The prospects for no-till in the cultivation of corn for grain

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Abstract. Low-fertile sod-podzolic soils of Chuvashia studied the influence of traditional, minimal and zero tillage on the yield and quality of corn grain. Traditional technology of maize cultivation for grain included disc discarding of stubble of spring wheat to a depth of 4–6 cm, peeling, dumping of plow for 20–22 cm, pre-sowing cultivation for 4–6 cm with simultaneous harrowing, sowing and packing. The system with minimal soil cultivation was based on autumn disking and stubble sinking to a depth of 6–10 cm, spring pre-sowing cultivation for 8–10 cm and sowing with the Amazone seed drill. At no-till processing in the autumn period, the herbicide was sprayed with a continuous Zero action and a direct sowing of maize by the Amazone complex in the spring. Research conducted on a highly efficient hybrid of the ROSS 199 MV universal direction showed the advantages of no-till of the ground before the minimal and traditional technologies. The coefficient of energy efficiency in this case was 2.11 (with the traditional - 2.02, with the minimum - 2.10), and the profitability level increased by 3.6 and 1.5% compared to traditional and minimal tillage. Biochemical analysis revealed that the corn grain at zero processing is not inferior in quality to the control variant. In all variants of the experiment, 1 kg of grain corresponded to 1.42 feed units and 13.01–13.05 MJ of exchange energy.

1. Introduction

The formation of stable high yields of crops with minimal labor and material resources, rational land use, preservation and reproduction of soil fertility today is the urgent task for resource-saving agriculture. In the Volga-Vyatka region, this problem is successfully solved by development of science-based adaptive-landscape agriculture and innovative technologies.

One of the fundamental factors of successful implementation of crop rotation – proper tillage adapted to the distinctive climatic conditions and cultivated crops [1–3].

Despite the uniformity of soil and climatic conditions of the Volga-Vyatka region, taking into account terrain and wooded areas, unfortunately, still many farms use mainly energy-intensive dump plowing with multiple passes of heavy equipment on the field during the pre-sowing treatment, which is often not justified neither from economic nor from the agronomic point of view. While to date, developed and scientifically substantiated by modern trends in the treatment prevailing in all the republics and oblasts of the chernozem, gray forest and sod-podzolic soils [4–7].

This is especially true of zero and minimum tillage under conventional (winter wheat and rye, spring wheat, barley, oats) crops, which is theoretically justified, based on the use of modern combined tillage units and have been successfully used in many agricultural enterprises [8–10].

The ambiguous assessment of soil cultivation in the scientific literature, as well as the lack of sufficient studies to evaluate the various methods of presowing tillage for sowing corn using combined
aggregates, necessitated additional studies in specific soil and climatic conditions, which determined the relevance of this work.

The purpose of our research is to study the effect of zero and minimum tillage on yield and grain quality of maize in agro-climatic conditions of the Volga-Vyatka region.

2. Experimental part

Experiments were carried out on sod-podzolic light loamy soils characterized by a low content of humus (1.95 %), a high concentration of mobile phosphorus (165 mg/kg) and an increased concentration of exchangeable potassium (137 mg/kg), a weakly acid reaction of the soil solution (6.4). Placing the variants was done by the method of randomized repetitions in a fourfold repetition. The area of the registered plot is 60 m².

The Volga-Vyatka region is characterized by a temperate continental climate with a long, cold winter and late, dry and cool spring. Summer is short, hot and humid, and autumn is cool, rainy and long.

The years of research (2016–2020) differed both in terms of heat availability and in the amount of precipitation, which made it possible to study the effect of the analyzed methods of processing sod-podzolic soil on the size of the crop and its quality.

Taking into account the market conditions, agroclimatic conditions and the regional aspect, the four-field crop rotation was as follows: clover – spring wheat – corn – potatoes.

The object of research is the hybrid ROSS 199 MV. The ROSS 199 MV is a complex, highly productive hybrid of the universal use direction. The grain is semicrystalline yellow. The cob is conical with a red stem. Has increased resistance to helminthosporium and fusarium, medium – to the bacteriosis of the ears, is susceptible to the papilloma.

