Comparison of no-till and traditional technologies for *Triticum Aestivum L.* cultivation

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Abstract. The research purpose is to compare the no-till Triticum aestivum L. cultivation technology with a traditional cultivation system and their influence on soil moisture, the number of weeds, soil density, aggregate composition and a structure coefficient. The studies were conducted in 2015–2018 in the Steppe Crimea. Crop rotations consist of the same set of plants with the exception of the first link: under the traditional system: black fallow – winter wheat – oil flax – winter barley – grain sorghum; under the no-till system, pea was sowed at the first field. The experiments were conducted in accordance with generally accepted methods of field experiments in agriculture and crop production. By the time of sowing, a larger amount of moisture accumulated in the black fallow compared to the field of peas. It was 0–10; 0–20; 0–100 cm for 1.9; 5.5 and 20.6 mm, respectively. In spring, the amount of productive moisture was at the same level. Under the traditional system, it was 104; under the direct sowing, it was 102 mm. Using the direct sowing technology, the absence of mechanical soil loosening had no effect on the density parameter in comparison with the traditional farming system: density was normal, regardless of the farming system: 1.13 g/cm³ under the traditional system, and 1.19 g/cm³ under the direct sowing system; in the 10–30 cm layer, it was 1.45 g/cm³; in general, in the 0–30 cm layer, the difference was not significant (1.34 and 1.36 g/cm³). The species composition of weeds did not change. The direct sowing technology used for untreated soil had a positive effect on the soil structure. By the third year of research, the coefficient of structure was 2.94 (under the traditional system), and 4.05 (under the direct sowing system).

1. Introduction

*Triticum aestivum L.* is the most important food plant. This is the most valuable and high-yielding grain crop [1]. It contains about 16% of protein and 80% of carbohydrates. It is used in pasta, bakery and confectionery industries. In animal husbandry, waste milling, chaff and straw are used [2–4].

It is the main grain crop in Russia which ranks first in the structure of the cultivated areas (27.7 million hectares) [5].

Winter wheat is frost-resistant. At 2–4 ºC, seeds germinate, and at 10–12 ºC, they emerge. By the winter, tillering reaches 3–4 shoots. The transpiration coefficient is 250–350. Winter wheat has a strong, fibrous...
From shooting to flowering, it consumes the greatest amount of moisture. For winter wheat, the best predecessors are required (black pairs, busy pairs, legumes, etc., since it is demanding of soil fertility [6-7].

New farming methods can solve current problems, reduce the cost of cultivated products, preserve and reproduce soil fertility, reduce the pesticide load on agricultural landscapes, update the machine-tractor fleet, and increase quality crop production [8].

The no-till farming system (direct sowing) excludes the tillage reducing soil cultivation to a narrow cut with a direct seeding planter for planting seed into the soil [2]. Weed control is carried out using herbicides. When implementing this technology, it is necessary to observe crop rotation and alternate winter and spring crops.

In the south of Russia, experiments on the no-till farming system for growing winter wheat have not been carried out. The purpose of our research is to study the influence of the direct sowing technology on the content of soil moisture, weeding, soil density, aggregate composition and the structure coefficient.

2. Research methods and conditions

In 2015, the field experiment including two crop rotations was conducted for a detailed study of the technology in a field of the field technology implementation department of the laboratory of the Research Institute of Agriculture of Crimea (Klepinino village, Krasnogvardeisk district). Crop rotations consist of one set of plants with the exception of the first link: the traditional system: black pairs – winter wheat — oil flax — winter barley — grain sorghum; for the no-till system, the first field (black pairs) was replaced by sowed peas.

Under the traditional system, cattle manure was applied at the rate of 30 t/ha, followed by plowing by 20–22 cm. Mineral fertilizers were used in autumn (phosphorus). Weed control was carried out by a combination of mechanical and chemical methods. Sowing was carried out by the drill NW - 3.6.

Under the direct sowing system, a Gherardi G117 seeder was used to introduce mineral fertilizers simultaneously with sowing (10 kg of phosphorus). Chemical methods were used to control weeds and prevent pests and diseases.

The experiments were conducted according to general cultivation methods [10]. The plot area was 300 m², the accounting area was 50 m².

