

OPTIRICE: AN ARTIFICIAL INTELLIGENCE (AI)-BASED SOIL ANALYSIS AND DECISION SUPPORT TOOL FOR FERTILIZER MANAGEMENT IN RICE FIELDS

Althea Nicole V. Concepcion, Jaymari Neo C. Cosmeño, Zane Almar M. Sato

ABSTRACT

Rice production is crucial in both cultural and economic settings in the Philippines. However, costly and time-consuming lab testing for soil is one of the primary reasons why rice production in the country has gone down. This study aimed to create OPTIRICE, a decision-support tool for fertilizer management in rice fields, giving out rapid data-driven solutions. The web application was designed using Lovable AI, incorporating key soil indicators such as, Nitrogen (N), Phosphorus (P), Potassium (K), and pH, while also including crop variety and growing season. The website was designed to provide precise fertilizer recommendations that were from numerous institutions. T - Test and Mean Absolute Percentage Error (MAPE) to evaluate the site's accuracy. The web app's fertilizer recommendations were incredibly accurate, ranging from 14.3 % to 0.51 % error in the Mean Average Percentage Error (MAPE) test, and the nutrients Nitrogen, Potassium, and pH shows high accuracy while Phosphorus has lower accuracy but nevertheless, accurate according to the T - Test. OPTIRICE is a highly accurate decision-support and fertility management tool. Although minor differences were observed, through further calibration OPTIRICE can be used as a platform for modern rice production.

Keywords: Data-driven Solutions, Decision-Support Tool, Fertilizer Management, Highly Accurate, Precise Fertilizer Recommendations

Introduction

In the Philippines, rice plays a crucial role serving as the way of life for many Filipinos nationwide, making up 35% of an average Filipino's calorie intake, and the source of income of millions of farmers in the country (Angeles-Agdeppa & Custodio, 2020). However, due to technological gaps and high costs for fertilizer and labor, rice production has gone down in the country. From 20.06 million metric tons in 2023, to only 19.09 million metric tons in 2024, making a decline of almost 5% in only a year (Department of Agriculture [DA], 2024).

As of 2025, Artificial Intelligence (AI), has gained popularity in multiple countries. With it being used to detect nutrient deficiencies and recommend fertilizer treatments, it has become an essential tool for modern agriculture, reducing production cost and wasted resources (Musnase et al., 2023).

An AI-powered soil analysis and fertilizer recommendation tool, "OPTIRICE" is designed to aid local Filipino farmers in making data-driven decisions for optimal rice growth in their respective rice fields. The web-app analyzes key soil nutrients: Nitrogen (N) for the yield's quality and speed of growth, Phosphorus (P), for energy storage, and Potassium (K), for photosynthesis and the crop's metabolism process, with pH also being critical for the NPK's availability in the crops. The website also considers the variety (hybrid and inbred), and the growing season (wet and dry) of the rice crops. OPTIRICE integrates a color-spectrum input system that aligns with the Department of Agriculture's (DA) soil test kits, and also a manual input option to make it user-friendly. OPTIRICE processes this information, and gives out fertilizer recommendations tailored to what that specific rice field needs.

Conclusion

The results of the study demonstrated that OPTIRICE is a reliable and accurate AI-assisted decision-support system for fertilizer

management in rice fields. Through the integration of Mean Absolute Percentage Error (MAPE) and Paired t-test, the system achieved strong performance in accuracy, statistical agreement, and consistency across different rice varieties and seasonal conditions. These outcomes confirm that OPTIRICE can effectively generate data-driven fertilizer recommendations that closely align with expert assessments while maintaining stable performance under variable environmental settings. The findings further highlight OPTIRICE's potential to enhance precision agriculture by minimizing human error, reducing the need for manual computation, and standardizing fertilizer recommendations. Although minor deviations were observed between AI and expert results, these differences fall within acceptable limits and do not affect the system's overall reliability. With further calibration using real field data, expanded nutrient parameters, and localized adaptation, OPTIRICE can become a fully functional and scalable platform for modern rice production systems. In conclusion, OPTIRICE proves that artificial intelligence can be a practical and sustainable tool for improving fertilizer management. By promoting efficient nutrient utilization and supporting evidence-based decision-making, the system contributes to more productive, cost-effective, and environmentally responsible rice farming practices.

