INTEGRATING CORN-LEGUME INTERCROPPING SYSTEM: INCREASING PROTEIN CONTENT ON YELLOW CORN THROUGH *Rhizobium* INOCULATION

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This research paper, entitled **"INTEGRATING CORN-LEGUME INTERCROPPING SYSTEM: INCREASING PROTEIN CONTENT ON YELLOW CORN THROUGH *Rhizobium* INOCULATION"**, prepared and submitted by JUNALYN M. UY and MC CYRYLL S. OTOC, in fulfillment of the requirements for the degree of **Bachelor of Science in Agriculture,** has been examined and is recommended for acceptance and approval.

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DEDICATION

I dedicate this to God for consistently gracing me
with His goodness.
I am grateful

for His never ending miracles.
I dedicate this to myself
for reaching this far,
unplanned but by faith I am here.

To my Auntie Inday,
who is God's
ultimate instrument.
My own lumière.

And to my most beautiful memory,
my Papa Goding.
This is all for you.

- June -

DEDICATION

To my parents and family, thank you for your constant love, patience, and sacrifices that made this academic journey possible. Your encouragement gave me the strength to keep going even during the most challenging times. This thesis stands as proof of everything you have done for me, and I share this achievement with you.

To my mentors, thesis partner, classmates and everyone who supported me along the way, thank you for your guidance, advice, and belief in my potential. Your presence and support shaped not only this work but also the person I have become. I dedicate this thesis to all of you with deep gratitude.

Lastly to Almighty God, I dedicate this work to You, the source of all wisdom, strength, and knowledge. Thank You for guiding me through every challenge, for giving me perseverance during difficult times, and for the blessings that made this work possible. Without Your grace, none of this would have been accomplished, thank you God.

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ABSTRACT

This study aimed to intercrop yellow corn with legumes (soybean, peanut, and mung bean) inoculated with *rhizobium* bacteria to increase the corn's crude protein and the Soil-Nitrogen level. The presence of *rhizobium* in different strains is to help legumes fix atmospheric nitrogen and convert them into ammonium (NH4+) and nitrate (NO3) that can be used by plants. to A Randomized Complete Block Design (RCBD) was employed in a single factorial experiment with four (4) treatments and four (4) replications, in a 359.6 sq. meter area, divided into sixteen 5.7m plots. The treatments were: T1 (yellow corn + yellow corn); T2 (yellow corn + *Glycine max* + *Bradyrhizobium japonicum*); T3 (yellow corn + *Arachis hypogaea* + *Bradyrhizobium elkaniiake*); and T4 (yellow corn + *Vigna radiate* + *Bradyrhizobium*). To determine the Soil-N levels, a soil analysis for NPK was done before and planting. As per analysis, T3 had the highest N-deficiency level by 135% but had the highest Nitrogen increase after planting by 45%. For the corn's protein content, T1 had the highest CP of 9.6675%, higher than those of being intercropped with legumes, due to the absence of light, air, water, and nutrient competition. But among all other three (3) treatments, T2 had a CP of 8.47%, followed by T3 of 7.92%, and T4 with 7.82%. The results proved that legumes can significantly increase nitrogen in the soil. Although, the intercropping did not produce higher crude protein than T1, but it's higher than the Philippine average corn crude protein (6-7%). The growth and yield parameters of corn were also identified, and T3 have produced the highest the vigorous yellow corn plants in height, width, and length; and highest yield. Thus, peanut is most recommended to be intercropped with yellow corn, an excellent producer of yield, crude protein in corn, and Soil-Nitrogen.

Keywords: *atmospheric nitrogen, crude protein, intercropping, legumes rhizobium bacteria, Soil-Nitrogen*

INTRODUCTION

Background of the Study

Zea mays, commonly known as corn, is the second staple food in the Philippines and is the largest crop used for livestock feed production, specifically in the swine and poultry industries (Dayo,2022). The Philippines cultivated corn on a 2.5 million ha of land area, which amounted to 8.41 million MT of production volume by December 2023 (Balita,2024). White and yellow corn are the most grown corn types in the country. At present, yellow corn has the largest production, 46% and 62.5% of its produce is sold for livestock and poultry feeding (Department of Agriculture,2023). However, regardless of the harvested yield, the production started to decrease year by year (ATI, 2024).

Cagayan Valley, the highest-producing region of yellow corn is experiencing a decline in crop productivity by 2.5 sacks per hectare. Central Luzon also decreased by 11.0%, and the Ilocos Region decreased by 16.92% in the third quarter of 2023. In summary, the Philippines recorded a 39.1% decline in total yellow corn production in the second quarter of 2024, equivalent to 1.13% per ha (Philippine Statistics Authority, 2024).

Along with the decrease in grain yield production, the Philippine Animal Protein sector was also alarmed by the yellow corn's protein yield status. There has been an annual yellow corn deficit of approximately 3-5 million MT since 2016, which has been found to be relatively affected by corn's whole-grain protein concentration levels (Tan, 2024). The concerns in protein deficiency in relation to livestock by-products worldwide were pointed out in a study by the Royal Agricultural College of Crencister, UK, that was carried out due to the high demand for meat and in solving the human protein deficiency dilemma (Chadd et al., 2020).

Livestock by-products like meat, eggs, and milk serve as the main source of protein and are heavily relied on for human consumption, as they provide up to 35% of protein and 16% of energy in human diets (FAO, 2024). However, the amount of protein these by-products can provide is highly dependent on their feed quality. Corn, moreover, provides 19% of the world's protein production, and yellow corn is the largest crop used for feed ingredients (Springer, 2022). Also, the study by the Clinical Nutrition Research Center (CNRC) in Singapore has reported that the protein quality intake of Southeast Asians from their meat-based diet was poor, as a result of their dietary evaluation (Tjahyo et al., 2024).

In addition, an accompanying study by the Philippine Food Nutrition Research Institute (2022) emphasized the inadequacy of corn's nutritional composition in response to fighting Protein-Energy Malnutrition (PEM) in the Philippines, which was identified as the highest deficiency disorder among Filipinos (DemNet, 2024). The deficiency of the corn's protein content (<7%) was found to be insufficient to aid bodily growth and development, which requires at least 10-35% of protein (Hernadez et al., 2022).

Numerous experiments were conducted to investigate the varying factors that upset protein levels in corn. Environmental and climatic conditions, hybridization and genetic engineering, and soil conditions have been scientifically proven to affect crude protein in corn (Ohio State University, 2024). However, the major factor responsible for its protein content is the amount of nitrogen it has in the soil. The Soil-N is considered to be the most vital macronutrient for plant growth and development, serving as the building blocks of enzymes in plants (Zayed et al., 2023). The application of nitrogen fertilizer can significantly increase the grain yield of corn, and its protein content by about 11.1-1%, and more than 12% of the protein in good soil conditions does not have a record of nitrogen deficiency, as described by the study of Goos and Westfall (2024) from Colorado State University. To improve the Nitrogen level in soil, the application of Urea and any Nitrogen fertilizer can help, but is not sustainable.

In the study of Zhang (2022), corn was intercropped with *Glycine max L.* to enable Nitrogen fixation and treated along with different Nitrogen applications, which resulted in an increase in the corn's grain yield of about 60.38% and a total protein yield of about 106.71% respectively. Intercropping corn with protein- sourced annual leguminous crops is also practiced to address nitrogen deficiency in the soil. Legumes fix atmospheric Nitrogen and convert this to ammonium ($NH4+$) and nitrate ($NO3$), which can be absorbed by the plants with the help of *Rhizobium* bacteria (Flynn & Idowu, 2024). To ensure successful nodulation, an inoculation of the *rhizobium* bacteria is highly recommended , as well as the introduction of the appropriate and well-strained *rhizobium* bacteria specific to each legume.

Thus, this study purposely intercropped yellow corn with legumes (soybean, peanut mung bean) inoculated with their own strains of *rhizobium* bacteria for Nitrogen fixation. This, to investigate whether the level of Soil-N can relatively increase the corn's protein concentration and yield with the help of *Rhizobium* bacteria inoculation on legumes.

Objectives of the Study

This study aimed to increase the protein content in corn through intercropping of leguminous crops (soybean, peanut, and mung bean) inoculated by their own strain of *rhizobium* bacteria. The level of nitrogen fixation on the inoculated legumes will also be identified through visual nodule scoring. Specifically, this study aimed to:

1. determine the agronomic performance of yellow corn under corn–legume intercropping with *Rhizobium* inoculation.
2. evaluate the yield performance of yellow corn under corn–legume intercropping with Rhizobium inoculation.
3. determine the nitrogen content of the soil before planting and after harvest under the corn–legume intercropping system with *Rhizobium* inoculation.
4. determine the crude protein content of yellow corn grains produced under corn–legume intercropping with *Rhizobium* inoculation.
5. determine the significant differences among treatments in terms of agronomic performance, yield, soil nitrogen content, and crude protein content of yellow corn.

Hypothesis

These are following hypotheses:

Null Hypothesis (H_0)

1. There are no significant differences among the treatments on the agronomic performance, yield performance, soil nitrogen content, and crude protein content of

yellow corn under the corn–legume intercropping system with *Rhizobium* inoculation.

Alternative Hypothesis (H_1)

2. The corn–legume intercropping system with *Rhizobium* inoculation significantly affects the agronomic performance, yield performance, soil nitrogen content, and crude protein content of yellow corn.

Significance of the Study

This study can contribute on the low protein intake problem among Filipinos. Although the yellow corn is mostly used as a livestock feed ingredient, humans indirectly consume these corn nutrients from eating meat, eggs, and milk. Also, the Philippines major problem in corn production is the rapid decline of the soil's health. Intercropping corn with legumes that are to be inoculated by *rhizobium* bacteria will not only potentially increase yield, but can also help in enriching the soil by fixing the atmospheric nitrogen.

The success of this study will mostly benefit the corn farmers. Aside from the low-cost of inputs, the availability of the inoculant is also accessible, allowing them to increase their yield and add their produce without compromising the soil, water, and the environment. Moreover, the data from this experiment can serve as a guide in intercropping corn with leguminous crops.

Scope and Limitation of the Study

This study examined only whether the specified inoculants can successfully help the legumes fix the atmospheric nitrogen and how this may affect the soil Nitrogen level and corn protein of corn. This study used NK6410 variety of yellow corn and intercrop with Manchuria soybean, Namnama peanut, and Pag-asa mungbean. These varieties were selected based on the suitability for the experimental site in terms of climatic and soil conditions. The *rhizobium* inoculants were specific strains intended for soybean, peanut, and mung bean.

The sole objectives for this study were: (1) to inoculate the legumes with rhizobium bacteria to ensure successful atmospheric nitrogen fixation, and increase the Soil-N level after planting, and increase the crude protein of corn grains; (2) to analyze and compare Soil-N levels among different plots in per treatment and replication; (3) to identify which legumes or treatment provides the highest soil-N level; (4) to determine the crude protein content in corn; and (5) to identify the total yield of yellow corn an differentiate this with their varying agronomic parameters. The results from this study might not be true to the other corn and legumes, especially when grown in different regions.

Definition of Terms

This section provides the definition of terms on the unfamiliar terminologies used for study.

Inoculation. The process of introducing commercially produced *rhizobium* bacteria into legumes in promoting nitrogen fixation.

Nodulation. A symbolic process leading to the formation of nodules when legume roots are infected by rhizobia bacteria.

Nodules. A swelling or knob-like structures formed in the roots of the leguminous plants.

Nitrogen Fixation. The process of converting atmospheric nitrogen (N_2) into ammonium and nitrates, a usable form of Nitrogen that can be used by the plants.

Legumes. A seed or pod that is edible for human consumption.

Intercropping. Growing of two or more different crops in the same space between rows.

MATERIALS AND METHODS

Date and Place of the Study

The experimental site was conducted at Wood Spring Farm in P4-Brgy. Labo, Ozamiz City, Misamis Occidental, from January 16, 2025 to May 9, 2025 (Fig.1).

