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Research paperr

Decomposition and release rate of *asystasiagangetica* (l.) T. Anderson litter nutrient using litterbag method

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Abstract

The research aimed to determine the rate of decomposition and release of *A. gangetica* litter in conditions without shading and shading, and in turn it can be simulated the effects of environmental factors on the decomposition rate and contribution of *A. gangetica*litter nutrients to the soil. Research was carried out at Research Farm, Faculty of Agriculture, UISU, Medan, North Sumatra, from January to April 2018. The study used a non-factorial randomized block design with five replications. The treatment is shade which consisting of two levels namely without shading, and with 50% shading. The results showed that the litter weight of *A. gangetica* decreases with the length of the decomposition period. The decrease in litter weight of *A. gangetica* is more influenced by the decomposition period than the shade treatment. However, decomposition rate, decreased nutrient concentration in litter tissue, and increased litter release of *A. gangetica* is affected by shading and decomposition period. Decomposition rate, decrease in litter concentration and release of litter nutrients more quickly in conditions without shadingby the longer decomposition period.

Keywords: *decomposition rate, A. gangetica, litterbag method*

1. Introduction

Asystasiagangetica (L.) T. Anderson is an annual weed in oil palm, rubber, and pineapple plantations due to its ability to produce large quantities seeds, can be thrown as far as 6 m, easy to germinate, new plants can grow from the stems base when they touch the soil, and within 6 weeks they have flowered and produced seeds [1], [2]. This make*A. gangetica* classified as invasive weeds because it quickly dominates a land.

Several research show that *A. gangetica* can be used as cover crops in matureoil palm plantations [3], [4], containing several nutrients such as N, P, K, Ca, Mg, Fe , Zn in the plant tissues [5], [6], increase soil water availability in dry season [4], increase carbon content, organic matter [4] and increase soil nutrient content of N, P, K based on nutrient balance in oil palm plantations [7]. Therefore, study on the decomposition rateof*A. gangetica* is very important to estimate the release of organic matter and nutrients from the litter tissue, and thus understand the contribution of organic matter and litter nutrients when used as cover crop.

Decomposition of organic litter has been widely studied, but is dominated by forest, tundra, swamp and farm litter [8]–[15] and very little studied decomposition of *A. gangetica* in oil palm plantations in Bogor, West Java [7] However, it is not known whether the decomposition rate of *A. gangetica* in Medan, North Sumatra is the same as in Bogor, West Java.

Decomposition is a fast, short-term process by reducing the biomass weight followed by a decrease in decay rates and approaching the constant end of decay rates [16]. Decomposition process is influenced by litter characteristics (such as chemical composition, size), environmental factors (eg temperature, humidity) and microbes (eg. decomposer community) [17].

It is known that *A. gangetica* decomposes much faster than most litter in forests, tundra, and swamps [18], but only one study is available regarding the decomposition rate of *A. gangetica* from many weeds, thus limiting decomposition prediction of *A. gangetica*in outside Java.

The most common method to determine the decomposition rate is litter incubation in litterbags, known as the litterbag method [19], [20]. Litterbags are made from gauze and filled with litter that has weighed its initial weight, then placed at ground [21]. Litterbags is a simple and cheap method, therefore it is widely used to determine the rate of littering decomposition [14], [22]–[24].

The research objective was to determine the rate of decomposition and release of *A. gangetica* litter in conditions without shading and shading, and in turn it can be simulated the effects of environmental factors on the decomposition rate and contribution of *A. gangetica* litter nutrients to the soil.

2. Material and Methods

The study was conducted at Research Farm, Faculty of Agriculture, North Sumatra Islamic University (UISU), Medan,North Sumatra from January to April 2018. The study site was made in an experimental plot with 1 m x 1 m in size.

The study used a non-factorial randomized block design with five replications. The treatment is shading treatment which consists of two levels, namely: without shading and with 50% shading. Measurement of decomposition and release rate of N, P, Kis using litterbag method [25]. Litterbag is made from fine perforated nylon tissue with a size of 20 cm x 30 cm per litterbag. Each litterbag contains 50 gof*A. gangetica* litter.

