Biodiesel Production from Various Crops

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Abstract The article discusses the possibility of using various oilseeds for the production of biodiesel in the Samara region. Purpose of the work: to determine the economic efficiency of using various crops as the basis for the production of biodiesel, as well as to compare the options for the cultivation of spring rapeseed as the main crop for the production of biofuel. Within the framework of this, the following tasks were completed: a list of oilseeds was determined, the use of which is possible for the production of biodiesel in the Samara region conditions; analysis of the economic parameters of their cultivation; calculated the economic efficiency of various technologies for growing spring rape (6 options). It was revealed that crops such as spring rape, mustard and soybeans have the best economic parameters (cost, yield) in the Samara region. Among the technologies for the cultivation of spring rapeseed, the best results were shown by the following options: direct sowing with fertilizers and plowing without fertilizers (profitability 42.34% and 41.72%, respectively).

Keywords Biodiesel · Crop · Technological map

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1 Introduction

Currently, increasing attention is paid to the use of alternative fuels, due to the reduction in the worldwide supply of biogenic energy carriers, tightened exhaust emission standards, and limitation of carbon monoxide emission [1]. Its chemical composition allows it to be used in diesel engines without other substances that stimulate ignition. The following useful properties of biodiesel should also be noted:

- biodiesel undergoes almost complete biological decay: in the soil or in water, microorganisms recycle 99% of biodiesel in 28 days;
- less CO_2 emissions;
- low a number of components content in exhaust gases, such as carbon monoxide CO, unburned hydrocarbons, nitrogen oxides NO_X and soot;
- low sulfur content;
- good lubricating characteristics. An increase in the service life of the engine and fuel pump by an average of 60% is achieved [2].

In order to calculate the possibility of developing biofuel production in the Samara region and providing the region's agriculture with biofuel (biodiesel), it is necessary to choose a crop, determine the most profitable cultivation technology, select equipment (identify the number of complexes necessary to provide the region's agriculture with biofuel and calculate its payback), consider the possibility of state support for this project [3–8]. It is important to know how different technologies for the cultivation of oilseeds will affect the cost of the produced crop products and other resulting technical and economic indicators of the technology [9–12]. For this purpose, an economic assessment of various technologies for the cultivation of oilseeds, used in the arable fields of the Samara region, was carried out on the example of the cultivation of spring rape. A feature of spring rape as a crop is the possibility of using rape as a green manure fallow, and the economy can cultivate cash crops on the saved areas.

2 Methods and Materials

Agronomic, technical and economic information necessary for the effective implementation of crop production technology contains a technological map. For this calculation, the methodology for developing technological maps was used in accordance with standard OST 10 1.3 for each variant of the technology of rapeseed cultivation [13–16].

To solve the problem posed in the study, used specialized software for calculating technological maps in crop production, developed by scientists of the Samara State Agrarian University, was used (Fig. 1). With its help, the diesel

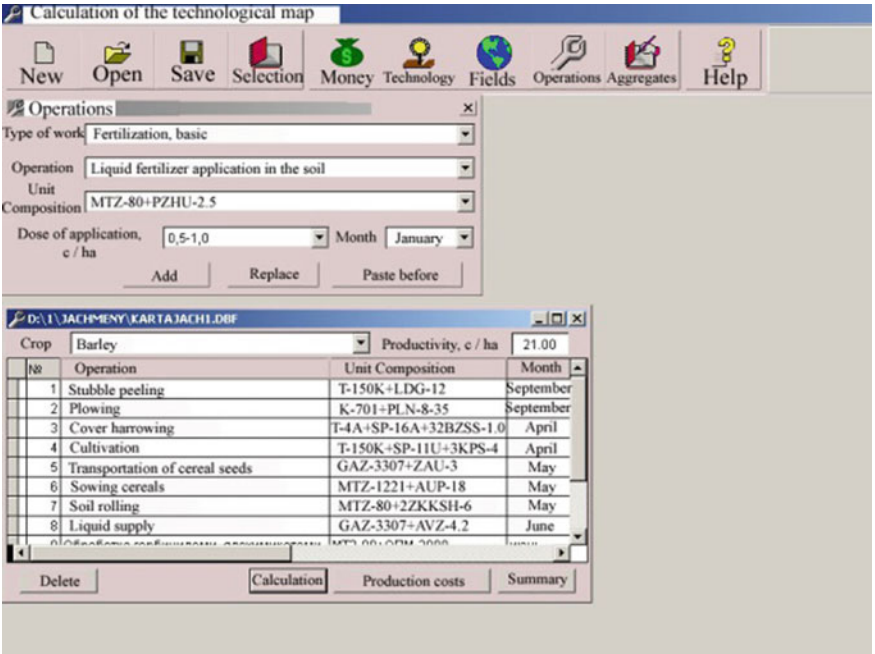

Fig. 1 An example of filling in the initial information for calculating the technological map in crop production [13]

fuel amount needed to complete the production program was determined. Subsequently, the monographic, abstract-logical method, situational and system analysis, economic-statistical methods, and the method of expert evaluations were used.