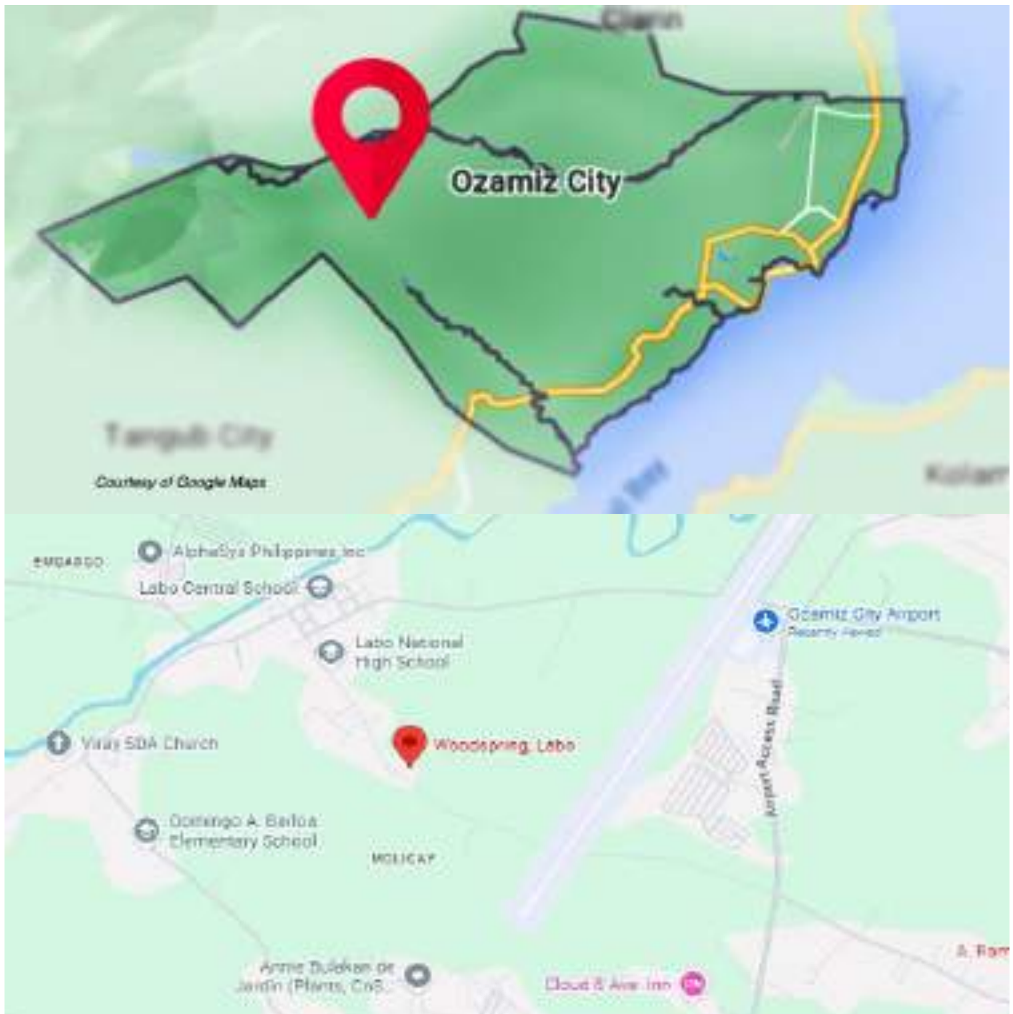

Figure 1. Experimental Site Map; (A) Location of Ozamiz City in Misamis Occidental, (B) Experimental Site Aerial View.

Description of the Study Area

Woodspring Farm is located in Brgy. Labo, Ozamiz City, in the province of Misamis Occidental. The experimental site is situated at least ten (10) meters away from Labo Airport. Ozamiz City experiences a Type III climate, which is relatively dry from November to April, making January to late April favorable for corn production. The city receives an average annual rainfall of 955 mm (37.7 inches) (PAGASA, 2024). In Brgy. Labo, rainfall commonly occurs during afternoons at least twice a week. January is considered the most suitable month for corn planting because it has the highest average sunshine duration (83.44 hours) and an average temperature of about 28 °C. In contrast, December records the highest rainfall of about 299.21 mm, with around 17 rainy days and 85% humidity, making it less suitable for corn farming (Zoomash, 2024).

The study area has a flat alluvial terrain with a 0–2% slope and is located approximately 29.7 meters above sea level at coordinates 08°11’0” N and 123°49’42” E (PhilAtlas, 2024). The soil is classified as moderately alkaline silty clay loam-meadow under the fine-loamy, mixed, mesic Fluvaquentic Endoquolls taxonomic class. The epipedon ranges from 25 to 38 cm thick, with a mean soil temperature of 8–11 °C (National Cooperative Soil Survey, 2011).

Woodspring Farm is a diversified orchard farm containing various fruit-bearing and hardwood trees. These include Longkong, Lanzones, Durian (Musang King, Black Thorn, and Puyat varieties), jackfruit, mangosteen, mango, banana, cacao, coffee, rambutan, santol, sampalok, atis, avocado, pink guava, papaya, and coconut trees. The farm also maintains approximately 700 fully grown mahogany trees, along with Gemilina and Tipolo trees planted for hardwood production.

Aside from fruit production, the farm is rich in natural water resources. A former sinkhole formed by runoff from nearby irrigated rice fields and spring water was converted into a fishpond for tilapia and koi. Irrigation for the orchard is supplied from this pond using submersible and low-head non-submersible water pumps. Vegetables such as squash, bottle gourd, pechay, eggplant, okra, string beans, chili, alugbati, kangkong, lettuce, cucumber, radish, and carrots are also grown mainly for household consumption.

According to the 2020 census, Brgy. Labo has a population of 3,586 people. Based on the 2015 census, the barangay had 723 households with an average household size of 4.20 persons (PhilAtlas, 2024). The Philippine Statistics Authority (2022) classified the barangay as successful, with relatively low poverty incidence. Most residents are educated professionals or business owners, while agricultural activities in the area mainly involve swine, poultry, vegetable, and hydroponic farming.

Materials

This study used 1Kg (2,260 seeds) of Syngenta NK 6410 yellow corn, 480 seeds each for Manchuria soybean, soybean, and mung bean. Different strains of *rhizobium* bacteria were used as legume inoculants that were provided by the University of the Philippines, Los Baños, Biotechnology Center. Plastic and eco bags, containers, soil auger, manual and digital weighing scales, and a marker were used for the soil sample collection. A soil test kit provided by the DA – City Office was then used in analyzing the soil samples.

A plowing tractor and animal-drawn harrower were used for the first and second passing of land preparation. In plotting and dividing the whole experimental area to 16 3 x 5.7m treatment boxes, shovel, manganese steel triangular hoe, thinned bamboo pins in marking the plots, and 1 roll of nylon thread to emphasize the markings and boundaries. Containers were used in mixing the inoculants and seeds before planting. For the irrigation, a non-submersible water pump and a 200-meter submersible discharge duct flat hose 4" PVC Pump Hose were installed. Two (2) water barrels of 200L volume were also placed as water storage. Other materials that were included and used during the whole duration were: manganese teeth weeder and asarol, lagaderas, record book, pens, portable calendar, weighing scales, tarpaulins, bamboo poles, and measuring tapes.

Methods

Experimental Design and Treatments

A Randomized Complete Block Design (RCBD) was employed in this study, a single factorial experiment with four (4) treatments and four (4) replications. The treatments are as follows:

T1: yellow corn + yellow corn

T2: yellow corn + *Glycine max* + *Bradyrhizobium japonicum* inoculant

T3: yellow corn + *Arachis hypogaea* + *Bradyrhizobium elkaniiake* inoculant

T4: yellow corn + *Vigna radiate* + *Bradyrhizobium* inoculant

The treatment control served as the basis of differences for any nodulation and nitrogen-fixing activity on legumes affecting the Nitrogen level in the soil, which is assumed to directly increase the corn's protein level. The measurement of the inoculants was based on their standard ratio.

Experimental Layout

The total land area for this experiment is 359.6 sq. meters, which was divided into sixteen (16) plots, corresponding to the replication of treatments (Fig. 2a and 2b). Each plot measured 22.48 sq. meters, giving each plot a size of 3m x 5.7m, with a 0.5-meter alleyways on each side. The purpose of alleys or canals is to serve as waterways to regulate water and manage water distribution for irrigation and drainage. This prevents excessive soil moisture that can affect the crops growth and development, and pests' occurrence and infestation. The canals are critical in increasing overall corn yield by transporting even water supply to crops during dry seasons or during irrigation.

The field layouts are presented below.

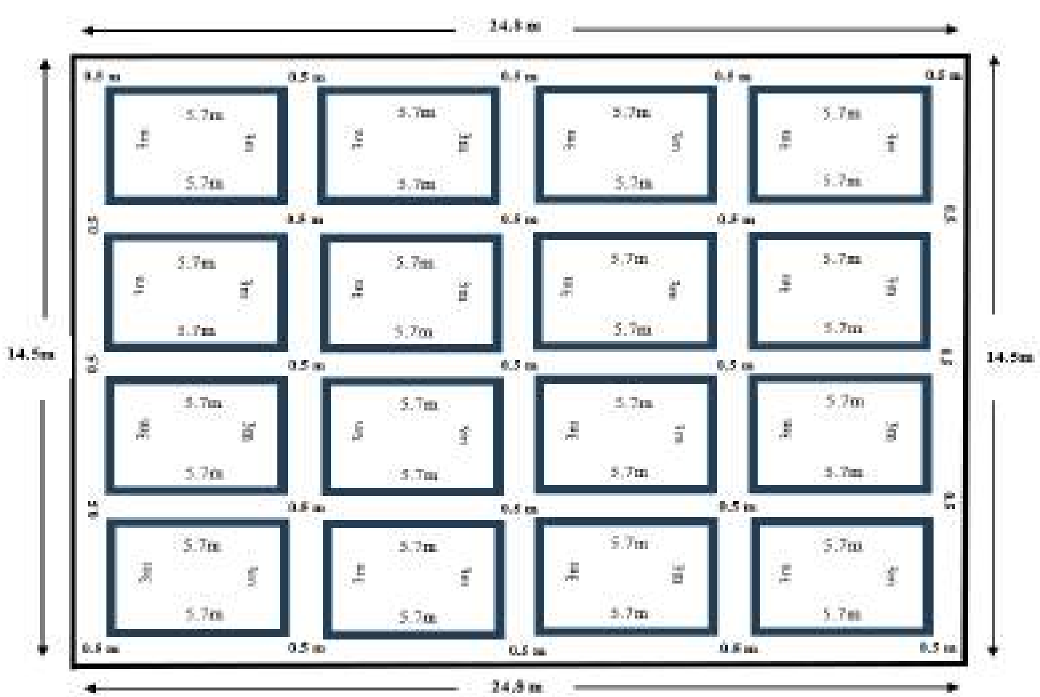

Figure 2a. Experimental Area Layout

A standardized planting distance for corn was observed during planting. For each plot, the corn was sown in a 70 cm planting distance per furrow and 20 cm per hill. The intercropped legumes were planted between corn furrows at a 30 cm hilling planting distance. There were four (4) furrows of corn per plot with fifteen (15) hills and five (5) furrows of legumes comprised of 10 hills.

