Information support for crop production automation in Russia and Belarus

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Abstract. The purpose of the study is to analyze the information support used in Russia and Belarus for crop automation. The authors have grouped software products by application areas: management of technical means; control and measurement of technological parameters of crop production; planning of crop production and support for making managerial decisions. In addition, a survey of Russian and Belarusian agricultural specialists was conducted, which identified the most popular programs: agro-calculators, mobile applications for navigation, nitrogen management, and support for the implementation of precision farming technologies. The Russian and Belarusian market of software for crop automation has just begun to develop and so it supports management decisions only at certain process stages. Insufficient attention is paid by developers to implementation of optimization models, in particular, to planning the operation of the machine and tractor fleet.

1. Introduction

In Russia and Belarus, crop production is one of the main branches of agriculture. This industry, in the context of the transition to the sixth technological order and low financial security, is slowly, step by step, moving towards automation and digitalization of technological processes and management. Quite a lot of works have been devoted to the problems of crop automation, and it is worth highlighting the most interesting ones: J Lowenberg-De Boer, I Y Huang, V Grigoriadis, S Blackmore, J Pratley, J Kirkegaard, T Ahamed, R Noguchi, T Takigawa, L Tian, J Billingsley [1–4]. Automation of technological processes is closely related to robotization of crop production [1, 4–6], use of the Internet of things [7–9] and creation of geographical information systems [10-11]. Information support for crop automation is considered by scientists at the level of separate programs [12, 13], software complexes [14, 15] and digital ecosystems [16].

Software packages are most often designed for production management, short-term, medium-term and long-term planning. Digital ecosystems are used for cross-industry interaction and M2M. Mobile applications for crop production can be separate programs, utilities of software complexes, multi-platform applications, and most often they are intended for operational management of agricultural production. Software packages are usually supplemented with similar mobile applications.

The level of information support for crop automation is determined by the need for it, the state of the IT market and the emergence of new technologies and technical means for which it is created. In
this article, the purpose of the study is to analyze the information support available in Russia and Belarus for crop production automation.

2. Materials and methods

2.1. Features of crop production automation in Russia and Belarus
Features and specifics of crop production and automation determine requirements for information support. It should be noted that technological processes are associated with tillage of land; cultivation and harvesting of plants; movement of workers, manufactured products, technical units; the need to monitor and, if possible, control the water and temperature balance; dependence on the natural, climatic and geographical features of territories. In conditions of short periods of sowing and harvesting, it is always necessary to have well-established logistics, prompt refueling, diagnostics and repair of equipment, and adjustment of management decisions.

Increasing labor productivity, reducing labor costs, ensuring resource conservation and sustainable development of crop production is achieved by automating agricultural production. The basis of modern crop automation is the development of sensor systems and environmental management engineering for growing plants; implementation of M2M, B2M models, precision farming technologies using robotics, geographic information systems (GIS), yield assessment technologies (Yield Monitor Technologies), variable rate technologies (Variable Rate Technologies), remote sensing of the earth, and the Internet of things (IoT).

2.2. Information support market for automation of crop production
According to StatCounter data for 2019, users of mobile operating systems were distributed as follows: Android – 74.85 %, iOS – 22.94 %, KaiOS – 0.81 % and others – 1.4 %. Consequently, the most popular mobile app platforms are Google Play from Google and Apple's App Store. Therefore, they were used as an information base for the study.

The market of information support for crop automation in Russia and Belarus is just beginning to develop, which is due to the still low demand from farmers and only the beginning of the development of digital agriculture. Existing developments are owned by research institutes and universities; companies offering technical support for crop production; private organizations, etc.

2.3. The methods used
For the research, the authors applied methods of a systematic approach, comparative analysis, interviews and statistical information processing. For the period 2019–2020, a survey of Russian and Belarusian agricultural specialists was conducted on the demand for information support for crop automation. The sample size was 28 people.

3. Results and Discussion
The authors analyzed mobile applications for crop automation based on data from 2019–2020 on Android and iOS platforms (Table 1).

