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# Innovations in the open-field vegetable growing

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**Abstract.** The development of vegetable production has good prospects in the future, which will certainly contribute to the introduction of innovative technologies. The introduction of the food embargo has stimulated an increase in the production of vegetables. Using theoretical and empirical research methods, the authors identified a positive trend in the development of the industry as a whole in the Russian Federation and agricultural producers in the Moscow region in particular. The research clearly shows that the level of investments in the industry is insufficient, despite the strengthening of state support. Expanding the business of existing agricultural producers and launching new projects do not yet allow to fully solve the issue of self-sufficiency. The level of profitability of the production of vegetables of large and small producers in the range of 20-30%. The main factors of the effectiveness of the cultivation of vegetables (yield, product quality, production costs) are considered. The evolutionary characteristics of intensive technology of growing vegetables are also reviewed in the paper. Transitioning to an adapted biologized model of growing vegetables is proposed, which is based on environmental and economic aspects. Directions of this model: constructing a competent plant protection, restoring soil fertility through working with crop residues, ensuring an effective use of mineral fertilizers. This innovative technology makes it possible, in the conditions of under-financing of the industry, to raise profitability in the vegetable farms to a level above 50% in a very short term.

## 1. Introduction

The Ministry of Agriculture of the Russian Federation at the All-Russian Agronomic Meeting (January 31, 2018) began considering new progressive farming technologies because of the difficult situation in the industry. Vegetable producers in the field of import substitution and increasing the export of vegetables do not have enough modern technologies and high-tech solutions. Innovative technologies can be viewed the solution of the problem of achieving high profitability and economic self-sufficiency of domestic vegetable production.

In connection with the relevance and insufficient development of questions about the introduction of nature-like technologies in the context of increasing the profitability of domestic vegetable production, our research significantly contributes to such goals and objectives.

Issues of developing the open-air vegetable growing industry, increasing the production of open-ground vegetables, improving their quality, marketability and safety are reflected in the research conducted by Yu.I. Agirbova, D. A. Korobeynikov, I. A. Minakov, A. F. Razin, E. A. Silko, and other Russian scientists.



## 2. Materials and methods

The purpose of the study is the economic rationale for developing an open-field vegetable growing based on the introduction of innovations into production.

To achieve the goal in the course of the study, the following tasks were set and solved:

- To study the current state of development of open-field vegetable growing on the materials of the Russian Federation and the Moscow region, to identify the main development trends and reasons hindering the increase in production efficiency;
- To study the problems and factors constraining the development of vegetable production on an innovative basis;
- To consider the main directions of innovative development of open-field vegetable growing;
- To propose the introduction of innovative developments in the production of vegetables in the open ground of the Moscow region.

## 3. Methods

All the conclusions and recommendations made in this research are based on the application of the following methods: monographic; economic and statistical, abstract-logical; forecasting.

The research is based on the official data of the Federal State Statistics Service of the Russian Federation, territorial bodies of the Federal State Statistics Service of the Moscow Region, regulatory documents of the Ministry of Agriculture and Food of the Russian Federation and the Moscow region, official reporting data of agricultural producers of the Moscow region, specializing in open field vegetable growing, materials of the periodical press of this problem. During the study, numerous Internet resources were used as well.

## 4. Discussion

Over the past few years, large agricultural holdings specializing in the production of potatoes and vegetables have been created in the country. Large-scale production should provide up to 60-70% of the urban population's need for such products.

The introduction of the food embargo has stimulated an increase in the production of vegetables. As a result, the harvest of these crops reached 100 kg per person, which is 20 kg more than the previous values. But the level of investments in the industry is insufficient, despite the strengthening of state support. In Russia, the total area occupied for growing vegetables in open ground for several years has been around 650 thousand hectares. The production in farms of all categories is about 14.7 million tons at the moment. Sown areas for types of vegetable crops are presented in Table 1.

