

Vegetative Growth of Ratooned Sugarcane and Yield of Cowpea (*Vigna unguiculata* (L.) WALP) with Mykovam Application under Intercropping System

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ABSTRACT

Intercropping and biofertilizer application are sustainable agricultural practices that increase farm productivity by improving the yield performance of components involved in the production system. This on-farm trial determined the effect of intercropping and Mykovam application to the yield of two cowpea varieties and vegetative growth of ratooned sugarcane. Intercropping cowpea to ratooned sugarcane reduced its plant height at the tillering stage, but the effect was not lasting. Moreover, it did not affect the yield predictive parameters of sugarcane. Intercropping Cp5 cowpea variety with ratooned sugarcane did not affect its maturity, yield, and harvest index. On the other hand, intercropped Cp3 cowpea variety matured earlier, had higher yield and harvest index. Mykovam application did not improve yield of cowpea, and land equivalent ratio (LER). Thus, Mykovam application is not necessary to improve the yield of cowpea and reduce the effect of intercropping on ratooned sugarcane. However, it is recommended that a follow-up study should cover the full cropping cycle of sugarcane, intercropping varying crops coupled with production management that minimize competition with sugarcane leading to an increased yield of both crops; cost-benefit analysis at the cropping pattern level is also recommended for a holistic approach.

Keywords: *Vigna unguiculata* (L.) WALP, sugarcane, intercropping, vesicular-arbuscular mycorrhiza

INTRODUCTION

Negros Occidental is considered as the sugar capital of the Philippines. From the total land area of 792,607 hectares, 190,213 hectares were cultivated to sugarcane in 2016 which contributed 52.47 % of the total sugarcane production in the Philippines (Philippine Statistics Authority, 2017). The usual practice is monocropping sugarcane which decreases the productivity and profitability of the farm over time. Thus, intercropping in newly planted or ratooned sugarcane is one of the options that provide additional income to the farmer while ameliorating the soil. This is because intercropping well-suited crop enhances sugarcane productivity (Alam *et al.*, 2015).

Crop diversification is an important decision for

every farm family. Sometimes, it is considered as a risk for those sugarcane farmers who have been practicing monocropping for a long time, but farmers need to understand that intercropping improves the quality of life in the farming community by raising income levels, provides employment and increases food security (Martin and Voldeng, 1987). Small scale cane growers who want to produce additional crops for food security or income while waiting for the sugarcane to mature can plant maize and cabbage in intermittent rows rather than cultivating them in a separate piece of land (Parsons, 2003).

Cowpea (*Vigna unguiculata* L. Walp) is widely cultivated for seed, young shoots/leaves, green and tender pods and immature seeds for human consumption and animal feed. As feeds, cowpea can be

in a form of silage or fresh roughages. Cowpea adapts to different types of soil and intercropping system. It also improves soil fertility and prevents soil erosion. Intercropping cowpea to sugarcane can increase the productivity of the sugarcane farm.

Biofertilizer application to intercrops is one of the management practices that lead to producing more without significantly adding production cost to farming. Biofertilizers can have direct or indirect beneficial effects on plant growth and crop yield (Ramirez *et al.*, 2005). Mykovam is a soil-based biological fertilizer containing spores, infected roots, and propagules of beneficial vesicular-arbuscular mycorrhizal fungi. It helps roots absorb water and nutrients, particularly phosphorus. It can also replace 60–85% of the chemical fertilizer requirement of plants. Mykovam can be used on crops such as vegetables, root crops, fruit trees, and forest trees except for pines and dipterocarps (UPLB, 2017).

An on-farm trial was conducted to evaluate the effect of intercropping and application of Mykovam to the yield of two cowpea varieties and vegetative growth of ratooned sugarcane. Specifically, this study determined the effect of intercropping cowpea applied with Mykovam to sugarcane's vegetative growth and to evaluate the yield of two cowpea varieties applied with Mykovam which were intercropped to ratooned sugarcane.

MATERIALS AND METHODS

The study was conducted at La Granja Research and Training Station, La Carlota City, province of Negros Occidental from November 2015 to March 2016.

Experimental Design, Treatment and Layout

The field experiment was laid out in a Randomized Complete Block Design (RCBD). A total of 27 plots were utilized in this study and each plot measurement was 20 m².

To evaluate the effect of intercropping two cowpea varieties applied with Mykovam to vegetative growth of ratooned sugarcane, a total of 5 treatment combinations replicated three times were analyzed. These treatments were: (1) sugarcane intercropped with Cp3 cowpea variety applied with Mykovam; (2) sugarcane intercropped with Cp5 cowpea variety applied with Mykovam; (3) sugarcane intercropped with Cp3 cowpea variety without Mykovam application; (4) sugarcane intercropped with Cp3 cowpea variety without Mykovam application; and

(5) monocropped sugarcane.

To determine the effect of intercropping and Mykovam application to two cowpea varieties, eight treatment combinations replicated three times were used: (1) intercropped Cp3 cowpea variety applied with Mykovam; (2) intercropped Cp5 cowpea variety applied with Mykovam; (3) intercropped Cp3 cowpea variety without Mykovam application; (4) intercropped Cp5 cowpea variety without Mykovam application; (5) monocropped Cp3 cowpea variety applied with Mykovam; (6) monocropped Cp5 cowpea variety applied with Mykovam; (7) monocropped Cp3 cowpea variety without Mykovam application; and (8) monocropped Cp5 cowpea variety without Mykovam application.

