Integration of logistic principles into resource-saving technologies, precision and organic farming

O V Moisseyenko1*, S I Bobkov1, M F Kozlova1, Zh G Jabassova1 and V S Kukhar2

1 Kostanay Engineering and Economics University named after M. Dulatov, Kostanay, Kazakhstan
2 Ural State Agrarian University, Yekaterinburg, Russia

* E-mail: mov.74@mail.ru

Abstract. The article presents an analysis of technical means and logistics principles used in the agro-industrial complex of the northern region of Kazakhstan in the implementation of resource-saving technologies, precision and organic farming. The analysis of scientific and technical literature and the production situation shows that the use of individual elements of the precision farming system in various technologies can increase labor productivity by up to 10% and reduce the total costs of cultivating crops by up to 25%, and the use of modern high-performance machine complexes equipped with recommended elements of the precision farming system can increase productivity by 1.7...2.3 times compared to the existing fleet of agricultural machinery. In turn, compliance with the logistics principles of resource provision of agricultural entities at the regional level at the present stage of development is an objective condition for their successful functioning. The allocation of resources should ensure the formation of effective logistics systems that guarantee the refinement of resources to places of consumption in accordance with the interests of all economic entities using resource-saving technologies, precision and organic farming.

1. Introduction

One of the most important problems in agriculture remains the increase in the production of crop and livestock products as the main food products. In a market economy, the efficiency of agricultural production largely depends on the competitiveness of products, which in turn depends on the technology chosen at the enterprise in combination with optimal control of technological processes.

It is only possible to ensure profitability, quality of agricultural products and maximum returns in the cultivation of crops and the industry as a whole by switching from costly agricultural technologies to resource and moisture-saving technologies using digital technologies in crop production, in particular, precision farming systems, as well as the use of organic farming. With the advent of new technologies in agriculture, such as precision farming (precision agriculture), organic farming (organicfarming), which are widely used in Europe, as well as in the USA, Canada, Argentina, there are ample opportunities for achieving optimal results in terms of profit + environmental safety [1-12].

The growing population of the world has led to an increase in demand for agricultural products. But at the same time, supply opportunities are shrinking due to declining land availability and climate change. Analysts argue that an "agro-technological revolution" is needed and precision farming is becoming an innovative solution. Precision farming is based on optimized cost management in the
field in accordance with actual crop requirements. This farming system includes data-driven technologies, including satellite positioning systems such as GPS, remote sensing and the Internet, to manage crops and reduce the use of fertilizers, pesticides and water.

This must be used in agricultural production throughout Kazakhstan and, especially, in the northern regions, which are the main grain-sowing region, on the sown areas of which most of the grain, legumes, oilseeds and cereals are cultivated. At the same time, their use in combination with other factors provides ample opportunities for increasing labor productivity. However, there is no scientific and methodological base that would give recommendations on the rational use of high-performance agricultural machinery in conjunction with digital systems and equipment for precision and organic farming in the Republic of Kazakhstan.

Promising directions for solving emerging problems are programs of "precision farming", "smart farming", which operate in dozens of countries, which are implemented through the application of the principles of logistics.

The basic principle of precision farming is to optimize cultivation technologies and production management for each specific area of the field. Thus, precision farming allows not only to obtain significant cost savings, increase productivity and yield, but also effectively protect the environment.

The basic principles of logistics include: consistency, complexity, scientific nature, concreteness, constructiveness, reliability and variability.

- consistency - presupposes an approach to the logistics system as to an object represented by a set of interrelated elements;
- complexity - coordination of actions of participants in the logistics process;
- scientific character - the use of a scientific approach and calculation principles when optimizing flows;
- specificity - a clear definition of the results of the activities of the logistics departments of the enterprise;
- constructiveness - operational regulation of the flow and tracking the movement of its individual elements;
- reliability - ensuring the continuity and safety of the flow;
- variability - the allocation of various options for the movement of goods and the choice of the optimal option in accordance with the criterion of the minimum total costs [13].

It is worth noting that in Kazakhstan, since 2017, a program for the digitalization of the agro-industrial complex has been operating, which includes the introduction of a system for tracking crop and livestock products in the country, the creation of a national spatial data infrastructure, and the development of e-commerce. Based on the results of the project implementation in 2021, every fifth agricultural producer should have an advanced level of implementation of digitalization elements.

