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RESOURCE-SAVING TECHNOLOGIES OF CULTIVATION OF GRAIN IN THE CONDITIONS OF NOVGOROD REGION

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Abstract

The article is devoted to the development of energy-saving technologies bezdeleva of the barley varieties BIOS-1, Zeus, Zazersky, Suzdalets and oat varieties Argamak, Borrus on sod-podzolic soil in the conditions of Novgorod region. As a result of the research, it was found that in varieties of barley BIOS-1, Zeus, Zazersky and oats of Borrus variety, when using mineral fertilizers at a dose of $N_{100}R_{60}K_{60}$, it is possible to obtain a grain yield of 4.2-5.1 tons per hectare with a grain nutrient: digestible protein 99-124 grams per kilogram and an energy feed unit of more than 1.0. Total energy consumption per 1 hectare amounted to 26-28 GJ, energy intensity of grain production is less than 4 GJ with a high coefficient of energy efficiency of production of more than 4.3 units. The authors studied the experience of the Novgorod scientific research Institute of agriculture which developed resource saving technology of cultivation of grain for feed purposes in the conditions of Novgorod region.

Keywords: Energy intensity, mineral fertilizers, varieties of spring grains, yield.

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1. Introduction

The issue of saving energy resources in modern conditions of cooperation remains relevant. One of the types of energy resources remain fertilizers. In these circumstances, it is important to ensure maximum profit from the use of fertilizers in the production of cheap, high-quality, competitive agricultural products (Kanash, Litvinovich, Kovleva, Osipov, & Saljnikov, 2018; Panova, Kanash, Semenov, Kulenova, & Blokhina, 2018).

The production of grain, including feed for the development of livestock in the Novgorod region, which gives priority to dairy cattle and poultry, the creation of highly productive agrophytocenoses for the cultivation of forage crops becomes extremely important. Spring crops grown in the conditions of the Novgorod region are mainly used for forage purposes. The main areas are occupied by barley and oats. Oats are an excellent feed for different types of livestock and poultry. Straw and oat sex for nutritional value to sleep and also successfully used in animal husbandry. In grain oats 12-13% protein, 40-45% starch, 4-5% fat. In 1 kg of straw contains more than 0.3 feed units (Gordeev, 1999). Barley grain has high fodder advantages. In its grain and rubí about 10 % protein. In the milled form the grain goes for fattening of cattle. Whole grain is the best feed for poultry. Barley straw and chaff contain a lot of protein: straw − 4.4 %, chaff − 6.2 % (Andreev, 1984).

Spring cereals are demanding to the reaction of the medium: spring barley is moderately sensitive to soil acidity and grows well on weakly acidic and neutral soils (pH 6.0-7.3); oats – in the range of soil reaction pH = 5.0-6.0. Oats grow well in all kinds of soils, except saline, where it is worse than barley. However, despite the ability to carry acidic soils, oats favorably responds to liming acidic sod-podzolic soils. Oats is a moisture-loving crop and gives higher yields on soils with increased moisture capacity, as well as in wet years with precipitation in the first half of summer. In oats, the root system goes deep into the soil and is able to extract nutrients from the lower layers of soluble elements. All this distinguishes it from other agricultural crops. Barley grows well and develops on soils of loamy and clay granulometric composition with a slightly acidic reaction of the soil medium (pH not lower than 5.5), increased content of mobile forms of phosphorus and potassium, and favorable agrophysical properties of the arable horizon. It is not recommended to place it on sandy, waterlogged and eroded soils (Gordeev, 1999).

Predominant soil types of the Novgorod region: sod-podzolic − 90% of the territory. Soil distribution of arable land by granulometric composition: clay and heavy-loamy − 6%, loamy − 56%, su-sandy, sandy − 38% (Novgorod, 1982; Moscow, 1990). The characteristic features of sod-podzolic soils are a small capacity of the upper humus horizon (14-18 cm), acidic reaction of the medium and weak structural properties, which adversely affects the microbiological activity, the air regime of the arable soil layer and, as a consequence, the yield of agricultural crops.