Considering that the total area of arable lands in the Samara region is 2871.2 thousand ha and that annually agricultural productions consume 60 kg of diesel fuel per 1 ha of arable land, the average consumption of diesel fuel is 172.2 thousand tons per year [17].

The results of the research are presented in tabular and graphical forms.

3 Results and Discussion

Table 1 shows a list of technological operations for each of the studied technologies for the cultivation of spring rapeseed. Cultivation technologies differed, first of all, by different intensity of soil cultivation: plowing by 25–27 cm, loosening by 10–12 cm, without mechanical tillage (direct sowing). Each variant of soil cultivation was studied at two levels of fertilization: without the use of fertilizers and against the background of the application of fertilizers at a dose of $N_{81}P_{38}K_{38}$, based on the calculation of the planned yield level of 15 cwt/ha.

Table 1 List of technological operations in the studied technologies of cultivation of spring rape

Rapeseed cultivation technologies based on		
Plowing	Shallow loosening	"Zero" tillage and direct seeding
1. Peeling 4–6 cm after harvesting the predecessor	1. Peeling 4–6 cm after harvesting the predecessor	Without autumn tillage
2. Application of complex mineral fertilizers randomly 1.5 c/ha diammofoska	2. Application of complex mineral fertilizers randomly 1.5 c/ha diammofoska	
3. Plowing by 25–27 cm with regrowth of weeds and fall of the predecessor	3. Loosening by 10–12 cm during the growth of weeds and fall of the predecessor	1. Application of the herbicide Hurricane 2 l/ha during the regrowth of perennial weeds and fall of the predecessor
4. Spring harrowing	4. Spring harrowing	Without spring tillage
5. Presowing cultivation by 3–4 cm	5. Presowing cultivation by 3–4 cm	
6. Sowing with a SZ-5.4 seeder with the simultaneous introduction of 0.6 c/ha of ammonium nitrate	6. Sowing with a SZ-5.4 seeder with the simultaneous introduction of 0.6 c/ha of ammonium nitrate	2. Sowing with the Amazone DMC seeder with the simultaneous introduction of 1.5 c/ha of diammofoska and 0.6 c/ha of ammonium nitrate
7. Rolling after sowing	7. Rolling after sowing	3. Rolling after sowing
8. Spraying with tank mix herbicide + insecticide + biostimulator	8. Spraying with tank mix herbicide + insecticide + biostimulator	4. Spraying with tank mix herbicide + insecticide + biostimulator
9. The introduction of ammonium sulfate by scattering into the feed 2.2 cwt/ha	9. The introduction of ammonium sulfate by scattering into the feed 2.2 cwt/ha	5. The introduction of ammonium sulfate by scattering into the feed 2.2 cwt/ha
10. Spraying with a tank mixture insecticide + biostimulator	10. Spraying with a tank mixture insecticide + biostimulator	6. Spraying with a tank mixture insecticide + biostimulator
11. Mowing into rolls	11. Mowing into rolls	7. Mowing into rolls
12. Selection and threshing of rolls	12. Selection and threshing of rolls	8. Selection and threshing of rolls
13. Oilseed transportation	13. Oilseed transportation	9. Oilseed transportation
14. Primary cleaning of oilseeds	14. Primary cleaning of oilseeds	10. Primary cleaning of oilseeds

Thus, six variants of technologies for cultivation of spring rapeseed, differing in the levels of costs for their implementation, have been put for study (Table 2).

The use of technologies based on minimum tillage and direct sowing can reduce the cost of fuels and lubricants on average by more than two times from 50 to 26% in the share of total costs. However, with direct sowing, the need for a double increase in the use of crop protection products increases—from 5.7% with traditional technology to 18.5% of the total costs with direct sowing.

Increasing the yield of rapeseed is a fundamental factor in obtaining gross harvest and sales proceeds. The high cost of fertilizers, and as a result, a large share of investments in the sector of variable costs is reflected in the profitability of the production of spring rapeseed with various cultivation technologies [18–24].

