Sweet corn induced shading reduces groundnut yield and alters dry matter partitioning in a durian-based intercropping system

Mohd Hizwan Ajud, Borhan Abdul Haya#, Sharif Azmi Abdurahman, Azwan Awang, Mohamadu Boyie Jalloh, Clament Chin Fui Seung, Siti Suliza Salamat, Januarius Gobilik, Salumiah Mijin

Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, Sandakan Campus, Mile 10, Sg. Batang, 90000, Sandakan, Sabah, MALAYSIA.

#Corresponding author. E-Mail: borhanyahya@ums.edu.my; Tel: +60 89 248 100 ext. 103880; Fax: +60 89 634 111.

ABSTRACT Intercropping of sweet corn and groundnut is often practiced in young durian orchards to generate income while waiting for durian trees to reach maturity. Groundnut, being a short-duration legume with nitrogen-fixing ability, is commonly paired with corn in such systems. This study was carried out to evaluate the effect of different intercropping arrangements on groundnut yield and dry matter distribution. The field trial was conducted at the Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, using a Randomized Complete Block Design (RCBD) with four treatments: monoculture of sweet corn (T1), monoculture of groundnut (T2), mixed relay intercropping with groundnut planted two weeks before corn (T3), and mixed relay intercropping with groundnut planted three weeks before corn (T4). Only treatments T2, T3, and T4 were considered for analysis of groundnut performance. Results showed that monoculture groundnut (T2) gave significantly higher yield in terms of both fresh and dry weight of marketable pods and seeds compared to the intercropping treatments. The lower yield in T3 and T4 was mainly due to shading from the corn canopy, which reduced light availability to the groundnut plants. While the findings indicate that groundnut performs better as a monocrop, this should be seen as a component-level result. In practice, intercropping with corn in durian orchards may still provide farmers with overall benefits through early cash income, efficient use of land, and soil fertility improvement, even though groundnut yield is reduced.

KEYWORDS: Groundnut, Sweet Corn, Intercropping, Monoculture, Yield, Pod

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INTRODUCTION

Durian (*Durio zibethinus Murr*.), known as the "King of Fruits," is highly popular and economically important in Malaysia for its large size, strong aroma, and thorny shell. Native to Southeast Asia, it thrives in tropical climates with temperatures of 27–30°C and humidity of 75–80% (Subhadrabandhu *et al*., 2001). As durian trees take five to six years to bear fruit, intercropping with short-cycle crops such as groundnuts and sweet corn can help provide farmers with supplemental income. Intercropping has been increasingly recognized for its benefits, such as improving soil fertility, pest control, and overall agricultural sustainability (Vandermeer, 1989). This practice can offer a viable solution to mitigate the long wait for durian crops while boosting local food production in Malaysia (Leong *et al*., 1996).

The economic viability of sweet corn and groundnut intercropping in durian orchards was demonstrated by Mappah *et al*. (2025). While the system is profitable, the performance and physiological responses of the groundnut component require further investigation. Therefore, this study aims to examine the effects of intercropping corn and groundnut on dry matter partitioning and groundnut yield. As durian cultivation continues to grow in Malaysia, it is important to find complementary crops that support both income generation and environmental health (Safari *et al*., 2018). Intercropping systems, by promoting efficient use of resources and enhancing soil quality, could play a crucial role in improving the profitability of durian farms while also providing farmers with an additional source of income.

Therefore, understanding the impact of intercropping on groundnuts growth and yield is essential for optimizing farming practices in durian orchards.

METHODOLOGY

Experimental Site and Study Period Description

This study was conducted on an area of 749.7 m² (31.9m x 23.5m) located in the durian orchard plot of the Faculty of Sustainable Agriculture, Universiti Malaysia Sabah (UMS), Sandakan Campus. The terrain of this area is hilly with a slight slope. The field experiment was conducted from July to October 2024.

Treatments and experimental design

The study involved four different cropping systems: monoculture of sweet corn (T1), monoculture of groundnut (T2), mixed relay intercropping (groundnut planted two weeks before sweet corn) (T3), and mixed relay intercropping (groundnut planted three weeks before sweet corn) (T4). The objective of this study was to examine the effects of different cropping systems on groundnut yield. Therefore, only T2, T3, and T4 were included in the analysis.