Litterbags are placed on soil surface in the experimental plots. Litterbags are secured by binding on bamboo stems that implanted

in the middle of the experimental plot to prevent carried out by water flow during rain.Litter of *A.gangetica*weighed on days 0, 30th, 60th, and 90th. On day 0, the litter weight is the air dried weight. Decomposition rate is calculated as the weight loss of decomposed litter in one time unit using the equation (Ribiero*et al*., 2002):

$$R=(W0-Wt)/t \quad (1)$$

Measurements of litter decomposition percentages are obtained using the equation (Wang.,*et al*., 2018):

$$Y=(W0-Wt)/W0 \times 100\% \quad (2)$$

Measurement of nutrient release from litter using Guo and Sim (1999) equation:

$$L =(W0C0 – WtCt)/W0C0 \times 100\% \quad (3)$$

WhereR is the decomposition rate (g/day); Y is percentage of decomposed litter (%); L is released nutrient (%), W0 initial weight of dry litter (g), Wt is weight of dry litter after observation time t (g), C0 is nutrient concentration of initial litter (mg kg^{-1}), Ct is nutrientconcentration of the remaining litter after decomposition (mg kg^{-1}).

The levels of tissue nutrients were measured at the end of the experiment by drying the plant materials in anoven at 80° C until reaching a constant weight, then to be finely ground with a grinder to pass0.5 mm sieve, and finally an analysis was carried out to find the content of organic Carbon (C-organic), total Nitrogen (N-total), Phosphor (P), and Potassium (K). The C/N ratio was also calculated.

Data was tested using analysis of variance (ANOVA) and LSD (least significant difference) tests at the significance level of P = 0.05 to evaluate differences in decomposition rates, percentage of litter biomass decomposition, and nutrient release for 30th, 60th, and 90th days of decomposition at shading and without shading conditions. To the end, the test was performed using Statistical Analysis System (SAS) Software 9.1 from SAS Institute Institute, USA [26].

3. Results and Discussion

Litter weight loss of *A.gangetica* was observed on days 30th, 60th, and 90th(Table 1). Table 1 showed that such losses are not affected by shading, but by the period of decomposition. This finding is confirmed [27], [28]which shows that loss of litter weight during the decomposition process is not influenced by shading, but it is significantly correlated with the decomposition period.

Table 1. Litter weight loss of *A. gangetica* at shading and without shading condition

Decomposition Period (day)	Without shading	Shading
0	100a(a)	100a(a)
30	91.62a(d)	91.65a(c)
60	93.38a(c)	91.92a(b)
90	93.68a(b)	91.97a(b)

Note: Same lowercase letters not parentheses indicate not significant differences between litterbag treatments (without shading and shading) at $P \leq 0.05$. Different lowercase letters in parentheses indicate significant differences between decomposing period at $P \leq 0.05$

Table 2. Decomposition rate of *A. gangetica*litter biomass in shading dan without shading

Decomposition Period (day)	Without shading	Shading
0	0.00a(c)	0.00a(b)
30	153.00a(b)	153.00a(a)
60	156.00a(a)	153.00b(a)
90	156.00a(a)	153.00b(a)

Note: Same lowercase letters not parentheses indicate not significant differences between litterbag treatments (without shading and shading) at $P \leq 0.05$. Different lowercase letters in parentheses indicate significant differences between decomposing period at $P \leq 0.05$

Table 2 showed that the rate of litter decomposition of *A. gangetica* increases with increasing decomposition periods and faster decomposition rates in without shade condition than shading. This finding is confirmed by [7] which shows the decomposition rate of *A. gangetica* litter is faster in immature oil palm plantations with higher sunlight intensity than mature oil palm plantations with lower sunlight intensity. Similarly, [15], [29] was showed that the rate of litter decomposition is faster in not too dense forests than dense forests. In contrast[27] showed that the decomposition rate of woody plants is faster in shading condition.

The higher temperatures will accelerate the decomposition rate by increasing microbial metabolic activity. Sunlight intensity and high temperatures will also increase the rate of chemical weathering which in the short term increases nutrients supply for microbes and thusincreases microbial activity to decompose [28]–[30]. Sunlight intensity and high temperatures will directly reduce lignin structure and indirectly change other cellular constituents, such as cellulose and hemicelluloses[31], [32].

Decomposition period will increase decomposers microbial activity which will significantly affect the rate of decomposition. This is becauseearly and middle of decomposition period provide hydrothermal conditions and adequate humidity for cellulose degradation [32], [33], then lignin as microbial byproduct increase in litter [34].