**Table 1.** Sown areas of vegetables in the Russian Federation by types, thousand hectares.

	Cabbage	Cucumber	Tomatoes	Beet table	Carrots table	Onion	Green peas
<i>Agricultural organizations:</i>							
2017	13.59	1.61	7.56	8.59	12.36	10.4	18,7
2016	14.8	1.6	6.1	9.6	13.8	11.9	16.7
<i>Peasant farms</i>							
2016	16.1	4.3	11.2	7.7	12.3	16	2.7
<i>In farms of all categories</i>							
2016	115.3	68.9	120	48.5	72.1	90	21.9
2015	113.9	70	118.7	48.2	70	89.5	20.7

Source: compiled by the authors according to [1, 3].

The largest acreage in Russia is allocated to tomatoes– 120 thousand hectares. Cabbage is in second place in terms of popularity (115.3 thousand hectares), and onion has the third position (90 thousand hectares). Carrots and cucumber occupy 72.1 and 90 thousand hectares, green peas totaling 21.9 thousand hectares.

The patterns revealed during the compilation of the species assortment are also preserved relative to the indicators of the gross yield of vegetables (Table 2).

**Table 2.** Gross yield by types of vegetables, thousand tons.

	<b>Cabbage</b>	<b>Cucumber</b>	<b>Tomatoes</b>	<b>Beet table</b>	<b>Carrots table</b>	<b>Onion</b>	<b>Green peas</b>
<i>Agricultural organizations:</i>							
2016	515.1	37.8	187.2	259.7	521.6	418.9	16.7
<i>Peasant farms</i>							
2016	480.5	77.1	342.2	143.4	287.8	570.7	2.7
<i>In farms of all categories</i>							
2016	3626.1	1143.4	2366.5	1097.0	1847.1	2023.3	21.9
2015	3611.4	1129.6	2282.3	1083.9	1781.2	2101.5	20.7

A more complete impression in the development of vegetable production and its significant contribution to the development of the industry as a whole is represented by yield indicators. Yield trends are unstable (table 3).

**Table 3.** The yield of vegetables by type, c / ha.

	<b>Cabbage</b>	<b>Cucumber</b>	<b>Tomatoes</b>	<b>Beet table</b>	<b>Carrots table</b>	<b>Open field vegetables Total</b>
<i>Agricultural organizations:</i>						
2016	377.4	251.5	377.7	290.3	410.7	262.2
<i>Peasant farms</i>						
2016	310.6	184.5	312.5	231.6	263.3	265.9
<i>In farms of all categories</i>						
2016	320.6	199	222.1	228.8	260.2	225.7
2015	334.5	185.9	232.3	183.2	202.7	226.2

Vegetable growing in the Moscow region is a priority for the development of agriculture. The Moscow region ranks fourth in Russia in the production of vegetables, in the collection of greenhouse vegetables thirteenth position. The yield of vegetables in 2017 amounted to 548 thousand tons, which was less by 10.3% than in 2016 due to adverse weather conditions. The largest agroholdings (“Dmitrovskiyevoshchi”, “Malino”, and “Prinevskoye”) are the integrated leaders operating in a closed cycle. The technological chain of production includes all stages from the production of vegetable seedlings to the delivery of packaged vegetables to large retail chains.

Cultivation of vegetable products is the most energy-intensive industry, and accordingly, it uses mainly expensive machines that large agricultural holdings have the opportunity to purchase. However, as before, the production of vegetables in open ground is costly.

In large agroholdings, a high degree of mechanization of sowing, planting, maintenance, and irrigation works is observed. In small farms, for this purpose, manual methods are mainly used with

technical means for plant protection and irrigation. A high level of using modern machines has been found in the cultivation of onions and beetroot. In agroholding and large farms almost all stages of the technological process of production of these crops, including harvesting, are fully mechanized.

There is a weak degree of protection of domestic producers, which leads to low competitiveness of domestic products in price and quality, as well as to insufficient development of vegetable production in both open and protected ground.