The experimental design employed a Randomized Complete Block Design (RCBD) with four replications per plot. Each research block consisted of four plots, with a 1.3-meter spacing between plots and a 5.3-meter spacing between blocks. The dimensions of each plot were 4.9 meters by 4 meters, and each plot was subdivided into three subplots, each 1.2 meters wide. Sweet corn was planted with a spacing of 30 cm x 30 cm, while groundnut was also planted at the same spacing of 30 cm x 30 cm. Additionally, a 20 cm planting distance was maintained between sweet corn and groundnut. This layout was designed to ensure proper plant spacing, facilitating effective plant management and accurate data collection throughout the study.

Planting Materials and Planting Procedure

The groundnut and sweet corn seeds were purchased from the nearby agricultural store in Sandakan, Sabah. Agronomical practices such as planting material preparation, site selection, and land preparation were based on Jabatan Pertanian Pulau Pinang (2020).

Parameter and statistical analysis

The parameters for this study are divided into five components: marketable pod weight, non-marketable pod weight, marketable seed weight, non-marketable seed weight, and pod shell weight of groundnuts. The dry weight production parameters include the marketable and non-marketable pod weights, marketable and non-marketable seed weights, and empty pod shells. These are further measured as percentages: the marketable pod dry weight rate, non-marketable pod dry weight rate, marketable seed dry weight rate, non-marketable seed dry weight rate, and pod shell dry weight rate. These rates are calculated using the formula: (weight of component) / (total weight) x 100. The method of analysis above is based on Borhan *et al.* (2017).

All data collected in this study were analysed using Analysis of Variance (ANOVA) to assess the effects of various designated intercropping systems on groundnut yield and dry weight distribution. Tukey's test was applied at a 5% significance level to determine significant differences between treatments.

RESULT

Dry Weight of Groundnut Pods

The dry weight of groundnut pods is influenced by different types of cropping systems (Figure 1). The total pod weight and marketable pod weight were significantly higher in T2 compared to T3. However, the non-marketable pod weight was not affected by any of the cropping systems introduced.

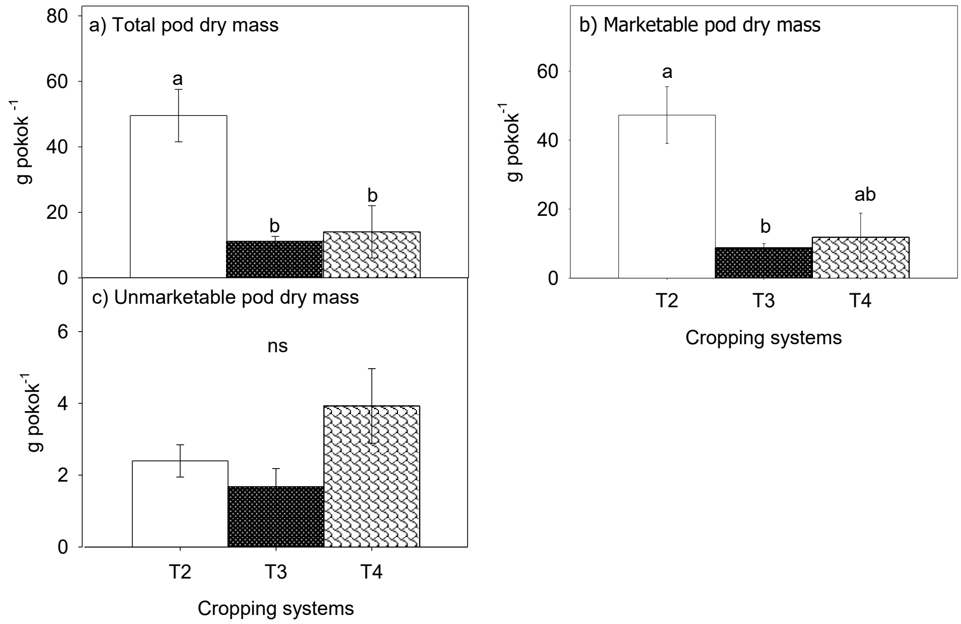

Figure 1. Dry weight of groundnut pods under different cropping systems at maturity. T2 = monoculture (control), T3 and T4 = mixed relay intercropping (groundnut planted 2 and 3 weeks before sweet corn, respectively). Different letters indicate significant differences ($p \leq 0.05$); means of four replications; ns = not significant.

