Cassava (*Manihot esculenta* Crantz) Growth and Yield under Intercropping with Soyabean: The Impact of Population

Muhammad Syamsoel Hadi[1*], Dewi Anggraini[1], Eko Pramono[1] and Kukuh Setiawan[1]

[1] Department of Agronomy and Horticulture, University of Lampung
Jl. S. Brojonegoro 1, Bandar Lampung, Indonesia
*msyamshadi@gmail.com

Abstract. The goal of this research is to analyze the vegetative development and yield of cassava in diverse populations, as well as the Land Equivalent Ratio (LER). This research was carried out from June 2022 to March 2023 at the field of the "Vegetable Seed Production Unit" ("UPBS"), Sekincau Subdistrict, West Lampung Regency, Lampung. In this investigation, the local waxy cassava clone and the soyabean variety Dega-1 were utilized. The treatments were monoculture cropping with 20,833 cassava per hectare (P_1), 16,667 cassava per hectare and 166,667 soyabean per hectare (P_2), 18,518 cassava per hectare and 166,667 soyabean per hectare (P_3), 18,182 cassava per hectare and 222,222 soyabean per hectare (P_4). A five-replicate experiment was set up in a completely randomized block design. Minitab Ver. 17 was utilized for data analysis for analysis of variance, Student's t-test, and DMRT at 5%. Our results showed that there were no differences in the cassava growth in various populations. Compared to various treatments of cassava populations, the yield in monoculture was higher. The treatment P_4 had a LER of 1.52 was attained.

Keywords: Monoculture, intercropping, soyabean, cassava, populations.

1 Introduction

Cassava is an important crop in Indonesia, particularly as a raw material in the tapioca industry. According to [1], the country produces nearly 18,5 million tons of cassava, and its annual consumption is 8.59 kg per capita [2]. The country's total planting area for cassava is 740,998 ha, of which 244,023 ha are in Lampung Province [1]. Cassava has traditionally been grown in monocultures. Since at the beginning of cassava growth there is still enough space between plants in this system, intercropping cassava with short-lived plants like sorghum [5], soyabean [3], or maize [4] is feasible.

When cassava starts to grow, there is space between the plants, and this space can be used to intercrop with other plants. It has the potential to raise land productivity, which will significantly boost farmers' incomes. Although the intercropping of cassava in diverse populations with soyabean has not been thoroughly documented up to this point, it is anticipated to be compatible due to the growth patterns of early maturing

A. Zakaria et al. (eds.), *Proceedings of the 1st International Conference on Industry Science Technology and Sustainability (IConISTS 2023)*, Advances in Engineering Research 235,
https://doi.org/10.2991/978-94-6463-475-4_3

soyabean and cassava. An LER of 0.90 to 1.20 was obtained by planting numerous varieties of soyabean alongside cassava [3].

Every variety of plant has an ideal plant population to achieve maximal productivity, according to [6]. The yield decreases with increasing planting population. It is necessary to modify the number of planting populations in order to achieve maximum output.

[7] claimed that plant competition, cultivars, plant spacing, and plant population density are all important determinants in effective intercropping. Plants will compete with one another for growth media if the plant density is too high. In intercropping systems, one way to reduce competition between plant species is to control plant numbers. Plant spacing and population density can be changed to achieve different population combinations in intercropping. Plant density, according to [8], may promote upward plant growth or stem elongation, resulting in stem enlargement, or it will inhibit lateral stem growth. Furthermore, [9] noted that the arrangement and assessment of plant populations are crucial elements that govern the development and yield of intercropping crops, as demonstrated by this study in intercropping systems of cassava and peanuts, which have the potential to yield 2.37–2.68 tons of dry pods annually on average.

The objectives of this study are to assess the cassava growth and yield and LER in multiple populations engaged in intercropping between cassava and soyabean.

2 Materials and Methods

In June 2022 to February 2023, this research was carried out at field of the "Vegetable Seed Production Unit" ("UPBS"), Sekincau Subdistrict, West Lampung Regency, Lampung. The research was at 5°2'27" S and 104°18'16" E. It was also conducted at Seed and Plant Breeding Laboratory, Department of Agronomy and Horticulture, University of Lampung, Bandar Lampung.

