Increasing the resource efficiency of storing agricultural products

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Abstract. The article presents statistical data on the dynamics of the development of the Russian agro-industrial complex in the direction of increasing productivity and notes the problems faced by the processing industry (crop products). For successful crop production, plant protection products are used that enter the soil and groundwater, which indirectly affects the state of the environment. The importance of the implementation of the Long-term strategy for the development of the grain complex of the Russian Federation was emphasized. Analyzed data from studies on the storage of grain harvest, which is subjected to fumigation; an assessment of the safety of the tightness of the filled power carriers was carried out. The features of soil, water and air pollution in the zone of influence are discussed. The danger of using pesticides, which create risks of chemical contamination of environmental objects and food products of the population, is emphasized. Statistical information characterizing modern methods of grain storage in the Southern and Central Federal Districts, the pros and cons of these methods are considered. Examples of the practical significance of power runners in the process of grain storage are given (based on data from representatives of the agro-industrial complex). The issues of fumigation of the grain mass at the stage of storage in silobags are touched upon. The possibility of environmental impact of by-products of storage of grain mass is discussed. Ecological aspects of this storage technology are analyzed. Proposals for improving approaches to the storage of grain mass are formulated.

1 Introduction

Increasing the export potential of the Russian Federation is based on the use of modern agricultural technologies in crop production (including the introduction of modern plant protection products (PPP), the use of liming of acidic soils on arable land, etc.) and the introduction of new arable lands into the farming structure. In 2023, agricultural production is carried out on an area of 170 thousand hectares [1]. It is expected that these approaches will allow to obtain additional growth in crop production, despite the negative effects caused by climate change. The main product of crop production is the grain of cereals and leguminous crops, which are goods exported by Russia abroad.

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According to the Federal State Statistics Service, an annual increase in the gross grain harvest is observed on the territory of the Russian Federation. Figure 1 shows the dynamics of the gross harvest for the main cereal crops, compiled taking into account the refinement of grain to basic indicators [2].

According to preliminary data of the Ministry of Agriculture of the Russian Federation for 2022, 153.8 million tons of grain crops were harvested in the country, of which more than 104 million tons were wheat, the leaders in the gross harvest of grain and leguminous crops are the Southern Federal District, the Central Chernozem Region and the Altai Territory [3]. Note that Russia is one of the ten largest world exporters of grain [4].

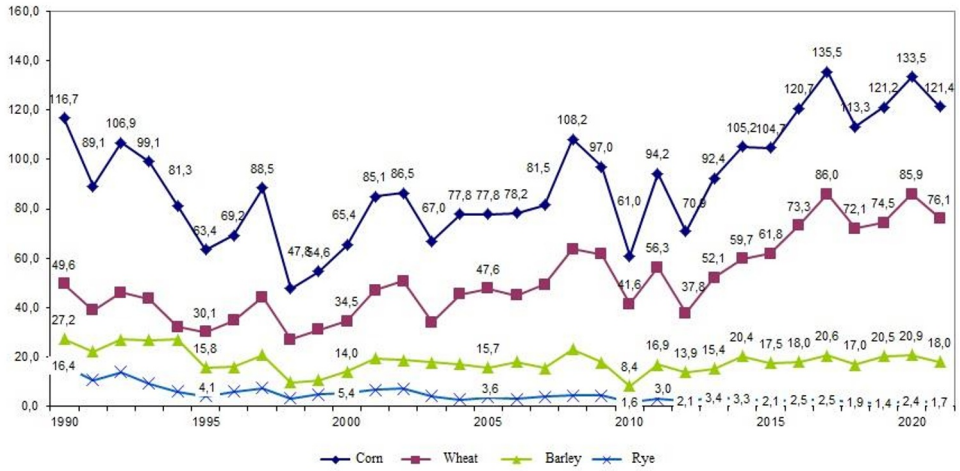

Fig. 1. Gross grain harvest in farms of all categories of the Russian Federation (test weight) (Source - Rosstat).

In most cases, high yields are determined both by natural conditions and the applied agricultural technologies, including plant protection means at the stage of plant vegetation. In addition, when growing a number of crops, they resort to the process of desiccation - the treatment of fields with special dehydrating agents; desiccation is aimed at reducing grain moisture and reducing its losses during harvesting. The active ingredients of desiccants are glyphosate (isopropylamine and potassium salts), diquat, and carfentrazone-ethyl, which can be retained in some organisms [5-6]. In recent years, cases of mass death of insects, which are recorded (honey bees) during the processing of fields with plant protection products, have become more frequent, but there are also representatives of wildlife (wild bees, wasps, etc.) whose records are not kept [7]. However, it is economically unprofitable to do without plant protection products in modern agricultural technology [8].

To reduce the negative impact on the environment, including that caused by the chemicalization process, it is necessary to ensure proper storage of the harvested crops. Loss-free storage of grain mass will ensure the rational use of resources and help reduce losses throughout the entire production chain.

At the same time, the quality of storage of marketable grain is affected by the material and technical base of stationary elevators and granaries. The Ministry of Agriculture of Russia notes the lack of granaries that fully meet modern requirements; Currently, only 60% of granaries meet such requirements [9]. The lowest percentage of modern grain storage capacities in 2017-2018. was observed in the Urals (42%), Southern (49%), Volga (57%) and Siberian (58%) federal districts. The long-term strategy for the development of

the grain complex of the Russian Federation until 2035 is intended to solve this problem [10].