Large agricultural holdings of the Moscow region, such as the Dmitrovskie Ovki GC, the Moskovsky Agrokombinat, the Malino Group of Companies work in a closed production cycle: planting vegetables, storing, processing, and delivering them through the distribution networks to the final consumer.

Ensuring the full cycle of production and sales in the Dmitrovskie Ovki Group of Companies is facilitated by the activities of the holding companies: Bunyatino Agrofirma CJSC, AgroTechnoParkTaldom, Fruchtring LLC; product development companies: Dmitrovskie Dainties LLC, Salateria LLC; a transport company: Dmitrovskiye Ovoshchi LLC; suppliers of agricultural machinery: DmitrovAgroResurs LLC.

The production volume of the Dmitrovskie Ovoshchi Group of Companies amounts to about 150 thousand vegetables and vegetable products per year, of which 75% of the harvest is stored in its own vegetable stores equipped with modern storage systems, making it possible to maintain the quality and presentation of vegetable products for several months.

In the assortment of the holding, there are more than 30 kinds of fresh and processed vegetables, including peeled and sliced ones (traditional: white cabbage, carrots, beets, onions, potatoes, cauliflower, green cultures, and also lettuce of various varieties). However, the costs of storage and sale companies are close to the costs of cultivation; in different periods, they even exceed them. In consequence of which there is a decrease in the economic performance of vegetable production, as well as the share of the cost of growing vegetable products in its full cost. So, the calculation of the unit weight of the cost of growing in the full cost of vegetables in 2015-2016 in the farms of the Dmitrovsky district and on average amounted to 61%, and it was 43.2% and 41.4% in the Kulikovo ZAO and Fruhring LLC, respectively.

One of the largest commodity producers of the Leninsky district of the Moscow region is the Moskovsky Agro-Industrial Complex ZAO, which production turnover exceeds 50% of the agricultural turnover of the district. The farm has 320 hectares of land, including 319 hectares of agricultural land, of which 114 hectares are covered by greenhouses. The volume of production for 2016 is 58,629 tons of vegetables. Of these, cucumbers constitute 15,859 tons, tomatoes – 20,367 tons, peppers – 453 tons, eggplants – 780 tons, green crops – 4,356 tons.

The Podmoskovnoe agrofirma has a unique greenhouse complex in the Ramenskoye district of more than 10 hectares, which is one of the largest greenhouses in the Moscow region. The company also provides rental services for greenhouses: greenhouses, parking lots, warehouses, non-residential premises, offices and land.

A wide range of services for the sale of vegetables in protected and open ground, as well as services related to the packaging, storage and delivery of products is provided by the agricultural firm Niva. The company has all the necessary production facilities for the production, storage, processing, packaging, and transportation of agricultural products. The company received a net profit of 41.04 million rubles in 2015, which was 24.15% less than last year. The cost of production increased in 2015 and amounted to 125.93 million rubles if compared with last year's figure of 97.52 million rubles.

For producers of vegetables storage, costs consist of depreciation charges on refrigerators and equipment, energy consumption, administrative and general expenses, salaries. In addition, there are costs of sailing the products, including its bulkhead, manual cleaning of heads, and packing them in the grid, transportation [9-11].

The production costs of vegetables in large specialized organizations with industrial technology of their cultivation (including planting materials) are significantly lower than those of farms with a lower

gross yield of vegetable products. In average (451 rubles/c), it is lower by 1.6-2.2 times in cabbage, carrots – 1.9-2.8 times, onions – 2.9-3.4 times, and beet – 3-4 times.

According to the Moskovsky agricultural holding, the cost of vegetable production in the winter period can reach 200 or more rubles / kg, in the spring period it drops to 70 rubles / kg, and in summer – to 30 rubles / kg. Therefore, in a certain period, the production of vegetables becomes unprofitable, since the price of the final production of production significantly exceeds the market average.

