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# Evaluation of Biomass Production, Nutrient Content and Digestibility of *Asystasia gangetica* as an Alternative Forage under Palm Plantation

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**ABSTRACT**: Integrated farming systems through the inclusion of forage into the plantation area can increase the forage supply for ruminants. The aim of the research was to evaluate biomass production, nutrient, mineral content, and digestibility of *A. gangetica* under different light intensity in palm plantation areas. The research was conducted under randomized complete block design based on three different light intensity on each block. Data were analyzed statistically with R i386 3.6.1 using the Analysis of Variance Test (ANOVA), and Duncan Test was applied to determine the level of significant difference. The research showed *A. gangetica* cultivation influenced the soil properties under palm plantations. *A gangetica* grew well until light intensity 14.39% which indicated by average biomass production on the first harvest time reached 78.58 g/plant. The light intensity decreases triggered an increase in *A. gangetica* dry matter percentage, ash content and crude protein. The light intensity unaffected the concentration of minerals Ca, P, Mg, and forage digestibility, on the other side the dry matter digestibility on the second harvest time decreased due to the soil properties influences. The research concluded that biomass production, nutrient, mineral content, and digestibility of *A. gangetica* under palm plantation area were affected by light intensity, soil properties, and harvest time.

**Keywords:** *A. gangetica*; Forage biomass; Light intensity; Nutrient content; Soil properties; Harvest time

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## INTRODUCTIONS

Indonesia has a vast land area of palm plantations, with an area almost 15 million ha in several islands (BPS 2021). The plantation area with simple tillage to the soil has led to low use efficiency of natural resources, such as light, soil, water, and nutrients (Shui et al. 2008). In a country with a tropical rainforest biome, such as Indonesia, land utilization can be increased by a double-cropping system (Affandi and Astuti 2019) and an increase in forage supply as expected by proper management to improve forage production (Nurhayati et al 2015). Integrated farming systems through the inclusion of forage into the plantation area will offer a solution to deal with such issues and increase the forage supply for livestock (especially ruminant).

*Asystasia gangetica* (L.) T. Anderson is often found and grows well in palm plantations (Ramdani et al. 2017). It has the potential to develop as forage in palm plantations related to high forage biomass, and nutrient content (Kumalasari et al. 2020), especially crude protein, fiber and mineral, for ruminants (Kumalasari et al. 2022). As a cover crop, *A. gangetica* improves soil physical, chemical, soil moisture, and nutrient availability after the decomposition stage (Asbur et al. 2015). This research was carried out to provide useful information regarding *A. gangetica* forage value to increase the utilization of integrated farming systems in palm oil plantations.

The constraints in the integrated farming system in palm plantation lie on the low light that reduces forage growth rate (Rayburn and Griggs 2020) and affects production (Castro et al. 1998). The aim of the research was to evaluate biomass production, nutrient, mineral content, and digestibility of *A. gangetica* under different light intensities in palm plantation areas.

## MATERIALS AND METHODS

The research was conducted at the Cikabayan Research Center of Palm Oil Plantation, and the Laboratory of Agrostology, Faculty of Animal Science, IPB University, from November 2018 – April 2019.

Forage quality was analyzed at the Research Center of Natural Resources, and Biotechnology, IPB University and the Laboratory of Feed Science Technology, Faculty of Animal Science, IPB University. Soil quality was analyzed at the Laboratory of Soil Science, Faculty of Agriculture, IPB University. The research was conducted under a randomized complete block design based on three different light intensities on each block (Table 1). The assessment was conducted two harvested times, consecutively.

**Table 1.** Average of light intensity on palm oil plantation during the research time

| Palm oil plantation area | Light intensity* (lux) | Light received above the ground (%) |
|---|---|---|
| Without plant | 21545.00±15448.70 | 100 |
| 6 years old plantation | 3862.29±2757.55 | 14.39±10.28 |
| 8 years old plantation | 1889.64±1454.69 | 8.88±4.87 |

Recorded daily on 09.00-11.00 (Jakarta Time Zone)

The research used *A. gangetica* cutting stem that was immersed auxin 25 ppm for 15 minutes and then planted in a polybag. The fertilizer was applied to polybag at the rate of manure was 250 g/polybag and Mutiara inorganic fertilizers (16% N, 16% $P_2O_5$, 16%$K_2O$) at the rate of 0.25 g/polybag (Kumalasari et al. 2020). The seedlings were transplanted to the field area after 21 days in the nursery. The seedlings were transplanted into 2 m x 2 m experimental plots under the different light blocks with three replications.

