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Growth and Yield Response of Corn *(Zea may L.)* Intercropped with Cowpea *(Vigna unguiculata L.)*

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ABSTRACT

This study evaluated the growth, yield, land-use efficiency, and economic profitability of corn *(Zea mays L.)* intercropped with cowpea *(Vigna unguiculata L.)* under varying planting ratios. A field experiment was conducted in Barangay Cabasaran, Marawi City, Philippines, from December 2023 to April 2024 using a randomized complete block design with five treatments and four replications: sole corn, sole cowpea, and corn–cowpea combinations of 1:1, 1:2, and 2:1. Plant growth, reproductive development, yield components, crop yields, land equivalent ratio (LER), and return on investment (ROI) were assessed using field measurements, analysis of variance, and economic calculations. The 1:1 treatment generally produced the most favorable growth and yield outcomes, including reported corn and cowpea yields of 1.95 and 0.97 t/ha, respectively, and the highest ROI (52%). However, its reported LER (0.94), like those of the other intercropping treatments (0.83), remained below 1.0, indicating no demonstrated combined land-use advantage. Thus, the 1:1 arrangement was the most profitable of the tested options, but economic performance did not coincide with superior land-use efficiency. Farmers in similar settings may consider this arrangement while evaluating production costs and field performance; additional trials should compare other crop combinations. Findings are limited to one site, one cropping period, and the tested varieties. The study provides locally relevant evidence for farm decisions and supports SDG 2 (Zero Hunger), SDG 8 (Decent Work and Economic Growth), and SDG 12 (Responsible Consumption and Production) through evidence on crop productivity, profitability, and resource-use assessment.

Keywords: *Corn, Cowpea, Crop Yield, Intercropping, Land Equivalent Ratio, Return on Investment, Sustainable Agriculture*

1. INTRODUCTION

Corn *(Zea mays L.)* is an important agricultural crop in the Philippines, contributing to food production, livestock feeding, and rural livelihoods. The Philippine Statistics Authority (2026) reported approximately 8.14 million metric tons of corn production in 2024, demonstrating its continued significance in Philippine agriculture. However, agricultural productivity depends on effective land utilization, crop management, and resource availability. Intercropping, which involves cultivating two or more crops on the same land during overlapping growing periods, offers a potential strategy for improving agricultural productivity through crop diversification and complementary resource utilization. Corn–cowpea intercropping combines a cereal crop with a legume capable of biological nitrogen fixation. Dimande et al. (2024) demonstrated that maize–cowpea intercropping can improve nutrient utilization and overall land productivity, although its effectiveness depends on environmental conditions and interspecific competition. Similarly, Kussie et al. (2024) reported that planting arrangements influence crop growth, yield, land-use efficiency, and economic returns. These findings emphasize the importance of evaluating suitable crop combinations under specific farming conditions. Accordingly, the present study investigated the growth, yield, land productivity, and economic profitability of corn intercropped with cowpea under different planting ratios in Barangay Cabasaran, Marawi City, Lanao del Sur, Philippines.

Research Problem

Agricultural production requires cropping systems that maximize available land resources while maintaining economically viable yields. Although monocropping simplifies crop management, it may limit opportunities to utilize complementary plant characteristics within the same cultivated area. Corn–cowpea intercropping offers a possible alternative because legumes can access atmospheric nitrogen through biological fixation, while differences in crop growth patterns may influence resource utilization. However, competition for sunlight, water, nutrients, and growing space can reduce the potential benefits of intercropping (Dimande et al., 2024). Recent studies have demonstrated varying responses to corn–cowpea intercropping. Kombat et al. (2024) reported that maize yield was influenced by planting arrangements and fertilizer applications, with favorable performance under a 1:1 maize–cowpea arrangement in their study conditions. Habib et al. (2024) likewise observed that row arrangements and cowpea varieties affected grain yield and land-use efficiency. In contrast, Kussie et al. (2024) found that sole cropping produced higher individual grain yields for both crops, despite the overall land-use and economic advantages of certain intercropping treatments. These findings indicate that the performance of intercropping systems is context-dependent. Despite the documented potential of cereal–legume intercropping, the suitability of different planting ratios must be assessed under local agroecological conditions. Specifically, this study addressed the need to compare monocropping with corn–cowpea intercropping at 1:1, 1:2, and 2:1 planting ratios in Barangay Cabasaran, Marawi City. It examined their effects on crop growth, yield components, combined land productivity, and economic returns to provide evidence relevant to local farming decisions.

