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The Effect of Shade and NPK Fertilization on Growth and Yield of *Asystasia gangetica* as a Forage

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ABSTRACT: *Asystasia gangetica* is a weed usually found in oil palm plantations, which is used as a source of forage and cultivated at a known effective shade level and optimal fertilizer dosage. Therefore, this study was carried out at a place without shade (NS) and 75% of shading net (S) at the Experimental Field of the Faculty of Agriculture, Universitas Mulawarman, Samarinda, Indonesia. The seedlings used were planted and fertilized with NPK at doses of 0 g, 1.6 g, and 3.2 g per polybag. The results showed that the level of shade affected plant height, several branches, yield of dry matter shoot, the content of chlorophyll a, b, and a/b content, CP, CF, EE, NFE, and ash, but not on chlorophyll a+b. The dosage of NPK fertilizer affected plant height, the number of branches, yield of dry matter, chlorophyll a, b, and a+b content, CP, CF, EE, NFE, and ash content, while chlorophyll a/b ratio was not influenced. The interaction between shade level and NPK fertilizer dose only occurred in the number of branches, chlorophyll a, b, and b+c content, CP, CF, EE, and ash content, but not on chlorophyll a/b ratio and NFE content. The flowering rate was faster in NS plants, where those with NPK fertilizer dose of 0.32 g/polybag gave the highest yield, except for CP and ash content which had the highest yields on S plants with 0.32 g NPK/polybag.

KEY WORDS: Branches, Chlorophyll, Flowering Time, Nutrient Content, Plant Height.

INTRODUCTION

Asystasia gangetica (L.) T. Anderson is a perennial herbaceous plant that grows upright or decumbent with broadleaf (CABI, 2020). It is characterized by rapid growth that covers the ground with height ranging from 15 to 60 cm and a stem with a square shape and scattered hairs. The leaves grow opposite, oval, about 4-9 cm long and 2-5 cm wide, seeded with the compound flower bunches protruding from the tip of the stem or axillary, and the petals were lanceolate with a length of approximately 3-50 mm. Furthermore, the crown is shaped like a white bell with a length of 20-25 mm (Hsu et al., 2005; Prawiratama, 2019). The two subspecies of *A. gangetica* include *micrantha* (Nees) Ensermu which spreads in tropical Africa, islands in the Indian Ocean, and Arabia. The second subspecies is Gangetic spreads in India, Sri Lanka, Southeast Asia, and the islands of the Pacific Ocean (Adetula, 2004). A previous study has shown that the plant grows in various humid places, especially as a weed in oil palm plantations (CRC, 2003).

In oil plantation, *A. gangetica* is a land cover crop that improves the physical properties of the soil (Asbur et al., 2016), controls erosion, and prevents the development of harmful weeds such as *Mimosa pigra* (L) and *Imperata cylindrica* (L) which have dangerous traits (Lee and Chen, 1992). Additionally, the biomass produced acts as a soil carbon stock (Satriawan et al., 2020) and it can live in 90% shade (Adetula, 2004).

A. gangetica species is often used as a source of forage that grows together with *Axonopus compressus*, *Ottochloa nodosa*, and *Paspalum conjugatum* (Daru et al., 2014). The cattle that were grazed under oil palm plantations consisting of a mixture of field grass and *A. gangetica* can provide daily body weight gain of 270-310 g per head (Adetula, 2004). Some of the food substances in the species include carbohydrates, proteins, amino acids, crude fiber, lipids, minerals, and several bioactive compounds such as steroids, alkaloids, tannins, saponins, phenols, and flavonoids (Janakiraman et al., 2012). The crude protein and fiber contents are 19.73% and 18.68%, respectively with dry matter content of 18.4% (Suarna et al., 2019). Meanwhile, mineral content such as Ca ranged from 18.8-20.5 g, P ranged from 11.2 to 17.4, and Mg ranged from 7.5-8.5 g/kg DM depending on location (Khalil et al, 2018).