Dry Weight of Marketable Groundnut Pod Parts

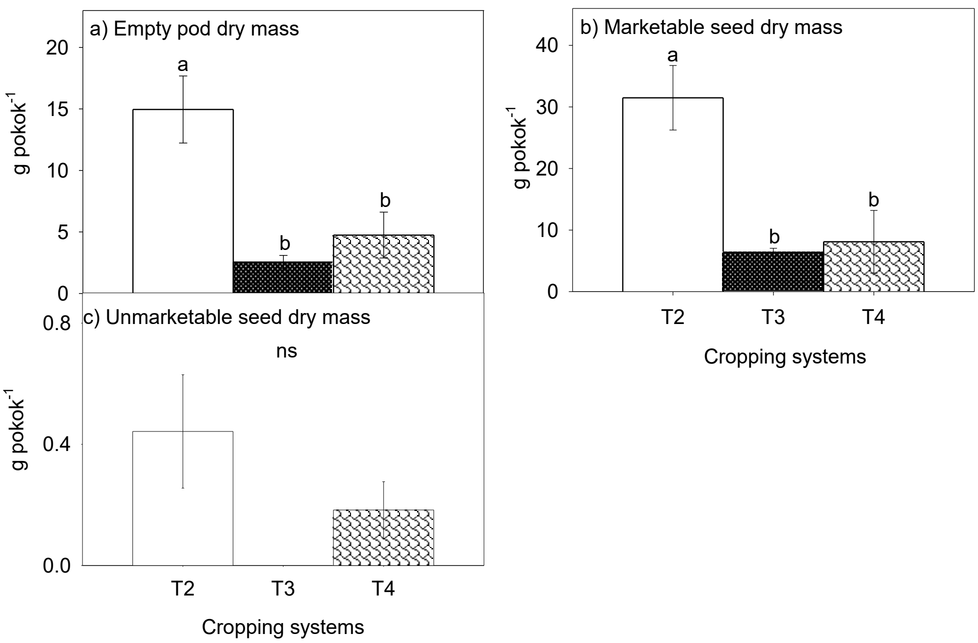

Figure 2. Dry weight of marketable groundnut pod parts under different cropping systems at maturity. T2 = monoculture (control), T3 and T4 = mixed relay intercropping (groundnut planted 2 and 3 weeks before sweet corn, respectively). Different letters indicate significant differences ($p \leq 0.05$); means of four replications; ns = not significant.

The effect of different cropping systems on the dry weight of marketable groundnut pod parts at maturity is shown in Figure 2. The empty pod shells and marketable seeds were significantly higher in S2 compared to the other cropping systems. However, the non-marketable seeds were not significantly affected by any of the cropping systems used.

Dry Weight Ratio of Marketable Groundnut Pods

The effect of different cropping systems on the dry weight distribution of all groundnut pod parts at harvest is shown in Figure 3. All the measured parameters did not show any significant effect due to the cropping systems used.

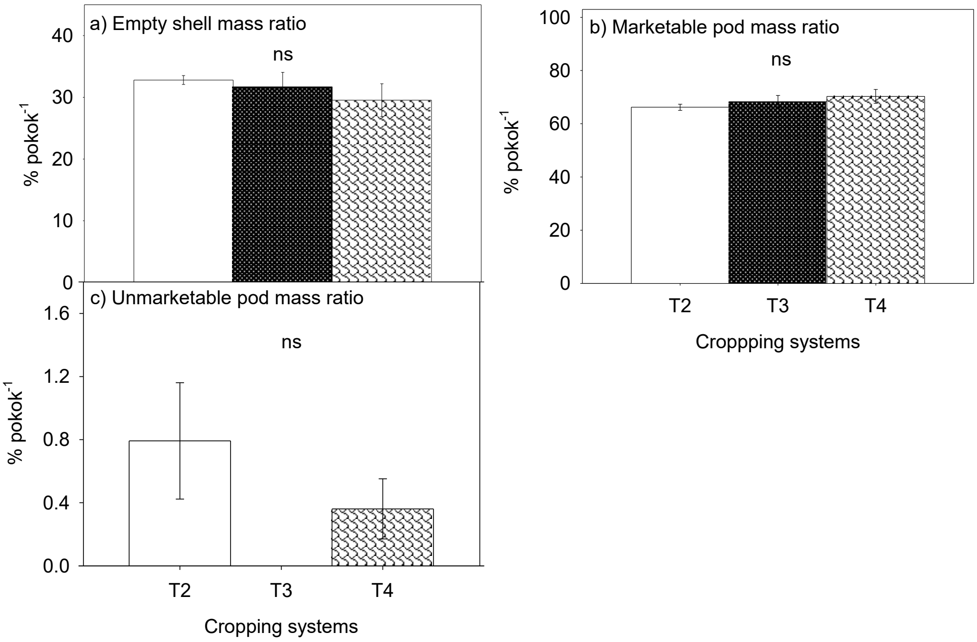

Figure 3. Dry weight ratio of marketable groundnut pods under different cropping systems at maturity. T2 = monoculture (control), T3 = mixed relay intercropping (groundnut planted 2 weeks before sweet corn), T4 = mixed relay intercropping (groundnut planted 3 weeks before sweet corn). Different letters show significant differences ($p \leq 0.05$); means of four replications; ns = not significant.