Assumptions of the Study

The study was based on the premise that the growth and yield responses of corn and cowpea may vary according to their planting arrangements and the degree of competition or complementarity between the crops. It considered that differences in plant population and crop proportions could influence access to sunlight, water, nutrients, and growing space. Previous research has established that intercropping outcomes depend on the balance between these interactions and the environmental conditions under which crops are cultivated (Dimande et al., 2024; Fajri et al., 2025). The study further assumed that comparisons between monocropping and intercropping treatments could provide a basis for assessing relative crop productivity and economic performance. Land equivalent ratio and return on investment were used as indicators

of land-use efficiency and profitability, respectively. The findings were considered applicable primarily to Barangay Cabasaran, Marawi City, and potentially to areas with comparable farming and environmental conditions.

Objectives of the Study

The study generally aimed to evaluate the growth, yield, productivity, and economic profitability of corn *(Zea mays L.)* intercropped with cowpea *(Vigna unguiculata L.)* under different planting arrangements. Specifically, it sought to assess the growth and yield performance of corn intercropped with cowpea at planting ratios of 1:1, 1:2, and 2:1 compared with their respective monocropping treatments; determine the productivity of the crop combinations using yield measurements and land equivalent ratio; and evaluate the economic profitability of the different cropping treatments through return-on-investment analysis. The investigation aimed to identify planting arrangements that could provide useful agronomic and economic information for farmers operating under comparable local conditions.

Theoretical or Conceptual Basis

The study was anchored in the ecological principles of resource complementarity and interspecific competition in intercropping systems. Resource complementarity occurs when crops utilize available environmental resources through different growth characteristics or nutrient-acquisition mechanisms, while interspecific competition arises when neighboring plants require the same limited resources. According to Dimande et al. (2024), corn–cowpea intercropping can enhance land productivity and nutrient acquisition through interactions between cereal and legume crops. However, differences in competitive ability may influence the growth and yield of individual crops. The conceptual basis also emphasizes the importance of planting arrangements in determining intercropping performance. Fajri et al. (2025) established that row orientation and cowpea row numbers influenced the growth, land equivalent ratio, and economic performance of sweet corn–cowpea intercropping. Moreover, Bott et al. (2026), in a meta-analysis of maize-based intercropping systems, demonstrated that crop combinations can improve overall land-use efficiency, although results differ across production environments. Within this framework, the study considered planting ratio as the primary experimental factor, while crop growth, yield performance, land equivalent ratio, and return on investment served as outcome indicators. The comparison of monocropping and intercropping treatments provided the basis for determining whether the potential benefits of resource complementarity outweighed competition under the prevailing field conditions. This conceptual approach recognized that agronomic productivity and economic profitability are related but distinct measures of intercropping performance.

The study aligns with Sustainable Development Goal 2 (Zero Hunger), particularly Target 2.4, by examining corn–cowpea intercropping as a potential approach to sustainable agricultural production. It also supports SDG 8 (Decent Work and Economic Growth) through its assessment of agricultural profitability and smallholder livelihoods. The United Nations Department of Economic and Social Affairs (2025) emphasized the importance of improving agricultural productivity, food security, and economic resilience. Furthermore, the study relates to SDG 12 (Responsible Consumption and Production) by evaluating land-use efficiency and crop productivity under different planting arrangements. Its sustainability contribution lies in providing evidence for economically viable crop management and more efficient agricultural practices. However, environmental benefits such as improved soil fertility, reduced fertilizer use, and lower carbon emissions were not directly assessed.