Land preparation

Land preparation started with the clearing of the area followed by furrowing using water buffalo drawn plow. The sugarcane utilized in this experiment was on the second ratoon. In the intercropping pattern, two furrows for cowpea were drawn in between two rows of sugarcane, 25 cm away from sugarcane rows. In the monocropping pattern, furrows were drawn 50 cm away from each other after clearing the area.

Planting of intercrops and application of Mykovam

In between two rows of sugarcane, two rows of cowpea with a planting density of 12 plants linear meter⁻¹ were planted in drill method. Five grams of Mykovam per hill was applied before sowing of cowpea seeds.

Harvesting

First priming for cowpea was done 53 days after planting. Harvesting was done manually by holding the stem end before twisting the pod free. Priming was done thrice with 3 days intervals.

Estimation of sugarcane tonnage, ton ha⁻¹ (Hombrebueno, 1980)

Using the tiller count at 117 days after stubble shaving (DASS), the period when the sugarcane reached its maximum tillering capacity:

Estimated tonnage = $P (100 - CF)$

Where:

P = the average number of millable stalks per square meter x average weight of stalk (theoretical) x 10,000

m² per hectare divided by 1000 kilograms per ton.
 CF = (Correction Factor) the expected losses expressed in percentage due to factors that may affect tonnage at the time the estimate was made.

Correction factors are:

Rat damage = 10%
 Ratooning = 20%
 Missing hills = 5 %
 Lodging of Canes = 3%
 Total = 38%

Statistical Analysis

Analysis of Variance (ANOVA) was done using the Statistical Tool for Agricultural Research (STAR) Software (IRRI, 2014). In significant treatments and interactions, Tukey's Honest Significant Difference (HSD) test was used to determine differences at a 5% level.

RESULTS AND DISCUSSION

Intercropping offers advantages to subsistence-oriented farm household. It enhances the diversity of farm product and increases the stability of farm productivity which satisfies the minimum food requirement of a farming family. One of the important

factors in the success of intercropping is minimizing the competition in which the peak demand for limited environmental resources in one crop does not coincide with that of the other (Gomez and Gomez, 1983).

Effect of Intercropping and Mykovam Application to Intercropson Vegetative Growth of Sugarcane

Sugarcane growth has four phases: germination phase from 0 to 35 days after planting or stubble shaving (DASS), a vegetative phase that includes tillering that starts from 36 to 120 DASS, grand growth phase from 121 DASS to 270 DASS, and ripening and maturation phase from 271 DASS to 360 DASS. The observations done for sugarcane were until 117 DASS, 30 days after intercrops were harvested and the sugarcane already reached its maximum tillering capacity.

Plant height. The effect of intercropping on the plant height of sugarcane was only evident sixty-eight days after stubble shaving (Fig. 1). Reduction in plant height of sugarcane intercropped with Cp3 cowpea variety without Mykovam was apparent. On the other hand, application of Mykovam on intercropped cowpea varieties did not affect the plant height of sugarcane. The negative effect of intercropping with cowpea, however, was already no longer evident 117 days after stubble shaving.

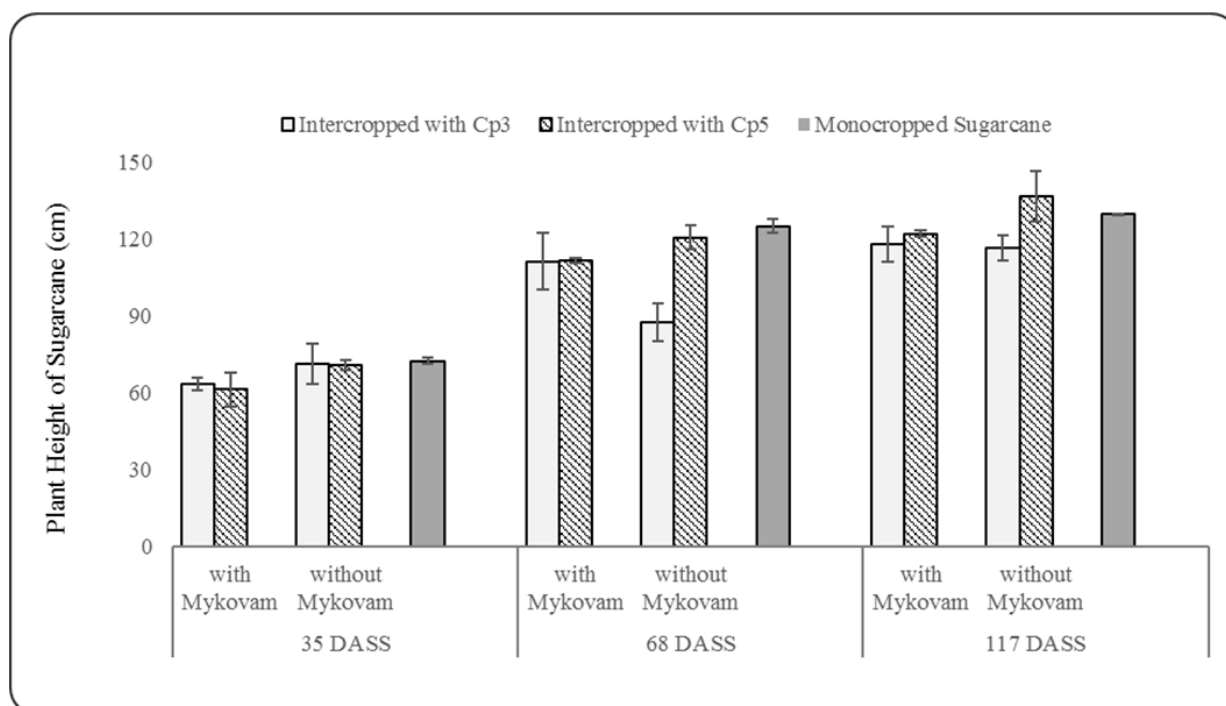


Figure 1. Plant height of ratooned sugarcane intercropped with two cowpea varieties applied with Mykovam ($p = 0.05$, $n=15$).

