



Study of *Asystasia gangetica* (L.) Anderson Utilization as Cover Crop under Mature Oil Palm with Different Ages

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Abstract

Asystasia gangetica (L.) Anderson is a kind of weed often found not only under immature oil palm plantation but also under mature oil palm plantation. *A. gangetica* can grow well in soil with a low fertility rate and under shaded condition, so that it can be used as a cover crop under mature oil palm plantation with different ages.

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The experiment was conducted under mature oil palm plantation the age of 5 years old (TM-2) and 17 years old (TM-14), in Cikabayan University Farm, IPB Bogor, West Java, from March 29 to 21 September 2014. The result showed that *A.gangetica* can be utilized as a cover crop under mature oil palm plantations (TM-2 and TM-14) since it is able to grow well in the two locations, improving soil physical and chemical properties and increasing soil moisture and nutrient availability through the rapid litter decomposition (decomposed within 30 days) and the release of litter nutrients nearly 100% within 30 days. Therefore, *A.gangetica* can be used for the implementation of sustainable oil palm plantations in accordance with the principles and rules of the RSPO and ISPO.

Keywords: *Asystasia gangetica* (L.) Anderson; cover crop; oil palm plantation

1. Introduction

In the past, when oil palm had reached a production age, they would be made free from plants, such as weeds, etc. However, with the existence of oil palm plantation management guidelines in the form of RSPO (Roundtable on Sustainable Palm Oil) and ISPO (Indonesia Sustainable Palm Oil), many large plantations have begun to follow the principles and criteria of RSPO and ISPO.

One of the principles and criteria contained in RSPO and ISPO is the application of technical guidelines for the cultivation and management of oil palm plantations. Land clearing should meet the standards of soil and water conservation, environmental responsibility, resource conservation, biodiversity, and the control of plant-disrupting organisms (OPT) [1, 2].

One form of the implementation of the principles and criteria of RSPO and ISPO is the use of beneficial weeds that grow under the mature oil palm plantations as cover crops to improve biodiversity under the mature oil palm plantations. In addition to serving as sources of carbon and nutrients, weeds can also acts soil and water conservation.

Asystasia gangetica (L.) Anderson or white flower or Chinese violet is a weed that is often found in oil palm plantations. It is actually an ornamental plant from Malaysia. In the 1960s, *A.gangetica* were planted as cover crops in the Malaysian Peninsula. [3]. However, due to its fast growth and development, *A.gangetica* had become one kind of weeds to be controlled under the mature oil palm plantations until it was revealed that this weed can be used as a cove crop as soil and water conservation as well as the enhancement of nutrients.

In addition to being able to grow well in soil with a low fertility rate and in a shaded area [4], even in 90% shade, *A.gangetica* contains various types of nutrients, prevents or reduces soil erosion from rain and surface run-off, suppresses the growth of other kinds of weeds, provides people with medicinal plant [5], functions as a biological control agent against bag caterpillar (*Metisa plana*), because it can attract predator hosts to lay their eggs [6], and serves as a biomonitor to detect the presence of heavy metals such as mercury (Hg) [7]. However, some of the benefits have not been widely studied, so this study aimed to determine the benefits of *A.gangetica* as cover crop under mature oil palm plantations.

2. Materials and Methods

The research was conducted under mature oil palm plantation the age of 5 years old (TM-2) and 17 years old (TM-14) in Cikabayan University Farm, IPB Bogor, West Java, from March 29 to 21 September 2014.

The *A.gangetica* plants used in the field experiment were two-segment stem cuttings which were directly planted into 2 m x 2.5 m experimental plots in accordance with the space treatment. The plots were arranged between the rows of mature oil palm trees of TM-2 and TM-14).

2.1. Experimental Design

The field experiment consisted of: (1) spacing plant experiment and (2) decomposition rate. The spacing plant experiment used a non-factorial randomized block design with three replications comprising three levels: 10 cm x 10 cm, 20 cm x 20 cm and 40 cm x 40 cm. The survived plant percentage, plant height, branch number, land coverage percentage, and crop growth rate were the features that were observed and studied.

The measurement of decomposition rate used a litterbag method [8]. The 20 cm x 30 cm litter bag was finely perforated and made of nylon netting, where 50 g of the oven-dried plant was put back into its research sites under mature oil palm plantation (TM-2 and TM-14). After 30 days, the observation was made to analyze such variables as Carbon (C-organic), Nitrogen (N), Phosphor (P), and Potassium (K), decomposition rate, and nutrient release.

