Complex of economic measures for the production of corn hybrids in the Russia

V Nechaev¹, P Mikhailushkin² and Y Davydova³

¹Department of organizational and economic problems of using the results of agricultural science, Federal scientific center of agrarian economics and social development of rural areas – All-Russian Scientific-Research Institute of Economics of Agriculture, 35 b.2 Khoroshevske shosse, Moscow 123007, Russian Federation
²Department of Economics and foreign economic activity, Kuban State Agrarian University named after I T Trublin, 13 Kalinina Street, Krasnodar 350044, Russian Federation
³Department of accounting, statistics and audit, Moscow State Institute of International Relations (University) of the Ministry of Foreign Affairs of the Russian Federation, 76 Vernadsky Avenue, Moscow 119454, Russian Federation

¹E-mail: vasilii_nechaev@vniiesh.ru

Abstract. The article is devoted to a set of organizational and economic measures for accelerated production of corn hybrids in the Russian Federation. The dynamics of corn grain production over the past 28 years has been studied and the organizational model of crop selection and seed production in the country has been shown. The scheme of seed production of zoned hybrids and their parent forms is shown, which shortens the path from a scientific institution to the real sector of the economy. A set of measures of the development of corn breeding and seed production is justified and proposed. These include: improvement of existing legislation, creation of specialized breeding and seed centers, application of state financial support, creation of innovative infrastructure and development of the system of training and retraining of personnel in the country.

1. Introduction

In the context of increasing globalization of the development of integration processes and the new geopolitical situation generated by unpredictable external economic shocks in the world economy, the country's leadership is facing the search and creation of conditions for further balanced and sustainable development of all sub-sectors of the agro-industrial complex. We should also take into account the effect of sanctions against Russia, as well as the retaliatory measures taken to restrict the import of certain food products.

In accordance with the Doctrine of food security of the Russian Federation, the share of seeds of agricultural crops of domestic selection in crops must be at least 75% [1].

World practice shows that breeding and seed production are the most affordable means of biological intensification of corn production [2-4]. This crop plays an important role in the development of domestic animal husbandry, because it is the most productive, and in terms of feed advantages exceeds other agricultural crops.
According to the “All-Russian Research Institute of Corn”, the area of corn cultivation for grain in 2019 was about 3 million hectares and for silage - 1.5 million hectares. About 100 of seeds are sown on these areas respectively, of which varieties and hybrids of domestic selection account for no more than 40 thousand tons. About 60 thousand tons of foreign seeds are imported to Russia.

According to experts’ “All-Russian Research Institute of Corn” forecasts, the further development of domestic animal husbandry will require increasing the production of corn for grain to 25 million tons, so the need for seeds will increase to 130-135 thousand tons (including corn for silage). According to the Doctrine of food security, it is necessary to produce about 105 thousand tons of domestic corn seeds in the country, and, consequently, to increase their production by more than 2 times, in order to remove dependence on foreign breeding achievements.

In this direction, a number of works are being carried out in the country aimed at ensuring the accelerated development of domestic breeding and seed production for the most important agricultural crops. For example, on July 24, 2019, the Federation Council of the Federal Assembly of the Russian Federation held a parliamentary hearing “On a set of priority measures aimed at ensuring the accelerated development of domestic breeding and seed production” [5].

Consequently, the purpose of the study was to systematize theoretical and practical knowledge, as well as to develop a set of practical organizational and economic measures for accelerated production of corn hybrid seeds in the Russian Federation. Together, all this implies the search of forms, methods, mechanisms and tools that would ensure the effective development of domestic selection and seed production of the most important agricultural crops.

2. Methods and materials
The legal basis of the research was made up of legislative and regulatory acts in the field of agro-industrial complex of the Russian Federation [4, 6-10].

