Effect of shading on availability and nutrient balance in soils planted with *Asystasia gangetica* (L.) T. Anderson as cover crop

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Abstract. This study aimed to examine the role of *A. gangetica* as cover crops in increasing the availability and nutrient content of N, P, K in the soil on the nutrient balance under with shade and without shade conditions. The experiment was conducted in Experimental Farm, Faculty of Agriculture, UISU, Gedung Johor Medan, Indonesia from February 2018 to June 2018. The research method is a non-factorial randomized block design with shading as treatment and six replications. Treatment consists of without shade and with shade 50%. *A. gangetica* was planted using stem cuttings measuring 15 cm or two segments with a spacing 20 cm x 20 cm and on a plot size of 2 m x 2 m. The shade is parnet 50%. Urea is given at a dose of 150 kg/ha. The results showed that *A. gangetica* as a cover crop, both in conditions without shade and with shade 50%, was able to increase the available N, P, K soil based on the nutrient balance, namely 16.25%, 86.33%, and 426.99% respectively in treatments without shade, and 13.10%, 171.06%, and 560.43% respectively in shade 50% treatment.

1. Introduction

It is well known that the use of cover crops in agriculture land is able to reduce run off and soil erosion in many agroecosystems [1-5]. Cover crops are also able to reduce nitrates accumulation and substantially reduce nitrogen leaching [6-7; 3]. The use of cover crops is a unique application because are not harvested due to their main function as nutrient leaching control [3; 8]. Another function of cover crops is as green manure for commercial crops [9] and increasing mineralization from residual cover crops during growth cycle [10].

*Asystasia gangetica* (L.) T. Anderson is an invasive weed that potential to be cover crop in mature palm oil palm plantations in South Lampung because able to improve soil chemical properties, rapidly decompose, reduce erosion and loss of soil N, P, K, able to increase the availability of N, P, K based on the nutrient balance, and able to increase the availability of soil water during the dry season [3-4;11-14]. However, further research is still needed to understand its uses as cover crops under shade and without shade conditions. This is aimed to determine the wider use of *A. gangetica* which and not only limited to mature oil palm with shaded environmental conditions, but open possibility of using *A. gangetica* in immature oil palm without shaded conditions. Research result of Asbur et al. [12] showed that *A. gangetica* was able to grow well in 5 years and 17 years old of oil palm plantations in South Lampung. Based on the foregoing this study examined the role of *A. gangetica* as cover crops in increasing the
availability and nutrient content of N, P, K in the soil on the nutrient balance under with shade and without shade conditions.

2. Materials and methods
The research was conducted at Experimental farm, Faculty of Agriculture, Universitas Islam Sumatera Utara, Gedung Johor, Medan, Indonesia, which was held from February 2018 to June 2018. The coordinates of the experimental plots are 2º27'00" - 2º47'00" S and 98º35'00" - 98º44'00" E, and the elevation is 25 m above sea level. The analysis of plants tissue and soil chemical properties was conducted in Soil Laboratory, Indonesian Oil Palm Research Institute, Medan, North Sumatera, Indonesia. The area has an average annual precipitation of 265.83 mm that ranges between 108-590 mm, an average annual temperature of 22.1-31.3 °C.

The research method is non-factorial randomized block design with shade as treatment and six replications. Treatments consisted of without shade and with 50% shade. A. gangetica is planted with a spacing of 20 cm x 20 cm and at a plot size of 2 m x 2 m. This spacing is refer to the previous studies [15]. A. gangetica was planted using stem cuttings measuring 15 cm or two segments obtained from PT PP Lonsum oil palm plantation. The shade used is paranet 50%. Urea is given at a dose of 150 kg ha⁻¹.

Soil chemical analysis was performed before and after the experiment. Soil sample were taken composite from five sampling site on topsoil as deep as 0-10 cm using a soil drill. The soil mixture is then taken as much as ± 1 kg soils, put into plastic bags and tied with rubber [16]. Analysis of total N was performed using the Kjeldahl digestion method [17], while analysis of P-available and K-available was using Bray method 1 [18].

