**Journal of Smart Farming and Food Security**
Universiti Malaysia Sabah, Malaysia

# EFFECTS OF EFFECTIVE MICROORGANISMS ON SOIL PH AND NUT YIELD OF COCONUT TREES IN THE TANIAGA PLANTATION LOCATED IN SANDAKAN, SABAH, MALAYSIA

**Clament Chin Fui Seung[1] and Lum Mok Sam[1*]**

[1]Faculty of Sustainable Agriculture, Universiti Malaysia Sabah Sandakan Campus, Locked Bag No. 3, 90509 Sandakan, Sabah, Malaysia
[*]Corresponding author: lmmoksam@ums.edu.my

***Abstract:***
Prolonged or overuse of chemical fertilizers can cause soil acidification in coconut plantations. This study investigated the effects of Effective Microorganisms (EM) on soil pH and nut yield of coconut trees in the Taniaga Plantation, Sandakan, Sabah, Malaysia. Conducted over 12 months (June 2023–May 2024), the experiment evaluated five treatments, including various EM application rates and dolomite, in a randomized design using Tagunan coconut varieties. Results showed that EM significantly increased soil pH from strongly acidic levels (3.82–4.08) to a more favorable range (up to 5.23), particularly in treatment T4 (8 kg EM). However, the highest nut yield was recorded in T3 (4 kg EM), indicating an optimal balance between microbial activity and nutrient availability. In contrast, dolomite treatment resulted in lower yields due to potential nutrient imbalances and suboptimal pH levels. The findings suggest that EM enhances soil health, buffers pH, and improves coconut yield, with 4 kg EM per tree identified as the most effective treatment. Continued EM application is recommended for sustainable coconut production and improved soil fertility.

***Keywords:*** Effective microorganism, soil pH, coconut yield, soil fertility

## 1. INTRODUCTION

Effective Microorganisms (EM) are mixed cultures of beneficial microorganisms, including lactic acid bacteria, photosynthetic bacteria, yeasts, and fermenting fungi, that are applied to agricultural systems for sustainable farming practices. The concept of EM was introduced by Dr. Teruo Higa in the 1980s and has since been utilized in various agricultural practices worldwide.

Application of EM on agricultural crops can enhance soil fertility by increasing the microbial diversity in the soil (Higa, 1994). It helps break down organic matter, leading to better soil structure and water retention. EM has been shown to improve root development, stimulate plant metabolism, and increase nutrient uptake, ultimately leading to higher crop yields (Nascimento & Cunha, 2015). In addition, EM also can suppress soil-borne diseases (Goh & Higa, 2011), reduce chemical fertilizer and pesticide use (Oka & Higa, 2004), increase soil organic matter (Radziah & Norhayati, 2007), improve crop resistance to stress (Higa & Wididana, 1991) and soil pH balance (Emmert, 2007).

Most crops prefer a pH of 5.5 – 6.5 for balanced nutrient availability. In coconut plantations, prolonged use of chemical fertilizers can cause soil acidification. Lower soil pH may reduce nutrient availability and absorption. At low pH (acidic soils), phosphorus binds with iron (Fe) and aluminum (Al), making it unavailable to plants (Fageria & Baligar, 2008). Application of EM helps buffer this effect by increasing microbial diversity and organic matter decomposition, mitigating pH declines (Younas *et al*., 2022). Therefore, this study aimed to determine the effect of EM application on soil pH and nut yield in coconut plantation.

## 2. MATERIALS AND METHODS

### 2.1 Study sites

Investigations into the improvement of soil quality and the nut yield of coconut trees were conducted from June 2023 to May 2024 in the Taniaga Plantation (6°00'24.1" N, 117°57'07.4" E), located in Mile 12, Sandakan, Sabah, Malaysia.

### 2.2 Experimental layout

The experiment was carried out in a coconut plot using a variety of Tacunan, aged 1 – 2 years, in a completely randomized design with five treatments; each replicated five times. The treatments were as follows: T1: no EM application (control; EM0); T2: 2 kg EM; T3: 4 kg EM; T4: 8 kg EM; and T5: 2 kg dolomite applied per mature tree per year. The EM product was supplied by Loongsyn Sdn Bhd.

### 2.3 Soil sampling and pH analysis

The soil pH was assessed periodically before and after the end of the study. Soil samples were collected from the depth at 0 – 20 cm from the diagonally opposite points at one meter from the trunk. They were combined to obtain a representative sample. Soil samples were analyzed for pH (1:2.5 soil solution).