2. METHODOLOGY

Research Design

The study utilized a Randomized Complete Block Design (RCBD) consisting of five treatments with four replications. The treatments included monocropping of corn (T1), monocropping of cowpea (T2), corn–cowpea intercropping at a 1:1 ratio (T3), corn–cowpea intercropping at a 1:2 ratio (T4), and corn–cowpea intercropping at a 2:1 ratio (T5). These treatments were established to determine the effects of different planting arrangements on crop growth, yield, land-use efficiency, and economic profitability.

Research Locale or Study Setting

The study was conducted in a farmer's field in Barangay Cabasaran, Marawi City, Lanao del Sur, Bangsamoro Autonomous Region in Muslim Mindanao (BARMM), Philippines, from December 2023 to April 2024. The experimental site served as the setting for evaluating the performance of corn and cowpea under monocropping and intercropping conditions.

Participants or Data Sources

The study utilized corn and cowpea plants established under the five experimental treatments as the primary sources of data. Ten selected corn plants and ten randomly selected cowpea plants were used for growth and yield measurements. Data were obtained from observations of plant development, reproductive characteristics, harvested produce, and computed productivity and economic indicators.

Research Instruments or Materials

The experimental materials included traditional corn seeds, black-eyed cowpea seeds, and complete fertilizer (14-14-14). Agricultural tools such as a plow, hoe, and shovel were used for land preparation, while sticks, straw, markers, placards, and netting were utilized for field layout. A measuring tape, weighing scale, and record book were used for data collection. Hot pepper extract and a sprayer were also used for pest management.

Data Gathering Procedure

The experimental area was plowed and harrowed two to three times using animal-drawn equipment, while furrows were prepared manually. Corn and cowpea seeds were directly sown at a spacing of 30 cm between hills and 60 cm between rows, with three seeds planted per hill. Seedlings were thinned one week after emergence, retaining two plants per hill. Complete fertilizer (14-14-14) was applied as basal fertilizer, while irrigation, weeding, and hilling were performed as necessary. Pest management involved foliar application of hot pepper extract prepared using two tablespoons of extract in a 30-mL sprayer, applied every three days during the late afternoon. Corn was harvested at 105 days after emergence, while cowpea was harvested at 82 days after sowing by manually collecting mature brown pods. Data collection included corn plant height, days to maturity, days to tasseling and silking, number of ears, and harvested weight per plot. Corn plant height was measured from ground level to the plant tip before tasseling, while tasseling and silking were recorded when 50% of the plants exhibited the corresponding reproductive characteristics. For cowpea, data included plant height, days to flowering, stem girth, number of pods, and harvested pod weight. Flowering was recorded when at least 50% of the plants had flowered. Measurements were obtained from the selected sample plants using appropriate measuring instruments. Crop yields were subsequently converted into tons per hectare, while land equivalent ratio and return on investment were computed to assess productivity and economic performance.

Data Analysis

The collected data were analyzed using Analysis of Variance (ANOVA) appropriate for a Randomized Complete Block Design through the International Rice Research Institute's Statistical Tool for Agricultural Research (STAR). The analysis was used to determine differences in the growth and yield characteristics of corn and cowpea across the experimental treatments. Land equivalent ratio was calculated using the relative yields of intercropped and monocropped corn and cowpea, while return on investment was determined using production costs and net income to evaluate the economic performance of each treatment.

Ethical Consideration

The study involved field experimentation using corn and cowpea plants. The original manuscript did not report formal ethical approval, documented permission to use the experimental site, or specific environmental protection protocols. Accordingly, no additional ethical procedures or compliance claims are presented.

