YIELD AND NUTRITIONAL QUALITY OF NAPIER GRASS (CENCHRUS PURPUREUS CV. PAKCHONG) AS INFLUENCED BY SHADED AND UNSHADED OIL PALM ENVIRONMENTS

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ABSTRACT. Light, second only to water, is essential for plant growth and development, as it directly influences photosynthesis. Plants exposed to higher light intensities tend to exhibit enhanced photosynthetic activity, leading to more robust growth compared to those grown under lower light conditions. This study was conducted to assess the impact of shading on the yield and nutrient quality of Napier grass (*Cenchrus purpureus* cv. Pakchong) grown in an oil palm plantation. Specifically, the research aimed to compare the effects of shaded and unshaded environments on the yield and nutritional content of Napier grass. In the shaded environment, the average light intensity was 4,689 lux, while the unshaded environment served as a control. Six forage plots were established (three in shaded and three in unshaded areas) for data collection, and representative samples of Napier grass were collected and analyzed for proximate composition. Statistical analysis revealed a significant difference ($p<0.05$) in dry matter (DM), crude protein (CP), total digestible nutrients (TDN), and metabolizable energy (ME) between the two treatments, with no significant difference in crude fiber (CF). The DM and CF content were higher in unshaded areas, while TDN and ME were significantly ($p<0.05$) higher in shaded regions. The results showed that Napier grass planted in unshaded areas provided higher yield and CF content, as well as TDN and ME, although with a lower CP value. Despite suggestions that intercropping Napier grass with oil palm trees can effectively utilize up to 26.63% of unused plantation space, Napier grass may not be the best option for shaded environments in silvopastoral system design for grazing, as its current standard practice is a cut-and-carry system. Further studies should explore other grass varieties suited for low-light conditions to optimize the yield and quality of grass and subsequently increase livestock productivity.

Keywords: Napier grass, yield, nutrient quality, shaded, unshaded

INTRODUCTION

Forages are an essential part of ruminants' diets, as they provide a nutritional balance for body maintenance, reproduction, productivity, and overall health benefits. Napier grass (*Cenchrus purpureus*) has proven to be one of the most promising, productive, and widely cultivated fodders for ruminant feed (Rusdy, 2016). The hybrid cultivar Pakchong (*Cenchrus purpureus* cv. Pakchong) was developed by the Nakhon Ratchasima Animal Nutrient Research and Development Center in Thailand in 2010 and is widely propagated and readily available in Thailand (Yammuen *et al*., 2017). Napier Pakchong is known for its vigorous growth and excellent biomass production. Under good management, Napier Pakchong can produce a high crude protein (CP) concentration (16-18%), tolerate a wide range of management practices, and exhibit high resistance to pests and diseases. It can also be ratooned for up to eight years under optimal management (Kiyothong, 2014). Nutritionally, Napier Pakchong provides nutritious and palatable green fodder year-round, with CP content ranging from 10-12%, 14.9% dry matter (DM), 35.8% neutral detergent fiber (NDF), 14.5% ash, and 36.5% soluble carbohydrates at harvest between 45 and 49 days (Pitaksinsuk *et al*., 2010).

The integration of ruminants into oil palm plantations for grazing has gained traction in Malaysia as a means of addressing the scarcity of new land for open pastures, with oil palm plantation areas reaching 5.65 million hectares in 2023 (MPOB, 2023). This practice presents a potential solution for increasing self-sufficiency in beef production, as outlined in the National Agrofood Policy 2021–2030 (NAP 2.0), which targets a 50% increase in ruminant numbers by 2030. A silvopastoral system is an agroforestry practice that integrates trees, forage, and livestock on the same land which offers mutual benefits to agriculture-based food production while minimizing environmental impacts such as carbon sequestration, topsoil restoration, enhanced biodiversity, and reduced pesticide and fertilizer use (Hoosbeek *et al*., 2018; Poudel *et al*., 2024).

However, light intensity, or irradiation, plays a crucial role in forage production, particularly under shaded conditions such as those found in oil palm plantations. Reduced light intensity can affect the photosynthetic activity and growth of plants. Most tropical grasses, except for those specifically adapted to shade, produce lower yields when grown in shaded areas, even if their nutritional and water requirements are met (Muhtarudin *et al*., 2020). Shade tolerance depends on the grass's ability to adapt morphologically and physiologically to a specific irradiance level (Lopes *et al*., 2021). Plants grown under higher light intensity exhibit more robust photosynthesis and thicker leaves compared to those in shaded regions (Zhang *et al*., 2022). Additionally, unfavorable climatic conditions, such as drought, edaphic factors (soil-related constraints), and excess or insufficient water supply, can degrade forage quality and reduce yield (Dada *et al*., 2015). This study aims to investigate the effect of oil palm shade on Napier Pakchong's yield and chemical composition.

