Experience and prospects of the use of precision livestock farming in the Russian Federation

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Abstract. The purpose of the work was to analyze the use of precision livestock farming technologies in the Russian Federation. A number of highly promising directions in the development of agriculture in general and animal husbandry in particular in the agro-industrial complex of the Russia Federation was described in the article. The main attention was paid to the development of precision livestock farming technologies as the most important component in the digital transformation of agricultural production with its most developed livestock segment and especially dairy cattle breeding. An overview of some important software products being developed, implemented and already widely used, information systems, and other digital solutions are extremely necessary for the effective functioning of the livestock industry of Russia. Some landmark developments, examples of the introduction of precision livestock farming elements, automation systems, information and analytical systems in agriculture, which are actively engaged in a number of organizations of the Russian Academy of Sciences and especially scientific and practical centers, scientific and research institutes as well as other domestic organizations of various departmental affiliation and form of ownership, have been considered. The new opportunities and advantages received by the state and farmers from the use of various digital solutions in the field of animal husbandry have been discussed.

1 Introduction

One of the highly promising fields for the development of the domestic agro-industrial complex is its digital transformation, which uses smart networks and data management tools. The purpose in digital agriculture is to use all available data, information and accumulated experience to automate processes in both crop and livestock production, i.e. digital agriculture means going beyond the mere availability and accessibility of data and

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creating truly actionable artificial intelligence and meaningful added value from such data. The main tool for digital agriculture is to ensure communication between individual units of agricultural machinery, complexes of complex equipment, etc. (machine2machine), and between the agricultural machine and the cloud data storage (machine2cloud), as well as the possibility of continuous data exchange between storages (cloud2cloud) [1, 2].

Development here is moving along the path of increasingly easier, unhindered and speedy exchange of various data and information. The technologies under consideration are being improved very dynamically, and active work is underway to create a single data collection center, which will accumulate the entire volume of information about the operation of equipment in fields, gardens, livestock farms, poultry farms, etc. Subsequently, as data is accumulated and continuously analyzed, automatic improvement and improvement of technologies in agriculture, livestock farming and other sub-sectors of the agricultural sector will occur [3, 4].

Currently, the level of digitalization of agricultural production in the Russian Federation is not enough. However, this is one of the most promising areas in the world, investments in which have overtaken even the financial sector over the past few years. Digital solutions are increasingly penetrating all segments of agriculture. With the rapid development and adoption of mobile computing, high-speed internet and satellite communications, digital technology in agriculture (AgTech) has gained widespread adoption. The leaders in the introduction of new technologies in the agricultural sector now are Israel, USA, Canada, Germany, Japan and other agriculturally developed countries [5].

A separate segment of digitalization has already formed in the world. These are digital technologies used in agriculture, and this segment is growing at a colossal pace. Earlier digitalization in agriculture was mainly limited to banal automation of certain types of activities. For example, monitoring the condition of crops or monitoring animal health, now we are talking about “smart” solutions for managing production processes and machines and equipment widely used in crop production, livestock farming, processing of obtained agricultural products. The two areas of digital transformation of the country’s agricultural sector are currently receiving the most attention: precision farming and “smart” or precision livestock farming [6].

For precision livestock farming a number of domestic large agricultural farms are already using robotic milking modules with monitoring the quality of milk and the physiological state of animals, which reduces the incidence of mastitis in cows by 25-30% and increases the longevity of cows to 4-5 lactations. At the same time, the profitability of products produced using the technology “Smart Farm” can already exceed 40% [7].

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2 Materials and methods

The analytic analyses of foreign and domestic management experience in the field of agricultural development such as experience and prospects, and also the impact of digitalization was done on the base of own date and references sources.

3 Results and discussion

Precision livestock farming is to use the advanced technology to optimize the contribution of each animal to the production process. According to some experts, precision livestock farming is a general requirement for all animal husbandry processes, which creates opportunities for economically effective making of new requirements using modern

technology, electronic identification of individual animals or groups of contents, registration of data on processes and products, and processing of information [8].

Domestic livestock scientists clearly define that "smart (digital) agriculture" aims to automate agricultural activities as much as possible, increase production volumes, and improve products quality. Precision livestock farming is a particularly promising area here. Of the elements of precision livestock husbandry the most widely used are the identification and monitoring of individual animals using modern information technologies such as feeding ration, milk yield, live weight gain, body temperature, activity, meeting the individual needs of animals; automatic microclimate regulation and control of harmful gases; monitoring of herd health and products quality; electronic database of the production process; robotization of the milking process.