In the developed technology of direct sowing with the use of a full range of fertilizers, despite the high level of operating costs, the highest profitability is achieved—42.34%. This is primarily due to an increase in the yield of oilseeds of rape: from 16.4 c/ha for plowing to 17.0 c/ha for "zero" tillage and direct sowing due to the moisture retained by surface plant residues in the soil and full provision of plant nutrition due to the applied mineral fertilizers. The use of direct sowing technology can reduce production costs by more than 2.8 thousand rub/ha. This is due to a decrease in the cost of performing energy-intensive tillage operations—deep plowing and subsequent pre-sowing tillage [25–28].

Direct sowing technology allows to reduce fuel consumption per hectare by half compared to the technology taken for control (using plowing) from 55 to 23.6 kg/ha and reduce labor costs per unit of production to 0.87 man-h/t produced oilseeds.

Thus, on the basis of the performed calculations of economic efficiency in the production of oilseeds of spring rape, along with the traditional technology in the Samara region, it is advisable to use the technology of direct sowing with the introduction of a full range of fertilizers. This technology in the conditions of insufficient moisture supply of the growing season allows to obtain a higher yield and reduces production costs per unit of manufactured product—rapeseed oilseeds. The use of direct sowing technology can reduce the cost of fuels and lubricants on average by more than two times, compared to conventional technology with plowing and reduce the per hectare consumption of motor fuel and labor costs by reducing energy-intensive operations [29].

Previously, we identified agricultural crops cultivated in the Samara region and suitable for the manufacture of oil (Table 3). In this regard, the interest in considering the economics of cultivation of these oilseeds is growing, studying the features of their place in crop rotation and technology, and the influence of these factors on the cost. The final value of the cost of each oilseed crop will be the minimum value among the considered cultivation technologies.

An example of revealing the dependence of the cost of cultivating oilseeds on the technology of their cultivation is given on spring rape. Spring rapeseed was selected as a sample crop taking into account the highest oil yield (1000 kg of oil per hectare). Further crops are presented in descending order of the value of this indicator [30].

In the Samara region, a certain technology for growing sunflower has developed, which allows you to get high yields at an earlier date while reducing financial and

Table 2 Comparative economic efficiency of technologies for cultivation of spring rapeseed

Indicators	Using plowing		Shallow moldless processing		Direct seeding	
	Without the use of fertilizers	$N_{81}P_{38}K_{38}$	Without the use of fertilizers	$N_{81}P_{38}K_{38}$	Without the use of fertilizers	$N_{81}P_{38}K_{38}$
Seeds, rub/ha	1035	1035	1035	1035	1035	1035
Fertilizers, rub/ha	0	3204	0	3134	0	3204
Plant protection products, rub/ha	492	492	518	518	1078	1078
Fuels and lubricants, rub/ha	4271	4371	2850	2950	1530	1580
Repair of equipment, rub/ha	180	184	163	168	153	157
Road transport, rub/ha	28	39	20	36	18	42
Electricity, rub/ha	14	20	11	19	9	22
Wages, rub/ha	743	774	677	710	458	492
Total: variable costs, rub/ha	6763	10,119	5274	8570	4281	7610
Depreciation deductions, rub/ha	1802	1841	1630	1675	1527	1569
Total: fixed costs, rub/ha	1802	1841	1630	1675	1527	1569
Total costs, rub/ha	8565	11,960	6904	10,245	5808	9179
Total revenue, rub/ha	12,138	14,856	8165	12,755	6224	13,541
Profit, rub/ha	3573	2896	1261	2020	343	3886
Profitability, %	41.72	24.21	18.27	19.72	5.91	42.34
Cost of 1 ton, rub	5227	6010	6941	5614	7046	5399

Table 3 Economic efficiency of oilseeds cultivation

Indicators	Rape	Sunflower	False flax	Mustard	Pumpkin	Flax	Soy
Seeds, rub/ha	1035	602	72	1440	198	7500	3780
Fertilizers, rub/ha	3204	2350	654	235	153	752	2685
Plant protection products, rub/ha	1078	246	832	389	432	517	950
Fuels and lubricants, rub/ha	1580	1894	1450	1930	1320	3235	3430
Repair of equipment, rub/ha	157	128	143	164	115	174	197
Road transport, rub/ha	42	35	15	37	18	35	45
Electricity, rub/ha	22	18	7	15	6	19	25
Wages, rub/ha	492	762	420	754	940	754	774
Total: variable costs, rub/ha	7610	6035	3593	4964	3182	12,986	11,886
Depreciation deductions, rub/ha	1569	1640	1462	1846	1327	1795	1890
Total: fixed costs, rub/ha	1569	1640	1462	1846	1327	1795	1890
Total costs, rub/ha	9179	7675	5055	6810	4509	14,781	13,776
Total revenue, rub/ha	14,147	10,873	6572	8998	5475	19,889	18,365
Profit, rub/ha	4968	3198	1517	2188	966	5108	4589
Profitability, %	54.1	41.7	30.0	32.1	21.4	34.6	33.3
Cost of 1 ton, rub	5381	10,923	8128	6200	12,004	9073	6937

labor costs. Taking into account the use of new hybrids and varieties with improved characteristics, farmers are able to achieve excellent results in this important branch of agriculture.