The source of the factual material for the scientific research was: statistical databases of official statistical bodies of the Russian Federation, information from regional authorities in the field of agro-industrial complex, information and analytical reviews describing the production of agricultural products and food, as well as the current state of selection and seed production in Russia, meetings and public speeches and hearings at various venues and levels of government, including the State Duma and the Federation Council of the Federal Assembly of the Russian Federation, archival materials of scientific research on the problem under study, as well as documentation of enterprises, organizations and scientific institutions.

The analysis and generalization of scientific literature, periodicals [11-13], works of domestic and foreign scientists [1-3,14-18], regulations [4,6-10], which allowed to define the main tasks and directions for further work were made at the stage of studying the problem on the basis of theoretical methods of the research. Historical and scientific abstraction methods were applied as additional research methods at the first stage.

At the stage of solving the tasks and checking the initial theoretical positions, the following set of research methods was used: analytical, economic and statistical, comparative, mathematical modeling, computational and constructive. At this stage the current state of selection and seed production in Russia was determined, which allowed us to identify the most important problems of the industry and gave individual recommendations aimed at ensuring its accelerated development.

Based on the researches and applied methods there were developed and proposed a number of organizational and economic measures for accelerated production of corn hybrid seeds in the Russian Federation.

3. Results and discussion
In general, the organizational model of selection and seed production of agricultural crops in the Russian Federation is shown in figure 1.
Figure 1. Organizational model of agricultural crop selection and seed production in the Russian Federation.

In accordance with this model, the selection and seed production of agricultural crops in general and corn, in particular, are carried out by research institutions of the Ministry of Science and Higher Education of the Russian Federation, as well as private breeding companies. State Commission of the Russian Federation for testing and protection of selection achievements (hereinafter, “Gossortkomissia”) produces testing and registration of new varieties and hybrids. The Russian agricultural center (hereinafter, “Rosselkhozcentr”) defines the seed quality. Production of seeds of corn hybrids and their parent forms take place in seed farms, and in recent years (after 1990) in agricultural organizations of any form of ownership and management.

As can be seen from the data shown in table 1, the gross corn harvest in the country in 2018 compared to 1990 increased by 8967 thousand tons, or at 4.6 times.

Table 1. Dynamics of corn grain production in the Russian Federation (farms of all categories)*.

| Years   | 1990 | 2000 | 2015 | 2016 | 2017 | 2018 | 2018 to 2000, % |
|---------|------|------|------|------|------|------|-----------------|
| Sowing area, th ha | 869  | 890  | 2761 | 2887 | 3019 | 2452 | 2.8             |
| Crop productivity, hw/ha | 28.2 | 17.2 | 49.3 | 55.1 | 49.0 | 48.1 | 2.8             |
| Gross harvest, th t | 2452 | 1530 | 13138| 15282| 13208| 11419| 7.5             |

*Compiled on the basis of information from the Federal State Statistics Service, the Ministry of Agriculture of Russia and the Federal Customs Service [20].

According to the Federal State Statistics Service, in 2018, corn for grain in all categories of farms was placed on the area of 2452 th ha, which is 1562 th ha, or 2.8 times more than in 2000. In this period, the level of crop yield, depending on weather conditions and the level of intensification of its cultivation, changed from 17.2 hw from 1 ha in 2000 to 48.1 hw from 1 ha in 2018, or increased 2.8 times.

The State register of breeding achievements approved for use (hereinafter, the State register) [14] contains a large number of domestic corn hybrids that fully meet the modern requirements of...
agricultural production. So, from 2008 to 2018, 154 hybrids of domestic selection were entered in the State register, the share of which is 20.8% of the total number of corn hybrids.

852 corn hybrids were registered in the State Register of breeding achievements in 2019. Of these, 60% are hybrids of foreign selection. The share of foreign corn hybrids in the area of sowing is 45.8%. From the analysis of the quantitative and qualitative composition of hybrids entered in the state register, the following conclusion follows: unreasonably large number of foreign varieties, they are not used for seed production in tour country.

