Technological development in maize cultivation

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Abstract. With limited financial, material and labour resources, agricultural production has to optimize technology solutions for important crop cultivation. "Green" economy current trends recommend using soil treatment and crop tending technologies that are able to minimize doses of organic and mineral fertilizers applied, to reduce the degree to which plants have been treated with chemicals. This will generally improve the environmental safety of farming. Maize is one of the most important raw materials for animal feed, in varying degrees of cob ripeness it is used as green feed, harvested as silage or as mature grain. An affordable way of livestock product cost reduction is to save on direct production costs. It has been proposed to improve the maize cultivation technology under the specific farm conditions in the Nonchernozem belt of Russia, through replacing mechanic means, combining several operations in one run and substituting fertilizers in a rational way. It has been proposed to replace tractors MTZ-82.1 and K744R1 with more productive and economical New Holland T8.390 and New Holland T4 F. Ploughing can be performed with simultaneous application of complex fertilizers (diasophoska) and disc ploughing. The Vaderstad TopDown 900 is offered as a seedbed maker. The Challenger CH9824 seed planter has been replaced with the John Deere DB37, which provides simultaneous fertilizer application. The picker Acros 595 has been replaced with the more efficient and economical John Deere X9. Original pesticides have also been replaced with cheaper counterparts. As a result of the technological development, direct costs were reduced by 9.6%.

1 Introduction

In dairy cattle-breeding, increasing animal productivity while decreasing the costs of final products have always been topical issues, and in crop production, a special role is assigned to the environmental safety of crop cultivation in the "green" economy. The proposed article is an example of a simultaneous solution to both important agricultural problems.

Mechanised work accounts for the largest share (up to 70%) in the direct costs of growing crops. In particular, when growing maize for silage or grain 62 % is spent on the operating costs of the mechanic means used for soil preparation and secondary tillage,

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herbicide and other seedbed treatment as well as for harvesting. Operating costs include labour costs (operators, drivers), fuel, maintenance and repair expenses [1].

Maize grain is the second most nutritious grain after the spiked crops grain (wheat, oats). Over the next 5-6 years a growth in maize planting area is forecast by 15-20%. Over the past 10 years, direct production costs for growing this feed crop have increased significantly leading to the final product cost increase (cattle meat and milk) [2]. At the same time, farm machinery is ageing and needs to be replaced with new machines. This context leads to the search for alternative maize cultivation technologies, replacing worn-out mechanic means with more advanced high-performance brands [1].

There are several soil preparation and secondary tillage technologies employed in growing maize for silage or grain in the Nonchernozem belt of the Russian Federation: fall tillage and nitrogen fertilizer application with diammophoska combine drilling, root fertilizer solution application following seedlings [3]. Technologies have their very own organizational, technical and agronomic features, and, most importantly for production, there are different economic results.

ZAO "Sovkhoz named after Lenin" is a multidisciplinary agricultural enterprise, which in addition to dairy cattle breeding, specializes in the cultivation of forage crops, roots, vegetables and berries. In 2021, compared to 2018, the profitability of homegrown feed crops decreased by 8 percentage points and amounted to 9.2%. The analysis results of the maize cultivation efficiency determined the relevance of the research topic.

The purpose of the study is to substantiate technological development in maize cultivation for grain, which allows significant reducing labour costs per unit, reducing farm production inputs and the cost of potatoes.

Improvement in feed production efficiency is based on optimising fodder cropping carried out due to enhancing farm produced fodder supply with autonomous feed preparation. This makes it possible to provide dairy herds with more nutritious homegrown fodder, thereby realizing the genetic potential of animal productivity, reducing feed costs and thereby increasing animal husbandry profitability. [4].

The objectives of the research are:

- To identify the replacement of the mechanic means used at certain processing steps of maize cultivation.
- To carry out a comparative evaluation of some alternative ways to apply fertilizers.
- To quantify direct production cost savings for the products.

A major production increase requires of many enterprises to introduce innovative machinery, which would help to carry out technological processes in the field faster and more efficiently. However, new technologies can lead to higher unit costs and higher production costs. Our task is to adopt a solution that will reduce the production cost taking into account environmental factors when applying fertilizers and chemical inputs [5].

2 Materials and methods

There are several processing methods of soil preparation, secondary tillage and crop tending in the domestic crop production that take into account soil consistency properties, crop characteristics, the preceding crop, the types and brands of machinery used [6]. In addition, the need to replace worn-out mechanic means with more advanced high-performance brands remains urgent, and the search for alternative maize cultivation technologies is relevant.

