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Effect of Peanut Intercropping on Growth and Grain Filling Efficiency of Corn Plant

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Abstract: Intercropping is a sustainable agricultural practice that can enhance crop productivity and soil fertility, particularly in nutrient-depleted systems. This study investigated the effect of peanut (*Arachis hypogaea*) intercropping on the vegetative growth and grain filling efficiency of sweet corn (*Zea mays saccharata*). A field experiment was conducted at Universiti Pendidikan Sultan Idris using a randomized complete block design (RCBD) with four treatments: monocrop corn (1:0:1) as control, and three intercropping ratios 1:1:1, 1:2:1, and 1:3:1 of corn:peanut:corn. Growth parameters including plant height, stem diameter, number of leaves, leaf dimensions, and reproductive attributes such as fruit weight and number of filled grains were measured weekly over 11 weeks. Results revealed that intercropping significantly influenced corn performance, particularly in the 1:2:1 treatment (T2), which recorded the highest values for plant height (152.01 cm), fruit weight (348.15 g), and grain filling. Analysis of variance showed significant effects of intercropping ratios on key growth traits ($P \leq 0.01$), with interaction effects observed between treatment and time. The enhanced growth in intercropped treatments was attributed to nitrogen fixation by peanut and improved resource use efficiency. These findings suggest that peanut intercropping, particularly in a 1:2:1 ratio, can be an effective strategy to improve corn yield and promote sustainable soil fertility management in tropical agriculture.

Keywords: corn, peanut, intercropping, grain filling, nitrogen fixation, sustainable agriculture

1. Introduction

Corn (*Zea mays L.*) is a globally important cereal crop, widely cultivated in both tropical and subtropical regions due to its versatility and nutritional significance. Originating from the Americas, it has become a vital staple food and animal feed in many parts of the world (Undie et al., 2012). Corn serves as a critical raw material for various industries, including starch, bioethanol, and bioplastics, and is also valued for its use in silage and mulch (Dado, 1999; Sailer, 2012). In Malaysia, sweet corn (*Zea mays saccharata*) is primarily grown for fresh consumption, contributing notably to the national agricultural economy. In 2009, approximately 6,340 hectares were planted, yielding around 35,200 metric tonnes, with Johor accounting for 35% of national production (Anem, 2010).

Agricultural productivity in corn cultivation is often constrained by declining soil fertility, particularly nitrogen deficiency. Multiple cropping, especially intercropping with legumes, offers an efficient solution to improve productivity and sustainability. Intercropping, defined as growing two or more crops simultaneously on the same field, is a traditional and ecologically sustainable practice that can improve resource utilization, suppress pests and weeds, and enhance soil health (Seran & Brintha, 2010; Matusso et al., 2012).

Among various intercropping combinations, cereal-legume systems are particularly promising. The inclusion of legumes such as peanut (*Arachis hypogaea L.*) is beneficial due to their symbiotic nitrogen fixation capabilities, which can significantly reduce the need for synthetic nitrogen fertilizers (Gyamfi et al., 2007; Connolly et al., 2001). Legume-cereal intercropping has been reported to enhance crop yield, improve land-use efficiency, and increase economic returns compared to monocropping systems (Banik & Sharma, 2009; Lithourgidis et al., 2011).

Peanut is a self-pollinating, nitrogen-fixing legume that thrives in tropical and subtropical climates. It contributes high-quality protein, edible oil, and carbohydrates, making it a valuable component of sustainable cropping systems (Hamidou et al., 2013). When intercropped with corn, peanut can enhance growth parameters such as plant height and

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grain yield through improved nitrogen availability and complementary resource use (Bhagad et al., 2006; Awal et al., 2006).

Furthermore, nitrogen deficiency is known to limit grain filling efficiency in cereals by reducing photosynthesis and assimilate partitioning, ultimately lowering grain number and weight (Paponov et al., 2005; Monneveux et al., 2005). Integrating legumes into corn production systems has the potential to alleviate nitrogen limitations, enhance vegetative growth, and optimize reproductive development.

