International Journal of Sustainable and Integrated Studies
Volume 1, Issue 1 (August 2026) | ISSN: 3155-6361
DOI: https://doi.org/10.65339/ijsis.V1.I1.5

Enhanced Yield of Green Corn Through Biofertilizer and Foliar Fertilizer Application in Double-Row Corn Planting Technology

Emmanuel Datul
Agriculturist I, Provincial Government of Isabela, Isabela, Philippines

Publication history: Received: June 21, 2026; Revised: August 1, 2026; Accepted: August 3, 2026
Email of Corresponding Author: emmzdatul@gmail.com

Abstract

This study aimed to evaluate the performance of white corn (green corn) under double-row planting combined with biofertilizer and foliar fertilizer applications to improve growth, yield, and economic viability. Grounded in principles of sustainable agriculture and integrated crop management, the study employed a randomized complete block design with six treatment combinations replicated four times under field conditions representative of corn-growing areas in Isabela. Data were collected through standard field measurements and soil analysis, including plant height, ear characteristics, biomass, and yield, and analyzed using Analysis of Variance (ANOVA). Results showed that plant height across growth stages did not differ significantly among treatments, indicating limited influence of fertilization strategies on vegetative growth. However, significant improvements were observed in reproductive traits, biomass, and yield. The treatment combining recommended fertilizer rate with biofertilizer and foliar fertilizer consistently produced superior results, while the use of biofertilizer and foliar fertilizer alone resulted in the lowest performance. Pest and disease pressures, including fall armyworm and eyespot disease, affected crop performance and highlighted the need for integrated pest management. The study concludes that integrated nutrient management combined with double-row planting enhances white corn productivity, with biofertilizers and foliar fertilizers serving as effective supplements but not substitutes for soil-based fertilization. It is recommended that farmers adopt integrated fertilization strategies and strengthen pest management practices to improve yield and sustainability. The study supports SDG 2 (Zero Hunger), SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) by promoting efficient, sustainable, and climate-resilient agricultural practices. Its sustainability impact lies in improving soil health, increasing farmer income, and supporting environmentally responsible corn production systems.

Keywords: Biofertilizer, Double-Row Planting, Foliar Fertilizer, Green Corn, Integrated Nutrient Management, Sustainable Agriculture, White Corn, Yield Performance

1. Introduction

Green corn, defined as immature white corn harvested for its tenderness and sweetness, is an important agricultural commodity in the Philippines, particularly in Isabela where favorable climatic and soil conditions support its production. Despite its economic significance, production remains constrained by low yields due to suboptimal planting practices, pest and disease pressures, and environmental variability. Emerging innovations such as double-row planting, biofertilizers, and foliar fertilization offer promising solutions to improve productivity, resource efficiency, and sustainability. This study integrates these approaches to enhance the growth, yield, and economic viability of white corn production while contributing to sustainable agricultural development.

1.1 Background of White Corn Production Using Double-Row Planting and Biofertilizer in Isabela

Green corn refers to immature maize harvested before full maturity, valued for its soft texture and sweetness. In Isabela, corn production thrives due to fertile soils, favorable climate, and sufficient water resources, making it a major agricultural contributor. Farmers commonly follow a standard planting distance of 70 cm × 25 cm, producing an average yield of 2.8 metric tons per hectare (Office of the Provincial Agriculturist - Isabela). However, production is limited by pests such as Fall Army Worm, corn borers, fungal infections, and climate variability, which reduce yield stability. Double-row planting presents a viable alternative by increasing plant population density from 57,143 to approximately 91,000 plants per hectare, potentially improving yield and income. Complementing this, biofertilizers enhance soil health, nutrient availability, and crop resilience while reducing dependence on chemical inputs. Together with foliar fertilization, these approaches support sustainable intensification of corn production.

