

# Optimizing Coconut Agroecosystems: Effects of Intercropping Corn, Mung Bean, and Sweet Potato on Pest Dynamics, Soil Health, and Crop Yields

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## Abstract

*Intercropping, the practice of cultivating two or more crops simultaneously on the same land, is a proven strategy to enhance land use efficiency, reduce pest pressure, and improve overall farm productivity. This study evaluated pest infestation, soil biodiversity, and productivity of corn (*Zea mays*), mung bean (*Vigna radiata*), and sweet potato (*Ipomoea batatas*) intercropped under coconut (*Cocos nucifera*) conditions across two cropping seasons in Bagong Oroquieta, Guipos, Zamboanga del Sur, Philippines. Eight cropping patterns (CP<sub>1</sub>–CP<sub>8</sub>) were tested. Major insect pests monitored included corn borer (*Ostrinia furnacalis*), corn earworm (*Helicoverpa zea*), corn weevil (*Sitophilus zeamais*), mung bean pod borer (*Maruca vitrata*), mung bean aphids (*Aphis craccivora*), and sweet potato weevil (*Cylas formicarius*). Results revealed that CP<sub>5</sub> (Mung bean–Corn), CP<sub>6</sub> (Sweet potato–Corn), and CP<sub>8</sub> (Sweet potato–Corn + Mung bean) consistently minimized pest infestation, maintained weed populations at tolerable levels, and supported a favorable soil biodiversity index. Productivity was assessed using the Land Equivalent Ratio (LER), an index that quantifies the relative efficiency of intercropping compared to monocropping. The corn + mung bean combination produced the highest LER values (1.30–1.53), indicating a 30–53% yield advantage over monocropping and the most favorable competitive ratio. The findings underscore the potential of mung bean–corn and sweet potato–corn-based intercropping systems under coconut to enhance farm productivity, reduce pest incidence, and promote ecological sustainability. The study recommends these patterns to coconut farmers for improved income and resource utilization.*

**Keywords:** biodiversity, cropping pattern, intercropping, pest infestation, productivity soil

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## 1. Introduction

Agricultural intensification driven by population growth and the conversion of traditional farmlands into plantation crops has led to declining yields despite expanding export opportunities (Kopittke *et al.*, 2019). Coconut-based intercropping offers a sustainable approach to enhancing resource-use efficiency, diversifying income, and improving ecological stability (Nelson & Morton, 2020). While various studies have shown its benefits, including reduced pest incidence, improved soil fertility, and yield stability, there is limited research that simultaneously addresses pest infestation, soil biodiversity, and productivity in sequential corn–mung bean–sweet potato systems under coconut, particularly in Zamboanga del Sur, Philippines. This study fills this gap by evaluating these parameters across different cropping patterns to determine the most productive and sustainable sequence for coconut-based farming systems.

Coconut plantations are particularly suitable for multi-canopy agriculture. The sunlight that filters through the coconut canopies is sufficient to support various annual crops (such as corn, vegetables, legumes, ornamentals, and herbal crops) and perennials (like bananas, pineapple, papaya, coffee, cacao, and black pepper). These intercrops not only diversify farm output but also enhance income compared to monoculture coconut farming (Padma, 2022).

In the Philippines, the primary coconut-producing regions include the Davao Region, CALABARZON, Northern Mindanao, and Zamboanga Peninsula. Among these, Zamboanga Peninsula ranks second in national coconut production, accounting for 13.6% of the total output. According to the Philippine Coconut Authority (2019), the region has a gross production spanning 1.747 million hectares.

Intercropping under coconuts is a traditional practice among local upland farmers, often involving sequential short-duration crops like corn, followed by a period of fallow. Corn is commonly planted in the spaces between coconut trees, and traditional fallow periods, typically several months, are used to restore soil fertility and suppress pests, following upland and swidden agricultural patterns.

Cropping patterns, defined as the succession and arrangement of crops in a specific field over a given period, play a crucial role in enhancing crop productivity, production efficiency, land-use efficiency, and economic returns (Matthews *et al.*, 2006; Negash *et al.*, 2017). Successful intercropping relies

on the compatibility of crop combinations, considering factors such as planting density, root systems, and nutrient competition (Ijoyah & Jimba, 2012). Compatible crops optimize the utilization of land, light, water, and fertilizers, thus enhancing growth habits and productivity (Thayamini & Brintha, 2010).

Cereal–legume intercropping systems enable cereals to acquire significantly more nitrogen than monocultures, partly due to biological nitrogen transfer from the legume component (Bedoussac *et al.*, 2020; Liang *et al.*, 2024). Their integration, particularly in rice-based ecologies, is recognized as a sustainable strategy to enhance productivity and maintain soil health (Islam *et al.*, 2023). Conservation agriculture practices, often incorporating legume rotations, have also demonstrated the potential to reverse negative nitrogen balances in intensive rice-based systems (Islam *et al.*, 2025). Successful examples include mung bean intercropped with corn, which has shown efficient land use (Legba *et al.*, 2025), and sweet potato–legume intercropping in semi-arid environments, which has improved productivity, resource use efficiency, microclimate, water utilization, and land productivity (International Institute of Tropical Agriculture [IITA], 2022). Furthermore, the adoption of conservation agriculture, frequently involving legumes in rotation, has consistently been associated with positive impacts on crop yield and soil properties in intensive cropping systems (Islam, 2017; Islam *et al.*, 2022a; Islam *et al.*, 2022b).