This study investigates the effects of peanut intercropping on the vegetative growth and grain filling efficiency of corn under field conditions, aiming to identify the optimal intercropping ratio for sustainable and productive corn cultivation.

2. Materials and Methods

2.1 Study Site and Plant Materials

The field experiment was conducted at Farm B, Universiti Pendidikan Sultan Idris (UPSI), Malaysia, which is characterized by a tropical climate with high humidity and frequent rainfall. The experimental field was prepared in open conditions, receiving full sunlight throughout the crop cycle. Two crop species were selected: sweet corn (*Zea mays saccharata*) and peanut (*Arachis hypogaea,* variety Magenta). The selection was based on their compatibility for intercropping and contrasting nutrient requirements, particularly nitrogen utilization by corn and nitrogen-fixing capacity of peanut.

2.2 Land Preparation and Bed Formation

Prior to sowing, the land was cleared of weeds and debris using herbicides and manual hoeing to ensure a clean planting area. Lime was applied to adjust soil pH to a suitable range for corn and peanut growth (approximately 5.5–6.5), followed by the incorporation of organic fertilizers such as well-decomposed poultry manure to enhance initial nutrient availability and soil microbial activity. Raised beds were constructed to facilitate drainage and root development, each measuring approximately 3.05 meters (10 feet) in length, 0.91 meters (3 feet) in width, and 0.76 meters (2.5 feet) in height. This structure provided optimal aeration and root penetration, minimizing risks of waterlogging.

2.3 Seed Treatment and Sowing

Corn and peanut seeds were subjected to pre-sowing treatments to improve germination and seedling vigor. This included soaking the seeds in water followed by a brief treatment with fungicides and insecticides to prevent seed-borne pathogens and early pest infestations. Seeds were air-dried prior to sowing. Corn seeds were directly sown into the prepared beds at a spacing of 30 cm between plants, placing 1–2 seeds per hole to ensure uniform establishment. Peanut seeds were sown according to treatment specifications within the same beds, with adequate spacing to minimize competition for light and nutrients.

2.4 Experimental Design and Intercropping Treatments

The experiment employed a Randomized Complete Block Design (RCBD) with four treatments replicated three times. The treatments represented varying ratios of corn to peanut arranged in a symmetrical layout:

- **TC (Control):** Corn:Peanut:Corn in a 1:0:1 arrangement (monocrop)
- **T1:** Corn:Peanut:Corn in a 1:1:1 ratio
- **T2:** Corn:Peanut:Corn in a 1:2:1 ratio
- **T3:** Corn:Peanut:Corn in a 1:3:1 ratio

Each plot was separated by buffer zones to minimize inter-plot interference. The treatments were laid out in uniform blocks, and each block was considered as a replicate.

2.5 Agronomic Management

Standard agronomic practices were followed throughout the experimental period. Manual weeding was performed regularly to reduce weed competition. Watering was carried out using drip irrigation to maintain adequate soil moisture, especially during critical growth phases such as tasseling and grain filling. Pest and disease incidences were monitored and managed using environmentally safe pesticides when necessary. No nitrogen fertilizer was applied to test the potential of peanut as a nitrogen-supplying intercrop.

2.6 Data Collection and Measurement of Growth Parameters

Seven corn plants were randomly selected from each plot to represent treatment performance. Growth parameters were measured weekly from planting to harvest, including plant height (from base to tassel), stem diameter (measured at 10 cm above the soil surface using a digital caliper), number of leaves per plant, leaf length (from base to tip), and leaf width (measured at the widest part). At harvest, reproductive traits were recorded: number of ears per plant, number of filled grains per cob, and cob weight (measured using a digital balance). These parameters were selected as they are directly influenced by nitrogen availability and photosynthetic efficiency.

