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Biomulch Treatment Effects on Weed Control and Soil Properties in Cassava Plantation

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Abstract

Legume Cover Crop (LCC) are plants grown as live mulch so that it is beneficial to the agro-ecosystem and can be included in cropping systems to regulate soil fertility and suppress weed growth. This study aims to determine the benefits of using *Arachis pintoi* as biomulch applied at different times on weed composition and soil fertility. The experiment was carried out at the Teaching farm of IPB, Jonggol, West Java, Indonesia; the soil type is Ultisol. This study used two factors and was designed in a factorial randomized block design. The first factor was four accessions of cassava "Ketan Malang", "Genjah Bayam", "IR Jonggol", and "Manggu"; the second factor is the time of the biomulch planting: 4, 8, and 12 weeks before planting the cassava, at cassava planting, and without biomulch + manual weeding as the control. Weed vegetation was analyzed before land preparation and before cassava harvest. The physical and chemical properties of the soil were analyzed before and after the biomulch treatment. Our study demonstrated that *Melastoma malabathricum, Tetracera indica, Oxalis barrelieri, Mimosa invisa, Ottochloa nodosa, Ipomoea sp* and *Cyperus sp.* are the dominant weeds in the cassava plantation. Biomulch planted four and eight weeks before cassava was able to reduce weed dry weight. All biomulch treatments were able to improve soil density and total pore space. Soil with biomulch planted eight weeks before cassava planting had the highest C-organic (7.59%) and total nitrogen (0.41%).

Keywords: legumes cover crop, live mulch, soil fertility, Ultisol, weed control.

Introduction

Cassava (*Manihot esculenta* Crantz) is a native American species that has become an important food crop in Africa and Asia, including Indonesia. Cassava is a high calorie food source with the most affordable price. Cassava carbohydrate contents are 20% higher than those in corn and 40% higher than those in rice (Tonukari, 2004). Cassava has high tolerance to drought and highly acidic environment. In Indonesia, cassava is an important raw material for the food industry which comes from processing starch and its derivatives (Howeler, 2012). The increasing population and the development of cassava-based industries will further increase the demand for cassava in the future (Nintania et al., 2021). According to Widyatmoko et al. (2018), several processed cassava products such as tapioca flour, modified cassava flour (mocaf), and cassava rice, are developing into industrial products for the domestic as well as international markets.

Cassava is widely grown on Alfisol, Ultisol, Entisol, and Inceptisol soil types, and it can grow on soils with low nutrient and organic matter or marginal land, where the soil's physical, chemical, and mineral content is sub-optimal. Therefore, cassava can be one of the crops that can utilize marginal lands (Saidi, 2020). Ultisol develops under forest vegetation containing argillic horizons, and like Alfisol, have a low alkaline cation content so it tends to be acidic (Yaalon, 1996). Ultisols are Indonesia's second largest soil area after Inceptisols, with a total area of 24.3% or equivalent to 45.8 million ha (Nursyamsi, 2006). The fertility of ultisol is affected by erosion as the organic matter in the top layer is prone to erosion, thereby reducing its organic matter and nutrients (Prasetyo and Suriadikarta, 2014). The low fertility of ultisols is reflected in their low pH, low soil C-organic, CEC and base saturation (Aswiguna et al., 2022). According to Ma'ruf et al. (2017), one of the determinants of a successful land improvement is the selection of the suitable legume cover crops (LCC), especially those that have fast growth to suppress weeds and produce high decomposed biomass.

Ultisol physical and chemical properties can be improved by adding organic matter. The use of LCC is an alternative to providing organic matter in the soil (Suwarto and Asih, 2021), as well as increasing soil nitrogen supply (Whittaker et al., 2022). LCC can improve soil physical properties including bulk density, soil porosity, soil moisture content (Crotty and Stoate, 2019). LCC increased the soil organic matter, N, P, and K, and improve the soil's biological properties including enhancing earthworms and mesofauna growth (Crotty and Stoate, 2019). The ornamental bean *Arachis pintoi* is a legume species that can add the soil nitrogen, reduce erosion, suppress weeds, and has ornamental values due to their attractive bright flowers. *Arachnis pintoi* was reported to reduce rate of soil erosion by 80.45% (Sarjono et al., 2019) and maintain soil water levels (Yuniarti et al., 2018). According to Muddarisna et al. (2009) growing *A. pintoi* combined with raising chicken, cows, and goats can increase soil organic C and improve soil porosity. A study by Kartika et al. (2009) reported that *Arachnis pintoi* as a ground cover can reduce water loss from evaporation and improve soil structure, soil porosity and density.

Our current study aimed to determine the optimal time to plant biomulch *A. pintoi* to suppress weed growth and to improve soil fertility in the cassava plantation.

Material and Methods

Experimental Site

The experiment was conducted in the experimental field of the Faculty of Agriculture, IPB University, at Singasari village, Jonggol District, Bogor Regency, West Java. The land in the study area is dry Ultisol with a slope of 15^{o} to 26.79%. The experiment was performed from November 2021 to September 2022. The study used stem cuttings of the ornamental bean *A. pintoi* and four cassava accessions, "Ketan Malang", "Genjah" "Bayam", "IR Jonggol", and "Manggu". The planting medium for *A. pintoi* cuttings consisted of soil and rice husks with a volume ratio of 2:1. Other materials used were cow manure, Urea, SP-36, and KCl fertilizers, herbicide (a.i. glyphosate), insecticide (a.i. carbofuran), 10x15 cm polybags, 0.5 m x 0.5 m^2 square frames for weed sampling, and a digital scale. The herbicide was applied before land preparation, insecticides were applied only when necessary.

Experimental Design

The experimental design used was a factorial randomized block design. The first factor was the cassava varieties: "Ketan Malang", "Genjah" "Bayam", "IR Jonggol", and "Mangu". The second factor was the planting time of the *Arachis pintoi*, i.e., B1 = planted at the time of cassava planting, B2 = four weeks, B3 = eight weeks, and B4 = 12 weeks before planting cassava, and without *A. pintoi* /B0, as a control. There were 20 treatments repeated four times to obtain 80 experimental units. Each experimental unit consisted of 25 cassava plants and 80 of the 4-week-old *A. pintoi* cuttings. Prior to planting in the field, a stem cutting of *A. pintoi* per polybag was prepared; the *A. pintoi* were planted in the field with a 20 cm distance between plants when they had 3-4 shoots. Cassava cuttings 25 cm in length were planted with a spacing of 100 x 100 cm, one cutting per planting hole. C-Organic, total N, available P, K_2O, and CEC, were determined prior to planting.

