Economics of spring wheat production in the Middle Volga

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Abstract. In order to identify the economic and energetic efficiency of the applied agricultural technologies of spring soft wheat by productivity in the conditions of the Middle Volga region, the influence of the main tillage methods was studied: plowing at 20-22 cm, loosening at 10-12 cm and without autumn mechanical processing, on yield, protein content and gluten fractions in wheat grain obtained without fertilizer and on the background of fertilizer application when sowing in N60P60K6 dose. On average, over the years of research, the yield of spring wheat for plowing and loosening the soil with the use of fertilizers was higher compared with the variant without autumn mechanical tillage. The content of protein in the grain with the application of fertilizers increased by 5.2-5.8% in comparison with the uncomfortable background. The protein content was maximum for plowing - 13.26%, medium - when loosening - 12.66%, and what was higher by 6 and 2%, respectively, with the option without autumn mechanical tillage. At the same time, the amount of gluten fractions was also the highest in plowing - 8.70% and loosening - 8.01%. Calculations of economic and energy efficiency showed that with loosening of the soil and without its autumn mechanical tillage. At the same time, the amount of gluten fractions was also the highest in plowing - 8.70% and loosening - 8.01%. Calculations of economic and energy efficiency showed that with loosening of the soil and without its autumn mechanical tillage, profitability was the highest, 79 and 75% respectively against the background without fertilizer and 70% with fertilizer. The most energy-efficient option has been without autumn mechanical tillage with the use of fertilizers. The highest energy effect of spring wheat cultivation is confirmed by the lowest coefficient of protein intensity, equal to 5.96.

1. Introduction
The main problem of agriculture at the present stage is the search for ways to increase grain production with guaranteed quality, taking into account its energy and economic status [1-2]. Research should be directed to the development of such techniques and tillage systems that would help preserve soil fertility, create optimal conditions for the growth and development of plants that provide high yields and high quality crops [2-4]. Currently, new cultivation technologies for grain crops are becoming more common, based on the use of minimal tillage [5-10].

The purpose of the research is to identify the economic and energy efficiency of applied agricultural technologies of spring wheat by the productivity factor in the conditions of the Middle Volga.

2. Materials and research methods
The studies were conducted in the fields of the Department of Agriculture and “Agroecology” laboratory of Samara State Agrarian University. We studied the effect of basic tillage methods and fertilizer on yield, protein accumulation, gluten fractions in the grain of spring soft wheat, economic and energy efficiency. The predecessor in the experiments was winter wheat for a clean pair. Variants of the experiment included three types of primary tillage: plowing to a depth of 20-22 cm; loosening to a depth of 10-12 cm; without autumn mechanical treatment, without fertilizers and against the background of...
use when sowing N60P60K60 at the rate of 3.8 c of azofoska per 1 ha. Crops were treated with herbicides in the tillering stage - Puma super at a concentration of 0.8 l/ha. The area of the plots was 1200 m². The repetition of experiments was threefold.

The relief of the experimental field was levelled, the afforestation of the surrounding territory was 8-10%. The soil of the experimental plot was a typical medium humus medium heavy loamy chernozem with a medium response (pH) close to the neutral and average humus content.

The meteorological conditions during the years of research were contrasting and were noted both as relatively favourable and extremely unfavourable for the growth and development of plants of spring soft wheat. Over the years of research, the hydrothermal coefficient (HTC) ranged from 0.42 to 1.20 with an average multi-year value of 0.83. At the beginning of the research, the HTC for the period from sowing to harvesting was 0.90; in the second year, the HTC was lower than the average multiyear values by 0.42. The third agricultural year was characterized by increased temperature and heavy rains, HTC was 1.20, during the fourth year HTC was 0.68.

Accounting of the harvest was carried out by continuous harvesting of the plots with a combine and the harvest led to 14% moisture and basic conditions for the content of trash. The selection of plants for analysis was carried out according to the method proposed by A.I. Ermakov, the isolation of protein fractions of wheat by the method of H.N. Pochinok based on the unequal solubility of proteins in various solvents [11]. The colorimetric method was used to determine protein content and fractions by the method of G. A. Kochetov [12-13]. The experimental data were processed by the analysis of variance according to B. A. Dospekhov (1985) using the STATISTICA program [14]. Calculations of economic and energy indicators were carried out on the basis of technological charts according to the methodological guidelines [15].

3. Research results and discussions

Integrating indicator of the influence of the main tillage method influence and fertilizer in most cases is the yield, protein content and its fractional composition in the grain of the cultivated crop [16-18].

