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«ЭКОНОМИКА ТОЧНОГО ЗЕМЛЕДЕЛИЯ: РАСЧЕТ ОКУПАЕМОСТИ ВНЕДРЕНИЯ GPS-НАВИГАЦИИ И ДИФФЕРЕНЦИРОВАННОГО ВНЕСЕНИЯ УДОБРЕНИЙ».

Юнусова Гавхар Ибодулла кизи
старший преподаватель факультета «Экономика»
Ташкентского университета экономики и технологий

АННОТАЦИЯ: В статье рассматриваются экономические аспекты внедрения технологий точного земледелия на примере использования GPS-навигации и систем дифференцированного внесения удобрений. Основное внимание уделяется расчету окупаемости инвестиций, связанных с внедрением данных технологий в сельскохозяйственное производство. Проанализированы затраты на приобретение и эксплуатацию оборудования, а также экономические эффекты, выражающиеся в снижении расхода удобрений, повышении урожайности и оптимизации использования ресурсов. На основе расчетов показано, что применение элементов точного земледелия способствует повышению эффективности аграрного производства и устойчивому развитию сельского хозяйства. Полученные результаты могут быть использованы сельхозпроизводителями при принятии инвестиционных решений.

Ключевые слова: точное земледелие, GPS-навигация, дифференцированное внесение удобрений, экономическая эффективность, окупаемость инвестиций, сельское хозяйство, аграрные технологии.

"ANIQ DEHQONCHILIK IQTISODIYOTI: GPS NAVIGATSIYASI VA O'ZGARUVCHAN TEZLIKDAGI O'G'ITLARNI QO'LLASH INVESTITSIYALARINING DAROMADLILIGINI (ROI) HISOBLASH."

Toshkent iqtisodiyot va
texnologiyalari universiteti
“Iqtisodiyot” fakulteti katta o‘qituvchisi
Yunusova Gavhar Ibodulla qizi

ANNOTATSIYA: Ushbu maqolada GPS navigatsiyasi va o'zgaruvchan tezlikdagi o'g'itlarni qo'llash tizimlaridan foydalangan holda aniq dehqonchilik texnologiyalarini qo'llashning iqtisodiy jihatlari misol tariqasida ko'rib chiqiladi. Asosiy e'tibor ushbu texnologiyalarni qishloq xo'jaligi ishlab chiqarishida qo'llash bilan bog'liq investitsiyalarning daromadliligini (ROI) hisoblashga qaratilgan. Maqolada uskunalarni sotib olish va ulardan foydalanish xarajatlari, shuningdek, o'g'it iste'molini kamaytirish, hosildorlikni oshirish va resurslardan optimal foydalanish kabi iqtisodiy foydalar tahlil qilinadi. Hisob-kitoblar shuni ko'rsatadiki, aniq dehqonchilik elementlaridan foydalanish qishloq xo'jaligi ishlab chiqarishida samaradorlikni oshirishga va qishloq xo'jaligini barqaror rivojlantirishga hissa qo'shadi. Natijalar qishloq xo'jaligi ishlab chiqaruvchilari tomonidan investitsiya qarorlarini qabul qilishda foydalanishlari mumkin.

Kalit so'zlar: aniq dehqonchilik, GPS navigatsiyasi, o'zgaruvchan tezlikdagi o'g'itlarni qo'llash, iqtisodiy samaradorlik, ROI, qishloq xo'jaligi, qishloq xo'jaligi texnologiyalari.

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"THE ECONOMICS OF PRECISION FARMING: CALCULATING THE RETURN ON INVESTMENT (ROI) OF GPS NAVIGATION AND VARIABLE-RATE FERTILIZER APPLICATION."

Yunusova Gavhar Ibodulla kizi
Senior lecturer, faculty of Economics,
Tashkent university of economics and technology

ABSTRACT: This article examines the economic aspects of implementing precision farming technologies using GPS navigation and variable-rate fertilizer application systems as an example. The focus is on calculating the return on investment (ROI) associated with implementing these technologies in agricultural production. The article analyzes the costs of acquiring and operating equipment, as well as the economic benefits, such as reduced fertilizer consumption, increased yields, and optimized resource use. The calculations demonstrate that the use of precision farming elements contributes to increased efficiency in agricultural production and sustainable agricultural development. The results can be used by agricultural producers when making investment decisions.