Due to the use of electronics, sensors, special software and computers, it is possible to accurately identify individual animals, allowing them to be treated individually. Currently, automatic feeding with individual dosing of feed is already in practice, electronic motion control systems are used to identify sick animals or animals in heat, individual milk and beef productivity, the quality of milk and beef are automatically documented. Further development of livestock digitalization systems is aimed at universalization, ensuring the compatibility of various systems, comparability of collected data, and coverage of the entire production chain [9].

Smart farms (sensors, devices and monitoring software) can improve animal productivity and products quality. According to market experts, automated systems for feeding, milking and monitoring the health of livestock can increase the milk yield of cows by 30-40%.

The scientists of the Federal Scientific Agro-Engineering Center VIM, Russian State Agrarian University – Moscow Timiryazev Agricultural Academy and others research organizations are actively engaged in the issues of automation, informatization, digitalization of agriculture, the development and implementation of elements of precision livestock husbandry in domastic agriculture [10].

Thus, the Federal Scientific Agro-Engineering Center VIM is developing individual elements of electronic agriculture systems. Unfortunately, at this point in time in our country, the development, production and use of precision livestock husbandry systems is still at a rather low and even rudimentary level. The center is actively working to create new systems for preparing and distributing feed. On many domestic farms with free-stall housing of animals concentrated feed is rationed by the automated cow feeding stations domestic and foreign production. The use these feeding stations makes it possible to automate the process of issuing concentrated feed, as well as to control the use of high-energy feed through automated process control systems on cattle farms.

Russian scientists have developed the automated installations for feeding calves, which allows us the use of both whole milk and its substitutes, as well as control the technological process of feeding calves through the automated process control system of the farm. It is mastering the serial production of these installations. The Federal Scientific Agro-Engineering Center VIM is also actively developing new systems for milking cows, and is mastering the production of an automated herd management system on dairy farms with automated process control systems, which is adapted for use in conjunction with milking control systems of domestic machine-type milking.

The Federal Scientific Agro-Engineering Center VIM is developing a National Automated Information System for the identification, registration, and traceability of animals and products of animal origin, used to register owners of animals of all forms of ownership, livestock facilities and animals themselves.

The system reflects in real time information about the health and veterinary welfare of each farm animal throughout its life, as well as about all supplies of meat and dairy

products produced from identified animals. The system receives daily information about by whom, what kind of products were produced and with what quality indicators, what raw materials, from what livestock facilities (up to the identifiers of specific animals) were used for its production, as well as a register of all shipments of each daily manufactured batch of products for each specific name with the provision, if necessary, of digital (electronic) passports of goods. Any participant in the supply chain can receive a single electronic veterinary certificate (EVC), containing data on shipment, and data on each specific item of product in the shipment, include quality and veterinary safety indicators.

The structure and format of the EVC comply with the international standard e-CERT, recommended by the UN Committee on Facilitation of Procedures in Trade, Transport and Logistics (UN/CEFACT).

Technical and economic advantages of the system show the following: it is can be the only information system in Russia as well as in Europe and Asia that provides an integrated approach to ensuring “end-to-end” safety of food chains from animals to finished meat and dairy products. As a result of the functioning of the system, the activities of livestock and veterinary services at all levels are automated. The system is integrated with the Russian state electronic veterinary certification system "Mercury", which simplifies the control of product shipments by the authorized bodies of the Russian Federation.

Innovative aspects of the system are: it uses modern international livestock and veterinary reference books, global standards for identification, traceability and electronic data exchange, and has a flexible configuration system. The system provides the ability to use both bar codes and RFID tags as animal identifiers.

The national automated information system for identification, registration, traceability of animals and products of animal origin is used in agriculture of the Russian Federation to identify owners of animals of all forms of ownership, livestock facilities and animals themselves. The new system is ready to be implemented and operated in the Russian Federation by the Federal Scientific Agro-Engineering Center VIM.

The Federal Scientific Agro-Engineering Center VIM has developed a program for automated control of the breeding process based on the MSAccess DBMS. The program consists of a mechanism for entering, storing, processing data and presenting reporting information.

This program includes a complex for entering the necessary primary livestock information: reference with means of data entry control and automatic conversion to standardized values using both existing and original methods with the ability to edit data; a data storage complex consisting of data storage tables and reference information on a coding and identification system developed for this program, providing the minimum required quantity and volume of data; a complex of output documentation, consisting of both standard forms of breeding reporting (journals, cards, breeding certificates, etc.), and reports necessary for analyzing the work of the herd (culling of animals, productivity, work of operators, sections, etc.) with the ability to sort and filtering data by farms, reasons for disposal, breeds, sex, time periods, etc.; modules necessary to optimize the work of the breeder such as mating on of pairs taking into account inbreeding, determination of family relations between animals, means, sorting and selection of animals according to productive traits, index assessment, work with the herd without the use of paper, data archiving.

