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Potency of *Arachis pintoi* Krap. & Greg. as Biomulch in the Tropical Upland Agriculture

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Abstract. The potential of upland for agriculture in Indonesia is **very high** which is about 76.2 million hectares. Upland consists of flat land (< 3%) and sloping land (slope > 3%). Most of the upland is sloping land i.e. range 77% while only 23% of the land is flat. The total upland area on the slopes of Java Island and Sumatra Island is 10.8 million and 33.7 million hectares respectively. The potential danger of erosion and land degradation is high on the area since the average rainfall is more than 2000 mm year^{-1}. For sustainable farming, great efforts on land conservations need to be reduced and prevented the danger of erosion and land degradation. One of the technologies that can be used as a sloping upland conservation is the use of legume cover crop (LCC). *Arachis pintoi* is legume plant that propagated by stem, creeping growth, does not twist the main plant, and able to cover the ground or soil surface perfectly. Basic research on the bio-ecology and agronomic characters, particularly related to its use as a biomulch. Include analysis of growth and development, the time needed to covering soil surface, their effectiveness in suppressing erosion, suppress weeds and improve the soil fertility as well as the nature of their interaction towards plant cultivation has not much reported. A series of studies have been carried out to study the characteristics of the growth and development of plants of *A.pintoi*, effectiveness in suppressing the rate of soil erosion, weed growth emphasis, improvement of physical and chemical properties of soil and its application as biomulch on the minimum tillage system. The results showed that *A.pintoi* has slow growth at the beginning, but cover the soil surface perfectly at 10 weeks after planting (WAP) so effectively suppress erosion, reduce evaporation from the soil, maintaining the availability of groundwater, soil organic matter, provides increased availability of nutrient N and P as well as suppressing the growth of weeds. The combination of minimum tillage and biomulch *A. pintoi* can be used as a method to be applied to different types of cultivation in tropical upland.

1. Introduction

A. pintoi in Indonesia is known as "*kacang hias*". This plant is an introduced species from Brazil imported to Indonesia via Singapore as an ornamental plant and cover crops [2]. Generally *A. pintoi* has growth properties that largely meet the criteria for cover crops or biomulch. In some tropical countries, the plant is widely used for various purposes, among others, to control erosion, control weeds, control nematodes, improve soil fertility, as animal feed and ornamental plants [3][2].

In contrast to other previously recognized LCCs, the results of research on the advantages of *A. pintoi* as cover crops or biomulch have not been widely reported. However, based on its properties *A. pintoi* has environmental advantages that are similar with another popular LCCs. Based on its properties, the use of *A. pintoi* in the cultivation of plants as biomulch has the potential to be used in conservation farming. The basic research on this plant, especially related to its usefulness as a biomulch includes analysis of growth and development, the speed of covering the ground surface, its effectiveness in suppressing erosion, suppressing weeds and improving soil fertility and the nature of its interaction on cultivation has not been reported. This research was conducted to study growth and development characteristics of *A. pintoi*, effectiveness in suppressing soil erosion rate, suppression of weed growth, improvement of soil physical properties and soil chemistry, containment of water loss and its application in cultivation of crops in upland.

2. Methods

A series of basic research to know the character of *A. pintoi* as biomulch has been done by IPB Experimental Station and Teaching Farm of Palm Oil and Soil Fertility Laboratory, Faculty of Agriculture IPB, Bogor, West Java, Indonesia. Research on the application of *A. pintoi* as biomulch on the minimum tillage system has been done in the Experimental Station of the Faculty of Agriculture IPB, Cikarawang, Dramaga. As a test plant are tomatoes, chili and sweet corn grew on land that covered by *A. pintoi* whose soil is treated with various levels of soil tillage system. The research of minimum tillage system was conducted for three seasons in 2015, 2016 and 2017. At the end of the experiment, an analysis of soil physical and chemical properties was performed. Data and information from all of this research is processed descriptively and analysed statistically.