### Data Collection

Fresh yields were harvested twice after 50 days by cutting approximately 5 cm from the ground from each plant and directly weighed to determine the fresh yield. Fresh herbage samples from each plot were taken, and air dried under sunlight for 2 x 12 h, then the samples were dried in an air-forced oven at 60$^o$C for 48 h, and ground to pass through a 1 mm sieve for chemical analyses. The dry matter, crude protein, crude fat, crude fiber, and ash contents were determined according to the AOAC (2005) procedure. The fiber was analyzed using the *Van Soest* method while forage digestibility was analyzed by a two-stage in-vitro technique (Tilley and Terry 1963).

The soil was sampled at the beginning of the research and after the harvested time (twice). The measurement of soil properties was carried out by taking soil samples in a composite way from five taking points in each block with a soil layer depth of 0-20 cm using a ground drill. The soil composite was taken ± 1 kg as soil sample and the analysis of C-organic was performed using the Walkley and Black method, N-total (Kjeldahl Method), P (method of 25% HCl extract with a spectrophotometer), and K (method of 25% HCl extract with a flame photometer). Data were analyzed statistically with R i386 3.6.1 using the Analysis of Variance Test (ANOVA), and Duncan Test was applied to determine the level of significant difference.

## RESULTS AND DISCUSSION

### Soil properties

The research showed *A. gangetica* cultivation influenced the soil properties under palm plantations. Planting *A. gangetica* was effective to increase soil pH after the first harvest time and Fe on the second time, and tend to increase Ca, Al, H, Cu, Zn, and Mn concentration. On other properties, *A. gangetica* tends to decrease C-organic and P concentrations.

The increase in exchangeable cation and minerals related to elated soil pH, although the soil pH failed to increase C-organic and P due to the increase in Al and Fe reacted to fix Al-P and Fe-P fraction (Ch'ng et al 2014), especially in the first harvest time The increasing of time and pH stability is essential to reduce the Al-soluble and dissolved Fe in the soil then release P into soil solution for plant use (Irfansyah, 2013). The soil properties and organic mineral sufficient also affect the mineral transformation to soluble minerals for higher forage quality (Khan et al 2006).

### Fresh Biomass Production

*A. gangetica* biomass production at different harvesting times was affected by different light intensity (Figure 1). The results showed *A gangetica* grew well until light intensity 14.39% which indicated by average biomass production on the first harvest time reached 78.58 g/plant. Regarding the light intensity, 100% sunlight resulted in the highest and most stable biomass production on both harvest times (68.04 and 83.20 g/plant). As for biomass production in light intensity 8.88%, there was a significant difference within $p<0.05$ on the first and second harvest time (39.21 and 1.65 g/plant).

The high biomass production in the first harvest time occurred in the 100% and 14.39% light intensity. The high plant biomass on the first harvest time is related to the plant's adaptation through a series of growth responses on light intensity level decreases. The adaptation formed in plant morphology, photosynthesis pattern, and leaf nutrient (Tang et al, 2022) affected forage production (Patton et al 2007).

### Nutrient content

The research showed that light intensity decreases triggered an increase in *A. gangetica* dry matter percentage, ash content, and crude protein (Table 3). However, the percentage of crude fat, crude fiber, ADF, and NDF decreased with lower light intensity. There was a different pattern of nutrient content between the first harvest time and the second harvest time. In the second harvest time, dry matter, ash content and crude protein were increased significantly (until 5.03% for crude protein), while the decreases occurred on fiber fractions (crude fiber, ADF, NDF).

