

REGULAR ARTICLE

Survivability and Growth Performance of Abaca (*Musa textilis* Née) using Biofertilizers in Masbate, Philippines Condition

ARTICLE HISTORY

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Abstract: The study was conducted to evaluate the effects of biofertilizers on the survivability and growth performance of abaca under Masbate conditions. A trial was carried out following a Randomized Complete Block Design (RCBD) with four treatments and four replications. The effects of different fertilizers, applied at their recommended rates, served as treatments, namely: Treatment A – 10 g of complete fertilizer per plant (Control); Treatment B – 10 g of complete fertilizer per hill combined with a foliar application of 15 mL of ANAA per 4 L of water; Treatment C – 20 g of Mykovam per plant; and Treatment D – 20 g of Mykoplus per plant. Abaca plants were monitored under field conditions for three months, and soil chemical properties were analyzed before and after treatment application. Growth parameters—including height increment, leaf development, pseudostem size, sucker production, and survival rate—showed no significant differences ($p > 0.05$) among treatments. These findings suggest that biofertilizers such as Mykovam and Mykoplus remain practical alternatives when inorganic fertilizers are limited, as their beneficial microbes help support nutrient uptake and root development. The consistently high survival rate across treatments also indicates that Masbate provides favorable conditions for establishing abaca. Further research should extend into later growth stages, focusing on fiber yield and quality, and evaluating whether combined or reduced fertilizer rates with biofertilizers can provide long-term benefits for plant performance and soil health.

Keywords: abaca; biofertilizer; growth; Masbate condition; survival rate

1. Introduction

Abaca (*Musa textilis* Née), commonly known as Manila hemp, is an economically significant crop native to the Philippines. Its fiber is widely valued for its exceptional strength and flexibility—three times stronger than cotton and twice as strong as sisal (Armecin et al., 2014). The Philippines remains the world's largest producer of abaca fiber, supplying key industries such as specialty paper, textiles, handicrafts, furniture, cosmetics, meat casing, and even composite materials for the automotive and construction sectors (Philippine Fiber Industry Development Authority, 2015).

However, despite its strong market demand, the abaca industry continues to face serious constraints. The growth and productivity of abaca are highly dependent on environmental conditions such as rainfall distribution, temperature, radiation, and soil fertility (Bureau of Agriculture and

Fisheries Standards, 2019). While the crop thrives in areas with evenly distributed rainfall and moderate temperatures (Type IV climate) (PhilFIDA, 2016), provinces such as Masbate fall under a Type III climate classification, where rainfall patterns and temperature levels may not readily support optimal abaca performance. This raises uncertainty regarding the adaptability and survivability of abaca under Masbate's agro-climatic conditions.

In addition, abaca is a shallow-rooted, heavy nutrient feeder that requires abundant nitrogen and potassium to sustain growth and fiber quality (Bande et al., 2012). Many abaca-growing areas rely heavily on inorganic fertilizers, which can lead to soil degradation, reduced soil biological activity, and long-term decline in productivity. This concern highlights the need for more sustainable nutrient management strategies in abaca cultivation.

Biofertilizers present a potential solution to this challenge. Products such as Mykovam and MykoPlus, developed by UPLB-BIOTECH, contain beneficial microorganisms that improve soil health, enhance nutrient uptake, increase plant vigor, and reduce susceptibility to environmental stress (Aggangan et al., 2013; Sindhu et al., 2010; Abdelaal et al., 2021).

While the Bicol Region is currently the country's leading abaca-producing region, contributing 35% of national output in 2019 (Magno-Ballesteros & Ancheta, 2022), Masbate has no documented research confirming whether abaca can survive or perform well under its local environmental conditions. This lack of information presents a critical knowledge gap. Without empirical evidence on abaca's adaptability and the effectiveness of biofertilizers in Masbate, farmers, researchers, and development agencies are unable to make informed decisions regarding potential abaca expansion in the province.