Intercropping Cp3 cowpea variety to ratooned sugarcane only hindered the vertical growth of sugarcane at 68 DASS. The reduction on vertical growth of sugarcane can be attributed to the branching habit and stage of intercropped Cp3 cowpea variety. At 68 DASS, Cp3 cowpea was in the fruiting stage and was branching out aggressively, limiting the sugarcane sunlight and nutrients.

Leaf area index. Leaf area index of sugarcane at 117 DASS, one month after harvesting of intercrops,

was not affected by intercropping cowpea with or without Mykovam application (Fig.2). The same leaf area index of sugarcane intercropped with cowpea varieties and monocropped sugarcane at 117 DASS was due to compensatory leaf area development of intercropped sugarcane after intercrops were harvested at 70 DASS. Sugarcane had to recover via tiller production and recovery lasted up to two months after harvesting the intercrops (Mendoza, 1986).

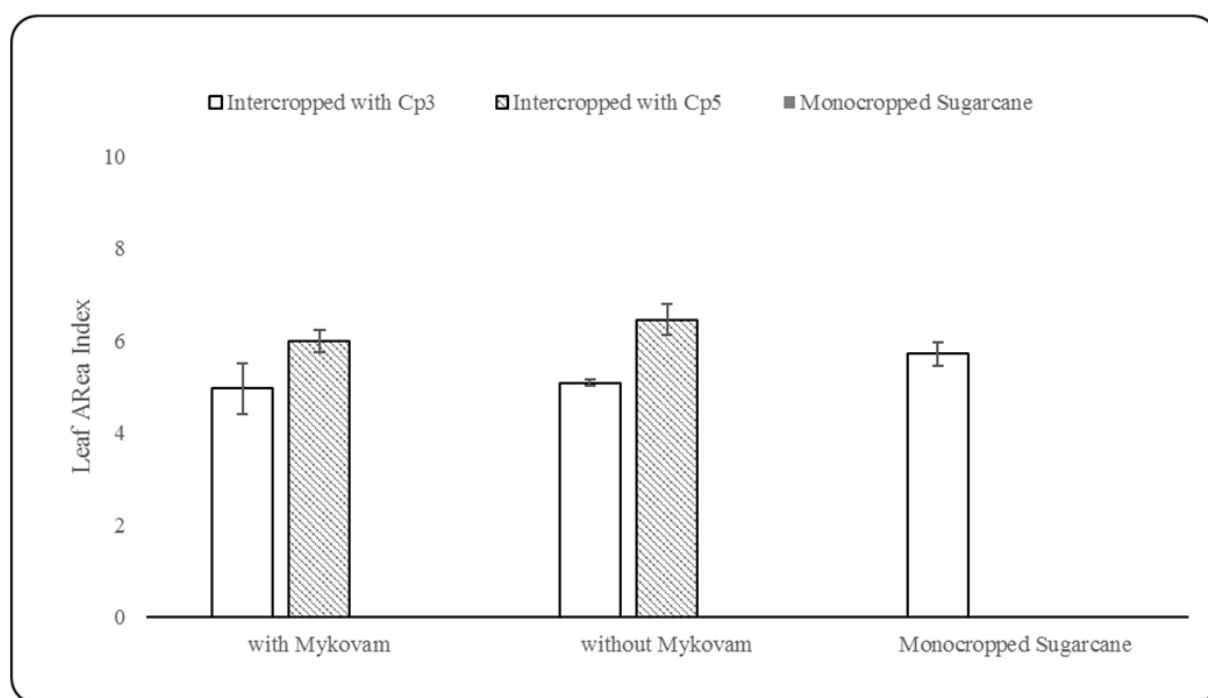


Figure 2. Leaf area index of ratooned sugarcane intercropped with two cowpea varieties applied with Mykovam ($p = 0.05$, $n=15$).

Chlorophyll Content. Reduction in chlorophyll content marks the start of leaf senescence to sugarcane (Bassi *et al.*, 2018). Intercropping Cp3 cowpea variety applied with Mykovam to ratooned sugarcane at 68 DASS decreased its chlorophyll content (Fig. 3). Reduction of chlorophyll content on the leaves of sugarcane intercropped with Cp3 cowpea applied with Mykovam was the competition effect of sugarcane and cowpea intercropping which was enhanced with Mykovam application to cowpea. Generally, this root interaction effect can be inhibited by increasing the fertilization level on the affected crop (Zhang *et al.*, 2013).

Plant fresh weight. This is the above-ground biomass of sugarcane increased when intercropped with

two cowpea varieties. However, when Mykovam was applied to Cp3 cowpea variety intercropped to sugarcane, the plant fresh weight of sugarcane was reduced (Fig. 4). This reduction of above ground biomass production of sugarcane implies that Mykovam application to Cp3 cowpea enhanced the canopy development of Cp3 cowpea creating a shading effect on the sugarcane. Shading can significantly reduce biomass production of sugarcane because the amount of radiation intercepted by the plant determined the rate of photosynthesis which will dictate the rate of plant growth (Murchie and Reynolds, 2013). The higher the canopy produced by Cp3 cowpea, the lesser would be the light intercepted by the sugarcane resulting in decreased above ground biomass production in intercropping system.