Intensive cropping systems under perennials, with sequential patterns and crop rotations, are vital for sustainable productivity. These systems optimize resource use, enhance microclimate conditions, and improve nutrient dynamics (Amosse *et al.*, 2014). Additionally, they increase output per unit area with minimal external inputs, reduce economic risk, and mitigate market fluctuations, thereby boosting smallholder farmers' incomes (Dodiya *et al.*, 2018).

Despite the prevalent practice of intercropping in the Zamboanga Peninsula, no studies have examined pest infestations and soil biodiversity in cropping patterns of agronomic crops grown under coconut trees. This study aims to evaluate pest infestation, soil biodiversity associated with it, and the productivity of selected agronomic crops under coconut, focusing on corn, mung bean, and sweet potato. The findings will provide growers with valuable insights into maximizing space between coconuts through intercropping, ultimately leading to higher farm productivity and enhanced biodiversity in a diversified farming system.

## **2. Methodology**

### *2.1 Description of the Experimental Site*

The study was conducted in Bagong Oroquieta, Municipality of Guipos, Zamboanga del Sur, Philippines (7.7317° N, 123.3210° E), within a 7-year-old coconut plantation of an unidentified local variety, spaced at 10 m × 10 m. The soil of the experimental site was classified as clay loam, moderately acidic (pH 6.5), with low organic matter content (0.25%) and available phosphorus (0.65 ppm), but relatively high in total nitrogen (1.92%) and potassium (54 cmol/kg). These characteristics necessitated the application of organic amendments, specifically vermicast, to replenish soil organic matter and improve nutrient availability for the subsequent sequential crops. Climatic conditions during the two cropping seasons were characterized by high rainfall (200–287 mm per season) and soil temperatures ranging from 28–31°C, reflecting the humid tropical environment of southern Philippines.

### *2.2 Experimental Design and Treatments*

The study was laid out in a 1,100 m<sup>2</sup> area. It was divided into three blocks, and each block was further divided into eight plots, with a dimension of 8 m × 3.5 m. The alleys between blocks were four meters, and between plots, one meter, to facilitate operations in the field. A Randomized Complete Block Design (RCBD) with eight treatments was replicated three times. The different treatments were as follows: CP<sub>1</sub> - Corn followed by mung bean sequential pattern (Corn – Mung bean), CP<sub>2</sub> - Corn followed by sweet potato sequential pattern (Corn – Sweet potato), CP<sub>3</sub> - Crop rotation of corn + mung bean intercrop and sweet potato (Corn + Mung bean – Sweet potato), CP<sub>4</sub> - Crop rotation of corn + sweet potato intercrop and mung bean (Corn + Sweet potato – Mung bean), CP<sub>5</sub> - Mung bean followed by corn sequential pattern (Mung bean – Corn), CP<sub>6</sub> - Sweet potato followed by corn sequential pattern (Sweet potato – Corn), CP<sub>7</sub> - Crop rotation of mung bean and corn + sweet potato (Mung bean – Corn + Sweet potato) and CP<sub>8</sub> - Crop rotation of sweet potato and corn + mung bean (Sweet potato – Corn + Mung bean).

### *2.3 Planting Materials*

The planting materials used for corn were NGR-800 white flint Open Pollinated Variety (OPV) and Pag-asa 21 variety mung bean seeds, which were secured from the Department of Agriculture, Research Division of Regional IX. On the other hand, cuttings of the NSIC SP 30 sweet potato

variety were obtained from the Visayas State University (VSU), Baybay, Leyte.

#### 2.4 Nutrient Management

The entire experimental site was applied with vermicast based on the initial soil analysis results. The recommended rate for sweet potato of three tons per hectare was used in the study, equivalent to 8.4 kg per experimental plot. The vermicast, with a pH of 6.98, an organic matter content of 3.514%, a total nitrogen of 3.98%, an available phosphorus of 0.201 ppm, and an exchangeable potassium of 1.23 cmol/kg, was incorporated into the soil during the final harrowing, one week prior to planting. This organic amendment served as the primary nutrient source, aiming to improve soil organic matter and nutrient balance. In the subsequent cropping season, no additional organic fertilizers were applied.

#### 2.5 Harvesting

Corn ears were harvested 103 days after sowing, when the grains were mature, as indicated by glazed kernels and the browning of 90% of the leaves. Mung bean pods were harvested 60 days after sowing, once the pods had turned brown or black and at least 75% had dried. Sweet potato roots were harvested at 153 DAP (5 months) in the first cropping and 294 DAP (10 months) in the second cropping.

#### 2.6 Data Gathered

##### A. Corn Pest Occurrence

1. Corn borer (*Ostrinia furnacalis*). Yield loss due to corn borer damage in the tunnel was assessed at harvest using the rating scale described by Lella and Srivastav (2013).

| Rating | Tunnel Length (cm) |
|--------|--------------------|
| 1      | 0-1                |
| 2      | 1.1- 2.1           |
| 3      | 2.2- 4.3           |
| 4      | 4.4- 6.4           |
| 5      | 6.5- 8.6           |
| 6      | 8.7- 10.7          |
| 7      | 10.8- 12.8         |
| 8      | 12.9- 15.0         |
| 9      | >5.0               |

2. Corn earworm (*Helicoverpa zea*). Assessment for corn earworm damage was done at harvest time by counting the number of ears with larval feeding caused by corn earworms. The percent incidence was computed based on the methods of Artienda (2014), the Equation 1 below:

$$\text{Incidence of corn earworm, (\%)} = \frac{\text{No. of damage ear}}{\text{Total no. of ears}} \times 100 \quad (1)$$

