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PRODUCTION OF WINTER CROPS' GRAIN FOR DEEP PROCESSING DEPENDING ON AGROTECHNOLOGIES

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Abstract

The article presents a variety of technologies for winter wheat and winter barley cultivation using different methods of primary tillage, different standards of organic fertilizers, a modernized plant protection system. The experiment was carried out in a stationary experiment on winter crops (winter wheat and winter barley). It was found that a gradual increase in the degree of the soil fertility and mineral fertilizers led to an increase in the productivity. When developing methods for cultivating these crops, it is necessary not only to contribute to a change in the grain yield, but also to focus on the costs of the resulting products. The authors established parameters that allow to realize the biological potential of winter crops, namely varietal features, rational doses of fertilizers and soil fertility in this zone. In the authors' opinion, increasing doses of fertilizers, modernization of agricultural methods helped to improve the crop productivity, but led to a growth in costs. Today, the solution of these tasks is very important for the sub-sector of deep grain processing, that is why the authors conducted this research to identify a rational combination of different techniques for ensuring growth, development and productivity, with an economic assessment of the data.

Keywords: Winter wheat, winter barley, mineral fertilizers, method of soil cultivation, economic efficiency, deep grain processing.

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1. Introduction

Presently, getting high crop yields of winter barley and winter wheat grain is impossible to imagine without the use of modernized cultivation technologies. The correct choice of variety and the optimal use of fertilizers is a determining factor in achieving stable and high crop yields (Gorpinchenko, 2007a; Neshchadim, Filipenko, & Koval, 2019; Neshchadim, Slusarev, Kravtsov, & Hurum, 2018; Neshchadim, Kvashin, Gorpinchenko, Fedulov, & Salfetnikov, 2018).

At present there are actual tasks: ways of primary tillage systems improvement, problems of energy costs reducing, the degree of different agricultural methods adaptability to a specific environment, maintaining the accumulation of productive moisture, optimizing the agrophysical and agrochemical parameters of the soil, phytosanitary conditions of crops and reducing impurity (Gorpinchenko, 2007a; Kvashin, Neshchadim, Gorpinchenko, & Kvashin, 2016).

2. Problem Statement

Effective production management production cannot be represented without energy analysis. Improving the technology of growing crops led to the creation of complex production, which requires significant energy costs (Gorpinchenko, 2014). Hence, the intensification of agricultural production is closely interconnected with the increase in the cost of non-renewable energy (Gorpinchenko, 2007b; Neshchadim, Kvashin, Gorpinchenko, Fedulov, & Salfetnikov, 2018). Therefore, it is necessary to create technologies for growing crops with the lowest energy costs (Neschadim, Gorpinchenko, Paceka, & Tsatsenko, 2018).

A feature of these crops is a reaction to a change in the soil preparation (Buranova, Cerny, Kulhanek, Vasak, & Balik, 2015; Decker, Epplin, Morley, & Peeper, 2008; Mangalassery, Kalaivanan, & Philip, 2019; Vasil'ko, Garkusha, Naidenov, Neshchadim, & Kravtsov, 2017). In the new economic conditions, the problem of the grain production efficiency has become an acute problem for agricultural production (Gorpinchenko, 2007b; Gorpinchenko, 2014). This problem is caused by an increase in the cost of energy, agricultural machinery, protection products, and fertilizers. The volume of these costs significantly increases as technology intensifies (Gorpinchenko, 2014; Kvashin, Neshchadim, Gorpinchenko, & Kvashin, 2016).

3. Research Questions

Therefore, the use of fertilizers, new equipment and technologies, the introduction of new varieties should be economically viable and energetically rational (Neschadim, Gorpinchenko, Paceka, & Tsatsenko, 2018). For the development of more advanced energy-saving technologies and taking into account the effectiveness of innovations in grain production, a comprehensive assessment is important while considering agronomic, economic and energy efficiency (Gorpinchenko, 2014; Kvashin, Neshchadim, Gorpinchenko, & Kvashin, 2016; Buranova, Cerny, Kulhanek, Vasak, & Balik, 2015; Shchutskaya, Afanaseva, & Kapustina, 2020).