Therefore, this study was conducted to evaluate the survivability and growth performance of abaca in Masbate using biofertilizers and Alpha-Naphthalene Acetic Acid (ANAA). Specifically, it assessed (1) soil chemical properties before and after the study, (2) growth parameters such as plant height, leaf number and size, pseudostem length and diameter, and sucker formation, and (3) the survival rate of abaca under field conditions. Findings from this research aim to support future academic studies, guide farmer awareness and adoption of biofertilizers, and contribute to developing sustainable fiber-based livelihood opportunities in the province.

2. Materials and Methods

2.1 Research Design and Experimental Unit

The experiment was arranged in a Randomized Complete Block Design (RCBD) with four treatments, each replicated four times, for a total of 16 plots. Each plot contained six hardened abaca plantlets and was located in the High Value Commercial Crops (HVCC) area of DEBESMSCAT under Masbate growing conditions. The treatments were: A (Control) – complete fertilizer (14-14-14); B – complete fertilizer (14-14-14) with foliar ANAA (15 mL per 4 L water); C – Mykovam; and D – Mykoplus.

2.2 Land and Planting Materials Preparation

The experimental area was prepared after the collection of a soil sample and a week prior to planting. Plowing was done to break the soil clods and remove the weeds present in the area to create a suitable environment for the abaca to grow well. A total of 96 hardened plantlets of the abaca variety 'Musa Tex 51' were collected from the Provincial Plant Nursery, Tissue Culture Laboratory. The plantlets were planted in a polyethylene bag and cared for 21 days before transplanting in the field.

2.3 Field Management and Treatment Application

The abaca plantlets were transplanted in the late afternoon using the square planting method, maintaining a plant-to-plant distance of 2 m. The hardened plantlets were irrigated twice daily (morning and afternoon) for one week to allow recovery from transplanting shock, and thereafter irrigation was

carried out every other day. Ring weeding was performed around each plant before fertilizer application.

For Treatment A (Control), 10 g of complete fertilizer was applied basally at transplanting, followed by 10 g every 15 days, applied in a ring 10 cm from the base of the plant. For Treatment B, 10 g of complete fertilizer was applied at transplanting, followed by 10 g every 15 days (ring method), along with a foliar application of ANAA at 100 mL per plant every seven days. For Treatment C, 20 g of Mykovam was placed into each planting hole at transplanting, followed by drenching 650 mL of a Mykovam solution (1 kg in 16 L of water) per plant every 10 days. For Treatment D, 20 g of Mykoplus was applied into each planting hole at transplanting, followed by drenching 650 mL of a Mykoplus solution (200 g in 16 L of water) per plant every 10 days.

2.4 *Pest and Disease Management*

The occurrence of pests and diseases was closely monitored from planting until termination. Shrubs, bushes, and grasses growing in the experimental site were removed to prevent them from providing shelter for insect and animal pests. Green-labeled pesticides were used to control leaf spot disease and insect pests.

2.5 *Data Gathering*

2.5.1 *Soil sampling and analysis*

Soil sampling was conducted before and after the experiment using a random sampling method. Prior to land preparation, composite soil samples were collected from the experimental area to determine the initial soil properties. After the study, soil samples were collected from each experimental plot and subsequently combined to form one composite sample per treatment.

All soil samples were air-dried under shade, pulverized, thoroughly mixed, and passed through a sieve (2 mm mesh) to obtain uniform particle size. The processed samples were then stored and prepared for chemical analysis. A total of 1 kg of soil per treatment, consisting of equal portions of fine and coarse fractions, was submitted to the Central Analytical Services Laboratory, Visca, Baybay City, Leyte, for the determination of soil pH, organic matter, total nitrogen, and available phosphorus.