The paper offers a technological development in the existing maize cultivation for grain of the GS-180 9 (rus) variety in the climate of the Moscow region on an area of 500 hectares with a conventional yield of up to 110 hundred kilograms per hectare.

Table 1 demonstrates the main elements of the basic cultivation technology flow process chart in the Moscow region, variety GS-180, 500 ha.

Table 1. The main elements of the basic cultivation technology flow process chart in the Moscow region, variety GS-180, 500 hectare.

Activity	Work amount, hectare (tonne)	Mechanic means			Productivity rate, hectare (tonne)/shift	Number of shifts
		Tractor/combine harvester/vehicle brand	farm machinery and tools			
			brand	number		
Diammophoska loading	110 tonnes	JCB LOADALL 540-140	0	1	45	2.44
Mineral fertilizer transportation	110 tonnes	KaMaz 65115	0	1	33	3.33
Mineral fertilizer application	500 hectares	MTZ 82.1	ZA1500	1	70	7.14
Tillage (20-22 cm)	500 hectares	K744P1	PPO-8-45-01	1	24	20.83
Full cultivation (12-14 cm)	500 hectares	K744P1	KSS-9	1	41	12.20
Harrowing (2-4 см)	500 hectares	K744P1	BG-14	1	51	9.80
Ammonium nitrate loading	125 tonnes	JCB LOADALL 540-140	0	1	45	2.78
Mineral fertilizer transportation	125 tonnes	KaMaz 65115	0	1	33	3.79
Mineral fertilizerapplication	500 hectares	MTZ 82.1	ZA1500	1	70	7.14
Full cultivation (10-12 cm)	500 hectare	K744P1	KSS-9	1	41	12.20
Preplanting cultivation (4-6 cm)	500 hectares	K744P1	KUSTO-14,4	1	41	12.20
Seed treatment	10 tonnes	ПС 10	0	1	60	0.17
Seed transportation	10 tonnes	KaMaz 65115	0	1	33	0.30
Seeding	500 hectare	New Holland T8.390	Challenger CH9824	1	52	9.62
Input ХСЗР	0.75 tonne	JCB LOADALL 540-140	-	1	45	0.02
Transportation ХСЗР	0.75 tonne	ГАЗ-3307	-	1	13.5	0.06
Water transport	75 tonnes	KaMaz 65115	-	1	33	2.27
Preparing spray material	75 tonnes	UG3000	-	1	0	0.00
Application СХЗР	500 hectares	МТЗ 82.1	UG3000	1	110	4.55
Harvesting	500 hectares	Acros 595	-	1	42	11.90
Grain	5500	KaMaz 65115	-	1	33	166.67

transportation	tonnes					

We propose to make some changes to the maize growing technology through replacing mechanic means, combining several operations in one run and substituting fertilizers in a rational way. It has been proposed to replace tractors MTZ-82.1 (rus) and K744R1 (rus) with more productive and economical New Holland T8.390 and New Holland T4 F. Ploughing can be performed with simultaneous application of complex fertilizers (diasophoska) and disc ploughing. The Vaderstad TopDown 900 is offered as a seedbed maker. The Challenger CH9824 seed planter has been replaced with the John Deere DB37, which provides simultaneous fertilizer application. The picker Acros 595 has been replaced with the more efficient and economical John Deere X9. Original pesticides have also been replaced with cheaper counterparts.

In order to compare the design parameters with the basic ones, let us present the main elements of the basic cultivation technology flow process chart of the proposed maize cultivation technology. In Table 2 demonstrates the main elements of the design cultivation technology flow process chart in the Moscow region, variety GS-180, 500 hectare.

Table 2. The main elements of the design cultivation technology flow process chart in the Moscow region, variety GS-180, 500 hectare.

Activity	Work amount, hectare (tonne)	Mechanic means			Productivity rate, hectare (tonne)/shift	Number of shifts
		Tractor/combine harvester/vehicle brand	farm machinery and tools			
			brand	number		
Diammophoska loading	92.5 tonnes	JCB LOADALL 540-140	0	1	45	2.44
Mineral fertilizer transportation	92.5 tonnes	KaMaz 65115	0	1	33	3.33
Deep tillage with simultaneous application of diammophoska	500 hectares	New Holland T8.390	Vaderstad TopDown 900	1	49	10.20
Full cultivation (12-14 cm)	500 hectares	New Holland T8.390	KSS-9	1	41	12.20
Harrowing (2-4 см)	500 hectares	New Holland T8.390	BG-14	1	51	9.80
Ammonium nitrate loading	125 tonnes	JCB LOADALL 540-140	0	1	45	2.78
Mineral fertilizer transportation	125 tonnes	KaMaz 65115	0	1	33	3.79
Full cultivation (10-12 cm)	500 hectares	New Holland T8.390	KSS-9	1	41	12.20
Preplanting cultivation (4-6 cm)	500 hectares	New Holland T8.390	KUSTO-14,4	1	41	12.20
Seed treatment	10 tonnes	PS 10	0	1	60	0.17
Seed transportation	10 tonnes	KaMaz 65115	0	1	33	0.30