Decomposition rate was calculated based on the weight depreciation of decomposed plant material in one unit of time using an equation [9]:

$$R = (W_0 - W_t) / t \quad (1)$$

Release nutrient was calculated using an equation [10]:

$$L = (W_0C_0 - W_tC_t) / W_0C_0 * 100\% \quad (2)$$

Where, R: decomposition rate (g day⁻¹), L: released nutrient (%), W₀: initial weight of dry litter (g), W_t: weight of dry litter after observation time t (g), C₀: nutrient concentration of initial litter (mg kg⁻¹), C_t: nutrient concentration of the remaining litter after decomposition (mg kg⁻¹).

2.2. Analysis of Plant Tissue and *A.gangetica* Compost

The levels of tissue nutrients were measured at the end of the experiment by drying the plant materials in an oven at 80° C until reaching a constant weight, then ± 10 g were taken to be finely ground with a grinder to pass 0.5 mm seive, and finally an analysis was carried out to find the content of Nitrogen (N) using a persulfate destruction method [11], Phosphor (P) using a wet destruction method of 18% perchloric acid followed by Scheel method [12], and Potassium (K) using a wet destruction method of 18% perchloric acid followed by the reading activity using AAS spectra 40 [13].

2.3. Analysis of Soil Physical and Chemical Properties

The analysis of soil physical and chemical properties was done at the beginning and end of the study. The measurement of soil physical properties included soil texture, bulk density, porosity, soil permeability, and soil moisture. The measurement of soil texture was carried out by taking soil samples in composite way from several taking points with a soil layer depth of 0-20 cm using a ground drill before the soil moisture and soil texture were analyzed.

The soil texture was analyzed with a pipette method, whereas the soil moisture was measured by weighing the air-dried soil sample in an aluminum cup with known weight to be finally dried in an oven at 105 °C for 24 hours. Next, the cup was removed using tweezers and put into an exicator. After the soil sample was cold, it was weighed and calculated by the equation:

$$\text{Soil moisture} = ((\text{wet soil} - \text{dry soil}) / \text{dry soil}) * 100\% (3)$$

The measurement of bulk density, porosity and permeability used a sample ring. The bulk density was determined by gravimetric method. When the value of bulk density was obtained, the porosity was then calculated using the equation:

$$\text{Porosity} = (1 - (\text{Bulk density} / \text{Weight of particles})) * 100\% (4)$$

While the permeability was set in the saturated state based on Darcy's law.

The availability of soil nutrients was analyzed by taking soil in a composite way from several taking points in the upper soil layer of 0-20 cm deep using a ground drill. Then the mixed soil was taken ± 1 kg as soil sample and the analysis of C-organic was performed using Walkley and Black method, N-total (Kjeldhal Method), P (method of 25% HCl extract with spectrophotometer) and K (method of 25% HCl extract with a flamefotometer).

2.4. Statistical Analysis

In experimental design, data were analyzed using the Statistical Analysis System (SAS) Software 9.1, SAS Institute Ltd., USA. Mean comparisons were made using the Duncan's multiple range tests at the 0.05 level of probability based on the analysis of variance [14].

3. Results and Discussion

3.1. Plant Growth of *Asystasia gangetica* (L.) Anderson

To see the potential of *Asystasia gangetica* (L.) Anderson as cover crop, a field experiment was conducted by planting *A.gangetica* with different spacings: 10 cm x 10 cm, 20 cm x 20 cm, and 40 cm x 40 cm. The main purpose was to find the best spacing plant for planting *A.gangetica* as cover crop under mature oil palm plantations.

The research results showed that the growth of *A.gangetica* with a spacing plant of 40 cm x 40 cm, both under mature oil palm plantations (TM-2 and TM-14) was good, with plant heights of 60.75 cm in TM-2 and 61.08 cm in TM-14 and having more branches (13.44 in TM-2 and 11.67 in TM-14) compared with a spacing plant of 20 cm x 20 cm and 10 cm x 10 cm (Table 1). In the meantime, the land coverage percentage and the highest crop growth rate were seen in the treatment of spacing plant of 10 cm x 10 cm, both in TM-2 (respectively 98.67% and 0.0002 g m⁻² day⁻¹) and the TM-14 (respectively 98.00% and 0.0002 g m⁻² day⁻¹) (Table 2). For the survived plant percentage, there was no different in all spacing plants, both TM-2 and TM-14 (Figure 2).