2.5.2 *Growth parameters*

All growth parameters were recorded at the initial measurement and subsequently measured at 30-day intervals throughout the duration of the study. Plant height increment was determined by measuring the increase in height from the base of the plant to the highest point. The number of leaves was obtained by counting only the fully developed leaves on each plant. Leaf size was assessed by measuring leaf length from the tip to the end of the leaf blade. The diameter of the pseudostem was measured one centimeter above the plant base using a caliper, while the length of the pseudostem was taken from the base of the plant up to the topmost petiole. The number of suckers per plant was determined by visually counting all suckers present in the surviving plants at the end of the study.

2.5.3 *Survival rate*

The percentage of survival was determined at the end of the experiment by counting the number of surviving plants. It was computed by dividing the number of surviving plants by the total number of plants initially planted, then multiplying the result by 100.

2.6 *Data Analysis*

The experimental data were analyzed using Analysis of Variance (ANOVA) to evaluate differences among treatments. Before analysis, the assumptions of ANOVA—normality and homogeneity of variances—were tested to ensure the validity of the results. All statistical analyses were conducted using

the Statistical Tool for Agricultural Research (STAR) software, version 2.0.1, developed by the International Rice Research Institute (IRRI).

3. Results and Discussion

3.1 Soil Chemical Properties

The initial soil pH, organic matter, total nitrogen, and available phosphorus were measured prior to fertilizer application and compared with the final values after treatment. The treatments included: the recommended inorganic fertilizer alone (TA), the combination of inorganic fertilizer and ANAA (TB), Mykovam (TC), and Mykoplus (TD). The table below (Table 1) shows the changes in soil chemical properties from the initial levels to the final values after the application of the respective treatments.

The application of the different fertilizer treatments resulted in slight variations in soil pH. The recommended inorganic fertilizer resulted in a pH of 5.28, while the combination of inorganic fertilizer and ANAA produced a pH of 5.26. Mykovam similarly decreased the pH slightly to 5.33. In contrast, Mykoplus increased the soil pH to 5.44. The slight increase associated with Mykoplus may be attributed to microbial activity that can buffer soil acidity or exert a mild liming effect. This trend aligns with the findings of Yasa et al. (2023), who reported that biofertilizers tend to increase soil pH, whereas continuous application of inorganic fertilizers may lead to gradual soil acidification.

The initial soil organic matter (OM) content was 1.689%, which falls within the commonly reported range for cultivated soils. After treatment application, OM content ranged from 1.762% to 2.481%. The recommended inorganic fertilizer resulted in the highest OM value (2.481%), followed by Mykovam (2.116%) and Mykoplus (2.011%). The combination of inorganic fertilizer and ANAA showed the lowest increase (1.762%). The increase in OM may be linked to enhanced plant growth and subsequent return of leaf residues, which contribute to organic matter buildup through decomposition. Pardo et al. (2010) noted that microbial inoculants can support nutrient cycling and organic matter turnover, which may explain the moderate increases under Mykovam and Mykoplus.

The initial soil nitrogen content was low at 0.139%. Mykovam-treated soil showed the highest nitrogen increase at 0.172%, while both the recommended inorganic fertilizer and Mykoplus increased nitrogen to 0.148%. The combination treatment did not result in any noticeable increase from the initial nitrogen level. The increase associated with Mykovam may be related to the role of vesicular arbuscular mycorrhiza in enhancing nutrient uptake by converting unavailable nitrogen into plant-available forms. This is consistent with Mulyani et al. (2017), who reported that endomycorrhizal biofertilizers can significantly improve soil nitrogen availability.

The initial available phosphorus level was 13.537 mg kg⁻¹. Mykoplus resulted in the highest increase to 20.737 mg kg⁻¹, followed by the recommended inorganic fertilizer, which increased phosphorus to 14.316 mg kg⁻¹. In contrast, Mykovam and the combination treatment produced slightly lower values (11.600 and 13.011 mg kg⁻¹, respectively). The substantial increase in phosphorus under Mykoplus may be attributed to the activity of P-solubilizing microorganisms that enhance phosphorus availability, particularly when soil pH is slightly improved. Fitriatin et al. (2021) observed similar effects with biofertilizers containing P-solubilizing microbes.

