Cultivation technology elements influence on the harvest structure and quality of crops products

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Abstract. The purpose of our research was to study the influence of the type of crop rotation, methods of basic land cultivation and fertilizers on the elements of winter wheat yield structure, spring barley and sugar beet and their qualitative characteristics. The studies were carried out on typical medium-thick low-humus heavy loamy chernozem on loess-like soil in the conditions of the Belgorod region. In The maximum increase in the indicators of crop yield structure was recorded on the organo-mineral fertilization system. The cultivation of barley and winter wheat in a crop rotation, the quality of grain increases. When growing beets in crop rotation, there is a tendency to a decrease in sugar content in comparison with grain-row crop rotation, while the sugar yield increases. Organo-mineral fertilization system reduces the starch content in the grain of barley by an average of 2.4% in the crop rotation and 1.3% in the grain crop rotation compared to the control, and increases the protein content in the grain of winter wheat by an average of 1.4%. The sugar content of beets on the organo-mineral fertilization system decreases on average by 0.8%, while the sugar yield, on the contrary, increases. Land cultivation methods in most cases do not affect the technological qualities of crops.

1. Introduction
Conducting agricultural production at the present stage dictates the need to improve crop rotations, land cultivation techniques and the search for alternative sources of plant nutrition. It is required to study the possibility of using nutrients by plants from the stubble-root remains of preceding crops. World and national experience shows that high and sustainable productivity of agriculture is possible only with integrated accounting and targeted regulation of all factors (preceding crops, timing and methods of sowing, seeding rate, fertilizer system, etc.) necessary for normal growth and development of plants, crop formation, and its quality.

The structure of the crop is the indicators of the components on which the size of the crop depends [1-3].

2. Methods
The quality of plant products is a set of properties and features that, to one degree or another, determine the satisfaction of human needs in accordance with the purpose. A quality indicator is a quantitative characteristic of one or several properties of a product that make up its quality (percentage of protein in wheat grain, percentage of protein in barley grain, or sugar percentage in sugar beet roots) [4-6].
The task of crop production is to ensure the appropriate quality of the products for which the plants are grown. The quality of plant products depends on many factors: soil and climatic conditions, varieties, agricultural technology and others [6-8].

3. Results
Analyzing the data of the structure of the barley yield on average for 2002-2004 it can be noted that the productive tilling capacity was 0.4 - 0.6 higher in the crop rotation compared with grain crops (table 1). This is due to a decrease in the seeding rate when sowing grasses. Moreover, with the use of mineral fertilizers, this indicator increased in both crop rotations. In the grain crop rotation in the control and in two crop rotations in the organic-mineral fertilization system, the tillering of barley was higher in plowing.

The height of the plants depends on the fertilizer. When mineral fertilizers are applied, this indicator increases by 9.2 - 12 cm in comparison with the control in the two studied crop rotations. The maximum plant height was observed with an organomineral fertilization system.

In the crop rotation without fertilization and with the combined application of organic and mineral fertilizers, plowing turned out to be more effective; in a grain crop rotation, this method of soil cultivation contributed to an increase in plant height in the variant with the application of mineral fertilizers. Crop rotations did not affect the height of plants, with the exception of unfertilized plowing options, where the advantage of crop rotation was noted.

The length of the spike and the number of grains in it varied depending on the fertilizer. So, with the combined application of organic and mineral fertilizers, the spike length increased by an average of 0.8 cm in the crop rotation and 1.1 cm in the grain crop rotation compared with the control. The number of grains on average is 2.5 pcs in two studied crop rotations. At the same time, soil cultivation techniques did not affect the change in the spike length. The exceptions are unfertilized options in both crop rotations and the organic-mineral fertilization system in the crop rotation, where the indicators were higher in plowing than in surface tillage. It should be noted that, in the crop rotation, the spike length was higher in comparison with surface tillage.

