ISSN: 1412-4718, eISSN: 2581-138x

Suwitono B · Chozin MA · Guntoro D · Suwarto

Response of four local cassava accessions to bio-mulch application time

Abstract. Cassava is widely planted on marginal land with low soil fertility. During the initial growth phase, cassava often loses competition against weeds. Legume cover crops are widely used to increase soil fertility, prevent erosion, and suppress weeds. This study aimed to determine the effect of *Arachis pintoi* bio-mulch application time on the growth and yield of cassava. This study was conducted using a factorial randomized block design. The first factor was four cassava accessions: Ketan *Malang*, *Genjah Bayam*, *IR Jonggol*, and Mangu. The second factor was six levels of bio-mulch planting time: manual weeding (without bio-mulch applications), bio-mulch planting at the same time as cassava planting, and four, eight, and twelve weeks before cassava planting. The observations included plant height, stem diameter, number of tubers, tuber weight, tuber length, plant biomass, dry matter, and productivity. The results showed that all cassava accessions responded similarly to the planting time of *A. pintoi* bio-mulch. Different bio-mulch application time was insignificant in the cassava growth, except for the number of tubers and tuber diameter. The twelve weeks before cassava planting tends to reduce the results of cassava accessions.

Keywords: *Arachis pintoi* · Cover crop · Dry land · Growth · Yield

Submitted: 5 January 2023, Accepted: 1 August 2023, Published: 10 August 2023
DOI: http://dx.doi.org/10.24198/kultivasi.v22i2.44256

Suwitono B[1,3]* ·Chozin MA[2] · Guntoro D[2] ·Suwarto[2]
[1] Departement Agronomy and Horticulture Graduate School, Faculty of Agriculture, IPB University. Jl. Meranti, Kampus IPB Darmaga, Bogor 16680, West Java, Indonesia.
[2] Departement Agronomy and Horticulture, Faculty of Agriculture, IPB University. Jl. Meranti Kampus IPB Darmaga, Bogor 16680, West Java, Indonesia.
[3] Food Crops Research Center, National Research and Innovation Agency, Cibinong Science Center, Jl. Raya Jakarta- Bogor, Cibinong, Bogor 16915, West Java, Indonesia
*Correspondence: bayu030@brin.go.id

Suwitono B, Chozin MA, Guntoro D, Suwarto. 2023. Response of four local cassava accessions to bio-mulch application time. Jurnal Kultivasi, 22(2): 183-191

Jurnal Kultivasi Vol. 22 (2) Agustus 2023
ISSN: 1412-4718, eISSN: 2581-138x

Introduction

Cassava is one of the promising commodities in the agricultural sector as a multifunctional crop that can be utilized as a raw material for alternative energy sources, food, and feed (Kristian, 2015). In 2020, Indonesia's total cassava production reached 18 million tons from a harvested area of 701,000 hectares. In 2017-2020, fluctuations emerged in cassava production in Indonesia, as the total cassava production decreased to 16 million tons in 2018, then increased in the following year (FAO, 2020). During 1970-2017, cassava production in Indonesia increased by 19 million tons, below Nigeria at 49 million tons and Thailand at 31 million tons (Ikuemonisan et al., 2020).

Cassava can become a solution for marginal and critical land use (Saidi, 2020). Mostly, cassava commodities are grown by farmers on marginal lands with less optimal soil based on the physical, chemical, and mineral properties. Furthermore, cassava is mainly developed on alfisol, ultisol, entisol, and inceptisol soil types with low nutrient status, low organic matter, and highly vulnerable to erosion. According to Radjit et al., (2008), cassava development in the following lands could show significant growth and increased production. Moreover, proper cassava varieties are also necessary for efficient cultivation technology.

However, the development of cassava is relatively long, e.g., 8-12 months. Also, cassava has a relatively low selling price, decreased nutrient contents, when transported to the market, and an inability to protect the soil from rainwater, thus vulnerable to erosion (Pramudita et al., 2014).

Cassava production is also affected by weeds in a rapid cassava cultivation system. Weeds are competitors for cassava plants that can reduce cassava yields by 75% in the first three months of growth. Similarly, Suwarto (2012) stated that the initial growth phase is one of the weaknesses in cassava planting, as it cannot compete with weeds at a critical period of 5-10 weeks after planting. The broadleaf weeds from the Asteraceae family are found around one-month-old cassava plantations. In addition to inhibiting cassava growth, weeds are a gathering place for cassava pests (Putra and Jeclin, 2019).