### 2.4 Nut yield (tree$^{-1}$ year$^{-1}$)

The crop yield, an indicator of its productivity, was periodically recorded every month, and the cumulative yield was determined annually.

### 2.5 Statistical analysis

All the experimental data represented the average of five replications. The data collected from the experiments were statistically analyzed using a t-test at $p < 0.05$. The analysis was performed using the Statistical Package for the SAS System.

## 3. RESULTS AND DISCUSSION

### 3.1 Effects of EM on the soil pH

From Table 1, the range of pH values shown by all treatments (T1 - T5) before EM application was acidic (3.82 - 4.08), indicated the soil was strongly acidic. After the EM was applied for 6 and 12 months, there was a significant change in the pH values for all treatments. The range of soil pH has increased (3.95 - 4.33 for 6 months and 4.58 – 5.23 for 12 months, respectively). All treatments showed an increase significantly in pH after EM application ($p < 0.05$). T4 showed the highest pH (5.23) after EM application of 12 months.

Table 1: Soil pH

| Treatment (N = 5) | Soil pH | | |
|---|---|---|---|
| | Before EM application | After EM application (6 months – Nov 2023) | After EM application (12 months – May 2024) |
| T1 (EM0) | 3.93 | 3.95 | 4.70 |
| T2 (EM2) | 3.92 | 4.09 | 4.58 |
| T3 (EM4) | 3.82 | 4.03 | 4.63 |
| T4 (EM8) | 4.08 | 4.33 | 5.23 |
| T5 (D2) | 3.95 | 4.02 | 4.72 |

T – treatment, EM – effective microorganisms, D – dolomite

Soil pH significantly influences nutrient availability and absorption by plants. pH affects the chemical forms of nutrients, microbial activity, and root interactions, ultimately determining how effectively plants can take up essential elements. Nutrients like nitrogen (N), phosphorus (P), and potassium (K) are most available in a pH range of 5.5–7.5. At low pH (acidic soils), phosphorus binds with iron (Fe) and aluminum (Al), making it unavailable to plants (Fageria & Baligar, 2008). On the other hand, at high pH (alkaline soils), phosphorus forms insoluble calcium phosphates, reducing its availability (Hinsinger, 2001). The nutrients release was limited due to slow decomposition and organic matter mineralization in very acidic or alkaline conditions.

Effective Microorganisms (EM) are a consortium of beneficial microbes, including lactic acid bacteria, yeast, and phototrophic bacteria, used to improve soil health and crop productivity. Their influence on soil pH in coconut plantations is significant due to their role in organic matter decomposition, nutrient cycling, and microbial balance.

EM promotes the breakdown of organic material into simpler compounds, releasing organic acids such as lactic acid and acetic acid, which can lower soil pH in alkaline soils (Higa & Parr, 1994). In acidic soils, EM can enhance the mineralization of organic matter, increasing cation exchange capacity (CEC) and buffering pH changes (Wididana & Higa, 1995). Besides, some EM strains help neutralize acidic soils by increasing microbial activity that enhances ammonification and nitrate assimilation, leading to pH stabilization (Xu *et al*., 2000). EM also facilitates calcium and magnesium solubilization, essential for pH balance, which is beneficial in coconut plantations where liming is a common practice to counteract soil acidification (Gopal *et al*., 2010). In addition, EM enhances nitrogen fixation and phosphorus solubilization, improving nutrient availability without drastic pH fluctuations (Sangakkara, 2014). The decomposition of organic residues by EM releases nutrients that influence soil pH dynamically. In addition, prolonged use of chemical fertilizers can cause soil acidification in coconut plantations. EM helps buffer this effect by increasing microbial diversity and organic matter decomposition, and increase pH in soil (Younas *et al*., 2022).

### 3.2 Effects of EM on nut yield

In this study, treatment T3 recorded the highest number of coconuts recorded (101) compared to other treatments. Studies show that coconut plantations treated with EM yield 15–30% more nuts per tree compared to conventional farming methods (Higa & Parr, 1994). EM application enhances fruit weight, kernel thickness, and oil content, leading to higher-quality copra and coconut oil (Younas *et al*., 2022). EM also improves nutrient availability (N, P, K, Mg, Ca), leading to enhanced flowering and fruit set (Sangakkara, 2014).