**Table 2.** The soil properties of the studied areas

| Soil Properties | Before Cultivation | After the 1st harvest time | After the 2nd harvest time |
|---|---|---|---|
| pH $H_2O$ | 4.73±0.29[b] | 5.91±0.13[a] | 4.41±0.48[b] |
| pH KCL | 4.14±0.18[b] | 5.12±0.08[a] | 4.16±0.25[b] |
| C-organic (%) | 1.85±0.09 | 1.69±0.02 | 1.34±0.54 |
| N-Total (%) | 0.24±0.17 | 0.19±0.007 | 0.26±0.03 |
| P-Bray(ppm) | 13.47±2.55 | 12.05±0.07 | 11.96±0.22 |
| Exchangeable cation | | | |
| Ca (cmol/kg) | 4.95±3.66 | 5.56±1.33 | 5.63±1.29 |
| Mg (cmol/kg) | 0.99±0.66 | 1.21±0.32 | 1.13±1.08 |
| K (cmol/kg) | 0.08±0.03 | 0.09±0.02 | 0.08±0.02 |
| Na (cmol/kg) | 0.06±0.007 | 0.10±0.01 | 0.06±0.03 |
| Cation Exchange Capacity (me/100g) | 17.84±2.19 | 18.18±6.98 | 19.58±2.55 |
| Exchangeable bases (%) | 32.83±2.01 | 33.08±2.74 | 33.16±10.12 |
| Al (mg/L) | 1.26±0.28 | 1.43±0.23 | 2.16±0.23 |
| H (mg/L) | 1.21±0.14 | 0.12±0.007 | 0.29±0.04 |
| Fe (mg/L) | 36.06±2.05[b] | 38.99±2.06[b] | 58.91±3.18[a] |
| Cu (mg/L) | 1.61±0.27 | 1.96±0.99 | 2.21±0.38 |
| Zn (mg/L) | 2.75±0.31 | 2.89±1.32 | 5.01±1.29 |
| Mn (mg/L) | 134.91±53.67 | 129.19±83.81 | 182.95±75.41 |
| Sand (%) | 7.58±2.51 | 7.95±5.42 | 7.65±4.52 |
| Silt (%) | 13.65±4.68 | 25.24±6.34 | 19.18±8.68 |
| Clay (%) | 78.77±7.19 | 66.79±11.75 | 73.16±13.20 |