3. RESULTS AND DISCUSSION

3.1 Growth and Development of Corn and Cowpea

3.1.1 Plant Height of Corn

Corn plant height varied across treatments during the growing period. At 30 days after emergence, T3 recorded the highest mean height of 90.95 cm, followed by T1 (79.79 cm), T4 (75.72 cm), and T5 (71.53 cm). At 60 days, T3 maintained the highest mean height of 251.10 cm, compared with T4 (219.20 cm), T1 (185.60 cm), and T5 (184.68 cm). At harvesting, T3 remained tallest at 286.19 cm, followed by T5 (230.03 cm), T4 (217.15 cm), and T1 (211.95 cm). The analysis indicated significant treatment differences at 30 and 60 days and highly significant differences at harvesting. These findings suggest that the 1:1 corn–cowpea arrangement was associated with greater corn height under the experimental conditions. Kussie et al. (2024) similarly reported increased maize plant height under a 1:1 maize–cowpea intercropping arrangement compared with sole maize cultivation. However, crop growth responses may depend on plant density, planting arrangement, and competition for available resources. Nyande et al. (2023) reported that sole maize performed better in certain growth characteristics, demonstrating that intercropping does not consistently improve individual crop development across production environments.

3.1.2 Plant Height of Cowpea

Cowpea plant height differed across cropping arrangements. At 30 days, monocropped cowpea (T2) recorded the highest mean height of 37.72 cm, followed by T3 (37.50 cm), T4 (33.91 cm), and T5 (33.45 cm). At 60 days, T3 produced the tallest plants at 74.25 cm, followed by T4 and T5 at 67.51 cm each, while T2 recorded 65.46 cm. At harvesting, T3 maintained the highest mean height of 85.43 cm, followed by monocropped cowpea (79.34 cm), T4 (71.13 cm), and T5 (70.01 cm). Differences were reported as nonsignificant at 30 and 60 days but highly significant at harvesting. The greater final height of cowpea under the 1:1 arrangement suggests that its growth response varied with the proportion of corn and cowpea plants. In contrast, Kussie et al. (2024) observed greater cowpea growth under sole cultivation, indicating that intercropping effects depend on crop interactions and local conditions. Sanfo et al. (2023) further demonstrated that maize–cowpea intercropping performance differs across cultivars and cropping arrangements. These findings support the importance of evaluating planting ratios rather than assuming that a particular combination will consistently produce superior vegetative growth.

3.1.3 Flowering, Tasseling, Silking, and Crop Maturity

Reproductive development varied among the treatments. Cowpea flowering was recorded at 38.75 days for T2 and T3, 37.50 days for T4, and 43.25 days for T5, with highly significant treatment differences reported. Corn in T3 developed tassels and silks at approximately 60.00 and 65.70 days, respectively, earlier than the other corn treatments for these characteristics. Highly significant differences were also reported for corn maturity, although the manuscript contains conflicting descriptions of the treatment with the shortest maturity period. The variation in reproductive development indicates that crop arrangement may influence the timing of flowering and reproductive growth. Competition for sunlight, soil moisture, and nutrients may affect plant development when crops are grown together. Nyande et al. (2023) likewise documented differences in reproductive and yield-related characteristics under different maize–cowpea planting arrangements. However, the present study did not directly measure the physiological mechanisms responsible for these differences, and the conflicting corn maturity records require verification before a definitive interpretation can be made.

3.1.4 Stem Girth of Corn

Stem girth varied among corn treatments, with the original narrative identifying T3 as producing the thickest stems, followed by monocropped corn. The manuscript reported significant treatment differences and indicated that the 1:2 and 2:1 intercropping arrangements produced comparatively smaller stems. However, the numerical values displayed in the original results do not fully correspond with this ranking. Stem development is an indicator of vegetative growth and may be affected by competition for environmental resources. Fajri et al. (2025) reported that planting arrangement and row orientation influenced stem diameter and other early growth characteristics in sweet corn–cowpea intercropping. These findings indicate that spatial arrangement can affect crop morphology, although the precise treatment ranking for stem girth in the present study must be verified using the original experimental records.