At the same time, this type of soil is strongly influenced by external factors and, when cultivated, acquires regimes and properties favorable for the cultivation of crops, and with insufficient input of energy resources, it quickly loses them. Consequently, the primary importance in increasing the fertility of sod-podzolic soils is the improvement of their quality by liming and the use of mineral fertilizers (Moscow, 2009).

The best predecessors for spring grain crops are cultivated and winter, leguminous, annual grasses fertilized with organic matter, the turnover of the layer of perennial grasses, flax, going through the layer

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of perennial grasses. Oats are sown in the final crop rotation after other grains. When placing oats, it is necessary to take into account that for its development it requires more nitrogen than other crops.

Barley and oats in the Novgorod region are the main grain crops. However, to obtain high grain yields, scientifically based agricultural technologies are required, based on a comprehensive knowledge of soil and climatic characteristics of a particular agricultural landscape, cultivated varieties and the provision of agricultural material resources.

For the North-Western region of Russia, including the Novgorod region, specializing in the production of livestock products, the creation of highly productive agrophytocenoses for the cultivation of feed grains of spring crops is of paramount importance. Spring grain crops have increased requirements for soil fertility. On sod-podzolic soils, a high yield can be obtained by liming and fertilization.

According to the data of domestic and foreign scientists, the share of feed factors affecting the productivity of animals is 60-70%, genetic 20-30% and 10% account for the conditions of detention.

In this regard, in the Novgorod scientific research Institute of agriculture was developed resource saving technology of cultivation of grain for feed purposes in the conditions of Novgorod region.

2. Problem Statement

The relevance of the research work is due to the need to create a solid food base for livestock, and, first of all, concentrated feed of its own production in the Novgorod region (Scientific bases of farming systems in Novgorod region, 1982).

The correct assessment and selection of varieties is of paramount importance for the development of resource-saving technologies for the cultivation of crops. Very important is the ability of the variety to respond to agronomic techniques significant increase in yield (Methods of resource and environmental evaluation of the efficiency of agriculture on the basis of bioenergy, 1999). Biological characteristics of varieties should correspond to the ecological resources of the region, and the technology of their cultivation should be economical and energy-saving (Perspective resource-saving technology of spring barley production, 2009).

3. Research Questions

The article explores the possibilities of using resource-saving technologies for the production of barley grain (three varieties) and oats (two varieties) based on the use of various doses of complex mineral fertilizers. The issues of optimization of mineral nutrition due to the use of fertilizers are considered, since fertilizers are the most powerful economic resource for increasing land productivity and increasing crop yields. A resource-economic assessment of crop cultivation technologies is presented, performed according to the VNIIZ and ZPE methodology and methodological guidelines developed at Yaroslav the Wise Novgorod State University. Cost-effective doses of mineral fertilizers in the conditions of the Novgorod region were determined, and energy-efficient elements of spring grain cultivation technologies (oats and barley) were developed and proposed for use, which together can significantly improve the profitability of production.

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4. Purpose of the Study

Goal and objectives – to develop resource-saving technologies of grain production of barley and oats for the creation of a stable fodder base for animal husbandry, first and foremost, concentrated feeds of own production with high grain yield, minimal consumption of energy for unit of production and conservation of soil fertility in the conditions of Novgorod region.

5. Research Methods

The research was conducted at the experimental field of the Federal state budgetary research Institute "Novgorod Scientific Research Institute of agriculture ". The soil of experimental plot is sod-podzolic, light loam on clay, moderately cultivated. The size of the experimental plots 240 m^2, repeat four times, placing options systematic.