Vegetation Analysis

Weed vegetation was analyzed before land preparation, and six months after planting cassava. Weed vegetation was analyzed using the quadratic method measuring 0.5 m x 0.5 m with three random throws in the experimental plots. Weed vegetation analysis data includes relative density (RDs), relative frequency (RF), relative dominance (RD), and sum dominance ratio (SDR) ((Marianan and Warso, 2016). The weed dominance ratio is calculated using the formula described in Listyowati et al. (2022):

$$\text{Relative density (RDs)} = \frac{\text{density of one species}}{\text{density of all species}} \times 100\%$$

$$\text{Relative frequency (RF)} = \frac{\text{frequency of one species}}{\text{frequency of all species}} \times 100\%$$

$$\text{Relative dominance (RD)} = \frac{\text{dominance of one species}}{\text{dominance of all species}} \times 100\%$$

$$\text{Sum dominance ratio (SDR)} = \frac{\text{RD + RF + RD}}{3}$$

Soil Analysis

The soil sample for chemical and physical property analysis were collected twice, before the land preparation, and the after the cassava was harvested. The soil chemical properties tested include C-Organic (Walkey and Black method), total N (Kjedahl method), available P (Bray method), K_2O (Morgan method), and CEC (basic percolation Method) as described in Eviati and Sulaeman (2009). Soil sampling (1000 g each) was collected diagonally at five sample points with a depth of 0-30 cm from the soil surface. The soil samples were homogenized and placed in containers for later analysis in the soil chemistry laboratory. Soil samples for the soil physical property analysis were collected using the sample ring with a diameter of 7.35 cm and a height of 4 cm. The ring has a cylindrical shape and was inserted to a certain soil depth then dismantled carefully so the volume of the soil remains constant. The sample points were determined randomly according to the ground cover treatments. Soil physical property analysis was conducted on soil bulk density, soil-specific gravity, and the total pore space at the soil physics laboratory at the Soil Research Institute, Bogor.

Result and Discussion

The growth of *A. pintoi* that were planted 12 weeks before cassava (B4) was even and covered almost the entire surface of the beds (85-90%). Arachis pintoi planted at eight weeks before cassava (B3) had a coverage of 60-75%, whereas those planted four weeks before cassava (B2) had the coverage of 30-45%. *Arachis pintoi* planted at the time of cassava planting (B1) grew very slowly and did not have much coverage (Figure 1).

Arachis pintoi planted at 12 weeks (B4) had a greater fresh weight (232.6 g.m^{-2}) and dry weight (65.1 g.m^{-2}) compared to those planted at the other times (Table 1). *Arachis pintoi* planted at cassava planting (B1) had the lowest weight, likely because they grew slower due to competition with the weeds and the cassavas.

Arachnis pintoi planted at 8 or 12 weeks before planting cassava was able to suppress weed growth (Table 2). At 6 MAP, the weed dry weight with *A. pintoi* planted at 8 weeks before planting cassava was 15.55 g per 0.25 m^2, whereas with *A. pintoi* planted 12 weeks before cassava was 14.65 g per 0.25m^2 (Table 2).

Summed Dominance Ratio

Vegetation analysis before land preparation and after cassava harvest are described in Table 3. Before planting cassava, 11 weed species were identified, nine of which were broadleaf weeds, one species of grass, and one species of sedge. Broadleaf weeds appeared to be more dominant at the beginning (before planting cassava) with an SDR value of 51.18% compared to the grass weeds (11.41%) and the sedge weeds (37.41%) (Table 3).

There was a shift in the weed dominance at six months after cassava planting, especially the broadleaf weeds, and this was influenced by biomulch treatments (Figure 2). Our results agreed with Silmi and Chozin (2014) who reported a shift in the weed

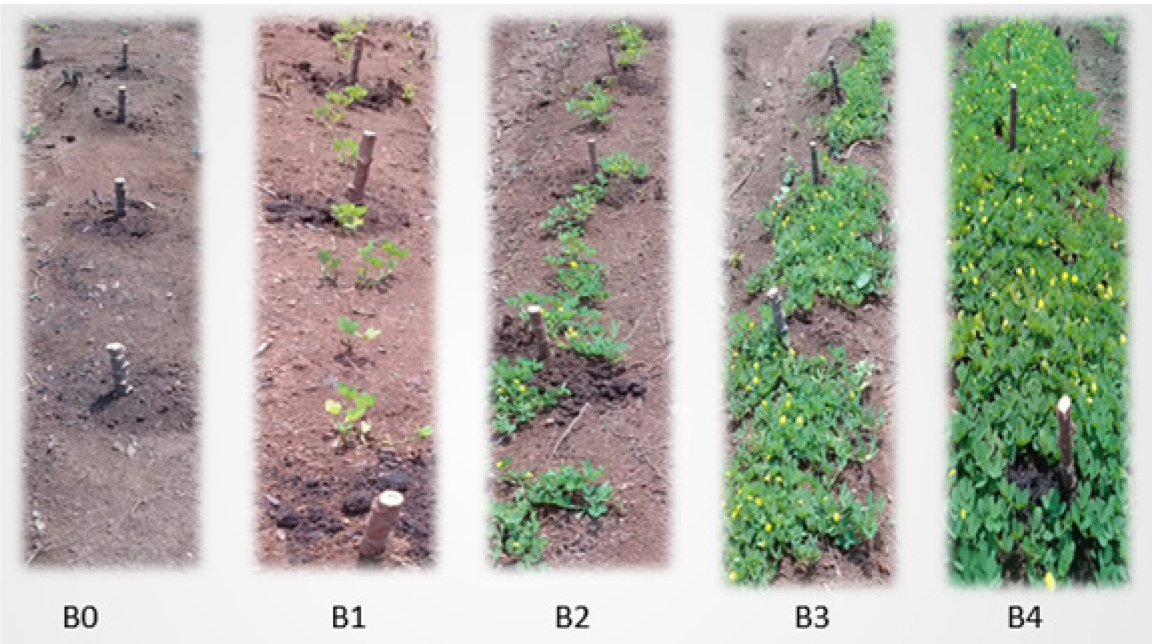


Figure 1. *Arachis pintoi* biomulch cover in the cassava plantation: control (without *A. pintoi*, B0), *A. pintoi* planted at the time of cassava planting (B1), and planted at four weeks (B2), eight weeks (B3), and 12 weeks (B4) before planting cassava.

Table 1. Fresh weight and dry weight of *A. pintoi* biomulch at six months after planting

Treatment	Fresh weight ($g.m^{-2}$)	Dry weight ($g.m^{-2}$)
B1	100.0 c	38.9
B2	161.2 b	55.3
B3	171.7 b	54.0
B4	232.6 a	65.1

Note: values followed by different letters within the same column are significantly different according to the Honestly Different test at α=0.05. MAP: months after planting. B0: without biomulch application, B1: simultaneously with cassava planting, B2: four weeks before cassava planting, B3: eight weeks before cassava planting, B4: twelve weeks before cassava planting

Table 2. The average weed dry weight at two and six months after cassava planting.