3.2 Yield Performance of Corn and Cowpea

3.2.1 Number of Corn Ears and Cowpea Pods

The number of corn ears differed significantly across planting arrangements. T3 recorded the highest mean count of 12.75, followed by T4 (11.00), T1 (10.50), and T5 (10.25). Similarly, cowpea pod production was highest under T3, with a mean of 37.75 pods, followed by T2 (30.00), T5 (28.50), and T4 (28.00). Highly significant differences were reported for both yield components, indicating variation in reproductive performance among the treatments. These findings suggest that the 1:1 planting arrangement was associated with greater reproductive output for both crops under the study conditions. Dimande et al. (2024) demonstrated that maize–cowpea intercropping can influence crop productivity through interactions in resource acquisition. Similarly, Pattnaik et al. (2025) found that appropriate sweet corn–cowpea arrangements improved yield performance, although the most productive planting configuration differed from the present study. The findings emphasize the importance of determining suitable crop proportions under specific field conditions.

3.2.2 Harvested Weight of Corn and Cowpea

The 1:1 intercropping treatment produced the highest recorded harvested weight for both crops. Corn harvested weight was highest in T3 at 29.04 kg per plot, followed by T1 (28.00 kg), T4 (27.21 kg), and T5 (24.78 kg). The recorded cowpea pod weights were highest in T3 (9.29), followed by T2 (7.43), T5 (6.52), and T4 (5.02). Highly significant treatment differences were reported for both

characteristics. The reporting unit and measurement basis for cowpea pod weight require confirmation because the original manuscript uses inconsistent labels. The higher harvested weights associated with T3 indicate that the 1:1 planting arrangement performed favorably in the experiment. However, planting ratios may influence yield differently depending on crop density and environmental conditions. Sanfo et al. (2023) demonstrated variation in maize and cowpea grain production across monocropping and intercropping systems, while Pattnaik et al. (2025) reported improvements in sweet corn yield under selected legume intercropping arrangements. These findings support the importance of spatial crop management in determining harvested output.

3.2.3 Computed Grain Yield of Corn and Cowpea

The reported computed grain yields differed among the cropping treatments. Corn grain yield was highest under T3 at 1.95 tons per hectare, followed by T5 (1.55 tons per hectare), T4 (1.52 tons per hectare), and T1 (1.43 tons per hectare). Cowpea grain yield was also highest under T3 at 0.97 tons per hectare, followed by T5 (0.77 tons per hectare), T4 (0.76 tons per hectare), and T2 (0.72 tons per hectare). The manuscript reported highly significant treatment differences, indicating that planting arrangements influenced computed crop yields. These findings suggest that the 1:1 corn–cowpea arrangement provided the highest reported individual crop yields under the experimental conditions. However, the response of individual crop yields to intercropping differs across studies. Kussie et al. (2024) found that sole cropping produced higher individual maize and cowpea grain yields, although intercropping improved combined land productivity and economic performance. Meanwhile, Jayshree et al. (2025) reported that maize–cowpea intercropping arrangements influenced nutrient availability and crop quality. The present results indicate a favorable yield response to T3, but the mechanisms underlying this response cannot be established without direct measurements of nutrient availability, soil conditions, or interspecific competition.

3.3 Land-Use Efficiency and Economic Profitability

3.3.1 Land Equivalent Ratio

The land equivalent ratio (LER) differed among the three intercropping treatments. T3 recorded the highest LER of 0.94, while T4 and T5 each obtained 0.83. All recorded LER values were below 1.00, indicating that none of the intercropping arrangements demonstrated a combined land productivity advantage over the corresponding monocropping systems based on the reported LER calculations. Nevertheless, T3 exhibited the highest relative land-use efficiency among the evaluated intercropping treatments. The LER results suggest that competition between corn and cowpea may have limited the potential productivity advantages of intercropping. However, an LER below 1.00 does not independently establish which resources caused the disadvantage. Dimande et al. (2024) demonstrated that maize–cowpea intercropping can improve land-use efficiency and nutrient acquisition under suitable conditions, while Liu et al. (2024), through a global meta-analysis, established that the benefits of intercropping depend partly on nitrogen management and crop combinations. These findings demonstrate that intercropping does not automatically provide greater land productivity and that its effectiveness depends on appropriate crop management and environmental conditions.