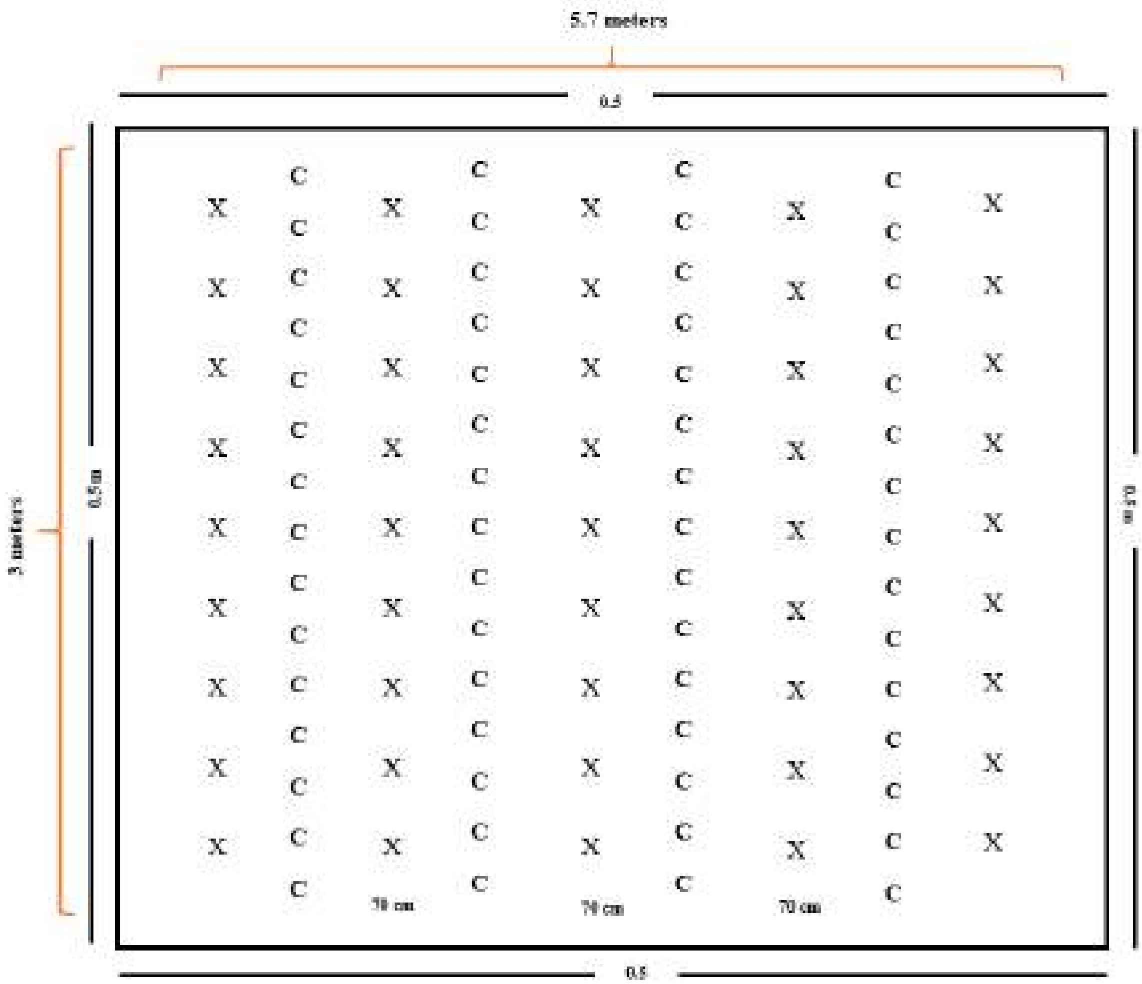

Figure 2b. Layout for the Plot Area

Variety and Source of Materials

NK6410, a yellow corn variety by Syngenta Philippines, was used for planting. It is a hybrid variety mainly grown in Cagayan Valley due to its high yield potential, including cob size, strong stalks, ease of husk and harvest, and drought resistance (Syngetnta, 2024). In addition, this variety is legally registered with the National Seed Industry Council (NSIC) to ensure it's safe, given its GM Bacillus thuringiensis (BT) traits. For the leguminous crops, Manchuria soybeans, Namnama peanut, and Pag-asa mung bean were used.

The NitroPlus rhizobium inoculants were provided by Dr. Jean Louise Damo, a researcher from the National Instituted of Molecular Biology and Biotechnology, UP Los Baños.

Site Selection

Yellow corn needs full sun and high amount of water to reach its optimum growth and yield. The location for this experiment is flat terrain, in an open field. The soil is well-drained, sandy loam, and has no history of crop cultivation except for coconut trees. The experimental area is surrounded with springs, allowing irrigation highly accessible.

Soil Sampling

The purpose of soil sampling was to get the composite soil samples of about one (1) kilogram of air-dried soil for each plot that are used for the soil nitrogen analysis. The guide provided by the Department of Agriculture (DA) Region X was followed, but modified some of its materials for more efficiency. These are the following steps:

1. Prepared the pail, shovel, bolo, meter stick, and plastic bag or container. But in this experiment, soil auger was used for digging the holes for precision and efficiency.

2. Divided the area according to the kind of crops to be grown, and identified its different soil types (sandy, clayey, or loamy) and its topography level. All bags were labeled individually.
3. Any trash, grass, and stones found on the surface were discarded.
4. Pushed down the topsoil to a depth of approximately 15cm, took a slice of soil sample (2cm thick and 5cm wide), and placed it in the plastic bag.
5. Took similar samples randomly and mixed them in the plastic bag. The sample unit weighed 1 kilogram per plot.
6. Air-dried the soil samples in a shaded area for at least one (1) week by spreading them in manila paper sheets to allow more air circulation and avoid wetting at the bottom. The samples were placed on a 1-meter table height to avoid any contamination, through this, foreign matters or dirt, specifically cigarette stick residues and animal feces.
7. After air-drying the soil, the samples were weighed at least 1 kilo from each composite soil sample and placed it separately in different containers. The containers were labeled according to their unit area. Note: In the absence of a weighing scale, get a can of condensed milk and fill it with full soil three (3) ties to get at least one kilo of air-dried soil.
8. After labeling the samples, we proceeded to soil analysis.

Soil Analysis

Soil analysis was done before planting and after harvesting. The main objective of this study is to identify the level of Nitrogen in the soil; however, since the researchers conducted the soil analysis, measurements for soil Phosphorus and Potassium were also included, as cost cutting was not necessary. This was done to fully calculate the NPK nutrient levels required in the soil to achieve optimal yield. Moreover, the sole purpose of the soil analysis is to compare the Nitrogen level of the field area before and after it has been planted with legumes with the help of rhizobium bacteria inoculation. The soil test kit was provided by the City Agriculture Office, which was procured from the Department of Agriculture – Bureau of Soils and Water Management (DA-BSWM). The STK comes in a small bag containing all the reagents and materials for determining soil pH and the available amounts of Nitrogen (N), Phosphorus (P), and Potassium (K). The STK also comes with the instruction brochure and Fertilizer Recommendation booklet, which are very site- and crop-specific regarding the type and amount of fertilizer to apply. The STK was also designed to use only color charts or visual comparison, but it can easily determine whether the soil is acidic or alkaline and whether the NPK level is low, medium, or high. The following are the steps on how to perform the Nitrogen, Phosphorus, and Potassium Tests:

A. Nitrogen Test

1. In a clean and dry test tube, transfer soil sample up to the first scratch mark (approximately 0.5-gram soil sample).
2. Fill the test tube with N reagent up to the second 2nd scratch mark (approximately 1mL).
3. Mix well by gently by tapping the test tube into the palm for 1 minute.
4. Stand the test tube for 5 minutes. Repeat step 3.

5. Heat the bottom of the test tube for about 30 seconds or until the solution starts bubbling.
6. Stand the test tube for 2 minutes.
7. Using a clean and white background, incline the test tube and match the color of the resulting solution with the colors in Figure 2.

B. Phosphorus Test

1. In a clean and dry test tube, transfer soil sample up to first scratch mark (approximately 0.5-gram soil sample).
2. Fill the test tube with P reagent up to the second scratch mark (approximately 1mL) then add 4 drops of P1 reagent.
3. Mix well by gently tapping the test tube into your palm for 1 minute.
4. Stand the test tube for 3 minutes. Repeat step 3.
5. Stand the test tube for 5 minutes.
6. Attach the tin foil to the stirring stick. Without disturbing the soil, stir solution for 1minute.
7. Stand the test tube for 2 minutes the stir for another 1 minute using tin foil.
8. Using a clean and white background, incline the test tube and match the color of the resulting solution with the colors in the figure.

NOTE: *The tin foil attached to the stick can be used up to four (4) times provided that the analyses are done on the same day. Rinse the tin foil with distilled water after each analyses.*

C. Potassium Test

1. In a clean and dry test tube, transfer soil sample up to first scratch mark (approximately 0.5-gram soil sample).
2. Fill the test tube with K reagent up to the second scratch mark (approximately 3mL).
3. Mix well by gently tapping the test tube into your palm for about 1 minute.
4. Stand the test tube for 1 minute. Repeat step 3.
5. Stand the test tube for 5 minutes.
6. In separate test tube, fill with K1 reagent up to the first scratch mark (approximately 0.5mL) and K2 up to the second scratch mark (approximately 1mL).
7. Mix well by gently tapping the test tube into your palm for 30 seconds.
8. Transfer aliquot from first test tube up to the third scratch mark (approximately 1mL).
9. Mix well by gently tapping the test tube into your palm for 1 minute.
10. Using the provided purple background, observe the formation of a turbid orange solution. Match the turbidity of the solution in Figure 4.

Cultural Management and Practices

Land Preparation

The experimental area was predominantly grown by grasses. The field was prepared 21-30 days before planting since the layout has to be followed including the alleyways. The field was mechanically ploughed in two (2) passing at a depth of 15-20cm, and harrowed one time using an animal-drawn plow. This is to evenly break soil clods, bury weeds, grass residues, create tilth that is suitable for planting seeds, good aeration, and easily form furrows.

To properly execute the layout, it has to be done manually. The soil moisture is the most critical factor at this stage. It's easier to work on the canals when the soil is slightly wet, but harder when it's too dry or too wet. To mark the boundary lines, a rattan string was used for its durability. This was used to divide all plots, alleyways, and the distances between furrows before planting.

After completing the alleyways or canals, the plots were leveled evenly inside to match with the other plots. This was also done manually since the area does not warrant the use of animal-drawn plows and any levelling equipment. Right after the soil in each plot were levelled, weeding was followed to ensure proper seed germination growth.

Before planting, plant markers were placed for each plot to avoid swapping of treatment positions before planting, and to prevent any mistakes or confusion in the gathering of data after planting. A bamboo, plywood, and printed tarpaulin were used to ensure visibility and durability. The plant markers were placed at the front of each plot. Each treatment has four (4) markers that was distributed per replication.

Seed Preparation

For this study 1,920 corn seeds and 1,600 legume seeds were distributed. In each treatment plot, 120 yellow corn seeds were sown, and 100 of legumes were sown. Since legumes varied depending on the treatments, 853 seeds of soybean, peanut, and mung bean were needed.

Before planting, the legume seeds were inoculated with rhizobium bacteria. Three (3) different variants of inoculants were used to provide the specific bacterial strain for the legumes. NitroPlus inoculants specific for soybean, peanut, and mung bean were used. The inoculant was developed over six (6) years at the National Institute of Molecular Biology and Biotechnology Research Center, located in UP Los Banos, to address soil degradation caused by the improper use of synthetic fertilizers. NitroPlus is a bio-fertilizer and inoculant for legumes consisting of pure, effective, cultured rhizobia.

The preparation was done on the same day as planting the legumes. The inoculants were in powdered form, and each weighed 100 grams - more than enough to cover all the legumes. Before inoculating, the seeds were sprinkled with tap water to moisten them and allow the inoculants to stick. In applying, the inoculants were thoroughly mixed until the seeds were evenly coated. The mixing was done inside a container under a shaded area. It’s important to note that these inoculants are sensitive to direct sunlight, thus, direct contact or inoculating and planting under the sun shall be avoided.

Sowing and Plant Thinning

In every furrow, there were fifteen (15) hills of corn and five (5) hills of legumes. Two (2) yellow corn seeds and legumes were sown per hill at 20 cm x 70 cm and 30 cm of legume hill planting distance. The legumes were planted in between furrows of yellow corn, two (2) weeks after planting the yellow corns.

Thinning was done after 15 – 30 days of sowing. Thinning cannot be done at once since the uniformity of seed germination is not synchronous. Only one (1) vigorous plant was remained per hill to avoid overcrowding and competition for sunlight, water, and soil nutrients.

Inter-row Cultivation

Weeds persisted and were visible from the 15th to the 20th day after planting. Weeding was done manually to avoid disturbing the soil and plants, twice in every week during the vegetative stage of yellow corn. Minimal weeding activities started during the reproductive phase up to physiological maturity stage. Chemical sprays such as herbicide was intentionally avoided to ensure the success of our bacterial inoculation and prevent any nutrients.