The series of studies that have been conducted and which still need to be done are presented in the research road map (figure 1)

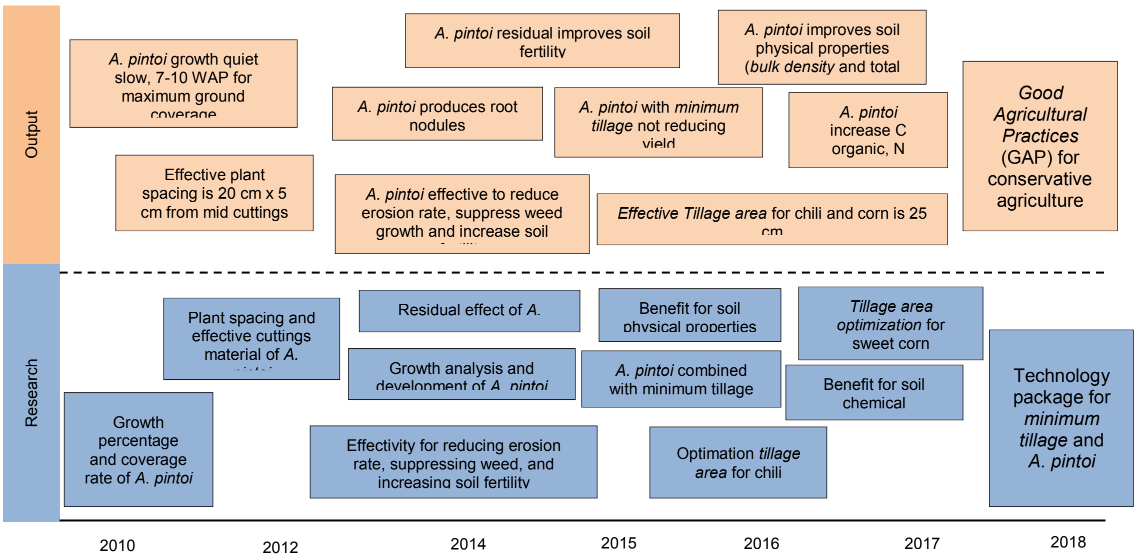

Figure 1. *Arachis pintoi* road map research.

3. Results and discussion

3.1. Growth and coverage rate

A. pintoi plant used is derived from rootless stem cuttings. The data show that the appearance of new roots is seen at 3 WAP. The growth of leaf-producing branch buds has begun to be seen in the first week of observation. In the early stages, *A. pintoi* growth is relatively slow, this is seen in the average increase in plant length and number of leaves each week is 4.21 cm and 13.1 leaf [4]. The results of this study are not far in contrast to the results of Dianita and Abdullah [5] studies indicating that *A. pintoi* has an average increase in plant length and number of leaves of 1.6 cm each and 15 leaves per week.

With relatively slow growth rates, ground coverage by *A. pintoi* is achieved at 10-12 WAP, depending on the spacing used [6][7]. The best spacing is 15 cm x 15 cm. From this series of research also obtained the information that to stimulate root growth of *A. pintoi* is using growth hormone, and the best propagation are middle cuttings.

3.2. Reducing weed growth

The effectiveness of biomulch against weed suppression has been attempted on maize at sloping land and flat land. The result of variance analysis showed that the slope of the land had significant effect on weed weight at 6 WAP, but it had no effect on 10 WAP, whereas mulch type treatment had a significant effect on weed weight at 6 and 10 WAP. There was no interaction between the slope of the land and the type of mulch on weed weight at 6 and 10 WAP. In line with [18] shows that the use of cover crops (*Desmodium ovalifolium* and *Centrosema pubescens*) is very effective in suppressing the rate of erosion in abaca cultivation (*Musa textilis* Nee.) compared with control (without ground cover).

Table 1. Average weed dry weight on slope and mulch type treatment.

Treatments	Weed dry weight (g 0.25 m^{-2})	
	6 WAP	10 WAP
Sloping land		
Flat land	16.03a	9.36
Sloping land	10.38b	9.12
Mulch		
Without mulch and without weeding	34.33a	57.15a
Without mulch, with weeding	2.81c	9.68c
Plastic mulch	2.91c	10.78c
Straw mulch	11.75b	32.00b
A. pintoi biomulch	14.22b	27.09b

The number followed by the same letter in the same column shows no significant difference in the DMRT (Duncan Multiple Range Test) advanced test at the 5% real level. WAP = week after planting.