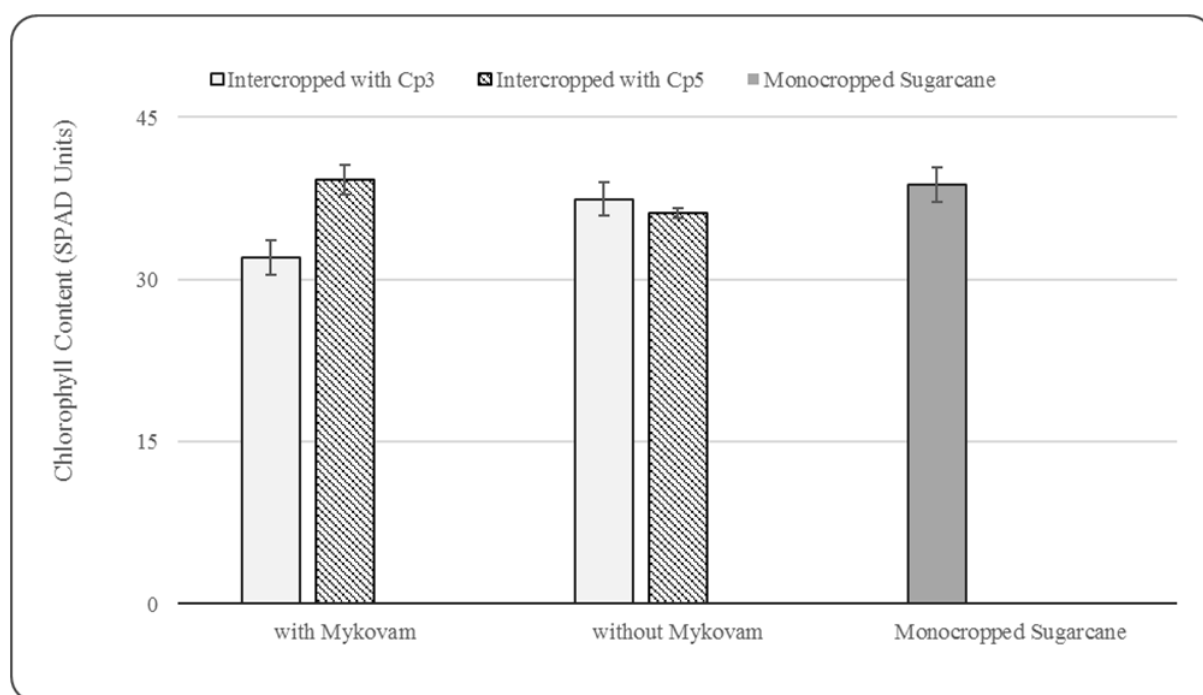


Figure 3. Chlorophyll content of ratooned sugarcane intercropped with different cowpea varieties applied with Mykovam ($p = 0.05$, $n=15$).

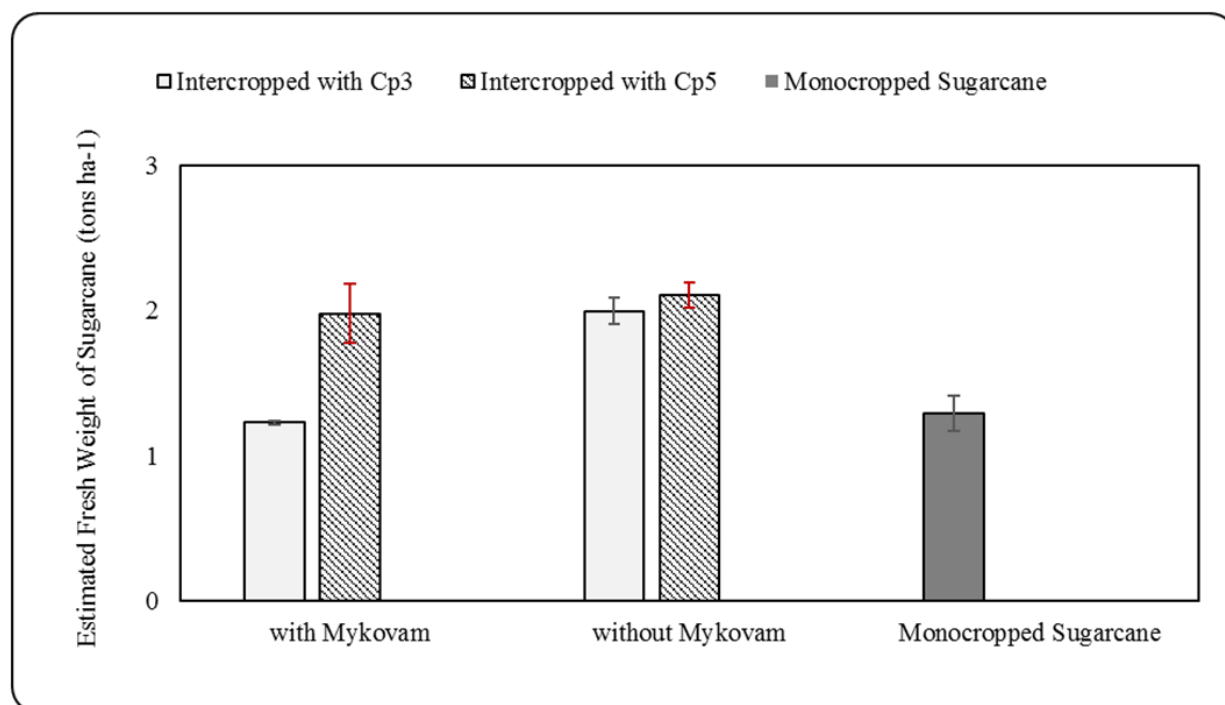


Figure 4. Estimated fresh weight of ratooned sugarcane intercropped with two cowpea varieties applied with Mykovam ($p = 0.05$, $n=15$).