From Table 1, Table 2 and Figure 2, it could be seen that the growth of *A.gangetica* plants under mature oil palm plantations (TM-2 and TM-4) showed that different growth patterns were observed for all parameters. In this case, it can be seen that *A.gangetica* could grow well under mature oil palm plantations, TM-2 and TM-14. The intensity of the sunlight under mature oil palm plantations was very different, i.e. 49,226 lux in TM-2, and 3,251 lux in TM-14, but the growth of *A.gangetica* showed no difference. This suggests that *A.gangetica* has broad adaptation to the environment where it grows, especially the intensity of the sunlight. It is also in line with literature which states that *A.gangetica* can grow well up to the rate of 90% shade [5].

Table 1. Plant height (cm) and branch number (branch) of *Asystasia gangetica* (L.) Anderson under mature oil palm plantations TM-2 and TM-17

Spacing Plant	TM-2		TM-14	
	Plant height (cm)	Branch number (branch)	Plant height (cm)	Branch number (branch)
10 cm x 10 cm	55.14 b	5.91 b	54.44 c	5.87 c
20 cm x 20 cm	57.33 ab	13.42 a	57.39 b	7.85 b
40 cm x 40 cm	60.75 a	13.44 a	61.08 a	11.67 a

Note : Data in the same column followed by the common letters are not significantly different at the P = 0.05 level according to the Duncan's Multiple Range Test.

The difference in spacing plant generates *A.gangetica* growth of different patterns. Plant height and branch number were the highest at a spacing plant of 40 cm x 40 cm, while the survived plant percentage, the land coverage percentage and the best crop growth rate were at a spacing plant of 10 cm x 10 cm, whether it was planted under mature oil palm plantations of TM-2 or TM-14. This suggests that planting *A.gangetica* with different spacing plants can be done in accordance with the purpose of planting activity. When the purpose of *A.gangetica* planting is intended as cover crop under mature oil palm plantations, the most important parameters to consider are the survived plant percentage, the land coverage percentage and the crop growth rate. Therefore, it is recommended to use a spacing plant of 10 cm x 10 cm, because the requirements for a plant to be used as cover crop are growing quickly, reproducing easily, covering the ground surface quickly, being tolerant to shades and stampings, and having no spines or tendrils.

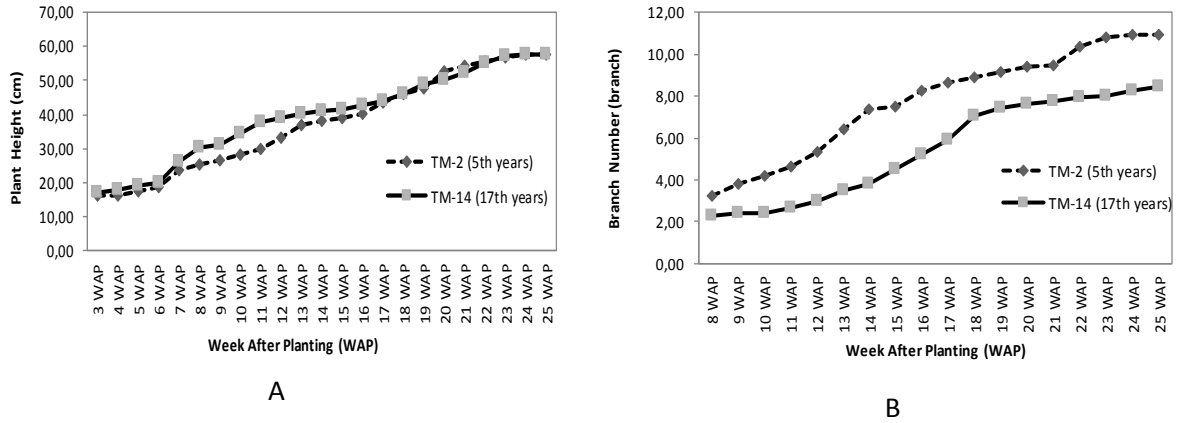


Figure 1. Increasing plant height (cm) (A) and branch number (branch) (B) of *Asystasia gangetica* (L.) Anderson under mature oil palm plantations TM-2 and TM-17