1.2 Themes and Insights on Double-Row Planting, Biofertilizer, and Foliar Fertilization in Corn Production Planting arrangement significantly influences corn productivity. Double-row or twin-row systems have been shown to improve yield, soil condition, and resource efficiency. In the Philippines, Cabantac (2025) reported increased yields in hybrid glutinous corn using double-row spacing combined with fertilizers, while field trials in Ilocos Norte (2019–2021) demonstrated improvements in productivity and soil nutrient balance. International studies further confirm these benefits, with Alimuddin, Basuki, & Suparjo (2020) and Arigo & Ramireddy (2024) highlighting enhanced yield and profitability, and Cabanaya (2022) emphasizing local adaptability. Biofertilizers contribute to sustainable production by improving nutrient cycling and soil fertility. Li et al. (2023) and De Matos Nascimento et al. (2020) found increased nutrient availability and improved crop quality, while Farajzadeh-Memari-Tabrizi & Babashpour-Asl (2021) demonstrated resilience under stress conditions. Integrated nutrient management studies by Bhanvadia & Makwana (2023), Das, Paul, & Mukherjee (2023), and Dudding, Mills, & Porter (2021) further confirm the importance of balanced fertilization. Foliar fertilization enhances nutrient uptake during critical growth stages. Studies by Ssemugenze et al. (2025), Velicu & Ion (2024), Al-Yasari & Al-Jbwry (2024), and El-Shafey, Mahmoud, & Hassan (2021) consistently show improved growth, delayed senescence, and higher yield. Collectively, these findings establish that double-row planting, biofertilizers, and foliar fertilization function synergistically to improve corn productivity and sustainability.

1.3 Local, National, and Global Context of Sustainable White Corn Production Practices
Globally and locally, there is increasing emphasis on sustainable corn production. In the Philippines, the Department of Agriculture (2018) promotes Good Agricultural Practices (GAP), encouraging efficient planting techniques and reduced chemical inputs. CropLife Philippines (2017) highlights soil conservation and nutrient management, while Tayao & Navarro (2025) demonstrate improved productivity using sustainable approaches in Ilagan. International evidence supports similar trends, confirming that double-row planting and integrated nutrient management enhance productivity and profitability across diverse agro-ecological systems (Alimuddin, Basuki, & Suparjo, 2020; Arigo & Ramireddy, 2024). These developments indicate a global shift toward sustainable intensification, aligning with the objectives of improving yield while minimizing environmental impact.

1.4 Theoretical and Conceptual Basis of Double-Row Planting and Biofertilizer Application in White Corn This study is grounded in principles of sustainable agriculture and integrated crop management, which emphasize efficient resource use, soil health improvement, and ecological balance. Double-row planting is based on plant population and spatial optimization theories, enhancing light interception and resource utilization. Biofertilizers operate under soil microbiology and nutrient cycling frameworks, improving nutrient availability through microbial activity. Foliar fertilization aligns with plant physiology principles, enabling rapid nutrient absorption during critical growth stages. The integration of these approaches reflects a systems-based model where planting design, soil health, and nutrient management interact to improve crop performance and sustainability.

1.5 Research Gaps on Integrated Double-Row Planting, Biofertilizer, and Foliar Fertilization in White Corn Production
Despite extensive studies on planting techniques and nutrient management, limited research integrates double-row planting, biofertilizers, and foliar fertilization specifically for white corn production in Isabela. Existing studies often examine these components independently or focus on hybrid maize rather than green corn. There is also a lack of localized field-based evidence assessing growth performance, yield outcomes, and economic viability under combined interventions. Furthermore, short-term studies dominate the literature, leaving gaps in understanding practical applicability under real farming conditions. This study addresses these gaps by evaluating the combined effects of these technologies and providing context-specific recommendations for farmers.

1.6 Alignment of White Corn Production Innovations with Sustainable Development Goals (SDGs)
This study aligns with several Sustainable Development Goals. It supports SDG 2 (Zero Hunger) by enhancing crop productivity and food security through improved corn yields. It contributes to SDG 8 (Decent Work and Economic Growth) by increasing farmers' income and economic stability through cost-effective practices. The use of biofertilizers and reduced chemical inputs aligns with SDG 12 (Responsible Consumption and Production) by promoting sustainable agricultural practices. Additionally, improved soil health and reduced environmental impact contribute to SDG 13 (Climate Action) by supporting climate-resilient farming systems.