Yield Predictive Parameters of Sugarcane

Stalk length, number of internodes, stalk girth and tiller number. These are important parameters that predict the yield of sugarcane. Intercropping cowpea varieties applied with Mykovam to ratooned sugarcane did not affect its stalk length, number of internodes, and tiller number production. Intercropping Cp3 cowpea variety to ratooned sugarcane reduced the stalk girth of sugarcane, but the negative effect was reduced when Mykovam was applied to Cp3 cowpea. (Fig. 5). On the other hand, Mykovam application to intercropped Cp5 cowpea variety resulted in smaller stalk girth of sugarcane. With these responses of sugarcane, it is important to know the effect on intercrops of different nutrient management practices employed to them to minimize the negative effect on sugarcane.

Estimated tonnage yield. This study only focused on the vegetative growth of sugarcane; however, sugarcane tonnage can be estimated before harvesting. The formula utilized was developed by Hombrebueno (1980) using the final tiller count. The estimation was done using the theoretical stalk weight of VMC 84-524 provided by the National Seed Industry Council. Intercropping cowpea varieties and Mykovam application to intercrops did not affect the estimated sugarcane tonnage yield of sugarcane. Although there are negative effects on other parameters of sugarcane during early vegetative phase, the effect was not lasting because sugarcane recovered after intercrops were harvested. This is a manifestation that with the proper timing, intercropping cowpea to sugarcane with or without Mykovam application is an acceptable practice.

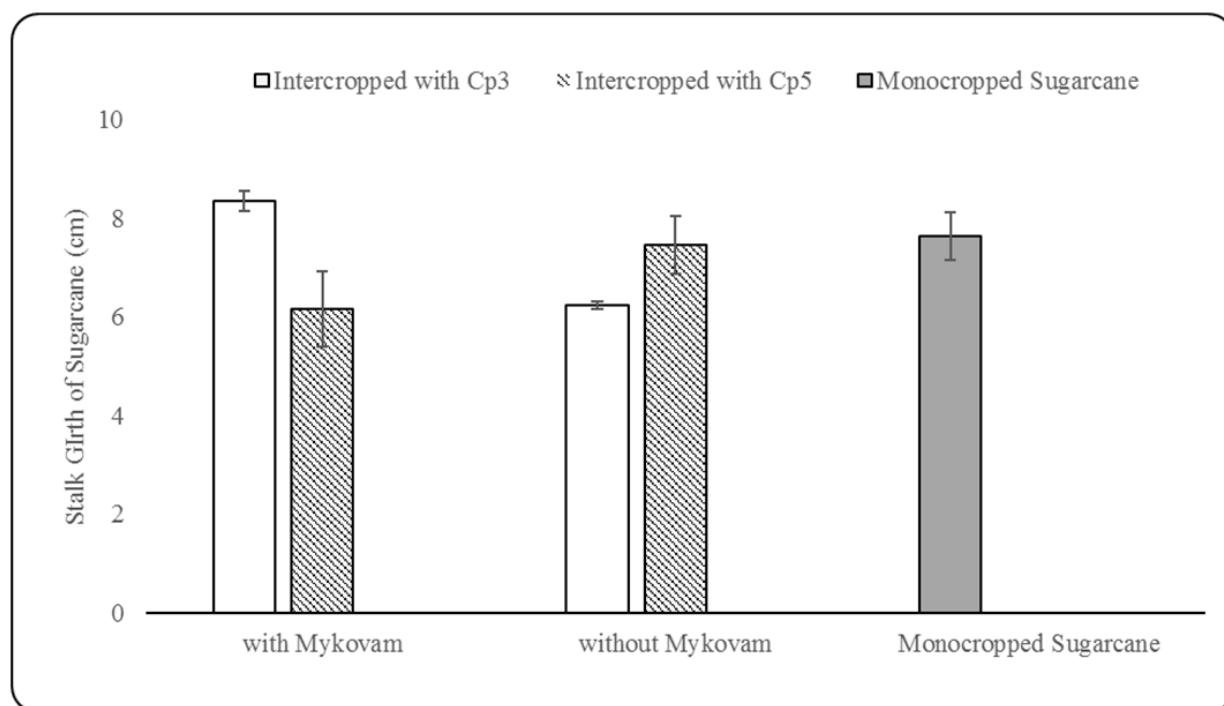


Figure 5. Stalk girth of ratooned sugarcane intercropped with two cowpea varieties applied with Mykovam ($p = 0.05$, $n=15$).

Yield of intercropped cowpea applied with Mykovam

Number of days to flower. Cp5 cowpea variety with or without Mykovam application matured earlier than Cp3 cowpea variety, whether monocropped or intercropped to ratooned sugarcane. However, Cp3 cowpea variety matured earlier in intercropping than in monocropping (Fig. 6). This response of Cp3 cowpea variety suggests that the microclimate

in intercropping system is favorable for its early maturity. Mykovam application to cowpea varieties does not influence the number of days to flower of two cowpea varieties.

