Use of ProPlanta Software in the Development of Recommendations for the Production of Agricultural Products

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Abstract. This article provides an overview of ProPlanta software, which is specifically designed to provide recommendations for the rational use of agricultural land. The software is based on more than 50 years of research, including data from more than 80 long-term field trials. Designed for use in the agricultural sector of Uzbekistan, ProPlanta provides farmers with recommendations on the optimal use of key nutrients and fertilizers, including nitrogen, phosphorus, potassium, lime, magnesium, zinc (Zn), copper (Cu), and manganese (Mn). In addition, the software offers recommendations for the cultivation of environmentally beneficial plants, thereby promoting sustainable agricultural practices.

Key words: agriculture, environmental policy, productivity, land resources, degradation, sustainable development, ProPlanta software, fertilization system.

1 Introduction

Food production and economic sustainability are inextricably linked to the agricultural sector, which plays a critical role in global food security and economic development. As the world population continues to grow, the demand for agricultural products increases, requiring collaboration between farmers, policymakers and various stakeholders to ensure that these products are grown sustainably and responsibly [1-2].

In this context, the rise of the Internet has facilitated the integration of e-commerce into everyday life, making it a vital component of modern agricultural practices [3]. The development of robust recommendation systems leveraging electronic software platforms is essential for optimizing agricultural production. These systems can provide farmers with tailored advice on best practices, including crop selection, resource allocation, and sustainable farming techniques.

Recent estimates indicate that reduced soil fertility incurs a cost of approximately USD 138.2 per hectare of agricultural land annually, translating to a staggering total of USD 384.7 million, or 17.9 percent of the region's total agricultural output. This statistic underscores a critical knowledge gap in the rational use of agricultural land and reflects a concerning lack of awareness regarding the ecological health of soils, as well as insufficient accountability for the consequences of economic activities in agriculture [4].

Addressing these challenges requires a multifaceted approach, including education and training for farmers on sustainable practices, increased investment in research and development, and the implementation of policy measures that incentivize responsible land use. By fostering a culture of sustainability and accountability, stakeholders can better support agricultural productivity while ensuring the long-term health of the ecosystem. Future research should focus on the effectiveness of recommendation systems in enhancing agricultural practices and mitigating the economic impacts associated with soil degradation [4-7].

In contemporary agricultural practices, countries around the globe are increasingly adopting various software solutions and models designed to enhance crop management and optimize agricultural productivity. Notable examples include decision support systems for crop recommendation that utilize machine learning classification algorithms, which facilitate data-driven choices for crop selection based on environmental conditions and soil characteristics. Additionally, machine learning applications for assessing environmental impact, such as those focused on crop yield prediction, enable stakeholders to evaluate the effects of different agricultural practices on both yield and sustainability. The IPECM (Intelligent Precision Environment Control Management) platform exemplifies the integration of machine learning and optimization algorithms for regulating greenhouse environments, thereby improving plant growth conditions and enhancing overall productivity. Furthermore, advanced modeling techniques, such as crop yield prediction using multi-attribute weighted tree-based support vector machines, allow for more accurate forecasting of agricultural outputs based on multiple variables, including climatic factors and soil nutrient content [8-11].

These technological advancements empower farmers and agronomists to predict crop growth dynamics, determine water needs, and analyze extensive data related to plant health and yield potential. By leveraging these software solutions, agricultural stakeholders can implement more efficient irrigation strategies, optimize resource allocation, and adopt sustainable practices that contribute to food security. As the agricultural sector faces increasing challenges from climate change and population growth, the ongoing development and application of predictive models and software will be crucial in fostering resilient agricultural systems capable of meeting future demands [12-16].

Currently, numerous recommendations have been developed for the cultivation of agricultural crops [16]. However, the improper application or complete disregard of these guidelines can have detrimental effects, not only on farmers' incomes but also on environmental health. Inefficient land use practices can result in diminished soil fertility, increased erosion, and suboptimal yields of vegetable crops, ultimately leading to disappointing economic returns.

The ProPlanta software discussed in this article addresses these challenges by maximizing the utility of agricultural land while minimizing environmental pollution, thereby promoting sustainable agricultural practices. This innovative software integrates scientific knowledge derived from extensive research and state-of-the-art software development, ensuring that farmers can make informed decisions that enhance both productivity and ecological sustainability.