Table 1 shows that *A. pintoi* biomulch is effective in suppressing weed growth. The weight of weeds of *A. pintoi* biomulch treatment of 14.22 g at 6 MST and 27.09 g at 10 MST was significantly lower than without mulch treatment without weeding (34.33 g) at 6 MST and 57.15 at 10 MST. The results of this study indicate that *A. pintoi* can suppress weed growth of 58.58% at 6 MST and 52.60% at 10 MST. Previous studies have reported that the use of *A. pintoi* is effective in suppressing the growth of weeds in coffee [8][9], potato [10], and tomato cultivation [7].

From the results of this study also obtained information that the use of *A.pintoi* as biomulch causes a shift of weed species. Prior to treatment, the land was dominated by broad leaf weeds namely *Borreria alata* with summed dominance ratio (SDR) amounted to 24.40%. With ***A.pintoi*** planting, the dominant weeds became *Axonopus compressus* (13.86%), *Pennisetum polystachion* (10.65%) and *Digitaria Adscendens* (10.49%). The three weeds are grass weeds.

3.3. Soil and water conservation
It was reported that the use of ground cover can suppress the rate of soil erosion and maintain ground water content. The results of this study indicate that *A. pintoi* planting can significantly reduce the rate of erosion, especially on slopes; and can maintain water levels in oil palm plantations during low rainfall.

3.3.1. Decreasing soil erosion rate
A.pintoi biomulch treatment has been tried on flat land and sloping land. Measurement of erosion is carried out each time the rain turns in the without mulch treatment with the weeding used as the control, the rate of erosion has increased enormously along with the increase of rainfall. In other types of mulch treatment, the rate of erosion also increases with increasing rainfall, but the rate of increase is smaller than the control.

Figure 2 shows that in control, rainfall and erosion rates have a fairly high positive correlation either on flat land or sloping land with R^2 values of 0.65 and 0.68 respectively. The rainfall and erosion rate of the *A. pintoi* biomulch treatment in both flat and sloping land plots has a low positive correlation with R^2 values of 0.17 and 0.48, respectively. This shows that the rate of erosion in biomulch treatment. *A. pintoi* is not significantly affected by rainfall. Figure 2 also shows that the rate of erosion in the treatment of *A. pintoi* biomulch on sloping land has a linear regression line coincided with the rate of erosion in the control treatment on flat land. The coincident line indicates that *A. pintoi* is effective in suppressing the rate of erosion. The rate of erosion on sloped land with *A. pintoi* planting can be reduced to equal the rate of erosion in the control treatment on flat land.

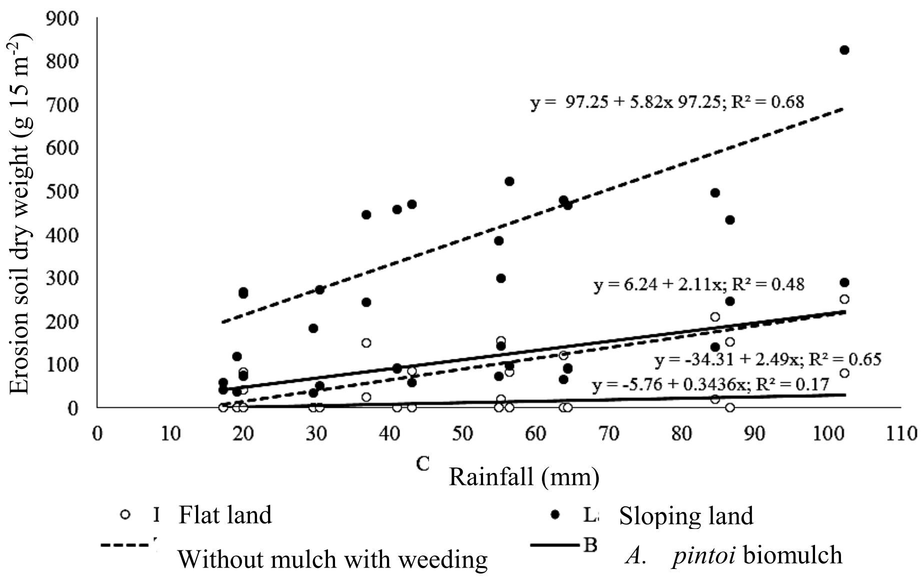

Figure 2. The relationship between rainfall and soil erosion on different mulch treatments.