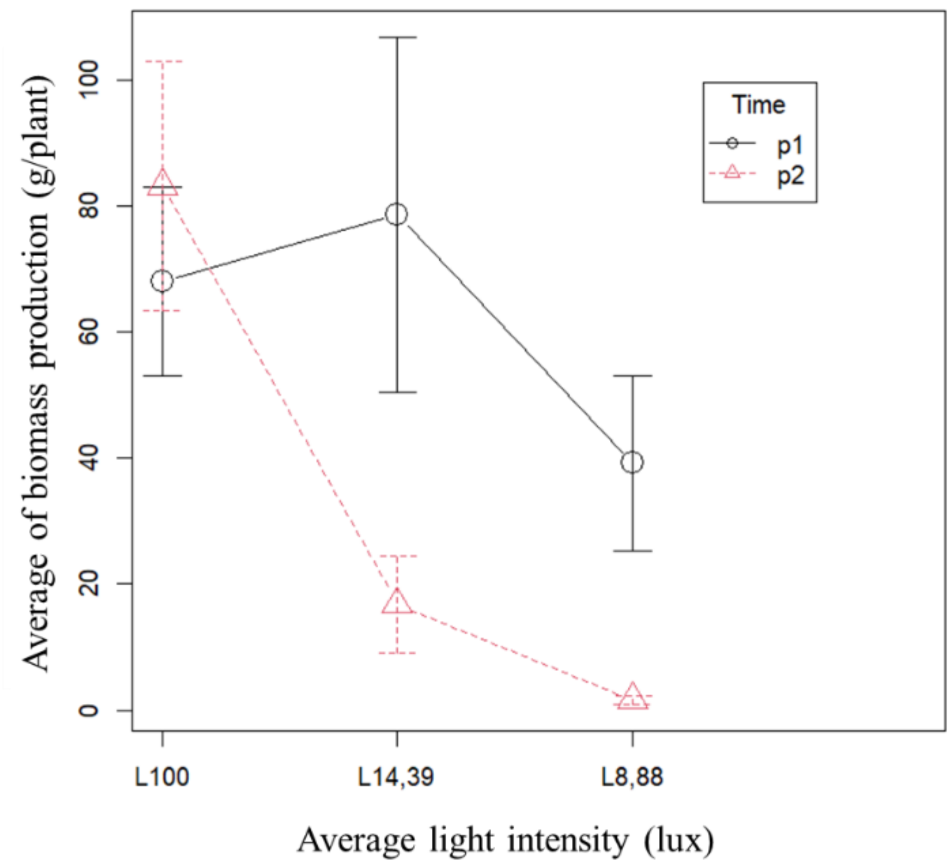


**Figure 1.** Average of biomass production on different light intensity

**Table 3.** Nutrient content on different light intensity and harvest time

| Nutrient | | L100 | L14.39 | L8.88 | Average |
|---|---|---|---|---|---|
| First Harvest Time | | | | | |
| DM (%) | | 11.26±3.94$^{b}$ | 11.16±2.47$^{b}$ | 17.24±6.42$^{a}$ | 13.22±0.34$^{y}$ |
| Ash | (100% DM) | 12.01±0.82 | 13.30±1.83 | 13.03±1.13 | 12.78±1.29$^{y}$ |
| CP | | 17.65±0.43 | 17.57±1.18 | 16.22±0.43 | 17.14±0.96$^{y}$ |
| CFat | | 2.25±0.39$^{a}$ | 0.91±0.07$^{b}$ | 1.15±0.21$^{ab}$ | 1.44±0.66 |
| CF | | 24.36±2.81$^{a}$ | 21.74±3.88$^{b}$ | 23.10±2.22$^{ab}$ | 23.06±2.87$^{x}$ |
| ADF | | 35.02±2.41 | 35.55±1.50 | 35.41±3.014 | 35.33±2.08$^{x}$ |
| NDF | | 41.52±2.06 | 42.49±2.39 | 42.00±2.77 | 42.00±2.14$^{x}$ |
| Second Harvest Time | | | | | |
| DM (%) | | 14.40±2.90 | 14.75±2.75 | 14.23±3.74 | 14.46±0.26$^{x}$ |
| Ash | (100% DM) | 14.16±1.66$^{ab}$ | 13.36±3.20$^{ab}$ | 16.90±1.47$^{a}$ | 14.81±2.52$^{x}$ |
| CP | | 20.50±3.80$^{ab}$ | 22.76±0.52$^{b}$ | 23.25±1.75$^{a}$ | 22.17±2.46$^{x}$ |
| CFat | | 2.20±0.45$^{a}$ | 1.65±0.41$^{b}$ | 1.61±0.47$^{b}$ | 1.82±0.47 |
| CF | | 24.75±3.92$^{a}$ | 13.31±2.76$^{b}$ | 11.55±1.09$^{b}$ | 16.53±6.67$^{y}$ |
| ADF | | 35.79±1.44$^{a}$ | 22.49±1.18$^{c}$ | 30.09±2.74$^{b}$ | 29.46±7.01$^{y}$ |
| NDF | | 42.35±0.94$^{a}$ | 31.73±1.89$^{c}$ | 35.29±2.16$^{b}$ | 36.46±4.92$^{y}$ |

DM= Dry matter; CP= Crude Protein; CFat= Crude Fat; CF= Crude Fiber; ADF= Acid Detergent Fiber; NDF= Neutral Detergent Fiber; $^{a, b}$ different superscripts show significant differences in the same row; $^{x, y}$ different superscripts show significant differences between columns (first and second harvest time)

The increased crude protein content of *A. gangetica* under partial shade in the second harvest time was caused by the reduction in N derived from atmosphere rates related to light intensity decreases (Sanna et al 2019). On the other side, the decreases in light intensity affects the net assimilation rates, net photosynthesis and its components, stomatal conductance, transpiration, water flux, and efficiency that are related to nutrient disposition in the plant (Baligar et al 2020), include crude fat (Glasser et al 2018) and fiber (Kumalasari et al 2018).

**Mineral concentration and forage digestibility**

The research revealed that light intensity unaffected the concentration of minerals Ca, P, Mg, and forage digestibility (Table 3). The mineral concentration on forage was relatively low in all harvest times, and there was a decrease in dry matter digestibility in the second harvest time.

The percentage of Ca and Mg in the forage tend to be declined for the second harvest time compared to that at the first harvest time. Khan et al (2013) reported mineral percentage on forage related to soil properties, such as pH, related minerals, and the antagonism mineral (Table 1). Although forage Ca and Mg concentration indicated a decrease at harvest time, this tendency was not found in forage P contents as it was higher on the second harvest time. The increasing P content on the second harvest time was predicted to be related to the soil pH elated (Table 1) because the higher soil pH could unlock the fixed P in soil (Johan et al 2021). The high variability in soil mineral composition, such as Fe, affects mineral concentration in forage (Marijanušić et al 2017).