In turn, in non-CIS countries, the European Union is gaining popularity in the use of environmentally friendly products grown using organic farming technology or moisture-energy-saving technologies, the implementation of which excludes the use of pesticides to destroy weeds, diseases and pests. For this, exclusively mechanical and biological methods are used, as well as rational crop rotations that allow suppressing the growth of weeds and diseases [14-16].

In organic farming, deep tillage is practically not carried out, since its use leads to the destruction of the soil structure and, accordingly, the loss of humus and nutrients. Surface treatment is allowed to control weeds and preserve soil moisture. Also, mineral fertilizers are not used, only organic fertilizers are applied (humus, manure, green manure). At the same time, crop rotations in organic farming play a key role, due to their use, a natural decompaction of the soil occurs (by alternating crops with different root systems), the soil is saturated with organic matter in the form of roots remaining in the soil, as well as plant, crop residues, grown green manures on it. surfaces that are not recommended to be repaired. Plants left on the soil surface inhibit the growth of weeds, prevent the evaporation of soil moisture, minimize wind and water erosion, and then, decomposing, saturate the upper layers with essential elements, including nitrogen and phosphorus. This allows farmers to get organic produce without the use of chemicals.
In this regard, the information provided will allow the farmers of Kazakhstan to receive exactly such products with sales markets in the EU countries, and the logistics structure will deliver these products with minimal costs.

The goal is to introduce the principles of logistics in the system of precision and organic farming in the conditions of the northern region of Kazakhstan, ensuring an increase in labor productivity and the quality of products obtained in the main technological operations.

2. Materials and methods

During the research, theoretical methods were used based on the application of a systematic analysis of production processes, the main provisions of the theory of machine-tractor units, the results of the analysis of scientific and technical literature, as well as methods for testing technical means in the system of precision farming.

3. Results and discussion

For the development of precision farming in the republic, the German company CLAAS, as well as scientists from Germany, were involved. The first result of the work of the center is the drawing up of a cartogram, which determined the state of the soil in the sown areas.

Currently, the main systems on tractors and combines for the cultivation of major crops are mainly GPS trackers with fuel level sensors, parallel and automatic driving systems that operate in two global positioning systems: American GPS and Russian GLONASS.

At the same time, GPS trackers with fuel level sensors can be part of these systems or be used independently (they allow, respectively, to determine the location of equipment and specific fuel consumption). Modern systems with GPS navigation allow you to lay and track both straight and curved paths of movement, and their combinations. The ability to memorize not only the end and start points of the row, but also any curve as a reference line allows you to implement a wide variety of field processing options.

These elements are presented by such manufacturers as "Trimble EZ Guide", "Commander", "AGROGLOBAL", which operate in two global positioning systems: American GPS and Russian GLONASS.

In addition, along with navigation systems, the following are widely used: seeding monitoring systems installed on sowing units during sowing operations (sowing grain, leguminous crops, corn); yield mapping systems installed on combine harvesters; as well as systems for the differentiated application of mineral fertilizers used for intra-soil application of mineral fertilizers, installed on tillage implements, as a rule, on cultivators-fertilizers for the cultivation of cereals, legumes and forage crops.

Each of the presented systems affects a number of functional, energy, operational and technological indicators of the functioning of agricultural machinery in the system of precision farming.

Analysis of scientific and technical literature and production situation shows that the use of parallel and automatic driving systems installed on units for sowing, plant protection, basic tillage and harvesting of spring wheat, can increase productivity by 3.0 ... 10.0%, reduce consumption fuel by 1.2 ... 7.0%, the rate of consumption of technological material (seeds, herbicides) by 3.0 ... 7.5% and the total cost of operating equipment by 2.5 ... 7.0%. Seeding monitoring systems allow reducing the proportion of siftings by 1.7 times, increasing productivity per hour of shift time by 4.0%, and reducing specific fuel consumption by 4.0%. Differential fertilization systems installed on wide-area cultivators-fertilizers with a class 6 tractor can increase the shift performance of the unit up to 2.0%, reduce specific fuel consumption up to 2.0%, actual dose of mineral fertilizers up to 60.0% and reduce total costs up to 25.0%. In addition, it was found that modern high-performance machine complexes equipped with the specified elements of the precision farming system can increase productivity by 1.7 ... 2.3 times compared to the existing fleet of agricultural machinery [17, 18].