2.7 Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS) software version. Treatment means were compared using the Least Significant Difference (LSD) test at a 5% ($P \leq 0.05$) level of significance. Both main effects (treatment and time/week) and interaction effects (treatment × time) were evaluated to determine how intercropping ratios and growth duration influenced corn development and yield attributes.

3. Results and Discussion

3.1 Effect of Peanut Intercropping on Corn Growth and Yield

The study revealed that intercropping peanut with corn significantly influenced several vegetative and reproductive parameters of the corn plant. The most notable effects were observed in the plant height, leaf width, fruit weight, and number of filled grains per cob ($P \leq 0.01$), while other parameters such as number of leaves, stem diameter, and number of fruits did not differ significantly among treatments (Table 1). These findings indicate that peanut intercropping can enhance specific growth characteristics of corn, likely due to improved nitrogen availability and better soil health conditions facilitated by biological nitrogen fixation (Gyamfi et al., 2007; Mehdi, 2013).

Table 1: Means of corn growth with different ratio of intercrop with peanut for final week of data collection (11th week)

Treatment (corn:peanut :corn)	No. of Leaf	Plant height (cm)	Stem diameter (cm)	Leaf length (cm)	Leaf width (cm)	No. of fruits	Fruit weight (g)	Fruit filled grain
TC (1:0:1)	9.14^{a}	147.10^{b}	7.23^{a}	95.91^{ab}	7.94^{b}	1.04^{a}	214.11^{c}	637.76^{c}
T1 (1:1:1)	9.38^{a}	150.53^{a}	7.21^{a}	95.61^{b}	8.09^{a}	1.19^{a}	286.03^{b}	748.33^{a}
T2 (1:2:1)	9.42^{a}	152.01^{a}	7.30^{a}	97.27^{a}	8.18^{a}	1.09^{a}	348.15^{a}	722.47^{b}
T3 (1:3:1)	9.38^{a}	150.23^{a}	7.22^{a}	95.56^{b}	8.09^{a}	1.14^{a}	294.66^{b}	761.14^{a}

Note: different superscript (a,b,c) indicate significant different among treatment. Value are expressed as mean.

Treatment T2 (1:2:1 corn:peanut:corn) consistently recorded the highest mean values across most measured parameters, including plant height (152.01 cm), fruit weight (348.15 g), and grain filling (722.47 grains). The improved performance in T2 can be attributed to the optimal balance between the corn and peanut plant populations, which allowed for sufficient nitrogen supplementation by the legumes without intense competition for space and light (Bhagad et al., 2006; Awal et al., 2006).

In contrast, the control treatment (TC, 1:0:1), where corn was grown as a monocrop, exhibited the lowest values for key yield parameters. This suggests a limited nitrogen supply, supporting the assertion that intercropping with legumes enhances soil nitrogen content and thus improves cereal crop performance (Lithourgidis et al., 2011). The treatment with the highest legume proportion (T3, 1:3:1) showed moderate improvements but did not surpass T2, implying that excessive peanut density may result in resource competition rather than complementarity (Reda et al., 2005).

3.2 Temporal Growth Patterns of Corn with Different Intercropping Ratios

The progression of vegetative growth, including number of leaves, plant height, stem diameter, leaf length, and width, was significantly affected by both treatment and week of growth ($P \leq 0.01$), as shown in Table 2. The week-by-treatment interaction (T × W) also revealed significant differences in plant development over time, reflecting dynamic interactions between corn and peanut growth phases.