An ornamental bean, *Arachis pintoi*, is a bio-mulch or a living mulch that can grow anywhere easily. *A. pintoi* can bind nitrogen from the air, which can be applied as a land cover plant, an ornamental plant in city parks, and erosion control on sloping land (Maswar, 2004). According to Insani et al. (2020), *A. pintoi* is a legume that can be planted using a mixed cropping pattern. Various cropping patterns between corn and *A. pintoi* can increase corn production.

According to Suwarto and Asih (2021), using LCC and organic matter elevation can also increase the soil moisture. Badriyah and Chozin (2017), stated that planting the *A. pintoi* beans as bio-mulch on sweet corn plants with minimal tillage can increase the sweet corn production. Meanwhile, Zhong et al. (2018) stated that long-term use of *A. pintoi* and *C. rotundifolia* in peach plantations improved the soil chemical properties and increased the soil organic matter. Furthermore, Evizal (2003), described that *A. pintoi* had several advantages, including drought resistance, shade tolerance, high biomass production capability, and low propagation on the mother plant.

This study aimed to evaluate the benefits of *A. pintoi* as a bio-mulch with different cropping times in cassava cultivation, expected to increase cassava fertility and yield.

Materials and Methods

This study was conducted from November 2021 – September 2022 in the IPB Teaching Farm, Faculty of Agriculture, IPB University. This area is located at 6°28'12'' South Latitude and 107°01'47'' East Longitude. The soil type at the study site was ultisol soil, dominated by clay texture with low soil pH < 5. Rainfall during the study was observed from the average number of rainy days (Figure 1).

The materials used in this study were *A. pintoi*, four accessions of cassava plants, i.e. *Ketan Malang*, *Genjah Bayam*, *IR Jonggol*, and *Mangu*, cow manure, urea, KCL, SP-36, glyphosate herbicides, and carbofuran pesticides. The study used a two-factor factorial randomized block design (RBD). The first factor was the cassava variety types (V), namely *Ketan Malang* (V1), *Genjah Bayam* (V2), *IR Jonggol* (V3), and *Mangu* (V4). The second factor was the planting time levels of *A. pintoi* bio-mulch, namely manual weeding (without *A. pintoi* bio-mulch applications) as a control (B0), 0 week of planting bio-mulch, before cassava planting (B1), planting bio-mulch on four weeks before cassava planting (B2), planting bio-mulch on eight weeks before cassava planting (B3), and planting bio-mulch on 12 weeks before cassava planting (B4).

The cultivation land was prepared manually, and the experimental plots were made with a 5 m x 5 m size and 100 cm distance between plots. The soil was processed to 20 cm depth, raked and leveled with a hoe to form beds at 5 m x 1 m. For *A. pintoi*, stem cuttings from the following plants were propagated by themselves. The cutting size was uniform at 12 cm length. *A. pintoi* cuttings were planted in polybags at 10 cm x 15 cm, one cutting in one polybag with soil and husk mixtures (2:1). After five weeks, the *A. pintoi* cuttings were transferred to the plot, according to the treatment at planting with 20 cm distance between plants.

For *A. pintoi* treatment applications, cassava plants were planted simultaneously after *A. pintoi* planting at 0 week after planting (WAP). Cassava cuttings were obtained from the cassava stems at 8-12 months with cuttings 25 cm long. Cuttings were planted upright, i.e., 2/3 in the ground. The spacing used 100 cm x 100 cm, where the distance between rows was 100 cm, with one cutting in each hole. There were 25 cassava plants with five sample plants in one experimental plot.

Fertilization with manure was applied by planting the cassava at 5 tons/ha. Fertilization with chemical properties was applied manually about 15 cm from the cassava plant, whereas 300kg.ha^{-1} urea, 100kg.ha^{-1} SP36, and 100kg.ha^{-1} KCl was performed twice, namely, urea was applied with 1/3 dose of all fertilizers. Meanwhile, the SP36 and KCl were applied ten days after planting, whereas 1/3 of urea was applied three months after planting. For the rest five months, urea was applied directly after planting.

The observed growth and yield variables included plant height (cm), stem diameter (mm), and plant yield components. The plant yield components were composed of plant biomass weight, number of tubers per plant, tuber diameter (mm), tuber length (cm), wet tuber weight per plant (kg), productivity (t/ha), and tuber dry matter (dry matter). Growth and yield data were obtained when the plants reached six months old or at harvest.