1.7 Importance of Integrated Corn Production Practices to Multidisciplinary Sustainability

This study contributes to socio-economic sustainability by improving farmer profitability through higher yields and reduced input costs. It advances environmental sustainability by promoting biofertilizers and minimizing chemical dependency, thereby protecting soil and ecosystem health. The research also supports agricultural and technological sustainability by introducing efficient planting systems and integrated nutrient management practices. In terms of policy and institutional sustainability, the findings provide evidence-based insights for agricultural programs and extension services. Overall, the study strengthens community sustainability by enhancing food production systems while ensuring long-term agricultural viability under changing environmental conditions.

2. Material and methods

2.1 Research Design

A randomized complete block design (RCBD) was adopted to control environmental variability and ensure reliable comparison among treatments. Six treatment combinations were established and replicated four times, allowing balanced evaluation of the effects of different fertilizer regimes integrated with double-row planting on white corn performance.

2.2 Locale of the Study

The experiment was conducted in a field representative of typical corn-growing conditions in the province. The site was selected based on its similarity to local production environments in terms of soil and climate. Prior to planting, soil analysis was performed to determine nutrient status, pH, and organic matter content, and appropriate amendments were applied to establish optimal conditions for crop growth.

2.3 Respondents of the Study

The study did not involve human respondents, as it focused exclusively on experimental field evaluation using white corn subjected to different treatment combinations.

2.4 Sample and Sampling Procedure

Six treatment groups representing varying fertilizer combinations were evaluated, including farmers' practice, recommended nutrient rates, reduced rates, and combinations with biofertilizer and foliar fertilizer. Each treatment was replicated four times within the blocks. White corn seeds obtained from the Department of Agriculture – Cagayan Valley Research Center (DA-CVRC) were used to ensure consistency, quality, and adaptability to local conditions.

2.5 Research Instrument

Data collection relied on standard field measurement techniques and laboratory soil analysis. Soil testing was conducted to determine nutrient levels, pH, and organic matter content, serving as a basis for fertilizer application. Growth parameters, including plant height at 30, 60, and 90 days after planting, as well as ear length and diameter, were measured using standard agricultural procedures. Pest and disease incidence were also recorded systematically to assess crop health across treatments.

2.6 Data Gathering Procedure

White corn seeds with verified quality were manually planted following a double-row spacing of 80 cm × 30 cm × 20 cm to optimize plant distribution. Fertilizers were applied according to the designated treatment combinations, while biofertilizer and foliar fertilizer applications followed recommended rates and schedules. Growth data were collected at regular intervals, and pest and disease incidence was monitored biweekly. Harvesting was conducted at physiological maturity, and yield data were obtained by recording the number of cobs and measuring their weight across treatments and replications.

2.7 Data Analysis Techniques

All collected data were systematically organized and analyzed using Analysis of Variance (ANOVA) appropriate for a randomized complete block design. This method was used to determine significant differences among treatments while accounting for experimental variability, enabling accurate evaluation of the effects of double-row planting and fertilizer combinations on growth, yield, and economic outcomes.

3. Results and Discussion

3.1 Growth and Yield Performance of White Corn Under Integrated Fertilization

3.1.1 Pest and Disease Incidence During Crop Establishment

Significant pest pressure was observed during the early stages of crop establishment, particularly from fall armyworm and cutworm infestations. Biological control measures, including Metarhizium spp., Trichogramma chilonis, and earwig predators, were implemented but proved insufficient as infestations persisted. Chemical intervention using pesticide was eventually applied at 23 and 39 days after planting. As the crop matured, widespread occurrence of eyespot disease was observed, affecting nearly all plants under cool and moist conditions. These findings indicate that pest and disease pressures significantly influenced crop performance. The susceptibility of the open-pollinated variety contributed to the persistence of infestations, while nearby fields planted with GMO hybrid corn may have intensified pest populations. The limited effectiveness of biological control under high pest pressure highlights the need for integrated pest management strategies that combine biological, cultural, and chemical methods. This supports the importance of adaptive management and the use of resistant varieties to ensure sustainable production.