This research was set up in a completely randomized block design (CRBD) with five replicates. The treatments are:

P_1: Monoculture cropping with 20,833 cassava per hectare (P1);
P_2: 16,667 cassava per hectare, interplanted with 166,667 soyabean per hectare;
P_3: 18,518 cassava per hectare, interplanted with 166,667 soyabean per hectare;
P_4: 18,182 cassava per hectare interplanted with 222,222 soyabean per hectare.
Every experimental unit was set up in a plot measuring 20 m² (4 m × 5 m).

Local waxy clone was the cassava clone employed in this experiment, and Dega-1 was the soyabean variety. Cassava plants were harvested at 32 WAP (week after planting), and soyabean at 13 WAP. Using a digging method at a distance of 15 cm from the plants, 4.4 g urea, 5.6 g SP-36, and 2.6 g KCl were applied as the initial fertilizer to cassava plants at 4 WAP. At 16 WAP, the plants received a second fertilizer using 6.7 grams of urea each. The initial fertilization of 4.2 g urea, 16.7 g SP-36, and 8.3 g KCl per row was applied to soyabean plants at 1 WAP. At 3 WAP, 8.3 g urea was applied to each row of soyabean, keeping a gap of 15 cm from the plants for the second fertilization.

Variables related to cassava growth and yield, such as plant height, leaf number, shoot weight (fresh and dry), number of tubers tuber fresh weight, tuber circumference, tuber length (per plant), and tuber fresh weight per 20-m2 plot, were observed.

Minitab Version 17 was used for analysis of variance, Duncan's Mutiple Range Test (DMRT), Student's t-test, and LER at the 5% level.

3 Results and Discussion

The findings demonstrated that as cassava plants grew older, their growth rate increased. Among the treatments, there were no appreciable variations. From 16 WAP until harvest (32 WAP), the P_2 (16,667 cassava/ha) treatment tends to grow taller than other treatments, measuring 248.9 cm (Fig. 1).

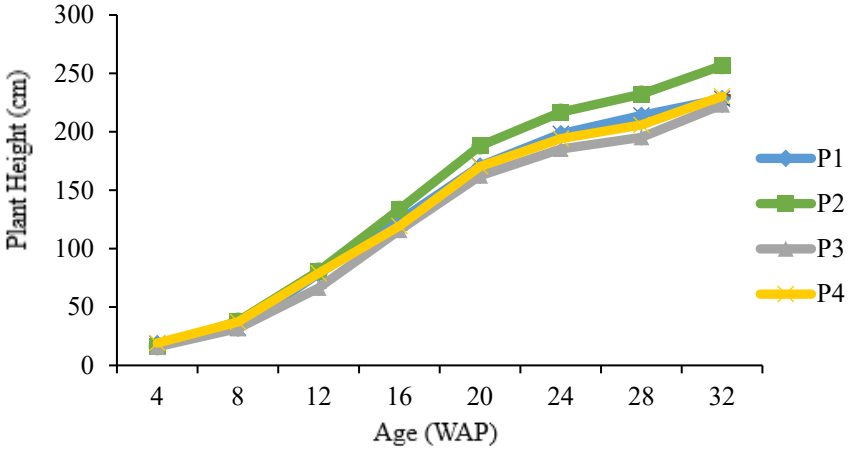

Fig. 1. Cassava plant height across different populations.

Cassava plants undergo leaf fall around one month before harvesting, a sign that the plants are prepared for harvesting. This accounted for the decline in leaf count at harvest for every treatment (Fig. 2). Six months after planting, cassava stem and leaf growth reach its maximum, according to [10]. At six to nine months of age, the cassava plant begins the process of transferring carbohydrates from leaves to its roots and the aging process of leaves, which results in falling leaves.