3.3.2. Maintaining soil moisture content
Measurement of soil moisture content conducted by sampling of soil using small-sized soil drill with 2 cm diameter and length 50 cm in depth of 0-10 cm and 10-20 cm. Result from study that conducted in oil palm plantations, *A. pintoi* which was 11 weeks of MST, could withstand higher moisture content (35.38%) was significantly different with *C. pubescens* biomulch (28.16%) and *C. mucunoides* (27.95%) with lower conditions from the previous week. This indicates that *A. pintoi* is able to maintain soil moisture during low rainfall [11].

3.3.3. Increasing soil fertility

Many studies reported that in the long term, biomulch could improved soil fertility. The ground cover crop of the bean plant species has nutrient residues (organic C and P total soil) and soil microbial population and better growth and yield of cabbage than the use of plastic mulch, although for soil physical properties there is no difference real [12]. *A. pintoi* biomulch residue can improve soil nutrient status and production that tends to be better than the biomulch residue of *Callopogonium sp, Centosema sp* and natural vegetation [13]. The results of this study indicate that after 3 years *Arachis* can improve soil physical and chemical properties. Differences in nutrient status and soil physical properties on conventional and land treated land with *Arachis pintoi* are presented in table 2.

Table 2. Differences in nutrient status and physical properties of soils on land not planted by *A. pintoi* for three years.

Variable	Without *Arachis pintoi*	Category*	*Arachis pintoi*	Category*	Gain (%)
pH	6.23	quite acid	6.71	neutral	107.70
C-organic (%)	1.71	low	5.77	very high	337.43
N-organic (%)	0.18	low	0.24	middle	133.33
C/N	9.67	low	23.53	high	243.33
P2O5 (ppm)	62.06	very high	275.2	very high	443.44
K2O (ppm)	27.42	middle	20.33	low	74.14
Water content (%)	14.03	-	14.52	-	103.49
Bulk density (g/cc)	1.11	-	1.15	-	103.60
Total pore space (%)	52.73	-	52.37	-	99.32

Compared with conventional soil tillage (without *A. pintoi*). Table 2 shows *A. pintoi* biomulch can increase organic C, organic N and soil P. C in treatment without *A. pintoi* of 1.71% (low) while in the treatment of *Arachis pintoi* of 5.77% (very high). Another benefit of *A. pintoi* biomulch is its ability to form a symbiotic root nodule with *Rhizobium* bacteria resulting in the accumulation of N_2 fixation in the soil around the crop [14]. The P_2O_5 content of *A. pintoi* (275.20 ppm) showed significant improvement compared with no *A. pintoi* (62.06 ppm). This increase is suspected because *A. pintoi* has the ability to be symbiotic with soil mycorrhiza. *A. pintoi* that bersimbiosis with mycorrhizal has a high content of nutrients in the soil and plant canopy. *A. pintoi* also has the ability to synthesize the enzyme acid phosphatase and express it to the soil solution around the roots of the plant. The enzyme serves to make unpopulated soil P available for the plant, so that the nutrient content of P available in the soil will increase [15].

In addition to improving soil nutrient status in *A. pintoi* can improve the soil physical properties. The results showed that the bulk density of land planted by *A. pintoi* 1.15 g.cc-1 was higher than that of land without *A. pintoi* (1,10 g.cc-1). Total pore space on land without *A. pintoi* 52.73% while using *A.pintoi* 52.37%. The research that *A. pintoi* biomuls significantly decreased the value of bulk density [16]. This is consistent with the study that soils with high total pore space tend to have low bulk density [17].

3.4. Application of *A.pintoi* as biomulch on minimum tillage system

The results of the research have shown that *A. pintoi* can play a role in soil conservation, even increasing soil fertility (table 2). On the other hand, the presence of *A. pintoi* together with crop can affect the growth and crop production because of competition in the use of resources. The results of biomulch in minimum tillage systems consistently have no significant effect on plant growth and production because the treatment does not cause competition between *A. pintoi* and the main crop.

3.4.1. Plant response to arachis biomulch in minimum tillage system

Growth and production of 4 varieties of tomatoes (*Lycopersicon esculentum*) grown on a minimum tillage system in first year planting is no difference from conventional tillage systems (without biomulch). Average crop production in different soil tillage system is presented in table 3.