Seeds of domestic corn hybrids, which are produced on corn-calibration factory with technology according to the “All-Russian research Institute of corn”, are not the worst of foreign hybrids, but it is 4-5 times cheaper. This confirms the fact that with a significant share of foreign hybrids (about 50%) in production when sowing for grain, for many years in the country the yield remains at the level of 4.0-4.8 t/ha, and for silage – 20.0-25.0 t/ha. Therefore, to pay for seeds more in several times does not make sense at this level of productivity. This is evidenced by the data in table 2, which shows the productivity and economic efficiency of corn grain production in agricultural organizations of the Krasnodar Territory – one of the main producers of grain and corn seeds in the country.

Table 2. Economic efficiency of corn cultivation for grain in agricultural organizations of Krasnodar Territory**.

| Rates                          | In average for period, years: | 2016-2018 to 2013-2015, % |
|-------------------------------|------------------------------|---------------------------|
|                               | 2013-2015                    | 2016-2018                 |
| Crop productivity, t/ha       | 5.82                         | 5.76                      | 99                        |
| Expenses (production), rub./ha| 26847                        | 32931                     | 123                       |
| Cost price 1 t, rub.          | 4609                         | 5764                      | 125                       |
| Price of realization 1 t, rub.| 6800                         | 8169                      | 120                       |
| Cost profit to 1 ha, rub.     | 12756                        | 14151                     | 111                       |
| Level of profitability, %     | 48                           | 43                        | -5                        |

**Compiled on [11].

On the other hand, according to the Russian agricultural center for the Voronezh Region over the past four years (2016-2019), the share of seeds of domestic-selected corn hybrids in the production crops of the region has decreased from 39.2 to 14.3% (table 3).

Table 3. Areas occupied by hybrids of domestic and foreign corn selection in the production of grain in the Voronezh Region for 2016-2019 (th ha).

| Year | Whole area, th ha | Including: | share of domestic selection, % |
|------|-------------------|------------|-------------------------------|
|      |                   | domestic selection | foreign selection |                     |
| 2016 | 209.0             | 81.9        | 127.1                         | 39.2                  |
| 2017 | 234.0             | 51.5        | 182.5                         | 22.0                  |
| 2018 | 177.5             | 43.3        | 134.2                         | 24.4                  |
| 2019 | 202.1             | 29.1        | 173.0                         | 14.3                  |

On the one hand, the advantage of domestic hybrids is evidenced by the data of production crops. Thus, in the Republic of Bashkortostan, when testing 41 hybrids of domestic and 13 of foreign production for grain yield of more than 6 t/ha, 23 hybrids were chosen, 20 of them were domestic, including 13 hybrids of the “All-Russian research Institute of corn”, and only 3 of foreign firms. These tests demonstrated the high competitiveness of domestic hybrids.

In the conditions of cold spring and summer of 2017 in the Republic of Bashkortostan, 14 hybrids of the selection of the “All-Russian research Institute of corn” and 22 hybrids of foreign selection (Pioneer, Evralis, Bayer) showed the best results in early-maturing hybrids Uralsky 150, Mashuk 150 MV, Baikal and Nur. Harvest grain moisture of domestic hybrids was at the level of 28-37%, and foreign – 57-67%.
This is due to the fact that in recent years there has been an acute lack of moisture during critical periods of corn development, which, along with extremely high air temperature, inevitably leads to a shortage of crops due to the formation of a low grain nature.

Comparable data were obtained [1] in semi-arid regions when cultivating corn for grain. As a way out of this situation, the authors suggest using water-saving technologies based on plastic mulch and increased (200 kg/ha) doses of nitrogen fertilizers. This approach allows you to retain moisture in the soil and increase the high mass of dry matter of corn plants, which will have a favorable impact on the level of productivity.