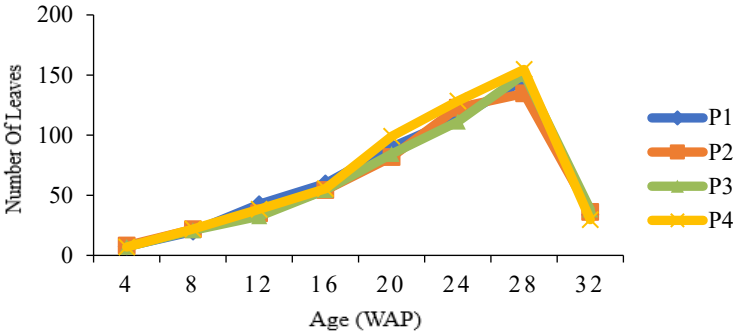

Fig. 2. Number of leaves on cassava in different populations.

A plant's leaves play a crucial role in determining its overall production. Since leaves are the primary site of photosynthesis, crop yields will be reduced by reducing the number of leaves. No significant differences were found between the treatments in this trial. Compared to the other treatments, the P_4 population treatment typically has a higher number of leaves (154.5 leaves). This offers preliminary evidence that intercropping soyabean and cassava has no effect on yield. Based on [3], planting cassava alongside legume crops gives two benefits: biomass production through the use of biological N fixing and increased yields. Cassava plants' photosynthetic processes function best when they have a lot of leaves, which influences the plants' growth and yield. [9] claimed that the size and spacing of the plants are crucial factors that affect the growth and yield of intercropping systems.

The accumulation of plant organs known as the canopy (above-ground biomass) dry weight is correlated with factors such as increased plant height, an increase in leaf number, and stem diameter [11]. Chlorophyll levels rise when nutrients are fully utilized, and this has an impact on how assimilates are created during photosynthetic processes. The plant's dry weight is then increased by the assimilates being stored in the tissues of the stem and leaves. The various populations of cassava plants in this experiment did not exhibit any discernible variations in their vegetative growth (Table 1). Prior to leaf fall, which denotes the maximum quantity of leaves, there are between 134.7 and 154.5 leaves on the plant. As the plant reached harvest (32 WAP), its height ranged from 223.2 cm to 256.7 cm. These findings differ slightly from those of [12], who measured plant heights of 195 cm at a 2x1 m spacing and 191 cm at a 1x1 m spacing and found that the quantity of leaves was 85.5 and 64.5, respectively.

Table 1. Some growth components of several populations of cassava

Treatment	PH 32 WAP (cm)	NL 28 WAP	SFW (g)	SDW (g)
P_1	228.2a	146.0a	1170a	310a
P_2	256.7a	134.7a	1300a	300a
P_3	223.2a	150.8a	950a	220a
P_4	230.4a	154.5a	1060a	300a
CV (%)	11.0	12.0	30.0	31.0

Note: The numbers in the same column which followed by the same letter are not significantly different at the 5% level, according to the DMRT test; PH: plant height; NL: number of leaves; SFW: shoot fresh weight per 20 m²; SDW: shoot dry weight per 20 m²; WAP: week after planting; CV: coefficient of variance.

Variables of growth components (Table 1) indicate that the decrease in cassava populations due to intercropping with soyabean plants had no significant impact to the cassava vegetative growth components. This result is rather different from that of [13], who discovered that the tallest plant at harvest was obtained when intercropping at 20,000 plants of cassava per hectare.

Except tuber fresh weight per m^2, the decline in the population of cassava had no discernible influence on yield components of this investigation (Table 2). The number of tubers per plant (5.17) in a spacing of 2 × 1 m, does not differ significantly from those of 4.39 in a spacing of 1 x 1 m, according to [12], which is consistent with our findings. In the meantime, [14] discovered that, relative to the yield generated by cassava cultivation alone, the production of cassava roots declined by 15%, 25%, 40%, and 44% at 12,300, 10,000, 8,888, and 6,666 plants per hectare, respectively. Furthermore, [15] discovered that, at the very least for an upright type, the populations of cassava should typically be raised at least 12,500 plants per hectare. Our analysis found no changes in results attributable to population differences across all intercropping regimens of at least 16,667 plants per hectare.