Table 1. Soil chemical properties as affected by different fertilizer treatments

Soil Properties	Initial Content	Final Content			
		TA	TB	TC	TD
pH	5.36	5.28	5.26	5.33	5.44
Organic Matter (%)	1.689	2.481	1.762	2.116	2.011
Total N (%)	0.139	0.148	0.139	0.172	0.148
Available P (mg kg ⁻¹)	13.537	14.316	13.011	11.600	20.737

3.2 Growth Response

Figure 1 presents the mean values of the measured growth parameters, including plant height increment, number of leaves, leaf length, pseudostem diameter, pseudostem length, and number of suckers per plant under the different fertilizer treatments. In general, all treatments supported plant growth throughout the duration of the study, with observable but generally not significant ($p>0.05$) variations among treatments. The treatments with microbial inoculants (Mykovam and Mykoplus) showed a tendency toward improved growth responses in several parameters compared to the recommended inorganic fertilizer alone and the combination of inorganic fertilizer with ANAA.

The growth performance of abaca under the different fertilizer treatments showed numerical variations among parameters measured, although these differences were not statistically significant. The plant height increment ranged from 11.25 cm to 19.53 cm, with the highest value observed in the recommended inorganic fertilizer (19.53 cm), followed by the combination of inorganic fertilizer and ANAA (17.00 cm), Mykovam (14.78 cm), and Mykoplus (11.25 cm). The number of leaves per plant showed very minimal variation, ranging only from 2.81 to 2.92, where Mykoplus obtained the highest mean (2.92), followed closely by Mykovam (2.90), ANAA + inorganic fertilizer (2.84), and the inorganic fertilizer alone (2.81). Leaf length ranged from 27.18 cm to 33.33 cm, with the longest leaves recorded in the inorganic fertilizer treatment (33.33 cm), followed by ANAA + inorganic fertilizer (30.42 cm), while Mykovam and Mykoplus produced shorter leaves (27.76 cm and 27.18 cm, respectively).

Similarly, pseudostem length increment ranged from 8.13 cm to 12.29 cm, wherein the inorganic fertilizer (12.29 cm) and the ANAA combination (12.21 cm) showed slightly higher increments than Mykoplus (8.79 cm) and Mykovam (8.13 cm). Pseudostem diameter ranged from 0.79 cm to 0.93 cm, with the largest mean diameter recorded in the inorganic fertilizer treatment (0.93 cm), followed by the ANAA combination (0.89 cm), while both Mykovam and Mykoplus resulted in the lowest and similar values (0.79 cm).