The main costs in the structure of the production cost of vegetables in a large specialized farm include the following: average mechanization (33.6%), wages (14.2%), seeds and seedlings (7.2%), overhead costs (30%), fertilizers and plant protection products (10.8%), fuel and lubricants (3.2%).

After analyzing a number of farms of the Moscow region for growing vegetables, it can be said that even if distribution costs of a product grow and the share of cultivation in production costs decreases to 41%, the profitability of production will be approximately 4-5 years.

Consequently, it can be summarized that for large agroholdings that are engaged in the cultivation of vegetables, it's still cost-effective in a difficult economic situation (rising production costs, difficulties with marketing products, etc.). The economic indicators of the production of large enterprises against producers of small farms exceed by 1.8-7.6 times per 1 ha in revenues; in revenues per 1 person / h labor, the costs are 1.5-2.8 times higher; and it is 1.4-1.6 times in the average profitability (Table 4).

**Table 4.** The area of farms and profitability of vegetable production in the farms of the Moscow region.

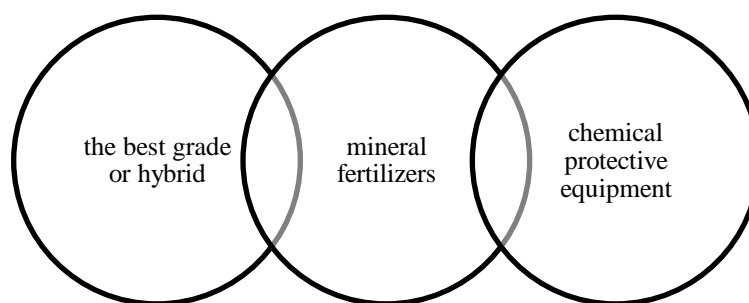
Years	KulikovoCJSC		BunyatinoAF		OzeryCJSC		A. A. GorshkovIE	
	Area, ha	Profitability, %	Area, ha	Profitability, %	Area, ha	Profitability, %	Area, ha,	Profitability, %
2010	440	44,7	410	29.7	614	25.8	80	25.3
2011	510	19	555	38	620	32.5	95	16.8
2012	497	36.7	595	16	590	30	112	17.3
2013	520	34.2	560	17.2	610	25	115	10.1
2014	540	35.1	540	15	615	27.4	120	12.5
2015	650	30.6	570	16.3	600	31.6	120	11
2016	680	33.8	610	17.5	613	30.1	130	13.4
AVE	548.1	33.4	548.6	21.4	608.9	28.9	110.3	15.2

In our opinion, the level of profitability of the production of vegetables of large and small producers should reach 50% or more in order to find solutions.

The effectiveness of the cultivation of vegetables is determined by the main factors:

- Crop yield (variety and its reproduction, soil and climatic conditions, fertilizers and cultivation technology);
- Product quality (complex of external and internal properties);
- Production costs.

Industrial production is focused on transportation requirements, storage requirements, sales rules, but not on ecologically qualitative parameters of vegetables. About 95% of vegetable farms use the N. Borlaut model (Figure 1).



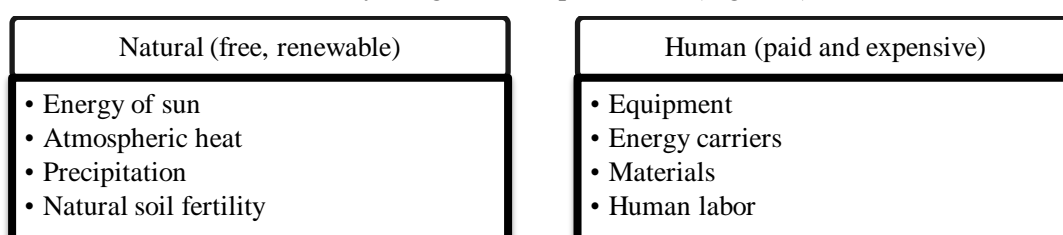
**Figure 1.** The plant model of N. Borlaug.