The number of grains also did not depend on the treatments, except for the crop rotation, where in the variant without fertilizers and on the organic-mineral fertilization system, the amount of grains was higher in plowing. Crop rotations did not affect the change in this indicator.

The weight of 1000 grains varied within 48.0 g in the crop rotation and 47.1 g in the grain crop rotation. Crop rotations and methods of soil cultivation did not affect the weight of 1000 grains.

Thus, all indicators of the structure of the spring barley yield depend on the use of fertilizers.

In the structure of the winter wheat yield, it can be noted that in the variant without fertilization, the methods of land cultivation and crop rotations did not affect the change in indicators, with the exception of the stooling coefficient, which was higher in the crop rotation (table 2).

The presence of mineral fertilizers in the winter wheat cultivation system contributed to an increase in plant height by 5.0 - 9.6 cm compared to the control in different types of crop rotations. At the same time, the spike length increased from 6.8 to 7.3 cm according to the studied crop rotations. The number of grains with the mineral fertilization system increased by an average of 3 pieces in both types of crop rotations. The mass of 1000 grains ranged from 47.9 - 48.1 g in the crop rotation and 47.3 - 47.9 g in the grain crop rotation.

The maximum increase in the indicators of the structure of the yield of winter wheat was observed with the combined application of organic and mineral fertilizers.

It should be noted that the height of plants on the organomineral fertilization system for plowing was higher in the crop rotation, and the spike length on the same fertilization system, but with respect to surface tillage, was also higher in the crop rotation. As for the change in plant height according to treatments, plowing in the crop rotation on an organic-mineral fertilization system proved to be more
effective. The spike length on the same fertilization system but in grain crop rotation was also higher for plowing.

**Table 1.** Structure of barley yield depending on crop rotations, fertilizers and methods of basic land cultivation.

| Barnyard manure* | Mineral fertilizers, dose | Height of plants, cm | Length of a spike, cm | Number of grains in a spike, pcs | Stooling coefficient | Weight of 1000 grains, g. |
|------------------|--------------------------|----------------------|-----------------------|-------------------------------|---------------------|-------------------------|
|                  |                          |                      |                       |                               |                     |                         |
| **CROP ROTATION**|                          |                      |                       |                               |                     |                         |
|                  |                          |                      |                       |                               |                     |                         |
| Plowing          |                          |                      |                       |                               |                     |                         |
| 0                | 0                        | 62.9                 | 6.8                   | 18.0                          | 1.8                 | 48.3                    |
| 0                | 1 dose                   | 72.5                 | 7.1                   | 19.3                          | 2.3                 | 48.4                    |
| 40               | 1 dose                   | 73.5                 | 7.5                   | 20.8                          | 2.5                 | 48.7                    |
| Surface tillage |                          |                      |                       |                               |                     |                         |
| 0                | 0                        | 58.2                 | 6.3                   | 16.7                          | 1.8                 | 47.2                    |
| 0                | 1 dose                   | 69.7                 | 7.1                   | 18.6                          | 2.3                 | 48.3                    |
| 40               | 1 dose                   | 69.8                 | 7.2                   | 18.8                          | 2.3                 | 48.5                    |
| **GRAIN CROP ROTATION** |                      |                      |                       |                               |                     |                         |
|                  |                          |                      |                       |                               |                     |                         |
| Plowing          |                          |                      |                       |                               |                     |                         |
| 0                | 0                        | 58.6                 | 6.2                   | 16.7                          | 1.4                 | 47.6                    |
| 0                | 1 dose                   | 70.6                 | 7.0                   | 19.0                          | 1.8                 | 47.8                    |
| 40               | 1 dose                   | 70.8                 | 7.2                   | 19.2                          | 1.9                 | 47.8                    |
| Surface tillage |                          |                      |                       |                               |                     |                         |
| 0                | 0                        | 57.8                 | 5.9                   | 16.5                          | 1.2                 | 46.4                    |
| 40               | 1 dose                   | 67.9                 | 7.1                   | 19.0                          | 1.8                 | 47.7                    |
| HCP05 for A factor |                        | 2.8                  | 0.3                   | 0.8                           | 0.1                 | 2.0                     |
| HCP05 for B factor |                        | 3.3                  | 0.3                   | 0.9                           | 0.1                 | 2.4                     |
| HCP05 for C factor |                        | 5.3                  | 0.6                   | 1.5                           | 0.2                 | 3.8                     |