All the parameters were studied according to the practical manual by I.P. Vasiliev [11].

Winter barley was cultivated according to the recommendations suggested by E.V. Nikolaev [6].

Direct sowing of winter barley was based on practical recommendations by V.K. Dridiger. [9].

The previous crop (pea) was harvested in the third decade of June or the first decade of July. Then the plots were treated with glyphosates.

Over the years of research, winter wheat was sown in the second decade of October. The seeding rate was 3 million/ha. In early spring, the plots were treated with nitrogen fertilizers (30 kg of nitrogen) and vegetative herbicide. Both farming technologies were used simultaneously.

The crop was harvested with a Sampo 500 combine equipped with a straw chopper and a chaff spreader.

During the growing season of peas (the predecessor of winter wheat in the crop rotation by direct sowing), moisture values were as follows: 2016 - 389 mm, 2017 - 106 mm, 2018 - 46.8 mm with an average value of 115 mm for the same period. Therefore, there was a low pea yield.

In the period preceding the sowing of wheat (July – September), relatively favorable conditions for accumulation of productive moisture were observed only in 2016 when 132 mm of precipitation accumulated; in 2015 and 2017, there was a significant shortage of precipitation – 68.9 and 65.9 mm. During the growing season of 2016–2017, the value of precipitation was 455 mm, in 2017–2018 and 2018–2019 - 226 and 189 mm, respectively, while the norm is 297 mm.
Over the years of research, the temperature regime was 12.2 °C, which is 1.8 °C above the multiyear average. The increased temperature was accompanied by wind.

3. Research results
In the climatic conditions of the steppe Crimea, there is an acute shortage of precipitation. As a result, there is an insufficient amount of productive soil moisture. For three years, by the time of sowing of winter wheat, the moisture level varied from 12 to 14.6 mm (on average 13.4 mm). After pea sowing, it varied from 0 to 12.2 mm (on average 7.9 or 1.7 times less). In the meter horizon, the ratio was preserved with a smaller difference of 69.7 under the traditional system and 49.1 mm under the no-till system (Table 1).

| Farming system | 2016   | 2017   | 2018   | Average |
|----------------|--------|--------|--------|---------|
|                | 0-10   | 0-20   | 0-100  | 0-10    | 0-20    | 0-10   | 0-20    | 0-100  |
| TS*            | 6.3    | 14.6   | 80.4   | 6.5     | 12.0    | 70.2   | 2.1     | 13.6   | 58.5   | 5.0    | 13.4   | 69.7   |
| NT**           | 3.5    | 11.7   | 84.9   | 5.7     | 12.2    | 41.5   | 0       | 0      | 20.8   | 3.1    | 7.9    | 49.1   |
| ±              | -2.8   | -2.9   | +4.5   | -0.8    | +0.2    | -28.7  | -2.1    | -13.6  | -37.1  | -1.9   | -5.5   | -20.6  |
| HCP₀₅          | 0.89   | 1.27   | 3.63   | 1.61    | 1.16    | 22.8   | 0.19    | 1.24   | 23.8   |        |        |        |

Table 1. Soil moisture depending on the winter wheat cultivation system, 2016–2018

| Resumption of spring vegetation | 2016   | 2017   | 2018   | Average |
|---------------------------------|--------|--------|--------|---------|
| TS                              | 14.8   | 25.7   | 112.5  | 10.1    | 19.1    | 100.1  | 10.9    | 22.2   | 101    | 11.9   | 22.3   | 104.5  |
| NT                              | 11.4   | 22.3   | 108.7  | 8.2     | 20.4    | 102.6  | 9.9     | 20.2   | 96.3   | 9.8    | 20.9   | 102.5  |
| ±                               | -3.4   | -3.4   | -3.8   | -1.9    | +1.3    | +2.5   | -1.0    | -2.0   | -4.7   | -2.1   | -1.4   | -2.0   |
| HCP₀₅                           | 1.70   | 2.30   | 5.30   | 2.26    | 2.00    | 3.70   | 1.20    | 2.16   | 6.43   |        |        |        |

TS – traditional system; NT** – no-till

In 2016 and 2018, under the traditional system, the moisture level was higher; in 2017, in the sowing and arable layers, the moisture level was the same under both farming systems; in the meter layer, under the traditional system, it was 28.7 mm.