Treatment	Weed dry weight (g per 0.25 m^2)	
	2 MAP	6 MAP
B0	11.07	19.27
B1	25.83	23.60
B2	19.23	22.90
B3	15.93	15.55
B4	17.27	14.65

Note: values followed by different letters within the same column are significantly different according to the Honestly Different test at α=0.05. MAP: months after planting cassava. B0: without biomulch, B1: biomulch was planted at the time of cassava planting, B2: biomulch was planted four weeks before cassava planting, B3: biomass was planted eight weeks before cassava planting, B4: biomass was planted twelve weeks before cassava planting.

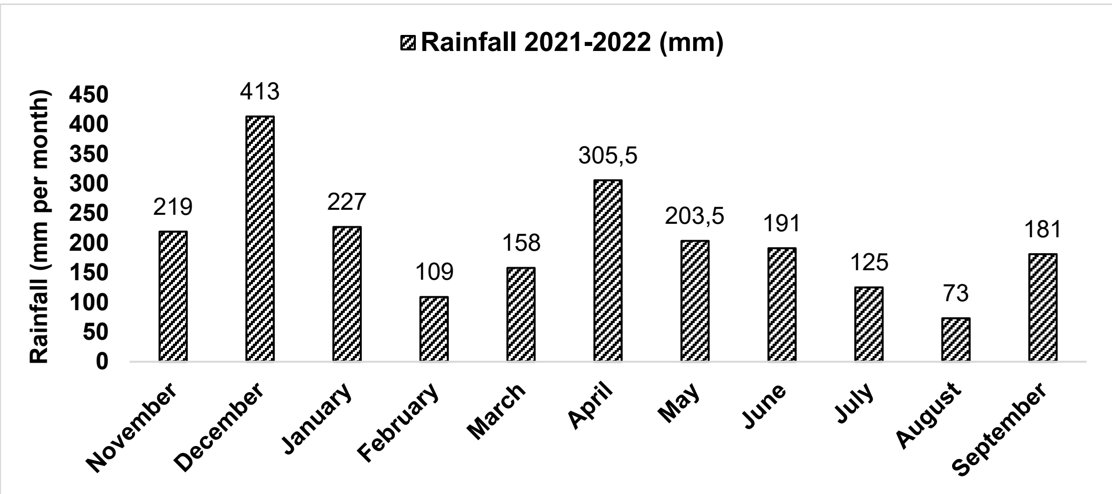


Figure 2. Rainfall at the research location from November 2021 to September 2022

types on sweet corn plantations due to biomulch treatment. Based on the summed dominance ratio (SDR), broadleaf weeds were more dominant than weeds and grasses in each treatment. The SDR values of each weed groups can be seen in Table 2, which clearly demonstrated that planting biomulch *A. pintoi* is effective to suppress sedge weeds but is less effective to suppress grass and broadleaf weeds.

Broadleaf weeds grow fast and tall, so they become cassava's competitor for sunlight. Weed competitiveness is also affected by the leaf morphology; the wider the leaf, the more it can capture light for photosynthesis. The slow growing nature of *A. pintoi* allows broadleaf weeds to grow faster. According to Ciaccia et al. (2014) it is crucial to plant the ground cover at the correct time, and the selection of living mulch is important for suppressing the weeds. Combination of ground cover crops and herbicides can effectively control broadleaf weeds

Table 3. Summed dominance ratio (%) of weeds at different biomulch treatments at six months after cassava planting.

No	Weeds species	Morphology	Summed dominance ratio (%)					
			Pre-planting	B0	B1	B2	B3	B4
1.	*Melastoma malabatrichum* L.	BL	0	10.16	0	11.28	21.54	5.66
2.	*Mimosa invisa* L.	BL	5.20	8.07	11.81	14.75	0	8.29
3.	*Oldenladia corymbosa* L.	BL	0	11.20	0	0	0	0
4.	*Oxalis barrelieri* L.	BL	2.35	0	0	5.64	16.30	4.15
5.	*Ottochloa nodosa* (Kunth) Dandy	G	11.41	21.61	18.77	13.66	21.03	26.08
6.	*Tetracera indica* (L). Merr	BL	2.10	0	7.01	4.55	0	4.15
7.	*Solanum* sp.	BL	0	10.94	10.34	9.11	0	4.15
8.	*Ipomoea* sp	BL	10.66	0	4.07	8.02	0	8.29
9.	*Cyperus* sp	S	37.41	18.49	14.36	12.37	16.03	11.32
10.	*Ageratum conyzoides* L.	BL	0	0	5.54	0	0	0
11.	*Panicum repens* L.	G	0	0	0	6.73	0	0
12.	*Desmodium turtuosum* (Sw). DC	BL	11.56	6.51	4.80	0	0	0
13.	*Cleome rutidosperma* D.C	BL	0	0	0	6.94	0	0
14.	*Melochia corchorifolia* L.	BL	0	0	13.68	0	0	0
15.	*Mimosa pudica* L.	BL	10.41	0	0	0	12.69	8.29
16.	*Stachytapherta indica*	BL	0	0	0	0	0	4.15
17.	*Hyptis brevipes Poit.*	BL	0	0	0	0	5.51	5.66
18.	*Portulaca oleracea* L.	BL	4.45	3.65	0	0	0	0
19.	*Emilia sonchifolia* (L).DC	BL	0	2.86	4.80	3.47	0	0
20.	*Dioschorea hispida* Dennst	BL	4.70	2.86	0	0	7.18	5.66
21.	*Phyllantus niruri* L.	BL	4.95	3.65	4.80	3.47	0	4.15
	SDR (%)	BL	51.18	59.90	66.86	67.24	62.95	62.60
		G	11.41	21.61	18.77	20.39	21.03	26.08
		S	37.41	18.49	14.36	12.37	16.03	11.32

Note: BL= broad leaf weeds; G = grasses; S = sedges.

(Majidi et. Al., 2020), and planting season, planting time, and tillage can affect the levels of weed control by the ground cover (Osipitan et al., 2019). Planting *A. pintoi* biomulch 8 and 12 weeks before planting cassava was able to suppress weed growth, demonstrated by a decrease in weed dry weight compared to without biomulch treatment (Table 2). This shows that biomulch *A. pintoi* can compete with weeds. Living mulch suppress weed growth by competing for water, light, and nutrients in the soil (Mohammadi, 2012).