The decrease of dry matter digestibility on the second harvest time was also influenced by soil properties (Table 1). These results corresponded with Harwanto et al (2022) that the harvest time had an influence on forage digestibility. Ishii et al (2005) reported that the second plant growth time was mediated by the emerging individual leaf area on the tillers at the first harvest time and this tended to be negatively related to the dry matter digestibility of leaves.

**Table 4.** Mineral concentration and forage digestibility

| Variable | L100 | L14.39 | L8.88 | Average |
|---|---|---|---|---|
| First Harvest Time | | | | |
| Ca (mg/100ml) | 7093.99±312.14 | 3408.49±347.49 | 4284.63±487.83 | 4929.04±1925.40 |
| P (mg/100ml) | 3626.36±475.90 | 1309.55±107.13 | 1855.52±368.55 | 2263.81±861.29 |
| Mg (mg/100ml | 16190.38±388.88 | 9554.06±572.41 | 11426.50±166.44 | 12390.31±3421.53 |
| DMD (%) | 63.51±8.28 | 66.04±0.92 | 68.37± 0.48 | 65.97±4.67[x] |
| OMD (%) | 63.31±8.98 | 62.92±1.23 | 65.73±1.01 | 63.99±4.74 |
| Second Harvest Time | | | | |
| Ca (mg/100ml) | 4280.94±779.13 | 4998.42±535.11 | 3602.99±1033.57 | 4294,11±697.81 |
| P (mg/100ml) | 3083.74±936.07 | 3611.61±318.21 | 3024.99±891.86 | 3240.11±722.15 |
| Mg (mg/100ml | 12791.48±538.07 | 10656.00±772.37 | 12956.29±986.21 | 12134.59±1283.14 |
| DMD (%) | 55.14±12.58 | 55.92±2.04 | 52.93±5.89 | 54.66±7.15[y] |
| OMD (%) | 50.98±3.44 | 54.36±1.87 | 49.24±7.62 | 51.53±8.10 |

Ca= Calcium; P= Phosphor; Mg= Magnesium; DMD= Dry Matter Digestibility; OMD= Organic Matter Digestibility; [x, y] different superscripts show significant differences between columns

## CONCLUSION

Biomass production, nutrient, mineral content, and digestibility of *A. gangetica* under palm plantation areas were affected by light intensity, soil properties, and harvest time.

## REFERENCES

Affandi, M. I., & Astuti, S. (2019). Development System Integration Plantation Palm Oil, Cattle and Energy In Rural Areas Lampung Province. In *Proceeding The 9th International Conference Rural Research & Planning Group (Ic-Rrpg)"Asian Rural Sustainable Development: Promoting Spiritual, Culture Values and Local Practices"* (pp. 378-387). Universitas Mahasaraswati Denpasar Bali Indonesia.

Asbur, Y., Yahya, S., Murtilaksono, K., Sudradjat, S., & Sutarta, E. S. S. S. (2016). The roles of Asystasia gangetica (L.) T. Anderson and ridge terrace in reducing soil erosion and nutrient losses in oil palm plantation in South Lampung, Indonesia. *Journal of Tropical Crop Science*.

[BPS] Badan Pusat Statistik. Luas tanaman perkebunan menurut provinsi (ribu hektar),

Baligar, V. C., Elson, M. K., He, Z., Li, Y., Paiva, A. D. Q., Almeida, A. A. F., & Ahnert, D. (2020). Light intensity effects on the growth, physiological and nutritional parameters of tropical perennial legume cover crops. *Agronomy*, *10*(10), 1515.

Castro, C. R. T. D., Garcia, R., Carvalho, M. M., & Couto, L. (1999). Grass forages production cultivated under light reduction. *Revista Brasileira de Zootecnia*, *28*, 919-927.

Ch'ng, H. Y., Ahmed, O. H., & Majid, N. M. A. (2014). Improving phosphorus availability in an acid soil using organic amendments produced from agroindustrial wastes. *The Scientific World Journal*, *2014*.

Glasser, F., Doreau, M., Maxin, G., & Baumont, R. (2013). Fat and fatty acid content and composition of forages: A meta-analysis. *Animal Feed Science and Technology*, *185*(1-2), 19-34.