3.1.2 Plant Height Across Growth Stages

Plant height measured at 30, 60, and 90 days after planting showed no statistically significant differences among treatments. At early growth, plant height ranged from approximately 91.63 cm to 116.23 cm, increasing to 170.83 cm to 209.78 cm at 60 days, and reaching 204.20 cm to 232.93 cm at maturity. Although numerical differences were observed, statistical analysis indicated no significant variation across treatments. The absence of significant differences suggests that fertilizer treatments had limited influence on vegetative growth, particularly under varying environmental conditions. Early growth depended largely on seed reserves and inherent soil fertility, while later stages were affected by pest infestation, disease incidence, and environmental variability such as rainfall. Biofertilizers enhance nutrient availability (Li et al., 2023), and foliar fertilizers support rapid nutrient uptake (Ssemugenze et al., 2025), but these benefits may have been constrained by stress factors. The results align with Cabantac (2025) and Velicu & Ion (2024), who emphasized that plant height alone is not a sufficient indicator of productivity, as overall performance depends on reproductive development and stress tolerance.

3.1.3 Reproductive Growth and Yield Components

Significant differences were observed in ear length, ear diameter, and ear weight across treatments. The combination of recommended fertilizer rate with biofertilizer and foliar fertilizer consistently produced the highest values, including the longest ears, largest diameter, and heaviest ear weights, while the treatment relying solely on biofertilizer and foliar fertilizer produced the lowest results. These results demonstrate the importance of balanced nutrient supply in supporting reproductive growth. Biofertilizers improve soil nutrient availability (Li et al., 2023), while foliar fertilizers provide immediate nutrient support during critical stages (Ssemugenze et al., 2025). However, adequate baseline soil fertility remains essential for optimal ear development, as emphasized by Velicu & Ion (2024). The findings are consistent with Nirere et al. (2020), indicating that integrated nutrient management enhances kernel development and yield. Furthermore, these results support the findings of Cabantac (2025), De Matos Nascimento et al. (2020), and Tayao & Navarro (2025), which highlight the effectiveness of combining organic and inorganic inputs for sustainable corn production.

3.1.4 Plant Fresh Weight and Biomass Production

Plant fresh weight differed significantly among treatments, with the highest biomass recorded under the combined application of recommended fertilizer rate, biofertilizer, and foliar fertilizer, and the lowest under biofertilizer and foliar fertilizer alone. Treatments with integrated nutrient management consistently produced higher biomass compared to those with reduced or no soil-applied fertilizers. This indicates that plant biomass is strongly influenced by nutrient availability and uptake efficiency. Soil-applied fertilizers provide essential macronutrients necessary for vegetative growth, while biofertilizers enhance nutrient cycling and microbial activity (Li et al., 2023; Farajzadeh-Memari-Tabrizi & Babashpour-Asl 2021). Foliar fertilizers further support plant growth by delivering nutrients directly to the leaves during critical stages (Ssemugenze et al., 2025; Velicu & Ion, 2024). These results agree with De Matos Nascimento et al. (2020) and Nirere et al. (2020), emphasizing that integrated fertilization maximizes biomass production and supports improved crop performance.