## B. Mung Bean Pest Occurrence

1. Pod borer (*Maruca vitrata*) incidence. This was assessed at flowering and maturity stages using 10 sample hills per plot. The insect damage was computed following the methods of Artienda (2014) in Equations 2 and 3 below:

$$\text{Damage inflorescence, (\%)} = \frac{\text{No. of damage inflorescence}}{\text{Total no. of sample inflorescence}} \times 100 \quad (2)$$

$$\text{Damage Pod, (\%)} = \frac{\text{No. of damage pod}}{\text{Total no. of sample pod}} \times 100 \quad (3)$$

| Rating Scale | Percent Damage | Degree of Infestation |
|--------------|----------------|-----------------------|
| 1            | None           | No infestation        |
| 3            | 1-10           | Slight                |
| 5            | 11-25          | Moderate              |
| 7            | 26-50          | Severe                |
| 9            | >50            | Highly severe         |

## C. Sweet Potato Incidence of Pests

1. Root weevil (*Cylas formicarius*) incidence. This was taken at harvest using 10 sample hills per plot. The insect damage was computed and rated using the formula used by Artienda (2014), Equation 4 below:

$$\text{Damage Fleshy Roots, (\%)} = \frac{\text{No. of damage fleshy roots}}{\text{Total no. of sample fleshy roots}} \times 100 \quad (4)$$

## D. Weed Dynamics

Prevalent weeds in one square meter quadrat per plot were identified and taken two weeks after hilling up cultivation.

## E. Biological Diversity Index

The soil organism population was taken in one quadrat, located in the middle of each plot. The excavation was done on the soil surface up to 10cm.

## F. Productivity Measurements

1. Land Equivalent Ratio (LER). This was used to measure the productivity of the intercropping system (Mead & Willey, 1980). Further, this was determined using Equation 5 below:

$$LER = \frac{\text{Intercrop yield of crop A}}{\text{Sole crop yield of A}} + \frac{\text{Intercrop yield of crop B}}{\text{Sole crop yield of B}} \quad (5)$$

Where:

*Intercrop A* = Yield of the Corn as intercrop

*Pure Stand A* = Yield of the Corn as monocrop

*Intercrop B* = Yield of the Mung bean as intercrop

*Pure Stand B* = Yield of the Mung bean as monocrop

2. Competitive Ratio (CR). This was used to measure the ultimate yields of the components corrected for the proportional areas on which the crops were sown (Willey & Rao, 1980). This was measured using Equation 6 below:

$$CR = \frac{L_a}{L_b} \quad (6)$$

Where: *L<sub>a</sub>* and *L<sub>b</sub>* were the partial LERs of the component

## 2.7 Statistical Analysis

The data were analyzed using statistical Analysis of Variance (ANOVA) in a Randomized Complete Block Design using Statistical Tool for Agricultural Research (STAR) software version 2.0.1. The Honestly Significant Difference (HSD) test was used to determine significant differences among treatments.

### **3. Results and Discussion**

#### *3.1 Rating and Percent Infestation of Insect Pests on Corn*

Insect pest assessment on corn across different cropping patterns under coconut was conducted at harvest (Table 1). Although analysis of variance showed no significant influence of cropping patterns on the rating of corn borer infestation, seasonal differences were evident. Corn planted during the first season (CP<sub>1</sub>–CP<sub>4</sub>) exhibited higher corn borer infestation, particularly CP<sub>3</sub> (corn + mung bean – sweet potato), with a mean rating of 6.33, compared to the second season (CP<sub>5</sub>–CP<sub>8</sub>), where infestation levels were consistently low (1.00–1.03). This seasonal disparity can be attributed to ecological conditions—higher pest incidence in the early planting coincided with periods of relatively drier weather, which favor the development and survival of corn borers (Nafus & Schreiner, 1987). In contrast, the second season was characterized by more frequent rainfall, which may have disrupted the pest life cycle and increased natural mortality due to higher humidity and natural enemies.

Corn earworm infestation showed no significant variation among cropping patterns, although it was present only in the first season, with values ranging from 3.33% in sole corn (CP<sub>1</sub>) to 10% in intercropped corn (CP<sub>3</sub> and CP<sub>4</sub>). The absence of earworm infestation in the second season suggests that rainfall patterns and cooler microclimatic conditions under coconut canopy reduced oviposition and larval survival. Intercropping may also have provided a “dilution effect,” whereby the presence of alternative host crops such as mung bean and sweet potato reduced the probability of pest colonization on corn.

Corn weevil infestation was significantly influenced by both cropping patterns and season. The highest incidence was recorded during the first cropping (43.33–83.33%), particularly in CP<sub>2</sub> (corn – sweet potato), compared to markedly lower infestation in the second cropping (0–20%). The strong seasonal effect reflects the biology of weevils, which thrive under warm and relatively dry conditions that facilitate kernel penetration and storage contamination. In contrast, wetter conditions during the second season likely limited population buildup. Interestingly, diversified patterns such as CP<sub>7</sub> (mung bean – corn + sweet potato) and CP<sub>8</sub> (sweet potato – corn + mung bean) showed the lowest weevil infestations (0–3.33%), indicating the ecological advantage of diversified systems. The complex canopy structures and root systems in these intercrops likely reduced pest mobility and host detection.