A similar dependence is observed in the corn production in the Russian Federation as a whole. So, according to the “Rosselkhozcentr” for the harvest of 2018, 77.9 thousand tons of seeds were sown in the country. Of these, the share of foreign-selected seeds in the total volume of sown seeds was 38.0 thousand tons or 48.8%. While the volume of sown seeds of domestic corn hybrids was 39.9 thousand tons, of which 2.8 thousand tons were not varietal and were not included in the State register.

Understanding the urgency of solving these problems in the corn cultivation, the company “Pioneer” has concentrated all its resources on breeding resistant hybrids for various soil and climate zones based on increased drought resistance, resistance to major diseases, and accelerated grain moisture recovery. Present high-yield stress-resistant corn hybrids were tested in the harshest conditions of East Africa (in Kenya, Uganda, Tanzania and Rwanda) in 2016 and 2017. Farmers in these countries evaluated the high yield, early maturation, size and number of formed ears of new hybrids, which is described in detail in the article [17].

| Hybrid     | Terms of maturity | Farm                | District       | Moisture, % | Crop productivity, hw/ha |
|------------|-------------------|---------------------|----------------|-------------|--------------------------|
| P9718E     | 390               | “Kolos”             | Alexandrovsky  | 13.6        | 81.1                     |
| P9718E     | 390               | “Novokhatsky A I”   | Alexandrovsky  | 13.5        | 92.3                     |
| P9718E     | 390               | “Dobrovolynie”      | Ipatovsky      | 15.8        | 106.2                    |
| P0023      | 420               | “Agrosoyuz”         | Krasnogvardeisky | 14.8    | 105.9                    |
| P0074      | 430               | “Nadezhda P”        | Novoselitsky   | 12.8        | 71.4                     |

Data from table 4 indicate that a feature of “Dupont” – “Pioneer” products is a high yield potential of hybrids with early corn maturity and a phenomenal moisture yield of hybrids of medium-ripened and medium-late groups.

V I Logvinov, the Deputy Chairman of the government of the Voronezh Region, compares corn crops of foreign selection for grain with domestic ones at the same terms of maturity: more even in height, cobs are located on the same level, which improves harvesting and speeds up maturation; by the time of harvesting, foreign hybrids give away moisture faster (on average they have 21-23%, domestic 27-29%), which allows you to start harvesting earlier in more favorable weather conditions and, in this regard, reduce the cost of drying and grain processing significantly; the yield is on average 2-3 tons higher than domestic hybrids and varieties. They have a narrow direction - grain or silage with the appropriate technology. Some domestic varieties and hybrids have both grain and silage directions and it is not always justified.

In addition, along with the presentation of high-quality seed material, the company “Pioneer” offers a number of free services for customers. For example, the company's specialists tested and calibrated the seeding devices of a number of popular seeders using the MeterMax Ultra stand. This device allows you to adjust the seeding machine, improving the uniformity of seeding up to 96%. The stand helps to set up the seeding device with respect to the seed fraction, sowing speed, placement and seeding rate [16].

According to the data of the “All-Russian research Institute of corn”, the success of domestic breeding is currently not fully realized, since the effectiveness of the implementation of selection
achievements depends on the state of seed production of this crop and the organizational and economic mechanisms for the sale of seeds, which is determined by business in practice. The main reason is that the country has destroyed the system of seed production of agricultural crops and as a result, corn seed production is conducted spontaneously.

It should be noted that the process of selection and seed production of corn consists of certain stages. Figure 2 shows the scheme of seed production of zoned corn hybrids and their parent forms. It shortens the path of the corn hybrid from the breeding field to the production one.

![Figure 2](image_url)

Compiled on [14, 15].

**Figure 2.** Scheme of seed production of double interline corn hybrids by the “recovery” type on the example of the Ross 209MB hybrid.

In accordance to the present scheme the “National center of grain named after P P Lukyanenko” grow: seeds of super elite, elite, the first reproduction of self-pollinated lines, their sterile analogues, analogues of sterility fixers and fertility restorers; super elite and elite seeds of varieties, as well as seeds of super elite and elite of zoned varieties; seeds of initial forms, as well as seeds of the elite or the first reproduction of zoned hybrid populations.