All data were analyzed with an analysis of variance at the 5% significance level using *SPSS* 22.0 to determine differences in the effect of the average treatment. If a significant different value was obtained among the data, the test was continued with an honest significant difference test (Tukey's test) at a significant level of 5% to determine the highest treatment effect among the treatments.

Results and Discussion

Components of cassava growth. The variance results showed no interaction between cassava accession and application time of *A.pintoi* bio-mulch on plant height and stem diameter. However, the height and stem diameter increased along with the increasing plant age. Cassava accession treatment and bio-mulch application time significantly affected the plant height and stem diameter (Table 1). Total plant height ($p<0.05$) was affected by the cassava accessions. The plant height of *IR Jonggol* cassava was higher than *Ketan Malang*, *Genjah bayam*, and *Mangu* during the vegetative growth until the harvesting age of 6 MAP (months after planting). The *IR Jonggol* accession had a genotype characterized by upright and symmetrical growth without branching. Moreover, the *IR Jonggol* are cassava types that are cultivated on ultisol soil conditions in the Jonggol area, thus more adaptive in their vegetative growth. According to Diaguna et al. (2022), plant height is one of the well-adapted morphological characteristics of plants based on the shape of the lobes and petioles. At 12 weeks before planting the cassava application, the bio-mulch application showed the lowest plant height compared to other application times. The growth of *A. pintoi* bio-mulch at 12 WBP may be highly fertile, affecting the cassava's vegetative growth. In addition, high rainfall (figure 1) in December accelerated the growth of *A. pintoi* bio-mulch.

The accession types affect cassava stem diameter. The *IR Jonggol* cassava stem diameter was larger than other cassava accessions. This condition indicates a relationship between plant height and stem diameter. The taller plant height, the wider stem diameter. Meanwhile, the 12 WBP bio-mulch treatment showed a smaller stem diameter than other bio-mulch application treatments. The low diameter of cassava stems impacted the number of roots and tubers. According to Suwitono et al. (2017), the size of the stem diameter affects the weight of the tubers and the number of cassava tubers. Cassava plant height significantly differed, whereas the *IR Jonggol* accession could grow well on Jonggol

Jurnal Kultivasi Vol. 22 (2) Agustus 2023
ISSN: 1412-4718, eISSN: 2581-138x

ultisol soil. In contrast to *Mangu* and *Genjah Bayam*, both accessions had lower plant heights than others. According to Cock and Connor (2021), cassava can grow well in various soil types that are low in nutrients. In common nutrient conditions, the crown growth is reduced, and tuber growth is increased. The plant height of *IR Jonggol* cassava in this study reached 3.11 m, which can be helpful as a source of cutting material for the next growing season. According to Misganaw and Bayou (2020), varieties and genetics affect the high and low of cassava plants. A taller plant can be used as a cutting material for the next growing season.

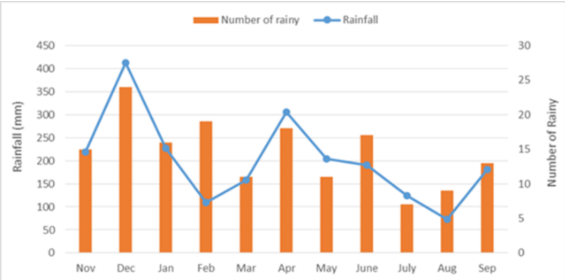

Figure 1. Rainfall data at the study site on November 2021 – September 2022. The line graphs show the rainfall and the bar graphs show the number of rainy. (Source: BMKG Bogor, West Java)

Tuber yield and yield components of cassava accessions. The number of tubers per plant is strongly influenced by the application time of the bio-mulch (Table 2). The 12 WBP (weeks before planting) cassava with bio-mulch application treatment produced the least number of tubers per plant, compared to other bio-mulch applications. According to Siswati et al. (2019), cassava tubers began to form from developing nodal and basal roots on a month after planting,. Soil as a medium for plant growth and soil conditions can affect the plant root system in the tuber formation. The plant root system includes the availability of water, nutrients, and aeration, which also involves the root spreading. With the bio-mulch application treatment, it is important to determine the bio-mulch spacing, so no competition between cassava and bio-mulch will occur.

