Ways to increase grain production efficiency

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Abstract. The paper presents an assessment of the current state of grain production in the region, determines the main sectoral strategy of increasing the economic efficiency of grain production. The comprehensive analysis of the development of the industry made it possible to compile a correlation and regression model of the grain yield and leguminous crops, which allowed determining the most significant factors – the expenses of fertilizers, plant protection agents and the maintenance of fixed assets. A methodological approach to the grouping of regions according to the level and efficiency of grain production is proposed, which allows identifying the main zones of concentration and specialization of grain production. The formation of the regional grain cluster, uniting all participants in the production, processing and sale of grain and grain products, stimulating an increase in the volume of grain production in agricultural organizations of the region by 2024 up to 13614.3 thousand centners, the profitability of the industry – up to 31.04 % is substantiated.

1 Introduction

The issues of volume gain of grain production, increasing its efficiency, providing the quality of products from grain are priorities in the complex of problems of the agro-industrial complex, since grain production is a strategic branch of agricultural production, owing to its economic and social significance [1–3]. Effective management of grain farming largely determines the efficiency of functioning of the entire agricultural production and the agro-industrial complex as a whole. Development of the grain industry reflects the level of consumption of food products from grain and the quality of the balanced ration for farm animals [4–6]. Significance of the industry is also conditioned by its impact on the socio-economic sphere of the country due to the necessity to provide food security.

In this regard, the study of the current level of development of grain production, determination of the factors and scientific substantiation of the main sectoral strategy of increasing the economic efficiency of grain production is relevant [7–10].

2 Materials and methods

The aim of the study is to develop best practices to improve the efficiency of grain production in the region.

To achieve this aim, the study analyzes the current state of grain production in the region, identifies the main sectoral strategy for increasing the economic efficiency of the industry. The object of the research was agricultural organizations as the main grain producers.

The research was carried out on data from the Ulyanovsk region.

The analysis of macro-regional grain production made it possible to conclude that the Ulyanovsk region belongs to the regions with industrial expansion of grain production, which is characterized by a decrease in grain yield and an expansion of the cultivated area (Table 1).

Table 1. Grouping of subjects of the Volga Federal District (VFD) by the level of development of grain production in agricultural organizations

Groups of subjects of the VFD by the level of development of grain production	Number of subjects	Name of the VFD subjects
Reduced grain production	5	Perm region, Kirov region, Orenburg region, Samara region, Saratov region
Industrial expansion of grain production	2	Penza region, Ulyanovsk region
Intensive development of grain production	7	Republic of Bashkortostan, Republic of Mari El, Republic of Mordovia, Republic of Tatarstan, Udmurt Republic, Chuvash Republic, Nizhny Novgorod region
Total	14	–

Analysis of the distribution of grain production in agricultural organizations by zones of the Ulyanovsk

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region made it possible to conclude that over the past five years, the main zone of concentration of grain production had shifted from the Central to the Eastern zone (Table 2).
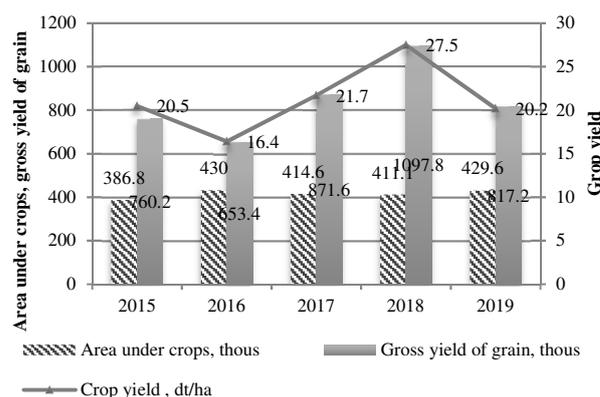
Table 2. Distribution of grain production in agricultural organizations by zones of the Ulyanovsk region.