Resource – saving technologies of production of grain of spring barley of grades – BIOS-1; Zeus; Zazersky; Suzdalets and two grades of spring oats – Argamak and Borrus at two levels of fertilizer- $N_{60}P_{60}K_{60}$; $N_{100}P_{60}K_{60}$ were developed. The main and pre-sowing tillage, sowing were carried out according to the generally accepted agricultural techniques of cultivation of crops for the conditions of the Novgorod region (Matyuk & Mazir, 2008).

Fertilizers remain the most powerful economic resource for increasing the productivity of land, as soil fertility resources are depleted and, as the experience of previous years, insufficient use of fertilizers leads to a decrease in crop yields. Optimization of mineral nutrition through the use of fertilizers provides a more complete (20-40 %) use of natural factors of productivity (photoactive radiation, moisture), energy resources of the soil (15-50 %), as well as increases the return on production costs for the cultivation of crops (Matyuk, Mazirov, 2008; The program of increase of soil fertility and plant protection in the non-Chernozem zone of the RSFSR for 1989-1995, 1990).

The studied varieties of barley: Zeus − mid-ripening, vegetation period 71-87 days, grain – fodder, protein content in grain 9.0-15.9 %; Suzdalets – mid-ripening, protein content in grain from 14 to 16% depending on the conditions of the year; BIOS-1 − growing period 70-86 days, resistant to lodging, protein content in grain from 11 to 15 %; Zazersky − high yields on a high agrophone, weight of 1000 grains 41.1-46.8 gram. Oat varieties: Argamak − mid-ripening, growing season 66-106 days, protein content in grain 12-14 %; Borrus − vegetation period of 80-93 days, uniform maturation, resistant to lodging and shedding, protein content in grain more than 11%.

Before sowing seeds were treated with the drug "Bunker" at the rate of 0.5 kg/t Sowing held drill SN-16 at the optimum time, seeding rate of 5 million units germinating of seeds per hectare. At the tillering stage of the crops processed from dicotyledonous weeds with herbicide Erbitux – 1 l/ha.

Observations were carried out with phenological stages of development of barley: germination, tillering, elongation, heading, milk ripeness, milk-wax and wax ripeness.

Noted phenophases of development of oats: germination, tillering, panicle inflorescence emerge, the ripeness of the milk, milk-wax and wax ripeness.

Meteorological conditions during the years of research were not quite favorable for the growth and development of spring crops of barley and oats, as evidenced by the hydrothermal coefficient.

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Hydrothermal coefficient (SCC) for May, June was 0.9 and 0.7. According to G. T. Selyaninov and S. A. Sapozhnikova the SCC characterizes the dry period.

6. Findings

The results of observations showed that the phenophases of the development of barley varieties BIOS-1, Zeus and Zazersky held nearly in the same dates and the growing period of the year amounted to 89-90 days. The varieties of barley Suzdalets dates of phenological stages (beginning of tillering) behind the barley varieties BIOS-1, Zeus and Zazersky 7-8 days and the vegetation period in the years of the studies amounted to 96-98 days.

In the studied oat varieties Argamak and Borrus all phases of development took place in the same period, and the growing season in the years of research was 90-91 day.

In the experiment, observations were made of the soil moisture of the experimental plot by the phases of grain development (table 01). Soil moisture from germination to milk-wax ripeness of the studied crops in the soil layer was within 40-50 % of the total field moisture capacity, which is not enough for the friendly germination of grain seeds and their growth.

Table 01. The moisture content of the soil plots dry soil, %

Horizon, cm	Sowing	Seedling	Tillering	Out in the tube	Earing	Milk ripeness	Milky-wax ripeness	Wax ripeness
0-10	14.2	19.3	14.8	10.8	18.2	15.3	16.3	21.8
10-20	16.3	19.8	19.9	16.9	15.5	16.0	11.5	22.1

Field germination of seeds (table 02) confirms the low moisture content during germination. The germination of grain seeds was 46-61 %, the survival of plants to harvest barley varieties-79-95 %, oats-82-95%.