Ecologically, the reduced infestation observed in diversified and sequential patterns is closely linked to enhanced soil biodiversity and weed suppression. For instance, sweet potato acted as a living mulch, suppressing weed density and altering the microhabitat, which indirectly reduced pest colonization. Furthermore, cropping patterns that integrated legumes (e.g., mung bean) not only improved soil nitrogen through biological fixation but also supported higher soil macrofauna populations such as earthworms (Section 3.5). These organisms contribute to soil health, indirectly strengthening crop resilience against pests. Hence, cropping patterns that minimized pest infestation also enhanced soil biodiversity and overall productivity, as reflected in higher Land Equivalent Ratio (LER) values (Section 3.6).

Table 1. Rating of corn borer (*Ostrinia furnacalis*, cm tunnel length), corn earworm incidence (*Helicoverpa zea*, %), and corn weevil infestation (*Sitophilus zeamais*, %)

| Code            | Cropping Patterns        |                          | Rating of Corn Borer ( <i>Ostrinia furnacalis</i> ) (cm tunnel length) | Corn Ear Worm ( <i>Helicoverpa zea</i> ) (%) (incidence) | Corn Weevil ( <i>Sitophilus zeamais</i> ) (%) (infestation) |
|-----------------|--------------------------|--------------------------|--|--|---|
|                 | 1 <sup>st</sup> Cropping | 2 <sup>nd</sup> Cropping |  |  |   |
| CP <sub>1</sub> | Corn                     | Mung bean                | 2.00   | 3.33   | 76.67 <sup>a</sup>  |
| CP <sub>2</sub> | Corn                     | Sweet potato             | 1.00   | 0.00   | 83.33 <sup>a</sup>  |
| CP <sub>3</sub> | Corn + Mung bean         | Sweet potato             | 6.33   | 10.00  | 76.67 <sup>a</sup>  |
| CP <sub>4</sub> | Corn + Sweet potato      | Mung bean                | 3.33   | 10.00  | 43.33 <sup>ab</sup>   |
| CP <sub>5</sub> | Mung bean                | Corn                     | 1.03   | 0.00   | 20.00 <sup>b</sup>  |
| CP <sub>6</sub> | Sweet potato             | Corn                     | 1.00   | 0.00   | 20.00 <sup>b</sup>  |
| CP <sub>7</sub> | Mung bean                | Corn + Sweet potato      | 1.03   | 0.00   | 0.00 <sup>b</sup>   |
| CP <sub>8</sub> | Sweet potato             | Corn + Mung bean         | 1.00   | 0.00   | 3.33 <sup>b</sup>   |
| F- Test         |                          |                          | ns   | ns   | **  |

Means followed by the same letter(s) and those without letters are not significantly different at 5% level based on the HSD test

\*\* – highly significant

ns- not significant

CP- Cropping Pattern

### 3.2 Rating of Insect Pest Infestation on Mung Bean

The rating of pod borer (at flowering and maturity stages) and aphids on mung bean as influenced by the cropping patterns (Table 2). The cropping patterns on the rating of the pod borer at the flowering and maturity stages of mung bean were not significantly influenced. At the flowering stage, the rating for pod borer on mung bean at different cropping patterns was 1.00 except for CP<sub>1</sub> and CP<sub>8</sub>, with both 1.03. On the other hand, during the maturity stage of mung

bean, pod borer slightly infested mung bean pods, with ratings ranging from 1.67 to 3.00, with the highest on CP<sub>5</sub>, corn + sweet potato – mung bean.

The aphid rating showed a significant difference among cropping patterns. Both CP<sub>5</sub>, sole mung bean, and CP<sub>3</sub> – mung bean + corn during the first cropping were severely infested with aphids with a rating of 9.00, but did not differ significantly from CP<sub>7</sub>- mung bean + sweet potato with a rating of 7.67. This confirmed Bailey (2007) statement that aphids occur in large numbers, especially after good rain following a dry period. During the second cropping, aphid infestation dropped, and values varied significantly with the first cropping but did not differ significantly within the second cropping, where CP<sub>1</sub>, corn–mung bean had the highest infestation rating of 3.00, CP<sub>4</sub>, corn + sweet potato-mung bean, of 2.33, and CP<sub>8</sub>, sweet potato-corn + mung bean, with a rating of only 1.67.

Table 2. Rating of insect pest infestation on mung bean under coconut in various cropping patterns

| Code            | Cropping Patterns        |                          | POD  | POD   | APHIDS<br>(rating,<br>1–9) |
|-----------------|--------------------------|--------------------------|--|---|----------------------------|
|                 | 1 <sup>st</sup> Cropping | 2 <sup>nd</sup> Cropping | BORER at<br>Flowering<br>(rating, 1–<br>9) | BORER<br>at<br>Maturity<br>(rating,<br>1–9) |                            |
| CP <sub>3</sub> | Mung bean + Corn         | Sweet potato             | 1.00                                       | 1.67  | 9.00 <sup>a</sup>          |
| CP <sub>5</sub> | Mung bean                | Corn                     | 1.00                                       | 2.33  | 9.00 <sup>a</sup>          |
| CP <sub>7</sub> | Mung bean                | Corn + Sweet potato      | 1.00                                       | 1.67  | 7.67 <sup>a</sup>          |
| CP <sub>1</sub> | Corn                     | Mung bean                | 1.03                                       | 1.67  | 3.00 <sup>b</sup>          |
| CP <sub>4</sub> | Corn + Sweet potato      | Mung bean                | 1.00                                       | 3.00  | 2.33 <sup>b</sup>          |
| CP <sub>8</sub> | Sweet potato             | Corn+ Mung bean          | 1.03                                       | 2.33  | 1.67 <sup>b</sup>          |
| F- Test         |                          |                          | ns   | ns  | **                         |