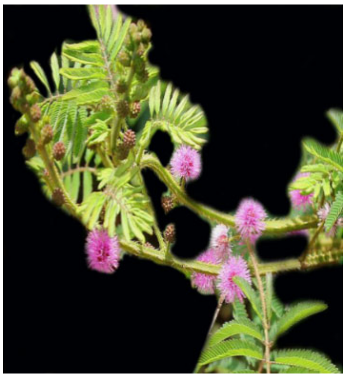
According to McKenzie-Gopsill et al. (2022), cover crops can produce large amounts of biomass so they can effectively suppress weeds. Biomulch planted 12 weeks before planting cassava had the highest biomass weight (Table 1), showing that a longer time is required for the biomass to cover the soil surface. In addition, the cassava canopy also reduces weed growth under the cassava plants. According to Mzabri et al., (2022) 70% of shade can inhibit weed growth, although this depends on the weed species and their tolerance to environmental stress condition.

The dominant weed species from the broadleaf group include *Melastoma malabathricum, Mimosa invisa, Oxalis barrelieri, Dioscorea hispida, Tertacera indica, Ipomoea obscura*, and from the grass group *Ottochloa nodosa* (Figure 3). It is suspected that these weed species are adaptable and tolerant to the environmental stress, making it difficult to be suppressed by ground cover plants. According to a

Melastoma malabatrichum

Tetracera indica

Ipomoea sp



Mimosa invisa L.

Oxalis barrelieri L.

Cyperus sp

Figure 3. Dominant weed species in cassava plantation at Jonggol, West Java, Indonesia.

study by Listyowati et al. (2022), the dominance of broadleaf weeds is due to by the growth of weed seeds after tillage; soil tillage brings the weed seeds to the soil surface and exposed them to light required for germination. The dominant weed species has vine and creeping growth habits, such as *Tetracera indica, Ottochloa nodosa, Dioscorea hispida*, and *Ipomoea obscura*. According to Sudira et al. (2017) root system greatly affects plant growth, those with shallow and creeping roots get more nutrients and water, whereas those with taproot can grow deep into the soil to access water.

The important characters for selecting cover crop are fast growth and tolerance to shades and drought, and these characters are very important for a long-term weed control (Schappert et al., 2019). Using *A. pintoi* as biomulch can be an option in environmentally friendly weed management because it can reduce the use of chemicals from herbicides. According to Monteiro and Santos (2022), using herbicides in weed control often causes weed resistance and ecosystem imbalance. Environmental pollution, weed resistance, and increased production costs are the effects of an excessive herbicide use (Pradhan et al., 2022). Long-term weed control for sustainable agriculture must be safe and efficient; it is important to select ground cover that can increase soil fertility, pore space (Pavlovic et al., 2022), and soil moisture (Yuniarti et al., 2018). According to Kaluba et al., (2021), intercropping of cassava and legumes can help suppress weed growth, use less fertilizer, and reduce labor input.

Cassava productivity can increase if weeded at least twice during cassava growing season (Kintché et al., 2017). Weed control by application of glyphosate herbicide is equivalent to five times manual weeding but is more expensive than the manual weeding conducted twice (Chikoye et al., 2002). Therefore, the use of biomulch can potentially reduce the use of herbicides and labor.

Soil Chemical Quality

The soil analysis before tillage showed that it had an acidic pH (4.12), low total nitrogen (0.14%), and low cation exchange capacity (28.53 cmol.kg^{-1}), and the soil has a dominant clay texture (51.79%), 25.34% sand, and 22.87% silt. The results of the soil chemical analysis are presented in Table 2. The soil chemical analysis six months after planting cassava showed an increase in C-organic, N-total, available P, and CEC (Table 3).

Table 4. Physicochemical properties of the topsoil (0–30 cm depth) of the experimental sites before tillage.

Soil properties	Values	Cassava suitability levels
pH (H_2O)	4.12	4.5-7.0
Total nitrogen	0.14	0.20-0.50
Organic-C (%)	3.69	2.0-4.0
C/N	12	
CEC (cmol.kg^{-1})	28.53	
BS (%)	47.65	
P_2O_5 - Bray (ppm)	8.6	
K_2O (ppm)	170	
Exchangeable bases (cmol.kg^{-1})		
K	0.37	0.15-2.5
Ca	4.92	1.0-5.0
Mg	8.14	0.4-1.0
Na	0.15	
Sand (%)	25.34	
Clay (%)	51.79	
Silt (%)	22.87	
Textural class	Clay	

Note: Cassava suitability level according to Howeler (2012) and Kaluba et al. (2022).

Table 5. Soil chemical properties at six month after planting

Soil properties	B0	B1	B2	B3	B4
C-organic (%)	1.97(L)	1.79(L)	5.12(VH)	7.54(VH)	2.60(M)
Total N (%)	0.18(L)	0.16(L)	0.36(M)	0.41(M)	0.22(M)
P_2O_5 (ppm)	16.6(M)	9.8(VL)	17.9(M)	12.9(L)	4.0(VL)
K_2O (ppm)	119.7(VH)	194.5(VH)	271.8(VH)	374.1(VH)	173.8(VH)
CEC (cmol.kg^{-1})	18.88(L)	20.47(L)	48.70(VH)	68.81(VH)	26.47(M)

Notes: B0: without biomulch application, B1: simultaneously with cassava planting, B2: four weeks before cassava planting, B3: eight weeks before cassava planting, B4: twelve weeks before cassava planting, CEC: capacity cation exchange, VL: Very Low, L: Low, M: moderate, H: high, VH: Very High

There was a decrease of C-organic content in the control and in the biomulch B1 treatment (planted at the same time as cassava planting). The initial C-organic value was 3.69% (moderate), in the treatment without biomulch it was 1.97% (low), and in the B1 treatment it was 1.79% (low). With treatment B2 the C-organic value was 5.12% (very high), B3 was 7.54% (very high), and treatment B4 was 2.60% (moderate). These results show that the C-organic content, which is abundant in the topsoil, can be easily leached by soil erosion. On the other hand, with the biomulch treatment B2 and B3 the amount of specific C-organic increased (Table 5). According to Nariratih et al. (2013), the amount of carbon in the soil is influenced by several factors including evapotranspiration, activity of soil microorganisms in breaking down organic matter, soil erosion, and carbon removal at harvest. High residual biomass from the ground cover increases soil organic matter, and the biomass production is affected by rainfall. Lower rainfall reduces growth, hence lower the biomass production (Blanco-Canqui et al., 2015).