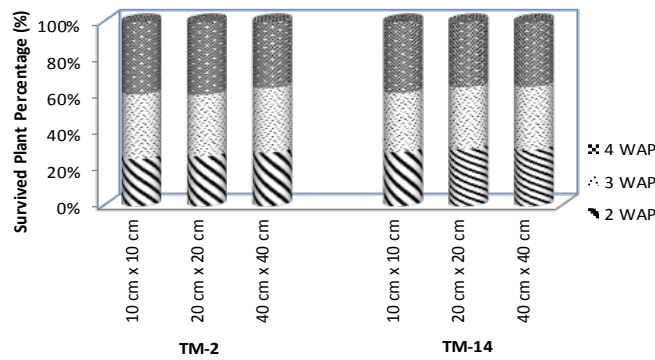


Figure 2. Survived plant percentage (%) of *Asystasia gangetica* (L.) Anderson under mature oil palm plantations TM-2 and TM-17

Table 2. Land coverage percentage and crop growth rate (CGR) of *Asystasia gangetica* under mature oil palm plantations TM-2 and TM-17

Perlakuan Jarak Tanam	TM-2		TM-14	
	Land Coverage Percentage (%)	CGR ($g\ m^{-2}\ hari^{-1}$)	Land Coverage Percentage (%)	CGR ($g\ m^{-2}\ hari^{-1}$)
10 cm x 10 cm	98.67 a	0.0002 a	98.00 a	0.0002 a
20 cm x 20 cm	57.00 b	0.00004 b	53.00 b	0.00004 b
40 cm x 40 cm	31.33 c	0.000006 b	21.00 c	0.000006 b

Note : Data in the same column followed by the common letters are not significantly different at the $P = 0.05$ level according to the Duncan's Multiple Range Test.

3.2. Nutrient Release of *Asystasia gangetica* (L.) Anderson

To determine the release of nutrients by *A.gangetica*, the analysis of *A.gangetica* plant tissue before and after the decomposition was first performed (Table 3) under mature oil palm plantations of TM-2 and TM-14.

Table 3 shows that the tissue of *A.gangetica* plant before decomposition contained 146.76% C-organic, 5.61% N, 0.86% P, and 14.26% K. After the decomposition, the content of *A.gangetica* plant tissue decreased successively to be 19.98% C-organic, 0.57% N, 0.16% P, 0.16% K, with a pH of 5.60 and C/N at 35.05 under mature oil palm plantations of TM-2 and 17.66% C-organic, 1.53% N, P 0.16%, 0.10% K, 13.58 C/N and pH 5.90 under mature oil palm plantations of TM-14.

The decrease in nutrient content of *A.gangetica* tissue after decomposition is related to the release of nutrients from the plant tissue to soil. Decomposition is an important process in the dynamics of nutrients in an ecosystem to determine the sustainability of nutrients in a plant. Decomposition process is also a combined process of fragmentation and changes in the physical structure of the plant material which is assisted by decomposer enzyme activity that converts organic material into inorganic compounds [15].

How quickly or slowly plant tissue can increase the availability of soil nutrients through decomposition process depends on the rate of decomposition of the plant tissue. The rate of plant tissue decomposition is calculated based on the change in dry weight of the litter during decomposition. The faster the decomposition rate of plant tissue, the faster the plant tissue can improve soil nutrient availability.

A.gangetica can get decomposed within 30 days. Before being decomposed, the dry weight was 50 g, but after decomposition the dry weight decreased to 48.3 g or 96.6% under mature oil palm plantations of TM-2 (data not shown) and 45 g or 90% under mature oil palm plantations of TM-14 (data not shown) with a successive decomposition rate under mature oil palm plantations of TM-2 and TM-14 being 1.61 g day⁻¹ and 1.50 g day⁻¹ (Figure 3).