Even in the presence of promising varieties, it is necessary to know the agrotechnical methods of controlling the processes of crop formation, which make it possible to fully realize the hereditary potential

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of plants taking into account their biological characteristics (Neshchadim, Filipenko, & Koval, 2019; Decker, Epplin, Morley, & Peeper, 2008; Vasil'ko, Garkusha, Naidenov, Neshchadim, & Kravtsov, 2017).

4. Purpose of the Study

The purpose of the research is the development and improvement of effective adaptive technologies (soil cultivation and mineral fertilizers) that ensure stable yield and high-quality grain of winter wheat and winter barley in the conditions of the Western Ciscaucasia. The main characteristics of grain should provide the best characteristics for further use in deep grain processing. On the basis of scientific experimental material to prove the feasibility of resource-saving technologies in the production of high-quality grain.

5. Research Methods

The relief of the experimental station field KubSAU is plain. The soil is leached, thick, light clay chernozem. The central zone of Krasnodar Region is characterized by a temperate continental, moderately humid and warm climate. The studies were carried out in an 11-field grain-grass-cultivated crop rotation (Table 01).

Table 01. Experiment scheme

Experiment variant	Fertility level (A)	Fertilizer system (B)	Plant protection system (C)
000 (c)	Original soil fertility (A_0)	Without fertilizers (B_0)	No protection products (C_0)
111	Medium soil fertility (200 t/ha of manure + 200 kg/ha P_2O_5; A_1)	Minimal ($N_{20}P_{30}$ + N_{30} in early spring; B_1)	Biological plant protection system (biologicals; C_1)
222	Increased soil fertility (400 t/ha of manure+400 kg/ha P_2O_5; A_2)	Medium dose ($N_{40}P_{60}$ + N_{60} in early spring; B_2)	Chemical plant protection system against weeds(C_2)
333	High soil fertility (600 t/ha of manure + 600 kg/ha P_2O_5; A_3)	High dose ($N_{80}P_{120}$ + N_{120} in early spring; B_3)	Integrated plant protection system against weeds, pests and diseases (C_3)

Source: authors.

Stationary experiment is represented by factors: level of fertility; fertilizer system; plant protection system C) and methods of primary tillage.

6. Findings

Productivity of the variety is dependent on environmental conditions, the growing area and the conditions for cultivation. It is found that the grain productivity experience made the following changes: 53,8-80,6 dt/ ha in plowing, and with direct sowing the average value of this index – 43.1 kg / ha, a decrease of 25.2 dt / ha (37%). The yield of winter barley grains increased a consistent improvement in soil fertility and fertilizer doses. A yield increase of 10.4 c / ha was obtained with the variant 111, the crop increased by

26.8 c / ha with increased fertilizers (Table 02). In general, identified regularities in the winter barley yield are described by the following equation:

$$У(grain.yield) = 29{,}88 + \frac{4{,}0(A)}{0{,}97} + \frac{31{,}5(B)}{7{,}38} + \frac{12{,}5(C)}{2{,}93} + \frac{42{,}3(Д)}{12{,}03}; (R^2 = 0{,}93),$$

Table 02. Winter barley yield depending on growing conditions, dt/ha, 2013-2017

Method of primary tillage (factor A)	Soil fertility, fertilizer, plant protection (factor B)	Year			Three-year average	Yield increase compared to control	
		2013	2014	2015	2013 – 2015	dt/ha	%
Plowing	000 (c)	56,7	45,5	59,1	53,8	-	-
	111	61,8	61,9	68,8	64,2	10,4	19
	222	67,8	74,2	81,6	74,5	20,7	38
	333	71,0	85,1	85,9	80,6	26,8	50
Direct sowing	000 (c)	21,5	21,4	25,4	22,8	-	-
	111	33,9	32,6	36,1	34,2	11,4	50
	222	54,9	53,7	67,6	55,4	32,6	142
	333	57,7	60,2	79,1	60	37,2	163
HCP_{05} by factor A		1,7	4,0	2,7	4,2		
HCP_{05} by factor B		2,4	5,7	3,8	6,0		
HCP_{05} by factor AB		3,4	8,0	5,4	8,5		

Source: authors.