Water Management

Supplemental irrigation was given to the yellow corn for the whole duration of the experiment. During the vegetative phase, the plants were irrigated manually through an overhead irrigation with sufficient amount of water twice a week either in morning and afternoon, just enough to moisten them. More water was given during the reproductive stage to ensure successful flowering, silk synchronization, pollination, and ear development. This was said to be the most critical stage for water management. Although the peak demand for water is during the pollination stage, significant moisture and amount of water is still needed up to the maturity stage. The irrigation was continued up to the last stage of corn development to attain maximum or optimum grain filling and prevent significant losses.

The water was supplied from the fish pond through using a low-head, high discharged non-submersible water pump. The pump can fill the 200L water barrel just in one minute. Water barrels were also used for water storage, particularly during the vegetative stage to allow overhead manual irrigation, avoiding soil erosion and nutrient leeching.

Nutrient Management

After 30 days of planting, each plot was top dressed fertilized as based on its recommended amount of fertilizer in Nitrogen, Phosphorus, and Potassium. The recommended amount was determined from the soil analysis results. As per the results, all unit areas have the same levels of Phosphorus and Potassium, and only differed in Nitrogen. Each yellow corn plant in all unit areas were given 2g of Phosphorus and 3g of Potassium. For the unit areas that resulted to Low Nitrogen Level, 13 grams of Nitrogen per plant were given, and for areas with Medium Nitrogen Levels, 9.26 grams of N were given. Urea (46-0-0) and Complete (14-14-14) fertilizer were used.

At the 50th day after planting, in preparation for the reproductive stage, high concentration of Potassium foliar fertilizer was given to corn plants. The duo of Heavy Weight Tandem and Power Grower Combo with 11% and 14% grade of Potassium were applied, as this induces flowering and tasseling stages of yellow corn. At the same time this regulates water usage and enhances plants' stress tolerance. This was observed to be very effective since the corn started to tassel a day or two after the spraying.

Crop Protection

This study has employed culturally Integrated Pest Management – biological, cultural, mechanical, and chemical means. Constant monitoring was also done 3-4 times a week to observe pest infestation and behaviors. For the biological pest control management, flowers were planted to attract natural enemies and provide ecological balance. Different varieties of flowers (cosmos and different varieties of zinnia) were planted surrounding the whole experiment area including its front and entrance, and other walk ways that are near the area.

For the cultural method, trap crops were planted near the area before the experiment has started. The following trap crops are sweet potato or *kamote* and watermelon. The sweet potato was successfully established, allowing its leaves as food for pests, breeding area, and their habitat.

For the first two (2) months, there were no visible signs of pest infestation; however, as the trap crops and surrounding untouched area were grass cut, army worm infestations have started. To control the pests, as they nearly infested the plant corns or reached the Economic Injury Level and Economic Threshold Infestation, chemical control was opted for. Karate was sprayed twice with two (2) weeks interval. But upon inspection and observation, this does not affect army worms. The best way to eliminate army worm larvae is to hand pick and crush them. The best time to pick the larvae is during the cooler parts of the day. The army worm's larvae are more visible inside the leaf whorl during early morning and late afternoon. Moreover, the best time to spray for the mother moth of army worm is in the evening or at night, as this is when they are most active in flying on the corn's leaf surfaces to lay eggs.

<u>Harvesting and Postharvest Operations</u>

Yellow corn ears were harvested on their full maturation stage – in which all leaves and stalks have turned brown and dry. The ears were carefully handpicked to avoid any damages. The harvested produce for each plot was also placed in different sacks and properly labeled to avoid swapping.

The legumes were not harvested on the same day since they were planted two (2) weeks after the corn. But upon harvesting, only its pods were taken, except for the peanut. The legumes' plants (leaves and stems) were left in the experimental area to fully enrich the soil.

After harvesting, we immediately de-husked the yellow corn to have it slowly dry for at least around 18-20% moisture content. Since the study needs to get the fresh weight of the corn with and without the ear, the corns were not sun dried.

The storage area plays an important role in preserving the harvest. Proper sanitation was observed to prevent fungi, insect pests, rodents, and birds from attacking the crops. Corns were kept in arable sacks and placed at least 1 foot above the ground to keep the air circulating and prevent mold growth. The sacks were also kept open.

A. Sample Collection for Protein Content Analysis

For the crude protein analysis, the corn must be processed into a very fine powder. After harvesting, three (3) samples of corn per treatment and replication were shelled. The kernels were labeled according to its treatment (T1, T2, T3, T4). The kernels were oven dried for two (2) days in 100 °C to attain its powdered form. After drying, the kernels were finely blended through a food processor. The powder is good when it gives a sweet corn aroma and a lemon-yellow color.

Each corn sample weighed 100 grams as per instruction, was placed in a transparent zip bags, and labeled with the full description of each treatment (eg. T2, Corn + Soybean). The samples were submitted to the Department of Science and Technology (DOST) Region X, located in Cagayan De Oro City. The samples were processed in four (4) trials to eliminate biases through using the Automated Kjeldahl Method, 21^{st} Edition.

Data to be Gathered

Agronomic Parameters

1. *Plant Height (cm)* - Plant height was measured by using a measuring tape starting from the base of the plant up to the tip of the flag. The data were collected in three different times: 30 DAP, 45 DAP, and 90 DAP. Only thirty (30) samples per plot (treatment and replication) will be measured, a total of 120 samples per treatment.
2. *Leaf Length (cm)* - The tip of the leaf was measured straight to the base of the lowest leaflets where they meet the leaf stem.
3. *Leaf Width (cm)* - The longest distance between two (2) points on the edge leaf blade was taken perpendicular to the leaf's length axis.

Yield Parameters

1. *Number of Ears Per Plot* - This was done by counting the number of ears harvested in each plot.
2. *Total Ear Weight Per Plot (Kg)* - Total ear weight per plot was taken by weighing all the harvested ears in every plot.
3. *Weight Per Ear (Kg)* - Thirty (30) random samples of ears per plot were collected and weighed in kilograms.
4. *Ear Diameter (cm)* - It was measured from thirty (30) randomly selected ears per plot using a tape measure.
5. *Ear Length (cm)* - It was obtained from the same samples used. A tape measure was used in measuring the base of the ear up to the space covered by kernels.
6. *Kernels Weight (grams)* - The 30 corn ear samples were shelled and weighed the kernels without the ear cob.
7. *Kernels Weight Per Treatment* - All the shelled kernels were weighed together after getting all the parameters needed for each plot.

Nitrogen Content

1. Soil samples were collected before planting and after harvest to determine the nitrogen status of the experimental area.

Crude Protein

1. Corn grain samples from each treatment were collected after harvest and subjected to laboratory analysis to determine crude protein content.

RESULTS AND DISCUSSION

Agronomic and Yield Parameters

During the first 90 days of planting yellow corn, its agronomic parameters were measured to allow close, and accurate monitoring for crop development, identifying stress (nutrient deficiencies, water stress, pest infestation), which can significantly help reduce or increase total yield. The agronomic parameters included: (a) plant height, (b) leaf width, and (c) leaf length. The data was measured three (3) times, starting from the onset of its 30th day after planting the corn, 45 DAP, and 90 DAP. These three phases covered growth and development performances of the yellow corn during on its vegetative stage, reproductive stage, and physical maturity.

Table 1. Agronomic parameters of yellow corn intercropped with different legumes inoculated with *Bradyrhizobium* bacteria.

TREATMENTS	PH 30 DAP	LW 30 DAP	LL 30 DAP	PH 45 DAP	LW 45 DAP	LL 45 DAP	PH 90 DAP	LW 90 DAP	LL 90 DAP
T1	51.87 ±1.78	33.92 ±4.20	6.96 ±0.35	126.46 ±19.16	76.89 ±5.29	9.70 ±0.69	187.96 ±3.95	88.07 ±3.41	9.00 ±0.52
T2	50.72 ±4.21	46.86 ±6.13	7.03 ±0.31	135.83 ±12.64	78.83 ±3.08	9.76 ±0.35	192.29 ±7.83	88.60 ±2.04	9.20 ±0.16
T3	69.81 ±6.41	49.50 ±1.98	7.34 ±0.10	173.55 ±6.88	89.51 ±0.95	10.29 ±0.16	209.06 ±8.67	93.42 ±1.27	9.94 ±0.17
T4	52.22 ±3.63	48.15 ±2.61	7.13 ±0.19	155.09 ±4.90	85.60 ±1.91	10.25 ±0.25	198.76 ±4.07	90.38 ±0.74	9.94 ±0.32
p-value	**.000*****	**0.001*****	**.241^{ns}**	**.001*****	**.001*****	**.210^{ns}**	**.005***	**.028^{ns}**	**.010***

^{a,b,c,d} Means within a column different superscripts differ significantly. P-value of treatment effects to corn's growth parameters at 30, 45, and 90 DAP (***p<0.000; ***p<0.001; *p<0.005; *p<0.10; NS: Not Significant). Values presented as mean ± standard deviation. PH = Plant Height; LW = Leaf Weight; LL = Leaf Length; DAP = Days After Planting; T1 = corn + corn; T2 = corn + *Glycine max* + *Bradyrhizobium japonicum*; T3 = corn + *Arachis hypogaea* + *Bradyrhizobium elkaniiake*; T4 = corn + *Vigna radiate* + *Bradyrhizobium*.

Table 1 presents the overall agronomic parameters of yellow corn from 30 DAP to 90 DAP in four treatments. The treatments labeled with number are as follows: T1 (corn + corn); T2 (corn + *Glycine max* + *Bradyrhizobium japonicum* inoculant); T3 (yellow corn + *Arachis hypogaea* + *Bradyrhizobium elkaniiake* inoculant); and T4 (yellow corn + *Vigna radiate* + *Bradyrhizobium* inoculant).

Plant Height (30 DAP)

Plant height is highest in T3 (*corn + peanut)* during the 30 days after planting. It is statistically higher than other treatments, with a mean of 69.81 cm and a p-value of .000 (*p<0.000*), in which is considered highly significant. The extremely small p-value and small differences in the data showed consistent variations among treatments. On the contrary, T2 (*corn + soybean)* showed to have produced the shortest yellow corn plants (M=50.72).

Leaf width, T3 produced the widest leaves (yellow corn + *Arachis hypogaea* + *Bradyrhizobium elkaniiake* inoculant) with a mean of 49.50 cm, while T1 had the narrowest leaves (M=33.92 cm). The data were highly significant with a p-value of 0.001, indicating that the treatments were effective in influencing leaf development during the yellow corn's vegetative stage.

Leaf length data at 30 DAP showed that T3 (yellow corn + *Arachis hypogaea* + *Bradyrhizobium elkaniiake* inoculant) produced the highest leaf length (M=7.34cm), while T1 as the lowest (6.96 cm). The data were not statistically significant (*p* = *.241*). This means that the treatments produced similar leaf lengths, thus, assuming that leaf length may have responded slower than other parameters, given the other data.

Overall, at 30 DAP, T3 produced the highest plant height, leaf width, and leaf length (M=69.81 cm; M=49.50 cm; M=7.34 cm), showing that intercropping inoculated peanut with corn is highly effective during the early stages of corn development. Also, peanut was said to be a heavy feeder of Nitrogen only at later stage of the vegetative phase, in which happens on the 5^{th}-7^{th} week of its growth (Ding et al., 2022). T2, produced the lowest plant height with a mean of 50.72 cm but is not the lowest on leaf width (M=46.86 cm). Corn plant height is determined primarily by genetics, but is also influenced by its environment. With the case of T2, scientists call this as a "short-stature corn", which is an evolutionary adaptation or "survival instinct" to its growth to maximize its survival in unfavorable conditions (Quinn & Olivia, 2024). Others also called this as a "trade-off": to compensate its slow growth, wider leaves are produced to increase photosynthetic activity and reduce water stress or loss, and be able to catch up on later stages (Basic Biology, 2020).