Indicators	Zone share, %			
	Western zone	Central zone	Eastern zone	Southern zone
2015				
Area under crops	14.71	36.20	36.32	12.77
Production expenditures	14.50	34.28	43.51	7.71
Expenditure of labour	14.15	28.18	49.78	7.89
Gross yield of grain	19.74	32.70	39.15	8.41
Volume of sales	14.58	32.21	39.58	13.63
Gross sales	15.31	36.65	40.15	7.89
Profit on sales	16.42	37.88	41.58	4.12
2017				
Area under crops	14.07	40.30	34.77	10.86
Production expenditures	12.70	39.31	40.50	7.49
Expenditure of labour	10.34	17.34	30.94	41.38
Gross yield of grain	11.67	36.79	44.94	6.60
Volume of sales	14.21	36.41	42.40	6.98
Gross sales	13.87	37.44	42.15	6.55
Profit on sales	6.14	18.98	71.23	3.65
2019				
Area under crops	10.53	39.00	38.02	12.44
Production expenditures	9.49	30.87	50.11	9.53
Expenditure of labour	9.13	31.12	44.47	15.28
Gross yield of grain	10.74	33.69	45.91	9.65
Volume of sales	9.81	33.96	45.09	11.14
Gross sales	9.22	31.60	48.33	10.86
Profit on sales	10.81	27.65	48.92	12.61

In the period from 2015 to 2019 the area under crops increased by 11 %. The average yield decreased by 2 %. However, the gross grain harvest in agricultural organizations in the region increased by 7.5 %, amounting up to more than 817 thousand tons (Fig. 1).

The efficiency of grain production in agricultural organizations by zones of the region shows that the highest profitability of the industry has been achieved in the Western and Southern zones due to the low production costs (Table 3).

The growth of economic efficiency of grain production by 9 percentage points over the past five years is due to the excess of the growth rate of the selling price over the growth rate of the full self-cost (Table 4).

Fig. 1. Dynamics of the areas under crops, yield and gross harvest grain crops in agricultural organizations of the Ulyanovsk region

Table 3. Efficiency of grain production in agricultural organizations by zones of the Ulyanovsk region

| Indicators	Rated value			
	Western zone	Central zone	Eastern zone	Southern zone
2015				
Crop yield , dt/ha	19.41	18.02	25.10	16.11
Labor costs per 1 dt, mhrs	0.83	0.37	0.43	1.00
Production cost of 1 dt, RUB	535.50	464.68	463.93	597.58
Total cost price of 1 dt, RUB	542.99	487.20	455.31	532.99
Selling price of 1 dt, RUB	551.34	577.88	593.89	598.63
Profit per 1 of seeds, RUB	8.35	90.68	138.58	65.64
Crop yield profitability, %	1.54	18.61	30.43	12.32
2017				
Productivity, dt/ha	19.76	21.32	29.07	14.78
Labor costs per 1 dt, mhrs	0.46	0.24	0.36	3.26
Production cost of 1 dt, RUB	594.36	496.86	520.40	574.63
Total cost price of 1 dt, RUB	675.79	694.45	355.50	621.13
Selling price of 1 dt, RUB	791.87	834.47	806.80	761.43
Profit per 1 dt of seeds, RUB	116.08	140.02	451.29	140.30
Crop yield profitability, %	17.18	20.16	126.94	22.59
2019				
Productivity, dt/ha	13.03	17.45	24.43	16.67
Labor costs per 1 dt, mhrs	0.30	0.33	0.35	0.57
Production cost of 1 dt, RUB	593.14	616.33	736.72	663.49
Total cost price of 1 dt, RUB	593.41	626.27	700.76	616.71
Selling price of 1 dt, RUB	747.39	739.99	852.29	774.73
Profit per 1 dt of seeds, RUB	153.98	113.72	151.53	158.02
Crop yield profitability, %	25.95	18.16	21.62	25.62

The constructed trend in the yield dynamics by groups of production profitability shows that with an

increase in the efficiency of the industry, the yield of grain crops increases on average by 3.69 dt/ha. Accordingly, the equation for the production profitability (Y) depending on the yield of grain crops (x) is as follows:

linear trend: $Y = -154.10 + 9.33x$
$R = 0.831$;
*parabolic trend:* $Y = -281.66 + 23.25x - 0.37x^2$
$R = 0.840$ (Fig. 2).