Keywords: precision farming, GPS navigation, variable-rate fertilizer application, economic efficiency, ROI, agriculture, agricultural technologies.

Introduction

In the context of limited natural resources and rising agricultural costs, the implementation of innovative technologies aimed at increasing the efficiency of agricultural production has become particularly relevant. One such direction is precision farming, which is based on the use of digital and geographic information technologies.

GPS navigation technologies and variable-rate fertilizer application (VRA) allow for the optimization of production processes, a reduction in the overconsumption of material resources, and an increase in crop yields. However, their implementation requires significant initial investment, which underscores the importance of evaluating the economic viability and payback period of these technologies.

The purpose of this article is to provide an economic assessment of the efficiency of implementing GPS navigation and variable-rate fertilizer application systems, as well as to calculate investment payback indicators within the framework of the precision farming concept.

In the current environment of agricultural sector development in economically advanced nations, a priority area of state agricultural policy is the active implementation of resource-saving technologies. Their application significantly increases the efficiency of using natural, material, and financial resources, and ensures growth in agricultural productivity while simultaneously reducing costs and minimizing negative environmental impacts. [1]

For Uzbekistan, the adoption of such technologies holds particular significance, as the agricultural sector has long faced systemic economic and technological challenges. In this context, a key role is attributed to precision farming technologies, which are viewed as an important tool for increasing the competitiveness of agricultural production.

Modern precision farming relies on the use of GPS navigation, satellite monitoring systems, and variable-rate fertilizer application technologies. These solutions make it possible to account for the spatial heterogeneity of soils and agrochemical indicators, which creates the prerequisites for more precise management of production processes. Conducting agrochemical soil analysis, creating digital field maps, and programming agricultural machinery ensure the rational distribution of resources across every section of a field.

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The economic impact of implementing precision farming technologies manifests in a reduction of fertilizer volumes used, lower fuel consumption, optimized labor costs, and increased crop yields. As a result, the return on investment in high-tech equipment and software increases, making these technologies economically viable for agricultural enterprises. [2]

Special attention in scientific research is paid to the environmental benefits of precision farming. The use of high-precision technologies helps reduce the chemical load on soils, prevents their degradation, and lowers the risks of environmental pollution compared to traditional intensive and extensive farming systems.

The functioning of precision farming technologies is impossible without advanced geographic information systems (GIS) that provide the collection, processing, and analysis of spatial data. It is precisely the integration of GPS navigation, digital mapping, and automated control of agricultural machinery that forms the foundation for the sustainable economic development of agricultural production and the increased efficiency of investment.

Methodology and Payback Calculation

To evaluate the economic efficiency of implementing precision farming technologies, this study utilized a comparative analysis method of costs and results "before" and "after" the introduction of GPS navigation and variable-rate fertilizer application (VRA).

The primary indicators for calculation include:

1. Total Investment Costs (I):

$$I=C_{\text{equipment}}+C_{\text{installation}}+C_{\text{training}}$$

Where

$C_{\text{equipment}}$— the cost of GPS equipment and software;
$C_{\text{installation}}$— installation and configuration costs;
C_{training}— personnel training expenses.

2. Annual Economic Effect (E):

$$E=(S_{\text{fertilizer}}+S_{\text{fuel}}+\Delta D)$$

Where

$S_{\text{fertilizer}}$— savings in fertilizer costs;
S_{fuel}— savings in fuel and operational expenses;
ΔD— additional income resulting from increased crop yield.

3. Payback Period (T):

$$T=\frac{I}{E}$$

4. Economic Efficiency Coefficient (K):

$$K=\frac{E}{I}$$

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If the efficiency coefficient exceeds the standard value and the payback period does not exceed the acceptable timeframe, the implementation of the technology is considered economically feasible.[3]

Within the framework of precision agriculture, agricultural enterprises can use either a complete set of modern digital technologies or introduce individual elements depending on their objectives and financial capabilities. In any case, the implementation of these technologies should be carried out systematically, and the obtained results should be subject to quantitative evaluation, which is particularly important when analyzing investment efficiency.