The tuber length was significantly affected by the cassava accession. The tuber length of *Genjah Bayam* and *Mangu* accession exceeds the *Ketan Malang* and *IR Jonggol* (Table 2). This is possible, because *Genjah Bayam* and *Mangu* accessions have long tuber genetical characteristics. According to Listyowati and Sutarno (2017), the length and shape of the tubers are influenced by genetic factors, cropping systems, and fertilization. In addition, the greater the number of tubers produced as sink organs, the more competition between sinks (tubers) can occur, which affects the length of tubers.

The type of cassava accession influenced the actual tuber diameter. Cassava accession of *Ketan Malang* produced the largest tuber diameter, compared to *Genjah Bayam*, *IR Jonggol*, and *Mangu*. These results indicate that the *Ketan Malang* accession with many twigs and double branches will produce more harvesting product, thereby increasing the assimilated products, that will be transported to sink organs, including tubers. In addition, the *Ketan Malang* cassava is quite adaptive to ultisols with a soil pH of <5. More tubers will likely be marketed, if the tuber diameter is more than 50 mm.

Meanwhile, the bio-mulch application time treatment showed that the bio-mulch treatment time on 12 weeks before cassava planting increased the cassava yield with the largest tuber diameter of 42.68 mm. It is possible that the presence of bio-mulch from the legume cover crop can reduce the soil bulk density. Soil conditions with low bulk density triggers the cassava tubers to grow and develop. Soil tillage, use of cover crops, and crop rotation are some of the soil conservation practices that can affect the soil bulk density (Abrougui et al., 2014). According to Nascente et al., (2015), the use of cover crops significantly affects the soil density and increases the organic C content in the soil layer.

Tuber weight per plant was significantly affected by the treatment time, which was significantly affected by the bio-mulch application time. The four applications of bio-mulch had no significant difference, except the 12 MAP bio-mulch treatment, which caused the lowest tuber weight per plant of 2.91 kg (Table 2). This was possible due to the relationship between the number of tubers and the weight of tubers per plant. Because the number of tubers in the B4 treatment was less, the weight of tubers per plant became smaller. The correlation value between the tuber weight per plant and the number of tubers per plant was (r= 0.72**) (Table 4), which indicates a positive correlation between both parameters. According to Hamdani et al., (2021), high tuber weight comes from the amount of assimilated product from plants. According Kaluba et al. (2022), planting cassava and legumes can increase the soil organic matter, besides producing the yield loss, which must be insignificant. The low yield of tubers from *Mangu* cassava and *Genjah Bayam* was possible because the leaf stalks and shapes of both plants were longer and wider, so they shaded each other between plants. The influence of shade between plants will receive sunlight less optimal. Therefore, *Genjah Bayam* and *Mangu* planting should consider the ideal spacing of more than one meter. According to Adeniji et al., (2011), the physiological process of the plant is still running at six months, maximally decreasing the tuber yield of 12 months after planting.

The weight of plant biomass at the harvesting stage, after six months after planting (MAP) was influenced by the interaction between cassava accession and the bio-mulch application time. The *IR Jonggol* accession without the bio-mulch obtained the highest biomass weight at 3.42 kg (Table 3). This indicates that the *IR Jonggol* accession, with growing upright, strong and tall stem characteristics, produces more biomass in the shoots. In contrast to *Mangu* accession with B4 treatment, the lowest biomass was at 2.13 kg. This condition presents that vegetative growth, especially plant height from *Mangu* accession, was lower, resulting in a lower plant biomass weight. According to de Souza et al. (2017), the total plant biomass is produced from overall photosynthesis assimilation.

Table 1. Plant Height (m) and stem diameter (mm)

Treatment	Plant Height (m)				Stem Diameter (mm)			
	3 MAP	4 MAP	5 MAP	6 MAP	3 MAP	4 MAP	5 MAP	6 MAP
Accession								
Ketan Malang	1.45 b	1.98 b	2.40 b	2.60 b	21.85 b	24.31 b	25.35 b	26.34 b
Genjah Bayam	1.21 c	1.68 c	2.11 c	2.36 c	22.73 b	25.87 ab	26.95 ab	27.75 ab
IR Jonggol	1.90 a	2.46 a	2.90 a	3.11 a	24.52 a	27.24 a	27.81 a	28.27 a
Mangu	1.23 c	1.68 c	2.13 c	2.35 c	22.73 b	25.15 b	26.63 ab	27.33 ab
Bio-mulch								
B0	1.58 a	2.08 a	2.53 a	2.72 a	24.15 a	26.96 a	27.63 a	28.56 a
B1	1.55 a	2.02 ab	2.44 a	2.63 ab	23.93 a	26.21 a	27.05 ab	27.45 ab
B2	1.51 ab	2.03 ab	2.45 a	2.64 ab	23.53 a	26.38 a	27.01 ab	27.85 ab
B3	1.36 bc	1.91 b	2.38ab	2.61 ab	22.42 ab	25.13 ab	26.48 ab	27.32 ab
B4	1.23 c	1.72 c	2.16 b	2,42 b	21.04 b	23.53 b	25.24 b	25.91 b