Table 02. Field germination of seeds and density of standing plants before harvesting

Variants	Variety	The doses of mineral fertilizers active ingredient kg / ha	Density of standing, pieces/m^2		Field germination, %	Survival, %
			During germination	Before cleaning		
1	BIOS-1	$N_{60}P_{60}K_{60}$	269	204	53	80
2		$N_{100}P_{60}K_{60}$	272	228	54	83
3	Zeus	$N_{60}P_{60}K_{60}$	303	240	61	79
4		$N_{100}P_{60}K_{60}$	283	220	57	78
5	Zazersky	$N_{60}P_{60}K_{60}$	232	200	46	86
6		$N_{100}P_{60}K_{60}$	240	200	48	83
7	Suzdalets	$N_{60}P_{60}K_{60}$	240	228	48	95
8		$N_{100}P_{60}K_{60}$	251	229	51	91
9	Argamak	$N_{60}P_{60}K_{60}$	260	220	52	85
10		$N_{100}P_{60}K_{60}$	270	222	54	82
11	Borrus	$N_{60}P_{60}K_{60}$	300	286	60	95
12		$N_{100}P_{60}K_{60}$	305	280	61	92

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Harvesting of grain crops of barley varieties Zazersky, Suzdalets, BIOS-1, Zeus and oats varieties Argamak and Borrus was carried out combine "Sampo" in the phase of full ripeness of grain.

The yield accounting data are presented in table 03. Statistical processing of experimental data was carried out by the method of field experiment of Dospekhov (1985).

Table 03. Influence of a variety and doses of mineral fertilizers on productivity of spring barley and oats

Variants	**Variety**	**The doses of mineral fertilizers active ingredient kg / ha**	**Average yield, t/ha**	**The addition of nitrogen, t/ha**	**The return of nitrogen in grain, kg/kg**
1	BIOS-1	$N_{60}P_{60}K_{60}$	3.8		
2		$N_{100}P_{60}K_{60}$	5.1	+1.3	32.5
3	Zeus	$N_{60}P_{60}K_{60}$	3.0		
4		$N_{100}P_{60}K_{60}$	4.2	+1.2	30.0
5	Zazersky	$N_{60}P_{60}K_{60}$	4.1		
6		$N_{100}P_{60}K_{60}$	5.0	+0.9	22.5
7	Suzdalets	$N_{60}P_{60}K_{60}$	2.6		
8		$N_{100}P_{60}K_{60}$	3.2	+0.6	15.0
9	Argamak	$N_{60}P_{60}K_{60}$	3.0		
10		$N_{100}P_{60}K_{60}$	3.5	+0.5	12.5
11	Borrus	$N_{60}P_{60}K_{60}$	3.6		
12		$N_{100}P_{60}K_{60}$	4.8	+1.2	30.0
Experience error (S_x)			0.13		
LSD_{05}			0.38		

LSD_{05} – least significant difference calculated with the confidence level 0.95.

Analysis of experimental data showed that mineral fertilizers, especially nitrogen fertilizers, had a positive impact on the yield of barley and oats. Making azofoski under cultivation at a dose of $N_{60}P_{60}K_{60}$ kg/ha contributed to obtaining high grain yield of barley varieties: Zazersky – 4.1 t/ha, the BIOS-1 – 3.8 t/ha. The difference in yield between these varieties is not significant – 0.3 t/ha, below LSD_{05} equal to 0.38 t/ha.

Compared with Zazersky variety, grain yield of barley of Zeus variety is lower by 1.1 t / ha (-27 %); in Suzdalets variety by 1.5 t/ha (-37 %). The yield difference is significant.

Increasing the dose of nitrogen to 100 kg active substance per hectare had the most beneficial effect on the varieties of barley BIOS-1 and Zeus. The yield increase, in comparison with the dose of mineral fertilizers $N_{60}P_{60}K_{60}$, amounted to 1.3-1.2 t/ha. Payback of 1 kg of active substance of nitrogen by grain of 32.5-30 kg respectively that is much higher than the standard accepted for the Northwest zone.