The calculation of nutrient balance was based on: (1) Nutrient sources, consisting of initial soil (initial soil nutrient content × initial soil weight) and fertilizer (fertilizer nutrient content × fertilizer weight); (2) recovery nutrients, consisting of final soil (nutrient content of final soil analysis × final soil weight) and nutrient uptake (plant nutrient content × dry weight); and (3) nutrient addition or subtraction (Recovery nutrient - Source).

3. Results and discussion
3.1. Availability of soil N, P, K
The statistical analysis shows that shade significantly affect the availability of N and P, but as no significant effect on the availability of K (Table 1).

| Availability of soil nutrient | Before treatments | After treatments |
|------------------------------|-------------------|-----------------|
|                              | Without shade     | With shade 50%  | Without shade | With shade 50% |
| N                            | 1900.00a          | 1900.00a        | 2200.00a      | 2100.00b       |
| P                            | 13.83a            | 13.82a          | 10.28b        | 15.19a         |
| K                            | 30.42a            | 30.43a          | 58.50a        | 54.60a         |

Numbers followed by not the same letters in the same treatment group are significantly different at 5% based on LSD test

Table 1 shows that shade significantly affects the availability of soil N after treatment, where N availability is higher in treatment without shade compared to 50% shade. The availability of N increased by 15.79% in the treatment without shade and by 10.53% in the treatment with 50% shade. Research result of Nugroho et al. [19] showed a higher availability of N in oil palm plantations aged 5 years (high sunlight intensity) compared to aged 26 years (low sunlight intensity). However, [20] shown that N availability is higher in shaded conditions.

The higher availability of N in the treatment without shade compared to 50% shade in this study may be due to decrease in microorganism’s activity to change soil organic matter so that they cannot
work optimally. According to Predick et al. [21], higher sunlight intensity will accelerate the decomposition of organic matter by increasing microbial metabolic activity. Besides that, in shaded conditions, N available in the soil are more commonly used for vegetative growth by *A. gangetica*, whereas in conditions without shade, vegetative growth of *A. gangetica* is smaller. According to Othman [22] and Isnaini [23], *A. gangetica* has high tolerance for less favourable environmental conditions and has certain strategies to exploit such environment. In shaded area, *A. gangetica* will produce more vegetative organs, while in open areas it will produce more generative organs. Furthermore, Gardner and Miller [24] suggest that N is the dominant element compared to other elements in vegetative growth.

Shade significantly affects the availability of P in the soil after treatment (Table 1). In contrast to N availability, P availability is higher in the treatment with 50% shade compared to without shade. At 50% shade, P availability increased by 9.91% and in treatment without shade, P availability decreased by 34.53%. According to Deng et al. [25], the increase in P availability in the soil in shaded conditions. But in contrast of [26-29] showed that P availability is higher in treatments without shade compared to 50% shade.