Moreover, T1, as indicated by the data, has the lowest means for leaf width and leaf length (M=33.92cm; M=6.96cm), but is third in plant height among all the treatments (M=51.87cm) – this suggests a corn plant with a long but thin or unhealthy structure. This is the structure of a nutrient-deficient plant, given the absence of its nutrient competitors (no legumes intercropped).

45 DAP

The data indicated significant differences among all treatments at the 45th day after corn planting, as indicated by a highly significant p-value of 0.001 ($p<0.001$). In general, the treatments were effective in promoting plant growth. Also, the results in plant height are consistent with the previous data. T3 still has the highest corn plants (M=173.55 cm), while T1 is still the lowest (M=126.46cm).

Leaf width is also consistent, with treatment T3 the widest leaves (M=85.60 cm), while treatment 1 producing the narrowest leaves (76.89cm), with a p-value of 0.001, or as referred as statistically highly significant. This showed that treatments had significant effects on the leaf development of corn.

The same consistency was also observed in measuring the leaf length during its 45th day after planting. T3 remained consistent from 30 DAP onward, with a 2.95 cm increase (M=10.29 cm). T1, also, remained to have the shortest leaf length (M=9.70 cm). The results, however, were not statistically significant as indicated by their p-value of .210 ($p=2.10$), showing that the treatments have not played a role on the leaf length's differences.

Overall, the same conclusion is still applies: T3 as the highest across all growth parameters, and T1 as the lowest.

90 DAP

T3 still took off at 90 DAP with the highest plant height mean of 209.06 cm, followed by treatments 4 and 2 (M=198.76 cm; M=192.29 cm). The lowest plant height was observed in Treatment 1 with a mean of 187.96 cm. The findings suggest that the treatments still significantly affect the corn's plant height at 90 DAP (p-value = .005).

T3 had the widest leaves (M=93.42cm) at 90 DAP, while T1 consistently produced the narrowest leaves (M=88.07 cm). The p-value of 0.028 showed a significant difference among treatments. Leaf length, moreover, also displayed a highly statistically significant result with a p-value of .010. Treatments 3 and 4 had the highest mean of 9.94 cm, while T1 still remained as the shortest among all the treatments (M=9.00 cm).

Overall, compared with the data from the 30 DAP and 45 DAP, T3 produced the tallest corn plants during the 90 DAP. T3 also produced the widest leaves and longest leaf length. T1, on the other hand, remained to be the least vigorous plant in terms of height, leaf width, and leaf length. However, upon observing the data, the corn plants' growth and development have increased steadily from 90 DAP onward. Their differences are closer than the other treatments, this is also due to the huge significant gaps of plant growth in between the 30 DAP and 45 DAP. The plants were supplemented with synthetic fertilizers that is rich in Nitrogen, Phosphorus, and Potassium. Moreover, their almost uniform growth on the later stage also proves that Nitrogen fixation happens on the later stage of vegetative growth in which happens in between 5th to 7th week, and is also the start or onset of the first week of reproductive stage.

Measuring corn yield performance is critical for making data-driven decisions to evaluate the specific performance of a yellow corn variety. This also helps farmers tailor fertilizer grades and amounts, optimize irrigation to maximize water uptake, and avoid over-application of fertilizer, synthetic chemicals, and water. Thus, it reduces environmental impacts and provides an ecological balance.

Table 2. Yield parameters of yellow corn intercropped with legumes inoculated with different strains of *Bradyrhizobium* bacteria.

TREAT MENTS	ME %	UME %	EL cm	ED cm	EW g	# KPE	KWPE g	TKW g	TEW g
T_1	78.75 ±5.38	21.25 ±5.38	19.58 ±0.27	3.94 ±0.04	232.33 ±8.10	451.83 ±9.19	10.63 ±1.26	175.18 ±7.44	14.79 ±1.84
T_2	73.25 ±8.58	26.75 ±8.58	19.86 ±0.46	3.96 ±0.10	226.33 ±16.36	440.81 ±6.15	10.24 ±1.03	164.74 ±7.62	14.95 ±1.98
T_3	68.25±6 .41	31.75±7 .32	20.02±0 .30	3.91±0 .41	240.08±1 3.46	469.55± 7.66	11.35±1 .09	172.86 ±6.91	16.13 ±1.52
T_4	68.50 ±14.27	31.50 ±14.27	19.62 ±0.93	3.78 ±0.10	229.30 ±21.79	449.31 ±8.75	9.88 ±0.65	163.88 ±11.63	14.89 ±1.16
p-value	**.392^{ns}**	**.392^{ns}**	**.658^{ns}**	**.687^{ns}**	**.649^{ns}**	**.002****	**.210^{ns}**	**.641^{ns}**	**.210^{ns}**

[a,b,c,d] Means within a column different superscripts differ significantly. P-value of treatments effects to corn's yield parameters (**p<0.002; NS: Not Significant). Values presented as mean ± standard deviation. ME = Marketable Ears; UME = Unmarketable Ears; EL = Ear Length; ED = Ear Diameter; EW = Ear Weight; KPE = Kernels Per Ear; KWPE = Kernels' Weight Per Ear; TKW = Total Kernel Weight; TEW = Total Ear Weight; T1 = corn + corn; T2 = corn + *Glycine max* + *Bradyrhizobium japonicum*; T3 = corn + *Arachis hypogaea* + *Bradyrhizobium elkaniiake*; T4 = corn + *Vigna radiate* + *Bradyrhizobium*.

Table 2.0 presented the yield performance of yellow corn in terms of: (a) percentage of marketable and unmarketable ears, (b) ear length, (c) ear diameter, (d) ear weight, (e) number of kernels per ear, (f) kernels weight per ear, (g) total kernels weight, and (h) total ear weight. The same treatments will be put in comparison.

The percentage of marketable ears did not differ significantly among all treatments with a p-value of 0.392 (*p=0.392*). Although T1 had the highest marketable ears of (M=78.75%), and T3 as the lowest (M=68.25%), the data were still statistically similar to other treatments. Thus, the treatments had no significant effect or has nothing to do with the number of marketable ears being available per treatments.

This, moreover, is influenced by the outside environmental or physical factors. T1, yellow corn not being intercropped with any legume, had no other competition in terms of space, air, sunlight, and nutrients – allowing it to grow ears in optimum environmental conditions. While T4 or mung bean grows higher and wider, it can physically interfere with the corn's stalks and space. In this sense, T1 had the highest marketable ears because its space was not physically compromised by any legume's presence. T4, on the other hand, is more abundant in leaves and has a wider canopy, promoting poor air circulation below the corn's canopy, inviting more pests, and could also function as a trap crop, and is more competitive in nutrient uptake. Thus. This also supports the rationale for why T3 has the highest unmarketable ears (M=31.75 %), and T1 has the least damaged ears (M=21.25%). Both are statistically non-significant, having the same p-value (p=.392).

Ear length is highest in Treatment 3 (*corn + peanut*) with a mean of 20.02 cm, followed by T2 (M=19.86 cm), and both T3 and T1 have the shortest ear length (M=19.62; M=19.58 cm). Also, ear length did not vary significantly among other treatments with a p-value of 0.658. The same case with the ear diameter, where T2 produced the widest ear corn with a mean width of 3.96 cm, and placing T4 narrowest ear (M=3.78 cm). This also is statistically non-significant (*p=.687*) since all values were comparable to all treatments.

Ear weight showed non-significant effects among all treatments applied as indicated by its p-value of .649 (p=.649). T3, however, has produced the heaviest ear weight, with a mean of 240.08 g, followed closely by T1 (232.33 g), T4 (229.30 g), and T2 (226.33 g). Although their differences were only minimal, they were still not significant. This suggests that the treatments provided in intercropping corn may have similar growing conditions, nutrient uptake, and other resource availability, resulting in almost the same ear development, particularly in weight or biomass accumulation. Also, the uniformity of ear weight indicates that the crop of a specific variety has already reached its varietal genetic potential for ear development, regardless of the treatments applied. In addition, the treatments applied may have been effective, as they encouraged optimal ear corn development in terms of environmental, nutrient, and water requirements, making it more difficult to identify any variation.

Furthermore, environmental conditions as to soil health in moisture and fertility, sunlight exposure, air circulation, cultural crop management and practices may have more contributed that minimizes the visibility of the treatment effects in relation to ear weight.

The number of kernels per ear showed to be statistically highly significant (*p=0.002*). T1, surprisingly produced the highest number of kernels per ear with a mean of 451.83 grams, while T4 and T2 are comparatively lower (M=449.31; M=440.81). These variations suggest that the treatments caused a significant effect on the kernel and grain development and formation. This, moreover, since T1 is only monocropped to corn, and was given the same amount of fertilizer applied in top dressed and foliar – have proved that no competitors for nutrient uptake is favorable for kernel development. As based on the study in relation to the response of corn yield to nitrogen application rates, the higher availability of nitrogen in the soil, particularly during the early stages can lead to a higher number of kernels per ear (Bao et al., 2025). Nitrogen is critical for determining the size of kernel and in reducing kernel abortion. Further, V8 growth stage, Nitrogen and Phosphorus is also crucial in the formation of kernel rows and pollination efficiency. Basically, deficiency of any of these macro-nutrient limits the potential of kernel row numbers (Yara, 2026).

On the contrary, since treatments 2,3, and 4 were intercropped with legumes, its number of kernels were affected, given that legumes are also heavy feeders of Nitrogen, thus, encouraging more nutrient competition between the corn plant and legumes of different kinds. The results further implied that the treatment applications on unit areas have significantly affected the number of kernels in every ear, being a major determinant of the corns' overall crop yield.

T3 had the highest mean of kernel weight per ear of 11.35 g, followed by T1 with only a 0.72 g difference (M=10.63 g). T4, however, weighed the least with a mean of 9.88 g. As indicated by their p-value of 0.210, the total kernel weight was not significantly influenced by the varying treatments applied. Although only very slight or minimal differences were observed these variations are not statistically significant. Further, kernel weight is determined by the plant's capacity to synthesize and allocate photosynthates or carbon assimilates during the rapid grain-filling stage. But this process is highly dependent on and sensitive to environmental factors (bioRxiv,2021). This assumes that the environment and resource availability in terms of water, nutrients, shade, air circulation, and sunlight are of the same conditions. Basically, the absence of significant differences that none of the treatments have failed to provide a clear advantage in increasing kernel weight or biomass production. Despite T3 (corn + peanut) displaying a slightly higher value, its increase or statistical gap isn't enough to determine a significant effect.

The total ear weight is also not statistically significant among other treatments with its p-value of 0.210. T3 produced the heaviest total ear weight of 16.13 Kg, while T1 weighed the least of 14.79 Kg. Although, its variation from other treatments resulted as non-significant, however, it's relationship from the total kernels weight are of the same or is consistent. T3 had the highest total yield, while T1 having the lowest yield that totaled to only 14.79 kg of corn.

To summarize all the measured yield parameters, the treatments showed mixed results, with significant effects observed in some parameters but mostly remaining statistically similar, resulting in no significance. This, including the size of the corn ear, does not equate to the number of kernels being produced. As presented in Table 2.0, T2 had the widest ear diameter (M=3.96 cm) but did not have the highest number of kernels produced (M=440.81).

Crude Protein

The main objective of this study is to identify whether the presence of legumes through intercropping them with corn can significantly increase the corn's crude protein, and whether the amount of Soil-N in soil can also directly affect the amount of crude protein in corn grains. Table 3.0 showed the crude protein of powdered corn kernels and the Soil-N before and after planting.

Table 3. Crude Protein and Soil-N content before and after planting; Nitrogen difference after planting

TREATMENTS	CP %	N-BP %	N-AP %	ND %
T_1	9.67±0.11	123.75±22.50	90.00±0.00	33.75
T_2	8.47±0.08	112.50±25.98	90.00±0.00	22.50
T_3	7.93±7.93	135.00±0.00	90.00±0.00	45.00
T_4	7.82±0.21	112.50±25.98	90.00±0.00	22.50
p-value	**.392**^{ns}	**.392**^{ns}	**.658**^{ns}	

^{a,b,c,d} Means within a column with different superscripts differ significantly. P-value of treatment effects on corn's crude protein and Soil-N content after planting (NS: Not Significant). Values presented as mean ± standard deviation. CP = Crude Protein; N-BP = Nitrogen – Before Planting; N-AP = Nitrogen – After Planting; ND = Nitrogen Difference; T1 = corn + corn; T2 = corn + *Glycine max* + *Bradyrhizobium japonicum*; T3 = corn + *Arachis hypogaea* + *Bradyrhizobium elkaniiake*; T4 = corn + *Vigna radiate* + *Bradyrhizobium*.

