Biometric indicators of corn and basic tillage systems

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Abstract. Studies on the influence of basic tillage systems on changes in soil fertility and biometric indicators of cultivated crops have been conducted at the Federal State Budgetary Scientific Institution "National Grain Center named after P. P. Lukyanenko" in the experimental fields of the Agriculture laboratory since 2008. The article presents part of the studies for the period from 2018 to 2020, during which it was determined that the minimum mulching basic tillage system with decompaction is not inferior in agronomic efficiency to the traditional system. Observations of the growth and development of corn for grain showed the priority of this tillage. The grain yield obtained over the years of research (2018-2020) on decompaction technology was formed at the level of traditional tillage (conditionally accepted as control) and amounted to 55.9 c/ha, significantly exceeding the minimum by 2.2 c/ha, while having a high content of crude protein in the grain - 11.2%.

1. Introduction
Every year there are new discoveries in the field of agriculture: these may be new forms and types of fertilizers, varieties and hybrids of various crops, but also the systems of basic tillage, this agricultural approach is rarely subject to changes. They have been known for a long time and rarely something new appears that will radically change the idea of them, nevertheless, the study of soil tillages should be conducted for many years. After all, this is the only way to trace the influence of basic tillage systems on soil fertility and cultivated crops [1].

Some methods confirm their effectiveness, others only gain the trust of modern farmers. The tasks of soil tillage include not only giving its optimal composition, improving the phytosanitary condition, but also one of the main ones – reproduction and preservation of its fertility. Without this, such expensive techniques as irrigation, land reclamation and use of fertilizers would lose their effectiveness. And thus, the system of basic tillage does not lose its importance, which creates the best conditions for plants, including corn [2, 3, 4, 5].

Corn is one of the most important grain and fodder crops, its grain contains a large amount of nutrients, and the stems are used not only for livestock feed, but also to produce paper, artificial resins, cellulose. The crop cleans the field well from weeds, is a good precursor for subsequent crops [6].

In our case, such systems of basic tillage were used for it as traditional using plowing and has long earned its favor among farmers, minimal mulching with decompaction (chiseling), which loosens the plow sole, helping to drain water from the fields and improving the agrophysical properties of the soil [1], as well as minimal mulching tillage, which proved advantageous due to a significant increase in fuel materials and a decrease in the number of passes in the fields.

The purpose of the research: to study the influence of basic tillage systems on the change of
biometric indicators of corn plants cultivated for grain in the soil and climatic conditions of the central zone of the Krasnodar Krai.

The objectives of the research included the following:
- determination of the effect of basic tillage systems on agrophysical fertility indicators;
- to study the influence of basic tillage systems on the change in biometric indicators of corn cultivated for grain;
- to establish the dependence of the yield and quality of corn grain on basic tillage systems.

2. Materials and methods
The research was carried out at the Federal State Budgetary Scientific Institution "National Grain Center named after P. P. Lukyanenko" in the Agriculture laboratory, located in the central zone of the Krasnodar Krai. The soil is leached chernozem, the climate is temperate continental.

Basic tillage systems have been studied since 2008 in a station, which consists of a six-field crop rotation, with the following alternation of crops: winter wheat, sunflower, winter wheat, corn for grain, winter wheat, soy. The station area is 10.2 hectares, the area of one field is 1.3 hectares, the area of the plot according to the tillage method is 0.43 hectares.

The precursor in our research was winter wheat, after harvesting, which prepared the soil according to three systems of basic tillage for subsequent sowing of corn for grain: traditional - plowing to a depth of 22-25 cm; mulching minimum treatment with decompaction - chiseling for row crops; minimum mulching - disking in two, three tracks (depth up to 12 cm).