In varieties of barley Zazersky and Suzdalets increase in nitrogen was 0.9 and 0.6 t/ha; payback of 1 kg of active substance nitrogen grain 22.5 and 12.5 kg, respectively.

The varieties of oats Argamak and Borrus when you make azofoski under cultivation at a dose of $N_{60}P_{60}K_{60}$ kg/ha obtained a grain yield of 3.0 and 3.6 t/ha.

With an increase in the dose of nitrogen to 100 kg of active substance per hectare variety Borrus gave an increase in yield by 1.2 t/ha with a payback of 1 kg of nitrogen in 30 kg of grain.

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In the variety of oats Argamak these figures are 2.4 times lower and amounted to 0.5 t/ha and 12.5 kg, respectively.

Tables 04 and 05 present the data of structural analysis of barley plants of 4 varieties and 2 varieties of oats at two levels of mineral nutrition. They show that the increase in yield at the level of mineral nutrition $N_{100}P_{60}K_{60}$ compared to $N_{60}P_{60}K_{60}$ was mainly due to an increase in the mass of 1000 grains by 5-10 grams (13-30 %).

Table 04. Structural analysis of grain crops on the background of mineral nutrition $N_{60}P_{60}K_{60}$

Culture	Variety	Plant height, cm	The mass of 1000 grains, gr.	The length of the ear, panicles, cm	The number of grains per spike, number	The ratio of grain : straw
Barley	BIOS-1	71	46	9.7	21.6	1:0.5
	Zeus	71	55	9.0	22.1	1:1.5
	Zazersky	82	35	6.5	37.1	1:0.5
	Suzdalets	57	46	7.5	19.1	1:1.5
Oat	Argamak	87	40	12.5	46.0	1:0.8
	Borrus	97	32	16.0	47.0	1:0.7

Table 05. Structural analysis of grain crops on the background of mineral nutrition $N_{100}P_{60}K_{60}$

Culture	Variety	Plant height, cm	The mass of 1000 grains, gr.	The length of the ear, panicles, cm	The number of grains per spike, number	The ratio of grain : straw
Barley	BIOS-1	79	60	9.1	19.5	1:1.0
	Zeus	69	65	7.3	18.7	1:1.3
	Zazersky	76	40	6.6	36.4	1:1.7
	Suzdalets	65	52	9.8	21.5	1:1.3
Oat	Argamak	87	45	13.5	44.6	1:0.5
	Borrus	102	38	15.0	40.0	1:0.7

A crucial role in increasing the productivity of cattle occupy concentrated feed – grain and its products. They are the main sources of energy and protein, as well as the main component for the preparation of concentrated feed mixtures. Indicators of quality of grain are carried out in Federal state budgetary institution "station of agrochemical service "Novgorod".

Table 06 shows the indicators of feed quality of grain on the options of experience.

Table 06. The indicators of the forage qualities of cereals, 1 kg of grain

Variants	Variety	Total moisture	Nitrogen	Crude fiber	Raw ash	Starch	Sugar	Calcium	Phosphor	Kalium
		%						g		
1	BIOS-1	13.2	2.24	4.6	2.3	26.56	3.52	0.51	4.21	4.63
2		15.4	2.48	4.4	2.2	26.63	2.96	0.79	4.00	4.66
3	Zeus	12.8	2.18	4.0	2.2	30.68	2.16	0.66	3.78	4.16

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4		13.2	2.30	4.2	2.1	31.67	2.10	0.79	4.25	4.73
5	Zazersky	12.9	2.00	5.2	2.2	33.33	2.13	0.36	3.67	4.94
6		12.6	2.16	5.1	2.1	32.81	3.12	1.17	3.58	4.69
7	Suzdalets	12.6	1.95	4.2	2.2	33.35	2.02	0.95	3.93	4.97
8		12.8	2.16	4.5	2.4	33.27	3.93	1.12	3.81	5.16
9	Argamak	11.4	2.13	10.9	2.7	27.67	3.10	1.57	3.58	4.58
10		11.1	2.43	10.7	2.6	26.82	2.28	1.37	4.48	5.08
11	Borrus	11.3	1.86	12.4	2.1	29.93	1.88	1.35	3.66	4.08
12		11.0	2.18	12.1	3.0	27.18	1.97	1.56	4.59	6.18