The soil total-N value before tillage is 0.14% which is in the low N category (Table 4), and this value is similar to the value before the cassava harvest. The total-N in the control (without biomulch) was 0.18%, and with biomulch B1 was 0.16% (also in the low category, Table 5). With the biomulch treatments B2, B3, and B4, there was an increase of 0.22-0.41% in the total N, which is in the moderate category. This shows that the biomulch treatment four, eight, and twelve weeks before planting cassava can increase nitrogen in the soil. Increased nitrogen levels in the soil with *A.pintoi* biomulch treatment might be due to nitrogen fixation by Rhizobium bacteria. According to a study by Parvin et al., (2022) the increase in total N-was influenced by the activity of rhizobium, and the use of legume cover crops under optimal growth conditions was able to fix up to 50 kg N/ha-1. According to De Notaris et al., (2020), using legume plants as ground cover increases soil carbon and nitrogen. Increasing the organic matter content in the soil may also increase the N content in the soil (Asbur et al., 2018; Plaza-Bonilla et al., 2015). Using *A. pintoi* cover crops can increase the availability of soil nitrogen and maintain soil moisture (Chozin et al., 2015). The use of cover crops can minimize N loss due to climate change (Kaye and Quemada, 2017), and reduce NO_3 leaching regardless of the type of soils (Lapierre et al., 2022).

The available soil P before the study was classified as very low (8.6 ppm, Table 4) but it increased after the biomulch treatment, except for the B4 treatment. This shows that *A. pintoi* biomulch can increase the available phosphorus in the soil. According to Lizcano Toledo et al. (2022), the use of cover crops for years can increase the soil available P. However, the increase in phosphorus does not guarantee that the plants can use the phosphorus because of the high levels of Fe, which may bind P and make P unavailable to the plants. The solubility of Fe and Al in acidic soils is relatively high and form strong bonds of Al-P and Fe-P, making them unavailable to the plants (Daras et al., 2012). According to Syahputra et al., (2015), ultisols' high and low P content depends on the P content in the parental materials. The unavailability of P for plants is also affected by the presence of P bonds in Al and Fe minerals. This is in line with a study by Mardamootoo et al. (2021), which stated that phosphorus is present in most soils, but it is not necessarily available for plants.

The CEC value before tillage was 28.53 cmol.kg^{-1}, which is classified as high. The high CEC values may be due to the soil texture at the study site which is dominated by clay fraction (Table 4). At the time of harvest, the results of soil analysis showed an increase in CEC compared to without cover crop treatment, whereas soil CEC values increased in all biomulch treatments (Table 4). The biomulch B2 and B3 treatments showed the highest CEC values, i.e., 48.7 cmol.kg^{-1} and 28.8 cmol.kg^{-1} (Table 5). This shows that cover crops can increase the soil CEC value. According to Husni et al. (2016) and Sari et al. (2022), soils that predominantly has the clay fraction tend to have a high capacity for ion exchange and bind water, so they have highly stable soil aggregates. In addition, these soils contain Ca, Mg, K, and Na, which also affects the CEC values (Husni et al. 2016, Sari et al., 2022). Soils with high CEC values can hold more nutrients in the form of cations (Taisa et al., 2019).

Soil Physical Quality

Our study showed that the biomulch treatment reduced soil bulk density (Table 6). At the beginning of planting, treatment B1 to B4 had a bulk density value of 0.77 g.cm^{-3} to 0.81 g.cm^{-3}, lower than without biomulch treatment (Table 6). At the time of harvest, the soil with biomulch treatment had a lower soil bulk density than those without the biomulch treatment (Table 6). The lowest bulk density was in the B2 treatment of 0.65 g.cm^{-3} or decreased by about 35% by weight. This shows that *A. pintoi* biomulch increased the soil organic matter and reduced soil bulk density. Study by Muddarisna et al. (2009) reported that the use of manures and green manure A. pintoi reduced the soil weight, increased soil porosity, and increased soil permeability and soil aggregates. Soil with low bulk density makes it easier for plant roots to penetrate the deeper soil layers (Maysarah et al., 2021), whereas high bulk density reduces soil pores hence reduces aeration (Meli et al., 2018).

Biomulch treatment B1, B2, and B3 reduced the specific gravity of the soil by 2.12 g.cm^{-3}, 2.14 g.cm-

Table 6. Effect of biomulch treatments on the soil bulk density, specific gravity, and total pore space at the beginning of planting (0 MAP) and at cassava harvest (6 months after planting).

Biomulch treatment	Bulk density (g.cm^{-3})		Specific gravity (g.cm^{-3})		Total pore space (%)	
	0 MAP	6 MAP	0 MAP	6 MAP	0 MAP	6 MAP
B0	0.85	1.00	2.03	2.23	58.2	55.3
B1	0.81	0.87	1.87	2.12	56.7	59.2
B2	0.79	0.65	2.20	2.14	63.8	69.8
B3	0.80	0.80	2.04	2.15	60.8	62.7
B4	0.77	0.95	1.97	2.23	60.9	57.5

Notes: results of soil testing in the soil research center laboratory. B0: without biomulch application, B1: simultaneously with cassava planting, B2: four weeks before cassava planting, B3: eight weeks before cassava planting, B4: twelve weeks before cassava planting. MAP: months after planting cassava.

3, and 2.15 g.cm^{-3}, respectively, whereas the control had 2.23 g.cm^{-3} (Table 6). These values show that the use of biomulch increases the soil organic matter, which presumably reduce the soil-specific gravity and bulk density as according to Safitri et al. (2018), the higher the organic matter applied to the soil, the lower the soil specific gravity. Increasing organic matter content improves soil physical properties, resulting in a more stable soil structure, and increased soil N and K (Yuliani and Rahayu, 2016). With the optimal crop and soil management, Ultisols can be utilized as agricultural land for food crops (Syahputra et al., 2015).

The total pore space at the study site was significantly increased by the *A. pintoi* biomulch treatment (Table 6), and treatment B2 had a total pore space increase of 20.7% (Table 6). This indicates that the decrease in bulk density increases the total pore space. Our results agree with Khair et al. (2017) in that soil bulk density is inversely proportional to the total pore space and is affected by the soil organic matter. The increase in the soil total pore space is related to the formation of soil aggregates by soil organic matter, hence increasing the soil volume and pores (Ardiansyah et al., 2015). The soil pores formed between soil particles affects the growth of plant roots; the high soil porosity allows the plant roots to penetrate deeper soil and access more water and nutrients (Taisa et al., 2019).

Conclusion

Arachnis pintoi planted four and eight weeks before planting cassava controlled the weed growth, demonstrated by the lowest weed dry weight of 15.55 g per 0.25 m^{-2} and 14.65 g per 0.25 m^{-2}, respectively at six months after cassava planting. All biomulch treatments increased the soil density and pore spaces. The soil with biomulch planted eight weeks before cassava had the highest C-organic (7.59%) and total N (0.41%) compared to the control/without *A. pintoi* biomulch. The dominant weeds in the cassava study site are *Melastoma malabathricum*, *Tetracera indica*, *Oxalis barrelieri*, *Mimosa invisa*, *Ipomoea* sp, *Ottochloa nodosa* and *Cyperus* sp.