A laboratory of information technology automated systems in livestock breeding has been established at the Center.

Main directions of laboratory research: development and implementation of a complex of software and hardware, administration of databases and data banks of breeding products (material) of livestock breeding subjects, and their integration at the industry level into the central data bank; centralized making of regulatory and reference information, support of the state information system in the field of livestock breeding.

One of the main Center developments is a system for organizing breeding work in the Russian livestock farming. A worthy example of the practical implementation of projects on automation and digitalization of livestock farming is in the industrial farm of the Moscow region. Just one person makes sure that all milking places are working, a special mechanism automatically brings the cows to the milking parlor, the cow enters an empty place for milking, the computer remembers the structural features of the udder of each animal, and the equipment massages the udder, processes it, and milks the first streams of milk, sorting milk into separate tanks [11].

The Ministry of Agriculture of the Russian Federation also supports projects for the introduction of automation systems in livestock farming and elements of livestock production in the country's agro-industrial complex. At the same time, services are provided in the field of information technology in the following areas: development, implementation and maintenance of automated information systems for the Ministry of Agriculture and agricultural enterprises; software development, implementation and maintenance of the state information system in livestock farming; development, implementation and support of automated enterprise management systems; technical service of computer equipment, creation of local computer networks and video surveillance systems.

An information system for cattle breeding is being developed at the Federal Scientific Agro-Engineering Center VIM. Its main tasks: software development, implementation and maintenance of the state information system in livestock farming as part of the implementation of the “Law on Breeding in Livestock Husbandry”; development of software for evaluation of animals for the quality of their offspring using modern internationally accepted methods as well as supporting the transition to genomic assessment of animals; development, implementation and support of interaction between the breeding oragnizations and the information system for identification, registration, traceability of animals and products of animal origin; development of software for communication with devices installed in centralized laboratories for the analysis of quality indicators of milk.

The information system for cattle breeding is intended for livestock and breeding records of cattle and ensures the functioning of four levels of management: farm level – computer-equipped workplace of livestock breeder; district level – district cattle database; regional level – regional cattle database, state bull-stud database, dairy laboratory software; country’s level – database of cattle of Russia central database of bulls.

The system software allows us to: optimization of the selection process at various levels of management; evaluation of sires based on the quality of their offspring and the linear profile of their daughters; establish and centralized maintenance of the State Stud Book; issuance of breeding certificates for young animals, cows, bulls and embryos; improvement of breeding methods based on the modern development of population genetics.

RFID technologies are developing in Russian livestock farming. Today there are more than two dozen domestic and foreign enterprises on the domestic market. The use of such technologies makes it possible to automate a range of tasks, including recording livestock and monitoring its movement, collecting accurate data and indicators, incl. timing of feeding, vaccination and optimization of breeding work.

Thus, labor costs are significantly reduced, the likelihood of errors caused by the human factor is minimized, information processing is accelerated, and the identification of positive and negative heredity is simplified. In general, radio frequency identification is one of the most promising technologies, which are used not only in livestock farming. It is also effective in the digitalization of other industries and sub-sectors of the domestic economy. Modern livestock and meat processing enterprises have to solve a lot of specific problems in order to ensure stable business growth and at the same time comply with industry standards. Here are just a few challenges that radically affect the efficiency of such enterprises: difficulty in tracking and controlling the movement of livestock; accuracy and

regularity of control over feeding and activity of animals; duration and complexity of the process of recording various activities (sampling, analysis, vaccination, collection and transmission of information to government agencies); the difficulty of collecting statistics on the condition of animals; ineffectiveness of the animal personal identification system; accounting for consumption of feed and related materials; human factor bordering on conflict of interest.

Almost all these issues will be helped by the introduction of a system for identifying and recording farm animals, feed and finished products based on RFID tags. The livestock enterprise receives the following opportunities and advantages: the emergence of a database with information about the life cycle of an animal at all stages; control and management of the movement and nutrition of each animal; control over the feed supply and accounting for consumption and distribution, dosing; electronic passports for each animal or finished product unit; improvement of the quality control system for finished products; increasing the loyalty of buyers of finished products by placing information about the product on the RFID tag (name, production date, expiration date, composition, storage conditions, marketing information, etc.); the buyer can read the information on the RFID tag using his smart phone right in the store; the tag cannot be faked - this will certify the authenticity of the product on the store shelf; RFID marking system for animals and finished products can be easily supplemented with a BAR or QR code subsystem [12].