Means followed by the same letter(s) and those without letters are not significantly different at 5% level based on the HSD test

\*\* – highly significant

ns- not significant

CP- Cropping Pattern

### 3.3 Rating of Insect Pest and Rat Percent Incidence on Sweet Potato

The rating of root weevil and rat percent incidence on sweet potato as influenced by cropping patterns is presented in Table 3. Analysis of variance shows no significant impact on both root weevil rating and rat percent incidence. The first cropping of sweet potato had less root weevil infestation, with a rate of 1.67 for CP<sub>4</sub>, CP<sub>6</sub>, and CP<sub>8</sub>, than on the second cropping, which ranged from 1.67- 2.33. Cropping pattern CP<sub>2</sub>, – corn – sweet potato and CP<sub>7</sub>- mung bean - corn + sweet potato had higher infestation ratings of both 2.33

but did not differ significantly with CP<sub>3</sub> - corn + mung bean – sweet potato with a rating of only 1.67. This aligns with the study of Nedunchezhiyan *et al.* (2010b), which found that sweet potato + maize strip intercropping reduced the percentage of weevil damage to roots. Korada, *et al.* (2010) also reported that sweet potato weevil had a lower percentage when sweet potato was intercropped with maize.

On the other hand, rat incidence ranged from 1.67 to 3.0 in both first and second cropping. CP<sub>6</sub> – sweet potato - corn, CP<sub>8</sub> – sweet potato - corn + mung bean, and CP<sub>3</sub> - corn + mung bean – sweet potato had the highest rate of 3.0 or were classified as having a slight infestation of rat damage.

Table 3. Rating of root weevil infestation and rat damage on sweet potato under coconut in various cropping patterns

| Code            | Cropping Patterns        |                          | Root Weevil<br>(rating, 1–9) | Rat Damage<br>(rating, 1–9) |
|-----------------|--------------------------|--------------------------|------------------------------|-----------------------------|
|                 | 1 <sup>st</sup> Cropping | 2 <sup>nd</sup> Cropping |                              |                             |
| CP <sub>4</sub> | Sweet potato + Corn      | Mung bean                | 1.67                         | 1.67                        |
| CP <sub>6</sub> | Sweet potato             | Corn                     | 1.67                         | 3.00                        |
| CP <sub>8</sub> | Sweet potato             | Corn + Mung bean         | 1.67                         | 3.00                        |
| CP <sub>2</sub> | Corn                     | Sweet potato             | 2.33                         | 2.33                        |
| CP <sub>3</sub> | Corn + Mung bean         | Sweet potato             | 1.67                         | 3.00                        |
| CP <sub>7</sub> | Mung bean                | Sweet potato + Corn      | 2.33                         | 1.67                        |
| F- Test         |                          |                          | ns                           | ns                          |

ns- not significant

CP- Cropping Pattern

Figure 1 present the insect pests and beneficial arthropods associated with corn: evidence of corn borer (*Ostrinia furnacalis*) infestation showing characteristic stem tunneling that compromises plant vigor and yields potential (a); slug caterpillar (*Parasa lepida*) feeding on the leaf surface, resulting in foliar damage that reduces photosynthetic efficiency (b); corn weevil (*Sitophilus zeamais*) observed on the ear, a major storage and field pest that bores into kernels, thereby diminishing grain quality and market value (c); and earwig (*Euborellia annulipes*) on the corn ear, an arthropod exhibiting dual ecological roles, functioning both as a minor pest through ear feeding and as a beneficial predator by preying on soft-bodied insect pests, thus contributing to natural pest regulation within the corn agroecosystem (d).



Figure 1. Insect pests and beneficial arthropods associated with corn: damage and the presence of corn borer (a), slug caterpillar on the leaf (b), weevil (c), and earwig on the corn ear (d)

### 3.4 Associated Weeds of Corn, Mung Bean, and Sweet Potato

Weed assessment was conducted two weeks after hilling-up cultivation within a 1 m<sup>2</sup> quadrat per plot in both cropping seasons. The most dominant weed species observed were white kyllingia (*Cyperus kyllingia*), goosegrass (*Eleusine indica*), goat weed (*Ageratum conyzoides*), dove weed (*Murdannia nudiflora*), and itch grass (*Rottboellia cochinchinensis*) (Table 4).

Population counts revealed no significant differences among cropping patterns for most weed species, except for goat weed. Sole corn (CP<sub>5</sub>) exhibited the highest density of goat weed (31 plants m<sup>-2</sup>), whereas diversified patterns, particularly corn + mung bean (CP<sub>8</sub>), had only four plants m<sup>-2</sup>. White kyllingia was most abundant in sole corn plots (25 plants m<sup>-2</sup>), while in corn + sweet

potato intercropping (CP<sub>7</sub>), it was completely absent, although goosegrass was more common. Sole sweet potato plots (CP<sub>2</sub>) had higher observations of itch grass (7 plants m<sup>-2</sup>).

The suppressive ability of sweet potato is particularly noteworthy. Sweet potato vines form an extensive canopy that quickly covers the soil surface, reducing light penetration to the ground and thereby limiting the germination and growth of light-sensitive weed species. Its sprawling vine and dense foliage create a living mulch that competes strongly with weeds for light, space, and soil nutrients. In addition, sweet potato residues may exert allelopathic effects, releasing biochemical compounds that inhibit weed seed germination and early seedling growth (Nedunchezhiyan *et al.*, 2012). By reducing weed density and altering the weed community composition, sweet potato not only improves crop competitiveness but also reduces the need for manual or chemical weed control.