Note: Means followed by the same letters in the same row are insignificantly different according to Tukey test α= 5%. B0: without bio-mulch (control), B1: 0 week before cassava planting, B2: 4 weeks before cassava planting, B3: 8 weeks before cassava planting, B4: 12 weeks before cassava planting.

Table 2. The effect of accession type and bio-mulch application time on the yield component of cassava at six months old

Treatment	Number of tubers/plant	Length of tubers (cm)	Diameter of tubers (mm)	Fresh tubers weight/plant (kg)
Accession				
Ketan Malang	15.1	36.35 b	50.15 a	3.62
Genjah bayam	14.8	41.70 a	44.94 b	3.53
IR Jonggol	16.7	35.90 b	46.03 b	3.45
Mangu	14.1	41.05 a	44.53 b	3.13
Bio-mulch				
B0	16.1 a	41.18	46.62 ab	3.68 a
B1	17.6 a	37.12	44.54 b	3.60 a
B2	16.1 a	39.25	46.10 ab	3.55 a
B3	14.1 ab	38.81	47.12 ab	3.41 a
B4	11.7 b	37.37	47.68 a	2.91 b

Note: Means followed by the same lowercase alphabet in the same column is insignificantly different based on Tukey test at the level of 5 %.

ISSN: 1412-4718, eISSN: 2581-138x

The dry matter of tubers was significantly affected by the interaction between accession and bio-mulch application time. The *Mangu* accession treatment with bio-mulch application time of 8 WBP and 12 WBP resulted in the highest tuber dry weight of 41.17% and 40.13%, respectively. This indicates that the low tuber weight is inversely proportional to the tuber dry matter value. The higher the tuber weight, the lower the tuber dry matter content. According to Tappiban et al. (2020), dry matter is more influenced by genetic characteristics than the environmental condition. According to Misganaw and Bayou (2020), the dry matter content of tubers is 41.2 - 50.2%, with an average of 45%. The tuber dry matter is formed from the translocation of photosynthate to the roots (Sulistiono et al., 2020).

Cassava productivity is affected by the bio-mulch application time. The B1, B2 and B3 treatments showed an insignificant different value with the control treatment (Figure 2). The average productivity was 32 – 44 t/ha. The *Mangu* cassava without bio-mulch treatment showed the highest productivity of 44.6 t/ha. At the same time, the B4 treatment showed the most negligible productivity at 22-33 t/ha with an average of 29.5 t/ha. This indicates that the different bio-mulch application time had no effect on the cassava productivity, but could suppress the weed growth in cassava plantations. According to Mansaray et al. (2022), legumes that are planted after cassava will increase the cassava productivity. According to Alves (2001), in achieving the maximum productivity, a plant must maintain a balance between the source and the sink.

The dry matter of tubers in the B3 and B4 treatments on *Mangu* accession showed the highest value, which was presumed that the bio-mulch application time on eight and twelve weeks before cassava planting had sufficient soil moisture, so the water requirement for cassava roots could still be met. According to Enesi et al. (2022), planting cassava at the end of the year, around October to December, forms more tuber dry matter than those produced at the beginning of the year. Drought in areas with low rainfall conditions can decrease the tuber dry matter <30% lower than in areas with higher rainfall and lower evapotranspiration (El-Sharkawy, 2004). In this study, the initial conditions for cassava planting received a relatively low rainfall from early March to May, with less than 300mm/month. This condition produced a lower tuber dry matter. According to Anikwe and Ikenganyia, (2018), the cassava growth will be slow under drought conditions, as marked by the stem segment shortage and tuber development termination.

According to Aye (2012) cassava can withstand drought by slowing the growth, not by puddles and floods, that cause tuber rot.

