Application of geoinformation systems in the agricultural complex

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Abstract. Precision farming, encompassing coordinated farming, adaptive landscape farming, and precision farming, represents a scientific paradigm in agricultural production that capitalizes on the inherent variability in soil fertility within localized areas. By tailoring practices to specific soil characteristics, precision farming optimizes profitability through the targeted application of fertilizers and plant protection products. Serving as the epitome of flexible landscape farming, precision farming integrates advanced agricultural technologies to achieve heightened productivity levels. Data collected through precision farming practices informs critical aspects of agricultural management, including strategic planting, precise calculation of input quantities, improved crop forecasting, and enhanced financial planning. Successful implementation of precision farming hinges on a thorough consideration of local soil attributes and climatic conditions, underscoring the importance of site-specific adaptation in modern agricultural strategies.

1 Introduction

Precision farming (precision farming, coordinated farming, adaptive landscape farming, precision farming) is a scientific concept and direction in agricultural production, which is based on the idea that there is variability in soil fertility within a single area, taking into account its specific characteristics, it allows to maximize profit by applying fertilizers and plant protection products in a differentiated manner. Precision farming is the highest form of flexible landscape farming based on high-tech agricultural technologies with high productivity.

In other words, precision farming is a management strategy using information technologies for optimal (precision) management of agricultural enterprises.

In horticulture, this is the management of crop productivity, taking into account the variability of the habitat of plants [1-6].

The following new technologies are used to assess and identify diversity in the field, such as:

- global positioning systems;

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- special devices (soil samples, mobile laboratories) and sensors (productivity, humidity, etc.);
- aerial photographs and field images taken from satellites;
- special hardware and software complexes created on the basis of geoinformation systems and technologies [7-9].

2 Methods

The gathered data serves multiple purposes, including aiding in planting plans, determining fertilizer and plant protection product quantities, enhancing crop forecasting accuracy, and facilitating financial planning. This approach necessitates a thorough understanding of local soil attributes and climatic conditions. Variable or differential fertilization technologies are employed in fields where fertilizer rates are tailored based on agrochemical testing and productivity maps, guided by agrotechnologists.

Consequently, certain areas of the field may receive below-average levels of fertilization or spraying, while others benefit from optimized fertilization through redistribution. Electronic documentation and storage of field and crop histories play a crucial role in decision-making processes and production cycle reporting, aligning with the increasing legislative requirements in developed nations [10-12].

3 Results and discussion

The electronic field map allows one to save the results of soil composition analysis as a layer. Other layers can also be implemented: previous crops, specific resistance of the soil, acidity, etc.

Electronic field maps can be created mainly in two ways:
- digitalization of contours by driving around fields with a GPS receiver installed on a car or tractor;
- selection and digitization of field boundaries from raster aerial photographs or space images.

At the same time, the vectorized raster image (for example, with the help of the Easy Trace vectorizer, the leaders of the Russian vectorizer market - the Ryazan company Easy Trace Group) must be correctly corrected and have an acceptable resolution, otherwise the quality of vectorization or digitization of the field image will be unsatisfactory.

Differentiation of the soil within the field depends on many factors: weather phenomena and climatic characteristics of the soil (granulation composition, strength of the humus layer, nitrogen supply), methods of soil processing (uncultivated, minimally cultivated), as well as fields contamination, their possession by diseases and pathogens. Indicator-constants, which are mainly related to soil properties, provide information about the main environmental constants. Point indicators allow monitoring the state of the crop and biomass. For example, it will be possible to control how much a certain disease affects the development and productivity of the plant, whether the plant is suffering from a lack of water, a lack of nitrogen in the soil, or whether it has any disease or is damaged by the cold.

Together with the analysis of the mechanical and chemical composition of the soil, the measurement of its electrical conductivity makes it possible to create an accurate map of agroecological conditions.

New information and communication technologies allow easy and reasonable management of crops in the field itself. Decision-making in the field of modern agricultural production requires special equipment and machines that can apply the changing technology.
For example, machines that can ensure the variability of the amount of seeds or allow the application of Fertilizers and plant protection agents in a differentiated way.

Fig. 1. RTK (Real Time Kinematic) technology.

The static base station is located in one place and is equipped with two-frequency signal reception technology. It sends a correction signal to any number of cars within a 15-20 km radius.

Precision farming technology includes three main components:

The first component of the precision farming system is parallel or automated driving equipment systems based on GPS/GLONASS navigation systems, which ensure planting accuracy, rows, evenness of fields, etc. Systems that rely only on satellite signals are not very accurate ± 30cm and their use is limited. Using the differential correction method of DGPS observations allows to increase the accuracy up to ±10 cm. In particular, the use of a base satellite station with RTK (Real Time Kinematic) technology located close to the field allows to achieve deviations of no more than 2.5 cm in trajectories of tractors and agricultural machinery [13].

The second component of the precision farming system is the system of differentiated application of fertilizers and plant protection agents depending on the condition of the soil and plants, the presence of weeds in each specific part of the cultivated fields. Recently, more and more attention has been paid to the problems of differentiated application of fertilizers. Due to the significant variation (variety) of soil fertility within a field, differential (soil-adapted) fertilization is able to fully take into account the nutrient needs of plants. This is directly related to their productivity and allows to save Fertilizers by reducing doses in relatively fertile areas. All this creates favorable conditions for the uniform ripening of plants, reduces the loss of nutrients, helps to increase the quality and reduce the cost of production.

Differential fertilization and plant protection systems have two main types [14]:

- Systems that distribute Fertilizers according to a given program according to pre-prepared program maps created on the basis of agrochemical cartograms, productivity cartograms or their combinations.
- Systems that determine the applied fertilizer dose directly in the field, in real time, depending on any parameter of the growing crop: the color of the leaf surface, the density of plant biomass, etc.
A typical composition of a differentiated fertilizer application and plant protection system [15-18]:

- Pocket computer (PDA);
- RAM PDA installation device on the tractor;
- SIRF III GPS receiver on Compact Flash memory card with external antenna;
- Cable for connecting the device to the on-board working computer;
- Car power source;
- Compact Flash card reader;
- Software.

Functional capabilities of the differentiated application system of fertilizers and plant protection products:

- PDA is connected to the work computer of the sprayer or sprinkler through a special cable included in the kit;
- Application classified program card is written to the Compact Flash device using office programs;
- You can enter the width of the device on the PDA and monitor the treated area on the map in real time;
- Existing change cards and legends based on application cards are recorded in PDA;
- PDA indicates the total amount of the substance to be introduced;
- Data can be imported/exported in the most common geoinformation systems formats: ArcView Shape File, MapInfo Interchange File, etc.
Fig. 3. Automatic soil sampling devices are mounted on a variety of vehicles, from ATVs to four-wheel-drive trucks or tractors. An automatic soil sampler is a vehicle-battery powered electric motor mounted as an attachment on the rear of the drive frame and drives a hydraulic system for direct drilling sampling. The sampler is equipped with a control unit, control electronics, a sensor and a working pressure regulator.

4 Conclusions

The established experience of agro-ecological assessment of land and design of adaptive-landscape farming systems for large agricultural enterprises in different natural-agricultural zones and regions shows the need to develop regional agro-geographical information systems. 30...50 years ago, various scientific recommendations and their generalized collections in the form of "zonal farming systems" and "agricultural systems" served as a supply for these works. Such collections are published for all administrative regions, regions, and republics. They served as a methodological guide for the development of intra-farm and inter-farm land development projects. Currently, it is necessary to create such manuals, but taking into account environmental restrictions, the requirements for their content and form have increased significantly.

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