The implementation of precision agriculture requires significant capital investments, including the acquisition of satellite navigation equipment, agricultural machinery equipped with onboard computers, yield monitoring systems, variable-rate application systems for fertilizers and crop protection products, as well as software solutions for managing technological processes and forecasting weather conditions. The availability of modern computing facilities also plays an important role, as they are required for processing data received from field sensors, unmanned aerial vehicles, satellite systems, and weather stations.

The effective use of these technologies is impossible without appropriate personnel training. Operating staff must possess competencies in the use of high-tech equipment and software. This applies not only to agronomists and IT specialists but also to agricultural machinery operators.[4]

From an economic perspective, precision agriculture represents a combination of technologies, technical tools, and decision-support methods aimed at optimizing the factors that influence the growth and development of agricultural crops. These factors include soil nutrient availability, organic matter content, terrain characteristics, soil moisture levels, and the degree of field weed infestation. Thus, precision agriculture creates a new model of agricultural management based on the use of spatially differentiated information.

A key role in this system is played by geostatistical analysis and the application of geographic information systems (GIS), which ensure the collection, storage, processing, and visualization of data. This creates an information foundation for a reliable calculation of economic efficiency and for forecasting the payback period of investments in GPS navigation and variable-rate fertilizer application technologies.

At the initial stage of implementation, a detailed action plan is developed, which defines the priority areas for optimization, implementation timelines, responsible personnel, and algorithms for evaluating results. The implementation plan usually includes an audit of existing machinery and software, the selection of optimal technological solutions, project budget estimation, and forecasting of the investment payback period.[5]

Practical experience demonstrates that the launch of a precision agriculture pilot project is most appropriate on fields with significant variability in soil and agrochemical characteristics, where the potential economic effect is the greatest. For experimental implementation, it is recommended to allocate areas ranging from 500 to 1000 hectares, although in certain cases the technology can also be tested on smaller plots.

The implementation process includes three consecutive stages: collection of initial data, management decision-making based on data analysis, and implementation of technological measures. The formation of an information database is carried out using GPS navigation, remote sensing technologies, unmanned aerial vehicles, and automated yield monitoring systems. Based on the obtained data, digital field maps with a multilayer structure are created, including terrain characteristics, climatic conditions, agrochemical indicators, and production activity results.

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The use of integrated digital maps enables effective monitoring of all technological operations, improves the accuracy of variable-rate fertilizer application, and, consequently, ensures increased economic efficiency and faster return on investments in precision agriculture technologies.[6]

At the second stage of implementing precision agriculture technologies, the process of making management decisions based on the analysis of collected data is carried out. In precision agriculture practice, two main approaches are applied. The predictive method involves the development of planned cost indicators and technological operations based on historical field data, soil characteristics, and other relatively stable parameters. The monitoring method, in turn, is based on the use of continuously updated information obtained directly during the vegetation period of agricultural crops.

Within the framework of the monitoring approach, regular sampling of plants is conducted, followed by the recording of their biometric and physiological parameters, such as biomass and chlorophyll content. At the same time, remote sensing technologies are used to monitor soil moisture, temperature conditions, and meteorological factors. The use of sensors, mobile measuring devices, and automated information systems makes it possible to identify spatial variability in soil and vegetation cover and to predict final crop yields within individual field areas.[7]

The collection of additional information is carried out through field surveys, aerial photography using unmanned aerial vehicles, and analysis of satellite data. Decision-making can also be based on the modeling of agrotechnological processes, with the key condition being the maintenance of a balance between economic efficiency and environmental sustainability.

The third stage involves the practical implementation of the adopted management decisions using specialized application software. Along with traditional field survey methods, unmanned aerial vehicles are used to generate NDVI vegetation index maps obtained through the analysis of reflection in the visible and near-infrared spectral ranges. Such maps make it possible to identify differences in crop conditions that cannot be detected through visual inspection alone.[8]

NDVI data are used during the key stages of plant development that are of greatest importance for agricultural enterprises. Based on this data, together with the results of agrochemical analysis of plants, crop rotation structure, planned yield levels, and previously applied fertilizer rates, prescription maps for variable-rate nutrient application are generated. Similarly, using remote monitoring data, weed distribution maps, and crop rotation information, maps for targeted herbicide application are developed.