Yield. One of the contributing factors in a successful intercropping pattern in sugarcane is selecting the most amenable crop or variety to intercrop. Yield is the most important determinant of the amenability of intercropping cowpea varieties to ratooned

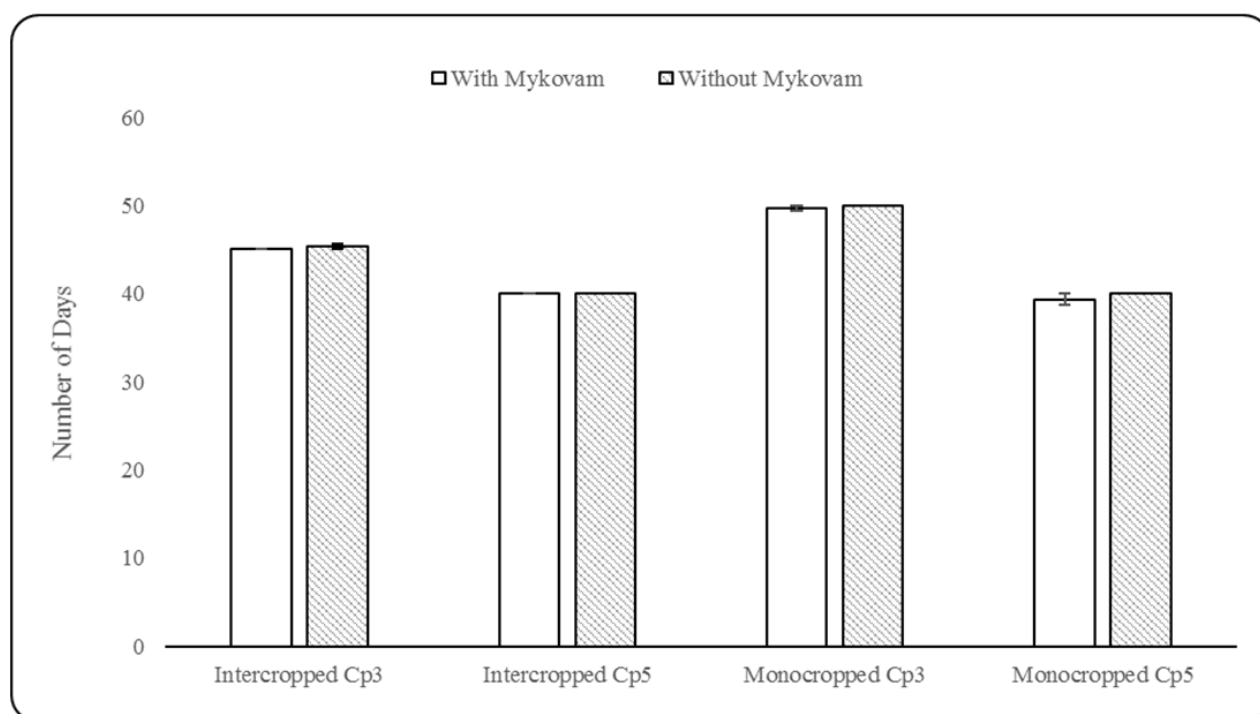


Figure 6. Number of days to flower of cowpea varieties with and without Mykovam intercropped to ratooned sugarcane ($p = 0.05$, $n=24$).

sugarcane. Yield performance is influenced by genetic and external factors. These external factors include physical, chemical, and biological factors (Bareja, 2014). Intercropping to ratooned sugarcane and Mykovam application can be one of the external factors that may either limit or enhance the yield performance of cowpea varieties.

Between two cowpea varieties, Cp5 without Mykovam application produced more yield in both cropping patterns which exhibited the adaptability of this variety to two cropping patterns. On the other hand, Cp3 cowpea variety only increased its yield when intercropped to ratooned sugarcane (Fig. 7). Mykovam application was not effective in increasing the yield of Cp3 cowpea variety in both cropping patterns. On the other hand, Mykovam application to Cp5 cowpea variety reduced its yield. This result is contrasting to increase in dry matter and yield effect of vesicular-arbuscular mycorrhiza (VAM) application to legume (Elsheikh *et al.*, 2000). The reduction on the yield of Cp5 cowpea variety could be attributed to insufficient nutrients in the soil that was available for the crop's utilization since no fertilizer was applied other than Mykovam which was not enough because Mykovam only enhanced roots intake of water and phosphorous (UPLB, 2017).

Harvest index. Harvest index can be a tool in interpreting the response of a crop to different environments and climate change (Hay, 2008). Increase in yield is concomitant to an increase in biomass production; thus, higher harvest index is ideal. Between two cowpea varieties, Cp5 cowpea variety had the highest harvest index in both cropping patterns whether or not Mykovam is applied (Fig. 8). This result implies that Cp5 cowpea variety is highly adaptable in both cropping patterns with or without Mykovam application. Moreover, Mykovam application is not necessary for improving the harvest index of two cowpea varieties in two cropping patterns.

Land equivalent ratio (LER). This is the most common index adopted in intercropping to measure land productivity. Often, this is used as an indicator to determine the efficacy of intercropping (Brintha and Seran, 2009). In intercropping cowpea varieties to ratooned sugarcane, intercropping Cp5 cowpea variety to ratooned sugarcane is more efficient than intercropping Cp3 cowpea variety to the ratooned sugarcane (Fig. 9). Since Mykovam application did not increase the yield of two cowpea varieties, yield being the important parameter in computing for LER, its contribution to the improvement of LER of two cowpea varieties was not observed.