Table 3. Plant nutrient content of *Asystasia gangetica* (L.) Anderson before and after decomposition

Umur Tanaman	Plant nutrient content of <i>Asystasia gangetica</i> (L.) Anderson					
	pH	C-org (%)	N (%)	P (%)	K (%)	C/N
Before Decomposition						
TM-2 (5 years old)	-	146.76	5.61	0.86	14.26	26.16
TM-14 (17 years)	-	146.76	5.61	0.86	14.26	26.16
After Decomposition						
TM-2 (5 years old)	5.60	19.98	0.57	0.16	0.16	35.05
TM-14 (17 years old)	5.90	17.66	1.53	0.16	0.10	13.58

The release of nutrients during decomposition process was calculated based on the ratio of tissue nutrient concentrations when taking corrected samples with a dry weight at a certain time (30 days) compared with the concentration of tissue nutrient at the beginning of the study which was expressed in percent (Figure 4).

The nutrient release of *A.gangetica* plant tissue was faster under the mature oil palm plantation of TM-2 compared to TM-14. The release of nutrient K (99.94% - 99.97%) of *A.gangetica* both under mature oil palm plantations of TM-2 and TM-14 was faster than N (99.05% - 99.72%), C-organic (98.99% - 99.62%) and P (98.44% - 99.48%). The rapid release of nutrient K during decomposition was due nutrient K was mobile and not firmly attached to the structure of plant cells and very easily leached [16], particularly in the plant tissue that underwent decomposition process, supported by decomposing microbes [17].

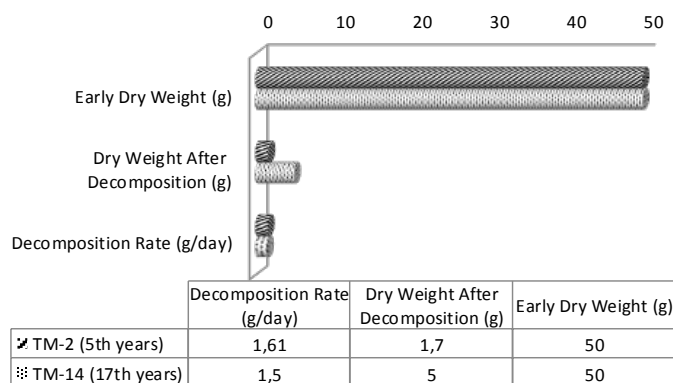


Figure 3. Early dry weight (g), dry weight after decomposition (g) and decomposition rate (g day⁻¹) of *Asystasia gangetica* under mature oil palm plantations TM-2 and TM-17

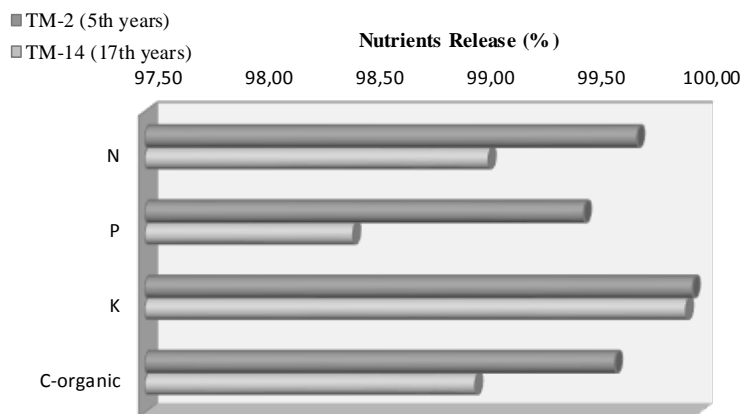


Figure 4. Nutrients release (%) of *Asystasia gangetica* during decomposition under different age of oil palm plantation

3.3. Soil Nutrient Availability and Physical Properties Before and After the Planting of *Asystasia gangetica* (L.) Anderson

The study results of soil physical properties showed that planting *A.gangetica* is effective to lower bulk density by 3.30% (from 0.91 g cm⁻³ to 0.88 g cm⁻³) and to raise the porosity and permeability of the soil respectively 1.45% (from 65.79% to 66.77%) and 9.53% (from 17.62 cm h⁻¹ to 19.33 cm h⁻¹). Planting *A.gangetica* can also

change the percentage of sand, silt and clay which are the building blocks of soil texture and can improve soil moisture from 21.28% to 25.00% (Table 5). On the oil palm plantation area where *A.gangetica* is not planted, the percentage of sand, silt and clay was respectively 6.73%, 13.29%, and 79.98%. After *A.gangetica* had been planted, there was a change in the content of sand, silt and clay respectively 6.49%, 14.94% and 78.57%.