Crude protein content was highly significant across all treatments (p=0.000). Treatment 1 had the highest CP of 9.6675%, higher than that of intercropping with legumes for nitrogen fixation alone. This followed by T2 (corn + soybean) with a CP of 8.4725%, T4 (corn + mung bean) of 7.9275., and T3 (corn + peanut) of 7.8225%.

Although T1 had the second-lowest nitrogen before planting, as indicated by a high N requirement of about 123.75%, it still produced high-yielding corn with high crude protein content. As observed in the Nitrogen after planting, all Nitrogen levels have leveled out due to the appropriate amount of fertilizer and nutrients being applied to all unit areas, as recommended by the soil analysis data. Moreover, as supposed, the presence of legumes was expected to produce a higher amount of crude protein. But T1, the only treatment with no legumes, has surpassed the other treatments.

However, as the Soil-Nitrogen differences from before and after planting was analyzed, T3, in fact produced the highest Nitrogen during the whole planting season, given it was the most deficient in Nitrogen or about 135%. T3's Soil-N had significantly increased by 45%, higher than T1 of 33%. This, moreover, proves that legumes can increase more nitrogen in the soil as compared to monocropped fields. Moreover, this also proved T3's optimum results in terms of its growth and yield parameters, for consistently leading all other treatments. Although intercropping yellow corn did not increase its crude protein content compared to T1, it did increase Soil-N, which can benefit the next cropping season. Given the nature of organic agriculture, the next cropping season can acquire most of the nutrients. Since T1 had all the synthetic fertilized Nitrogen to itself and was free from competition, it produced corn ears with the highest crude protein content. As reported in other studies, the crude protein content does not depend solely on the amount of Nitrogen present in the soil; spacing, soil moisture, and overall environmental conditions are also major factors that were compromised in T3 due to the presence of peanut.

While it is true that legumes are best intercropped with corn given its ability to produce its own nitrogen due to its nitrogen fixing nature, competition occurs when legumes are overly aggressive in its growth. This is the case in this study, since the legumes were planted in between furrows of corn, allowing them to only utilize the 70 cm planting distance. Basically, the legumes were only compensated of the available space provided for them, rather than planting them accordingly to the recommended space of planting distance that they needed. Instead of the corn as the main and heavy feeder of Soil-N and the legume to only rely for the atmospheric nitrogen for its own consumption, the corn and legumes have competed for water, sunlight, and other macro-nutrients including Nitrogen. As the legumes continued to grow, this also affected the corn's ability to breathe, regulate its soil moisture underneath, its capacity to expand, and be protected from pests.

Moreover, research has proven that in low-nitrogen soils, the competition between corn and legumes is highest (Salgado et al., 2021). Although the legumes can replenish the nitrogen consumed, but this will mostly happen on later stage and after harvesting. With the case of T1 (*corn + corn*), the corn has fully assimilated all the nutrients all for its own, while the other treatments have competed against each other. It's important to note that the higher availability of nitrogen increases the availability of crude protein in corn grain since Nitrogen is the foundational component of amino acids that helps in building blocks of protein (Nieweglowski et al.,2024). By the aid of supplemental fertilization, after the 30th DAP and 50th DAP, all nutrients were provided based on its deficiency, allowing their nutrients to level even up to after harvesting. As indicated in Table 3.0, the Nitrogen levels' high deficiency have reduced to 90%, meaning, that the soil nitrogen has improved from low to medium level.

Further, as reported from the study of HAL Open Science, that legumes planted one (1) meter away from corn can still affect the Nitrogen (N) availability of corn. It also emphasized that at a distance, the legumes can focus on fixing nitrogen with less competition. Although some nitrogen is only stored in the plant, but mycorrhizal networks, a specialized fungus has the ability to connect to the root system of different species, allowing the fixed nitrogen by the legumes to be transported to nearby corn (Liu et al., 2022). By these findings, this can also be applied with the T1's highest crude protein content (9.6675%).

Table 4. Phosphorus and Potassium Levels Before and After Planting

TREATMENTS	**P-BP %**	**K-BP %**	**P-AP %**	**K-AP %**
T_1	20.00	30.00	20.00	30.00
T_2	20.00	30.00	20.00	30.00
T_3	20.00	30.00	20.00	30.00
T_4	20.00	30.00	20.00	30.00
p-value	-	-	-	

[a,b,c,d] Means within a column different superscripts differ significantly. P-value of treatment effects to corn's yield parameters (-: Cannot be quantified). Values presented as mean ± standard deviation. P-BP = Phosphorus – Before Planting; K-BP = Potassium – Before Planting; P-AP = Phosphorus – After Planting; K-Ap = Potassium – After Planting; T_1 = corn + corn; T_2 = corn + *Glycine max* + *Bradyrhizobium japonicum*; T_3 = corn + *Arachis hypogaea* + *Bradyrhizobium elkaniiake*; T_4 = corn + *Vigna radiate* + *Bradyrhizobium*.

Table 4.0 is a continuation to Table 3.0. As presented in the table, the available Phosphorus and Potassium in the experimental area are of the same level. It's p-value cannot be quantified as it is impossible to identify due to its similar values. But given the data, this supports the results in crude protein, since all unit areas has the same amount of P and K (20.00; 30.00), and were also supplemented evenly, resulting to no changes.

Basically, those differences in results were mostly based on the available Soil-Nitrogen levels.

CONCLUSION AND RECOMMENDATIONS

The yellow corn's crude protein content was highest in monocropped yellow corn (9.67%), but Soybean produced the highest crude protein of 8.47% than peanut (7.82%), and mung bean (7.93%). Moreover, T3 (yellow corn + peanut) produced the highest Nitrogen level by 45%, thus, legumes can significantly increase Nitrogen levels in the soil.

Based on the following conclusion, the following recommendations are drawn:

1. That the National Crop Research Center in Agriculture shall conduct experimental studies on the intensified intercropping systems of yellow corn and legumes in at least 2 or 4 cropping seasons in the contexts of: crude protein, soil-nitrogen, correct planting distance, and optimum environmental conditions.
2. That the National Crop Protection Center shall create user friendly brochures and manuals in reference from the Crop Research Center's data, emphasizing the different crop protection methods in providing yellow corn a pest-free environment. Moreover, stressing more on the benefits of biological control.
3. That the Bureau of Soil and Water Management shall provide the yellow corn farmers free soil sampling and soil analysis to reach optimum yield, reduce synthetic fertile soil-residues, and preserves soil microbiota ecology. The BSWM shall also conduct free seminars and give out free soil test kits, encouraging the farmers to farm sustainably.
4. That the Misamis University – College of Agriculture and Forestry shall encourage their students to conduct researches that can provide organic and sustainable farming practices – incorporating six (6) branches of agriculture (soil

science, crop science, animal science, economics, extension, and crop protection).

5. That the future researchers shall serve this as their basis in research gap, diving deeper to the crude protein of corn be it through intercropping or other cropping systems such as crop rotation.

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Appendix A

ANOVA and Post HOC Test Data

ANOVA on GROWTH PERFORMANCE						
		Sum of Squares	df	Mean Square	F	Sig.
PlantHeight_30D	Between Groups	999.539	3	333.180	17.749	.000
	Within Groups	225.260	12	18.772		
	Total	1224.799	15			
LeafWidth_30D	Between Groups	623.200	3	207.733	12.618	.001
	Within Groups	197.557	12	16.463		
	Total	820.757	15			
LeafLength_30D	Between Groups	.318	3	.106	1.599	.241
	Within Groups	.796	12	.066		
	Total	1.115	15			
PlantHeight_45D	Between Groups	4570.520	3	1523.507	10.184	.001
	Within Groups	1795.236	12	149.603		
	Total	6365.757	15			
LeafWidth_45D	Between Groups	334.808	3	111.603	10.622	.001
	Within Groups	126.086	12	10.507		
	Total	460.894	15			
LeafLength_45D	Between Groups	.894	3	.298	1.753	.210
	Within Groups	2.040	12	.170		
	Total	2.934	15			
PlantHeight_90D	Between Groups	891.402	3	297.134	7.051	.005
	Within Groups	505.713	12	42.143		
	Total	1397.115	15			
LeafWidth_90D	Between Groups	57.766	3	19.255	4.285	.028
	Within Groups	53.923	12	4.494		
	Total	111.690	15			
LeafLength_90D	Between Groups	1.932	3	.644	5.969	.010
	Within Groups	1.295	12	.108		
	Total	3.227	15			

Table 5.0 ANOVA on Growth Performance

ANOVA on YIELD PERFORMANCE						
		Sum of Squares	df	Mean Square	F	Sig.
No.of.Marketable_Ears	Between Groups	293.188	3	97.729	1.087	.392
	Within Groups	1079.250	12	89.938		
	Total	1372.438	15			
No.of.NonMarketable_Ears	Between Groups	293.188	3	97.729	1.087	.392
	Within Groups	1079.250	12	89.938		
	Total	1372.438	15			
EarLength	Between Groups	.517	3	.172	.550	.658
	Within Groups	3.762	12	.314		
	Total	4.280	15			
EarDiameter	Between Groups	.072	3	.024	.503	.687
	Within Groups	.575	12	.048		
	Total	.647	15			
EarWeight	Between Groups	418.940	3	139.647	.565	.649
	Within Groups	2967.886	12	247.324		
	Total	3386.826	15			
No.of.Kernelsp_per_Ear	Between Groups	1750.372	3	583.457	9.064	.002
	Within Groups	772.448	12	64.371		
	Total	2522.820	15			
TotalKernelWEight	Between Groups	4.776	3	1.592	1.501	.264
	Within Groups	12.728	12	1.061		
	Total	17.503	15			
TotalEarWeight	Between Groups	4.741	3	1.580	.576	.641
	Within Groups	32.901	12	2.742		
	Total	37.643	15			
KernelsWeight per Ear	Between Groups	389.049	3	129.683	1.749	.210
	Within Groups	889.605	12	74.134		
	Total	1278.654	15			
	Between Groups	389.049	3	129.683	1.749	.210

Table 6.0 ANOVA on Yield Performance

Table 7.0 ANOVA on Crude Protein

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
NitrogenBefore	Between Groups	1392.188	3	464.063	1.000	.426
	Within Groups	5568.750	12	464.063		
	Total	6960.938	15			
PhosphorusBefore	Between Groups	.000	3	.000	.	.
	Within Groups	.000	12	.000		
	Total	.000	15			
PotassiumBefore	Between Groups	.000	3	.000	.	.
	Within Groups	.000	12	.000		
	Total	.000	15			
NitrogenAfter	Between Groups	.000	3	.000	.	.
	Within Groups	.000	12	.000		
	Total	.000	15			
PhosphorusAfter	Between Groups	.000	3	.000	.	.
	Within Groups	.000	12	.000		
	Total	.000	15			
PotassiumAfter	Between Groups	.000	3	.000	.	.
	Within Groups	.000	12	.000		
	Total	.000	15			
CrudeProtein	Between Groups	8.590	3	2.863	154.848	.000
	Within Groups	.222	12	.018		
	Total	8.812	15			

PlantHeight_30D

Tukey HSD[a]

Treatments	N	Subset for alpha = 0.05 1	2
Corn x Soybean	4	50.7175	
Corn x Corn (Control)	4	51.8650	
Corn x Mungbean	4	52.2150	
Corn x Peanut	4		69.8075
Sig.		.960	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 4.000.

Table 8.0 Tukey Post HOC Plant Height_30DAP

LeafWidth_30D

Tukey HSD[a]

Treatments	N	Subset for alpha = 0.05 1	2
Corn x Corn (Control)	4	33.9175	
Corn x Soybean	4		46.8575
Corn x Mungbean	4		48.1500
Corn x Peanut	4		49.4975
Sig.		1.000	.795

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 4.000.