Table 3. Average yield of four tomatoes varieties on conventional and minimum tillage system.

Treatment	Yield per plant (g)	Yield per plot (kg 5.76 m^{-2})
Soil Tillage		
Conventional	512.51	2.86
Minimum tillage	403.32	3.43
Variety		
Permata F1	854.31a	4.65a
Yasmin	194.86c	1.62c
Tora	522.46b	3.58b
Sukon	260.03c	2.73b

The number followed by the same letter in the same column shows no significant difference in the DMRT (Duncan Multiple Range Test) advanced test at the 5% real level.

The four varieties tested showed varied potential yields, the highest yield potential was shown by Permata F1 varieties having harvesting weight on the conventional planting system as 854.31 g / plant, higher and significantly different with other varieties (194.86 - 522.46 g / plant). For all varieties, the use of *A. pintoi* as biomulch does not significantly affect its production. The benefits of *A. pintoi* have not been seen in the first year of planting because it takes time so the nutrients can be available for main crop.

3.4.2. Optimum Tillage Area on Minimum Tillage System with A. pintoi as Biomulch

Experimental arrangement of appropriate tillage areas to reduce the influence of *A.pintoi* competition on cultivation plants in the utilization of resources, while maintaining the conservation role of the *A.pintoi* with the plant has been done using chili and sweet corn as indicator plants. The average yield of chili and sweet corn yields per plot is presented in table 4.

Table 4. The average yield of chili and sweet corn per plot.

Second Year (Chili)		**Third Year (Sweet Corn)**	
Tillage area	Yield (g 10,5 m^{-2})	Tillage area	Yield (g 4 m^{-2})
Conventional	3.442,6 a	Conventional	4104,00 a
Zero tillage	1.331,9 b	*Zero tillage*	2377,30 b
Minimum tillage		*Minimum tillage*	
5 cm	4.238,8 a	8 cm	3550,70 a
15 cm	3.079,0 a	16 cm	4392,00 a
20 cm	2.961,6 a	24 cm	3662,70 a
25 cm	3.800,9 a	32 cm	3691,00 a

The number followed by the same letter in the same column shows no significant difference in the DMRT (Duncan Multiple Range Test) advanced test at the 5% real level.

The results of this study indicate that zero tillage treatment, by allowing *A. pintoi* to cover the whole area of chili (2016) and sweet corn (2017) significantly decrease the production of chili and sweet corn. This shows that the presence of *A. pintoi* interfere growth and production of main crops. However, with minimum tillage, growth and production are not significantly different from conventional tillage. Chili production for conventional tillage was 3442.0 g / plot, not significantly different from the minimum tillage (2961.6 - 4238.8 g / plot). Data on sweet corn showed the same pattern, conventional tillage yielded 4104.00 g / plot, not significantly different with the minimum tillage (3662.70 - 4392.70 g / plot). This indicates that the minimum tillage system with *A.pintoi* as biomulch with tillage area of 5 - 32 cm is feasible agronomically. In addition, the use of *A. pintoi* can provide great ecological benefits. These benefits include reducing the rate of erosion, the ability to maintain soil moisture, and suppressing the growth of weeds (table 1 and figure 2), and in the long term increasing the soil fertility (table 2). The influence of *A. pintoi* residues is better than *Centrosema* sp. and *Callopogonium* [13]. From an economic point of view, the use of *A. pintoi* with minimum tillage can reduce the use of labor for soil tillage and weed control.

Overall, the results of a series of studies that have been conducted since 2010 have indicated that *A. pintoi*, which is currently used as an ornamental plant, has many positive values in conservation agriculture. This plant is also very well used as a biomulch in a minimum tillage system for upland agriculture in the tropics.

4. Conclusion

Arachis pintoi is a potential biomulch that has many advantages, there are reducing weed growth to 58.58%, reducing soil erosion rate, maintaining soil water content up to 35.38%, and increasing the available nutrients for main crop. *A. pintoi* is suitable as a cover crop for vegetable cultivation in the tropics such as chili, tomato and sweet corn, especially in minimum tillage system.