Seeding with ammonium nitrate application	500 hectares	New Holland T8.390	John Deere DB37	1	52	9.62
Input XC3P	0.75 tonne	JCB LOADALL 540-140	0	1	45	0.02
Transportation XC3P	0.75 tonne	GAZ-3307	0	1	13.5	0.06
Water transport	75 tonnes	KaMaz 65115	0	1	33	2.27
Preparing spray material	75 tonnes	UG3000	0	1	0	0.00
Application CX3P	500 hectares	New Holland T4 F	UG3000	1	110	4.55
Harvesting	500 hectares	John Deere X9	0	1	60	8.33
Grain transportation	5500 tonnes	KaMaz 65115	0	1	33	166.67

The use of more efficient machinery in the design technology and the combination of operations in a single run, the total number of shifts worked during cultivation will be reduced [1]. Therefore, the proposed measures should lead to cost savings.

3 Results and Discussion

We propose to evaluate the effectiveness of technological developments [4].

Taking into account the presented changes in the technological complex, let us calculate direct costs by cost element according to technology flow process chart for basic and design technology.

The calculations of direct costs include material inputs for fertilizers and chemicals, maintenance expenditure (fuel consumption, depreciation, maintenance and repair of equipment), labour costs.

Table 3 presents comparative saving calculations for all major items of production costs; the costs per 1 hectare of planting area and per 1 hundredweight of gross maize grain harvest are determined.

Table 3. Calculation of material costs for maize cultivation according to the basic and design technology, thousand rubles.

Cost Item	Basic Technology	Design Technology	Relative change, %
Labour costs including deductions and contributions	506.1	435.3	-14.0
Seeds and planting stock	5330.0	5330.0	0.0
Mineral and organic fertilisers	6495.0	5455.8	-16.0
Plant protection products, chemicals	1657.6	1342.7	-19.0
Fuel and technical fluids	3117.0	2587.1	-17.0
Allocation for depreciation	692.2	844.5	22.0
Costs of maintenance	414.2	459.8	11.0
Electricity costs	70.8	70.8	0.0
General expenses of production	1092.7	987.3	-9.6

Total	19304.9	17442.5	-9.6
Total costs per 1 hectare of planting area, RUR.	38609.95	34884.97	-9.6
Total costs per 1 hundred kilograms of product, RUR	351.00	317.14	-9.6

Reducing material expenditure is especially important in crop production, where this item usually has the highest proportion, up to 50% of total costs. Given the reduction in mineral fertilizer rates when combine drilling from 220 kilograms per hectare (kg/ ha) to 185 kg/ ha, the cost of those has been reduced by 1039 thousand rubles (or 16%). The pesticide consumption rate when replacing technologies has decreased from 230 kg/ ha to 186.3 kg/ha [6], providing the savings of about 315 thousand rubles (or 19%). Given the reduction of a single New Holland T8.390 run when loosening with combine drilling and fertilizer application, diesel fuel savings will amount to 10950 liters, which at a fuel cost of 48.4 rubles/litre is 530 thousand rubles. Changes in technology and replacement of vehicles with more productive ones will reduce labour costs by 14% by applying labour saving on six main operations. Due to the high cost of new vehicles, depreciation charges have increased by 22% and maintenance and repair deductions have increased by 11%.
In general, the new technology will reduce the maize cultivation direct costs by 9.6%, or by 33.86 rubles per hundredweight of grain.

4 Conclusion

The paper suggests specific business conditions; if the basic parameters of the initial or project technologies change, the result may be different. The article considers one of the ways to increase the crop cultivation efficiency. It is worth noting that this method of processes structuring allows one to cope with several direct costs saving tasks at a time: by saving mineral and organic fertilizers (diammophoska and ammonium nitrate), reducing the dose of pesticides, reducing the amount of fuel consumed, as well as reducing labour costs. These comprehensive measures will reduce direct costs by more than 1.8 million rubles, or by 9.6 %.

The direct cost reduction will lead to lower production cost for obtaining feedstock, and eventually to livestock product cost reduction.

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