The Impact of Technologies on the Production Ability of Winter Wheat in the South of Russia

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Abstract. Food security is one of the main conditions for the stable development of society and the country as a whole. The main food crop in the South of Russia is winter wheat. The aim of the research was to study the influence of the system without tillage and the traditional technology of cultivating crop on the production ability of plants and soil quality. The studies were conducted on the territory of Agrokhhleboprodukt JSC in the Ipatovsky Region of the Stavropol Territory. The technology without soil cultivation has a positive effect on soil indicators: soil density (1.27–1.28 g/cm³), productive moisture supply (64.7 mm for sunflower and 76.2 mm for chickpeas). The content of exchange potassium before sowing in sunflower was 361.3–365.7 mg/kg, for chickpea - 399.0-403.0 mg/kg; mobile phosphorus - 32.1-33.2 and 36.8-37.4 mg/kg respectively; nitrogen - 12.6-14.4 and 13.0-14.9 mg/kg respectively. On average, in the variant where sunflower acted as the forecrop, the yield of winter wheat varied within 39.2-44.4 c/ha, chickpeas - 44.5-46.7 c/ha. Trend models reflected a very close relationship between factor features (potassium and phosphorus) and winter wheat productivity (r = 1.0).

1. Introduction

Russia's food security is based on ensuring its full food independence and is a guarantee of both physical and economic accessibility for any citizen of the country of food products in volumes not less than rational consumption standards [1-3].

The leading food crop in the Central Ciscaucasia is soft winter wheat (Triticum aestivum L.). In recent years, economic and weather conditions (in terms of precipitation and the sum of active air temperatures) are becoming increasingly unstable. To meet the needs of the population, ways are being sought to intensify agriculture, increase crop yields and preserve soil fertility. The most important role in solving these problems is played by agricultural technologies, which involve the use of fertilizers that compensate for the consumption of nutrients in the soil carried out with the crop, creating optimal conditions for plants. Wrong selection of the soil tillage system is accompanied by negative natural processes [4-6].
Today, direct sowing technology (no-till) and traditional one are becoming competing in the South of Russia [7-10]. At the present time an important choice for farms is the choice of technology based on the resulting winter wheat yield, the cost of cultivating crop, etc. [11-14].

2. Problem statement
World experience shows that the leading countries of grain production (Canada, Australia, Argentina, USA) have long ago switched to resource-saving technologies based on the application of zero tillage, which allows reducing the cost of grain production and at the same time to obtain a stable crop while preserving the environment. [15,16]. Many Russian and foreign scientists believe that, unlike traditional technology, the technology of direct seeding ensures the accumulation of organic matter due to the retained roots and crop residues on the surface []. However, there is opposite opinion. In the traditional technology there is a mixing of soil and residue, and in combination with seedbed dressing is more rapid saturation of the soil necessary for the growth and development of plants with agrochemical elements []. In addition, stabilization and increase in the yield of winter wheat is influenced by soil and climatic conditions of the Central Caucasus. The arid climate and the lack of powerful snow cover negatively affect the accumulation of productive soil moisture, so necessary from the moment of sowing and the entire period of growth and development of winter wheat. Therefore, it is important to analyze the use of new and traditional resource-saving technologies of cultivation of crops under conditions of bogharic agriculture [17-20].

3. Purpose of the study
The purpose of the study is to choose the most rational technology for the cultivation of winter wheat on sunflower and chickpea in the arid climate in the South of Russia, which contributes to the conservation and reproduction of soil fertility, in terms of agrophysical and agrochemical indicators. It directly affects the formation of high and sustainable crops of the main food crop.

4. Research materials and methods
An analysis of the influence of cultivation technologies on soil fertility and winter wheat productivity was carried out in a stationary experiment from 2017 to 2019 in the territory of Agrokhleboprodukt JSC, the Agrokevsalinsky branch, which belongs to the arid zone of the Central Ciscaucasia.

![Figure 1. Weather and climatic conditions of the arid zone of the Stavropol Territory.](image-url)

The temperature fluctuations are not expressed. The average annual air temperature is 9.6 ... 11.2 °C. The amount of precipitation for the year varies from 421 to 451 mm [21]. The hydrothermal coefficient is 0.6-0.7 [22]. During the study period by the outlet phase of the tube the amount of soil moisture increased, which is associated with precipitation in March. In 2019, there was a seizure of
plants caused by drought, as well as a decrease in soil moisture reserves and water supply to the root system by the second half of vegetation [23].

The soils of the agricultural enterprise are dark chestnut carbonate, heavy loamy, formed on loesslike loams.

The experiment is three times repeated, the area of one plot is 500 m². The analyzed varieties of winter wheat are Zustrich, Bagira and Bagrat, the forecrops are chickpea and sunflower.