In the remaining variants, the indicators of the yield structure did not depend on the type of crop rotation, with the exception of the stooling coefficient, which was higher in the crop rotation. Tillage methods did not affect these indicators.

**Table 2.** The structure of the winter wheat yield depending on crop rotations, fertilizers and methods of basic land cultivation.

| Barnyard manure* | Mineral fertilizers, dose | Height of plants, cm | Length of a spike, cm | Number of grains in a spike, pcs | Stooling coefficient | Weight of 1000 grains, g. |
|------------------|--------------------------|----------------------|-----------------------|-------------------------------|---------------------|-------------------------|
|                  |                          |                      |                       |                               |                     |                         |
| **CROP ROTATION**|                          |                      |                       |                               |                     |                         |
|                  |                          |                      |                       |                               |                     |                         |
| Plowing          |                          |                      |                       |                               |                     |                         |
| 0                | 0                        | 67.2                 | 6.9                   | 33.1                          | 1.9                 | 47.9                    |
| 0                | 1 dose                   | 76.8                 | 7.3                   | 35.5                          | 2.0                 | 48.1                    |
| 40               | 1 dose                   | 78.9                 | 7.6                   | 35.6                          | 2.3                 | 48.3                    |
| Surface tillage |                          |                      |                       |                               |                     |                         |
| 0                | 0                        | 67.5                 | 6.9                   | 32.7                          | 1.8                 | 47.3                    |
| 0                | 1 dose                   | 74.1                 | 7.2                   | 35.6                          | 2.0                 | 47.9                    |
| 40               | 1 dose                   | 75.1                 | 7.3                   | 35.8                          | 2.1                 | 48.2                    |
| **GRAIN CROP ROTATION** |                      |                      |                       |                               |                     |                         |
|                  |                          |                      |                       |                               |                     |                         |
| Plowing          |                          |                      |                       |                               |                     |                         |
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When analyzing the structure of the yield of sugar beet, we took into account the ratio of the mass of tops to the mass of root crops (table 3). In the variants without fertilization, this indicator was higher in the crop rotation and did not depend on the methods of land cultivation. With the introduction of mineral fertilizers, an increase in the mass of sugar beet tops is observed by 0.3 - 0.5 in two crop rotations, and in a crop rotation, this ratio is higher compared to grain-tilled crops. According to the methods of soil cultivation in the crop rotation, this indicator is higher in plowing.

**Table 3.** The ratio of the sugar beet tops mass to the root crops mass.

| Barnyard manure, t/ha | Mineral, dose | Crop | Grain crop |
|-----------------------|--------------|------|------------|
|                       |              | plowing | surface | plowing | surface |
| 0                     | 0            | 0.7    | 0.7      | 0.6    | 0.6     |
| 0                     | 1 dose       | 1.2    | 1.0      | 1.0    | 1.0     |
| 40                    | 1 dose       | 1.2    | 1.2      | 1.2    | 1.2     |
| HCP05 for factors: A – 0.03; B – 0.1; C – 0.1 |

With the combined application of organic and mineral fertilizers, the ratio of the mass of sugar beet tops to the mass of root crops also increased, except for the option with plowing in a crop rotation. Crop rotations and methods of land cultivation in this case did not affect this ratio.