The structure of the harvest is represented by the number of productive plants per unit of area, the length of the ear and the number of grains in it, as well as a mass of 1000 grains. Taking into consideration the number of plants per 1 m² of crops during the harvest period, it was shown that in unfertilized test options the number of plants reached 340, fertilized - 370 pcs. The greatest number of plants is noted for plowing at 20-22 cm, depending on the application of fertilizers. The length of the ear did not differ significantly and ranged from 5.8 to 6.3 mm. The largest number of grains per ear was obtained during plowing against the background of fertilizer application - 19.4 pcs. It should also be noted that the smallest number of grains per ear was obtained using the variant without autumn mechanical tillage both without and with fertilizer (table 1).

The yield of spring soft wheat grain on the variants without fertilizers was the highest in plowing and loosening the soil of up to 1.36 t/ha. At the same time, the protein content in the grain was higher in plowing, by 4.4% compared with loosening the soil and by 5.5% of the variant without autumn mechanical processing.

The maximum protein content in the grain was contributed by the greatest accumulation of gluten fractions. Their amount reached 8.0 mg/kg. Gluten fraction is a compound protein complex which includes two fractions - gliadin (prolamin) and glutelin. This complex is a cohesive elastic mass that is formed during swelling in water and is of great importance in breadmaking. Therefore, the quality of the baked bread will depend on the amount of these fractions [19-21].

Fertilization in a dose of N60P60K60 gave the highest reliable yield increases by 15.0-26.5%, and also increased the protein content of spring soft wheat grain by 5.8%, the amount of gluten fractions - by 8.8%. Moreover, the values of these indicators were maximum for plowing, and for yield they were maximum for plowing and loosening the soil.
Table 1. The average over the years of research productivity of spring wheat, depending on the methods of the main tillage and fertilizers.

| Tillage                      | Fertilizers   | Total amount of plants, un/m² | Ear length, mm | Number of grains in the ear, un. | Yield, t/ha | Protein, % | Σ of gluten fractions | Total protein |
|------------------------------|---------------|-------------------------------|----------------|----------------------------------|-------------|------------|-----------------------|--------------|
| Plowing at 20–22 cm without | N₀₆P₀₆K₀₆₀     | 344                           | 6.3            | 19.0                             | 1.36        | 8.00       | 12.48                 |
| Loosening at 10–12 cm without| N₀₆P₀₆K₀₆₀     | 374                           | 6.3            | 19.4                             | 1.60        | 8.70       | 13.26                 |
| Without autumn machining    | N₀₆P₀₆K₀₆₀     | 331                           | 6.0            | 18.2                             | 1.34        | 7.30       | 11.93                 |
|                              | N₀₆P₀₆K₀₆₀     | 368                           | 6.2            | 18.9                             | 1.60        | 8.01       | 12.66                 |
|                              | N₀₆P₀₆K₀₆₀     | 336                           | 5.6            | 15.8                             | 1.14        | 7.21       | 11.79                 |
Thus, on average over the years of research, the main tillage — plowing at 20–22 cm with fertilizer applied at a dose of N₀₆P₀₆K₀₆₀ during sowing contributed to the best indicators of crop structure elements and the highest yield of spring soft wheat - 1.60 t/ha; grain to 13.26% and the amount of protein fractions - 8.70%.

Calculations of economic efficiency showed that in the cultivation of spring soft wheat, the maximum production costs are obtained with the use of 20–22 cm plowing as the main tillage, while the average - when loosening the soil by 10–12 cm, and the minimum - without autumn mechanical tillage. Fertilization contributed to the yield increase and an increase in the protein content of wheat grain, as a result of which the cost of the main production increased. Large production costs, despite the high yield, reflected on the cost of grain. At the same time, the lowest cost price of 1 ton of spring wheat grain and the highest net income per 1 ha were obtained when using the variant without autumn mechanical tillage. Profitability at the level of 79% showed options - loosening and without autumn mechanical tillage. On the background of fertilizer application, production costs increased, and the level of profitability decreased by plowing and loosening the soil to 12%, and by 5% without autumn mechanical tillage (table 2).

Table 2. Profitability (%) and energy efficiency ratios of spring soft wheat cultivation, depending on the main tillage and fertilizers (on average over the years of research).

| Tillage                      | Fertilizers   | Profitability, % | Energy efficiency ratio in the harvest | Energy intensity factor in protein |
|------------------------------|---------------|------------------|----------------------------------------|----------------------------------|
| Plowing at 20–22 cm without | N₀₆P₀₆K₀₆₀     | 61.44            | 1.16                                   | 6.90                             |
|                              | N₀₆P₀₆K₀₆₀     | 53.96            | 1.13                                   | 6.69                             |
| Loosening at 10–12 cm without| N₀₆P₀₆K₀₆₀     | 78.90            | 1.20                                   | 6.98                             |
|                              | N₀₆P₀₆K₀₆₀     | 70.00            | 1.19                                   | 6.63                             |
| Without autumn machining     | N₀₆P₀₆K₀₆₀     | 74.50            | 1.11                                   | 7.09                             |
|                              | N₀₆P₀₆K₀₆₀     | 70.48            | 1.35                                   | 5.96                             |
Thus, such relative indicator of economic efficiency as profitability was the most profitable in the cultivation of spring wheat in the following options: loosening by 10–12 cm and without autumn mechanical tillage, which contributed to the reduction of labour costs, cash and other resources.
The energy efficiency of spring wheat cultivation showed a positive balance of energy consumption. It means that the resulting product included more energy than was spent on its production (table 3).