Due to the importance of *A. gangetica* as animal feed, it is necessary to make efforts in its cultivation. Meanwhile, several experiments that have been carried out both in situ and ex-situ include the nutrient cycle and mineral balance due to decomposition

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in oil palm plantations (Asbur et al., 2018), plant production and nutrient content, (Kumalasari et al., 2020), as well as the administration of the leaf meal to poultry (Sabayo et al., 2012). It was discovered that *A. gangetica* grows well in shaded conditions, therefore, it is necessary to compare the plants that grow with and without shade including NPK fertilizer to determine their production potential.

MATERIALS AND METHODS

The current study was carried out at the experimental field of the Faculty of Agriculture, Mulawarman University from September to December 2020. The seedlings of *A. gangetica* were obtained from the field and planted on soil which placed in 17 x 30 cm polybags.

The pols of *A. gangetica* are planted in polybags until they were 30 days old and cut to a height of 6 cm from the soil surface. Furthermore, each plant was placed in the unshaded group (NS) and shaded with a 75% shading net group (S). Each NS and S group was given NPK fertilizer (16-16-16) with various doses, namely 0 g/polybag (F1), 0.16 g/polybag (F2), and 0.32 g/polybag (F3), which was replicated 10 times. For leaf chlorophyll data collection, a set of experiments was also carried out at the same place and was cut at the age of seventh weeks.

The parameters measured include plant height, which was measured from the base of the stem to the highest part, the number of branches growing from the main stem, the shoot dry matter yield (DM) that was obtained from drying the fresh shoot in an oven at 60ºC for 48 hours (constant weight), chlorophyll content (CHL) which was prepared by extracting 1 g of leaves in 10 mL of 90% acetone using a mortar. The mixture was filtered with Whatman paper no. 42 and the leaf extracts were measured using a spectrophotometer at different wavelengths. The calculations to obtain the content of CHL a = 1.07 (OD663) - 0.094 (OD644) and CHL b = 1.77 (OD644) - 0.28 (OD663) was carried out according to Hendriyani & Setiari, (2009). The flowering time was calculated based on the average percentage measured each week only in plants that were not given NPK fertilizer. The composition of nutrients content measured included crude protein content (CP), crude fiber (CF), ether extract (EE), and ash with procedures from AOAC International (2016) was conducted at the Animal Nutrition Laboratory, Department of Animal Husbandry, Faculty of Agriculture, Universitas Mulawarman. Meanwhile, the nitrogen-free extract (NFE) was obtained from the expression NFE=100- (CP+CF+EE+ash).

The experiments were arranged in a split-plot design and the data collected were analyzed by analysis of variance (ANOVA). Meanwhile, when there was a significant difference, it was tested by the least significant difference (LSD) test at a 5% level.

RESULTS

Plant Height, Number of Branches, Dry Matter of Shoot, and Chlorophyll Content

Based on the Anova, it showed that the plant height, the number of branches, the DM of the shoot, and the CHL a and b content were separately influenced by the shading level and the NPK fertilizer dose. However, the CHL a+b content was only affected by the NPK fertilizer dose ($P<0.01$), and the CHL a/b ratio was only affected by the level of shading. The shading level and the NPK fertilizer dose together affected the number of branches and the content of the a, b, and a+b (Table 1).

Although the S plant had higher height and CHL b content, the number of branches, DM of the shoot, and CHL a content together with the CHL a/b ratio were lower compared to the NS plant. Subsequently, based on NPK fertilization, there was a highly significant difference ($P<0.01$) for all parameters measured. It was discovered that the fertilizer can increase plant height, the number of branches, DM of the shoot, CHL a, b, and a+b content, but not at the CHL a/b ratio.

Nutrient Content

Based on the Anova, the shade treatment gave a highly significant difference ($P<0.01$) to the CP, CF, NFE, EE, and ash content. The S plant showed higher CP, NFE, and ash content, as well as lower CF and EE contents compared to the NS plant (Table 2).