Of the agricultural practices that contribute to an increase in the sugar content of sugar beet root crops, deep soil cultivation, planting density, and fertilization have a special effect. With an excess of nitrogen fertilizer, the sugar content of root crops decreases by 0.5 - 0.7%, and phosphorus-potassium fertilizers increase the sugar content by 0.2 - 0.5%.

Our studies of barley quality indicate that the protein content in grain ranges from 8.6 to 10.5% (table 4). At the same time, the tendency of increase in the protein content during the application of fertilizers is clearly expressed. So, in the crop rotation with the introduction of mineral fertilizers, the amount of protein increased by 0.4 - 0.9% compared with the unfertilized option, and in grain-tilled crops - by 0.3 - 0.5%.

It should be noted that the protein content was higher in plowing compared to surface tillage, except for the unfertilized option in grain crop rotation. In addition, on options without fertilization for plowing and when applying mineral fertilizers for plowing, the amount of protein was higher in the crop rotation. In other cases, the protein content did not depend on the type of crop rotation.

As for the starch content in the grain of barley, there was a tendency to decrease its amount when fertilizing. So, on the organo-mineral fertilization system, the starch content decreased by 2.1 - 2.7% in the crop rotation and 0.7 - 1.8% in the grain crop rotation.

At the same time, there is a tendency for the starch content to increase with fine processing in comparison with plowing. In general, this advantage is 0.4 - 1.8% in crop rotation and 0.3 - 1.4% in grain crop rotation.
The technological qualities of winter wheat grain included protein and gluten content. Based on the studies carried out, the following features are observed: the protein content increases with the introduction of organo-mineral fertilizers. If in the options without fertilization the amount of protein was about 12.4% in the crop rotation and 11.4% in the grain crop rotation, then with the combined application of mineral and organic fertilizers, this indicator increased on average by 1.4% and 1.3%, respectively (table 5).

There is a noticeable advantage in the protein content of the crop rotation in comparison with grain crop rotation. In general, according to the experience in the crop rotation, its content is 0.9% higher than that of grain-tilled crops. It should be noted that the methods of land cultivation did not affect the change in the protein content.

According to the content of gluten in the grain of winter wheat, the following regularities are noted: with the introduction of organo-mineral fertilizers, the content of gluten increases with plowing, and with surface tillage, there is a tendency to increase this indicator, and the advantage of crop rotation in comparison with grain cultivation is also clearly expressed. On the options without fertilizers, the gluten content was higher for surface tillage, and on the remaining plots, the methods of soil cultivation did not affect the amount of gluten.

**Table 4.** Technological qualities of spring barley grain depending on crop rotations, fertilizers and methods of basic land cultivation.

| Barnyard manure*, t/ha | Mineral fertilizers, dose | Protein content, % | Starch content, % |
|------------------------|---------------------------|-------------------|-----------------|
|                        |                           | plowing           | Surface tillage |
|                        |                           |                   |                 |
| Crop rotation          |                           |                   |                 |
| 0                      | 0                         | 9.5               | 8.6             |
| 0                      | 1 dose                    | 10.4              | 9.0             |
| 40                     | 1 dose                    | 10.5              | 9.9             |
| Grain crop rotation    |                           |                   |                 |
| 0                      | 0                         | 9.0               | 8.6             |
| 0                      | 1 dose                    | 9.5               | 8.9             |
| 40                     | 1 dose                    | 10.4              | 9.6             |
| HCP05 for A factor     | 0.4                       | 2.3               |                 |
| HCP05 for B factor     | 0.5                       | 2.8               |                 |
| HCP05 for C factor     | 0.8                       | 4.4               |                 |

**Table 5.** Technological qualities of winter wheat grain, depending on crop rotations, fertilizers and methods of basic land cultivation.