**Table 3.** Energy efficiency of spring wheat cultivation, depending on the main tillage and fertilizer (on average over the years of research).

| Tillage                  | Fertilizers | Energy accumulated, thousand MJ/ha in the harvest | Anthropogenic energy costs, thousand MJ/ha in protein | Gain energy in the harvest, thousand MJ/ha | Energy cost, thousand MJ/t в урожае | в белке |
|--------------------------|-------------|---------------------------------------------------|------------------------------------------------------|------------------------------------------|-----------------------------------|--------|
| Plowing at 20-22 cm      | N₀P₀K₀₀₀    | 17.92                                             | 2.24                                                 | 15.45                                    | 2.47                              | 11.36  | 123.60 |
|                          | without     |                                                    |                                                      |                                          |                                    |        |        |
|                          | N₀₀P₀₀K₀₀₀  | 21.09                                             | 2.80                                                 | 18.74                                    | 2.35                              | 11.71  | 140.90 |
| Loosening at 10-12 cm    | N₀₀P₀₀K₀₀₀  | 17.66                                             | 2.10                                                 | 14.66                                    | 3.00                              | 10.94  | 123.19 |
|                          | without     |                                                    |                                                      |                                          |                                    |        |        |
|                          | N₀₀P₀₀K₀₀₀  | 21.09                                             | 2.68                                                 | 17.76                                    | 3.33                              | 11.10  | 139.84 |
| Without autumn machining | N₀₀P₀₀K₀₀₀  | 15.03                                             | 1.77                                                 | 13.55                                    | 1.48                              | 11.89  | 114.83 |
|                          | without     |                                                    |                                                      |                                          |                                    |        |        |
|                          | N₀₀P₀₀K₀₀₀  | 20.43                                             | 2.53                                                 | 15.08                                    | 5.35                              | 9.73   | 121.61 |

In our studies, on the background without fertilizer plowing by 20-22 cm, anthropogenic energy of 15.45 thousand MJ per 1 hectare was expended, and during soil loosening, energy was 14.66 thousand MJ/ha, and without autumn mechanical processing - 13.55 thousand MJ/ha. Fertilization led to an increase in the cost of all tillage technologies, taking into account the harvest by 3 thousand MJ/ha when plowing and loosening and by 1.5 thousand MJ/ha without autumn mechanical tillage. The maximum increase in energy in the crop at the level of 5.35 thousand MJ/ha was provided in the variant without autumn mechanical tillage against the background of fertilizer in a dose of N₀₀P₀₀K₀₀₀, while the energy cost of grain in the crop and protein was the lowest.

The coefficient of energy efficiency in the crop for all variants of the experiment was obtained above zero, and then the studied technologies of spring wheat cultivation can be considered energy efficient (table 2). At the same time, this coefficient decreased in the plowing options of 20-22 cm with and without fertilizer, while loosening the soil by 10-12 cm was at the level of 1.20 cm.

The variant without autumn mechanical tillage using mineral fertilizers proved to be the most energy efficient, the energy efficiency ratio in the crop was the highest - 1.35, and the energy intensity coefficient in the protein was the smallest - 5.96.

4. Conclusions

On average over the years of research, the highest yield of spring soft wheat (1.60 t/ha) was obtained by plowing 20-22 cm and loosening the soil by 10-12 cm amid the application of mineral fertilizers when sowing N₀₀P₀₀K₀₀₀ at the rate of 3.8 c of azofoska per 1 ha. The protein content in the grain of wheat on the background of fertilizer increased to 6% in comparison with the uncomfortable background. Protein values were maximum for plowing - 13.26%, medium - when loosen the soil - 12.66%, the lowest without autumn mechanical tillage - by 6 and 2%, respectively. At the same time, the amount of gluten fractions was highest on plowing - up to 9% and loosening - 8%.

According to the calculations of economic and energy efficiency in the conditions of the Middle Volga region, using as the main tillage for spring wheat - loosening by 10-12 cm and without autumn mechanical tillage, profitability was higher at the level of respectively 79% and 75% against the background without fertilizer and up to 71% amid the introduction of N₀₀P₀₀K₀₀₀. The most energy-efficient option was shown to be a variant without autumn mechanical tillage with mineral fertilizers, moreover, the coefficient of energy efficiency in the crop was the highest, with the lowest energy-intensity coefficient in the protein.
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