3. Results and discussion
Studying the basic tillage systems and their impact on changes in biometric indicators of agricultural crops, it is necessary to understand how these tillages affect the agrophysical properties of the soil [7]. During the conducted studies, the dependence of the agrophysical indicators of leached chernozem on the studied systems of basic tillage, the data of which are presented in Table 1, was revealed.

| Basic soil tillage system | Volume weight, g/cm³ | Content of agronomically valuable aggregates (0.25-10 mm), % | Structural coefficient, Cs | Water stability, % | Total porosity, % |
|--------------------------|----------------------|----------------------------------------------------------|---------------------------|------------------|------------------|
| Traditional              | 1.26                 | 61.1                                                     | 3.2                       | 59.4             | 50               |
| Minimal mulching         |                      |                                                          |                           |                  |                  |
| with decompaction        | 1.29                 | 65.7                                                     | 3.1                       | 65.2             | 51               |
| Minimal mulching         | 1.33                 | 69.7                                                     | 3.1                       | 62.3             | 51               |
| LSD₉₅                   | 0.02                 | 2.8                                                     |                           | 2.3              |                  |

In the conducted studies, the volume mass for an average of 3 years was 1.26 g/cm³ for traditional tillage, which is 2.4% less than for decompaction and 5.5% for minimum mulching tillages. The soil, according to traditional tillage, has good volume mass indicators, but the number of agronomically valuable aggregates is inferior to other options in the experiment by 4.6 (decompaction) and 8.6 (minimal mulching)% and amounted to 61.1%. It is worth noting that the obtained results on the assessment of the soil structural condition correspond to score "good". This, in turn, affects the soil structural coefficient, values of which above 1.5 are considered as good indicator. In our studies, this value has an insignificant difference between the options, based on this, it can be argued that the aggregate state of our soils is excellent.

Nevertheless, tillage also has a protective character, both from the destructive effects of wind and water. To control this action, there is an indicator of the water resistance of soil aggregates, namely
their ability to counteract the destructive effect of water. Thus, on the traditional tillage system, it amounted to 59.4%, which is 2.9% inferior to the minimum mulching tillage and 5.8% to decompaction tillage.

The soil is a living organism and the processes occurring in it are closely interrelated: a change in one of the indicators affects other processes. Thus, the granulometric composition affects the density, and that in turn affects the porosity. Porosity is an important indicator on which the amount of moisture and air available to plants in the root layer depends. The data obtained in the course of the conducted studies, 50-51%, having no significant difference between the studied options, fully satisfy the needs of corn.

In turn, there are studies showing that various methods of tillage also affect the biological properties of cultivated crops [8, 9]. The data presented in Table 2 on the change in the duration of interphase periods depending on the studied soil tillages confirm this statement.

**Table 2. Duration of interphase periods of corn depending on the systems of basic tillage (2018-2020), days**

| Basic soil tillage system                      | Sowing – shoots | Shoots – 5-6 leaves | 5-6 leaves – panicle | Panicle – milk ripeness | Milk ripeness – full ripeness | Growing season |
|-----------------------------------------------|-----------------|---------------------|----------------------|-------------------------|-----------------------------|----------------|
| Traditional                                   | 13              | 23                  | 33                   | 18                      | 37                          | 111            |
| Minimal mulching with decompaction            | 16              | 25                  | 35                   | 18                      | 37                          | 115            |
| Minimal mulching                              | 18              | 27                  | 37                   | 20                      | 39                          | 123            |

To obtain high yields of corn grain with good quality, it is of paramount importance to obtain seedlings. In our experimental conditions, the period from sowing to germination lasted 13-18 days, depending on the tillage system. Considering the different soil density of the studied tillages, it can be assumed that its increase delayed the emergence of seedlings, due to the difficulty of passing to the surface. Thus, on the traditional processing with the lowest density, the sowing – germination period was 13 days, which is 3 days less than on the decompaction tillage and 5 days less than on the minimum mulching tillage. In general, the dependence remains the same on the duration of the period from germination to panicle. Plants on traditional tillage reached this phase 4 and 8 days earlier than on decompaction and minimal tillages.

In general, the duration of the growing season on the traditional basic tillage system was 111 days, which is 4 days less than with decompaction and 12 days less than with minimal mulching technology.