The fertilizer system (31.5%) and soil cultivation methods (42.3%), according to the mathematical processing of the data, had the maximum effect on the yield of winter barley. A close relationship between productivity and cultivation technologies can be emphasized, looking at the value of the correlation coefficient, which was 0.93.

In agricultural production, various energy-saving technologies adopted in order to reduce costs. In our experiment, various methods of secondary tillage during the cultivation of winter wheat cultivar 'Brigada' were studied (Table 03). It was established that with the direct sowing and other things being equal, the yield of winter wheat decreases and these changes are mathematically significant.

Table 03. The yield of winter wheat grain depending primary tillage techniques and mineral fertilizers rates (the average for 2014-2017)

Primary tillage technique (factor A)	Fertilizer rate (factor B)	Yield, dt/ha	Factor average	
			A	B
Chisel tillage (20 – 22 sm)	Without fertilizers	38,9		
	$N_{50}P_{50}K_{120}$	58,7	54,7	
	$N_{100}P_{100}K_{240}$	66,5		
Direct sowing	Without fertilizers	34,5		
	$N_{50}P_{50}K_{120}$	42,3	42,5	
	$N_{100}P_{100}K_{240}$	50,7		

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Plowing (20 – 22 sm)	Without fertilizers	39,0		
	$N_{50}P_{50}K_{120}$	59,1	55,0	
	$N_{100}P_{100}K_{240}$	66,9		
Disk shallow plowing (control) (8 – 10 sm)	Without fertilizers (control)	36,6		37,2
	$N_{50}P_{50}K_{120}$	52,3	52,0	53,1
	$N_{100}P_{100}K_{240}$	67,3		62,8
HCP_{05}	A		0,6	
	B			0,6
	Variants	1,71		

Source: authors.

Table 04. Bioenergetic assessment of winter barley growing technology 2013-2015

Indicator	Primary tillage technique							
	Plowing				Direct sowing			
	000	111	222	333	000	111	222	333
Getting per 1 ha, dt: - of grain	53,8	64,2	74,5	80,6	22,8	34,2	55,4	60,0
Energy output per 1 ha, GJ, in total:	60,2	71,8	83,4	90,2	25,5	38,3	62,0	67,1
Total energy consumption per 1 ha, GJ	12,5	17,1	23,3	29,2	3,3	6,0	10,2	15,0
Energy increment, GJ	47,7	54,7	60,1	61,0	22,2	32,3	51,8	52,1
The ratio of received and expended energy	4,82	4,20	3,58	3,09	7,73	6,38	6,08	4,47
Net efficiency ratio	3,82	3,20	2,58	2,09	6,73	5,38	5,08	3,47
Labor costs, man-hours per 1 ha	8,0	9,4	10,8	11,5	3,8	4,7	7,5	8,0
Liquid fuel consumption, kg per 1 ha	45,3	51,7	58,3	61,5	28,4	31,7	45,4	47,3
The output of the main products, 1 dt calculated on:								
1 GJ of consumed energy	4,30	3,75	3,20	2,76	6,91	5,70	5,43	4,00
1 kg of liquid fuel	1,19	1,24	1,29	1,31	0,80	1,08	1,22	1,27
1 man - hours	6,73	6,83	6,90	7,01	6,00	7,28	7,39	7,50

Source: authors.