Table 4. The number of associated weeds per square meter quadrant with crops during the first cropping seasons

| Code            | Cropping Patterns           |                             | White<br>Kyllingia<br>(plants<br>m <sup>-2</sup> ) | Goose<br>Grass<br>(plants<br>m <sup>-2</sup> ) | Goat<br>Weed<br>(plants<br>m <sup>-2</sup> ) | Dove<br>Weed<br>(plants<br>m <sup>-2</sup> ) | Itch<br>Grass<br>(plants<br>m <sup>-2</sup> ) |
|-----------------|-----------------------------|-----------------------------|--|--|--|--|---|
|                 | 1 <sup>st</sup><br>Cropping | 2 <sup>nd</sup><br>Cropping |  |  |  |  |   |
| CP <sub>1</sub> | Corn                        | Mung bean                   | 14   | 7  | 14 <sup>ab</sup>                             | 2  | 3   |
| CP <sub>2</sub> | Corn                        | Sweet potato                | 11   | 3  | 11 <sup>ab</sup>                             | 3  | 7   |
| CP <sub>3</sub> | Corn +<br>Mung bean         | Sweet potato                | 15   | 6  | 13 <sup>ab</sup>                             | 1  | 2   |
| CP <sub>4</sub> | Corn +<br>Sweet potato      | Mung bean                   | 21   | 1  | 7 <sup>ab</sup>                              | 1  | 4   |
| CP <sub>5</sub> | Mung bean                   | Corn                        | 26   | 8  | 31 <sup>a</sup>                              | 1  | 4   |
| CP <sub>6</sub> | Sweet potato                | Corn                        | 5  | 2  | 7 <sup>ab</sup>                              | 2  | 1   |
| CP <sub>7</sub> | Mung bean                   | Corn +<br>Sweet<br>potato   | 0  | 20   | 5 <sup>ab</sup>                              | 0  | 3   |
| CP <sub>8</sub> | Sweet potato                | Corn +<br>Mung bean         | 11   | 1  | 4 <sup>b</sup>                               | 1  | 1   |
| F- Test         |                             |                             | ns   | ns   | *  | ns   | ns  |

Means followed by the same letter(s) and those without letters are not significantly different at 5% level based on the HSD test

\* - significant

ns- not significant

CP- Cropping Pattern

Overall, intercropping patterns that included sweet potato, such as CP<sub>6</sub> (Sweet potato - Corn) and CP<sub>7</sub> (Mung bean - Corn + Sweet potato), consistently recorded lower weed densities compared to sole cropping. This ecological mechanism, physical shading, nutrient competition, and potential allelopathy,

underscores the role of sweet potato as a multifunctional intercrop that enhances weed management while supporting soil conservation.

Table 5 presents the number of associated weeds per square meter quadrant with crops planted in a cropping pattern during the second season. Data reveal that white kyllingia and goat weed were observed to be significantly different from the other cropping patterns. Thus, CP<sub>4</sub> plots planted with sole mung bean (corn + sweet potato- mung bean) substantially had a higher density of 38 white kyllingia compared to cropping pattern planted with sole corn (CP<sub>2</sub>, Corn – Sweet potato), sweet potato (CP<sub>3</sub>, Corn + Mung bean – Sweet potato), and intercropping corn + sweet potato (CP<sub>7</sub>, Mung bean - Corn + Sweet potato) with only 3-10 population. A lesser number of white kyllingia density was observed in CP<sub>2</sub> (Corn – Sweet potato) with only three hills.

Table 5. The number of associated weeds per square meter quadrant with crops during the second cropping seasons

| Code            | Cropping Patterns        |                          | White Kyllingia (plants m <sup>-2</sup> ) | Goose Grass (plants m <sup>-2</sup> ) | Goat Weed (plants m <sup>-2</sup> ) | Dove Weed (plants m <sup>-2</sup> ) | Itch Grass (plants m <sup>-2</sup> ) |
|-----------------|--------------------------|--------------------------|---|---------------------------------------|-------------------------------------|-------------------------------------|--------------------------------------|
|                 | 1 <sup>st</sup> Cropping | 2 <sup>nd</sup> Cropping |   |                                       |                                     |                                     |                                      |
| CP <sub>1</sub> | Corn                     | Mung bean                | 21 <sup>ab</sup>                          | 16                                    | 5 <sup>a</sup>                      | 9 <sup>a</sup>                      | 2                                    |
| CP <sub>2</sub> | Corn                     | Sweet potato             | 3 <sup>b</sup>                            | 4                                     | 0 <sup>b</sup>                      | 2 <sup>b</sup>                      | 4                                    |
| CP <sub>3</sub> | Corn + Mung bean         | Sweet potato             | 9 <sup>b</sup>                            | 11                                    | 0 <sup>b</sup>                      | 3 <sup>b</sup>                      | 1                                    |
| CP <sub>4</sub> | Corn + Sweet potato      | Mung bean                | 38 <sup>a</sup>                           | 8                                     | 4 <sup>ab</sup>                     | 5 <sup>b</sup>                      | 0                                    |
| CP <sub>5</sub> | Mung bean                | Corn                     | 29 <sup>ab</sup>                          | 13                                    | 1 <sup>ab</sup>                     | 12 <sup>a</sup>                     | 1                                    |
| CP <sub>6</sub> | Sweet potato             | Corn                     | 17 <sup>ab</sup>                          | 9                                     | 0 <sup>b</sup>                      | 4 <sup>b</sup>                      | 2                                    |
| CP <sub>7</sub> | Mung bean                | Corn + Sweet potato      | 10 <sup>b</sup>                           | 13                                    | 0 <sup>b</sup>                      | 2 <sup>b</sup>                      | 3                                    |
| CP <sub>8</sub> | Sweet potato             | Corn + Mung bean         | 7 <sup>ab</sup>                           | 8                                     | 4 <sup>ab</sup>                     | 1 <sup>b</sup>                      | 0                                    |
| F- Test         |                          |                          | *   | ns                                    | **                                  | *                                   | ns                                   |