Fresh Weight of Marketable Pods and Seeds

The fresh wet weight of both marketable pods and seeds was significantly higher in S2 compared to S3 and S4 as presented in **Figure 4.**

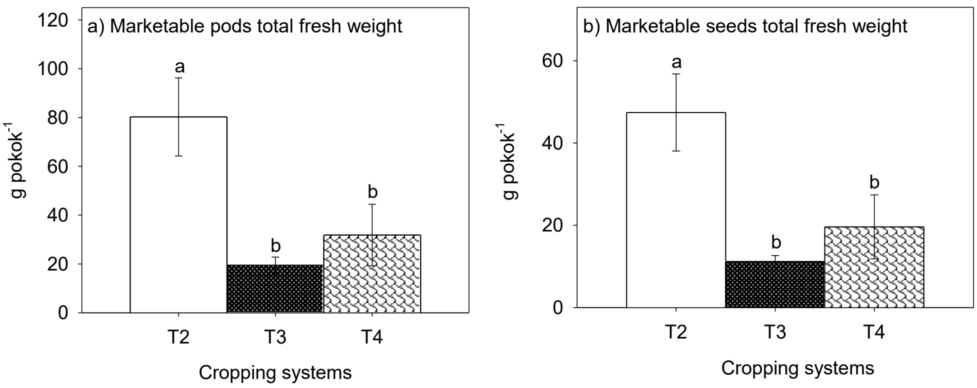

Figure 4. Fresh weight of marketable pods and seeds under different cropping systems at maturity. T2 = monoculture (control), T3 = mixed relay intercropping (groundnut planted 2 weeks before sweet corn), T4 = mixed relay intercropping (groundnut planted 3 weeks before sweet corn). Different letters show significant differences ($p \leq 0.05$); means of four replications; ns = not significant.

Table 1. Correlation relationship between various parameters related to the production and dry mass distribution of groundnut at the harvesting stage.

Parameter	MarP	Non MarP	TotP	EmPSh	MarSd	Non MarSd	EmPShR	MarSdR	NonMarSdR	PFW
NonMarP	0.33									
TotP	0.99***	0.40								
EmPSh	0.99***	0.27	0.99***							
MarSd	0.99***	0.37	0.99***	0.98***						
NonMarSd	0.75**	0.05	0.74***	0.79**	0.72**					
EmPShR	0.07	-0.18	0.05	0.15	0.02	0.15				
MarSdR	-0.22	0.15	-0.21	-0.31	-0.17	-0.35	-0.98			
NonMarSdR	0.79**	0.14	0.77**	0.81**	0.75**	0.99***	0.13	-0.32		
PFW	0.96***	0.38	0.96***	0.96***	0.96***	0.64**	0.12	-0.25	0.684**	
MarPFW	0.97***	0.35	0.99***	0.99***	0.99***	0.74**	0.09	-0.24	0.777**	0.98***

Notes: MarP = Marketable pod; NonMarP= Non-marketable pod; TotP = Total pods; EmPSh = Empty pod shell; MarSd = Marketable seed; NonMarSd = Non-marketable seeds; EmPShR = Empty pod shell ratio; MarSdR= Marketable seed ratio; NonMarSdR= Non-marketable seed ratio; PFW= Pod fresh weight; MarPFW= Marketable pod fresh weight. *, **, *** indicate significance at $p \leq 0.05$, $p \leq 0.01$, and $p \leq 0.001$, respectively, while growth parameters without * indicate no significant correlations. The values represent the means of four replicates.

DISCUSSION

Marketable Pods

Marketable pods showed a positive effect on the cropping system (T2). The highest marketable groundnut pod weight was 166.04 g ± 8.23 for T2, while the lowest marketable pod weight was 37.84 g ± 1.19 for T3. T4 showed a marketable pod weight of 67.58 g ± 6.99. A similar finding by Evans (1960) reported that the range for marketable pod dry weight was 106-126 g. Additionally, Salisu *et al.* (2022) found that groundnut yields were higher in monoculture compared to intercropping systems. Manasa *et al.* (2018) also stated that monoculture systems for groundnut yield better results compared to intercropping between groundnut and corn. This is because intercropping does not have a positive effect on groundnut but benefits corn growth.