Table 9.0 Tukey Post HOC Leaf Width_30DAP

PlantHeight_45D

Tukey HSD[a]

Treatments	N	Subset for alpha = 0.05 1	2	3
Corn x Corn (Control)	4	126.4575		
Corn x Soybean	4	147.0075	147.0075	
Corn x Mungbean	4		155.0925	155.0925
Corn x Peanut	4			173.5500
Sig.		.135	.787	.197

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 4.000.

Table 10.0 Tukey Post HOC Plant Height_45DAP

LeafWidth_45D

Tukey HSD[a]

Treatments	N	Subset for alpha = 0.05 1	2
Corn x Corn (Control)	4	76.8925	
Corn x Soybean	4	83.3750	83.3750
Corn x Mungbean	4		85.6000
Corn x Peanut	4		89.5075
Sig.		.064	.082

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 4.000.

Table 11.0 Tukey Post HOC Leaf Width_45DAP

PlantHeight_90D

Tukey HSD[a]

Treatments	N	Subset for alpha = 0.05	
		1	2
Corn x Corn (Control)	4	187.9600	
Corn x Mungbean	4	198.7575	198.7575
Corn x Soybean	4	199.1150	199.1150
Corn x Peanut	4		209.0600
Sig.		.124	.166

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 4.000.

Table 12.0 Tukey Post HOC Plant Height_90DAP

LeafWidth_90D

Tukey HSD[a]

Treatments	N	Subset for alpha = 0.05	
		1	2
Corn x Corn (Control)	4	88.0650	
Corn x Mungbean	4	90.3750	90.3750
Corn x Soybean	4	90.4275	90.4275
Corn x Peanut	4		93.4175
Sig.		.427	.231

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 4.000.

Table 13.0 Tukey Post HOC Plant Height_90DAP

LeafWidth_90D

Tukey HSD[a]

Treatments	N	Subset for alpha = 0.05	
		1	2
Corn x Corn (Control)	4	88.0650	
Corn x Mungbean	4	90.3750	90.3750
Corn x Soybean	4	90.4275	90.4275
Corn x Peanut	4		93.4175
Sig.		.427	.231

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 4.000.

Table 14.0 Tukey Post HOC Leaf Width_90DAP

No.of.Kernelsp_per_Ear

Tukey HSD[a]

Treatments	N	Subset for alpha = 0.05	
		1	2
Corn x Soybean	4	440.8075	
Corn x Mungbean	4	449.3075	
Corn x Corn (Control)	4	451.8250	
Corn x Peanut	4		469.5525
Sig.		.262	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 4.000.

Table 15.0 Tukey Post HOC No. of Kernels per Ear

Crude Protein

Tukey HSD[a]

Treatments	N	Subset for alpha = 0.05		
		1	2	3
Corn x Peanut	4	7.8225		
Corn x Mungbean	4	7.9275		
Corn x Soybean	4		8.4725	
Corn x Corn (Control)	4			9.6675
Sig.		.701	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 4.000.

Table 16.0 Tukey Post HOC
Crude Protein

Appendix B

Financial Statement

LABOR PRODUCTION COST					
ITEM	**UNIT OF MEASURE**	**QUANTITY**	**NUMBER OF DAYS**	**UNIT PRICE**	**AMOUNT**
Plowing	Man – Machine Hour	1	4 hours	P 200.00 / Hour	P 800.00
Outlining of Treatment Blocks	Man-Day	2	1 Day	P 450.00 / Day	P 900.00
Blocking and Canaling	Man-Day	2	10 Days	P 450.00 / Day	P 9,000.00
Setting Up Irrigation Pump Machine and Hose	Man-Machine Hour	3	3 Days	P 700.00 / Day (Skill) P 450.00 / Day (Labor)	P 4,800.00
Setting Up Irrigation Barrels	Man-Days	1	1 Day	P 450.00	P 450.00
Ridging and Weeding	Man-Day	2	7 Days	P 450.00 / Day	P 6,300.00
Planting (Corn)	Man-Day	3	1 Day	P 450.00 / Day	P 1,350.00
Planting (Soybean, Mung bean, Peanut)	Man-Day	2	1 Day	P 450.00 / Day	P 900.00
Irrigating (Flooding – before planting)	Man-Machine Hours	2	30 Minutes	P 150.00	P 300.00
Irrigating (Vegetative Stage)	Man-Machine Hours	2	32 Hours = (2 Hours in 4x/Week; as needed); (6Weeks)	P 150.00	P 7,200.00
Irrigating (Flooding - Tasseling Stage)	Man-Machine Hours	2	3 Hours = (30 minutes 2x/Week; as needed); (3Weeks)	P 150.00	P 1,800.00

Irrigating (Flooding – Silking to Reproductive Stage)	Man-Machine Hours	2	3 Hours = (30 minutes 2x/Week; as needed); (7Weeks)	P 150.00	P 1,800.00
Weeding	Man-Day	2	4 Hours / Day = (2x per week in 10 weeks)	P 250.00	P 10,000.00
Harvesting and Hauling	Man-Day	3	1 Day	P 500.00	P 1,500.00
Planting (Cosmos and Zinnia Flowers)	Man-Day	1	30 Days	P 500.00	P 15,000.00
TOTAL LABOR COST					**P 62,100.00**

Table 17.0 Labor Production Cost

FUEL AND EQUIPMENT COST				
ITEM	**UNIT OF MEASURE**	**QUANTITY**	**UNIT PRICE**	**AMOUNT**
Tractor Rent for Plowing	PCS	1	P 250.00 / Hour	P 1,000.00
Tractor Fuel	Liter	25	P 63.00 / Liter	P 1,575.00
Tractor Motor Oil	Liter	1	P 400.00 / Liter	P 400.00
Soil Auger Fuel	Liter	2	P 63.00 / Liter	P 126.00
Hauling Fuel during harvesting	Liters	2	P 63.00 / Liter	P 126.00
TOTAL LABOR COST				**P 3,227.00**

Table 18. Fuel and Equipment Cost

INPUT COST				
ITEM	**UNIT OF MEASURE**	**QUANTITY**	**UNIT PRICE**	**AMOUNT**
NK6414 Syngenta Corn Seeds with Shipping Fee	Kg	1	P 1,000.00 P 240.00	P 1,240.00
Mung Bean Seeds	Kg	1 ½	P 100.00	P 150.00

Peanut Seeds	Kg	2	P 120.00	P 240.00
Soybean Seeds	Kg	1	P 500.00	P 500.00
Nitro-Plus with Shipping Fee	Pack (100g)	6	P 60.00 P 240.00	P 600.00
14-14-14 Fertilizer	Kg	50	P 39.00	P 1,950.00
46-0-0 Fertilizer	Kg	50	P 34.00	P 1,700.00
Grow More and Heavy Weight Tandem Foliar Fertilizer	Kg	1	P 1,332.00	p 1,332.00
Karate Pesticide	Liter	1	P 1,200.00	P 1,200.00
Brodan Pesticide	Liter	1	P 550.00	P 550.00
Rattan String	Ply	1	P 180.00	P 180.00
Bamboo Culm	Pc	2	P 100.00	P 200.00
Plywood	Foot	½ (4ft x 8ft)	P 650.00	P 650.00
Tarpaulin	Sq. Foot	½ (4ft x 8ft)	P 9.50	P 304.00
Thumbtacks	Pack	2	P 15.00	P 30.00
Horizontal Centrifugal Water Pump	Pc	1	P 15,000.00	P 15,000.00
Submersible Discharge Duct Flat Hose 4" PVC Pump Hose 100mm	Meter	200	P 9,844.00	P19,688.00
Water Pump Power Switch	Pc	1	P 399.75	P 399.75
Electric Wire	Meter	10	P 46.00	460
200L Water Barrel	Pc	2	P 1,800.00	P 3,600.00
10L Lagadera	Pc	4	P 240.00	P 960.00
Plaschoop Shovel	Pc	1	P 450.00	P 450.00
Round Head Shovel	Pc	1	P 326.00	P 326.00
Manganese Steel Triangular Hoe	Pc	4	P 99.00	P 396.00
Manganese Steel Asarol	Pc	2	P 181.00	P 362.00
Manganese Steel 6th Teeth Weeder Hoe	Pc	2	P 135.00	P 270.00
Eco Bag	Pc	30	P 5.00	P 150.00
Small Digital Weighing Scale	Pc	1	P 141.00	P 141.00

Human Electronic Digital Weighing Scale	Pc	1	P 480.00	P 480.00
Solar LED Trapping Light	Pc	1	P 1,800.00	P 1,800.00
15Kg Kitchen Weighing Scale	Pc	1	P 1,162.00	P 1,162.00
TOTAL LABOR COST				**P 56,470.75**

Table 19. Input Cost

CRUDE PROTEIN ANALYSIS COST				
ITEM	**UNIT OF MEASURE**	**QUANTITY**	**UNIT PRICE**	**AMOUNT**
Crude Protein Analysis	Pc	4	P 1,000.00	P 4,000.00
Bus Fare (Ozamiz to CDO; CDO to Ozamiz)	-	2	P 650.00	P 1,300.00
TOTAL LABOR COST				**P 5,300.00**