Table 3. Effect of bio-mulch application time and accession type on tuber dry matter and plant biomass weight at six months of harvest

Bio-mulch	Cassava accession			
	Ketan Malang	*Genjah bayam*	*IR Jonggol*	*Mangu*
Plant biomass weight (kg)				
B0	2.95	2.86	3.42 a	3.00 ab
B1	2.45	3.00	3.03 ab	2.90 ab
B2	2.80	3.01	3.22 ab	2.93 ab
B3	2.51	3.10	2.92 ab	2.71 ab
B4	2.38	2.99	2.92 ab	2.13 b
Dry matter of tuber (%)				
B0	32.79	37.04	28.73	38.56
B1	37.63	27.42	37.38	37.79
B2	34.77	34.62	40.10	28.14
B3	32.25	33.78	37.73	41.17
B4	32.41	34.47	37.13	40.34

Note: Means followed by the same letters in the same row are insignificantly different according to Tukey test α= 5 %. B0: without bio-mulch (control), B1: 0-week application before cassava planting, B2: 4-week application before cassava planting, B3: 8-week application before cassava planting, B4: 12-week application before cassava planting.

Table 4. Correlation matrix between yield and components.

Traits	PH	SD	PB	TN	TL	TD	FW	DM
SD	0.50*	1						
WB	0.57**	0.78**	1					
TN	0.54*	0.53*	0.54*	1				
TL	-0.56*	0.22ns	0.01ns	-0.22ns	1			
TD	0.10ns	-0.41ns	-0.46*	-0.20ns	-0.42ns	1		
FW	0.29ns	0.37ns	0.34ns	0.72**	-0.08ns	0,20ns	1	
DM	0.27ns	0.16ns	0.00ns	-0.08ns	0.13ns	-0.30ns	-0.37ns	1
TY	0.14ns	0.54*	0.456*	0.52*	0.24ns	-0.04ns	0.61**	-0.21ns

Note: PH = plant height, SD = stem diameter, PB = plant biomass, TN = tuber number, TD = tuber diameter, FW = fresh weight, DM = dry matter content, TY = total tuber yield, *significant (α =5%), and ** highly significant (α = 1%)

Plant height showed a positive correlation to stem diameter (r = 0.50*), number of tubers (r = 0.54*), and highly significant to plant biomass weight (r = 0.57*). This condition presents a higher plant height, a greater cassava stem diameter, and plant biomass weight. A higher plant weight biomass indicates an increased crown's weight, including the mature leaves, as the plant product for photosynthesis to produce and assimilate.

Cassava stem diameter showed a significant correlation with the number of tubers (r = 0.53*) and tuber productivity (r = 0.54*). Also, it showed a robust correlation with plant biomass weight (r = 0.78**). Therefore, increasing the diameter of cassava stems can significantly increase the biomass weight compared to leaf organs. Bulb weight is strongly correlated with number of tubers (r = 0.72*) and tuber productivity (r = 0.61*). Therefore, the greater number of tubers, the heavier tuber weight, and the higher tuber productivity. Cassava productivity shows a significant correlation with stem diameter (r=0.54*), plant biomass (r = 0.45*) and number of tubers (r=0.52*). According to Enesi et al. (2022b), the production of cassava tubers is influenced by soil fertility, tillage, and weeding.

Conclusions

Based on the experimental results and discussion, it can be concluded that:

1. No interactions were found between the cassava accession type and bio-mulch application time on the growth and yield of cassava plants
2. Cassava accession treatments showed a significant difference in growth parameter components, namely plant height, stem diameter and yield components, including tuber length and diameter.
3. The bio-mulch planting time on twelve weeks before planting cassava tends to reduce the product yield of four cassava accessions.

Acknowledgments

The authors would like to thank the Agricultural Research and Development Agency for funding this project through the Agricultural Research and Development Agency scholarship. The authors would also thank Mr. Anton Nialek, Mr. Ardi, Dian, and Rafi for field technical assistance.

References

Abrougui K, Chehaibi S, Boukhalfa H, Chenini I, Douh B, et al. 2014. Soil bulk density and potato tuber yield as influenced by tillage systems and working depths. Greener J. Agric. Sci., 4(2): 046–051. doi: 10.15580/gjas.2014.2.020314087.

Adeniji OT, Odo PE, Ibrahim B. 2011. Genetic relationships and selection indices for cassava root yield in Adamawa state, Nigeria. African J. Agric. Res., 6(13): 2931–2934. doi: 10.5897/AJAR10.143.