Table 2: No. of coconut produced after EM application for 12 months

| Treatment (N = 5) | Yield / Mean no. of coconut produced (Jun 2023 - May 2024) |
|---|---|
| T1 (EM0) | 92 |
| T2 (EM2) | 93 |
| T3 (EM4) | 101 |
| T4 (EM8) | 81 |
| T5 (D2) | 52 |

T – treatment, EM – effective microorganisms, D - dolomite

The beneficial microbes in EM (e.g., lactic acid bacteria, yeast, and actinomycetes) suppress soil-borne pathogens by outcompeting harmful microorganisms and producing antimicrobial compounds (Javaid & Bajwa, 2011). EM improves root health by increasing beneficial mycorrhizal associations, leading to better water and nutrient uptake (Younas *et al*., 2022). Besides, EM enhances soil structure by promoting the production of polysaccharides and glomalin, which improve soil aggregation and water-holding capacity (Gopal *et al*., 2010). Coconut plantations treated with EM show increased resistance to drought stress due to improved microbial activity and water conservation (Sangakkara, 2014). EM potentially reduces premature nut drop by improving tree vigor and stress resistance (Gopal *et al*., 2010).

In addition, young coconut seedlings treated with EM establish faster, leading to earlier fruiting (Xu *et al*., 2000). EM may boost root development, allowing seedlings to absorb nutrients more efficiently. EM-treated trees flower 6–12 months earlier than untreated trees, reducing the time to first harvest (Sangakkara, 2014). The study conclude that continuous application of EM restores soil microbial balance, reducing dependence on chemical fertilizers and maintaining yield stability over time (Higa & Parr, 1994).

The application of dolomite in coconut plantations can result in lower nut yield due to a variety of soil and plant nutrient dynamics. Dolomite, which contains calcium carbonate and magnesium carbonate, is typically used for soil pH adjustment and to supply magnesium and calcium. However, improper or excessive application can lead to issues that ultimately reduce coconut yield.

Dolomite is rich in magnesium, and its excessive use can result in an imbalance of calcium to magnesium in the soil. Coconut palms require an optimal ratio of these two nutrients for healthy growth. Excessive magnesium can interfere with calcium uptake, which is critical for cell wall structure and fruit development (Zaki *et al*., 2018). This imbalance can hinder the growth of the coconut tree, affecting fruit size and quality.

Dolomite is commonly used to raise soil pH, particularly in acidic soils. However, if the soil pH increases too much (becoming alkaline), it can cause the precipitation of certain nutrients like phosphorus and iron, which become less available to the coconut palms. Coconut palms generally thrive in slightly acidic to neutral soils (pH 6 to 7). A pH above 7 could reduce nutrient uptake, leading to nutrient deficiencies that affect overall coconut production (Mishra *et al*., 2017).

The application of dolomite can lead to an imbalance in essential nutrients. High magnesium levels can inhibit potassium and calcium uptake, both of which are crucial for the coconut tree's growth and fruiting. Potassium, for example, plays an essential role in photosynthesis, water regulation, and the production of fruit. This imbalance could cause stunted growth, reduced fruiting, and poor nut quality (Wahid *et al*., 2016).

Excessive dolomite application can increase soil salinity, particularly in regions where dolomite is used in conjunction with other soil amendments. Coconut palms are sensitive to high salinity, which can limit water uptake, reduce nutrient absorption, and impair growth. Furthermore, if dolomite is used in poorly drained soils, it can exacerbate these issues, affecting root health and reducing yield (Latha & Venkatesh, 2019).

Dolomite is a slow-release source of calcium and magnesium. Coconut trees may have immediate nutrient demands that are not met quickly enough by dolomite, leading to temporary nutrient deficiencies. This delayed nutrient release can result in suboptimal tree growth, reduced flowering, and poor nut set (Kumar & Yadav, 2015).

The improper use of dolomite in coconut plantations can lead to nutrient imbalances, high soil pH, excessive magnesium, and slow nutrient release, all of which can impair coconut growth and reduce nut yield. The key to successful coconut production lies in careful soil management, including soil testing and the judicious application of fertilizers like dolomite.

## 4. CONCLUSION

Application of EM and dolomite will increase the soil pH significantly after 6 and 12 months as shown in Table 1. For better yield performance of crops, soil pH should be increased to 5. It is recommended to apply another round of EM in the soils (following year) to increase the crop performance. Treatment T3, with 4 kg of EM application, is concluded as the best treatment for coconut planting.


## ACKNOWLEDGEMENT

The author express gratitude for the financial assistance from the research grant, LPS2305 from Universiti Malaysia Sabah, the EM provided by the Loongsyn Sdn Bhd and Taniaga Plantation to execute the study.