From a research perspective, ProPlanta utilizes a comprehensive database comprising data on soil characteristics, crop performance, and plant nutrition gathered from a network of long-term fertilization experiments. This dataset encompasses over 80 long-term field tests conducted over more than 50 years, which provides ProPlanta with spatially and climatically reliable data. Such a robust foundation allows for the generation of tailored recommendations that reflect local conditions and agricultural practices.

When experimental results are entered into the database, an intuitive graphical user interface facilitates seamless interactions, enabling users to perform queries efficiently and access relevant information with ease. This user-friendly design enhances the software's accessibility, ensuring that farmers can quickly obtain the guidance they need to implement best practices in crop cultivation.

Some notable features of the ProPlanta software, as well as results obtained from its implementation, include the following:

Diverse Crop Recommendations. ProPlanta is capable of providing tailored recommendations for over 150 crops, encompassing both vegetable and field crops. This extensive coverage ensures that a wide range of agricultural producers can benefit from the system's insights, enhancing the potential for optimized crop management across different farming contexts.

Nutrient Calculations. The software excels in calculating the necessary nutrient inputs for soil health, including precise dosages of lime, magnesium, zinc, copper, manganese, nitrate, and phosphorus. By providing these calculations, ProPlanta enables farmers to make informed decisions regarding soil amendments, thereby improving soil fertility and promoting sustainable agricultural practices.

Zone-Specific Recommendations. ProPlanta is designed to meet specific agricultural requirements by generating recommendations tailored to an almost unlimited number of geographical zones. This flexibility allows for the consideration of local climatic, soil, and agricultural conditions, ensuring that recommendations are relevant and applicable to diverse farming environments.

The implementation of ProPlanta has shown promising results in enhancing agricultural productivity and sustainability. By equipping farmers with the tools to make data-driven decisions, the software facilitates more efficient use of resources, ultimately leading to improved crop yields and reduced environmental impact. Future research should focus on quantifying the economic and ecological benefits of using ProPlanta across various agricultural systems, further establishing its role as a pivotal resource in modern agricultural management.

2 Methodology

This study employs a comprehensive approach to the development and implementation of the ProPlanta software, aimed at optimizing agricultural productivity and promoting sustainable practices. The methodology is structured into four main stages: basic research, applied research, software development, and field testing.

1. Basic Research: The initial phase involved extensive mathematical modeling to describe the relationships between soil nutrient supplies (nitrogen, phosphorus, and potassium – NPK) and their effects on crop performance. This analysis utilized a robust database of local external NPK fertilization experiments, which provided empirical data essential for establishing correlations between soil nutrient levels and agricultural outputs. Statistical methods were employed to analyze the data, ensuring that the relationships identified were statistically significant and applicable to various agricultural contexts.

2. Applied Research: Following the basic research, an algorithm was developed for the ProPlanta system, focusing on creating an eco-friendly crop-growing advisory tool. This algorithm incorporates the mathematical models derived from the previous phase, allowing the software to generate precise recommendations for nutrient application tailored to specific

crops and local conditions. Additionally, the algorithm considers environmental factors to ensure that recommendations promote both agricultural productivity and ecological sustainability.

3. Software Development: The third stage entailed the development of a user-friendly computer program that serves as the agricultural crop advisory system. The software was designed with an intuitive graphical user interface (GUI) to facilitate ease of use for farmers and agricultural practitioners. This design approach ensures that users can efficiently navigate the system, input relevant data, and access customized recommendations. The software also features a comprehensive database that encompasses over 80 long-term field tests, providing reliable and region-specific information on soil characteristics, crop performance, and plant nutrition.

4. Testing in Local Field Experiments: The final phase involved the implementation of the ProPlanta software in local field experiments. These trials aimed to assess the practical effectiveness of the software in real-world agricultural settings. Data were collected on crop yields, soil health, and economic outcomes before and after the adoption of ProPlanta's recommendations. Statistical analyses were conducted to evaluate the improvements in agricultural productivity and sustainability, comparing results from fields utilizing ProPlanta with those employing traditional farming practices.

Through this systematic methodology, the study aims to quantify the impacts of the ProPlanta software on agricultural practices, providing insights into its effectiveness in enhancing crop yields and promoting sustainable land use. The findings from this research will contribute to the ongoing discourse on the integration of technology in agriculture, highlighting the importance of data-driven decision-making in achieving food security and economic sustainability. Future research will expand upon these findings by exploring the long-term effects of ProPlanta's implementation across diverse agricultural systems and geographical regions.