Seed farms of the first group under the guidance of breeding and experimental institutions: seeds of the first generation of sterile simple interline hybrids are grown, which are the mother forms of double interline, three-line and varietal hybrids. Before growing hybrid seeds without breaking off the panicles seeds of the first generation of maternal simple fertile hybrids are also produced for each zoned hybrid; produce seeds of the first generation of paternal simple hybrids both by crossing a sterile line with a line-reducing fertility, and by crossing fertile lines with the breaking of panicles; propagate by replanting the seeds of the first generation of paternal simple hybrids to obtain seeds of the second generation. Simple paternal hybrids are propagated to the second generation by those hybrids which were described above; seeds of the first generation of three-line hybrids, which are the parent forms of five-line hybrids are grown; propagate to the first, and if necessary, to the second reproduction of sterile analogues of varieties and varieties – fertility restorers.

The seed growing farm of the second group: seeds of the first generation of double interline, three-line, five-line, variety-line and inter-varietal hybrids, as well as simple hybrids for forage use are grown at the hybridization sites; seeds of zoned varieties and hybrid populations are propagated, which are transferred to farms for variety renewal.
Variety renewal of seeds of varieties and hybrid populations for production crops should be carried out after the fourth reproduction. All links of seed production are organically linked. Failure to perform work in one of these links leads to a violation of the order in the cultivation of seeds and the supply of hybrid seeds to farms. The main condition for maintaining a high yield of other valuable qualities and properties of zoned hybrids is to maintain the high quality of the original seed material in the process of seed production, its typicity in morphological and economically valuable characteristics and properties. The implementation of such a scheme of corn seed production simplifies significantly and reduces the cost of its seed production [21].

On figure 2 the present organizational scheme functions on the basis of state-private partnership. In fact, the “All-Russian research Institute of corn” jointly with the selection and seed company “Kukuruza”, “Seed growing of Kuban”, “Kos-Mais”, “Otbor”, Povolzhsky branch “All-Russian research Institute of irrigated agriculture”. Unfortunately, none of these organizations (firms) are officially registered as breeding and seed centers, which could contribute to their support from the state in financial and material development. Obviously, it is necessary to develop a regulation on the selection and seed center and legalize in this status those who meet this provision.

Breeding and seed centers should be created on the basis of first of all breeding institutions that have the necessary gene pool of source material for breeding, leading primary seed production at the modern level, high-class specialists, have an instrument base and a sufficient number of specialized breeding equipment.

In our opinion, state that it is necessary to make changes in the present legislation in future of selection and seed of agricultural crops in the Russian Federation:

1. In accordance with the decree of the Government of the Russian Federation of March 31, 2017 No. 396 “On amendments to the state program of the development of agriculture and regulation of markets of agricultural products, raw materials and food for 2013-2020” [8] allows you to create selection and seed centers in crop production on the basis of economic entities that have “ownership and (or) lease of agricultural lands”. Subsidies for co-financing are provided for “…the creation and (or) the modernization of the seed-growing centers in plant growing, belonging to agricultural producers by right of ownership”.

To involve scientific institutions in the implementation of the most important national economic tasks, it is necessary to take measures to eliminate legal obstacles to participation of scientific institutions in state development and support programs, as well as to make additions (changes) to the Land Code of the Russian Federation in terms of granting scientific organizations priority (without participation in auctions) the right to lease agricultural lands for use for research purposes, as well as subleasing these lands to established dependent economic entities – pilot production farms or unitary enterprises that are being transformed into economic entities, or the adoption of a resolution of the Government of the Russian Federation, in which it is necessary to formulate law enforcement practice for the purposeful implementation of the provisions of Federal laws.