## REFERENCES


1. Emmert, E. A. (2007). Microbial applications in organic agriculture: Soil microorganisms and their role in soil health. *Agricultural Systems*, 94(1), 83–94.
2. Fageria, N. K., & Baligar, V. C. (2008). "Ameliorating soil acidity of tropical Oxisols by liming for sustainable crop production." *Advances in Agronomy,* 99, 345–399.
3. Goh, K. M., & Higa, T. (2011). The effect of EM (Effective Microorganisms) on plant disease suppression in agriculture. *International Journal of Agricultural Science*, 3(2), 128–137.
4. Gopal, H., Gupta, A., & Thomas, G. V. (2010). "Soil biological health in coconut plantations: Role of organic amendments." *Journal of Plantation Crops,* 38(3), 225-232.
5. Higa, T. (1994). *Effective microorganisms for sustainable agriculture*. In: Higa T, Parr JF, editors. *Sustainable Agriculture and the Environment in the Humid Tropics*. Washington, D.C.: National Academy Press.
6. Higa, T., & Parr, J. F. (1994). *Beneficial and Effective Microorganisms for a Sustainable Agriculture and Environment*. International Nature Farming Research Center.
7. Higa, T., & Parr, J. F. (1994). *Beneficial and Effective Microorganisms for a Sustainable Agriculture and Environment*. International Nature Farming Research Center.
8. Higa, T., & Wididana, G. (1991). The role of microorganisms in sustainable agriculture. *Soil Microbiology*, 31(2), 55–70.
9. Hinsinger, P. (2001). "Bioavailability of soil inorganic P in the rhizosphere as affected by root-induced chemical changes." *A review. Plant and Soil, 237*(2), 173–195.
10. Javaid, A., & Bajwa, R. (2011). Field evaluation of effective microorganisms (EM) application for growth, nodulation, and nutrition of mung bean. *Turkish Journal of Agriculture and Forestry, 35*(4), 443-452.
11. Kumar, A., & Yadav, S. S. (2015). Effect of dolomite on soil fertility and coconut productivity: A review. *Journal of Coconut Research*, 20(1), 45-58.
12. Latha, P., & Venkatesh, P. (2019). The effects of soil amendments on coconut growth in coastal areas: Impact of salinity and nutrient imbalance. *International Journal of Agronomy and Agricultural Research*, 14(4), 45-54.
13. Mishra, R. P., & Bhatt, J. (2017). Soil pH and its effect on nutrient uptake in coconut. *International Journal of Agricultural Sciences*, 13(2), 250-254.
14. Nascimento, A. S., & Cunha, J. L. (2015). Effect of effective microorganisms (EM) on soil microbial activity and tomato yield. *Acta Horticulturae*, 1079, 281–286.
15. Oka, Y., & Higa, T. (2004). Effect of effective microorganisms (EM) on pest control in crops. *Environmental Technology*, 25(9), 1055–1061.
16. Radziah, O., & Norhayati, S. (2007). The effect of EM on soil properties and crop yield. *Journal of Agricultural Science and Technology*, 3(2), 75–81.

17. Sangakkara, U. R. (2014). "Impact of effective microorganisms on soil properties and productivity in tropical farming systems." *Scientia Horticulturae, 168*, 103-109.
18. Wahid, A., Ahsan, M., & Saleem, M. (2016). Nutrient management in coconut: Implications for enhanced productivity. *Journal of Plant Nutrition*, 39(1), 1-12.
19. Wididana, G. N., & Higa, T. (1995). "The concept and theories of effective microorganisms in nature farming." *Proceedings of the 3rd International Conference on Kyusei Nature Farming*, 1-5.
20. Xu, H. L., Wang, R., & Mridha, M. A. U. (2000). "Effects of EM on soil properties and plant growth in vegetable production." *APNAN Report, 7*, 76-80.
21. Younas, T., Umer, M., Husnain Gondal, A., Aziz, H., Khan, M. S., Jabbar, A., Shahzad, H., Panduro-Tenazoa, N., Jamil, M., & Ore Areche, F. (2022). A Comprehensive Review on Impact of Microorganisms on Soil and Plant, *Journal of Bioresource Management*, 9(2), 109-118.
22. Zaki, A. S., Abdul-Aziz, A., & Abdullah, N. (2018). Impact of magnesium on coconut palms (*Cocos nucifera* L.): Effect of different levels of dolomitic limestone on coconut productivity in sandy soils. *Journal of Soil Science and Plant Nutrition*, 18(2), 567-574.