Alves AAC. 2001. Cassava botany and physiology. Cassava: biology, production and utilization. p. 67–89

Anikwe MAN, Ikenganyia EE. 2018. Ecophysiology and Production Principles of Cassava (Manihot species) in Southeastern Nigeria. Cassava. p. 105–122

Aye TM. 2012. Land preparation, time and method of planting and harvest, plant

ISSN: 1412-4718, eISSN: 2581-138x

spacing and weed control. In: Howeler, R.. ., editor, The cassava handbook : A reference manual based on the Asian regional cassava training course, held in Thailand. Centro Internacional de Agricultura Tropical (CIAT), Bangkok. p. 588–612

Badriyah RN, MA Chozin. 2017. Optimasi tillage area untuk penanaman jagung manis (Zea mays saccharata Sturt) pada sistem olah tanah minimum dengan biomulsa Arachis pintoi Krap. & Greg. Seminar Nasional dan Kongres Perhimpunan Hortikultura Indonesia (PERHORTI) 2017. IPB Press, Bogor. p. 117

Cock J, Connor D. 2021. Cassava. In: Sadras, V.. and Calderini, D., editors, Crop Physiology Case Histories for Major Crop. p. 588–633

Diaguna R, Suwarto, Santosa E, Hartono A, Pramuhadi G, et al. 2022. Morphological and physiological characterization of cassava genotypes on dry land of ultisol soil in Indonesia. Int. J. Agron. 2022. doi: 10.1155/2022/3599272.

El-Sharkawy MA. 2004. Cassava biology and physiology. Plant Mol. Biol. 56(4): 481–501. doi: 10.1007/s11103-005-2270-7.

Enesi RO, Hauser S, Pypers P, Kreye C, Tariku M, et al. 2022a. Understanding changes in cassava root dry matter yield by different planting dates, crop ages at harvest, fertilizer application and varieties. Eur. J. Agron., 133: 126448. doi: 10.1016/j.eja.2021.126448.

Enesi RO, Pypers P, Kreye C, Tariku M, Six J, et al. 2022b. Effects of expanding cassava planting and harvesting windows on root yield, starch content and revenue in southwestern Nigeria. F. Crop. Res., 286(April): 108639. doi: 10.1016/j.fcr.2022.108639.

Evizal R. 2003. Pembibitan dan Penanaman Arachis pintoi Sebagai Penutup Tanah di Perkebunan. Agrotropika, 8(2): 1–5.

FAO. 2020. Food Agriculture Organization of the United Nation. Stat. Database-FAOSTAT. http://www.fao.org/faostat/en/#data/.

Hamdani JS, Sumadi, Kusumiyati, Mubarok S, Harisy MP. 2021. Pengaruh cara pemberian pupuk NPK dan frekuensi pemberian paclobutrazol terhadap pertumbuhan dan hasil benih kentang G0 di dataran medium. Kultivasi, 20(3): 222–229. doi: 10.24198/kultivasi.v20i3.35977.

Ikuemonisan ES, Mafimisebi TE, Ajibefun I, Adenegan K. 2020. Cassava production in Nigeria: trends, instability and decom-position analysis (1970–2018). Heliyon, 6(10). doi: 10.1016/j.heliyon.2020.e05089.

Insani AN, Nompo S, Natsir A. 2020. Growth characteristics of the corn crop planted with mixed crop planting system with Arachis pintoi. IOP Conference Series: Earth and Environmental Science

Kaluba P, Mwamba S, Moualeu-Ngangue DP, Chiona M, Munyinda K, et al. 2022. Performance of Cassava under Lime, Fertilizer, and Legume Intercropping on Exhausted Land in Northern Zambia. Int. J. Agron. 2022. doi: 10.1155/2022/3649355.

Kristian S. 2015. Determinasi produksi, konsumsi dan harga ubi kayu Indonesia. J. Kelitbangan, 03(01): 1–23.

Listyowati C, Sutarno. 2017. Respons agronomi varietas ubi kayu tanam baris ganda pada sistem tumpangsari di lahan kering. Prosiding Seminar Hasil Penelitian Tanaman Aneka Kacang dan Umbi 2017. p. 564–573

Mansaray A, Karim AB, Yormah TBR, Conteh AR, Yila KM. 2022. Effect of time of introduction of legumes into cassava on the productivity of cassava in cassava-legume based intercropping systems. Asian J. Adv. Agric. Res., (April): 1–15. doi: 10.9734/ajaar/2022/v18i230213.