Table 2. Some components of cassava yield in different populations

Treatment	NTP	TCP (cm)	TLP (cm)	TV (ml/plant)	TFW (g/plant)	TFW/m^2 (g)
P_1	10.5a	12.7a	29.9a	6,844a	2480a	3900a
P_2	11.1a	12.3a	29.8a	6,692a	2420a	2850b
P_3	11.4a	11.9a	31.1a	6,603a	2120a	2930b
P_4	11.3a	11.3a	30.5a	6,281a	2190a	3660ab
CV (%)	31.6	12.6	18.8	17.6	24.8	3.9

Note: The numbers in the same column which followed by the same letter are not significantly different at the 5% level, according to DMRT test; NTP: number of tuber per plant; TCP: tuber circumference per plant; TLP: average tuber length; TV: tuber volume per plant; TFW: tuber fresh weight per plant; TFW/m^2: tuber fresh weight/m^2; CV: coefficient of variance.

Moreover, [16] found that intercropping soyabean–cassava did not affect the crop yield. Intercropping promotes soil fertility and increases crop diversity. In comparison to other legume crops, intercropping soyabean with cassava reduces competition and improves soil structure. The soyabean-cassava intercrop performed similarly to a pure soyabean stand. When developing legume-cassava intercropping, it is important to consider the longer root system maturation period, as well as disease and drought difficulties.

According to the findings of the study [13], solitary cropping produced much higher root circumference than intercropping. Their findings are different from those that we

discovered (Table 2). These variances in tuber circumference could be due to varieties, localities, or microclimatic circumstances. Tuber circumference is strongly linked with the quantity of tubers per plant [17]. It is obvious from our findings that population differences had no effect on either variable. Because there is a strong relationship between tuber circumference and weight [17], a larger perimeter may imply a larger tuber.

In general, changes in populations of cassava had no effect on volume of tuber or tuber fresh weight per plant. Volume of tuber per plant was between 6,281 ml and 6,844 ml due to changes in cassava population, whereas tuber fresh weight per plant was between 2120 g and 2480 g. This is disagreement with [12], who suggested that the quantity of cassava plants in a specific area could affect cassava plant productivity.

The results of this study revealed that reducing the number of cassava to 18,518 plants per hectare reduced the tubers fresh weight per m^2. When population was reduced to 18,182 plants per hectare, yield increased, the same results as monoculture (Table 2). This is made possible by an increase in the number of intercropped soyabean plants and the availability of nitrogen delivery from soyabean. This is partly consistent with the findings of [14], which found that the yield reduced by 15%, 25%, 40%, and 44% at 12,300, 10,000, 8,888, and 6,666 plants per hectare, respectively, when compared to yield achieved with solo cassava.

Table 3. Land Equivalent Ratio (LER) for cassava yield.

Treatment	LER	T-value	T-table
P_2	1.36	2.97	2.78
P_3	1.37	3.11	2.78
P_4	1.52	4.45	2.78

Note: T-table: 5% (2.78).

The LER data (Table 3) reveal that intercropping cassava–soyabean is a more appropriate land use. The value raises from 1.0 to 1.36-1.52 based on cassava and soyabean crop production. Based on LER of 1.52 (P_4) discovered in our experiment, growing cassava and soyabean together results in a 52% higher yield than growing them separately. According to [18], intercropping is more profitable than monoculture cropping since it improves land productivity and efficiency. Furthermore, [16] found that intercropping raised LER higher than monoculture cropping. Despite the fact that intercropping yielded lower individual component crop yields than monoculture cropping, it resulted in higher total land productivity.

4 Conclusion

Most of growth components observed were unaffected by different populations in cassava plants. Other than the tuber fresh weight per m^2 component, changes in cassava plant populations had little effect on other of the observed yield components.

A population of 18,182 cassava per hectare intercropped with 222,222 soyabean per hectare yielded 52% more than planted in monoculture system.

Acknowledgments. We express our deepest appreciation to all parties who have provided assistance in carrying out this research.