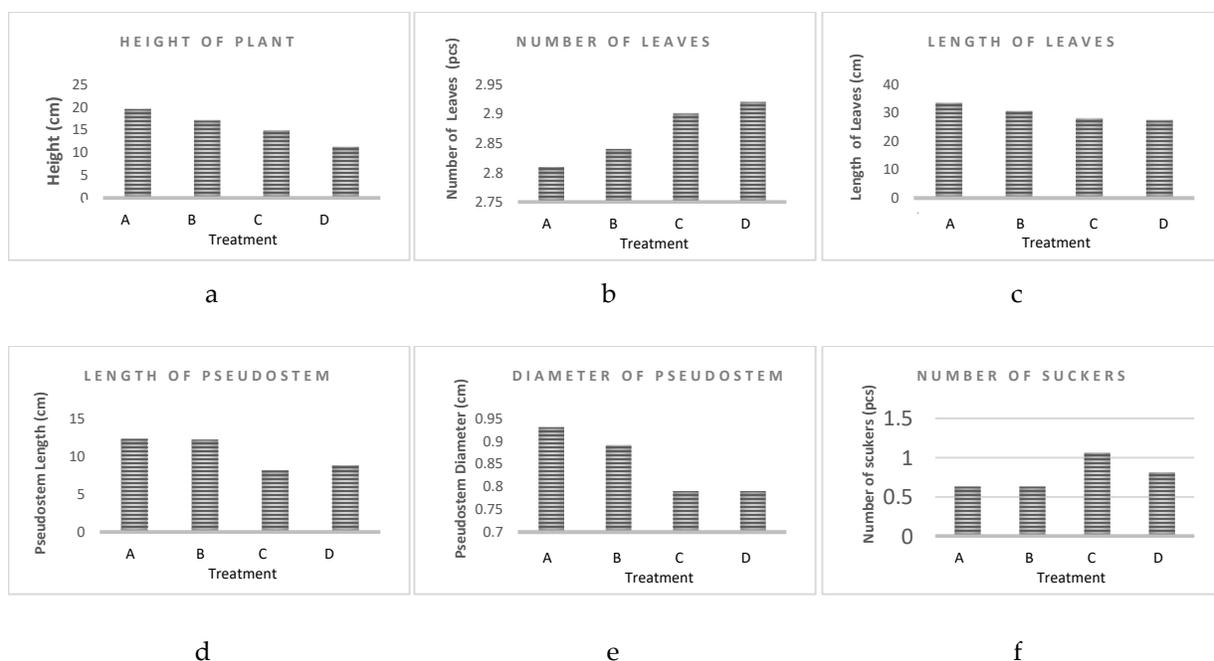


Figure 1. Growth performance of abaca under different fertilizer treatments: (a) plant height increment, (b) number of leaves, (c) leaf length, (d) pseudostem diameter, (e) pseudostem length, and (f) number of suckers per plant.

Meanwhile, the number of suckers per plant varied from 0.63 to 1.06, where Mykovam produced the highest average (1.06), followed by Mykoplus (0.81), while both inorganic fertilizer and the ANAA combination produced the lowest means (0.63).

Despite these numerical variations in all growth parameters, the ANOVA results indicated no significant differences ($p > 0.05$) among treatments, suggesting that the growth responses were generally comparable across fertilizer types. This may be attributed to the sufficient nutrient availability provided by all treatments. The inorganic fertilizer supplied readily available N, P, and K for immediate uptake (Asadu et al., 2024), while the biofertilizers contributed plant growth-promoting microorganisms that enhanced nutrient accessibility through nitrogen fixation, phosphorus solubilization, and improved mycorrhizal colonization (Hartman & Six, 2023; Bora et al., 2016). Such microorganisms are also known to produce natural growth regulators like auxins, which promote cell elongation and shoot development (Keswani et al., 2020; Kumar et al., 2021), helping supplement nutrient uptake even when inorganic input levels are lower. It is also proven that the biofertilizers used (MykoVam and MykoPlus) are effective in enhancing the growth of abaca and other similar crops (Abadayan & Coracero, 2024; Aguilar et al., 2018)

3.3 Survivability

The survival rates of abaca under different fertilizer treatments showed no significant differences despite numerical variation (Figure 2). Mykoplus recorded the highest survival (100%), followed by Mykovam (91.67%), while both the no-fertilizer treatment and the complete fertilizer + ANAA combination showed the lowest survival (75%). Since these differences were not statistically significant ($p > 0.05$), all treatments were considered adequate to support early plant establishment, suggesting that essential nutrients in the soil were sufficient to maintain vigor during the initial growth stage (Neves & Costa, 2020).

These findings indicate that abaca can establish successfully even under varying levels of fertilizer input. The comparable survival rates across treatments support earlier studies showing that abaca's early growth is not highly dependent on external nutrient supplementation (Bande et al., 2016). Although biofertilizers such as Mykovam and MykoPlus can enhance nutrient uptake through root colonization, their benefits are often more pronounced in later growth phases when nutrient demand increases (Aggangan et al., 2013; Hou et al., 2025; Inocencio et al., 2025; Zarate & Jardeniano., 2022). The influence of biofertilizers also depends on soil microbial activity and plant physiological response, which may explain the limited observable differences in survival (Abdelaal et al., 2021).