3 Results and discussion

The ProPlanta system was rigorously evaluated in comparative studies against other advisory software systems through both small plot and field trials. These experiments were conducted on representative arable land soils, specifically brown forest soils, chernozem, and grassland soils. A comprehensive range of major crop types, including maize, winter wheat, winter barley, sunflower, and rapeseed, were included in the trials. The results confirmed the validity of the principles underpinning the ProPlanta system and verified the accuracy of its fertilizer dosage calculation methodology.

ProPlanta is characterized as an eco-friendly and cost-effective plant fertilization advisory system, effectively addressing the need for sustainable agricultural practices. The software includes a Company Universal Unique Identification Number (UYID), enhancing its credibility and traceability within the agricultural sector. Furthermore, the program is designed to support multiple languages, including Uzbek, English, German, and Bosnian, thereby improving accessibility for a diverse user base and facilitating broader adoption among farmers in various regions.

In addition to its multilingual capabilities, ProPlanta is programmed for regular updates, ensuring that it remains current with the latest agronomic research and user feedback. However, it is important to note that the current version of the program is scheduled to expire on January 10, 2024, necessitating timely updates to maintain its functionality and relevance. The user interface is designed to promote intuitive navigation, allowing users to efficiently proceed through the various steps of the program. Upon clicking “Next” from the initial interface, users are seamlessly directed to subsequent sections, enhancing the overall user

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experience (Figure 1). This design not only improves accessibility but also empowers farmers to implement best practices in crop management effectively.

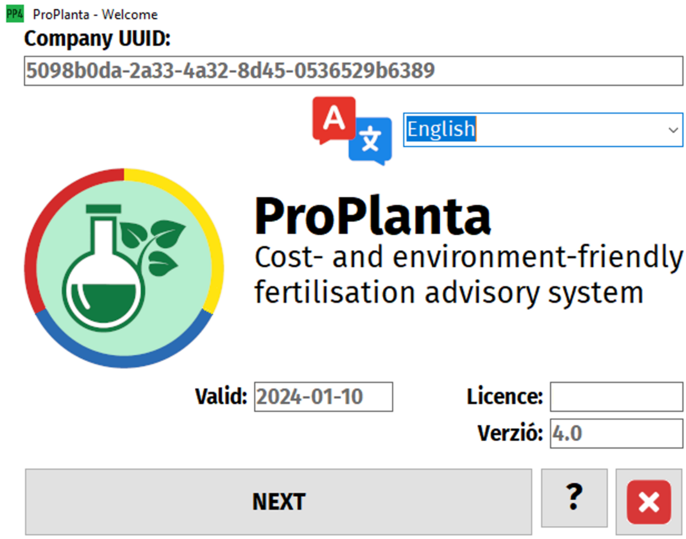

Fig. 1. Running the Software.

In the subsequent stage of the user interface, users are required to input essential personal information, including their role, full name, date of birth, username, and password. Upon completing this information, users can click on the "Recommendation" button to access the main menu and initiate the program (Figure 2). This structured approach to user onboarding ensures that the system is tailored to individual profiles, facilitating personalized recommendations and enhancing user engagement with the software.

Fig. 2. Uploading Personal Data to the Program.

Upon successful entry of personal information, users are presented with a screen that contains three primary sections: *Plots, Product and Recommendation* (Figure 3). This organization allows users to navigate seamlessly between different functionalities of the software. The *Plots* section enables users to input and manage data related to specific agricultural plots, while the *Product* section provides options for selecting the type of crops to be cultivated. The *Recommendation* section offers tailored insights and guidance based on the input data, thereby enhancing the user experience and supporting informed decision-making in agricultural practices.

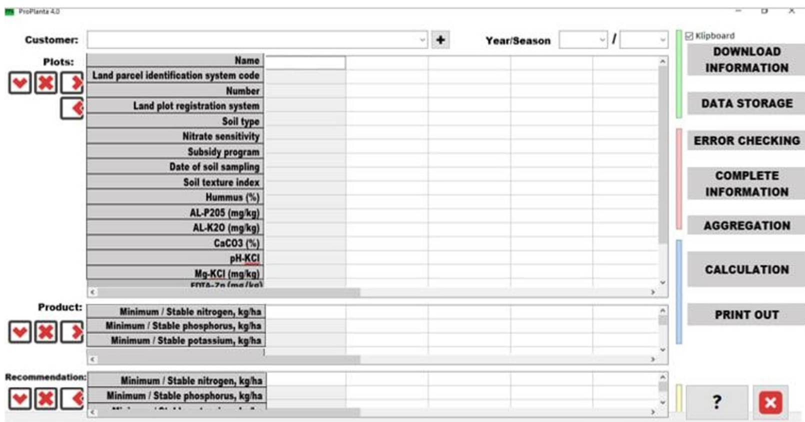

Fig. 3. Software Overview.