Acknowledgment

The researchers also want to share their heartfelt appreciation to their parents— the people who made it all happen Emma V. Concepcion and Vicente D. Concepcion, Grace C. Cosmeño, Marineo C. Cosmeño, Nena Liza M. Sato, and Almar M. Sato. Their unwavering love, trust, and support, inspired them to keep marching forward even if they were tired.

The researchers also thank their Research teacher, Sir Henry Haranay, and their coach, Ma'am Myrill Bautista, for their continuous guidance and advice in every stage of the research process.

Finally, the researchers would like to express their sincere gratitude to their qualified scientists, Dr. Dernie Olguera and Ma'am lleisa Betacura, for giving their precious time and effort even though they were busy, and provide expertise and insights that greatly contributed to the success of this study.

We dedicate these findings to the Lord.



References

- [1] Angeles-Agdeppa, I., & Custodio, M. R. S. (2020). Food sources and nutrient intakes of Filipino working adults. *Nutrients*, 12(4), 1009. <https://doi.org/10.3390/nu12041009>
- [2] Briones, R. M., Pastolero, H. L. C., & Galang, I. M. R. (2024). Prospects for widespread adoption of organic-based fertilizers in the Philippines: A rapid appraisal (PIDS Discussion Paper No. 2024-30). Philippine Institute for Development Studies. <https://doi.org/10.62986/dp2024.30>
- [3] Bureau of Soils and Water Management (2024). BSWM Fertilizer Recommendations - Department of Agriculture. <https://www.bswm.da.gov.ph/download/bswm-fertilizer-recommendation/>
- [4] Cruz, B. M. D. (2024). Fertilizer price hikes to curb PHL rice yields, consumption – ADB. BusinessWorld Online. <https://www.bworldonline.com/economy/2024/04/30/592046/fertilizer-price-hikes-to-curb-phl-rice-yields-consumption-adb/> BusinessWorld Online
- [5] Department of Agriculture. (2024). PH palay output hits record high of 20.06millionMT. <https://www.da.gov.ph/ph-palay-output-hits-record-high-of-20-06-million-mt/>
- [6] Hidalgo, H. A., Villano, R. A., Lustre, M. S. A., & Hidalgo, K. E. S. (2025). Productivity and technical efficiency of organic rice farming in Camarines Sur, Philippines. *International Journal on Advanced Science, Engineering and Information Technology*, 15(1), 223-230. <https://doi.org/10.18517/ijaseit.15.1.19927>
- [7] International Rice Research Institute (2025). Rice Crop Manager. PDF. <https://dev-static.irri.org>
- [8] Marikyan, D., & Papagiannidis, S. (2025). Technology Acceptance Model: A review. In S. Papagiannidis (Ed.), TheoryHub Book. <https://open.ncl.ac.uk/theories/1/technology-acceptance-model/>
- [9] Musanase, C., Vodacek, A., Hanyurwimfura, D., Uwitonze, A., & Kabandana, I. (2023). Data-Driven Analysis and Machine Learning-Based Crop and Fertilizer Recommendation System for Revolutionizing Farming Practices. *Agriculture*, 13(11), 2141. <https://doi.org/10.3390/agriculture13112141>
- [10] Philippine Rice Research Institute (2018). Minus-One Element Technique. DOCUMENTA-RICE VIDEOS VISUA-RICE INFOGRAPHICS LOGO. <https://www.phil-rice.gov.ph/minus-one-element-technique-moet-app/>
- [11] PhilRice. (2022). Rice varieties and nutrient management guide. Science City of Muñoz, Nueva Ecija: Philippine Rice Research Institute. Retrieved from <https://www.foi.gov.ph/requests/rice-related-datasets/>
- [12] PhilRice. (2024). Soil fertility, nutrient status and soil pH maps dataset. Retrieved from <https://www.foi.gov.ph/requests/rice-related-datasets/>

- [13] Sridevy, S., Nirmala Devi, M., & Sankar, M. (2023). Decision support systems in agricultural industry perspective. *International Journal of Statistics and Applied Mathematics*, 8(2 Special Issue), Part A. <https://doi.org/10.22271/math.2023.v8.i2sa.984>
- [14] United States Department of Agriculture - Foreign Agricultural Service. (2025). Grain and feed update: Manila, Philippines (RP2024-0031). <https://apps.fas.usda.gov/newgainapi/api/Report/DownloadReportByFileName?>

© GSJ