Comparative evaluation of different machines for seedbed for sorghum

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Abstract. The purpose of research - selection of the optimal composition of agricultural equipment for seedbed preparation for sweet sorghum. Identified and disclosed to the essential characteristics of technology. Thus, innovation in relation to agribusiness - is a new technology, new equipment, new plant varieties, new fertilizers and plant protection products. A special place is occupied by technical-technological and production innovations. In order to optimize the total cost in the cultivation of sorghum it is recommended to review the composition of sowing complexes, in order to optimize the timing of sowing, as well as reducing the complexity of the implementation.

At the present stage of development of agrarian and industrial complex is carried out at an accelerated pace modernization of agriculture. From year to year improved tillage, there are various power-saving technologies of cultivation of crops. At the same time, the RF energy supply (in hp 100 hectares of crops) tends to decrease as well as decreased in comparison with the year 2014 by 1.9%, compared to 2010 in 2015, energy supply - by 13.2%. Similar rates of decline remain and the Republic of Tatarstan: 1.8% in 2014 and by 11.9% compared to 2010. At the same time arable land accounts for 3.3 tractors per 1,000 hectares of grain crops, two combine harvesters and 100 tractors only 5 sowing complexes. At the same time the rate of renewal of agricultural machinery low. In 2015, the rate of renovation of tractors amounted to 3% to the presence at the end of the year, combine harvesters - 5.3%, sowing complexes - 7.2%, while the elimination of factors were as follows: for tractors - 4.6%, grain harvesters - 5.9% and sowing complexes - 2.3%.

In general, in Russia the share of the main types of equipment in operation for more than 10 years is as follows: 60% of tractors, combine harvesters by 45%. Against the backdrop of these trends, the share of imported machinery in Russian agriculture: tractors - more than 65% of combine harvesters - more than 20%, with high productivity.

With the increase in supply of agricultural machinery to grow and the cost of its purchase, use and maintenance. In this regard, an evaluation of the economic efficiency of individual machines or units and tractor fleet as a whole for managing integrated units. Determination of the effectiveness of techniques used in the cultivation of crops in terms of value is currently difficult because of the constant fluctuations in the prices of equipment, fertilizers, fuel and lubricants, and others. Therefore, it is advisable to evaluate the efficiency of machines and tractors park based on innovative
technologies in energy costs. The total energy used in the cultivation of the crop, characterizes the effectiveness of a product obtained, and cultivation techniques.

For the production of agricultural products in plant are used as a classical technique and technology with minimum or zero tillage. Technology of cultivation of agricultural crops, including sweet sorghum should be based on a holistic, systemic approach, aimed at obtaining the final results.

Application of these technologies allows for reducing the number of passes of units on the field as a result of combination and with wide machines, which reduces soil compaction, and to reduce labor costs by reducing the volume of process operations or multiple operations in a single pass machine optimization system and the composition of machine, and and staff, reduce the cost of fuel and lubricants and the timing of field work\[7,8,9,10,11,12\].

Practice shows that the mechanical mixing of different technologies or the use of foreign, with limited use of means of intensification, does not ensure the achievement of goals, on the contrary leads to soil compaction, weed crops and others \[13,14,15,16\].

Combined machines appeared at the turn of 1970-80-ies. The pioneer in this direction was the company John Deere. The first machines that combine the functions of tillage and sowing, appeared in the 1980-s. They consisted of two or more guns. By 1990 combined machines for soil cultivation and sowing began to rapidly gain popularity. In 1993 another manufacturer Kverneland Group (Norway) suggested that the combined units, representing a harrow in combination with a grain drill, it was one whole machine. In the Republic of Tatarstan modular machines began producing 90-ies of the last century \[1\].

Improved combined machines in the modern sense began to produce of 2005-2007. In the market of tillage and seeding equipment began to appear combo units providing seed crop at the minimum and zero tillage \[2\].