MATERIALS AND METHOD

Experimental Plot

The study was carried out from June 2019 to June 2020 in an oil palm plantation located near Jalan Parit Jambul, Parit Raja, Batu Pahat, Johor. The plantation, with an average palm tree age of 18 years, had a planting distance of 10×10×10 meters. The trees were 6-8 meters tall, with an estimated crown measurement of 1.9 meters for palms over 15 years old (Korol *et al*., 2021). The unshaded environment was located 200 meters from the shaded area. Light intensity in the shaded area was measured using a UT383S digital light meter (UNI-T, China), recording an average of 4,689 lux. Three experimental plots were prepared for each condition (shaded and unshaded conditions) and each measuring 4×4 meters. Napier Pakchong stem cuttings were sown in rows with a spacing of 0.6×0.6 meters within each plot.

Ground magnesium limestone was applied at 2 metric tons per hectare, and basal fertilizer was applied at 60 kg of nitrogen (N), 30 kg of phosphorus (P), and 30 kg of potassium (K) per hectare to each plot. After 90 days of establishment, an initial cut was made close to the ground level to standardize plant uniformity across the plots before the first treatment cut. Subsequently, treatment cuts for sampling were made at 60-day intervals over three ratooning cycles. Random samples from each plot were harvested by cutting the whole plot from each treatment. These samples were then sent to the Feed Analysis Laboratory at the Veterinary Institute of Malaysia (IVM), Kluang, Johor, for proximate analysis. After each cutting, maintenance fertilization was applied at the rates of 150:60:100 (N: P: K in kg/ha/year) to each study plot.

Dry matter yield

Fresh samples collected from each treatment were weighted to determine the wet basis yield. The samples were pre-dried in a forced-air drying oven set at 60 °C overnight, then ground to pass through a 1 mm sieve. The samples were then dried in an oven at 103±2 °C for 4 hours to determine the DM content (Close *et al.*, 1986). The DM yield per hectare was then calculated.

Chemical Composition

The samples of Napier grass (Pakchong variety) were dried, ground and analyzed for CP, crude fiber (CF), total digestible nutrient (TDN) and metabolizable energy (ME). CP content (Nx6.25) was determined by the Kjeldahl method using Kjeltec™ (FOSS, Denmark) methods (2003), CF was determined using Fibertec™ (FOSS, Denmark) methods (2010), TDN was calculated using equation from Davendra (1979) and ME was calculated using the Close and Manke equation (1986).

Picture 1: Unshaded Area

Picture 2: Unshaded Area

Picture 3: Shaded Area

Picture 4: Shaded Area

Figure 1. Unshaded area and shaded area

Statistical Analysis

Data were analyzed using a T-test via the Statistical Analysis Sofware (SAS) version 9.4 (SAS, USA) to determine significant differences between shaded and unshaded environments. A p value of less than 0.05 ($p<0.05$) was considered statistically significant.

RESULTS AND DISCUSSION

Comparison of Yield Parameters: Dry Matter Yield

As shown in Table 1, statistical analysis of dry matter (DM) yield revealed significant difference ($p<0.05$) between the shaded and unshaded treatments. The average DM yield in the unshaded area was 13.95 tons/ha/harvest, which was higher than the shaded area, indicating greater forage productivity under unshaded conditions. The significant difference in DM values indicates that lower light intensity under shaded conditions may reduce photosynthetic activity, limiting the plant's ability to produce energy and assimilate carbon, which ultimately compromises the growth and biomass production of Napier grass. Morphologically, plants under shaded conditions experience reduced stomatal conductance, net photosynthetic rate, and chlorophyll content due to damage to chloroplasts and the photosynthetic system, resulting in a decrease in overall yield (Yang *et al*., 2020). Reduced light also leads to the development of spongy tissues in plants, which hamper dry matter accumulation (Deepthi *et al*., 2023). These findings align with research by Islam *et al.* (2023), which indicated that high yields of Napier grass are achievable in temperate or unshaded regions with strategic plant management. Similarly, Ito and Inaga (1988) reported higher yields in Tokyo during the summer months compared to tropical regions, where light intensity is lower than in Japan.

Table 1. Dry matter basis yield of Napier Pakchong under shaded and unshaded environment

Parameter Tonnes/ha/harvest	Treatment	
	Shaded	Unshaded
Dry matter yield	1.55^{b}	13.95^{a}

Note: Means within the same row with different superscripts are significantly different at ($p<0.05$) level as determined by independent sample t-test.

Nutritional Composition of Napier Grass: Dry Matter, Crude Protein, Crude Fiber, Total Digestible Nutrients, and Metabolizable Energy

Dry matter content is a crucial factor in determining forage quality, as most essential nutrients in feed are contained within the dry matter fraction. The results of the DM content analysis for Napier grass under shaded and unshaded conditions are presented in Table 2. Previous studies by Tiwana *et al.* (2015) and Widodo *et al.* (2019) reported that Napier grass grown in open areas generally exhibits higher DM content compared to shaded areas. This is attributed to more favorable conditions for photosynthesis in unshaded environments, where increased light availability enhances organic matter accumulation, thereby contributing to higher DM content. However, contrary to these previous findings, the DM analysis in this study revealed an opposite trend. The DM content of Napier grass grown in open land was 12.63%, whereas grass under shade had a significantly higher DM content of 14.9%. This result suggests that other environmental or physiological factors may have influenced dry matter accumulation in shaded conditions.