**Table 3. The height of corn depending on basic tillage systems (2018-2020), cm**

| Basic soil tillage system                      | Vegetation phases |
|-----------------------------------------------|-------------------|
|                                               | 5-6 leaves | 10-11 leaves | milk ripeness | wax ripeness |
| Traditional                                   | 37.5        | 79.5         | 210.9         | 208.1        |
| Minimal mulching with decompaction            | 34.8        | 76.1         | 208.7         | 206.3        |
| Minimal mulching                              | 33.2        | 75.6         | 201.2         | 199.5        |
| LSD_{0.05}                                    | 2.1         | 2.6          | 7.1           | 7.1          |

One of the biometric indicators of corn is its height, which is subject to change depending on various agrophysical properties of the soil. In phases of 5-6 and 10-11 leaves, the highest rate of plants
was noted on traditional tillage, which is by 7.8 and 12.9 (phase of 5-6 leaves) % and by 4.5 and 5.2 (phase of 10-11 leaves) % higher than on the decompaction and minimum technologies, respectively. In the phase of milk and wax ripeness of the plant on traditional and decompaction technologies, the difference in height is not significant and on average exceeds the minimum tillage by 4.3% and 3.9%. Nevertheless, if we consider the growth rates of corn plants in the phases of vegetation, we can see that from the phase of 5-6 leaves to the phase of 10-11 leaves they were lower on traditional and decompaction tillages - 1.8% compared with the minimum technology. Already by the milk ripeness phase, the same tillages showed an increase in growth rates by 4.6 and 5.6% compared to the minimum tillage. It is worth noting that plants cultivated by traditional and decompaction tillage are on average 2.45 cm higher in relation to the minimum technology.

Corn is a multidirectional crop, which has found application in many industries, including livestock due to highly productive feed properties. Grain, green mass, corn cob are used for feed, and thus, the accumulation of biomass by corn is of paramount importance (Table 4).

Table 4. Dynamics of raw weight accumulation by corn plants depending on basic tillage systems (2018-2020), g/plant

| Basic soil tillage system              | Vegetation phases | 5-6 leaves | 10-11 leaves | milk ripeness | wax ripeness |
|----------------------------------------|-------------------|------------|--------------|--------------|--------------|
| Traditional                            |                   | 25.5       | 210.3        | 1435.0       | 785.3        |
| Minimal mulching with decompaction     |                   | 25.0       | 205.1        | 1420.7       | 773.6        |
| Minimal mulching                       |                   | 23.4       | 196.0        | 1390.8       | 758.1        |
| LSD₀.05                               |                   | 1.0        | 6.5          | 39.8         | 20.1         |

The increase in the raw weight of corn plants proceeded unequally, the best options were on traditional and minimal mulching with decompaction tillages, which increase this indicator to the greatest extent in comparison with minimal mulching technology. In the phase of 5-6 leaves, the plant weight on traditional and decompaction technologies was 25.5 and 25.0 g/plant, then there is a gradual accumulation of weight and to the phase of milk ripeness it was 1435.0 and 1420.7 g/plant, then to wax ripeness there is a natural drying of plants, the weight of which was 785.3 and 73.6 g/plant, respectively. Whereas, on the minimum tillage system, a decrease in the weight of corn plants was noted from 6.0% in the phase of 5-6 leaves to 3.0% in the phase of wax ripeness in relation to traditional tillage.

The accumulation of dry weight by plants is an important indicator of the impact of the external environment on them, on its synthesis of organic matter, which largely depends on soil conditions [10]. Table 5 shows data on the accumulation of dry weight by corn plants.

Table 5. Dynamics of dry weight accumulation by corn plants depending on basic tillage systems (2018-2020), g/plant

| Basic soil tillage system              | Vegetation phases | 5-6 leaves | 10-11 leaves | milk ripeness | wax ripeness |
|----------------------------------------|-------------------|------------|--------------|--------------|--------------|
| Traditional                            |                   | 3.4        | 35.6         | 314.9        | 323.4        |
| Minimal mulching with decompaction     |                   | 3.1        | 32.9         | 309.9        | 319.7        |
| Minimal mulching                       |                   | 3.0        | 31.7         | 305.1        | 306.6        |
| LSD₀.05                               |                   | 0.1        | 1.3          | 7.8          | 15.6         |

Thus, in the phase of 5-6 leaves, the dry matter weight on traditional tillage was 3.4 g/plant, which is significantly 9.7% higher than on decompaction and 13.3% higher than on minimal tillage, between minimal tillages it remained insignificant. This trend continued to the phase of 10-11 leaves. The dry
matter weight in the subsequent phases began to gradually increase and during the traditional tillage in the phase of milk ripeness amounted to 314.9 g/plant, the data obtained exceed the minimum mulching tillage, but at the same time it has an insignificant difference with the decompaction technology. This pattern can also be traced in the wax ripeness phase. Thus, a higher accumulation of dry weight by corn plants was noted with traditional tillage, and a lower one with minimal mulching.