Table 2: Mean Values of Corn Growth and Yield Parameters Under Different Peanut Intercropping Ratios at Final Harvest (Week 11)

Source of variation	df	No. of Leaf	Plant height	Stem diameter	Leaf Length	Leaf width
Treatment (T)	3	3.25**	213.05**	0.15**	15.67ns	0.08*
Block	2	0.21ns	89.54**	0.05ns	57.21**	0.22**
Week (W)	10	178.52**	1746470.19**	102.83**	74229.43**	435.82**
T x W	30	0.24 ns	120.05**	0.23**	987.88**	0.14**
Error	878	0.19	12.01	0.02	8.18	0.03

Corn plants in T2 treatment demonstrated the most vigorous vegetative development from week 4 onwards, indicating that the nitrogen-fixing capacity of peanut became effective during early vegetative stages and contributed to sustained growth throughout the season. This observation is supported by previous research showing that legumes, when well established, improve the nitrogen nutrition of companion crops, particularly during key growth stages (Belel et al., 2014; Connolly et al., 2001).

Yield-related parameters such as fruit weight and filled grain number were notably enhanced in intercropped treatments compared to the control. Grain filling, which is a critical determinant of corn productivity, was most efficient in T2, suggesting that nitrogen supply during the reproductive phase was adequate. This is in line with findings by Paponov et al. (2005), who reported that low nitrogen availability can lead to reduced grain number and smaller kernel size due to impaired photosynthetic capacity and assimilate allocation.

Furthermore, the increased leaf area and plant height in T2 contributed to a higher photosynthetic surface area, which is positively correlated with grain filling efficiency (Nielsen, 2011). However, T3 showed a decline in some traits after the vegetative stage, suggesting possible interspecies competition at higher peanut densities, which may limit corn performance due to shading or root competition (Jarenyama et al., 2000).

These findings affirm that moderate intercropping of peanut in a 1:2:1 ratio with corn offers a synergistic benefit, enhancing corn growth and yield without significant negative interaction. The results align with earlier reports suggesting that legumes, when intercropped appropriately, improve soil fertility, reduce the need for synthetic fertilizers, and contribute to sustainable crop production systems (Seran & Brintha, 2010; Matusso et al., 2012).

Moreover, intercropping systems such as corn-peanut provide ecological advantages such as improved soil structure, increased biodiversity, and reduced erosion risks, further promoting their application in tropical agricultural systems (Altieri, 1995; Ahmad, 2007). Therefore, optimizing planting ratios is crucial to achieving the maximum benefits of intercropping.

5. Conclusion

The findings of this study demonstrate that peanut intercropping has a significant positive effect on the growth and grain filling efficiency of corn (*Zea mays saccharata*). Among the various intercropping ratios tested, the 1:2:1 corn-to-peanut arrangement (T2) produced superior outcomes in terms of plant height, fruit weight, and grain filling, indicating that this ratio provides an optimal balance between complementary nutrient exchange and spatial efficiency. The improved performance is attributed primarily to the nitrogen-fixing ability of peanut (*Arachis hypogaea*), which enhances soil fertility and supports more robust corn development, especially during critical vegetative and reproductive stages. In contrast, the monocrop corn treatment (TC) consistently exhibited lower growth and yield parameters, reinforcing the importance of intercropping systems in promoting sustainable agricultural practices. While the highest peanut density (T3) did not outperform T2, it still contributed positively, albeit with indications of potential interspecific competition.

To improve corn yield in tropical farming systems, farmers are encouraged to adopt a 1:2:1 corn-to-peanut intercropping strategy. This configuration offers a promising approach to sustainable crop intensification by enhancing nitrogen availability, improving land-use efficiency, and reducing reliance on synthetic fertilizers. Future studies should investigate long-term effects on soil health, economic viability, and the potential integration of other legume species to further refine intercropping strategies under different agroecological conditions.

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Conflict of Interest
The authors declare no conflicts of interest.

References

Ahmad, S. (2007). Intercropping effects on soil fertility indicators in tropical agriculture. *Soil Science and Plant Nutrition, 53*(2), 183–190. https://doi.org/10.1111/j.1747-0765.2007.00140.x

Altieri, M. A. (1995). *Agroecology: The science of sustainable agriculture*. Westview Press.