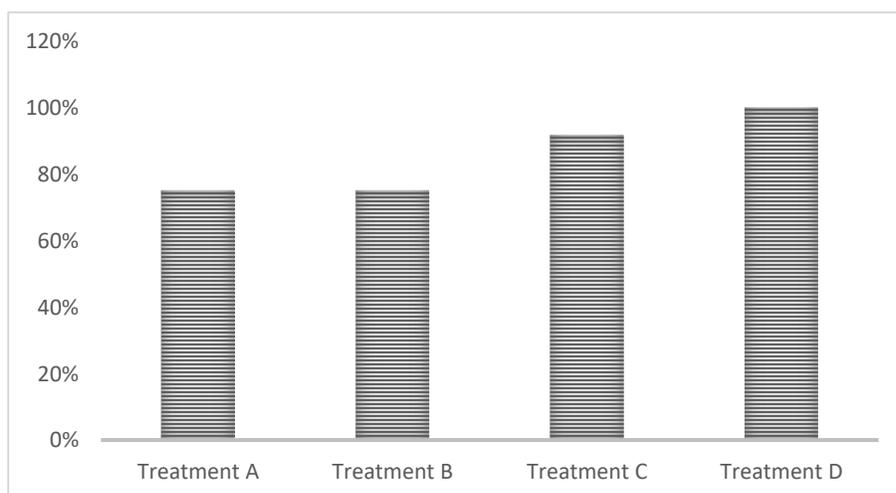


Figure 2. Survivability of Abaca Per Treatment Using Biofertilizer

The consistently high survival rates further demonstrate that Masbate provides a favorable environment for abaca cultivation. The province's warm, humid climate and relatively uniform rainfall align well with the ecological requirements of abaca, while its well-drained loamy soils help prevent waterlogging during early establishment (Armezin et al., 2011; Gagula et al., 2024; Shahri et al., 2014). These environmental conditions, combined with abaca's natural adaptability to diverse agroecological settings (Bande et al., 2012), likely contributed to the successful establishment observed.

4. Conclusion

The study found that the application of biofertilizers did not significantly affect the height increment, number of leaves, leaf size, pseudostem length and diameter, number of suckers, and survival rate of abaca compared to inorganic fertilizer and the control, indicating that abaca can establish well even under varying nutrient inputs. This suggests that biofertilizers can be used as an effective alternative when inorganic fertilizers are limited, as the beneficial microbes in products such as Mykovam and Mykoplus support nutrient uptake and root development. The consistently high survival across treatments further demonstrates that Masbate provides favorable environmental conditions for abaca cultivation. Future studies are recommended to extend the evaluation into later growth stages, particularly fiber yield and quality, and to explore combined or reduced fertilizer rates with biofertilizers to determine potential synergistic effects and long-term impacts on soil health.

5. Conflict of Interest

The author declares that there are no conflicts of interest associated with this manuscript.

6. Use of Artificial Intelligence (AI)-Assisted Technology

The author confirms that no artificial intelligence (AI)-assisted technologies were used in the preparation of the scientific content of this manuscript. ChatGPT and Grammarly were used solely to improve grammar and writing flow; all writing and intellectual content are the work of the author.