References

[1] William C N, Uzo J O, Peregrine W T H 1993 Produksi Sayuran di Daerah Tropika. Ronoprawito S, penerjemah; Tjitrosoepomo G, editor. (Yogyakarta (ID): UGM Pr.) from *Vegetable Production in the Tropics*. Ed ke-1

[2] Maswar 2004 Kacang hias (*Arachis pintoi*) pada usahatani lahan kering. Balai Penelitian Tanah [Internet]. [diunduh 2013 Maret 10]. Tersedia pada: http://balittanah.litbang.deptan.go.id/index.php?option=com_contentdanview=articledanid=43:kacang-hias-arachis-pintoidanid=23:leafletdanItermid=91

[3] Argel P J, Kerrige P C, Pizzaro E A 1996 *Arachis pintoi*; a multipurpose legume for sustainable land use. Di dalam: *Forages in Cropping Systems 19*. Cabi (Columbia:CIAT) p 83-84

[4] Sumiahadi A and Chozin M A 2017 Growth and Coverage Rate of *Arachis pintoi* with Hormone Concentrations Application and Different Stolon Lengths. *Jurnal Agrosains dan Teknologi,* **2**(1): 70-79

[5] Dianita R, Abdullah L 2011 Effect of nitrogen fertilizer on growth characteristics and productivity of creeping forage plants for tree-pasture integrated system. *J. Agric. Sci. Technol.* **1**: 1118-1121.

[6] Febrianto Y and Chozin M A 2014 Effect of Density and Type of Cutting on The Coverage of *Arachis pintoi* as Biomulch on Tomato Cultivation. *Bul. Agrohorti* **2**(1): 37-41.

[7] Chozin M A, Kartika J G, Baharudin R 2014 The Use of *Arachis pintoi* as Biomulch in Tomato Cultivation. *J. Hort. Indonesia* **4**(3): 168-174.

[8] Perez-Nieto J, Valdes-Velarde E, Hernandez-San Roman M E, Ordaz-Chaparro V 2005 Rain, runoff, and soil erosion in shaded coffee agroforestry systems. *Agrosciencia*. **39**: 409-418.

[9] Santos J C, da Cunha A J, Ferreira F A, Santos R H S, Sakiyama N S, de Lima P C 2013 Cultivation of perennial herbaceous legumes in weed management in coffee plantation of the Cerrado. *J. Agric. Sci. Technol.* **3**: 420-428.
[10] Samad S, Mustafa M, Baharuddin, Rampisela A 2009 Optimalisasi produksi kentang ramah lingkungan di Parigi Kecamatan Tinggi Moncong Kabupaten Gowa. *J. Sains. Teknol.* **9**(1): 36-43.
[11] Yuniarti 2016 Potential of *Arachis pintoi* Karp & Greg. as Biomulch in Oil Palm Plantations. (Thesis). Bogor Agricultural University
[12] Rosliani R, Sumarni N, and Sulastrini I 2010 The Effect of Tillage Methods and Legumes as Cover Crops on Soil Fertility and Yield of Cabbage on Highland. *J. Hort*. **20**(1): 36-44
[13] Munawir F A and Chozin M A 2015 The Usage of *Arachis pintoi* and Other Legume Biomulches Residue in Corn-Tomato Cropping System. *Bul. Agrohort.* **3**(1): 127-136
[14] Sumiahadi A, Chozin M A, Guntoro D 2016 Evaluation on Growth and Development of *Arachis pintoi* as Biomulch in Tropical Upland Agriculture. *J. Agron. Indo.* **44**(1): 98-103.
[15] Ortiz N C 2006 Phospohorus efficiency of *Arachis pintoi* genotypes and possible mechanisms for tolerance to low soil P supply. Disertation. Georg-August University of Gottingen. Gottingen.
[16] Candog-Bangi J and Cosico W C 2007 Corn yiel and soil properties in cotabato as influenced by the living mulch *Arachis pintoi. Philipp. J. Crop. Sci*. **32**(3): 59-68
[17] Haryati U 2014 Soil Physical Characteristics of Highland Vegetable Farming Area, It's Relationship with Land Management Strategy *Jurnal Sumberdaya Lahan* **8**(2) : 125-138
[18] Armecin R B, Seco M H P, Caintic P S, Milleza E J M 2005 Effect of leguminous cover crop on the growth and yield of abaca (*Musa textilis* Nee.) *Ind. Crop. Prod*. **21**:317-323