References

1. Kementrian Pertanian: Produktivitas dan luas tanam ubikayu: Laporan Tahunan Direktorat Jenderal Tanaman Pangan. Jakarta (2020)
2. Dinas Kominfo Provinsi Jawa Timur Homepage https://kominfo.jatimprov.go.id/read/umum/singkong-bukan-pangan-inferior, accessed 2022/10/8
3. Sundari T., Purwanto, Artari, R., Baliadi, Y.: Respons genotipe sebagai tanaman sela pada tumpangsari dengan ubikayu. Jurnal Ilmu Pertanian Indonesia **25**(1), 129-137 (2020)
4. Wylis, A. R., Endriani, Asnawi, R.: Nilai gizi ubikayu yang ditanam secara monokultur dan tumpangsari jagung dan kedelai. Jurnal Penelitian Pertanian Terapan **22**(1), 30-36 (2022)
5. Ulin, N. M. R., Susilo, F. X., Hadi, M. S.: Purnomo Kelimpahan kumbang kubah predator pada berbagai genotipe tanaman sorgum (*Sorgum Bicolor* [L.] Moench) secara monokultur dan tumpangsari dengan tanaman ubikayu. Jurnal Agrotek Tropika **9**(3), 407-411 (2021)
6. Andrews, R. E., Newman, E. I.: Root density and competition for nutrient. Journal of America Social **6**(12), 757-763 (2000)
7. Rezaei-Chianeh. E., Nassab, A. D. M., Shakiba, M. R., Ghassemi-Golezani, Aharizad, S., Shekari, F.: Intercropping of maize *(Zea mays L.)* and faba bean (*Vicia faba L.*) at different plant population densities. African Journal of Agricultural Res **6,**1786‑1793 (2011)
8. Mayadewi, N. N. A.: Pengaruh jenis pupuk kandang dan jarak tanam terhadap pertumbuhan gulma dan hasil jagung manis. Jurnal Agritop 26(4), 153-159 (2007)
9. Subandi: Teknologi budidaya tumpangsari ubikayu-kacang tanah mendukung sistem integrasi ternak-tanaman pada lahan kering masam. Buletin Palawija **19**, 1-13 (2010)
10. Saleh. N., Abdullah, T., Yudi, W., Titik, S., Dadang, G., Ricardo, P. R., Samsi, A. S.: Pedoman Budi Daya Singkong di Indonesia. Indonesian Agency for Agricultural Research and Development (IAARD) Press, Jakarta (2016)
11. Sarman, Indraswari, E., Husni, A.: Respons pertumbuhan bibit kelapa sawit (*Elaeis guineensis* Jacq.) terhadap *Decanter Solid* di pembibitan utama. Jurnal Media Pertanian **6**(1), 14-22 (2021)
12. Beja, H. D., Apelabi. G. O.: Pengaruh jarak tanam pola tumpangsari jagung dan pupuk anorganik terhadap pertumbuhan dan produksi ubikayu (*Manihot esculenta Crantz*) Varietas Gajah. Jurnal Pendidikan, Sains, dan Humaniora **7**(6), 828-842 (2019)
13. Joseph, I., Agnes, A. G., Akaazua, Wanger, B.: Cassava/maize intercrop yield response to different plant population densities in Makurdi and Lafia. World Journal of Research and Review **6**(3), 98 – 108 (2018)
14. Ayoola, O. T., Makinde, E. A.: Influence of cassava population density on the growth and yield performance of cassava - maize intercrop with a relayed cowpea. Tropical and Subtropical Agroecosystems **8**, 235 – 241 (2008)
15. Onasanya, O. O., Hauser, S., Necpalova, M., Salako, F. K., Kreye, C., Tariku, M., Six, J., Pypers, P.: On-farm assessment of cassava root yield response to tillage, plant density, weed control and fertilizer application in Southwestern Nigeria. Field Crops Res **262**, 108038 (2021)

16. Benti, G., Degafa, G., Jafar, M., Birhanu, H.: Effect of cassava intercropping with legume crops followed by sorghum on growth, yield and yield parameters of cassava-based double cropping system. Plant **8**(2), 37-42 (2020)
17. Ntui, V. O., Uyoh, E. A., Affangideh, U., Udensi, U., Egbonyi, J. P.: Correlation and genetic variability in cassava (*Manihot esculenta* Crantz). Journal of Food, Agriculture & Env. **4** (3&4), 147-150 (2006)
18. Saragih, B. W. M., Setyowati, N., Prasetyo: Optimasi Lahan dengan Sistem Tumpangsari Jagung Manis-Kacang Tanah, Kacang Merah, dan Buncis pada Sistem Pertanian Organik. Jurnal Agroqua **17**(2), 734-739 (2019)