When cultivating winter wheat in arid regions, the applied technological operations and agricultural units vary depending on traditional technology and direct sowing. They are presented in Table 1.

**Table 1.** Technological operations in the cultivation of winter wheat by various technologies.

| Technological operation               | Parameters | Composition of the agricultural unit |
|---------------------------------------|------------|--------------------------------------|
|                                       |            | traditional technology | technology | direct seeding |
| Stubble peeling                       | 6-8 cm     | Buhler+Salford 870 | -          |              |
| Stubble peeling                       | 10-14 cm   | Buhler+Salford 870 | -          |              |
| Cultivation                           | 8-10 cm    | Buhler+Wil-Rich | -          |              |
| Cultivation                           | 6-8 cm     | Buhler+Wil-Rich | -          |              |
| Pre-sowing treatment with herbicides  | 2 l/ga     | -                      | Self-propelled sprayer Caffini |
| (Sprut Extra)                         |            |                        |            |
| Planting of winter wheat              | 210 kg/ha  | Buhler+John Deere 1890 |            |
| Application of seed fertilizer (ammonium nitrate) | 100 kg/ha | Buhler+John Deere 1890 |            |
| Early spring feeding (ammonium nitrate) | 100 kg/ha | MTZ 1221+Amazone |            |
| Introduction of leaf feeding (urea-ammonia mixture) | 100 kg/ha | MTZ 80+ sprayer 2000 |            |
| Herbicide treatment (Balerina)        | 0.4 l/ga   | MTZ 80+ sprayer 2000 |            |
| The first fungicide treatment (Altosuper) | 0.5 l/ga  | MTZ 80+ sprayer 2000 |            |
| Second fungicide treatment (Kolosal Pro) | 0.4 l/ga  | MTZ 80+ sprayer 2000 |            |
| Insecticide treatment (Borey)         | 0.1 l/ga   | MTZ 80+ sprayer 2000 |            |
| Harvest                               | -          | Harvester CLAAS            |            |

A distinctive feature of direct sowing technology is the reduction of mechanical impact on the soil, including passage of equipment for applying mineral fertilizers and phytosanitary tillage.

5. **Findings**

The applied technologies influence the soil fertility indices of dark chestnut soils. Average data on agrophysical and agrochemical indicators for the period under consideration are presented in Tables 2 and 3. Over the years of observation, winter wheat crops have been densified in the soil layer of 10-20 cm, which is associated with long-term use of tillage. The soil density according to two technologies (direct sowing and traditional) is close in values: by sunflower - 1.27 g/cm³ and 1.28 g/cm³, by chickpea - 1.19 g/cm³ and 1.20 g/cm³, respectively. Chickpea, as the forecrop, shows itself as a decompression component of crop rotation.
Table 2. The impact of technology on the agrophysical parameters of the soil during the cultivation of winter wheat for various forecrops (average for 2017-2019).

| Predecessor | technology          | tradition technology |
|-------------|---------------------|----------------------|
|             | direct seeding       | traditional          |
|             | Soil density in the soil layer 0…30 cm, g/cm³ |
| Sunflower   | 1.27                | 1.28                 |
| Chickpea    | 1.19                | 1.20                 |
| Reserve of productive moisture in the soil layer 0…100 cm, mm |
| Sunflower   | 64.7                | 62.1                 |
| Chickpea    | 76.2                | 72.1                 |

In terms of the reserves of productive soil moisture in sunflower (64.7 mm) and chickpea (76.2 mm), the indicators are higher by direct sowing technology by 4.2% and 5.7%, respectively. Consequently, the problem of accumulating moisture reserves is to some extent solved during the use of the no-till system, by leaving crop residues on the soil surface, covering and contributing to the reduction of moisture evaporation from the surface under conditions of elevated temperature inherent in the arid climate of the territory.

In terms of the dynamics of the content of organic matter, the technologies showed themselves almost the same in sunflower and chickpea - 2.61-2.64% and 2.69-2.73%, respectively. The soil in the study area is assigned to the group with a low humus content. The content of exchange potassium, nitrogen and mobile phosphorus has the same picture. At the same time, the highest nitrate nitrogen content in winter wheat crops is observed after the chickpea forecrop (13.8-14.9 mg/kg), because after its harvesting until the sowing of the main food crop takes about 2-3 months, which has a positive impact on the current nitrification, which helps to enrich the soil with nitrate nitrogen. And it accumulates more in the soil according to traditional technology by 3.8%.