The common technology for the Volga-Vyatka region for cultivating maize for grain included disking stubble of spring wheat to a depth of 4–6 cm with a harrow disk heavy BDT-6, peeling plowshare PLL–10–25, plowing PLN–4–35 at 20–22 cm, presowing cultivation of KPS–4 for 4–6 cm with simultaneous harrowing of BZSS-1.0, seeding with SZ-3.6 and packing of 3KKSH–6.

When testing the technology of maize cultivation with minimal soil cultivation, autumn disking and stubble plowing were carried out to a depth of 6–10 cm of BDM–6 and PLL–10–25, spring presowing cultivation for 8–10 cm with block-modular cultivator KBM-10.8 and seeding the Amazone seed drill.

In an option with no-till processing in the fall period, the Zero continuous herbicide was sprayed and the maize sown with the Amazone complex in the second decade of May. Regardless of the technology, the sowing was carried out according to the scheme of 70x30 cm with the consumption of conditional seeds of 25 kg/ha and the introduction of mineral fertilizers in a dose of N90P60K60.

The integrated system of crop protection from weed vegetation included 3–5-leaf spraying with a tank mix of Kalisto herbicides (0.2 l/ha) and Milagro (1.2 l/ha). Harvesting was carried out in the phase of full ripeness of maize in late September – early October.

Statistical processing of yield data was carried out according to B.A. Dospehov.

3. Results and considerations

Despite similar experimental conditions and simultaneous sowing of seeds at the control and despite the similar experimental conditions and simultaneous sowing, the first shoots appeared in the field with autumn plowing, which, apparently, is associated with a faster heating of the upper soil layer. After the emergence of mass shoots, the differences between the variants are insignificant, although outwardly the plots with traditional and minimal soil cultivation favorably differed from the site with direct sowing. The rows of maize plants were distinctly distinguished in the first two cases, whereas on the field without preliminary preparation of the soil, it was difficult to distinguish between shoots of a cultivated species due to a continuous carpet of weeds. Only after chemical weeding 9–12 days
later did the rows of pale green corn plants appear among this yellowed weed, which subsequently did not differ much from the cultivated plants on two other experimental plots.

The first measurements of the height of maize plants and the counting of the number of leaves on them also showed the advantages of traditional tillage. This can be explained by a certain delay in growth in other variants due to the reduction of the area of nutrition of the cultural species in competition with the weed component of the agrocenosis. But as soon as the corn has outgrown the weeds, the method of tillage has ceased to have any significance for its growth and development.

Subsequent measurements of linear parameters of vegetative maize plants showed no apparent differences between the control and trial variants and by the end of the vegetation the above-ground part of almost all analyzed plants was characterized by the same growth and biomass.

Possessing a high growth rate, the hybrid ROSS 199 MV by the beginning of August managed to form a 1-2 ear of maize of milk ripeness. On average, 4 productive maize plants were formed at the end of vegetation per 1 m² (table 1).

**Table 1.** Economic indicators of cultivation of maize for grain with various methods of soil cultivation.

| Options          | Average number of cobs 1 plant, pcs. | Average number of plants, pcs/m² | Weight 1000 grains, g | The average number of grains in 1 ears, pcs. | Productivity, t/ha | Coefficient of energy efficiency | Level of profitability, % |
|------------------|--------------------------------------|----------------------------------|-----------------------|---------------------------------------------|-------------------|-------------------------------|--------------------------|
| Traditional technology | 1.7                                  | 4                               | 115.5                 | 336                                         | 2.64              | 2.02                          | 18.4                     |
| Mini-till        | 1.7                                  | 4                               | 114.1                 | 330                                         | 2.56              | 2.10                          | 20.5                     |
| No-till          | 1.7                                  | 4                               | 109.8                 | 328                                         | 2.45              | 2.11                          | 22.0                     |
| HCP05            |                                      |                                 |                       | 0.06                                        |                   |                               |                          |

On average, the maximum in the collection of corn grain (2.64 t/ha) was noted in the maize cultivation variant according to conventional technology, the minimum (2.45 t/ha) with no-tillage. The variant with minimal soil treatment was inferior to the maximum value of 0.08 t/ha or 3.0%, but exceeded the minimum by 0.11 t/ha or 4.3. In general, over the years of research, the yield in the control was higher than in the variants with minimal and zero tillage, by 2.8–3.2 and 7.5–7.9 %, respectively. This is explained by the formation of a larger number of grains in the cob and their high mass of 1000 grains relative to the other two analogous analyzed variants.