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References

Adiele, J. G., Schut, A. G. T., Ezui, K. S., Pypers, P., and Giller, K. E. (2021). Dynamics of N-P-K demand and uptake in cassava. *Agronomy for Sustainable Development* **41**. https://doi.org/10.1007/s13593-020-00649-w

Ardiansyah, R., Banuwa, I. S., and Utomo, M. (2015). Pengaruh sistem olah tanah dan residu pemupukan nitrogen jangka panjang terhadap struktur tanah, bobot isi, tuang pori total dan kekerasan tanah pada pertanaman kacang hijau (*Vigna radiata* L). *Jurnal Agrotek Tropika* **3**, 283–289. https://doi.org/10.23960/jat.v3i2.2034

Asbur, Y., Handayani, D. R. R., Purwaningrum, Y., and Kusbiantoro, D. (2018). Potential of several weeds as cover crop on mature oil palm area. *Jurnal Penelitian Kelapa Sawit* **26**, 113–128. https://doi.org/https://doi.org/10.22302/iopri.jur.jpks.v26i3.69

Aswiguna, S., Sarno, S., Afrianti, N. A., and Supriatin, S. (2022). Pengaruh pemberian biochar batang singkong dan pemupukan P terhadap serapan hara N dan K pada tanaman jagung (*Zea mays* L.). *Jurnal Agrotek Tropika* **10**, 455–459. https://doi.org/10.23960/jat.v10i3.6109

Benesi, I. R. M., Labuschagne, M. T., Dixon, A. G. O., and Mahungu, N. M. (2004). Stability of native starch quality parameters, starch extraction and root dry matter of cassava genotypes in different environments. *Journal of the Science of Food and Agriculture* **84**, 1381–1388. https://doi.org/10.1002/jsfa.1734

Blanco-Canqui, H., Shaver, T. M., Lindquist, J. L., Shapiro, C. A., Elmore, R. W., Francis, C. A., and Hergert, G. W. (2015). Cover crops and ecosystem services: insights from studies in temperate soils. *Agronomy Journal* **107**, 2449–2474. https://doi.org/10.2134/agronj15.0086

Chozin, M. A., G. Kartika, U., and Baharudin, R. (2015). Penggunaan kacang hias (Arachis pintoi) sebagai biomulsa pada budidaya tanaman tomat (*Lycopersicon esculentum* M.). *Jurnal Hortikultura Indonesia* **5**, 168. https://doi.org/10.29244/jhi.5.3.168-174

Crotty, F. V., and Stoate, C. (2019). The legacy of cover crops on the soil habitat and ecosystem services in a heavy clay, minimum tillage rotation. *Food and Energy Security* **8**, 1–16. https://doi.org/10.1002/fes3.169

Chikoye, D., Manyong, V., Carsky, R.J., Ekeleme, F., Gbèhounou, G., and Ahanchede, A. (2002). Response of speargrass (*Imperata cylindrica*) to cover crops integrated with hand weeding and chemical control in maize and cassava. *Crop Protection* **21**, 145-156. doi: 10.1016/S0261-2194(01)00078-3.

Daras, U., Tjahjana, B. E., and Herwan. (2012). Status hara tanaman lada Bangka Belitung. *Jurnal Tanaman Industri Dan Penyegar* **3**, 23–32. https://doi.org/10.21082/jtidp.v3n1.2012.p23-32

De Notaris, C., Olesen, J. E., Sørensen, P., dan Rasmussen, J. (2020). Input and mineralization of carbon and nitrogen in soil from legume-based cover crops. *Nutrient Cycling in Agroecosystems* **116**, 1–18. https://doi.org/10.1007/s10705-019-10026-z

Eviati, S. 2009. “Analisis Kimia Tanah, Tanaman, Air dan Pupuk”. 2nd ed. Balai Penelitian Tanah. Bogor.

Fageria, N. K., dan Santos, A. B. (2018). Comparative efficiency of nitrogen sources for lowland rice production. *Communications in Soil Science and Plant Analysis* **49**, 515–525. https://doi.org/10.1080/00103624.2018.1424892

Howeler, R. (2012). A reference manual based on the Asian regional cassava training course held in Thailand *In* “The Cassava Handbook” (R.H. Howeler, ed.). CIAT Cassava Field Crop Research Institute. Thailand.

Husni, M. R., Sufardi, S., and Khalil, M. (2016). Evaluasi status kesuburan pada beberapa jenis tanah di lahan kering kabupaten Pidie provinsi Aceh. *Jurnal Ilmiah Mahasiswa Pertanian* **1**, 147–154. https://doi.org/10.17969/jimfp.v1i1.950

Jaiswal, D. ., Verma, J. ., Prakash, S., and Meena, V. S. (2016). Potassium as an important plant nutrient in sustainable agriculture: a state of the art. *In* “Pottasium Solubilizing Microorganism for Sustainable Agriculture” pp. 21–29. Springer. https://doi.org/http://dx.doi.org/10.1007/978-81-322-2776-2_2

Kaluba, P., Mwamba, S., Moualeu-Ngangue, D.P., Chiona, M., Munyinda, K.L., Winter, E., Stützel, H., and Chishala, B.H. (2021). Cropping practices and effects on soil nutrient adequacy levels and cassava yield of smallholder farmers in Northern Zambia. *International Journal of Agronomy*. doi: 10.1155/2021/1325964.

Kaluba, P., Mwamba, S., Moualeu-Ngangue, D.P., Chiona, M., Munyinda, K.L., Winter, E., Stützel, H., and Chishala, B.H. (2022). Performance of cassava under lime, fertilizer, and legume intercropping on exhausted land in Northern Zambia. *International Journal of Agronomy*. doi: 10.1155/2022/3649355.