Under the sweet sorghum is relatively new culture for the farmers of the Republic of Tatarstan, has not yet been tested and is not recommended resource techniques seedbed. Therefore, on the basis of the foregoing, we have the 2013 field trials and laboratory tests with a set of tillers were established and carried out. The test results are given below \[3,4,5\].

Maximum yield 44,1 t/ha of sorghum on the average for three years received during seedbed combination unit CBM-10.5 (tab. 1). The increase in control was 11,3 t/ha. Low yields of 28,2 t/ha of sorghum obtained by preplant tillage unit VNIISS-P.

Table 1 - Yields of sorghum depending on seedbed preparation, t/ha

| Unit     | Years | The average for 2013-2015 | Increase (+, -), t/ha |
|----------|-------|---------------------------|-----------------------|
|          | 2013  | 2014 | 2015 | 2013-2015 | |
| CPS-4    | 33,6  | 30,3 | 34,4 | 32,8     | –              |
| CBM-10.5 | 44,7  | 42,1 | 45,4 | 44,1     | 11,3           |
| VNIISS-P | 30,1  | 26,6 | 28,1 | 28,2     | 4,5            |
| CPG-4    | 33,4  | 31,8 | 32,6 | 32,6     | -0,2           |

Using cultivator CPS-4 for the treatment of the soil allowed to collect 32,8 tons of green matter per 1 hectare. The highest yield of 45,4 t/ha of sorghum produced in 2015 during the preplant soil unit CBM-10.5, the lowest - in 2014. Studied techniques seedbed preparation had an impact on the nutritional value of green mass of sorghum (tab. 2).

Table 2 - Charges feed units, protein and protein supply of forage sorghum units for 2013-2015.

| Unit     | Charges feed units, kg/ha | Collection protein, kg/ha | Availability of 1 kg of feed. u protein, g |
|----------|---------------------------|---------------------------|-------------------------------------------|
|          | years | average over |                  |                                           |

2
The largest collection of 8593 kg of fodder units per hectare obtained by the treatment of the soil combined unit СВМ-10.5. Slightly inferior to this embodiment tillage cultivators CPS-4 and СPG-4, which is collected from one hectare respectively 6402 and 6357 kg of fodder units. The lowest collecting fodder units 5512 kg/ha was obtained when tillage harrow VNIISS-P.

The basis for calculating the evaluation of economic efficiency of crop cultivation technologies is operating costs. In the developed economic and mathematical model as an objective function is selected criteria specific minimum amount of reduced costs for the j-th unit performs the i-th operation:

$$Z_{ji} = \{[ (K_{Mj} \times SM_{ji} + KP_{ji} \times SP_{ji} ) \times W_{ji} ] + TCM_{ji} \times P_{ji} + [ CV_{i} (QTR_{j} + QKR_{j} ) / GN_{j} ] + \sum_{i=1}^{N} CV_{i} \} \times T_{i} \times L_{i},$$

where $N$ - set of agricultural machinery belonging to the j-th unit performs the i-th operation;

$K_{Mj}$, $KP_{ji}$ - the number of machine and auxiliary workers the j-th unit performs the i-th job, people;

$SM_{ji}$, $SP_{ji}$ - hourly rate mechanic and auxiliary workers the j-th unit performs the i-th operation, rub/h.;

$W_{ji}$ - hour performance of the j-th unit performs the i-th job, ha/h.;

$TCM_{ji}$ - consumption of fuels and lubricants j-th unit in the performance of the i-th operation, l;

$P_{ji}$ - the price of fuel and lubricants used by j-th unit in the performance of the i-th operation, ths. rub.;

$[CV_{i}$, $CV_{1}$ - the carrying amount of the j-th energomashiny and l-th agricultural machines, ths. rub.;

$QTR_{j}$, $QTR_{l}$ - cost ratios respectively for the current repairs and maintenance energomashiny j-th and l-th of agricultural machines;

$QKR_{j}$, $QKR_{l}$ - respectively the coefficients of the cost of major repairs of the j-th energomashiny and j-th of agricultural machines;

$GN_{j}$, $GN_{l}$ - respectively annual load energomashiny j-th and l-th agricultural machines, h.;

$KOM_{iji}$ - the number of agricultural machines l-th type of make up with the j-th energomashiny when the i-th operation, pcs;

$T_{i}$ - the number of hours in a change in the performance of the i-th operation, h.;

$L_{i}$ - shift factor in the performance of the i-th operation.