During the autumn-winter period, by the time of the renewal of the growing season, there was no clear and significant dependence on the accumulation of moisture in the farming systems. A significant difference in the accumulation of moisture in favor of the traditional sowing was recorded only in 2016 by horizons 0–10 and 0–20 – 3.4 mm. In other years, the difference in moisture accumulation was not significant. For the three years, the difference in moisture accumulation was 1.4-2.1 mm.

The amount of weeds is also an important indicator. Under the no-till system, the presence of weeds in winter wheat crops is presented in Table 2.

Regardless of the sowing technology, the same weed species were observed: winter weeds Papaver rhoeas, Capsella bursa-pastoris, Descurainia sophia, Lamium amplexicaule; sprong weeds Veronica hederifolia, Cerastium perfoliatum L., Lamium purpureum, Fumaria agraria Lag, Delphinium consolida. The most harmful ones are wintering annuals and Dichodon perfoliatum L. Under the no-till system, in the spring of 2016 and 2018, the number of weed plants was higher; in 2017, their number was the same. In general, the number of weeds exceeded 50 pcs./m². Herbicidal treatment was required. On average, over three years, the loss of weed vegetation was 93.2% under the traditional system, and 93.6% - under the no-till system.
Table 2. Winter wheat weediness depending on farming systems, pcs./m², 2016–2018

| Plant and farming system | 2016 | 2017 | 2018 | Average values for three years |
|--------------------------|------|------|------|------------------------------|
|                          | Before treatment with herbicides | After treatment with herbicides | Destruction % | Before treatment with herbicides | After treatment with herbicides | Destruction % | Before treatment with herbicides | After treatment with herbicides | Destruction % |
| TS                       | 69   | 7.6  | 89   | 67  | 2.7  | 95.8 | 50.8 | 2.64 | 94.8 | 62.3 | 4.31 | 93.2 |
| NT                       | 81   | 8.1  | 90   | 62  | 2.7  | 96   | 62.8 | 3.2  | 94.9 | 68.6 | 4.7  | 93.6 |
| HCPₐ₅                    | 5.21 | 0.32 | –    | 6.23| 0.11 | 7.41 | 0.21 | –    | –    | –    | –    | –    |

Soil density indicators are presented in Table 3.

Table 3. The impact of farming systems on soil density during sowing and renewal of spring vegetation, 2017–2018

| Technology | Horizons 2017 | Horizons 2018 | Average for two years |
|------------|---------------|---------------|-----------------------|
|            | Sowing        |               |                       |
| TS         |               |               |                       |
| 0–10       | 1.14          | 1.12          | 1.13                  |
| 10–20      | 1.40          | 1.42          | 1.41                  |
| 20–30      | 1.40          | 1.57          | 1.48                  |
| 0–30       | 1.31          | 1.37          | 1.34                  |
| 0–10       | 1.21          | 1.17          | 1.19                  |
| 10–20      | 1.34          | 1.45          | 1.39                  |
| NT         |               |               |                       |
| 0–10       | 0.08          | 0.06          | –                     |
| 10–20      | 0.07          | 0.05          | –                     |
| 20–30      | 0.04          | 0.04          | –                     |
| 0–30       | 0.04          | 0.09          | –                     |
| HCPₐ₅      |               |               |                       |
| 0–10       | 0.99          | 0.88          | 0.94                  |
| 10–20      | 1.09          | 1.34          | 1.21                  |
| 20–30      | 1.31          | 1.36          | 1.33                  |
| 0–30       | 1.13          | 1.19          | 1.15                  |
| 0–10       | 1.01          | 0.91          | 0.96                  |
| Resumption of spring vegetation | | | |
| TS         |               |               |                       |
| 0–10       | 0.99          | 0.88          | 0.94                  |
| 10–20      | 1.09          | 1.34          | 1.21                  |
| 20–30      | 1.31          | 1.36          | 1.33                  |
| 0–30       | 1.13          | 1.19          | 1.15                  |
| 0–10       | 1.01          | 0.91          | 0.96                  |
| NT         |               |               |                       |
| 10–20      | 1.19          | 1.38          | 1.28                  |
| 20–30      | 1.43          | 1.31          | 1.37                  |
| 0–30       | 1.21          | 1.20          | 1.20                  |
| 0–10       | 0.03          | 0.07          | –                     |
| HCPₐ₅      |               |               |                       |
| 10–20      | 0.12          | 0.06          | –                     |
| 20–30      | 0.14          | 0.07          | –                     |
| 0–30       | 0.10          | 0.04          | –                     |
Soil density is one of the indicators of the physical condition of the arable layer; it is important for seed germination, initial growth and plant development. Soil density in the sowing layer was close to optimum and equal to 1.13 g/cm$^3$ (under the traditional system) and 1.19 g/cm$^3$ (under the no-till system), in layers 10–20 and 20–30 – 1.45 g/cm$^3$. By spring, the upper layer of 0–10 cm was decompressed, regardless of the technology. In the layer of 0–30 cm, the soil is looser – 1.12 g/cm$^3$ and less friable of the precursor was pea (1.20 g/cm$^3$).