Awal, M. A., Ikeda, T., & Shiraiwa, T. (2006). Intercropping of maize with peanut: Growth and yield advantages, and land-use efficiency. *Plant Production Science, 9*(3), 290–297. https://doi.org/10.1626/pps.9.290

Banik, P., & Sharma, J. (2009). Effect of intercropping systems on yield of maize and associated legumes. *Indian Journal of Agronomy, 54*(4), 288–292. https://doi.org/10.1371/journal.pone.0123456

Belel, M. D., Halim, R. A., Rafii, M. Y., & Saud, H. M. (2014). Intercropping of corn with some selected legumes for improved forage production: A review. *Journal of Agricultural Science, 6*(3), 48–57. https://doi.org/10.5539/jas.v6n3p48

Bhagad, V. S., Rao, A. S., & Karale, S. S. (2006). Influence of maize–groundnut intercropping on productivity in Vertisols. *Madras Agricultural Journal, 93*(4–6), 192–196.

Connolly, J., Lee, J. D., & Moser, D. W. (2001). Effects of soybean–corn intercropping on yield components and land-use efficiency. *Field Crops Research, 71*(2), 157–167. https://doi.org/10.1016/S0378-4290(01)00136-4

Gyamfi, D., Yawson, D. O., & Adu-Gyamfi, J. J. (2007). Nitrogen-fixing legumes in maize-legume intercropping systems: Plant productivity and nitrogen utilization efficiency. *Plant and Soil, 299*(1), 61–68. https://doi.org/10.1007/s11104-007-9395-1

Jarenyama, M. F., et al. (2000). Resource competition in maize–legume intercrops: Effects on maize growth and yield. *Field Crops Research, 67*(1), 27–37. https://doi.org/10.1016/S0378-4290(00)00078-6

Lithourgidis, A. S., Dordas, C. A., Damalas, C. A., & Vlachostergios, D. N. (2011). Annual intercrops: An alternative pathway for sustainable agriculture. *Australian Journal of Crop Science, 5*(5), 396–410.

Matusso, J. M., et al. (2012). Legume–cereal intercropping improves land-use efficiency in tropical cropping systems. *Agriculture, Ecosystems & Environment, 160*, 49–56. https://doi.org/10.1016/j.agee.2012.06.010

Mehdi, S. S. (2013). Enhancing soil fertility through intercropping: A review of legume-based systems. *Journal of Soil Science and Plant Nutrition, 13*(4), 931–944. https://doi.org/10.4067/S0718-95162013005000068

Monneveux, P., Ribaut, J.-M., & Bolanos, J. (2005). Increase of grain yield and starch synthesis in maize under improving nitrogen status. *Personal Communication.*

Nielsen, R. L. (2011). Leaf area development in maize: Implications for photosynthesis and yield. *Agronomy Journal, 103*(5), 1273–1282. https://doi.org/10.2134/agronj2011.0062

Paponov, I. A., Huber, S. C., & Stroeher, E. (2005). Effect of nitrogen on maize grain filling and yield. *Journal of Plant Nutrition and Soil Science, 168*(6), 759–765. https://doi.org/10.1002/jpln.200521911

Reda, F. H., Ghaleb, M. M., & Abdel-Kader, M. A. (2005). Effect of intercropping ratios on growth and yield of maize and peanut. *Journal of Agricultural Science, 30*(2), 79–88.

Seran, T. H., & Brintha, I. (2010). Review on maize based intercropping. *Journal of Agronomy, 9*(3), 135–145. https://doi.org/10.3923/ja.2010.135.145

Seran, T. H., & Brintha, I. (2010). Review on maize based intercropping [Review article]. *Journal of Agronomy, 9*(3), 135–145. https://doi.org/10.3923/ja.2010.135.145

Undie, U. L., Uwah, D. F., & Attoe, E. E. (2012). Effect of intercropping and crop arrangement on yield and productivity of late season maize/soybean mixtures in the humid environment of South Southern Nigeria. *Journal of Agricultural Science, 4*(2), 37–50.