In the *Plots* section, users are prompted to provide a comprehensive range of information essential for effective agricultural management. The requested data includes the following: plot name, land plot identification system code, land plot registration system, size of the cultivated area, soil type, date of soil sampling, and soil texture index. Additionally, users must input critical soil nutrient parameters, such as the amount of humus, soil content of AL-P_2O_5, AL-K_2O, $CaCO_3$, pH (KCl), MS (KCl), EDTA-Zn, EDTA-Cu, and EDTA-Mn (Figure 4). This detailed information is crucial for generating accurate recommendations and optimizing fertilization practices, thereby enhancing soil health and crop productivity.

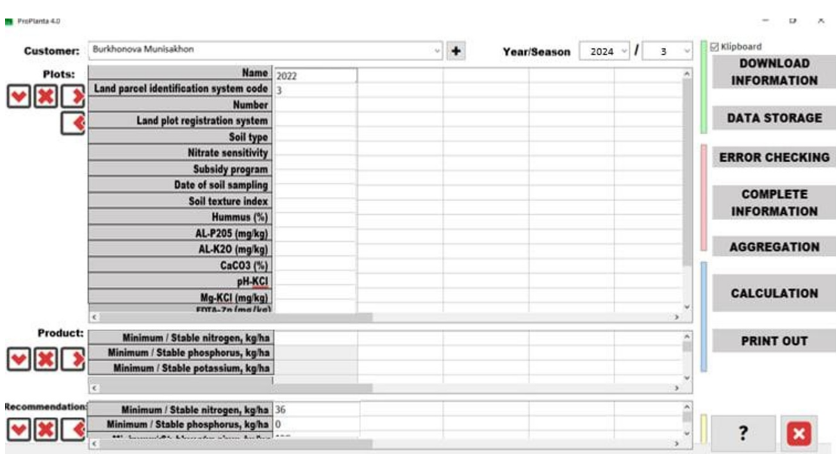

Fig. 4. Information Requested in the "Plots" Section.

In the *Product* section, users are required to provide a comprehensive array of information pertaining to the plant. This includes the expected harvest year, harvest season, type of plant being cultivated, planned number of years for cultivation, actual number of years, planned yield rate, and year of planting. Additionally, users must input critical nutrient data such as leaf nitrogen levels, foliar phosphorus content, and foliar potassium content. Other relevant parameters include the tree-to-tree ratio, average tree trunk diameter, grass cover, type of previous crop, expected harvest time, projected yield, and details regarding by-product or weed manure management.

Moreover, the system requests information on nutrient applications, specifically the amounts of nitrogen, phosphorus, and potassium applied during the current year, as well as the humus content in the soil, the amount of liquid manure used, mulching practices, liming procedures, and the quantity of zinc fertilizer applied. Users are also asked to provide data on the amounts of nitrogen, phosphorus, and potassium applied in the previous year (Figure 5). This extensive information is vital for generating tailored recommendations that optimize plant growth and enhance overall agricultural productivity.

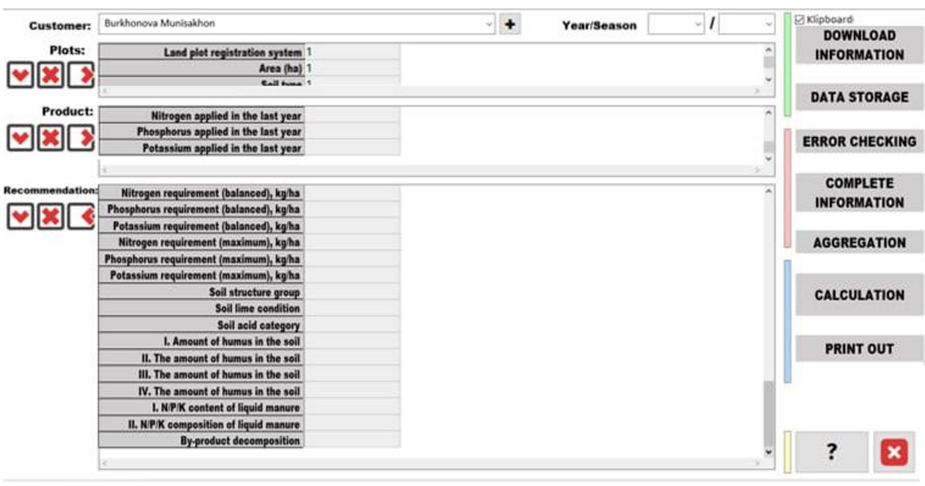

Fig. 5. “Product” means information requested about the plant.