Shading has significant effect on litter nutrient concentrations of C, P, and K in *A. gangetica*. There is a decrease in litter concentration of *A. gangetica*with increasing decomposition period. In shading treatment, the nutrient concentration is low with increasing decomposition period found (Table 3).This shows that during the decomposition process, beside decrease in litter weight, there was also litter decomposition of *A. gangetica*. This finding is in accordance with [7], [28] which shows that the reduction of nutrient concentration is faster in litter without shading.

There is a decrease in nutrient concentration in litter tissue due to chemical content and temporal dynamics [29]. The initial stage of decomposition is characterized by abundant nutrient content in litter tissue, by decomposition process, soluble compounds and low molecular weight will loss rapidly causing an increase in cellulose and lignin concentration in litter tissue [35]–[37], so that the nutrient concentration in the litter tissue decreases.

The C/N ratio is used as litter quality index, because low C/N ratio generally decomposes quickly[38]. [27]stated that the concentration of C and N and C/N ratio haslinear relationship with the rate of decomposition.

Release pattern of C, N, P and K is similar to decrease in nutrient concentrations of C, N, P, and K of *A. gangetica* during the decomposition period (Table 3). Nutrients release of C, N, P, and K is increase during the decomposition period. This findingis consistent with [3], [39], [40] who also showsincreasing pattern of C, N, P, and K release during the decomposition period. According to [41], the general pattern of nutrient release from decomposed litter in tropical forests includes: (1) domination of nutrients washing and the release at initial phase; (2) net immobilization phase as long as nutrient transferred to residues by microbes; and (3) phase of net nutrient release when litter weight decreases.

Table 3. Litter Nutrient Concentration of *A. gangetica*during decomposition period

Treatment	Litter nutrient concentration				Nutrient release			
	Decomposition period (day)							
	0	30	60	90	0	30	60	90
	C-organik (%)				C-organic (%)			
Without shading	47.23a(a)	35.43b(b)	30.64b(c)	24.85b(d)	-	93.74a(c)	95.71a(b)	96.68a(a)
Shading	47.23a(a)	39.53a (c)	34.51a(b)	29.11a(b)	-	92.99b(c)	94.10b(b)	95.05b(a)
	N-total (%)				N-total (%)			
Without shading	3.15a(a)	2.25a(b)	2.04a(c)	2.03a(c)	-	94.03a(c)	95.73a(b)	98.92a(a)
Shading	3.15a(a)	2.26a(b)	2.07a(c)	2.05a(c)	-	93.19b(b)	93.17b(b)	96.56b(a)
	P (%)				P (%)			
Without shading	0.56a(a)	0.55a(b)	0.31a(c)	0.12b(d)	-	91.66a(c)	96.23a(b)	98.65a(a)
Shading	0.56a(a)	0.62a(b)	0.44a(c)	0.15a(d)	-	90.65a(c)	93.64a(b)	97.93b(a)
	K (%)				K (%)			
Without shading	3.68a(a)	1.16b(b)	0.12b(b)	0.07b(c)	-	97.36a(b)	99.78a(a)	99.87a(a)
Shading	3.68a(a)	1.35a(b)	0.15a(c)	0.22a(b)	-	96.93b(b)	99.67b(a)	99.51b(a)
	C/N ratio							
Without shading	14.99	15.74	15.01	12.24				
Shading	14.99	17.49	16.67	14.20				

Table 3 showed that K is nutrient with the greatest decrease in concentration and release compared to C, N and P.In contrast, [42] shown that the concentration and release of K is the slowest compared to C, N and P. However, this finding is confirmed by [3], [39] which showed that K nutrient concentration was the most rapidly reduced in *A. gangetica* in oil palm plantations and litter in peat swamp forests. According to [33], [40], K is a highly mobile nutrient, both in plants and soil, and is very easy to leach.

Decreased concentration and release of C, N, P and K of *A. gangetica*is faster in without shading treatment than shading. Such finding is consistent with [28], [42]. The higher levels of solar radiation in without shading conditions than shading can increase the decomposition rate of litter by microbes, thereby accelerating decrease in litter nutrient concentration and increasing litter release[30], [32]. This is because at higher level of solar radiation, high temperature wills increases microbial activity [38].

4. Conclusion

The litter weight of *A. gangetica* decreases with the length of the decomposition period. Decrease in litter weight of *A. gangetica* is more influenced by decomposition period than shading treatment. However, decomposition rate, decrease in litter nutrient concentration and release of litter nutrient is more quickly in conditions without shading and longer the decomposition period.

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