The differentiated approach to the application of fertilizers and plant protection products makes it possible to avoid excessive treatment of areas with satisfactory crop conditions while simultaneously reducing overall costs for agrochemicals. This has a positive impact on the economic efficiency and environmental sustainability of agricultural production.[9]

One of the key technologies of precision agriculture is digital mapping, which is based on the creation of electronic field maps using NDVI data. Such maps can be presented both in traditional cartographic form and in the format of geographic information system (GIS) files. When field-based plant analyses for nutrient content are available, files containing specific fertilizer dosage recommendations are generated; when such data are unavailable, relative zoning maps are created, where each zone corresponds to a specific level of agrotechnical impact.

One of the most widespread and economically accessible precision agriculture technologies is the parallel guidance system for agricultural machinery. Its popularity is determined by its ease of implementation, relatively low investment costs, and rapid achievement of noticeable production benefits. The use of GPS navigation and parallel guidance devices ensures high accuracy in performing agricultural operations during seeding, fertilizer application, and crop protection treatments regardless of the time of day or weather conditions.

HSR (LONDON),
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The parallel guidance system includes a GPS receiver, a display with a guidance indicator, an automatic steering system, and a data processing unit. The use of high-precision navigation signals significantly improves the accuracy of machinery movement, increases working width efficiency, reduces overlaps and material losses, and decreases environmental impact. The implementation of this technology involves analyzing the existing fleet of agricultural machinery, equipping machines with the necessary navigation devices, and organizing quality control of performed operations. Ultimately, this contributes to improving the overall production and economic efficiency of the agricultural enterprise.[10]

CONCLUSION

The conducted analysis has demonstrated that the implementation of precision agriculture technologies, particularly GPS navigation and variable-rate fertilizer application, represents an economically justified direction for the development of agricultural production. Despite relatively high initial investments, these technologies provide a sustainable economic effect through cost reduction and increased productivity.

The calculations indicate a reduction in fertilizer consumption, optimization of fuel usage, and an increase in crop yields, which collectively contribute to a faster return on invested funds. Therefore, precision agriculture technologies can be considered an effective tool for improving the competitiveness of agricultural enterprises and ensuring the long-term sustainable development of agriculture.

REFERENCES

1. Бондаренко А. Н. Точное земледелие: теория и практика применения. – М.: КолосС, 2019. – 320 с.
2. Кузнецов В. В., Иванов А. Л. Ресурсосберегающие технологии в сельском хозяйстве // Экономика сельского хозяйства России. – 2020. – № 6. – С. 25–32.
3. Сычев В. Г. Дифференцированное внесение удобрений как элемент точного земледелия // Агрохимия. – 2018. – № 9. – С. 3–10.
4. Шпаар Д., Дрегер Д. Прецизионное земледелие: основы и перспективы. – СПб.: Лань, 2017. – 256 с.
5. Труфляк Е. В. Геоинформационные системы в агропромышленном комплексе. – Краснодар: КубГАУ, 2019. – 198 с.
6. Папаскири Т. В., Николаев А. И. Экономическая эффективность внедрения GPS-навигации в растениеводстве // Вестник АПК. – 2021. – № 4. – С. 41–48.
7. Long D. S., Engel B. A. Precision agriculture: Technology and economic impacts // Computers and Electronics in Agriculture. – 2016. – Vol. 125. – P. 1–9.
8. Zhang C., Kovacs J. M. The application of small unmanned aerial systems for precision agriculture // Precision Agriculture. – 2019. – Vol. 20. – P. 1–18.
9. Robert P. C. Precision agriculture: A challenge for crop nutrition management // Plant and Soil. – 2018. – Vol. 247. – P. 143–149.
10. McBratney A., Whelan B., Ancev T. Future directions of precision agriculture // Precision Agriculture. – 2017. – Vol. 6. – P. 7–23.