In the NPK fertilization treatment, there was a highly significant difference ($P <0.01$) in all nutrients content measured, which increased with the application of NPK fertilizer, except NFE as shown in Table 2. Subsequently, interactions of the level of shading and NPK fertilization treatments also showed highly significant differences ($P<0.01$) on all nutrients content, except for

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NFE had significant difference. The application of NPK fertilizer significantly increased the CF content, but when shaded (S), it decreased the CF content as indicated in Table 2.

Flowering Time

A. gangetica began to show flowering at the second week, but the rate of flowering was affected by shading conditions. The NS plants flowered 100% at aged week fourth, while S plants had 100% flowering at aged week seventh as exhibited in Figure 1 and Figure 2.

DISCUSSION

This study showed that *A. gangetica* planted at 75% shade level (S) have a higher plant height with fewer branches than unshaded plants (NS). Generally, plants that grow in shaded places tend to form higher growth as compensation based on light, which is called the photoadaptive mechanism (Atanasova et al., 2003). In a shaded place, the photosynthesis rate was lower than in an open place, thereby, reducing the production of organic substrates and the reserve material was only used for plant growth (Mathur et al., 2018). This showed that shaded plants have lower dry matter yields (Villalobos et al., 1992; Watanabe et al., 1993). However, this is significantly different from plants that grow in unshaded places, where they form more branches and leaves due to the fulfillment of light sources for photosynthesis, which becomes more effective and increases the yield of dry matter.

The CHL a content in S plants was lower than in NS plants, while the CHL b content was higher. A previous study stated that CHL a is a plant pigment that converts light energy captured by CHL b into chemical energy (Sirait, 2008). When sunlight intensity decreases, the amount of CHL a also decreases due to ineffective light reception (Fanindi et al., 2010). Based on the observations, the leaves of the S plant looked greener than the NS plant, while those with dark green leaves were caused by high CHL b content (Martins et al., 2013; Purwantari, 2016). Although the CHL a + b content did not show a significant difference in NS and S plants, the CHL a / b ratio in NS plants was significantly higher, which showed that *A. gangetica* likes sunlight (Mathur et al., 2018).

The level of shading treatments also affected the flowering time, although statistically not tested, it appears that the time of NS plants was faster than S plants (Figure 1). The formation of *A. gangetica* flowers that grew in shaded places is slower, while those that were not shaded tend to flower more quickly (Mishra et al., 2012). In shaded places, the stomatal conduction will decrease causing a reduction in the content of malondialdehyde (MDA), which delays the initial flowering time (Zhao et al., 2012).

Moreover, the level of shading treatment has a highly significant effect on the nutrient content such as CP, CF, NFE, EE, and ash. It was also discovered that the S plants contain higher CP, NFE, and ash than the NS plants. This is because S plants use available resources for the formation of light-absorbing pigments and the accompanying proteins compared to the needs of Rubisco and other dissolved proteins involved in CO_2 fixation (Mathur et al., 2018). The high CF content in *A. gangetica* growing in a shaded area was the same with a study by Widodo et al. (2019). These results indicated that the formation of CF was influenced by the intensity of sunlight. The CF is a description of the cell wall fraction, which is usually affected by shading conditions. This showed that when the plant was not shaded, the CP was low and the CF content was high (Norton et al., 1991).