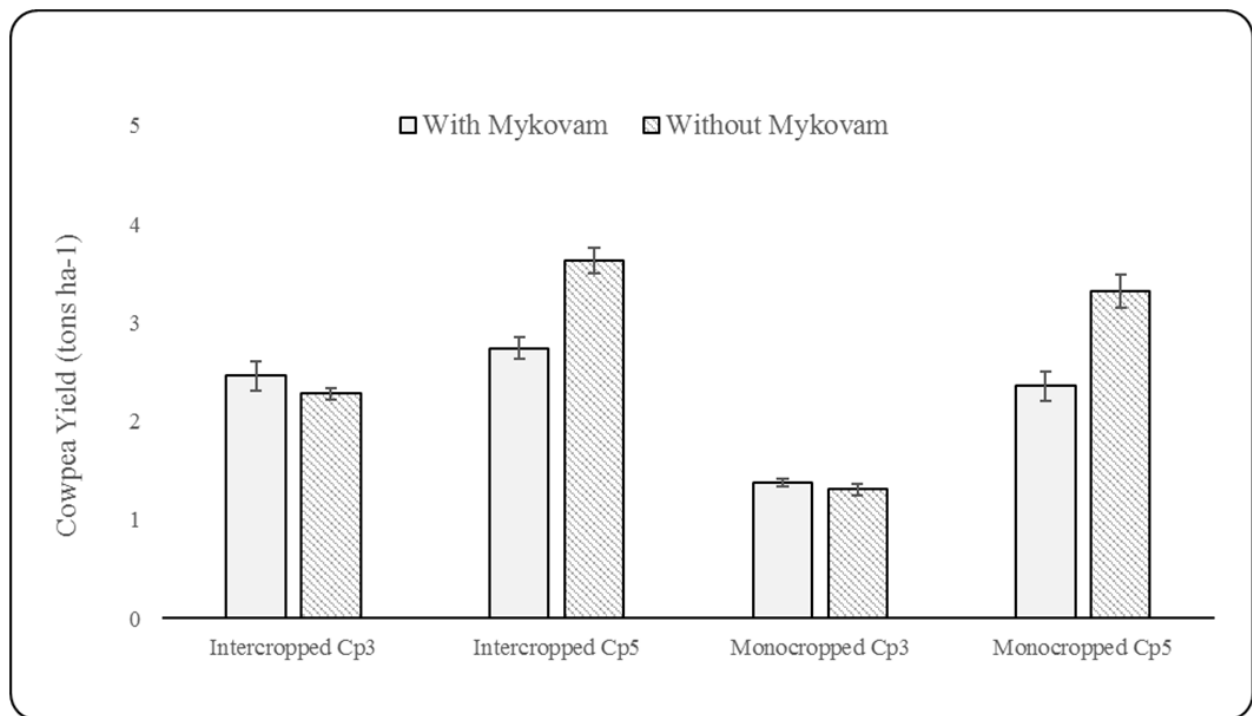


Figure 7. Yield of cowpea varieties with and without Mykovam intercropped to ratooned sugarcane ($p = 0.05$, $n=24$).

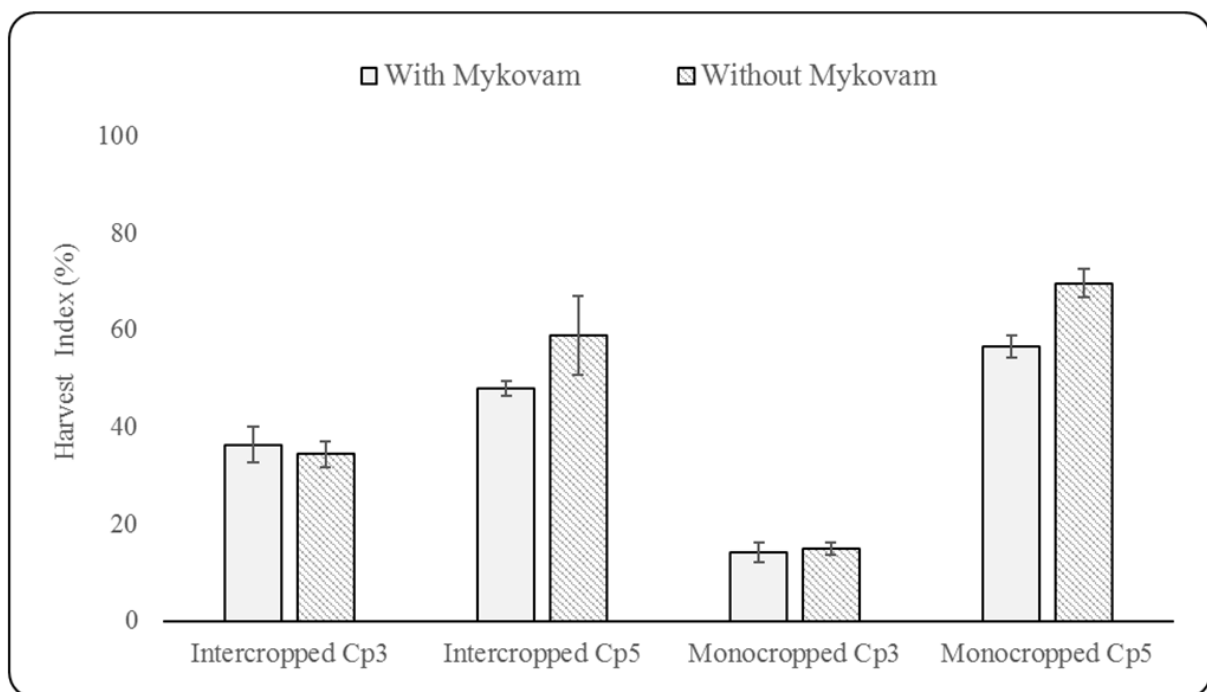


Figure 8. Harvest index of cowpea varieties with and without Mykovam intercropped to ratooned sugarcane ($p = 0.05$, $n=24$).