Table 20. Crude Protein Analysis Cost

Appendix C

<u>Turnitin and Grammarly Results</u>

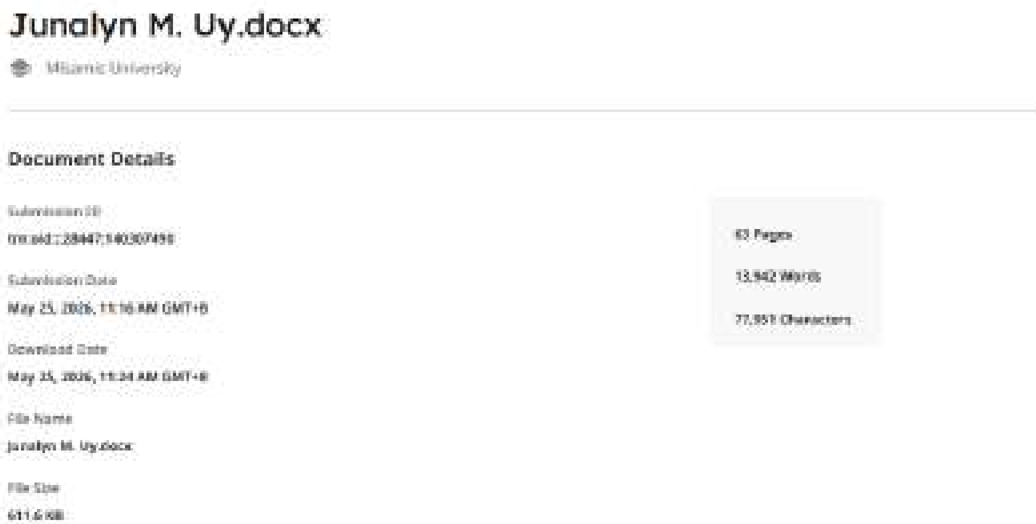

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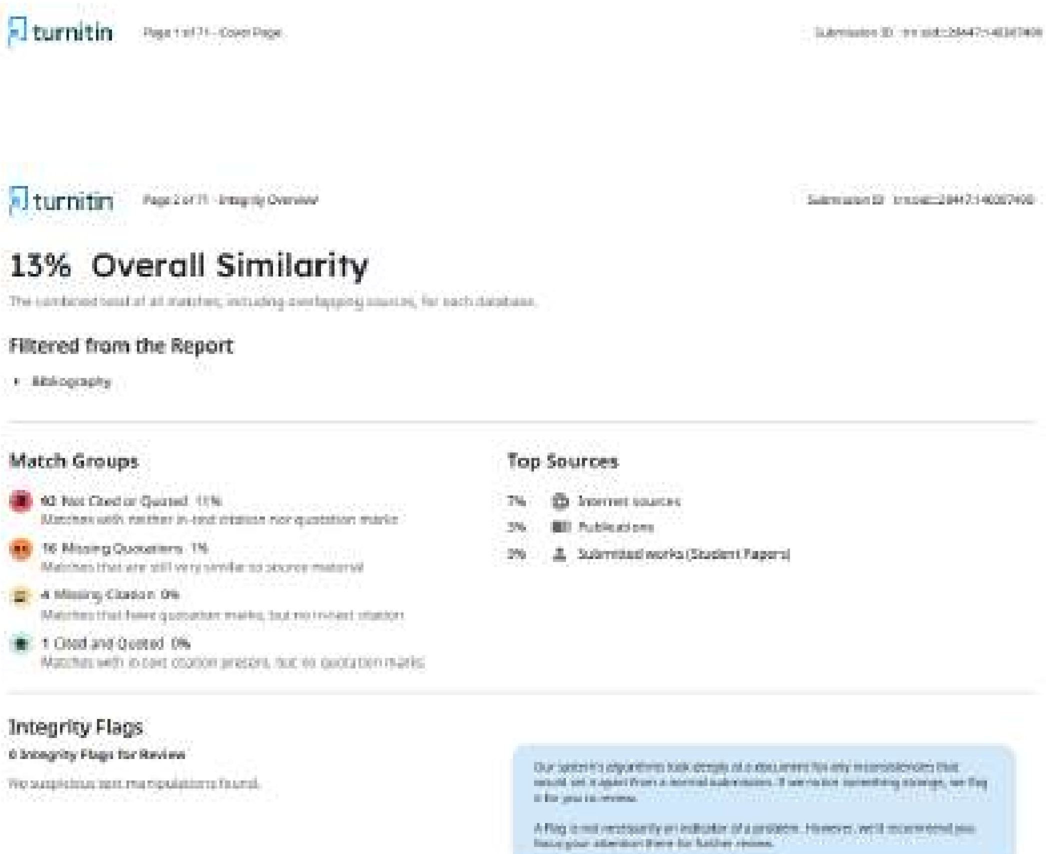
Figure 4. Turnitin Result



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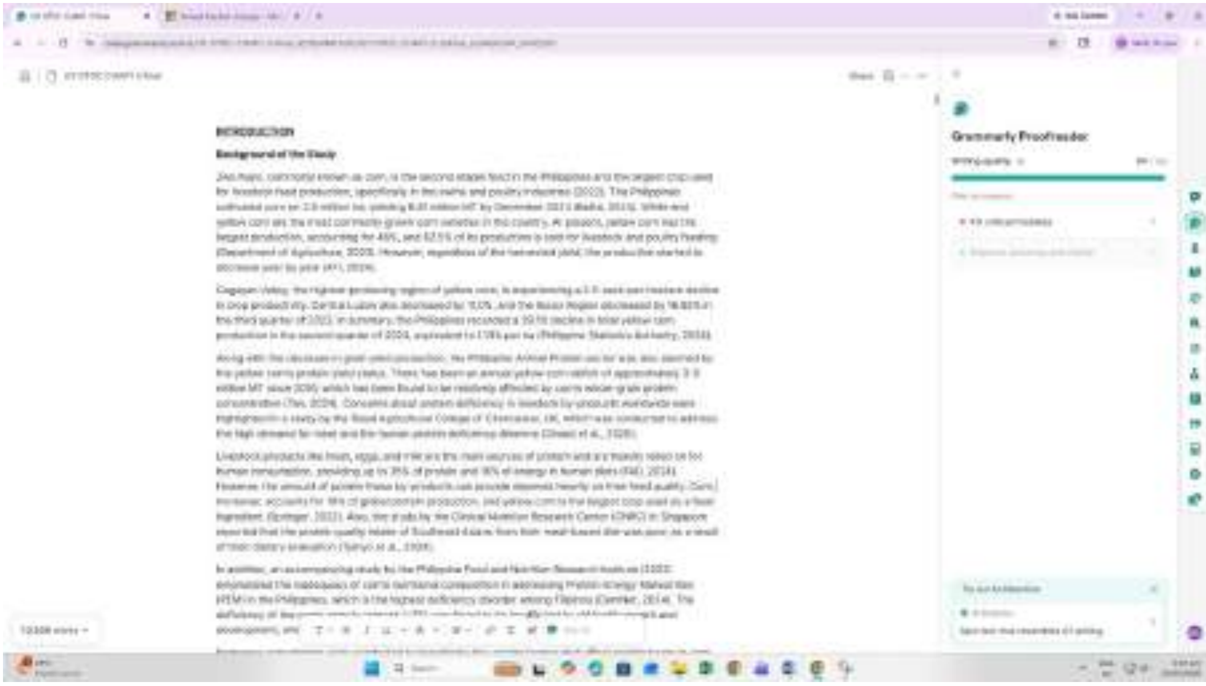

Figure 5. Grammarly Result

Appendix D

Land Preparation

Figure 6. Tractor-ploughing the field

Figure 7. Harrowing the field

Figure 8. Measuring the experimental area

Figure 9. Bordering the area

Figure 10. Canal-ing the whole area

Figure 11. Bordering the area

Figure 12. Canals

Figure 13. Leveling the plots before weeding and lay-outing the planting distance of corn furrows

Figure 14. Final Lay-out

Soil Sampling

Figure 15. Soil Sampling Collection

Figure 16. Digging soil using Soil Auger

Figure 17. Air-Drying Area

Figure 18. First trial of Air-Drying; Alternating 8 Samples per Batch

Figure 19. Second Trial and Final Air-Drying of Soil Samples in One Batch

Figure 20. Pulverizing Soil Samples or Powdering

Figure 21. Weighing Soil Sample (1Kg)

Soil Analysis

Figure 22. Soil Test Kit and Apparatus

Figure 23. Testing soil samples for NPK

Planting and Weeding Before Planting

Figure 24. Weeding and Planting Corn

Figure 25. DIY Tool for Marking Planting Distance

Figure 26. Planting Legumes Two Weeks After Planting Corn

Figure 27. Corn Intercropped with Legumes

<u>Legume Seeds Inoculation</u>

Figure 28. Inoculating Peanuts with Rhizobium Bacteria

Weeding

Figure 29. Weeding each unit area

Irrigating the Field

Figure 30. Source of Water Supply

Figure 31. 200 Meter Duct Hose

Figure 32. 200 L Water Drum for Storage

Figure 33. Flood Irrigation on Alleyways or Canals

<u>Plotting Treatments</u>

Figure 34. Plant Markers

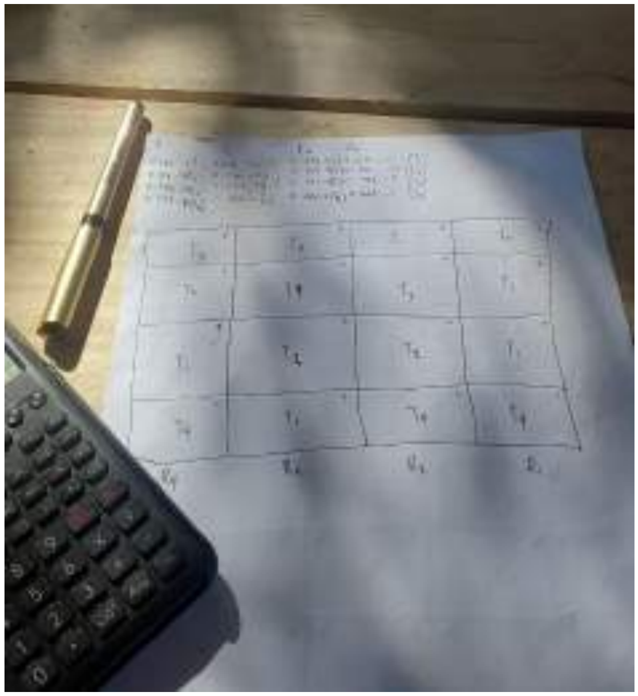

Figure 35. Plotting the treatments to specific unit areas

Crop Protection

Figure 36. Biological Control; Encouraging Natural Enemies

Figure 37. Chemical Control

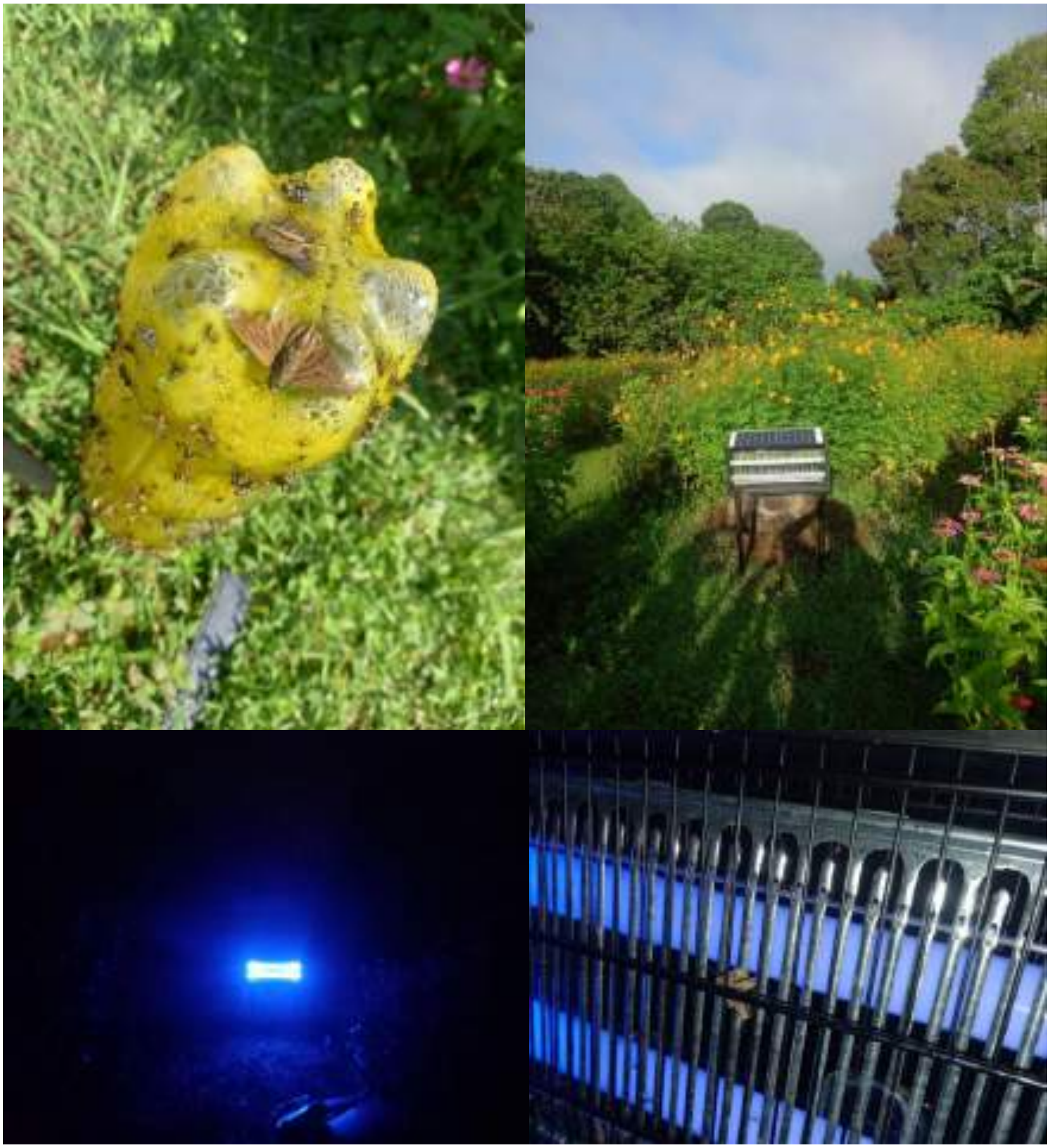

Figure 38. Pheromone Sticky Trap and UV Light Trapping

Data Collection

Figure 39. Agronomic Data Collection

Figure 40. Yield Data Collection

Experimental Plots

Figure 41. Corn Intercropped with Legumes

Figure 42. Experimental Area; Full Grown

Damage from Pests

Figure 43. Army worm being active at night

Figure 44. Damaged leaves caused by army worms

Figure 45. Ear rot disease caused by fungus; carried out by pests

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