Favorable during this period, the weather conditions characteristic of the Volga-Vyatka region, allowed to accumulate a sufficient number of nutrients to create a full-fledged corn crop (table 2).

However, in terms of economic and energy efficiency in the cultivation of maize for grain on sod-podzolic soils of the Volga-Vyatka region, it is more preferable to use zero tillage. In this variant, the maximum (2.11) values of the energy efficiency coefficient and the level of profitability (22.0%) were obtained, which were higher than those of the energy efficiency factor when using minimal tillage and plowing by 0.01 and 0.09, and indicators of the level of profitability of the same options - by 1.5 and 3.6% respectively.

The determination of qualitative indicators made it possible to reveal that the corn grain obtained with the minimal soil treatment contained the largest amount of crude (9.06%) and digestible (64.33 g/kg) protein. The least quantity of these nutrient components in the grains was noted on the variant with zero tillage – 8.63% and 61.27 g/kg, respectively. The use of traditional soil cultivation contributed to the average accumulation of raw and digestible protein in corn grain. A similar pattern was also observed with respect to the accumulation of nitrogen-free extractives (NFE).
On the contrary, the maximum (3.14%) amount of raw fiber was formed on a variant with traditional plowing, and the minimum (2.87%) - on a variant with minimal tillage.

With regard to the content of raw fat and raw ash, their highest concentrations were revealed by us on a variant with traditional soil treatment, and the smallest - on a variant with zero tillage. The use of minimal processing contributed to a smaller (by 0.30 and 0.23% respectively) accumulation of these elements compared to plowing and slightly larger (by 0.06 and 0.08% respectively) than on the zero-tillage version.

The content of nitrates for all variants of the experiment was significantly lower than the maximum allowable concentrations for crop production.

| Options                | Contained in grain |
|------------------------|--------------------|
|                        | Crude protein, % GOST 13496.4 | Raw fiber, % GOST 13496.2 | Crude fat, % GOST 13496.15 | Crude ashes, % GOST 26226 | NFE, % | Nitrates, mg/kg | Feed units, kg/kg | Exchange energy, MWA/kg | Digestible protein, g/kg |
| Traditional technology | 8.95               | 3.14               | 3.62               | 1.74               | 73.87 | 22           | 1.42               | 13.05               | 63.55               |
| Mini-till              | 9.06               | 2.87               | 3.32               | 1.51               | 74.37 | 21           | 1.42               | 13.02               | 64.33               |
| No-till                | 8.63               | 3.11               | 3.26               | 1.43               | 73.67 | 19           | 1.42               | 13.01               | 61.27               |

Thus, the results of biochemical analysis indicated that soil treatment technologies do not have a significant effect on the nutritional and energy value of corn grain, allowing to obtain products in which 1 kg of grain contains 1.42 feed units and 13.01-13.05 MJ of exchange energy.

4. Summary
The temperature conditions of the Volga-Vyatka region, the warming of the soil in the spring months, the moisture content, the fertility level of sod-podzolic soils, the selection of a hybrid, the rotation and the cultivation technology, fully meet the requirements necessary for corn to guarantee maturation and obtain a stable yield of quality grain.

No-till cultivation of the soil when growing maize for grain in the agro landscapes of the Volga-Vyatka region exceeds the minimum and traditional energy efficiency coefficient and the profitability level, not inferior at the same time to the qualitative characteristics of marketable grain.

Acknowledgments
The reported study was funded by RFBR, project number 20-016-00078.

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