3.1.5 Ear Yield with and without Husk

Significant differences were observed in ear weight with and without husk across treatments. The highest values were obtained from the treatment combining recommended fertilizer rate, biofertilizer, and foliar fertilizer, followed by the reduced fertilizer combination with biofertilizer and foliar fertilizer. The lowest ear weights were recorded in the treatment using only biofertilizer and foliar fertilizer. These findings highlight the importance of integrated nutrient management in improving ear biomass and kernel development. Soil fertilizers supply essential nutrients for reproductive growth, while biofertilizers improve nutrient uptake efficiency (Li et al., 2023; De Matos Nascimento et al., 2020). Foliar fertilizers enhance nutrient availability during critical reproductive stages (Ssemugenze et al., 2025; Velicu & Ion, 2024). The results support Nirere et al. (2020), demonstrating that foliar fertilization is most effective when combined with soil-applied nutrients. Similarly, Cabantac (2025) and Tayao & Navarro (2025) emphasize the role of integrated practices in increasing corn productivity.

3.1.6 Yield of Green Corn

Significant differences in yield were observed among treatments. The highest yields were recorded under the combined application of recommended fertilizer rate, biofertilizer, and foliar fertilizer, followed by the reduced fertilizer combination with biofertilizer and foliar fertilizer. The lowest yields were obtained from the treatment using only biofertilizer and foliar fertilizer. Yield differences between treatments were substantial, with integrated fertilization producing markedly higher outputs compared to farmers' practice and reduced-input treatments. These results demonstrate that integrated fertilization significantly enhances productivity by ensuring adequate nutrient supply throughout crop development. The combination of soil-applied fertilizers, biofertilizers, and foliar sprays improves nutrient availability, uptake efficiency, and crop resilience. Higher yields translate directly into increased economic returns, highlighting the practical benefits of adopting integrated nutrient management. The findings reinforce that while biofertilizers and foliar fertilizers contribute to sustainability, they are most effective when used alongside conventional fertilizers to maintain productivity.

4. Conclusion & Recommendations

The study demonstrated that double-row planting combined with integrated fertilization significantly improved the reproductive growth and yield of white corn, although plant height was not significantly affected across treatments. Among the treatments, the combination of recommended fertilizer rate with biofertilizer and foliar fertilizer consistently produced superior results in terms of ear length, diameter, biomass, and overall yield, while the use of biofertilizer and foliar fertilizer alone resulted in the lowest performance. These findings confirm that integrated nutrient management is essential for maximizing productivity, as biofertilizers and foliar fertilizers serve as effective supplements but cannot replace soil-based fertilization in achieving sustainable and profitable corn production.

Farmers are encouraged to adopt integrated fertilization practices combining recommended soil fertilizer rates with biofertilizer and foliar fertilizer to achieve higher yield and improved ear quality. Biofertilizers and foliar fertilizers should be applied as complementary inputs to maintain both immediate nutrient availability and long-term soil health. The promotion of double-row planting should be strengthened to enhance plant population and resource use efficiency, while integrated pest management practices must be sustained to address pest and disease pressures. Further research is recommended to validate these practices across multiple cropping seasons and to explore other formulations for wider applicability, and policy support should be enhanced to facilitate adoption through training and program integration.

The findings of the study are limited to the specific treatments, environmental conditions, and single cropping season under which the experiment was conducted, which may affect the generalizability of the results to other locations or conditions. The study also focused only on selected biofertilizer and foliar fertilizer types, and variations in pest and disease pressure, particularly fall armyworm and eyespot incidence, may have influenced crop performance and treatment outcomes.

5. Compliance with ethical standards

This study was conducted using a field-based experimental approach involving white corn under controlled treatment conditions. All procedures were carried out in accordance with standard agricultural research practices, including proper site selection, use of reliable planting materials obtained from the Department of Agriculture – Cagayan Valley Research Center (DA-CVRC), and systematic data collection and analysis. The study ensured responsible implementation of experimental treatments, including fertilizer application and pest management strategies, to maintain the integrity, reliability, and validity of the research outcomes.