Harwanto, H., Hendarto, E., Bahrun, B., Hidayat, N., Istiqomah, D., & Candrasari, D. P. (2022). Productivity and Nutrient Digestibility of Sorghum Fodder at Different Urine Fertilizers Levels and Harvest Times. *Animal Production*, *24*(1), 23-30. http://103.30.145.38/index.php/JAP/article/view/94

Ifansyah, H. (2014). Soil pH and solubility of aluminum, iron, and phosphorus in Ultisols: the roles of humic acid. *Journal of Tropical Soils*, *18*(3), 203-208.

Ishii, Y., Yamaguchi, N., & Idota, S. (2005). Dry matter production and in vitro dry matter digestibility of tillers among napiergrass (Pennisetum purpureum Schumach) varieties. *Grassland science*, *51*(2), 153-163.

Jian-Guo, S. H. U. I., Qiu-Zhen, W. A. N. G., Gen-Qing, L. I. A. O., Au, J., & Allard, J. L. (2008). Ecological and economic benefits of vegetation management measures in citrus orchards on red soils. *Pedosphere*, *18*(2), 214-221.

Johan, P. D., Ahmed, O. H., Omar, L., & Hasbullah, N. A. (2021). Phosphorus transformation in soils following co-application of charcoal and wood ash. *Agronomy*, *11*(10), 2010.

Khan, Z. I., Ahmad, K., Mukhtar, M. K., Mirzaei, F., & Hussain, G. (2013). Assessment of pasture and plasma minerals of cows: A case study in Pakistan.

Khan, Z. I., Ashraf, M., & Valeem, E. E. (2006). Forage mineral status evaluation: the influence of pastures. *Pakistan Journal of Botany*, *38*(4), 1043.

Kumalasari, N. R., Abdullah, L., Khotijah, L., Wahyuni, L., Indriyani, I., Ilman, N., & Janato, F. (2020). Evaluation of Asystasia gangetica as a potential forage in terms of growth, yield and nutrient concentration at different harvest ages. *Tropical Grasslands-Forrajes Tropicales*, *8*(2), 153-157.

Kumalasari, N. R., Abdullah, L., Khotijah, L., Indriyani, I., & Ilman, N. (2022). Evaluation of auxin and cytokinin use for vegetative propagation of Asystasia gangetica for forage production.

Kumalasari, N. R. (2017). Interaction of fertilizer, light intensity and media on maize growth in semi-hydroponic system for Feed production. In *International Seminar on Tropical Animal Production (ISTAP)* (pp. 90-96).

Marijanusic, K., Manojlovic, M., Bogdanovic, D., Cabilovski, R., & Lombnaes, P. (2017). Mineral composition of forage crops in respect to dairy cow nutrition. *Bulgarian Journal of Agricultural Science*, *23*(2), 204-212.

Purwantari, N. D., Tiesnamurti, B., & Adinata, Y. (2015). Availability of forage under oil palm plantation for cattle grazing.

Patton, B. D., Dong, X., Nyren, P. E., & Nyren, A. (2007). Effects of grazing intensity, precipitation, and temperature on forage production. *Rangeland Ecology & Management*, *60*(6), 656-665.

Ramdani, D., Abdullah, L., & Kumalasari, N. R. (2017). Analysis of local forage potential under ruminant-palm plantation integration system in Mandau District, Bengkalis Regency of Riau Province. *Buletin Ilmu Makanan Ternak*, *15*(1), 1-8.

Rayburn, E. B., & Griggs, T. C. (2020). Light interception and the growth of pastures under ideal and stressful growing conditions on the allegheny plateau. *Plants*, *9*(6), 734.

Sanna, F., Re, G. A., Piluzza, G., Campesi, G., & Sulas, L. (2019). Forage yield, nutritive value and N-fixation ability of legume based swards are affected by light intensity in a Mediterranean agroforestry system. *Agroforestry Systems*, *93*, 2151-2161.

Tang, Wei, Haipeng Guo, Carol C. Baskin, Wangdan Xiong, Chao Yang, Zhenyi Li, Hui Song et al. "Effect of light intensity on morphology, photosynthesis and carbon metabolism of alfalfa (Medicago sativa) seedlings." *Plants* 11, no. 13 (2022): 1688.

Tilley, J. M. A., & Terry, D. R. (1963). A two-stage technique for the in vitro digestion of forage crops. *Grass and forage science*, *18*(2), 104-111.

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