7. References

- Abadayan, J. G., & Coracero, E. E. (2024). Seedling Growth and Survival of the Endangered *Pterocarpus indicus* Willd.(Fabaceae) as Affected by Provenances and Biofertilizer Amendments. *Forestist*, 74(2).
- Abdelaal, K., Alkahtani, M., Attia, K., Hazef, Y., Kiraly, L., & Kunstler, A., (2021). The role of plant growth-promoting bacteria in alleviating the adverse effects of drought on plants. *Biology*. Vol. 10. Pp. 520.
- Aguilar, E. A., Elleva, L. I. F., Fabro, D. M. A., Garcia, G. R., Divina, F. I., & Aggangan, N. (2018). Arbuscular Mycorrhizal fungi increased root-mycorrhizal association and enhanced seedling growth of abaca, papaya, and sugarcane.
- Aggangan, N.S., Tamayao, P. J. S., Aguilar, E. A., Anarna, J. A. and Dizon, T. O. (2013). Arbuscular mycorrhizal fungi and nitrogen fixing bacteria as growth promoters and as biological control agents against nematodes in tissue-cultured banana var. Lakatan. *Philippine Journal of Science*, Vol. 142, No. 2, p. 153-165.
- Armezin R.B, Sinon F.G, Moreno L.O. 2014. Abaca Fiber: A renewable bio-resource for industrial uses and other applications. 2014. In: Hakeem KR, Jawaid M, Rasid U, editors. *Biomass and Bioenergy Applications*. London: Springer. p. 343–352.
- Armezin, R. B., Cosico, W. C., & Badayos, R. B. (2011). Characterization of the different abaca-based agro-ecosystems in Leyte, Philippines. *Journal of Natural Fibers*, 8(2), 111-125.
- Asadu, C., Ezema, C., Ekwueme, B., Onu, C., Onoh, I., Adejoh, T., Ezeorba, T., Ogbonna, C., Otuh, P., Okoye, J., & Emmanuel, U. (2024). Enhanced efficiency fertilizers: Overview of production methods, materials used, nutrients release mechanisms, benefits and considerations. *Environmental Pollution and Management*. Vol. 1. P. 32-48. doi: 10/1016/j.eom.2024.07.002.

