.76±0.28* |
| Atmospheric pressure, mm Hg | 2006   | 752.44±0.15 | 754.49±0.16** |
| Relative humidity,%         | 2006   | 71.1±0.35 | 72.43±0.36* |
| Wind speed, m/s             | 2006   | 2.42±0.03 | 2.19±0.02** |
| Horizontal visibility range, km | 2006 | 24.82±0.43 | 23.25±0.42* |
| Dew point temperature, ºС   | 2006   | -3.42±0.25 | -2.54±0.25* |
|                            | 2016   |       |       |
|                            |        |       |       |

* p<0.05; ** p<0.001.

As can be seen from Table 2, significant changes are characteristic for all considered climatic characteristics. In 2016, an increase in air temperature (p < 0.05), atmospheric pressure (p < 0.001), relative humidity (p < 0.05), dew point temperature (p < 0.05), as well as a decrease in wind speed (p < 0.001) and horizontal visibility range (p < 0.05). Changes in climatic conditions are also observed in other regions of the Northern Trans-Urals [21].

The content of mobile forms of Cu, Zn, Ni, Cd and Pb in the arable horizon for 2011–2019 in the Tyumen region without autonomous regions is shown in Fig. 1. It was found that their level does not exceed the MPC, i.e., they are suitable for growing any crops without limitation. However, over 9 years, there has been a tendency towards the accumulation of copper (R² = 0.15), zinc (R² = 0.22), nickel (R² = 0.22) in the arable horizon, with no change in the content of lead (R² = 0.03) and cadmium (R² = 0.004).
4. Conclusions

In recent decades, the climate in the south of the Tyumen region has become milder, which is reflected in an increase in atmospheric temperature and dew point temperature, in an increase in relative humidity, as well as in a decrease in wind speed. Not exceeding the MPC for the content of mobile forms of copper, zinc, nickel, lead and cadmium in the arable horizon in the south of the Tyumen region indicates that the soils are suitable for growing any crops without restrictions.

Thus, the natural and ecological characteristics are favorable for the active economic use of the agricultural landscape, and the Northern Trans-Urals from the zone of risky agriculture are gradually moving to a more favorable area for growing, in particular, grain and leguminous crops.

Nevertheless, the sown area of agricultural crops for the harvest in 2006 and 2016 in the Tyumen region (excluding autonomous regions), the structure of sown areas, including grain and leguminous crops, the area of agricultural land, including arable land, practically did not change. In this regard, it is necessary to develop the necessary recommendations for making agrotechnical decisions to optimize the use of agricultural land in the Northern Trans-Urals.

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