Table 06 shows that all varieties of barley and oats increase the dose of nitrogen by N40 (variants 2, 4, 6, 8, 10, 12) there is an increase in the nitrogen content in the grain by 0.2-0.32 %. The ratio of phosphorus and calcium in varieties of barley BIOS-1 and Zazersky is improved and in variants 1 and 5 it is 8.2:1 and 10.2:1, in variants 2 and 6 – 5:1 and 3:1 respectively.

Using the data of table 6 and Methodological guidelines for assessing the quality and nutritional value of feed (Sychev & Lepeshkin, 2002), the calculation of crude protein, digestible protein, exchange energy and energy feed units of feed grains of new varieties of barley BIOS-1, Zeus, Zazersky, Suzdalets and oats Argamak and Borrus for cattle (table 07) was carried out.

Table 07. Influence of grades and doses of mineral fertilizers on grain nutrition of barley and oats

Variants	**Variety**	**The doses of mineral fertilizers active ingredient kg / ha**	**Crude protein, cattle, g/kg**	**Digestible protein, cattle, g/kg**	**Exchange energy, cattle, MJ/kg**	**Energy feed unit, cattle**
1	BIOS-1	$N_{60}P_{60}K_{60}$	146	112	10.7	1.05
2		$N_{100}P_{60}K_{60}$	155	124	10.9	1.09
3	Zeus	$N_{60}P_{60}K_{60}$	136	109	10.8	1.05
4		$N_{100}P_{60}K_{60}$	144	115	11.1	1.11
5	Zazersky	$N_{60}P_{60}K_{60}$	125	100	10.6	1.02
6		$N_{100}P_{60}K_{60}$	135	108	10.8	1.00
7	Suzdalets	$N_{60}P_{60}K_{60}$	122	98	10.5	1.02
8		$N_{100}P_{60}K_{60}$	135	108	10.8	1.05
9	Argamak	$N_{60}P_{60}K_{60}$	121	97	10.7	1.04
10		$N_{100}P_{60}K_{60}$	129	103	11.0	1.07
11	Borrus	$N_{60}P_{60}K_{60}$	106	85	10.5	1.00
12		$N_{100}P_{60}K_{60}$	124	99	10.8	1.04

The data of table 7 show that the increase in the dose of nitrogen by N40 leads to an increase in digestible protein (for cattle) in grain of BIOS-1 variety by 12 g/kg; Zeus varieties by 6 g/kg; Zazersky varieties by 8 g/kg; Suzdalets varieties– 10 g/kg; oat grains by 6 and 14 g/kg of Argamak and Borrus varieties, respectively.

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Energy and economic efficiency of cultivation technologies

A resource-economic evaluation of technologies of cultivation of crops carried out by the method of All-Union research Institute of agriculture and soil protection from erosion (Kursk, 1999) and methodical instructions Yaroslav-the-Wise Novgorod State University (Tiranova & Tiranov, 2005).

The lowest level of total energy consumption per 1 hectare of 20-22 GJ (table 08) was observed in the cultivation of grain with a dose of mineral fertilizers N60P60K60.

Increasing the dose of nitrogen to 100 kg A.D. per hectare in barley varieties BIOS-1 and Zeus and oats Borrus leads to an increase in grain yield by 1.2-1.3 tons per hectare and reduce the energy intensity of a ton of grain by 0.1-0.3 GJ, increase energy efficiency of production of tons of grain by 0.2-0.4 units, increase in profitability by 30-43%.