| Description                                      | Without shade | With shade 50% |
|--------------------------------------------------|---------------|----------------|
| **Nutrient Balance of N, P, K in Without shade and with shade 50% treatment** |               |                |
| **N-total (kg ha⁻¹)**                            |               |                |
| Source                                           |               |                |
| Nutrient availability before treatment           | 1900.00       | 1900.00        |
| Fertilizer                                       | 67.50         | 67.50          |
| Total Source                                     | 1967.50       | 1967.50        |
| Recovery nutrient                                |               |                |
| Nutrient availability after treatment            | 2200.00       | 2100.00        |
| Uptake                                           | 87.15         | 125.29         |
| Total recovery Nutrient                          | 2287.15       | 2225.29        |
| Nutrient increase/loss                          | 319.65 (+)    | 257.79 (+)     |
| **P (kg ha⁻¹)**                                  |               |                |
| Source                                           |               |                |
| Nutrient availability before treatment           | 13.83         | 13.82          |
| Fertilizer                                       | -             | -              |
| Total Source                                     | 13.83         | 13.82          |
| Recovery nutrient                                |               |                |
| Nutrient availability after treatment            | 10.28         | 15.19          |
| Uptake                                           | 15.49         | 22.27          |
| Total recovery Nutrient                          | 25.77         | 37.46          |
| Nutrient increase/loss                          | 11.94 (+)     | 23.64 (+)      |
| **K (kg ha⁻¹)**                                  |               |                |
| Source                                           |               |                |
| Nutrient availability before treatment           | 30.42         | 30.43          |
| Fertilizer                                       | -             | -              |
| Total Source                                     | 30.42         | 30.43          |
| Recovery nutrient                                |               |                |
| Nutrient availability after treatment            | 58.50         | 54.60          |
| Uptake                                           | 101.81        | 146.37         |
| Total recovery Nutrient                          | 160.31        | 200.97         |
| Nutrient increase/loss                          | 129.89 (+)    | 170.54 (+)     |

(+) : Source < Recovery nutrient = enhancement nutrient done; (-) : Source > Recovery nutrient = reduction nutrient done.
The lower availability of P in the soil in the treatment without shade compared to 50% shade is due to the higher demand for leaf photosynthetic requirements to be used for flower and seed formation because *A. gangetica* growth in shade conditions will produce more generative organs [22-23]. According to Koutika et al. [30], the low P availability in the soil is due to high P uptake by plants.

Shade has no significant effect on the availability of K in soil after treatment (Table 1). This is because the availability of K is not affected by sunlight intensity but depends on K exchangeable (K-\(\text{ex}\)), pH, number and types of clay minerals, other cations in the soil, and K nutrients added or transported by plants [31-32]. Table 1 shows that although shade has no significant effect on the availability of K, but after treatment there is an increase in K availability, both in treatments without shade and 50% shade, that is 92.31% and 79.43% respectively. This is due to the high concentration of K in organic residues of *A. gangetica* (litter, leaves, and branches), which is 3.68%, and decomposition rate of *A. gangetica* is quite high, which is 91.62% in a 30-day period [10].

### 3.2. Nutrient balance of N, P, K

Nutrition calculations show unmeasured nutrients due to leaching, evaporation, mobilization, immobilization (inorganic to organic), nutrient fixation and mineralization (organic to inorganic) [13]. Calculation of nutrient balance is presented in Table 2.

Table 2 shows that in without shade treatment, there is an addition of N, P, and K based on the nutrient balance, namely 16.25%, 86.33%, and 426.99% respectively. In 50% shade treatment, there is an addition of N, P, and K in the soil, namely 13.10%, 171.06%, and 560.43% respectively. Asbur et al. [13], [15], and Landriscini [33] showed that the addition of N, P, and K with the presence of soil cover crops based on the nutrient balance.

The addition of P and K in the soil based on the nutrient balance in 50% shade is higher than non-shade treatment. This was due to the absorption of nutrients by *A. gangetica* in the treatment of 50% shade is higher than non-shade treatment, resulting higher nutrient recovery through its biomass residue. According to Epron et al. [34], high nutrient absorption by plants causes high nutrient availability due to its biomass residual decomposition.

Increased availability of N, P, K after treatment, both in the non-shade and 50% shade treatment (Table 2) was attributed to *A. gangetica* plant as cover crop that has significant role in the availability of N, P, and K in the soil as it could reduce loss of N, P, and K soil through leaching, evaporation, and erosion compared to empty land [3; 29].

### 4. Conclusion

*A. gangetica* as cover crop, both without shade and with 50% shade treatment can increase the availability of N, P and K in the soils and able to increase N, P, K based on the nutrient balance by 16.15%, 86.33% and 426.99% in without shade treatment, and 13.10%, 171.06%, and 560.43% in with 50% shade treatment.

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