2. In order to implement the Federal scientific-technical program of development of agriculture for 2017-2025 years (hereinafter, FSTP) aimed at creating scientific and (or) scientific and technical results and products for the agro-industrial complex, works are being carried out on the formation of the complex research plans (hereinafter, CRP), which are currently a tool for improving the effectiveness of fundamental and exploratory researches and accelerate the implementation of received developments in the real sector of the economy.

In this regard, it is necessary to develop the order of the CRP, to provide it with goals, tasks, mechanisms, and conditions for the formation of such plans. 12 FSTP subprograms were planned for implementation in 2019. One of these subprograms is “Development of corn breeding and seed production”. According to the calculations of the Ministry of Science and Higher Education of the Russian Federation, the amount of funding for the implementation of these 12 FSTP subgroups should amount to 1.5 billion rubles.

3. It is necessary to tighten the legal procedure of importing foreign seeds to the Russian Federation. Importers must provide a test report on the degree of hybridity when replacing a foreign
certificate with a domestic one for cross-pollinated crops (corn, sunflower). In Russia, there are accredited laboratories for this purpose. This procedure exists in the Republic of Belarus and in many other countries, which reduces the flow of low-quality seeds.

4. The final stage of selection work is the testing of varieties and their expert assessment, including zoning. This is done on the basis of a network of stations of the “Gossortkomissia”, which provide an assessment of the applicability of varieties in different regions and soil and climate zones. Currently, the material and technical base and human resources of the “Gossortkomissia” require updating, but funds for this purpose are not allocated from the budget within the framework of the state task for testing varieties and their expert evaluation. As a result, the “Gossortkomissia” approved the provision of services related to the main activities in August 2018. According to Appendix 2 to this Provision, the cost of one variety test for distinctness, uniformity and stability should have been 41900.62 rubles, and the cost of one variety test for determining economic utility by competitive variety tests 43264.70 rubles. In addition, a project has been developed for the distribution of crops by variety stages, according to which the typical number of variety stages that will be tested will be reduced for certain crops. Thus, it is planned to solve the problems of underfunding the “Gossortkomissia” by reducing the list of works performed and transfer to paid services.

The question of financing these works remains open, since the state task of selection institutions of the Ministry of Science and Higher Education of the Russian Federation has not had any sufficient funds for these purposes.

4. Conclusion
Based on the researches conducted, we consider it appropriate to propose a set of priority organizational and economic measures for accelerated production of corn hybrid seeds in the Russian Federation.

1. Improvement of existing legislation in the field of selection and seed production of agricultural crops in the Russian Federation and protection of intellectual property in the country.

2. Changes in the scale of state financial support for the sub-sector of breeding and seed production. At the same time, it should be recognized that it is possible to compete strenuously in the world seed market only with comparable amounts of funding for science. In addition, it is necessary to make more effective use of existing state support measures set out in the FSTP [10].

3. Creation of innovative infrastructure in the field of breeding and seed production on the basis of the national project “Science” developed with the May Decree of the President of Russia [7] and the FSTP.

4. Improvement and development of the system of training and retraining of personnel in the field of selection and seed production both on the basis of agricultural universities of the Ministry of Agriculture of the Russian Federation and the leading scientific and educational centers of the country [22].

5. Upgrade existing plants and find funds for the construction of new corn-sizing plants for the production of first-generation hybrids, elite seeds, parent forms and experimental hybrids based on public-private partnerships. At the same time, it should be remembered that the return (profit) from the invested funds in the selection of corn does not occur immediately, and a certain (sometimes quite long) time lag is required before the implementation of these projects.

6. There is a need for state marketing and export organizational and economic support for existing corn hybrids in order to enter both the seed market of the member States of the Eurasian economic Union and the world markets.

Implementation of the listed organizational and economic measures for accelerated production of corn hybrids in the country will contribute to solving the problem of import substitution of seeds, designated by the President of the Russian Federation in the doctrine of food security of the country [4].
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