Maswar. 2004. Kacang Hias (Arachis Pintoi) pada Usaha Tani Lahan Kering.

Misganaw CD, Bayou WD. 2020. Tuber yield and yield component performance of cassava (Manihot esculenta) varieties in Fafen district, Ethiopia. Int. J. Agron. 2020. doi: 10.1155/2020/5836452.

Nascente AS, Li Y, Crusciol CAC. 2015. Soil aggregation, organic carbon concentration, and soil bulk density as affected by cover crop species in a no-tillage system. Rev. Bras. Cienc. do Solo, 39(3): 871–879. doi: 10.1590/01000683rbcs20140388.

Pramudita MH, Utomo WH, Prijono S. 2014. Implementasi pemeliharaan lahan pada tanaman ubikayu : pengaruh pengelolaan lahan terhadap hasil tanaman dan erosi. J. Tanah dan Sumberd. Lahan, 1(2): 88–92.

Putra SHJ, Jeclin M. 2019. Identifikasi gulma pada kebun singkong (Manihot esculenta Crantz) di Desa Nitakloang Kecamatan Nita Kabupaten Sikka tahun 2018. Lumbung, 18(2): 60–73. doi: 10.32530/lumbung.

v18i2.158.
Radjit BS, Saleh N, Subandi, Ginting E. 2008. Teknologi produksi ubi kayu mendukung industri bioetanol. Bul. Palawija, 16(16): 27–36.
Saidi D. 2020. Potensi lahan marginal untuk pengembangan tanaman singkong (Manihot esclenta Crantz) spesifik lokasi di Daerah Istimewa Yogyakarta. In: Setyaningrum, T., Pratiwi, L.F.L., and Kafiya, M., editors, Prosiding seminar nasional fakultas pertanian upn " veteran " yogyakarta 2020". Fakultas Pertanian Universitas Pembangunan Nasional "Veteran" Yogyakarta, Yogyakarta. p. 382–390
Siswati L, Ardie SW, Khumaida N. 2019. Pertumbuhan dan perkembangan ubi kayu genotipe lokal manggu pada panjang setek batang yang berbeda. J. Agron. Indones. (Indonesian J. Agron., 47(3): 262–267.
de Souza AP, Massenburg LN, Jaiswal D, Cheng S, Shekar R, et al. 2017. Rooting for cassava: insights into photosynthesis and associated physiology as a route to improve yield potential. New Phytol., 213(1): 50–65. doi: 10.1111/nph.14250.
Sulistiono W, Hartanto S, Brahmantiyo B. 2020. Respons beberapa varietas ubi kayu terhadap pemupukan NPK pada tanah latosol di Maluku Utara. Bul. Palawija, 18(1): 43. doi: 10.21082/bulpa.v18n1.2020.p43-51.
Suwarto. 2012. Menjadikan ubi kayu sebagai sumber ketahanan pangan dan energi di Indonesia. In: Melati, M., Aziz, S.A., Efendi, D., Armini, N.M., Sudarsono, et al., editors, Prosiding Simposium dan Seminar Bersama PERAGI-PERHORTI-PERIPI-HIGI Mendukung Kedaulatan Pangan dan Energi yang Berkelanjutan. Departemen Agronomi dan Hortikultura. p. 1–2
Suwarto, Asih R. 2021. Growth of legume cover crops under cassava and its effect on soil properties. Legum. Res., 44(9): 1077–1081. doi: 10.18805/LR-607.
Suwitono B, Hendaru IH, Putri PH. 2017. Prosiding seminar nasional Hasil penelitian tanaman aneka kacang dan umbi tahun 2017. Inovasi Teknologi Akabi Siap Mendukung Tercapainya Swasembada dan Kedaulatan Pangan. p. 510–517
Tappiban P, Ying Y, Pang Y, Sraphet S, Srisawad N, et al. 2020. Gelatinization, pasting and retrogradation properties and molecular fine structure of starches from seven cassava cultivars. Int. J. Biol. Macromol., 150: 831–838. doi: 10.1016/j.ijbiomac.2020.02.119.
Zhong Z, Huang X, Feng D, Xing S, Weng B. 2018. Long-term effects of legume mulching on soil chemical properties and bacterial community composition and structure. Agric. Ecosyst. Environ., 268 (November 2017): 24–33. doi: 10.1016/j.agee.2018.09.001.