Evolutionary results of using intensive technology of growing vegetables:

- Varietal seeds (traditional plants: hybrids, genetically modified organisms (designed to increase yield and reduce production costs);
- The use of mineral fertilizers (from 1849 – Liebig’s theory) leads to the destruction of natural soil fertility and the growth of non-productive costs;
- Chemical plant protection products (first, second generation) made the soil dead, progressing plant diseases, growing non-productive costs.

It is necessary to look for new progressive technologies for the production of agricultural products and for the production of vegetables in particular. For the first time, they began to consider new progressive farming technologies in the Ministry of Agriculture in January 2018. The system of Adapted Biological Agriculture developed by A. Kharchenko received official support. The report “Necessity and Possibility of Changing the Agrotechnological Structure in Agriculture (Environmental and Economic Aspects)” outlined the experience of introducing nature-like technologies in crop production [1].

Natural-like technologies are those technologies that do not cause damage to the outside world, but they exist with it in harmony and allow one to restore the balance disturbed by man between the biosphere and the technosphere. The definition of nature-like technologies includes the action titled “the reproduction of objects of living nature” [8]. In his report, A. Kharchenko considers only two resources that determine the efficiency of agricultural production (Figure 2).



**Figure 2.** Factors of agricultural production.

There is no doubt about the need to learn how to use natural resources to obtain high profitability and competitiveness, as well as to restore it. The profitability of vegetable production is determined by these two resources (natural and human). Accordingly, the production of vegetables in European countries has an artificial profitability through subsidies. Currently, organic vegetable cultivation has also been widely developed, including archaic technologies enshrined in standards.

Biologized technology lies between intensive and organic technologies. This direction is built on a new system of ideas about soil processes, about the plant nutrition system, about the production process of plants, etc. The main principles of biologized farming are “healthy soils” and “healthy products for all”.

Biologization consists of three levels:

1. “Biomethod”: a combination of the use of chemical and biological agents.
2. “Biocontrol”: the saturation of the plant surface and the space around them with a large number of agronomically valuable microorganisms that enter into various forms of interaction with the plant.
3. “Biologization”: a technology for creating a stable cenosis and managing the development strategy of cenosis (restoration of the biological activity of the soil).

By combining organic and biologized technology is the restoration and use of natural resources. Comparisons of the two technologies are presented in Table 5.

**Table 5.** Comparison of organic and biological technologies.

Direction of agriculture	Bind to standard	Bonus prices	Yield / productivity	Risks of total crop loss
Organic	+	+	low	Very high
Biologized	-	-	high	-

Organic technology is tied to standards, but biologized ones are not. The yield of organic technology is low (40-60% of the yield is intensive), and it is high in the biologized technology (with growth from 40 to 250% according to the model developed by N. Borlaug).

## 5. Future research

Prospects for further research are to analyze the results of a pilot project on the introduction of nature-like technologies in the context of increasing the profitability of domestic crop production in the regions of the Russian Federation, announced by the Ministry of Agriculture on January 31, 2018.

## 6. Conclusions

An analysis of the development trend of vegetable production in the Russian Federation led to the conclusion that, due to political (Western sanctions) and economic (food embargo), they contribute to the development of this industry.

In the course of the study, the current state of the domestic vegetable industry was assessed and it was found that the industry was lagging behind the foreign one, but the lag was in the use of growing technologies and the level of state support. This industry requires new agronomic technologies, the need for ways to optimize costs in the context of the practical lack of support for agriculture in Russia, in particular, the vegetable industry.

In order to achieve high profitability and economic self-sufficiency of domestic vegetable production, the agrotechnological system of A. Kharchenko is aimed, which officially received support as the system of the Adapted Biologized Agriculture.

Models of adaptive biologic farming in the conditions of under-financing of the industry, allows in the short term to raise profitability in vegetable farms above 50%. Directions of this model:

1. Building a competent plant protection;
2. Restoring the soil fertility through working with crop residues;
3. Effective using of mineral fertilizers;
4. Elements of conservation agriculture.

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