Means followed by the same letter(s) and those without letters are not significantly different at 5% level based on the HSD test

\*\* – highly significant

\* – significant

ns- not significant

CP- Cropping Pattern

Goat weed was significantly different from the other cropping patterns, where CP<sub>1</sub> (corn – mung bean) had a higher number of 5 weeds than the other plots. Some had no observation of this weed. On the other hand, the dove weed was

significantly different from the other patterns. Thus, CP<sub>1</sub> (Corn – Mung bean) and CP<sub>5</sub> (Mung bean – Corn) showed high density with 9 and 12 compared to the other patterns, while CP<sub>8</sub>, Sweet potato - Corn + Mung bean got the lowest number of 1. Also, goose grass and itch grass density showed no significant difference among cropping patterns. Thus, goose grass was observed to be higher on CP<sub>1</sub> (corn – mung bean), with 16 plots planted with sole sweet potato (CP<sub>2</sub>, Corn – Sweet potato) and only four numbers of goose grass. On the other hand, itch grass was observed high on CP<sub>2</sub> (corn – sweet potato) with four densities, while CP<sub>4</sub> and CP<sub>8</sub> were no observation of the said weeds.

There were no observed differences in all weed density in sole cropping or intercropping within the season. However, the results show that sole corn and mung bean had a higher density than sole or intercropped with sweet potato.

Table 6 presents other weeds observed in the area with very low density: knotgrass, spreading dayflower, garden spurge, water primrose, stonebreaker, synedrella, and carabao grass. The majority belonged to the broadleaf morphology, and some were grasses.

Overall, weeds were observed to have more density on the cropping pattern planted with monocrop mung bean and corn while less on the plots planted with sweet potato due to its characteristic of serving as a living mulch that could suppress over weeds. This ratifies the study of Nedunchezhiyan *et al.* (2012) that sweet potato vines grown between corn rows act as mulch in the inter-row space, thereby minimizing weeds grew, soil evaporation, reducing run-off or increasing infiltration.

Table 6. Other association weeds in corn, mung bean, and sweet potato during the two-cropping patterns

| Common Name         | Scientific Name              | Characteristics |
|---------------------|------------------------------|-----------------|
| Knot grass          | <i>Paspalum distichum</i>    | Grass           |
| Spreading dayflower | <i>Commelina diffusa</i>     | Broadleaves     |
| Garden spurge       | <i>Euphorbia hirta</i>       | Broadleaves     |
| Water primrose      | <i>Ludwigia hyssopifolia</i> | Broadleaves     |
| Stonebreaker        | <i>Phyllanthus niruri</i>    | Broadleaves     |
| Synedrella          | <i>Synedrella nodiflora</i>  | Broadleaves     |
| Carabao grass       | <i>Paspalum conjugatum</i>   | Grass           |

### *3.5 Biological Diversity Index*

The population of soil organisms was assessed using the quadrat method, with soil samples collected at a depth of 10 cm after harvest in both cropping seasons. Sampling was conducted early in the morning to account for the vertical migration of soil fauna in response to heat and light. The organisms observed were counted individually, with the main species identified being earthworms, Scarabaeidae larvae, earwigs, and mole crickets. Results (Table 7) showed no statistically significant differences among cropping patterns, yet variations in population counts were apparent. Plots planted with corn + sweet potato – mung bean (CP<sub>4</sub>) had the highest earthworm population (14 individuals per quadrat), while corn – mung bean (CP<sub>1</sub>) had fewer earthworms (7 individuals) but the highest Scarabaeidae larvae count (5 individuals). The consistent presence of Scarabaeidae larvae was attributed to the coconut-based system, which provides a stable habitat for this group.

The observed differences in earthworm populations among cropping patterns, though not statistically significant, are ecologically meaningful. Earthworms are highly sensitive to soil organic matter availability, moisture, and disturbance. Cropping patterns that incorporated sweet potato (e.g., CP<sub>4</sub> and CP<sub>6</sub>) likely provided more organic residues and root biomass, which serve as both food and habitat for earthworms. The dense vine covers of sweet potato also reduced soil temperature fluctuations and maintained higher soil moisture, creating favorable microclimatic conditions for soil fauna. In contrast, sole corn systems provided less surface cover and lower quality organic residues, resulting in fewer earthworms.

The ecological significance of these findings lies in the role of earthworms as ecosystem engineers. Higher populations improve soil structure, porosity, and nutrient cycling, which in turn support crop productivity. Intercropping systems that encourage earthworm activity therefore not only sustain soil biodiversity but also enhance long-term soil fertility and resilience. Similarly, the presence of other soil macrofauna such as earwigs and mole crickets reflects the ability of diversified systems to sustain a wider range of niches within the soil food web.

The results suggest that cropping patterns with greater crop diversity and organic inputs, particularly those involving sweet potato, create more favorable soil habitats.