The results showed that the NPK fertilizer plays an important role in the growth and yield of *A. gangetica* by increasing the plant height, the number of branches, DM of the shoot, CHL a, b, and a+b content, but not in the CHL a/b ratio. It was also discovered that the content of CP, CF, EE, and ash was increased, while NFE content was reduced. A previous study has shown that the application of chemical fertilizers such as NPK can increase the growth and yield components in plants for a positive effect (Daşci and Çomakli, 2011). Nitrogen is an important element in plant growth and yield, which was not only specific to crops but also for all plant types (Alwi et al., 2018). It plays a role in the formation of protein and chlorophyll (Leghari et al., 2016), therefore, the application of nitrogen fertilizers can increase the yield of DM of the shoot, CP, and chlorophyll content of *A. gangetica*. The application of phosphorus in the soil also improves various functions in plant growth such as photosynthesis, energy transfer, the transformation of sugars and starches, as well as the transfer of plant genetic properties (De Villiers, 2007). This condition was discovered with the increase in various plant components by the application of NPK fertilizer. Similarly, potassium is important for various factors that affect plant growth, which plays a role in plant physiological functions and increases the efficiency of nitrogen absorption (Prajapati and Modi, 2012).

The interaction of shade level and NPK fertilizer dosage was only observed in the number of branches, the content of the a, b, and a+b, and all nutrients, namely CP, CF, EE, and ash except for NFE. It was discovered that NS plants applied with NPK

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fertilizer dose of 0.32 g per polybag gave the highest yield, except for the CP and ash content which gave the highest yield on S plants. This showed that the contents of CP, ash and CHL b will give the highest value when planted under shade and applied with NPK fertilizer. According to Widodo et al. (2018), the application of nitrogen fertilizer to the shaded *Pennisetum purpureum* increased the crude protein content but decreased the dry matter and crude fiber content. Nitrogen is a mineral that is often limited to plant growth and productivity. Due to the large demand for nitrogen, especially in the chlorophyll bond, the shade intended for interception efficiency will require greater nitrogen (Niinemets, 2007).

CONCLUSION

This experiment was still being carried out in polybags and in places where the shade was designed, so that other factors, such as the level of sun exposure vary from morning to evening as well as interspecific and intraspecific competition in terms of nutrient sources, water, space, and sun could not be described. Subsequent experiments should also be carried out in situ on oil palm fields of different ages, as this will affect the level of shade.

CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial, personal, or other relationships with other people or organizations related to the material discussed in the manuscript.

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Table 1. Growth and yield of *A. gangetica* aged seventh weeks under different shade and NPK fertilization treatments.

Treatments	Plant height (cm)	Number of branches	DM of the shoot (g/plant)	CHL a (mg/g)	CHL b (mg/g)	CHL a+b (mg/g)	CHL a/b ratio
Level of shading							
Unshaded (NS)	18.98^{b}	30.78^{a}	6.59^{a}	1.90^{a}	1.58^{b}	3.48	1.29^{a}
Shaded 75% (S)	22.77^{a}	18.61^{b}	6.02^{b}	1.78^{b}	1.70^{a}	3.48	1.05^{b}
NPK fertilizer dose							
0 g/polybag (F1)	19.48^{b}	18.83^{c}	5.69^{c}	1.74^{b}	1.56^{b}	3.30^{c}	1.12
0.16 g/polybag (F2)	21.13^{a}	23.83^{b}	6.30^{b}	1.92^{a}	1.72^{a}	3.64^{a}	1.12
0.32 g/polybag (F3)	22.00^{a}	30.80^{a}	6.94^{a}	1.86^{a}	1.63^{b}	3.49^{b}	1.27
Interaction							
NS x F1	17.68	23.96^{c}	5.84	1.78^{b}	1.48^{c}	3.26^{c}	1.20
NS x F2	18.88	28.41^{b}	6.54	1.94^{a}	1.62^{b}	3.55^{ab}	1.20
NS x F3	20.39	38.74^{a}	7.40	1.99^{a}	1.63^{b}	3.61^{a}	1.48
S x F1	21.29	13.70^{e}	5.54	1.70^{b}	1.63^{b}	3.33^{c}	1.06
S x F2	23.39	19.25^{d}	6.06	1.90^{a}	1.83^{a}	3.73^{a}	1.04
S x F3	23.63	22.86^{c}	6.48	1.73^{b}	1.63^{b}	3.37^{bc}	1.06
CV (%)	9.41	5.82	5.08	8.20	6.97	5.70	7.41

Mean numbers in the same column followed by different letters indicate significant differences (P<0.05).