Table 08. Energy and economic efficiency of technologies of cultivation of spring barley and oats

Variants	Variety	Yield, t/ha	The cost of the total anthropogenic energy, GJ/ha	The energy intensity of primary production, GJ/t	The energy efficiency of the main production, units	Profitability, %
1	BIOS-1	3.8	22	3.2	5.0	35
2		5.1	28	3.1	5.2	82
3	Zeus	3.0	20	4.0	3.9	7
4		4.2	26	3.7	4.3	50
5	Zazersky	4.1	22	3.0	5.4	44
6		5.0	28	3.1	5.1	60
7	Suzdalets	2.6	20	4.7	3.4	-7
8		3.2	24	4.9	3.2	3
9	Argamak	3.0	21	4.9	4.3	17
10		3.5	26	5.4	3.9	23
11	Borrus	3.6	22	4.2	5.0	40
12		4.8	28	4.0	5.3	70
LSD05			0.38			

The most cost-effective is the cultivation of barley varieties BIOS-1 on the background of mineral nutrition $N_{100}P_{60}K_{60}$ – the profitability of production was 82 %.

To cultivate barley varieties Suzdalets on the background of mineral fertilizers $N_{60}P_{60}K_{60}$ (yield 2.6 t/ha) − at a loss. The level of profitability was -7 %. With the introduction of nitrogen at a dose of 100 kg active substance per hectare, the yield of barley of Suzdalets variety was 3.2 t/ha, which led to an increase in profitability to 3%. Consequently, the cultivation of barley varieties Suzdalets in the conditions of Novgorod region turned out to be inefficient.

In the cultivation of barley varieties Zazersky cost-effective application of a dose of mineral fertilizers $N_{100}P_{60}K_{60}$ compared to $N_{60}P_{60}K_{60}$, as the profitability was 60%, the net profit of 8.5 thousand rubles/ha.

In oats Argamak from making a dose of nitrogen N_{100} (compared with N_{60}) grain yield increased by 0.5 tons per hectare. This led to an increase in profitability by 6%. The Borrus variety increased the

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dose of nitrogen to 40 kg active substance per hectare increased the profitability of production by 30% compared to the dose of $N_{60}P_{60}K_{60}$.

7. Conclusion

On sod-podzolic soil in the Novgorod region in the production of grain of spring crops in the cultivation of spring barley and oats energy-saving technology elements are:

1. In barley varieties BIOS-1 and Zazersky introduction of mineral fertilizers for cultivation at a dose of $N_{100}P_{60}K_{60}$ provided a high return on grain of more than 32 kg and 22 kg of one kilogram of nitrogen, obtaining 124 and 108 g/kg of digestible protein with an energy feed unit of 1.09 and 1.00, respectively, with energy efficiency of production of more than 5 units and low energy intensity of production of 3.1 GJ tons of grain.

2. The introduction of mineral fertilizers for cultivation at a dose of $N_{100}P_{60}K_{60}$ provided a high return on grain of 30 kg of one kilogram of nitrogen, obtaining 115 g/kg of digestible protein with an energy feed unit 1.11 with an energy efficiency of production of 4.3 units and a low energy intensity of production of 3.7 GJ tons of grain.

3. In borrus oats, the introduction of mineral fertilizers for cultivation at a dose of $N_{100}P_{60}K_{60}$ provided a high return on grain of 30 kg of one kilogram of nitrogen, obtaining 99 g/kg of digestible protein with an energy feed unit of 1.11 with an energy efficiency of 5.3 units and a low energy intensity of production of 4.0 GJ tons of grain.

4. To obtain these indicators, it is necessary to observe the following technological methods: to process the seeds before sowing with a grain protectant; to conduct weeding in the tillering phase with a herbicide against dicotyledonous weeds.

Observance of the listed agrotechnical receptions allows to receive productivity of grain of 4.2-5.1 t / ha with profitability of production of 50-82 %.

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