The effectiveness of all agricultural practices is confirmed by the obtained yield of the studied crop, and what makes up this yield is characterized by the structure of the crop, which is presented in Table 6.

Table 6. Structure of the corn crop for grain depending on the system of basic tillage, (2018-2020)

| Basic soil tillage system       | Weight, g | Number of cobs per 1 plant, pcs. | Height of lower cob attachment, cm |
|---------------------------------|-----------|----------------------------------|-----------------------------------|
| Traditional                     | 311.3     | 126.8                            | 78.8                              |
| Minimal mulching with decompaction | 310.5     | 123.9                            | 78.5                              |
| Minimal mulching                | 313.9     | 118.1                            | 71.2                              |
| LSD<sub>0.05</sub>             | 9.8       | 4.3                              | 2.7                               |

The weight of 1000 grains in the conducted studies varied from 310.5 to 313.9 g, no significant difference between the studied tillages was revealed. The weight of grain from the cob on the traditional and decompaction tillage systems was 126.8 and 123.9 g, respectively. Having no significant differences between each other, the obtained data exceeded the minimum mulching tillage by 7.4 and 4.9%, respectively. The yield value is also determined by the number of ears formed on one plant. In the course of research, it was revealed that with traditional and decompaction tillages, this indicator was 1.1 pcs., whereas with minimal mulching tillage, it is less by 0.2 pieces. It should be noted that the height of the attachment of the cob on the corn plant with the traditional processing system is 7.5 cm higher than with minimal mulching tillage.

The yield obtained during the research is a good criterion for the effectiveness of the studied basic tillage systems (Table 7).

Figure 7. Corn grain yield depending on the basic tillage systems, c/ha

| Basic soil tillage system       | Corn yield per grain, c/ha |
|---------------------------------|---------------------------|
|                                 | 2018 | 2019 | 2020 | 2018-2020 |
| Traditional                     | 44.4 | 63.2 | 63.3 | 56.9       |
| Minimal mulching with decompaction | 40.4 | 64.6 | 62.6 | 55.9       |
| Minimal mulching                | 40.0 | 63.0 | 58.2 | 53.7       |
| LSD<sub>0.05</sub>             | 1.9  | 2.1  | 2.2  | 2.0        |

In 2018, the maximum yield was obtained on the traditional tillage system of 44.4 c/ha, which is 9.9 and 11.0% more than on the minimum mulching tillages. In the conditions of 2019, there were no significant differences in yield between the studied variants. In 2020, the yield on traditional and decompaction tillages is the same, whereas with minimal tillage it is lower by 8.8 and 7.6%, respectively. Thus, the analysis of the average data for the period 2018-2020 revealed that the same yield was obtained on the traditional and minimum mulching with decompaction tillage systems, which is 2.2 - 3.2 c/ha higher than on the minimum mulching.
The data presented in Table 8 make it clear to us that tillage systems affect not only the yield and biometrics of corn, but also the grain composition.

**Table 8.** Corn grain quality depending on the basic tillage system (2018-2020), %

| Basic soil tillage system          | Crude protein | Crude ash | Dry matter |
|-----------------------------------|---------------|-----------|------------|
| Traditional                       | 11.4          | 1.32      | 86.6       |
| Minimal mulching with decompaction| 11.2          | 1.27      | 86.6       |
| Minimal mulching                  | 10.9          | 1.26      | 86.1       |
| LSD<sub>0.05</sub>                | 0.4           | 0.04      | 2.9        |

The protein content in the grain depended on the studied soil tillages, with a significant difference between traditional and minimal mulching tillage of 0.5%. The ash content on traditional tillage was 1.32%, which is 0.05 and 0.06% higher than on minimal systems of basic tillage. The amount of dry matter did not depend on the studied factors.

**4. Conclusions**

In the course of the conducted studies, it was revealed that the traditional and decompaction systems of basic tillage have the same effect on corn plants and ultimately on its yield, which amounted to 56.9 and 55.9 c/ha (according to data for the period 2018-2020), while at the minimum technology this indicator is lower by an average of 2.7 c/ha. The increase in yield is justified by an increase in the yield of grain from the cob and an increase in the number of cobs formed on one plant.

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