Data for economic efficiency are shown in table 3.

### Table 3 - Economic efficiency of cultivation of sorghum green mass

| Unit       | Yield of green mass, t/ha | Gross output value, rub. | The cost of 1 hectare, rub. | The net income from 1 hectare, rub. | The level of profitability, % | The cost price of 1 ton of green mass, rub. |
|------------|--------------------------|--------------------------|-----------------------------|-----------------------------------|------------------------------|-----------------------------------------|
| CPS-4      | 32.8                     | 4002                     | 2886                        | 1116                              | 38.7                         | 88.0                                    |
| CBM-10.5   | 44.1                     | 5380                     | 3085                        | 2295                              | 74.4                         | 70.0                                    |
| VNIISS-P   | 28.3                     | 3452                     | 2862                        | 590                               | 20.6                         | 101,1                                   |
The greatest experience in the net income of 2295 rub/ha and the lowest cost per 1 ton of green mass of sweet sorghum to 70 rub/t obtained in the processing of the soil combined unit CBM-10.5.

The lowest in the experience of the net income and the highest production cost was during harrows VNIISS P seedbed preparation and amounted to 590 rub/ha and 101.1 rub/t.

The results of the energy evaluation are shown in table 4. The greatest experience in the energy efficiency ratio of 7.2 and a coefficient of bioenergy potential agro-ecosystems 8.1 sweet sorghum produced in the processing of the soil combined unit CBM-10.5. The lowest ratio of 4.4 energy efficiency obtained in the form seedbed preparation undertaken harrows VNIISS-P. When processing cultivators CPS-4 and CPG-4 energy efficiency ratio was 5.0.

Table 4 - Energy efficiency preplant soil at cultivation of sorghum

| Unit     | Yield of green mass, t/ha | Energy savings, GJ/ha | It took power, GJ/ha | Energy efficiency ratio | BEP agro-ecosystems |
|----------|---------------------------|-----------------------|---------------------|------------------------|---------------------|
| CPS-4    | 32.8                      | 151.53                | 30.23               | 5.0                    | 1.9                 |
| CBM-10.5 | 44.1                      | 209.75                | 29.18               | 7.2                    | 8.1                 |
| VNIISS-P | 28.3                      | 129.82                | 29.43               | 4.4                    | 1.3                 |
| CPG-4    | 32.6                      | 150.61                | 30.25               | 5.0                    | 1.9                 |

The energy remaining in the plant residues sweet sorghum was determined on the basis of the linear regression equation derived AM Lykov [6]:

\[ Y = 0.1 X + 6.27. \]

And it was on the options accordingly:

\[ Y = 0.1 * 32800 + 6.27 = 3286.27 \]
\[ Y = 0.1 * 44100 + 6.27 = 4416.27 \]
\[ Y = 0.1 * 28300 + 6.27 = 2836.27 \]
\[ Y = 0.1 * 32600 + 6.27 = 3266.27 \]

Analysis of the data of the equation shows that the greatest amount of energy in the plant remains in the version 4416.27 was seedbed preparation, held a combined unit CBM-10.5.

As a result, the comparative evaluation seedbed treatment options, it was found that the low surface evenness and great lumpy 6.0 pcs./m² were present in the form of tillage cultivators harrows VNIISS-P. Maximum yields of sorghum 44.1 t/ha on average for three years received during the pre-treatment of the soil combined unit CBM-10.5, to control growth was 11.3 t/ha. On average over three years of research the largest collection of fodder units produced during seedbed combination unit CBM-10.5. This option proved to be a cost and energy efficient.

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