The total number of applications is about 65, of which 95.3 % are in Russian. All have user ratings.

According to the scope of application, the authors identified mobile applications for managing technical means; for monitoring and measuring technological parameters of crop production, planning crop production, secondary.

The "Hardware Management" group contains only applications for navigational hardware. User reviews are positive, with an average quality rating of 4.7 out of 5 points.

The second group "Control and measurement of technological parameters of crop production" contains mobile applications from the categories Navigation, Business and Productivity. This includes applications for measuring and videotaping land plots, supporting the system for measuring soil moisture and managing irrigation, diaries for monitoring fields, and maintaining farm statistics. User satisfaction ratings for these apps range from 2.8 to 4.6.
Table 1. Crop production automation support with the use of mobile applications

| No. | Scope of application                                      | Mobile Application Groups                                                                 | Mobile Application Category |
|-----|----------------------------------------------------------|------------------------------------------------------------------------------------------|-----------------------------|
| 1   | Management of technical units                           | Navigation                                                                               | Navigation                  |
| 2   | Control and measurement of technological parameters of   | Measurement, video recording of land plots Support for soil moisture measurement and irrigation management Field observation diary Maintaining household statistics | Navigation Business Performance |
|     | crop production                                         | Navigation                                                                               |                             |
| 3   | Planning of crop production                             | Agricultural production planning The placement of crops in fields                         | Business                    |
| 4   | Secondary                                                | Guidelines for regulation, configuration, troubleshooting, and selection Guides Catalogues Agro-calculator | Education Business Guides   |

The third group contains mobile apps from the Business category. This includes applications for planning agricultural production, placing crops on the fields using, if necessary, the GIS function. User satisfaction ratings for these apps are low (less than 3 out of 5).

The most popular group is the last one, where we have included applications for making management decisions. It includes agro-calculators, reference books and catalogs, guidelines for regulating, configuring, troubleshooting, and selecting equipment. This group combines applications from the Education, Business, and Reference categories. Users rated their satisfaction with auxiliary applications very high, from 4.1 to 4.8.

A review of crop automation software used in Russia and Belarus has highlighted the following applications:

- Applications based on MS Office products. To work with them, you need an independent formation of source databases, a good knowledge of crop cultivation technologies, as well as knowledge of the production operation of equipment and the specifics of performing economic calculations. One of these products is the Agroplan program (http://agrosite.org/index/tekhnologicheskaja_karta_vozdelyvanija_selskokhozjajstvennykh_kul tur/0-13). It performs calculations in MS Excel of the main agronomic cost items and outputs summary data. With a fairly clear classical form of the flow chart, the disadvantage of the program is the complexity of filling out the document, operating with standard indicators of machine performance and fuel consumption (which may differ significantly when operating equipment in different natural production conditions). In addition, such products do not have functionality for analyzing summary indicators, performing optimization calculations, etc., which significantly reduces their value for practical use. At the same time, software products built on the basis of standard MS Office applications have limited potential, and the possible list of tasks to be solved does not meet the modern requirements of agricultural production.

- ExactFarming app (https://www.exactfarming.com). The service provides the user with the ability to create process maps individually for each field, using personal or basic expert templates.
• OneSoil app (https://onesoil.ai). This service is a new platform for implementing precision farming technologies. A special feature of the offered software is the automated marking of field plots and determination of cultivated crops based on original mathematical algorithms.

• Agrivi app (http://www.agrivi.com). This is a program for planning and accounting of production factors and technological processes. It includes planning crop rotation by field, accounting and distribution of fixed assets, accounting for employees, analysis of financial activities, and so on. However, the application does not provide for optimization calculations and preparation of appropriate recommendations.

• iAgri Online app (https://www.iagri.com). This is a program for budgeting farm work and managing accounts (it also contains auxiliary utilities: diaries, libraries, and map information).