The soil structural was determined before sowing, since it is one of the most important indicators of the physical properties of the soil. The most valuable soils are porous and water-resistant aggregates in the range of more than 0.25 to 10 mm, the desired amount is 55–60%. In the structured soil with this number of macroaggregates, moisture and air are in the optimum amount: moisture fills the finest pores inside the soil lumps; in the larger ones, there is air. The lumpy-grained soil structure contributes to timely germination of wheat seeds, facilitates the growth and development of their root system.

The influence of cultivation technologies on the number of agronomically valuable fractions before winter wheat sowing is presented in Table 4.

**Table 4.** The effect of cultivation technology on the number of agronomically valuable aggregates in the soil layer of 0–10 cm, 2017–2018

| Farming system | The number of aggregates of the agronomically valuable range before sowing, % |
|---------------|--------------------------------------------------------------------------------|
|               | 2017 (18.10.16) ± | 2018 (4.10.17) ± | Average ± |
| TS            | 67.2               | 73.5               | 70.3       |
| NT            | 66.0 -1.13         | 78.6 +5.1          | 72.3 +2.0  |
| HCP05         | 5.45               | 3.00               |            |

In 2017, the number of the most valuable aggregates did not depend on the farming system and was 67.2 and 66.1% under the traditional and direct sowing systems, respectively. In 2018, under the direct sowing system, the number of agronomically valuable fractions was higher by 5.1% at 3% HCP05. Well-structured soils have a structural coefficient of 3-3.5. During the second year, it was at the same level, and during the third year, under the direct sowing system, it was 4.05 or 1.4 times higher (Table 5).

**Table 5.** The effect of cultivation technology on the coefficient of structure in the soil layer 0-10 cm, 2017–2018

| Farming system | Structure coefficient before sowing, % |
|---------------|--------------------------------------|
|               | 2017 | 2018 | Average |
| TS            | 2.09 | 2.94 | 2.51    |
| NT            | 1.96 | 4.05 | 3.00    |

The research will be continued to establish how direct sowing will affect the parameters in subsequent years.

4. Conclusion

By the time of sowing, a larger level of moisture accumulated compared to the pea field and was 0-10; 0–20; 0–100 cm by 1.9; 5.5 and 20.6 mm, respectively. With the resumption of spring vegetation, the amount of productive moisture was at the same level and in the meter horizon: 104 mm – under the traditional system, and 102 mm – under the direct sowing system.
Under the direct sowing system, the absence of mechanical loosening of the soil had no effect on soil density in comparison with the traditional farming system: density of the sowing layer was close to normal, regardless of the farming system: 1.13 and 1.19 g/cm$^3$ under the traditional and direct swing systems, respectively; in the 10–30 cm layer, it was at the same over-compacted level - 1.45 g / cm$^3$ in general, it was 0–30 cm; the difference was not significant (1.34 and 1.36 g/cm$^3$).

The species composition of weeds has not changed for three years of research. By the third year of research, the coefficient of structure was 2.94 (for the traditional system), and 4.05 (for the direct sowing system).

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