Growing sunflower in accordance with the most promising technology allows you to get a good income from this industry, since sowing requires about 10 kg of seeds per 1 ha, and the yield per hectare can reach 25 cwt. Moreover, not only vegetable oil is obtained from the collected seeds, but also meal, husk, cake, which can become a tangible additional source of income.

Compliance with crop rotation when growing sunflower with the correct alternation of crops in the field is the key to a successful harvest. Sunflower seeds can be sown at the same place no earlier than after 6 years, otherwise the seeds of broomrape and pathogens will accumulate in the ground, which can have an extremely negative effect on the crop.

Mineral and organic fertilizers applied in sufficient quantities contribute to the increase in yield and acceleration of the development of sunflower. Throughout the growing season, sunflower needs phosphorus, nitrogen, potassium fertilizers, as well as trace elements such as boron, zinc and manganese.

False flax is a small-seeded oilseed crop of the cruciferous family. It is an annual plant with an erect, branched stem up to 100 cm tall.

Agricultural enterprises are interested in obtaining oil on unproductive lands, which will strengthen the economy of the economy (average yield of 10–13 cwt/ha). Its seeds contain over 40% oil and 30% crude protein.

The most promising technology is the cultivation of spring camelina using herbicidal fallow, the preparation of which is carried out using soil-protective moisture-saving technology.

Mustard is a triple industrial crop due to its widespread use. It is grown for high quality edible oil, mustard powder and green animal feed. In addition, mustard is widely used as green manure crops, since it has the unique property of absorbing difficult-to-reach forms of nutrients from the soil and transforming them into easily digestible forms.

The average pumpkin yield is relatively low—13.7 c/ha. On average, the mass of 1000 seeds in pumpkins does not exceed 420 g. The seeds remain viable for up to 6–8 years.

Pumpkin seeds are most responsive to the application of manure or other organic fertilizers in doses of 20–40 t/ha. These works are performed after the main plowing, presowing cultivation or cutting of irrigation furrows. With intensive technology, mineral fertilizers are applied simultaneously with sowing. The oil content in oil flax seeds reaches 32–48%. In 7–8-field crop rotations, flax should occupy no more than one field, and return it to its original place no earlier than 6–7 years later. In crop rotations, flax is placed after the best predecessors: perennial grasses, according to the seam turnover, cereals, legumes, winter crops, going in pairs or after grasses, as well as after row crops. Soybeans are the most widespread pulses of the world. Its seeds contain on average 36–42% of complete protein, consisting of globulins and a small amount of albumin, 19–22% of semi-drying oil and up to 30% of carbohydrates. The best predecessors of soybeans in many areas of its cultivation include green manure fallows, the layer and turnover of the layer of perennial grasses, cereals and spike crops that go in clean and busy pairs, as well as row crops (corn, potatoes, sugar beets, sweet potatoes, etc.) Soybeans are not grown after Sudanese grass and sunflower, it is not recommended to place it after corn, under which the herbicides simazine and atrazine were applied. The optimal saturation of crop rotations with soy is from 22 to 40%. To avoid the negative impact of repeated crops on the yield of soybeans, it is recommended to return it to the field no earlier than after 4 years. In the calculation, we neglect such crops as corn, oats and lupine—this is due to the low content of seed oil (less than 200 kg of oil per hectare). This indicator is two times lower in comparison with the oilseeds described above. Thus, we assume a decrease in the oil yield in these crops.

4 Conclusion

The values given in Table 3 are determined from the calculation of the most successful cultivation technologies for each crop. The most profitable oilseeds for cultivation are rapeseed and sunflower, it is interesting that these crops are widely used in the production of biofuel. The amount of diesel fuel used to cultivate the planted area of the Samara region is 77,062.9 tons of diesel fuel. Based on described calculations of comparative effectiveness of biofuel production using MIXER-2 11 AB with a production capacity of 5000 tons per year, we were able to determine that 15 units will be enough to provide agricultural producers of the Samara region with biofuel.

For greater convenience, 5 units should be located in every agricultural zone of the Samara region.

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