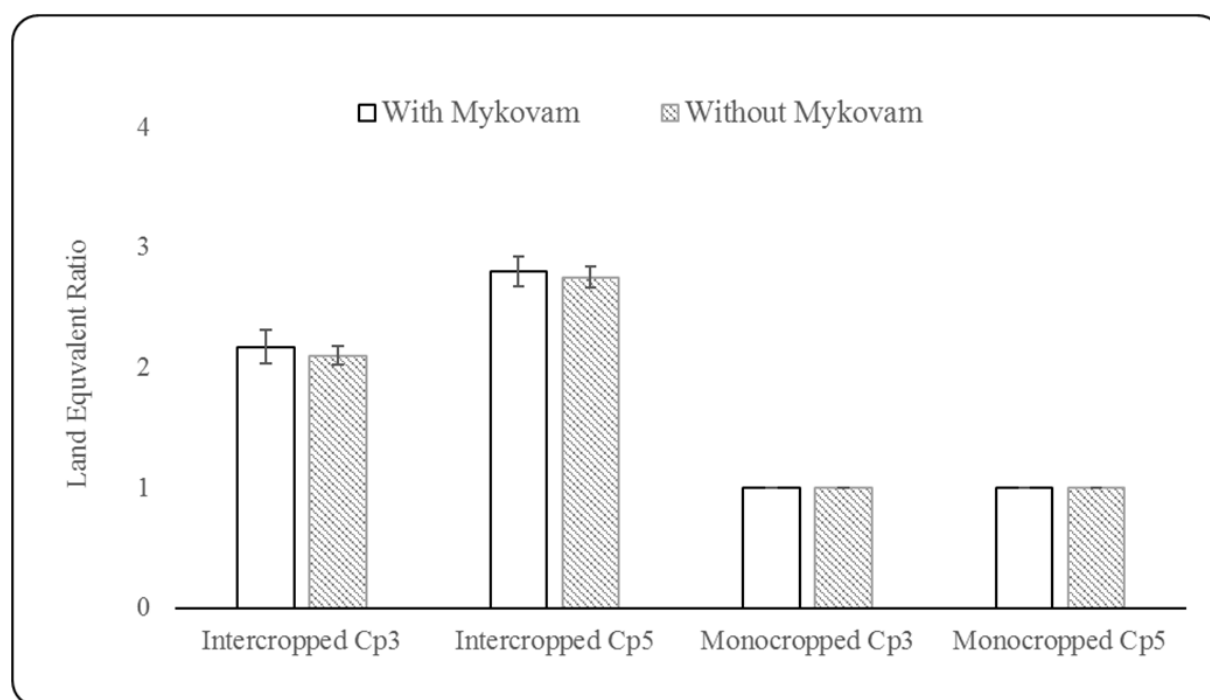


Figure 9. Land equivalent ratio cowpea varieties applied with Mykovam intercropped to ratooned sugarcane ($p = 0.05$, $n=24$).

SUMMARY AND CONCLUSION

Ratooned sugarcane takes 3 months for its canopy to close, allowing intercropping of short duration crops to improve the productivity of the area. One of the important factors in the success of intercropping is minimizing the competition in which the peak demand for limited environmental resources in one crop does not coincide with that of the other (Gomez and Gomez, 1983). Intercropping cowpea varieties to ratooned sugarcane reduced plant height at 117 days after stubble shaving, but the effect was minimized when cowpea varieties were harvested. Leaf area index (LAI) and yield predictive parameters *i.e.* stalk length, number of internodes, stalk girth, and tiller number of sugarcane were not affected by intercropping cowpea varieties nor Mykovam application to intercrops. On the other hand, intercropping Cp3 cowpea variety applied with Mykovam reduced the chlorophyll content and plant fresh weight of ratooned sugarcane. Intercropping with ratooned sugarcane did not affect the maturity, yield, and harvest index of Cp5 cowpea variety. On the other hand, intercropping shortened the vegetative stage and increased the yield and harvest index of Cp3 cowpea variety. Mykovam application to Cp5 cowpea variety reduced the yield of cowpea in both cropping patterns, but did not affect the Cp3 cowpea variety. The highest land equivalent ratio (LER) was in intercropping Cp5 to ratooned

sugarcane. Mykovam application to cowpea varieties did not improve the productivity of intercropping cowpea to ratooned sugarcane.

In conclusion, the most amenable intercropping pattern is ratooned sugarcane + Cp5 cowpea variety without Mykovam application. This pattern did not negatively affect the vegetative growth of sugarcane. Increased productivity of the area is evident in land equivalent ratio (LER). However, it is recommended that a follow-up study should cover the full cropping cycle of sugarcane and intercropping varying crops coupled with production management that minimize competition with sugarcane leading to an increased yield of both crops. Cost-benefit analysis at the cropping pattern level is also recommended for a holistic approach.

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