Table 4. Economic efficiency of grain production in agricultural organizations of the Ulyanovsk region

Indicators	2014	2015	2016	2017	2018	2018 % 2014
Crop yield, dt/ha	20.54	16.44	21.72	27.46	20.22	98.44
Labor intensity 1dt, mhrs	0.43	0.53	0.40	0.40	0.37	86.05
Production cost of 1 dt, RUB	500.62	646.31	585.06	517.17	654.96	130.83
Full self-cost of 1 dt, RUB	515.45	668.61	659.80	539.96	636.94	123.57
Price for 1 dt, RUB	587.32	800.54	811.73	637.22	780.98	132.97
Total profit thous. RUB	426430	668291	982244	775827	1208016	2.83 times
including per 1 ha, thous. RUB	1.102	1.554	2.369	1.887	2.812	2.55 times
Per 1 dt, RUB	71.87	131.92	151.93	97.26	144.04	2.00 times
Production profitability, %	13.94	19.73	23.03	18.01	22.61	x
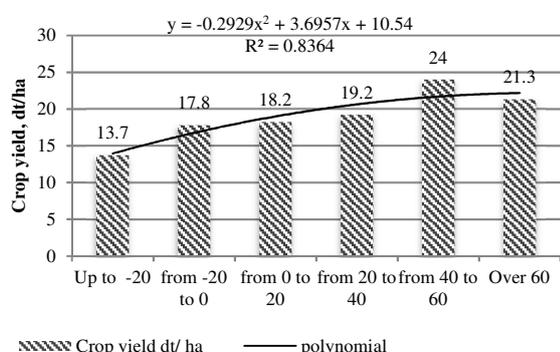
Fig. 2. Variation in the yield of grain and leguminous crops in different groups of agricultural enterprises by the level of profitability

At the same time, the labor intensity of production of 1 dt of grain is reduced from 1.08 to 0.25 mhrs, or 4.32 times (Fig. 3). Calculations have shown that direct labor costs per 1 dt of grain are reduced by an average of 0.51 mhrs.
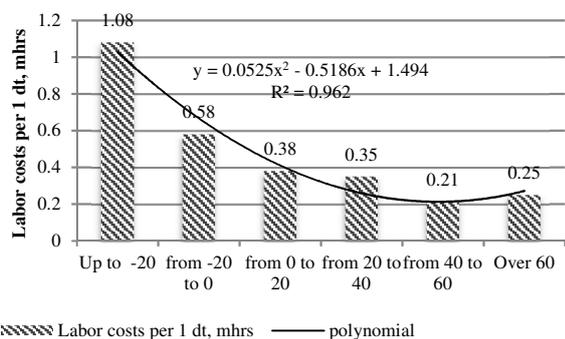
Fig. 3. Variation of labor costs per 1 dt of grain in different groups of agricultural enterprises by the level of profitability
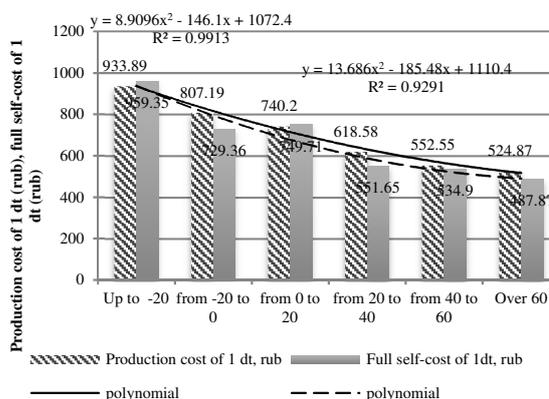
The dependence of production profitability (Y) on the labor intensity of 1 dt of grain (x) is as follows:
linear trend: $Y = 70.86 - 99.51x$
$R = 0.823$;
parabolic trend: $Y = 136.31 - 375.8x + 210.40x^2$
$R = 0.915$.