• CropTracker app (https://www.croptracker.com). The program is a management decision-making system based on tracking and analyzing actual information: monitoring the use of resources, labor, and so on. Its disadvantage is that it is not possible to perform planned calculations based on both actual data and forecast models. It is important to note that such remarks are common for almost all currently used software applications.

• Agroptima app (https://www.agroptima.com). This is an application for planning tasks, managing inventory, and accessing up-to-date reference information. And this is the only software product that retains its full functionality without Internet connection. The feature of this application is the ability to determine the most profitable crops based on actual data on the cost of their production and calculate the minimum allowable yield for current product prices.

• FarmLogs app (https://farmlogs.com). A comprehensive farm management application that includes financial and production accounting, the ability to use mobile solutions to collect data in the field, the actual accounting of pests and diseases of crops, as well as meteorological conditions.

• Agrimap app (https://www.agrimap.com). The app is positioned as a task scheduler and messaging resource on the farm. This application is a fairly simple software product, in fact, it is an extended notebook.

• Adapt-N app (http://www.adapt-n.com). This is a software application for agronomists to manage soil nitrogen content with mapping information. The system is based on modeling the processes of crop growth and changes in the nitrogen content in the soil to develop recommendations for the most effective use of nitrogen.

• Agroop app (https://www.agroop.net). This software allows farmers to manage their activities, keep records of work, manage expenses and revenues, determine production costs, analyze data from the nearest weather station, and forecast risk factors for crops. However, it requires installation of specialized sensors.

• Agribotix app (https://agribotix.com). Adapted drones transmit images to the Agribotix FarmLens platform for processing. Agribotix is a software application for analyzing soil and crop conditions. According to the manufacturer, it is the most powerful real-time decision support tool available to any farmer.

Software products for crop automation can also be divided into groups of management of technical means; control and measurement of technological parameters of crop production; planning of crop production; secondary. The group of secondary software products is the largest.

An additional survey in the form of interviews was conducted among agricultural workers. The authors selected 28 respondents who have experience in using software products for crop production. We received the following answers to the question “What software products do you need for crop automation”:

• agro-calculators;
• mobile apps for navigation;
• management of nitrogen content in the soil. Respondents highlight the Adapt-N software product;
• preparation of flow charts. Like, for example, ExactFarming;
• platform for implementing precision farming technologies. Positive reviews were given to OneSoil.

Thus, respondents noted the need for applications of all four selected groups. With the growth of crop automation and the development of precision farming technologies, the need for information support and its diversity will grow.

4. Conclusion
Thus, the existing information support in Russia and Belarus mainly helps farmers make management decisions. Currently, a significant number of online applications for task planning and accounting in agriculture are being developed and actively implemented in everyday practice. There are at least 10 most popular services that provide farmers with services for mapping fields, planning crop rotations and developing cultivation technologies, budgeting work, accurately calculating the need for material resources (for example, mineral fertilizers based on the analysis of dynamically changing vegetation indices), analyzing weather data, and so on.

Given that the market for this software is in the stage of active growth, the development of online systems is very promising. However, software development, testing, and debugging is quite a time-consuming and expensive process. The analysis carried out by the authors showed that most of the proposed software products are intended for keeping records, or making plans in manual mode, which is a rather laborious and painstaking process. These software products do not implement optimization models that allow you to quickly provide the user with a set of possible solutions based on actual data.

It has been found that when developing software applications, insufficient attention is paid to the issues of effective planning of the operation of the machine and tractor fleet, including such issues as rational acquisition of machine units, optimization of their performance, conducting comparative assessments for making managerial decisions when choosing machines, optimizing the machine and tractor fleet as a whole, and so on.

The most popular among Russian and Belarusian farmers are agro-calculators, applications for navigation and implementation of precision farming technologies, drawing up flow charts and managing the nitrogen content in the soil.

We believe that further digitalization of agriculture requires further development and improvement of systems for collecting and analyzing data from on-board equipment systems, controlling traffic paths, monitoring the correctness of operation, the technical condition of units, and inter-machine interaction. Another step forward will be to exclude human from the elements of the technological process chain, assigning humans only with a general managerial function.

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