Kanto, U., Jutamanee, K., Osotsapar, Y., and Jattupornpong, S. (2012). Effect of swine manure extract on leaf nitrogen concentration, chlorophyll content, total potassium in plant parts and starch content in fresh tuber yield of cassava. *Journal of Plant Nutrition* **35**, 688–703. https://doi.org/10.1080/01904167.2012.653074

Kartika, J., Reyes, M., and Susila, A. (2009). Review of literature on perennial peanut (*Arachis pintoi*) as potential cover crop in the tropics *In* “Seminar Ilmiah Perhorti” pp. 391–399. https://vtechworks.lib.vt.edu/handle/10919/68125

Kaye, J. P., and Quemada, M. (2017). Using cover crops to mitigate and adapt to climate change, a review. *Agronomy for Sustainable Development* **37**. https://doi.org/10.1007/s13593-016-0410-x

Khair, R. K., Utomo, M., Afandi, A., and Banuwa, I. S. (2017). Pengaruh olah tanah dan pemupukan nitrogen jangka panjang terhadap bobot isi , ruang pori total, kekerasan tanah dan produksi tanaman jagung (Zea mays L) di lahan Polinela Bandar Lampung. *Jurnal Agrotek Tropika* **5**, 175–180. https://doi.org/10.23960/jat.v5i3.1826

Kim, N., Zabaloy, M. C., Guan, K., and Villamil, M. B. (2020). Do cover crops benefit soil microbiome? A meta-analysis of current research. *Soil Biology and Biochemistry* **142**, 107701. https://doi.org/10.1016/j.soilbio.2019.107701

Kintché, K., Hauser, S., Mahungu, N., Ndonda, A., Lukombo, S.M., Nhamo, N., Uzokwe, V.N., Yomeni, M., Ngamitshara, J., Ekoko, B.E., Mbala, M., Akem, C., Pypers, P., Matungulu, K.M., Kehbila, A.G., and Vanlauwe, B. (2017).

Cassava yield loss in farmer fields was mainly caused by low soil fertility and suboptimal management practices in two provinces of the Democratic Republic of Congo. *European Journal of Agronomy* **89**, 107-123.

Lapierre, J., Machado, P. ., Debruyn, Z., Brown, S., Jordan, S., Berg, A., Biswas, A., Henry, H. ., and Wagner-Riddle, C. (2022). Cover crop mixtures: a powerful strategy to reduce post-harvest surplus of soil nitrate and leaching. *Agriculture, Ecosystems and Environment*, 325. https://doi.org/https://doi.org/10.1016/j.agee.2021.107750

Listyowati, C., D. Indradewa, and S.N.R. Irwan. (2022). Study on weeds abundance on rice fields in mycorrhizal inoculation and different planting methods. *Caraka Tani Journal of Sustainable Agriculture* **37**: 259. DOI:10.20961/carakatani.v37i2.53131.

Lizcano Toledo, R., Lerda, C., Moretti, B., Miniotti, E., Santoro, V., Fernandez-Ondoño, E., Martin, M., Said-Pullicino, D., Romani, M., and Celi, L. (2022). Cover crops increase N and P cycling and rice productivity in temperate cropping systems. *Agronomy* **12**. https://doi.org/10.3390/agronomy12092193

Mardamootoo, T., du Preez, C., and Barnard, J. (2021). Phosphorus management issues for crop production: A review. *African Journal of Agricultural Research* **17**, 939–952. https://doi.org/10.5897/ajar2020.15205

Ma’ruf, A., Zulia, C., and Safrudin. (2017). “Legume Cover Crop di Perkebunan Kelapa Sawit”. Forthisa Karya.

Maysarah, S., Nugroho, Y., and Susilawati, S. (2021). Analisis sifat fisika tanah pada lahan gambut di kecamatan Liang Anggang kota Banjarbaru provinsi Kalimantan Selatan. *Jurnal Sylva Scienteae* **4**, 166. https://doi.org/10.20527/jss.v4i1.3104

McKenzie-Gopsill, A., Mills, A., MacDonald, A.N., and Wyand, S. (2022). The importance of species selection in cover crop mixture design. *Weed Science* **70**, 436 - 447.

Melati, M., Ari, A. N. H. G., and Aziz, S. A. (2021). Plant growth and morphological characters of Sonchus arvensis L. from different chicken manure rates and harvest intervals with ratooning practices. *Journal of Tropical Crop Science* **8**, 60–70. https://doi.org/10.29244/jtcs.8.02.60-70

Meli, V., Sagiman, S., and Gafur, S. (2018). Identifikasi sifat fisika tanah ultisols pada dua tipe penggunaan lahan di desa Betenung kecamatan Nanga Tayap kabupaten Ketapang. *Perkebunan dan Lahan Tropika* **8**, 80–90. https://doi.org/10.26418/plt.v8i2.29801

Mohammadi, G. (2012). Living mulch as a tool to control weeds in agroecosystems : a review in “Weed Control” pp. 75–100. https://www.intechopen.com/books/advanced-biometric-technologies/liveness-detection-in-biometrics [January 1, 2023].

Mota, L. H. S. O., Fernandes, A. M., Assunção, N. . S., and Leite, H. . M. F. (2020). Leaf area development and yield of cassava in response to pruning of shoots and the late supply of nitrogen and potassium. *Agronomy Journal* **112**, 1406–1422. https://doi.org/10.1002/agj2.20113

Muddarisna, N., Sugeng Priyono, D., Pertanian, F., Whisnuwardana, U., and Brawijaya, U. (2009). Implementasi pemeliharaan lahan budidaya ubikayu melalui perbaikan dan monitoring kualitas tanah. *Buana Sains* **9**, 47–56. https://doi.org/https://doi.org/10.33366/BS.V9I1.223

Mzabri, I., Rimani, M., Charif, K., Kouddane, N., and Berrichi, A. (2022). Effect of shade on agro-morphological parameters and weed flora of saffron (*Crocus sativus* L.) cultivation in the semiarid zone of eastern Morocco. *The Scientific World Journal*, 2022. DOI: 10.1155/2022/9954404

Nariratih, I., Damanik, M. M., and Sitanggang, G. (2013). Ketersediaan nitrogen pada tiga jenis tanah akibat pemberian tiga bahan organik dan serapannya pada tanaman jagung. *Jurnal Online Agroekoteknologi* **1**, 479–488. https://doi.org/https://doi.org/10.32734/JAET.V1I3.2645

Nintania, R., Setiawan, K., Yuliadi, E., and Hadi, M.S. (2021). Evaluasi pertumbuhan dan kadar pati beberapa klon ubikayu (*Manihot esculenta* Crantz). *Journal of Tropical Upland Resources* **3**, 36–44.

Nursyamsi, D. (2006). Kebutuhan hara kalium tanaman kedelai di tanah ultisol. *Jurnal Ilmu Tanah Dan Lingkungan* **6**, 71–81.

Parvin, S., Condon, J., and Rose, T. J. (2022). Potential nitrogen contributions by tropical legume summer cover crops in mediterranean-type cropping systems. *Nitrogen* **3**, 592–599. https://doi.org/10.3390/nitrogen3040038

Plaza-Bonilla, D., Arrúe, J. L., Cantero-Martínez, C., Fanlo, R., Iglesias, A., and Álvaro-Fuentes, J. (2015). Carbon management in dryland agricultural systems, a review. *Agronomy for Sustainable Development* **35**, 1319–1334. https://doi.org/10.1007/s13593-015-0326-x

Prasetyo, B. H., and Suriadikarta, D. A. (2014). Karakteristik, potensi, dan teknologi pengelolaan tanah ultisol untuk pengembangan pertanian lahan kering di Indonesia. *Litbang Pertanian* **25**, 39–47.