Table 3. The influence of technology on agrochemical indicators of soil fertility during the cultivation of winter wheat according to various forecrops, 2017-2019.

| Predecessor | technology          | tradition technology |
|-------------|---------------------|----------------------|
|             | direct seeding       | traditional          |
|             | 2017 2018 2019      | 2017 2018 2019       |
| Sunflower   | Organic matter content in the soil layer 0…30 cm, % |
|             | 2.63                | 2.62                | 2.61                | 2.64                | 2.63                | 2.62                |
| Chickpea    | 2.70                | 2.69                | 2.69                | 2.73                | 2.72                | 2.71                |
| Sunflower   | Content of exchangeable potassium in the soil layer 0…30 cm, mg/kg of soil |
|             | 372.3               | 362.7               | 352.0               | 371.3               | 361.7               | 354.3               |
| Chickpea    | 413.3               | 402.3               | 386.0               | 414.7               | 403.3               | 386.7               |
| Sunflower   | Mobile phosphorus content in the soil layer 0…30 cm, mg/kg of soil |
|             | 31.6                | 33.8                | 32.8                | 32.8                | 35.2                | 33.9                |
| Chickpea    | 34.8                | 38.7                | 37.3                | 36.2                | 40.1                | 38.6                |
| Sunflower   | Nitrogen content in the soil layer 0…30 cm, mg/kg of soil |
|             | 13.6                | 13.4                | 13.2                | 14.4                | 14.1                | 13.7                |
| Chickpea    | 14.0                | 13.9                | 13.8                | 14.9                | 14.6                | 13.8                |

Over the years of observation, the yield of winter wheat when sown on the forecrop sunflower was 39.2-44.4 c / ha, for the chickpea - 44.5-46.7 c/ha. The yield of winter wheat, cultivated using the technology without tillage, exceeds the yield of traditional technology by 8.8% on average.

The results of three years of research were subjected to regression analysis. On the basis of calculated regression equations, trend models of winter wheat yield changes depending on the content
of soil indicators and forecrops have been developed. The models reflected the level of connection between the indicators and were described by regression equations (Table 4).

**Table 4.** The impact of technology on the yield of winter wheat for various forecrops, kg / ha.

| Predecessor | 2017 | 2018 | 2019 | r   | Interpretation             | Regression equation |
|-------------|------|------|------|-----|----------------------------|---------------------|
| Sunflower   | 47.4 | 45.0 | 40.7 | 1.0 | fully connected            | Y = -100,712 + 0.358x4 + 0.471x5 |
| Chickpea    | 49.8 | 46.8 | 43.5 | 1.0 | fully connected            | Y = -33,986 + 0.216x4 – 0.159x5 |
| Sunflower   | 45.3 | 33.7 | 38.6 | 1.0 | fully connected            | Y = 148,665 + 0.109x4 – 4.394x5 |
| Chickpea    | 47.5 | 44.4 | 41.6 | 1.0 | fully connected            | Y = -22,753 + 0.190x4 – 0.239x5 |

x1 - soil density, g/cm³.

x2 - stock of productive moisture, mm.

x3 – humus.

x4 - potassium, mg/kg.

x5 - phosphorus, mg/kg.

x6 - nitrogen, mg/kg.

When sowing winter wheat after sunflower and chickpea, a very high correlation (r=1.0) between factors (potassium and phosphorus) and yield is determined. For other agrophysical and agrochemical indicators, no significant relationship has been identified.

6. Conclusion

The cultivation of winter wheat using two technologies on dark chestnut soils in the arid climate of the Central Ciscaucasia for three years did not lead to its compaction. The soil density was within the optimal values for the growth of winter wheat (1.27-1.28 g/cm³). An increase in the stock of productive moisture was noted by direct sowing technology (for sunflower - 64.7 mm and chickpea - 76.2 mm). On average, the content of exchange potassium before sowing on sunflower was 361.3-365.7 mg/kg, on chickpeas - 399.0-403.0 mg/kg; mobile phosphorus - 32.1-33.2 and 36.8-37.4 mg/kg, respectively; nitrogen - 12.6-14.4 and 13.0-14.9 mg/kg, respectively. On average, in the variant where sunflower acted as a forecrop, the yield of winter wheat varied within 39.2-44.4 c/ha, chickpeas - 44.5-46.7 c/ha.

The trend models reflected a very close relationship between factor features (potassium and phosphorus) and winter wheat productivity (r = 1.0).

Based on the analysis of the influence of the two technologies on soil fertility and winter wheat productivity, it is recommended that the technology of direct sowing be further developed in the arid climate of the Central Caucasus. In a field crop rotation, give preference to a nitrogen-containing forecrop. Pay attention to stabilizing the content of exchange potassium and mobile phosphorus, which will increase the production ability of winter wheat and the food security of the region as a whole.

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