3.3.2 Return on Investment

The economic analysis indicated differences in profitability among treatments. Based on the detailed economic results, T3 achieved the highest return on investment (ROI) of 52.00%,

followed by T4 (47.60%), T5 (40.90%), T1 (30.80%), and T2 (28.00%). T3 also recorded the highest reported gross income of ₱441.25 and net income of ₱151.25 against a production cost of ₱290.00, using the monetary scale presented in the original experimental records. These findings indicate that the 1:1 corn–cowpea treatment generated the highest reported economic return. The higher ROI of T3 suggests that the 1:1 cropping arrangement provided an economic advantage under the study's production costs and income assumptions, despite its LER remaining below 1.00. Kussie et al. (2024) similarly reported favorable economic performance under 1:1 maize–cowpea intercropping. Pattnaik et al. (2025) also demonstrated that selected sweet corn–cowpea arrangements improved system profitability compared with monocropping. These findings indicate that the most economically favorable treatment is not necessarily the treatment with a demonstrated land-use efficiency advantage. Economic performance should therefore be considered alongside agronomic productivity when assessing intercropping systems.

4. CONCLUSIONS AND RECOMMENDATIONS

The study demonstrated that planting arrangements influenced the growth, yield, productivity, and economic performance of corn *(Zea mays L.)* intercropped with cowpea *(Vigna unguiculata L.)* under the field conditions of Barangay Cabasaran, Marawi City. Among the five treatments, the 1:1 corn–cowpea intercropping arrangement (T3) generally exhibited the most favorable performance in terms of plant growth, yield components, and reported crop yields. This treatment also achieved the highest return on investment of 52%, indicating its economic advantage under the experimental conditions. However, the reported land equivalent ratios did not consistently establish superior land-use efficiency, highlighting the distinction between agricultural productivity and economic profitability. Overall, the findings suggest that the 1:1 planting arrangement was the most economically favorable treatment among those evaluated. The study provides localized experimental evidence that may assist farmers in selecting appropriate corn–cowpea planting arrangements based on crop performance and economic returns.

Based on the findings, farmers in Barangay Cabasaran, Marawi City, may consider adopting the 1:1 corn–cowpea intercropping arrangement because it demonstrated the highest reported return on investment and generally favorable growth and yield performance. However, its application should consider the prevailing field conditions, available resources, and production costs to determine whether similar economic benefits can be achieved. Farmers should also assess crop performance and profitability when implementing intercropping practices, particularly because higher economic returns do not necessarily indicate greater land-use efficiency. Future researchers are encouraged to conduct additional field experiments involving corn intercropped with other suitable crops, as recommended in the original study, to determine whether alternative crop combinations provide better productivity and economic outcomes. Further comparative investigations under different planting arrangements and comparable farming conditions may strengthen the available evidence and provide a more reliable basis for recommending economically viable intercropping practices to local farmers.

The study was limited to a single experimental location in Barangay Cabasaran, Marawi City, during the December 2023 to April 2024 cropping period. It involved local corn and cowpea varieties, five cropping treatments, and four replications, restricting the applicability of the findings to comparable agricultural conditions. The investigation focused primarily on crop growth, yield, land equivalent ratio, and return on investment. Additionally, inconsistencies in the reported land equivalent ratios and selected summary measurements require verification against the original experimental records. Future investigations involving additional cropping

periods, locations, and crop combinations may help establish the consistency and broader applicability of the findings.

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