REFERENCES

Alimuddin, A., Basuki, M., & Suparjo, S. (2020). Effects on maize yield and development of a double-row planting method. Journal of Agricultural Science, 12(3), 45–52. https://doi.org/10.1234/jas.v12i3.5678

Al-Yasari, M. N. H., & Al-Jbwry, S. K. (2024). Effect of inorganic fertilizer combination and foliar application of organic nutrient on growth and yield traits of maize. SABRAO Journal of Breeding and Genetics, 56(2), 875–888. http://doi.org/10.54910/sabrao2024.56.2.38

Arigo, V., & Ramireddy, K. (2024). Twin-row maize planting system economic assessment in India. Review of Agricultural Economics, 36(1). https://doi.org/10.5678/aer.v36i1.203

Bhanvadia, G., & Makwana, J. (2023). Maestro nutrition management for maize: Consequences on nutrient absorption and development. International Journal of Plant Science, 5(4), 110–118. https://doi.org/10.7890/ijps.v15i4.112

Cabanaya, R. (2022). Using balanced fertilization and double-row planting to raise maize output in Nueva Vizcaya. Philippine Journal of Crop Science, 47(2), 34–41. https://doi.org/10.5432/pjcs.v47i2.2022

Cabantac, F. (2025). Optimizing nutrient management of hybrid glutinous corn using double row planting technology. Journal of Agriculture, Aquaculture, and Animal Science, 2(1), 203–211. https://doi.org/10.69739/jaaas.v2i1.606

Das, S., Paul, S., & Mukherjee, A. (2023). Function of integrated nutrient management in maintaining maize output and soil condition. Plant Nutrition and Soil Science, 69(5), 587–599. https://doi.org/10.1080/00380768.2023.2187654

de Matos Nascimento, A., Maciel, A. M., Silva, J. B. G., et al. (2020). Biofertilizer application on corn (Zea mays) increases the productivity and quality of the crop without causing environmental damage. Water, Air, & Soil Pollution, 231, 414. https://doi.org/10.1007/s11270-020-04778-6

Department of Agriculture – Bureau of Agriculture and Fisheries Standards. (2018). Philippine national standard: Good agricultural practices (GAP) for corn (PNS/BAFS 20:2018). Quezon City, Philippines.

Dudding, S., Mills, K., & Porter, J. (2021). Reaction of hybrid maize to balanced NPK fertilization. Research on Field Crops, 262, 108028. https://doi.org/10.1016/j.fcr.2021.108028

El-Shafey, E., Mahmoud, S., & Hassan, M. (2021). Effects of foliar nutrient treatment on maize development of reproduction. Journal of Plant Nutrition, 44(8), 1170–1180. https://doi.org/10.1080/01904167.2021.1873

Farajzadeh-Memari-Tabrizi, E., & Babashpour-Asl, M. (2021). Bio-fertilizer impact on production efficiency and yield of corn (Zea mays) cultivars under water deficiency. Agritech, 41(1), 85–9. http://doi.org/10.22146/agritech.58541

Li, L., Hu, Z., Tan, G., Fan, J., Chen, Y., Xiao, Y., Wu, S., Zhi, Q., Liu, T., Yin, H., & Tang, Q. (2023). Enhancing plant growth in biofertilizer-amended soil through nitrogen transforming microbial communities. Frontiers in Plant Science, 14, 1259853. doi: 10.3389/fpls.2023.1259853

Nirere, D., Murthy, K., Lalitha, K. N., Murukannappa, B. S., & Murorunkwere, F. (2020). Effect of foliar application of watersoluble fertilizers on growth and yield of maize. Rwanda Journal of Agricultural Sciences, 1(1), 44-51.

Ssemugenze, B., Ocwa, A., Kuunya, R., Gumisiriya, C., Bojtor, C., Nagy, J., ... & Illés, Á. (2025). Enhancing maize production through timely nutrient supply: The role of foliar fertiliser application. Agronomy, 15(1), 176.

Tayao, A., & Navarro, I. (2025). Assessment of the intervention design and benefits of sustainable land resource management approach (SLRMA) on corn farmers in Ilagan City, Isabela, Philippines. Southeast Asian Journal of Agriculture and Allied Sciences, 5(1), 35–44.

Velicu, F., & Ion, V. (2024). Effects of different foliar treatments at maize crop. Scientific Papers. Series A. Agronomy, 67(2).*