- Bande, M. M., Grenz, J., Asio, V. B., & Sauerborn, J. (2012). Nutrient uptake and fiber yield of abaca (*Musa textilis* var. Laylay) as affected by shade, irrigation and fertilizer application. *Annals of Tropical Research*, 34(1), 1-28.
- Bande, M. M., Grenz, J., Asio, V. B., & Sauerborn, J. (2013). Fiber yield and quality of abaca (*Musa textilis* var. Laylay) grown under different shade conditions, water and nutrient management. *Industrial Crops and Products*, 42, 70-77.
- Bande, M. M., Asio, V. B., Sauerborn, J., & Romheld, V. (2016). Growth performance of abaca (*Musa textilis* Née) Integrated in multi-strata agroecosystems. *Annals of Tropical Research*, 38(1), 19-35.
- Bora, L., Tripathi, A., Bajeli, J., Chaubey, A.K., & Chander, S. (2016). A review on microbial association: Its potential and future prospects in fruit crops. *Plant Archives*. Vol. 16. No. 1. Pp. 1-11.
- Bureau of Agriculture and Fisheries Standards. (2019). Philippine National Standard PNS/BAFS 266:2019 – Non food crops – Abaca: Code of Good Agricultural Practices (GAP). Department of Agriculture – Philippines.
- Fitriatin, B.N., Dewi, V.F., & Yuniarti, A. (2021). The impact of biofertilizers and NPK fertilizers application on soil phosphorus availability and yield of upland rice in tropic dry land. *Web of Conferences*. 232. doi:10.1051/e3sconf/202123203012.
- Gagula, A. C., Paredis, M. Y., Tubo, W. A. S., & Parac, E. P. (2024, January). Combining land suitability models in determining the optimal locations for establishing abaca plantations (*Musa testilis*) in Caraga Region, Philippines. In *Eighth Geoinformation Science Symposium 2023: Geoinformation Science for Sustainable Planet* (Vol. 12977, pp. 87-94). SPIE.
- Hartman, M. & Six, J. (2023). Soil structure and microbiome functions in agroecosystems. *Nat. Rev. Earth Environ.* Vol. 4. Pp. 4-18. doi: 10.1038/s43017-022-00366.
- Hou, J., Yin, J., Liu, L., & Xu, L. (2025). Optimal Dark Tea Fertilization Enhances the Growth and Flower Quality of Tea *Chrysanthemum* by Improving the Soil Nutrient Availability in Simultaneous Precipitation and High-Temperature Regions. *Agronomy*, 15(7), 1753.
- Inocencio, L. G., Edaña, M. L. S., Cruz, P. C., Ocampo, E. T., & Sanchez, P. (2025). Agronomic Traits of Direct-Seeded Rice (*Oryza sativa*) Applied with Microbial Inoculants and Varying Fertilizer Levels. *Biosaintifika: Journal of Biology & Biology Education*, 17(2).
- Keswani, C., Singh, S.P., Cueto, L., Garcia-Estrada, C., Mezaache-Aichour, S., Glare, T.R., Borriss, R., Singh, S.P., Blazquez, M. & Sansinenea, E. (2020). Auxins of microbial origin and their use in agriculture. *Applied Microbiology and Biotechnology*. Vol. 104. Pp. 8549-8565. doi: 10.1007/s00253-020-10890-8.
- Kumar, A., Maurya, B. M., & Raghuwanshi, R. (2021). The microbial consortium of indigenous rhizobacteria improving plant health, yield and nutrient content in wheat (*Triticum aestivum*). *J. Plant Nutr.* 44, 1942-1956. doi:10.1080/01904167.2021.1884706.
- Magno-Ballesteros, M., & Ancheta, J. A. (2022). Public-Private Partnerships in Agriculture Value Chains: The Case of Project ConVERGE in the Philippines (No. 2022-37). PIDS Discussion Paper Series.
- Mulyani, O., Trinurani, E., Sudirja, R., & Joy, B. (2017). The effect of bio-fertilizer on soil chemical properties of sugarcane in Purwadi Subang. 2nd international conference on Sustainable Agriculture and Food Security: A Comprehensive Approach, Life Sciences. Pp. 164-171. doi: 10.18502/kl.v216.1035.
- Neves, R. T., & Costa, F. A. (2020). Unique Plant Adaptations to Varied Environments: A Comprehensive Review of Evolutionary Mechanisms Shaping Plant Survival Across Diverse Habitats. *Advances in Herbal Research*, 3(1), 1-5.
- Pardo, M., Almendros, G., Zancada, M., & Lopez-Fando, C. (2010). Biofertilizer of Degraded Southern African Soils with Cyanobacteria Affects Organic Matter Content and Quality. *Arid Land Research and Management*. Vol. 24. No. 4. Pp. 328-343. doi: 10.1080/15324982.2010.502918.
- Philippine Fiber Industry Development Authority (2015). *Abaca Technoguide*.
- Philippine Fiber Industry Development Authority (2016). *Abaca Sustainability Manual*. Department of Agriculture, Philippines.
- Shahri, W., Tahir, I., & Ahad, B. (2014). Abaca fiber: A renewable bio-resource for industrial uses and other applications. In *Biomass and Bioenergy: Processing and Properties* (pp. 47-61). Cham: Springer International Publishing.

- Sindhu, S., Verma, N., Dua, S., & Chaudhary, D. (2010). Biofertilizer Application for Growth Stimulation of Horticultural Crops. *Haryana Journal of Horticultural Sciences*. Vol. 39. Pp. 48-70.
- Yasa, N.A.M., Kassim, N.Q.B. & Othman, N.M.I. (2023). The effects of different types of biofertilizers on selected peat properties and growth response of pak choy (*Brassica rapa* L.). *Earth and Environmental Science*. Vo. 1182. Doi:10.1088/1755-1315/1182/1/012032.
- Zarate, J. T., & Jardeniano, Jr, C. V. (2022). Combined mykoplus biofertilizer and inorganic fertilizer increased straw and rice grain yield in two field sites in Negros Occidental, as well as significantly increased the residual P and N content in the soil after cropping.