Table 7. Number of species on the soil after being planted with corn, mung bean, and sweet potato in a cropping pattern

| Cropping Patterns                                 | Earthworm<br>(individuals per<br>quadrat, 1 m <sup>2</sup> ×<br>10 cm depth) | Scarabaeidae<br>Larvae<br>(individuals per<br>quadrat, 1 m <sup>2</sup> ×<br>10 cm depth) |
|---|--|---|
| CP <sub>1</sub> - Corn – Mung bean                | 7  | 5   |
| CP <sub>2</sub> - Corn – Sweet potato             | 10   | 1   |
| CP <sub>3</sub> - Corn + Mung bean – Sweet potato | 9  | 3   |
| CP <sub>4</sub> - Corn + Sweet potato – Mung bean | 14   | 1   |
| CP <sub>5</sub> - Mung bean - Corn                | 12   | 1   |
| CP <sub>6</sub> - Sweet potato - Corn             | 11   | 1   |
| CP <sub>7</sub> - Mung bean - Corn + Sweet potato | 10   | 1   |
| CP <sub>8</sub> - Sweet potato - Corn + Mung bean | 12   | 1   |
| F- Test   | ns   | ns  |

ns – not significant

CP- Cropping Pattern

### 3.6 Productivity Measurements of Corn, Mung Bean, and Sweet Potato in a Cropping Pattern

#### 3.6.1 Land Equivalent Ratio (LER) of Intercropping

The land equivalent ratio (LER) is the relative area of a sole crop required to produce the yield achieved by intercropping. The LER value is equivalent to one, so there is no yield advantage. However, when the LER is greater than one, it means that there is a yield advantage. Data in Table 8 showed that LER values of corn + mung bean (CP<sub>1</sub> & CP<sub>8</sub>) were more significant than one, both in the first cropping with 1.3 and the second cropping with 1.53 LER. The range of yield advantage over sole cropping was between 30% and 53%, which means the intercrop system was 30% and 53% more productive compared to sole crop production. Intercropping of corn + sweet potato (CP<sub>2</sub>) was the first cropping was less than one, which means that there was no yield advantage this season. However, corn + sweet potato intercropping was already more than one on the second cropping. These results are parallel to the study of Rashwan and Zeneldin (2017), which found that intercropping patterns increased LER values and recorded yield advantages compared with solid plantings of corn and other crops such as soybean. The possible reason for the higher productivity of the intercropping system may be due to the efficient utilization of growth resources by component crops and the intercropping advantage of nitrogen fixation and increased light use efficiency (Reddy, 2004, as cited by Amanu *et al.*, 2021). In line with this result, Baishya

*et al.* (2022). stated that intercropping maize with mung bean increased land use efficiency by 43%. Legba *et al.*, (2025) stated that maize + mung bean intercropping was a more productive and efficient system in utilizing land compared to sole cropping.

### 3.6.2 Competitive Ratio (CR) of Intercropping

The competitive ratio of the two-intercropping is presented in Table 8. The better (the lowest) competitive ratio was found for the corn + mung bean in both first and second cropping. Values for CR of corn as the main crop were higher than mung bean values, which revealed that corn was more competitive than mung bean and is an advantage. It complements the study of Rashwan and Zeneldin (2017) that corn and legume crops like soybean and mung bean had a lower competitive ratio than corn. For corn intercrop with sweet potato, all values of sweet potato CR in two-cropping were greater than corn. This means that intercropping competition between corn and sweet potato was higher, and sweet potato was more competitive than corn. The good thing is that in both seasons, all values for CR were less than 1. Therefore, the patterns of competition between corn intercrop with mung bean and sweet potato were not severe.

Table 8. LER and the competitive ratio of corn intercrop with mung bean and sweet potato under coconut in various cropping patterns

| Cropping Patterns                     | LER  | Competitive Ratio |           |              |
|---------------------------------------|------|-------------------|-----------|--------------|
|                                       |      | Corn              | Mung bean | Sweet potato |
| First cropping season                 |      |                   |           |              |
| CP <sub>1</sub> - Corn + Mung bean    | 1.30 | 0.93              | 0.37      |              |
| CP <sub>2</sub> - Corn + Sweet potato | 0.93 | 0.44              |           | 0.49         |
| Second cropping season                |      |                   |           |              |
| CP <sub>7</sub> - Corn + Sweet potato | 1.24 | 0.43              |           | 0.81         |
| CP <sub>8</sub> - Corn + Mung bean    | 1.53 | 0.80              | 0.73      |              |

#### 4. Conclusion and Recommendation

The intercropping system showed no significant effect on the major or key insect pests of corn, mung bean, and sweet potato. Similarly, the weeds observed were common and did not pose an economic threat to crop production. Among different combinations, intercropping corn + mung bean (CP<sub>1</sub> and CP<sub>8</sub>) has recorded the highest Land Equivalent Ratio values of 1.30 and 1.53 with corn as the main crop. These findings suggest that cropping patterns such as Sweet potato - Corn (CP<sub>6</sub>), Mung bean – Corn (CP<sub>5</sub>), and multiple cropping of Sweet potato - Corn + Mung bean (CP<sub>8</sub>) are recommended for the coconut-based farming system. These patterns offer complementary benefits among crop components and exhibit minor infestation of insect pests, tolerable levels of associated weeds, and a biodiversity index. The corn + mung bean intercropping combination is particularly advantageous due to its high LER and competitive ratio. Furthermore, it is recommended that studies with different crop combinations and cropping patterns under coconut in other areas must be explored to further validate the results of this study.

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