Table 2. Nutrient content of A. gangetica aged seventh weeks under different shade and NPK fertilization treatments.

Treatments	CP	CF	NFE	EE	Ash
Level of shading					
Unshaded (NS)	12.12^{b}	32.65^{a}	45.70^{b}	4.57^{a}	4.96^{b}
Shaded 75% (S)	16.75^{a}	21.71^{b}	49.76^{a}	4.10^{b}	7.67^{a}
NPK fertilizer dose					
0 g/polybag (F1)	13.72^{b}	23.10^{c}	54.17^{a}	3.57^{b}	5.44^{c}
0.16 g/polybag (F2)	14.30^{b}	28.33^{b}	46.31^{b}	4.75^{a}	6.32^{b}
0.32 g/polybag (F3)	15.28^{a}	30.10^{a}	42.72^{c}	4.70^{a}	7.18^{a}
Interaction					
NS x F1	12.37^{d}	27.66^{c}	51.61	3.60^{c}	4.76^{e}
NS x F2	12.07^{d}	33.46^{b}	44.75	5.04^{a}	4.68^{e}

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NS x F3	11.93[d]	36.81[a]	40.75	5.07[a]	5.44[d]
S x F1	15.08[c]	18.54[e]	56.73	3.53[c]	6.13[c]
S x F2	16.53[b]	23.20[d]	47.86	4.45[b]	7.96[b]
S x F3	18.64[a]	23.39[d]	44.68	4.32[b]	8.91[a]
CV (%)	8.24	8.02	6.04	7.74	9.25

Mean numbers in the same column followed by different letters indicate significant differences (P<0.05).

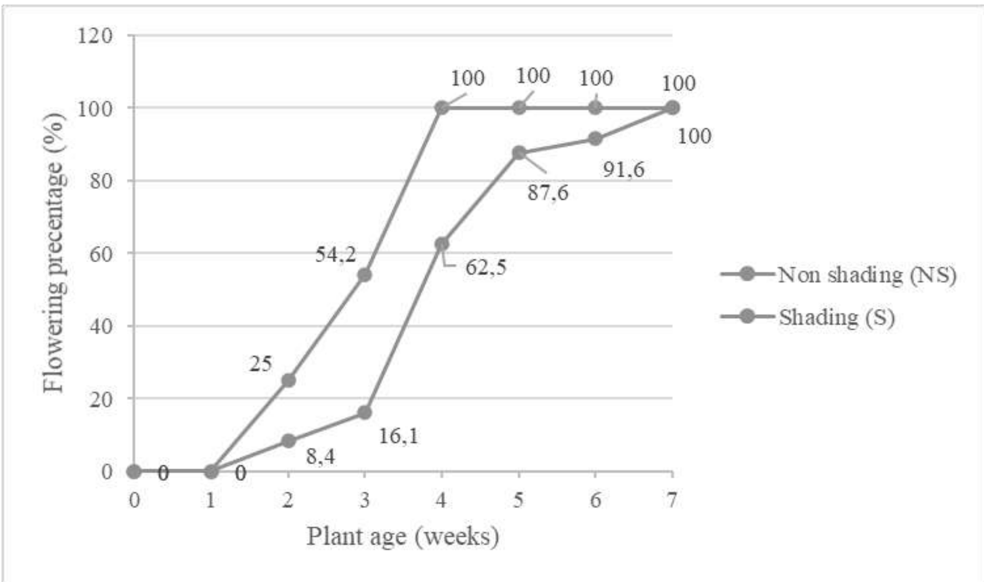

Figure 1. Flowering time of *A. gangetica* at different levels of shading

Figure 2. *A. gangetica* at different levels of shading

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