The right-side panel of the software interface features several functional options, including “Load Data,” “Save Data,” “Error Checking,” “Fill Data,” “Aggregate,” “Calculate,” and “Print.” When users select “Load Data,” the corresponding data is retrieved and populated into the *Plots* and *Product* sections, facilitating streamlined data management. Upon clicking the “Calculate” button, the system utilizes its comprehensive database to generate a tailored recommendation based on the input data provided in the *Plots* and *Product* sections.

The information presented in the *Recommendation* includes the minimum and maximum amounts of essential nutrients—namely nitrogen, phosphorus, potassium, lime, magnesium, zinc (Zn), copper (Cu), and manganese (Mn)—that should be applied to the soil. Additionally, the system recommends specific supply categories for these nutrients, alongside crucial parameters such as soil structure group, soil lime status, soil acidity category, soil humus content, and the nitrogen (N), phosphorus (P), and potassium (K) content of liquid manure.

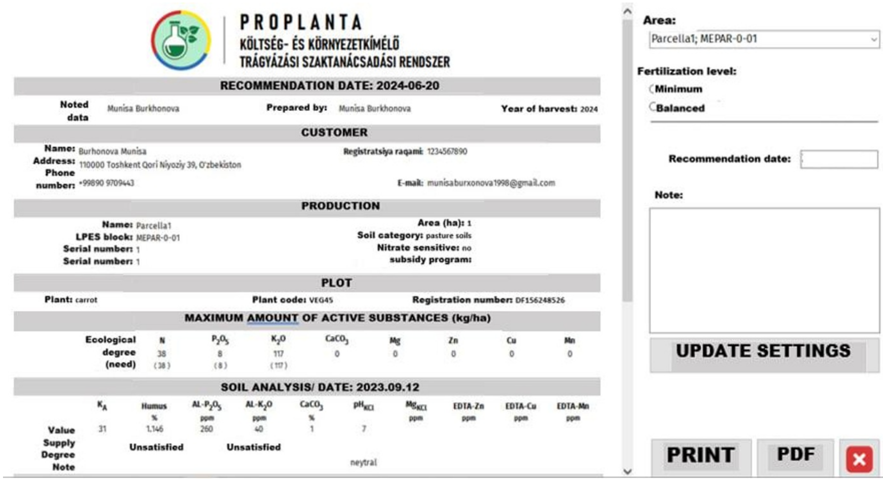

Fig. 6. Overview of recommendation.

The output generated in the *Recommendation* section can be formatted for printing via the "Print" function. This printed document includes critical information such as the date of receipt, recorded data, client details, and specific information about the agricultural plot. Furthermore, the recommendations encompass the maximum allowable amounts of active substances and pertinent soil analysis results. Users also have the option to save or print this information in PDF format, ensuring accessibility and ease of documentation for future reference (Figure 6). This comprehensive reporting feature enhances the utility of the ProPlanta system as a reliable tool for informed agricultural decision-making.

4 Conclusion

The ProPlanta software serves as a vital tool for farmers, enabling the optimal use of agricultural land and the efficient application of essential nutrients and fertilizers, including nitrogen. It systematically calculates the appropriate standards for the application of phosphorus, potassium, lime, magnesium, zinc (Zn), copper (Cu), and manganese (Mn), all of which are derived from the comprehensive database of the ProPlanta system.

By implementing this software, farmers can ensure the accurate cultivation of agricultural crops while mitigating various negative impacts commonly observed in field conditions, such as soil erosion and degradation. Moreover, the software addresses potential issues related to non-compliance with plant quality standards, which can adversely affect agricultural yield and farmer income.

Additionally, the use of ProPlanta fosters a holistic approach to agricultural management by promoting sustainable practices that consider social, economic, and ecological dimensions. By preventing soil degradation and enhancing crop quality, the software not only supports farmers' economic viability but also contributes to environmental sustainability. Future research should explore the long-term effects of using ProPlanta on agricultural productivity and soil health, further validating its role in advancing sustainable agriculture. Ultimately, the ProPlanta system embodies a significant advancement in agricultural advisory technology, equipping farmers with the necessary tools to make informed decisions that promote both productivity and ecological integrity.

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