Rahmiati, T. M., Purwanto, Y. A., Budijanto, S., and Khumaida, N. (2017). Sifat fisikokimia tepung dari 10 genotipe ubi kayu (*Manihot esculenta* Crantz) hasil pemuliaan. *Agritech* **36**, 459–466. https://doi.org/http://dx.doi.org/10.22146/agritech.16771

Rosmarkam, A., and Yuwono, N. (2002). “Ilmu Kesuburan Tanah”. PT Kanisius.

Safitri, I. N., Setiawati, T. C., and Bowo, C. (2018). Biochar dan kompos untuk peningkatan sifat fisika tanah dan efisiensi penggunaan air. Techno: *Jurnal Penelitian* **7**, 116. https://doi.org/10.33387/tk.v7i01.611

Saidi, D. (2020). Potensi lahan marginal untuk pengembangan tanaman singkong (*Manihot esclenta* Crantz) spesifik lokasi di Daerah Istimewa Yogyakarta. *In* “Prosiding Seminar Nasional Fakultas Pertanian UPB Veteran Yogyakarta 2020 (T. Setyaningrum, L. F. L. Pratiwi, and M. Kafiya, eds.) pp. 382–390. Fakultas Pertanian Universitas Pembangunan Nasional “Veteran” Yogyakarta.

Sari, A. N., Muliana, M., Yusra, Y., Khusrizal, K., and Akbar, H. (2022). Evaluasi status kesuburan tanah sawah tadah hujan dan irigasi di kecamatan Nisam, kabupaten Aceh Utara. *Jurnal Ilmiah Mahasiswa Agroekoteknologi* **1**, 49. https://doi.org/10.29103/jimatek.v1i2.8467

Sarjono, A., Guntoro, D., and Supijatno, D. (2019). Perbandingan Arachis pintoi dengan tanaman kacang-kacangan penutup tanah lain dalam menekan laju erosi pada lahan kelapa sawit berbukit. *Jurnal Agronomi Indonesia (Indonesian Journal of Agronomy)* **47**, 90–96. https://doi.org/10.24831/jai.v47i1.22891

Schappert, A., Schumacher, M., and Gerhards, R. (2019). Weed control ability of single sown cover crops compared to species mixtures. *Agronomy* **9**. DOI: 10.3390/agronomy9060294.

Sudaryono, S. (2016). Tingkat kesuburan tanah ultisol pada lahan pertambangan batubara Sangatta, Kalimantan Timur. *Jurnal Teknologi Lingkungan* **10**, 337–346. https://doi.org/10.29122/jtl.v10i3.1480

Sudira, P., Shiddieq, D. and Tohari. (2017). “Aspek Dasar Agronomi Berkelanjutan”. Gadjah Mada University Press.

Sumiahadi, A., Chozin M.A., Guntoro, D. (2019). Effectiveness of Arachis pintoi Karp & Greg as biomulch to control weeds on maize cultivation. *International Journal of Innovative Approaches in Agricultural Research* **3**, 680-689.

Suwarto, and Asih, R. (2021). Growth of legume cover crops under cassava and its effect on soil properties. *Legume Research* **44**, 1077–1081. https://doi.org/10.18805/LR-607

Syahputra, E., Fauzi, and Razali. (2015). Karakteristik sifat kimia sub grup tanah ultisol di beberapa wilayah Sumatera Utara. *Jurnal Agroekoteknologi* **4**, 1796–1803.

Taisa, R., Purba, T., Sakiah, Herawati, J., Junaedi, A., Hasibuan, H. S., Junairiah, and Firgiyanto, R. (2019). “Ilmu Kesuburan Tanah dan Pemupukan” (A. Karim, ed.). 1st ed. Yayasan Kita Menulis.

Tan, X., Gu, B., Li, X., Xie, C., Chen, L., and Zhang, B. (2017). Effect of growth period on the multi-scale structure and physicochemical properties of cassava starch. *International Journal of Biological Macromolecules* **101**, 9–15. https://doi.org/10.1016/j.ijbiomac.2017.03.031

Tappiban, P., Ying, Y., Pang, Y., Sraphet, S., Srisawad, N., Smith, D. R., Wu, P., Triwitayakorn, K., and Bao, J. (2020). Gelatinization, pasting and retrogradation properties and molecular fine structure of starches from seven cassava cultivars. *International Journal of Biological Macromolecules* **150**, 831–838. https://doi.org/10.1016/j.ijbiomac.2020.02.119

Tonukari, N. J. (2004). Cassava and future of starch. *Electronic Journal of Biotechnology* **7**, 5–8. https://doi.org/10.4067/S0717-34582004000100003

Whittaker, J., Nyiraneza, J., Zebarth, B. J., Jiang, Y., and Burton, D. L. (2022). The effects of forage grasses and legumes on subsequent potato yield, nitrogen cycling, and soil properties. *Field Crops Research* **290**. https://doi.org/10.1016/j.fcr.2022.108747

Widyatmoko, H., Subagio, A., and Nurhayati, N. (2018). Sifat-sifat fisikokimia pati ubi kayu terfermentasi khamir indigenus tapai. *Agritech* **38**, 140. https://doi.org/10.22146/agritech.26323

Wowor, A. E., Thomas, A., and Rombang, J. A. (2019). Kandungan unsur hara pada serasah daun segar pohon mahoni, nantu dan matoa. *Eugenia* **25**, 1–7. https://doi.org/10.35791/eug.25.1.2019.31395

Yaalon, D. (1996). Soil classification. *Nature*, 380. https://doi.org/10.5771/0943-7444-2019-6-467

Yuliani, and Rahayu, Y. S. (2016). Pemberian seresah daun jati dalam meningkatkan kadar hara dan sifat fisika tanah pada tanah berkapur. Prosiding Seminar Nasional Biologi 11, 213–217.

Yuniarti, Chozin, M. A., Guntoro, D.,and Murtilaksono, K. (2018). Comparing Arachis pintoi versus other cover crops as biomulch in immature oil palm plantations. *Jurnal Agronomi Indonesia* **46**, 215–221.

Zhu, F. (2015). Composition, structure, physicochemical properties, and modifications of cassava starch. *Carbohydrate Polymers* **122**, 456–480. https://doi.org/10.1016/j.carbpol.2014.10.063