Table 5. Soil physical before and after planted with *Asystasia gangetica* (L.) Anderson

	Bulkdensity ($g\ cm^{-3}$)	Porosity (%)	Permeability ($cm\ jam^{-1}$)	Soil Texture			Soil Humidity (%)
				(%)			
				Sand	Dust	Loamy	
Control plot	0.91	65.79	17.62	6.73	13.29	79.98	21.28
<i>A.gangetica</i> plot	0.88	66.77	19.33	6.49	14.94	78.57	25.00

Bulk density is a critical factor in determining land productivity because it can reflect the density of the soil which will affect the penetration ability of plant roots, ground water, and soil aeration [18]. The denser the soil is, the higher the bulk density will be, which means it will be more difficult for water to penetrate the ground or reach plant roots. On the contrary, the smaller the bulk density is, the more porous the ground will be, making it easy for water to penetrate the ground and reach plant roots. In general, the bulk density which is good for the development of plant roots is no more than 1.1-1.6 $g\ cm^{-3}$ [19].

Soil porosity indicates the total condition of soil pores that are important to the availability of water and air circulation in the soil to support root respiration, activity of microorganisms, and the absorption of nutrients [20]. Improvement of soil porosity will affect the increased permeability of the soil because of the formation of more soil pores that make the flow rate of the water become faster.

Soil porosity is greatly influenced by organic matter content, soil structure and texture. Soil texture also determines the groundwater system in the form of infiltration rate, penetration rate, and the ability to bind water by the soil. The highest binding ability is clay fraction, followed by dust and sand, since the surface area of the clay fraction is higher than the sand and dust fraction [19]. Soil texture is also related to soil moisture and nutrient availability (Table 5 and Table 6). Clay-textured soil has a greater surface area so that the ability to hold water and provide nutrients is high [21].

In accordance with the results of this study, the planting of *A.gangetica* can increase soil moisture (Table 5) and soil nutrient availability (Table 6). This indicates that the planting of *A.gangetica* under mature oil palm plantations can be developed as cover crop because they can generate moisture and good soil nutrients. The cover crop will increase the water content to the maximum level. The litter will decompose into organic material

that can bind water by six times of its own weight, making the infiltration ability high [22] in addition to its capacity to keep nutrients much greater than clay [23].

Table 6. Soil nutrient availability before and after planted with *Asystasia gangetica* (L.) Anderson

	pH	C-org (%)	N (%)	P (%)	K (%)	C/N
Before planted <i>A.gangetica</i>						
Control plot	4.20	19.29	1.82	0.15	0.07	10.59
<i>A.gangetica</i> plot	4.20	19.29	1.82	0.15	0.07	10.59
After planted <i>A.gangetica</i>						
Control plot	4.20	19.57	1.73	0.12	0.06	11.31
<i>A.gangetica</i> plot	4.30	23.85	2.20	0.15	0.08	10.84

Soil nutrient availability is determined by the factors that affect soil ability to supply nutrients and the factors that affect plant ability to use the nutrients supplied by the soil [19]. Tabel 6 shows that the planting of *A.gangetica* could improve soil nutrient availability: 23.64 % C-organic, 20.88 % N, and 14.29% K. This effort was also able to raise soil pH to become 4.30. The improvement of soil nutrient availability is due to the release of nutrients from *A.gangetica* during its growth (Figure 4), since one of the nutrient sources in the soil is litter. After undergoing a process of decomposition, the litter changes into simple organic compounds and produces nutrients.

The study results showed that the planting of *A.gangetica* can improve the content of soil C-organic to be higher than the nutrients N, P, and K. The content of C-organic is an indicator of the amount of organic materials that are available in the soil. The higher the content of C-organic in the soil, the higher the organic matter content of the soil. The high content of organic matters will be quickly decomposed and will be released in form of such nutrients as N, P, and K, which are available for living plants [24].

4. Conclusion

The result showed that *Asystasia gangetica* (L.) Anderson can be utilized as a cover crop under mature oil palm plantations (TM-2 and TM-14) since it is able to grow well in the two locations, improving soil physical and chemical properties and increasing soil moisture and nutrient availability through the rapid litter decomposition (decomposed within 30 days) and the release of litter nutrients nearly 100% within 30 days. Therefore, *A.gangetica* can be used for the implementation of sustainable oil palm plantations in accordance with the principles and rules of the RSPO and ISPO.

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