The constantly increasing energy intensity of agricultural production contributes to a decrease in the relative value of the manufactured product, despite its growth. At the same time, the efficiency of bioenergy is reduced – the ratio of the received product energy to the total energy that was consumed in the production process (Table 04).

Consequently, the intensification of agricultural production is closely interconnected with the increase of non-renewable energy in the cost. Therefore, it is necessary to create technologies for growing crops with the

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lowest energy costs. It was established that over the years of the experiment, the minimum total energy expenditures were noted on the options without tillage and varied from 3.3 GJ (000) to 15.0 GJ (033).

The maximum energy increment among all the experimental variants was noted in the variant with the use of intensive technology (333) and amounted to 61 GJ, that is more for 13.3 GJ (28%) compared to the control. In variants with plowing, the maximum value of net efficiency coefficient was noted on the control variant – 3.82 GJ. Improving the technology for growing winter barley led to a decrease in this indicator, where it amounted to 2.09 GJ on variant 333.

If we compare indicators such as total energy costs, labor costs and liquid fuel consumption, the minimum values were noted when using direct sowing – 3.3 GJ, 3.8 person-hours, 28.4 kg, that is less for 9.2 GJ, 4.2 man-hours, 16.9 kg compared to plowing. The maximum values of the main product output (dt) per unit of energy consumption were obtained with direct sowing options and varied from 6.91 (000) to 4.00 (033). But these variants had low yields. According to the analysis of bioenergy efficiency, it is advisable to use options for plowing (111,222), with a net efficiency ratio of 3,20,2,58 and a main output of 3,75, 3,20.

Table 05. Economic efficiency of winter wheat cultivation, depending on the methods of primary tillage, norms of mineral fertilizers, 2014-2017 (in prices of 2017)

Primary tillage technique	Fertilizer rate	Crop yield, t/ha	Net cost 1 t of grain, rub.	Net profit per 1 ha, rub.	Profitability rate, %
Chisel tillage (20-22 sm)	Without fertilizers	38,9	406,17	19210	121,58
	$N_{50}P_{50}K_{120}$	58,7	358,60	31780	150,97
	$N_{100}P_{100}K_{240}$	66,5	407,55	32748	120,83
Direct sowing	Without fertilizers	34,5	265,01	21907	239,60
	$N_{50}P_{50}K_{120}$	42,3	342,79	23570	162,55
	$N_{100}P_{100}K_{240}$	50,7	372,78	26730	141,43
Plowing (20-22 sm)	Without fertilizers	39,0	417,95	18800	115,34
	$N_{50}P_{50}K_{120}$	59,1	364,64	31640	146,82
	$N_{100}P_{100}K_{240}$	66,9	412,59	32608	118,14
Disk shallow plowing (control) (8-10 sm)	Without fertilizers	36,6	434,43	17040	107,17
	$N_{50}P_{50}K_{120}$	52,3	407,65	25750	120,78
	$N_{100}P_{100}K_{240}$	67,3	404,46	33350	122,52

Source: authors.

The cost of gross output increases due to a higher yield and selling price with the addition of mineral fertilizers and herbicide with increasing production costs in winter wheat growing (Table 05). The highest net income on plowing was observed when applying $N_{100}P_{100}K_{240}$ – 32 608 rubles / ha, and the lowest on disk shallow plowing without the use of fertilizers and amounted to 17 040 rubles / ha.

Considering studied methods of winter wheat growing, it is most economically profitable to cultivate winter wheat with the option of moldboard plowing with the introduction of the recommended norms of

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mineral fertilizers. At the same time, there is a high net income, with a rather high level of profitability (146%).

7. Conclusion

To obtain high-quality grain suitable for use in the production of deep processing products in the conditions of the Western Ciscaucasia, it is advisable to use plowing or surface cultivation after sunflower forecrop in winter barley and wheat cultivation. This contributes to sustainable crop productivity, high net profit and profitability.

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