The production cost of 1 dt of grain by 43.8%, the full prime cost by 49.1% (Fig. 4).

The dependence of the profitability of the grain industry (Y) on the production cost of 1 dt of grain (x) is as follows:
linear trend: $Y = 186.70 - 0.23x$
$R = 0.954$;
parabolic trend: $Y = 394.48 - 0.835x + 0.0004x^2$
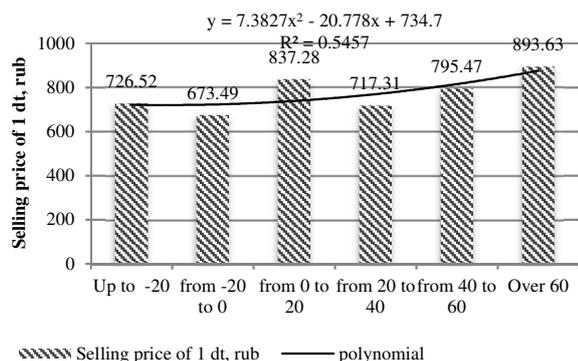$R = 0.974$.

Fig. 4. Variation of the production and full self-cost of 1 dt of grain in different groups of agricultural enterprises by the level of profitability

The dependence of the profitability of the grain industry (Y) on the full prime cost of 1dt of grain (x) is as follows:
linear trend: $Y = 156.80 - 0.20x$
$R = 0.909$;
parabolic trend: $Y = 363.84 - 0.811x + 0.0004x^2$
$R = 0.948$.

The selling price of 1 dt of grain is characterized by an ambiguous trend, therefore its influence on the profitability of grain production is less noticeable (Fig. 5).

$$y = 7.3827x^2 - 20.778x + 734.7$$
$$R^2 = 0.5457$$

Fig. 5. Selling price variation of 1 dt of grain in various groups of agricultural enterprises by the level of profitability

The dependence of the grain industry profitability (Y) on the selling price of 1 dt of grain (x) is as follows:
linear trend: Y = –246.20 + 0.35x
R = 0.739;
parabolic trend: Y = 599.08 – 1.82x + 0.0012
R = 0.761.

The research made it possible to determine that the full prime cost of 1 dt of grain has the greatest influence on the formation of the profitability of the grain industry. At the same time, the complex influence of the factors considered allowed agricultural organizations of the sixth group to make a profit on the production and sale of grain per 1 dt of crops above the average level for the statistical grouping by 2.8 and 2.9 times respectively.

3 Results and discussion

The grouping of agricultural organizations according to the level of efficiency of the grain industry has shown that the cost of 1 centner of grain has the greatest influence on the formation of the profitability of the grain industry. At the same time, the complex influence of the factors mentioned allowed agricultural organizations of the highest group to make a profit on the production and sale of grain per 1 ha of crops in the amount of 406 rubles per 1 centner of grain, which is 3 times higher than the average level for the grouping (Table 5).

The conducted correlation and regression analysis revealed that the yield of grain crops in agricultural enterprises of the Ulyanovsk region is determined, first of all, by the cost of fertilizers, plant protection agents and the maintenance of fixed assets (Table 6).