2 Materials and methods

The main method of obtaining the data analyzed in the article is case studies conducted by visiting pilot sites of the Russian agro-industrial complex in the Central Chernozem region. Case studies are quite widespread in applied environmental work. As a rule, in such studies, according to the principle of audit, evidence is identified, first of all, deviations from the required characteristics of certain parameters, the reasons for the observed deviations are established, and recommendations are developed for their elimination [11]. In cases where the identified evidence (audit), on the contrary, characterizes the advantages (organizations, technologies, approaches to solving the problem), in the course of case studies, the possibility of replicating technologies, technical and managerial solutions that are of greatest interest is established [12].

3 Results and Discussion

When examining pilot facilities, not only was there a shortage of granaries, but also a high degree of deterioration of those that are currently used, although they are structures of the 1970-1980s. The walls of the silo buildings are destroyed from the inside, the throughput of grain is reduced (to be finalized to the baseline). Granaries cannot accommodate grain in the quantities indicated in official documents (passports).

In this regard, the surveyed agricultural enterprises are forced to carry out temporary storage of grain (without refining) in riots on currents or in the open air; under such conditions, the grain can be for a significant period of time (from 1-2 weeks to a month), which leads to the development of self-heating processes and deterioration of quality indicators, since irreversible protein denaturation occurs at elevated temperatures.

To prevent such losses, the heads of agro-industrial enterprises located in the Southern Federal District and the Central Chernozem Region decided to use modern technologies for storing grain of a non-stationary type with the placement of power carriers with grain in open areas.

Silobags are three-layer polymer sleeves designed for long-term storage of the crop, their length is 60-75 m, the capacity varies in the range of 200-250 tons of grain. When grain is placed for storage in silobags, it is, as a rule, pre-treated (brought to the baseline for moisture, weed and grain / oil impurities, etc.) and hermetically sealed.

It has been established that in some cases grain storage is carried out with high humidity of grain (17-19%), which leads to conservation of products due to anoxianabiosis, in other words, storage of products without air access, in an oxygen-free environment. However, this approach requires preliminary preparation of the stored grain (bringing it to the baseline) and reliable sealing to exclude the access of atmospheric oxygen. A reliable scientific rationale for the benefits of storing cereals with a high moisture content of up to 19% in silobags has not yet been published.

Increasing the resource efficiency of the process of storing crop products, reducing losses and the possibility of reducing the involvement of chemicals in grain production is of undoubted interest in the context of the sustainable development of the agro-industrial complex. Therefore, scientific research in this area should be continued, also paying attention to the development of recommendations for Russian enterprises.

From a practical point of view, in accordance with the positions of representatives of large agro-industrial complexes, the main advantages of storing grain in silobags are [13]:

- No need to stop harvesting due to lack of storage capacity.
- The possibility of storing any grain, legumes and oilseeds.

On Figure 2 shows the area reserved for grain storage in silobags.

Fig. 2. Grain storage area in silobags (photo by the authors).

In the course of case studies, it was found that the tightness of the silobags is often violated, in some cases - in the process of grain quality control. Sampling from silobogs is carried out with the help of grain samplers or a manual sampler of bulk materials; during sampling, the walls of the power carriers are damaged, and the resulting holes are sealed after sampling is completed. In addition, due to the fact that the power runners are made of polyethylene and are stored outdoors, in unfenced areas, they are often damaged by wild animals.

On Figure 3 shows a damaged silobog with a scattering of grain.

Fig. 3. Damaged power runner (authors photo).

It should be noted that spilled grain can be a hazard to wildlife when fumigated.

Another circumstance that should not be overlooked is the formation of polyethylene waste (since silobags cannot be reused). The Federal Classification Catalog of Waste classifies polyethylene containers as hazard class IV waste. Usually, at agricultural enterprises, attention is paid to the handling of waste generated during cleaning of

equipment, cleaning up spills, etc. Despite the fact that polyethylene silobags are low-hazardous waste, the task of separate collection of such waste with subsequent disposal remains relevant, especially in the context of the federal project "Ecology ".

In the information and technical guide on the best available technologies ITS 15-2021 "Utilization and disposal of waste (except for thermal methods" [14] systematized approaches to the disposal of obsolete products made of polymeric materials (low-pressure polyethylene, high-density polyethylene, polypropylene). These approaches should be taken into account when developing enterprise management systems and identifying organizations that can accept production waste for processing and disposal.For example, ITS-15-2021 describes methods for obtaining granules from polymer waste with a finished product yield of at least 90% of the mass of pre-treated waste received for recycling [14].

4 Conclusion

In modern conditions, one of the main tasks of the cultivation of agricultural crops is to create an integrated grain storage system, supplemented by systems for the timely processing of grain to basic indicators (such as moisture, weed and grain / oil impurities). The grain storage system is designed to reduce quantitative losses and prevent the deterioration of quality characteristics during crop storage.

For this it is necessary to provide:

- Development of new and improvement of known methods of storage, allowing for the operational processing of grain to baseline indicators in the field, in order to reduce the load on elevators and grain receiving points during the period of an active procurement campaign.
- Development of guidelines for the storage of grain in silobags, taking into account the climatic conditions of the regions of Russia.
- Conducting a production check of the methods of disinfecting the grain mass from pests of the grain stock in the silobegs.
- Assessment of the expediency of referring grain storage processes to the areas of application of the best available technologies in the Russian Federation (with the subsequent development and application in practice of an appropriate information and technical reference book).

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