More than a dozen domestic companies are engaged in the development, production or supply from abroad of automated and robotic milking systems and equipment. An automatic milking machine completely replaces working personnel and eliminates the occurrence of the “human factor”. Robotic milking machine can be placed in any room. An animal identification system, instant display of deviations in the milking process, full control at all stages. These are just the main advantages of robotic installations [13].

The equipment allows us to increase the efficiency of farm management: constant monitoring of livestock, statistical data containing information about each milking with measurements of milk quality. The robots itself provides information about the analysis of its parameters, helping to track and change consumables in a timely manner and maintain mechanisms in excellent technical condition [14].

Robotic milking has many advantages such as: health control and stress-free animals. Due to robotic milking, animals avoid group movements and long waits in line for milking. This has the best effect on the quality and quantity of milk; automatic milking provides control over the amount of milk in the udder, excluding incomplete milking or over milking. The milking robot for cows is programmed to prevent mastitis. Each quarter of the udder is checked for blood and electrical conductivity; if problems are detected, the milk will be automatically redirected to a separate container. All processes are automated, from udder treatment before and after milking to teats stimulation. Milk quality control takes the farm to a new level. Dairy products from robotic farms are used to make baby food and cheese of the highest quality; the increase in milk yield with the help of a system for automatic milking of cows is due to the optimal organization of the animals’ lives on the farm, allowing them to determine for themselves how many times a day they need to go for milking. In some animals with an increased amount of milk, this process can be carried out 4-5 times per day. This approach allows us to increase farm productivity by 10% in the first month; saving time and staff. This significant problem the lack of the required number of personnel is solved by the use of robotic installations on the farm. Human resources are freed up for tasks such as herd management and decisions about the effectiveness of care and feeding. Hard work on the dairy farm is being easily replaced by robotic systems for cows. The robot operates 24/7, while the quality of care for the cow's udder and milk control remains unchanged; robotic milking collects statistics and helps you see the big picture. You can track your results remotely; another important advantage is the modular

structure of robots. As the number of heads in the herd increases, you can purchase as many boxes as needed. And the compactness of milking robot solutions indoors allows you to place a larger number of cows in a smaller area, which is more economically profitable [15, 16].

Animals for which robotic milking is organized feel more comfortable, and therefore their milk yield and quality of dairy products increase. When the cow decides for herself whether to eat, rest or go to milking. She is most productive because she does not feel the danger and discomfort of waiting for many hours for milking. Free housing system of the herd not only increases the efficiency of livestock farming, but also makes its management easier and more enjoyable. But before the final choice of option occurs, you will first need to determine what basic characteristics the milking parlor equipment must meet. Here it is important to take into account everything: the price of robots, their dimensions and technical parameters as well as the number of livestock in the herd for which the equipment is designed [17].

It is quite obvious that it is very difficult to create effective digital solutions for a specific agricultural enterprise. It is even more difficult to implement them and achieve maximum efficiency in their use. Thus, according to the authoritative analytical company McKinsey, about 84% of all digital transformation projects fail. According to surveys conducted by the Ministry of Digital Development, Communications and Mass Media of the Russian Federation in 2020, it was revealed that only 35% of state-owned companies are actively carrying out conscious work on digital transformation, 48% understand that this is important. But so far the process has not been systematically launched and only 18% of state-owned companies have a clear understanding that digital transformation is an absolute priority. It is impossible without it to talk about creating a fully competitive business.

It is modern digital technologies and systems that in the near future, with a consistent, competent approach to their implementation and subsequent use, are capable of: uniting and linking all structural divisions and components of both a specific small agricultural farm and large agricultural production and processing holdings and even sub-sectors at all. Already at a completely new management level, regardless of their versatility or the often extremely complex structure of these managed organizations, it is optimal to use the entire set of available various tools and resources to create a truly effective, holistic, coordinated and rhythmically functioning management in agricultural business at all levels (both at the level of enterprise, district, region, and ultimately at Russian level).

4 Conclusions

Consequently, precision livestock farming and its further automation represents a higher level of digital integration, which affects the most complex organizational changes in government structures and business, but the implementation of this issue can radically affect the profit and competitiveness of products and the agricultural industry at all.

We especially note that maximum automation of all stages of the production cycle is becoming a primary task of information and the latest digital technologies. However, even in this case the result applies only to finished agricultural products and does not guarantee one hundred percent profit, because before the finished product reaches the consumer it must be stored, undergo primary processing and be transported.

We should not forget about the technological problems that await electronic agriculture with its further implementation in the agricultural sector of the economy. These are the complexity of using and analyzing large amounts of data, ownership of data and data sovereignty, interoperability, slow implementation of innovations in agriculture and problems with cybercrime. The widespread use of Internet resources increases the vulnerability of digital relations in the agricultural sector.

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