Table 5. Grouping of agricultural organizations of the Ulyanovsk region by the profitability level of grain

Indicators	Groups of agricultural organizations by the profitability level of grain,%						Total in average
	Up to–20.0	–20.0–0.0	0.0–20.0	20.0–40.0	40.0–60.0	Over 60.0	
Number of enterprises	8	15	75	30	14	15	157
Production profitability, %	–24.3	–7.7	11.7	30.0	48.7	83.2	21.3
production expenditures per 1 ha, thous. RUB	12.33	14.3	14.9	11.4	13.2	11.1	13.49
Grain yield and leguminous crops, kg/ha	13.7	17.8	18.2	19.2	24.0	21.3	19.2
Labor costs per 1 dt, mhrs	1.08	0.58	0.38	0.35	0.21	0.25	0.36
Production cost of 1 dt, RUB	933.8	807.1	740.2	618.5	552.5	524.8	673.6
Full self-cost of 1 dt, RUB	959.3	729.3	749.7	551.6	534.9	487.8	655.5
Selling price of 1 dt, RUB	726.5	673.4	837.2	717.3	795.4	893.6	795.2
Profit (loss) from the sale of grain per 1 ha of crops, thous. RUB	–4.32	–1.02	1.68	3.38	5.50	7.57	2.74
Profit (loss) from the sale of 1 dt of grain, RUB	–232.8	–55.8	87.5	165.6	260.5	405.7	139.6

Table 6. Matrix of partial coefficients of correlation and regression model of the yield of grain and leguminous crops

Factorial features	Partial correlation coefficientand r_{x_iy}	Relation pattern
X_1 – labor costs per 1 ha	0.060	weak, straight
X_2 – expenditures for seeds per 1 ha	0.291	weak, straight
X_3 – fertilizing costs per 1 ha	0.624	noticeable, straight
X_4 – expenditures for plant protection agents per 1 ha	0.558	noticeable, straight
X_5 – expenditures for maintenance of fixed assets per 1 ha	0.462	noticeable, straight
X_6 – manufacturing equipment depreciation expenses per 1 ha	0.451	noticeable, straight
X_7 – fuel costs per 1 ha	0.449	noticeable, straight
X_8 – labor costs per 1 ha	–0.055	weak, reverse

The groups of the greatest interest, from the point of view of the development of grain production in the Ulyanovsk region, are represented by the groups, which include three administrative districts. The regions included in these groups should focus on intensifying grain production by implementing innovations,

minimizing costs and improving the quality of raw materials.

To increase the efficiency of the region's grain industry, it is also necessary to develop a cluster for the production and processing of grain, which will further stimulate an increase in the competitiveness of this industry.

To create a cluster, a backbone unit is needed. This unit can be a production and sales integration association in the region, established by regional grain producers and financed by private-venture capital and based on processing plants. In our opinion, the participants of the grain cluster should be:

• agricultural enterprises, peasant farms producing grain;

• processing industry enterprises (flour and cereal enterprises):

• food industry enterprises (bakeries, pasta and confectionery organizations);

• various intermediaries (retail and wholesale trade, distributors, trade networks);

• enterprises-suppliers of mineral fertilizers, agricultural machinery and processing equipment, spare parts and units;

• seed research institutes, laboratories;

• trade organizations;

• organization of innovation infrastructure and infrastructure to support small and medium-sized entrepreneurship.

4 Conclusion

Organizing a regional grain cluster will allow to create acceptable conditions for the development of small and medium-sized entrepreneurship. Leading enterprises of the cluster, as a rule, concentrate activities on the main sectoral strategy and delegate the production of intermediate products and the provision of services to small and medium-sized enterprises.

The main effects which should arise from the implementation of the cluster policy in the grain sub-complex of the region include:

1. the increase of the competitiveness of products of the grain sub-complex on the foreign markets;

2. the increase in the volume of exports of grain processing products;

3. the development of competition among domestic enterprises, which will contribute to the overall development of grain processing and improve the quality of products at the enterprises of the region;

4. the increase in the production of flour and an increase in its quality due to the effective use of productive capacities, modernization of grain-cleaning and milling equipment;

5. application of alternative resource-saving technologies for deep processing of grain.

The implementation of the proposed measures will increase the volume of grain production in agricultural organizations of the region up to 1360 tons by 2024. In accordance with the current dynamics of prime costs and prices of grain, the profit from the sale of 1 centner will increase up to 259 rubles, which is 80 % higher than the level in 2019. The profitability will gradually increase from 22 to 31 %.

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