Based on the analysis of scientific and technical literature and the test results of agricultural machinery in the system of precision farming, it was found that digital equipment, which is most
widespread in the northern region of Kazakhstan, should be used as the recommended elements of the precision farming system [17-20]. Recommended elements of a precision farming system are presented in Table 1.

At the same time, the above elements of the precision farming system can be effectively used in various resource-saving technologies and organic farming.

In turn, the observance of the logistic principles of resource provision of economic entities of the agro-industrial complex at the regional level when using various technologies at the present stage of development is an objective condition for their successful functioning. The allocation of resources should ensure the formation of effective logistics systems that guarantee the fine-tuning of resources to places of consumption in accordance with the interests of all economic entities.

Table 1. List of names of the recommended elements of the precision farming system.

| System element type | Name | Main factors |
|---------------------|------|--------------|
| Remote equipment monitoring systems with fuel consumption sensors | «AutoGRAPH GSM/GSM+», Teletrack TT2-21, CAP VT-10, GNS-GLONASS v. 4.7, Azimuth 5.1 PRO | data transmission channel SMS, SMTP, GPRS |
| Parallel driving systems | «Trimble EZ-Guide 250», «Teejet Matrix Pro 570 GS» | driving accuracy - 30.0 ... 40.0 cm |
| Automatic driving systems | «Trimble CFX-750», «Teejet Matrix Pro 570 GS» with automatic steering system «Teejet Unipilot», «AutoTrac», «Trimble AgGPS Autopilot» | driving accuracy - 5.0 ... 30.0 cm |
| Seeding monitoring (control) systems | "Argonaut", "Scythian" | input range of the capture width - 1.0 ... 30.0 m; area measurement error - up to 5.0%; error in measuring the depth of the coulters - ± 1 cm; the number of seed tubes on one hopper - up to 16 |
| Differential fertilization systems | "Agronavigator-dispenser" | operating mode - off-line; connection interface - RS-232; accuracy of parallel driving in open areas - 10.0 ... 20.0 cm; error in measuring the area along the track its contour - no more than 1 ha; stroke of the actuator rod - 10 cm |
| Yield mapping system | «Trimble» | grain flow sensor - optical; pass-to-pass DGPS-system accuracy - ± 2.5 cm; Combine Compatibility - CNH John Deere, Claas, Gleaner, Massey Ferguson, Challenger, Rostselmash |
| The system of differentiated application of plant protection products | «WeedSeeker» | program for differential application - TrimbleField-IQTM; operating mode - online; sensor scanning width - 300 ... 380 mm |

Since 2014, the Food and Agriculture Organization of the United Nations (FAO) has promoted sustainable agriculture strategies, and the European Commission (EC) has promoted the development of precision farming (TK) technologies through the reform of the Common Agricultural Policy (CAP) 2014-2020 and project financing based on promoting its principles and dissemination, examples of which are the Erasmus + projects.
Having a quick overview of this latter type of projects, they mainly focus on educating students, teachers and farmers in environmental technology and business. In particular, educational activities can be professional (for example, "AGRO e-learning" - a precision farming project with elements of geoinformatics, 2016; "The use of precision farming in agricultural production and processing industry as a condition for the development of a rural areas project", 2017), adult education (Development of a training program that expands the use of ICT tools in the implementation of a precision farming project, 2018), as well as high-level education (Smart Agriculture, 2017; Project "New and Innovative Courses for Precision Farming", 2018 g.; New curricula in Precision farming using GIS technologies and sensing data, 2018). They look for long term results.

These training projects are accompanied by more applied ones. Some examples are those promoting innovative tools such as drones used as sensors (DroneEuropeanPlatform project, 2017) and knowledge and experience sharing (Implementation of digital systems in agriculture project, 2014). In addition, another common type of application is the implementation of hands-on experience (Precision Farming: Design for a Future Agricultural Production System, 2014).

The above list of EU projects is of course not complete, but it gives an idea of their usefulness, mainly due to insufficient dissemination of knowledge and, therefore, low level of implementation of TK technology in Europe.

In addition, in these times of environmental change, agriculture cannot ignore this type of education and actions that provide a beneficial effect on the environment and improve the quality of the final product.

4. Conclusions
Considering the above, it can be stated that the use of foreign experience and methodological recommendations for the use of optimal machine complexes and a scientifically grounded model of the use of precision and organic farming systems by farms based on the principles of logistics in the agro-industrial complex is currently relevant and in demand by the production of Kazakhstan, and also allows to increase labor productivity and reduce the total cost of cultivating staple crops.

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