| Barnyard manure*, t/ha | Mineral fertilizers, dose | Protein content | Starch content |
|------------------------|---------------------------|-----------------|---------------|
|                        |                           | plowing         | Surface tillage |
|                        |                           |                 |                |
| Crop rotation          |                           |                 |                |
| 0                      | 0                         | 12.4            | 12.3           |
| 0                      | 1 dose                    | 13.0            | 12.8           |
| 40                     | 1 dose                    | 13.9            | 13.5           |
| Grain crop rotation    |                           |                 |                |
| 0                      | 0                         | 11.4            | 11.4           |
| 0                      | 1 dose                    | 12.2            | 12.1           |
| 40                     | 1 dose                    | 12.7            | 12.6           |
| HCP05 for A factor     | 0.5                       | 0.9             | 0.9            |
| HCP05 for B factor     | 0.6                       | 1.1             |                |
| HCP05 for C factor     | 1.0                       | 1.7             |                |
The main indicator of the quality of sugar beets is the sugar content of root crops. As a result of our research, a tendency for a decrease in the sugar content of root crops during fertilization has been established.

So, in the crop rotation in the variant without fertilization, the sugar content was 17.0 - 17.5%. On the organo-mineral fertilization system, this indicator decreased by 0.7% and 0.8%, depending on the method of land cultivation. At the same time, the methods of land cultivation themselves and the types of crop rotations did not affect sugar content, with the exception of variants with an organomineral fertilization system for surface tillage, where the sugar content was higher in grain crop rotation (table 6).

**Table 6.** Technological qualities of sugar beet depending on crop rotations, methods of basic land cultivation and fertilizers.

| Barnyard manure*, t/ha | Mineral fertilizers, dose | Sugar degree, % | Sugar recovery, t/ha |
|------------------------|--------------------------|----------------|----------------------|
|                        |                          | plowing | Surface tillage | plowing | Surface tillage |
| Crop rotation          |                          |         |                |         |                |
| 0                      | 0                        | 17.5    | 17.0           | 4.4     | 4.0            |
| 0                      | 1 dose                   | 16.8    | 16.8           | 7.3     | 6.7            |
| 40                     | 1 dose                   | 16.8    | 16.2           | 8.3     | 7.4            |
| Grain crop rotation    |                          |         |                |         |                |
| 0                      | 0                        | 17.5    | 17.5           | 4.3     | 3.6            |
| 0                      | 1 dose                   | 17.0    | 17.2           | 6.9     | 6.2            |
| 40                     | 1 dose                   | 16.9    | 17.0           | 7.8     | 6.6            |
| HCP05 for A factor     | 0.7                      | 0.7     | 0.2            |
| HCP05 for B factor     | 0.8                      | 0.8     | 0.3            |
| HCP05 for C factor     | 1.4                      | 1.4     | 0.5            |

The sugar yield depended on the size of the yield and the sugar content of the root crops. It increased with the introduction of fertilizers, reaching 8.3 t / ha in the crop rotation, and 7.8 t / ha in grain crop rotation. It should be noted that the sugar yield was higher for plowing compared to surface tillage. So, in the crop rotation, the difference between treatments was 0.4 - 0.9 t / ha, and in grain crop rotation - 0.7 - 1.2 t / ha.

In general, according to the experience, the sugar yield was higher in the crop rotation in comparison with grain-tilled crops, with the exception of unfertilized plowing options.

4. **Conclusion**

The maximum increase in the indicators of the structure of the crop yield was recorded on the organo-mineral fertilization system.

With the cultivation of barley and winter wheat in a crop rotation, the quality of grain increases. When growing beets in a crop rotation, there is a tendency to a decrease in sugar content in comparison with grain crop rotation, while the sugar yield increases.

The organo-mineral fertilization system reduces the starch content in the grain of barley by an average of 2.4% in the crop rotation and 1.3% in the grain crop rotation compared to the control, and increases the protein content in the grain of winter wheat by an average of 1.4%. The sugar content of beets on the organo-mineral fertilization system decreases on average by 0.8%, while the sugar yield, on the contrary, increases. Land cultivation methods in most cases do not affect the technological qualities of crops.
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