The production of non-marketable pods was positively influenced by T4, which had 11.48% fewer non-marketable pods than T2 and 61.9% fewer than T3. The T2 system improved groundnut yield, as groundnuts are sensitive to shading, which impacts growth and yield (Adjahossou *et al*., 2008). This system reduces competition for sunlight, allowing better growth. Bugilla *et al.* (2023) observed that monoculture groundnuts produced more branches early on compared to intercropped groundnuts, which were shaded by taller plants like sweet corn, hindering branching. Monoculture allows optimal growth without shading or space competition.

Dry Weight of Marketable Groundnut Pods

The marketable groundnut seeds in the T2 cropping system showed a positive effect, with the highest seed weight recorded at 109.52 g ± 5.24 for T2, compared to 25.52 g ± 0.65 for S3 and 67.58 g ± 5.09 for T4. The T2 system had 99.2% marketable seeds, while T3 had 50% and T4 had 160.6%. The dry weight of marketable groundnut pods showed similar results, as both parameters were highly correlated (r = 0.99***). This suggests that although sweet corn in intercropping systems was planted 2 to 3 weeks later, it still caused shading stress on the groundnuts. Shading negatively affects groundnut growth by reducing sunlight needed for photosynthesis, leading to slower growth and lower yields. A lack of light also disrupts flower formation and pollination, reducing pod production (Noertjahyani *et al*., 2020).

Intercropping between groundnuts and sweet corn affects light interception, with groundnuts receiving less sunlight due to the corn canopy, which lowers their photosynthesis rate and negatively impacts their growth and yield (Feng *et al*., 2021). These findings support the idea that groundnuts require ample sunlight to thrive and do not perform well in shaded conditions. Higher sunlight intensity increases groundnut photosynthesis, enhancing their growth (Hunt, 2003). A strategy to improve groundnut growth in intercropping is adjusting planting dates. Aksarah *et al.* (2022) demonstrated that planting groundnuts four weeks earlier results in better growth, as the earlier-planted groundnuts are not shaded by the corn canopy.

Fresh Weight of Marketable Pods and Seeds

The fresh weight of marketable pods and seeds responded positively to the T2 system, with the highest fresh weights of 320.79 g and 109.52 g, respectively, compared to the lowest of 77.80 g and 25.52 g for T3. T2 had 101.1% and 99.4% higher fresh weights than T3, and 88.5% and 63.9% higher than T4. These results suggest that mixed intercropping systems significantly influence key processes like photosynthesis (Cardona, 2018). Adjustments in planting distances, times, and crop selection enhance light interception efficiency. Li *et al.* (2019) noted that tall corn canopies reduce light reaching groundnut plants, which negatively impacts groundnut yield, despite higher corn yields in intercropping. Additionally, legumes in corn rows improve soil fertility by fixing nitrogen, benefiting both crops (Zhang *et al*., 2019).

This suggests that as the dry weight of pods increases, so does their fresh weight (r = 0.99***). Similarly, as the dry weight of groundnut seeds increases, so does their fresh weight (r = 0.96***). A similar finding was reported by Raza *et al.* (2019), who found that intercropped groundnuts received less light energy, which reduced the efficiency of photosynthesis. As a result, the plants produced fewer carbohydrates for growth and pod filling. The results indicate that mixed relay intercropping of groundnut and sweet corn is not suitable for groundnut yield production.

CONCLUSION

The T2 (monoculture) cropping system produced the highest groundnut yields, with greater pod weight, dry weight, and fresh weight compared to the mixed relay intercropping systems (T3 and T4), where competition for space and sunlight reduced growth and productivity. Groundnuts require ample sunlight for efficient photosynthesis, and the monoculture system provided optimal conditions, whereas intercropping with corn limited light availability, resulting in slower growth and lower yields. Therefore, farmers are advised to adopt the monoculture system (T2) for groundnut cultivation, as it ensures better productivity than mixed relay intercropping with corn. It is recommended that while monoculture is best for maximizing groundnut yield, intercropping systems may offer greater overall profitability at the system level, as supported by previous studies. Information in this study, provides the physiological basis for understanding the trade-off between groundnut yield and system profitability.

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