Crude protein (CP) content differed significantly ($p<0.05$) between shaded and unshaded treatments, with shaded Napier grass recording a higher CP content of 17.27%, compared to unshaded grass, with CP of only 14.17%. The 17.27% CP recorded here is above the typical range, which is between 9% to 15% range for Napier grass (Halim *et al*., 2013; Haryani *et al*., 2018), but comparable to values reported under optimal growth conditions, such as 19.48% in Pakchong Napier harvested at 45 days with high soil fertility (Siti Syahirah Safiah *et al*., 2022). These findings are consistent with Widodo *et al.* (2019), who observed CP contents of 16.38% in shaded grass compared to 13.92% in open fields, and Tiwana *et al.* (2020), who found higher CP in shaded (11.64%) than unshaded (8.37%) Napier grass. The increase in CP under shading conditions may result from stress-induced growth responses, whereby reduced light limit photosynthate production and reallocates resources toward protein synthesis rather than carbohydrate storage (Kephart & Buxton, 1993; Taufan *et al*., 2014). This adaptation also enhances chlorophyll concentration to maintain photosynthetic efficiency which may also contribute to increased CP levels (Attridge, 1990).

There was no significant difference in CF content between the shaded (30.90%) and unshaded (31.50%) treatments in this study. A study by Muhtarudin *et al.* (2020) suggests that Napier grass grown under shade may allocate more resources to stem growth in an attempt to reach better light conditions, thereby affecting the stem-to-leaf ratio. Statistical analysis of TDN values showed significantly lower TDN in the shaded region (50.40%) than in the unshaded region (56.53%). Similarly, ME was significantly lower in the shaded area (7.43 MJ/kg) compared to the unshaded area (8.50 MJ/kg). These results confirm that reduced light availability under shaded conditions generally results in reduced grass yield and quality, except for CP content, which was higher in shaded areas.

CONCLUSION

Based on the results of this study, it can be concluded that while the crude protein content of Napier grass increased under shaded conditions, both yield and other key parameters significantly decreased. Although intercropping Napier grass with oil palm offers the potential benefit of utilizing up to 26.63% of unused plantation space (Mohammed *et al*., 2015), Napier grass may not be an ideal option for shaded environments in silvopastoral systems, particularly for grazing purposes, as its current management primarily involves a cut-and-carry

Table 2. Nutrient quality of Napier Pakchong under shaded and unshaded environment

Parameter (%)	Treatment	
	Shaded	Unshaded
Dry Matter (DM)	14.90[a]	12.63[b]
Crude Protein (CP)	17.27[a]	14.17[b]
Crude Fiber (CF)	30.90[a]	31.50[a]
Total Digestible Nutrient (TDN)	50.40[b]	56.53[a]
Metabolizable Energy (ME) (MJ/Kg)	7.43[b]	8.50[a]

Note: Means within the same row with different superscripts are significantly different at ($p<0.05$) level as determined by independent sample t-test.

system. Therefore, further research is necessary to identify alternative cultivars that can thrive under low light conditions and limited irradiance, making them more suitable for shade-based cultivation in silvopastoral systems.

REFERENCES

1. Attridge, T. H., (1990). Light and Plant Responses. Hodder and Stoughton Ltd., Great Britain, p. 101.
2. Close, W.H. and Menke, K.H. (1986). Selected Topics in Animal Nutrition Universitat. *Hohenheim*, p. 65.
3. Dada, V. A. and Adejumo, S. A. (2015). Growth and Yield of Okra (Abelmoschus esculentus Moench) as Influenced by Compost Application under Different Light Intensities. *Not Sci Biol*., 7 (2): 217-226.
4. Devendra, C., 1979. *Malaysian feedingstuffs*. Malaysian Agricultural Research and Development Institute (MARDI), Serdang, Selangor, p. 134-135.
5. Halim, R. A., Shampazuraini, S., & Idris, A. B. (2013). Yield and nutritive quality of nine Napier grass varieties in Malaysia. *Malaysian Journal of Animal Science*, 16(2): 37–44.
6. Haryani, H., Norlindawati, A. P., Norfadzrin, F., Aswanimiyuni, A., & Azman, A. (2018). Yield and nutritive values of six Napier (Pennisetum purpureum) cultivars at different cutting age. *Malaysian Journal of Veterinary Research*, 9(2): 6-12.
7. Hoosbeek, M. R., Remme, R. P., and Rusch, G. M. (2018). Trees enhance soil carbon sequestration and nutrient cycling in a silvopastoral system in south-western Nicaragua. *Agroforestry Systems*, 92, 263–273.
8. Islam, M. R., Garcia, S. C., Sarker, N. R., Islam, M. A., & Clark, C. E. (2023). Napier grass (Pennisetum purpureum Schum) management strategies for dairy and meat production in the tropics and subtropics: yield and nutritive value. *Frontiers in Plant Scienc*e, 14.
9. Ito, K., and Inaga, S. (1988). Studies on the Dry Matter Production of Napier Grass: III. Areas and light-photosynthesis relations in single leaves from different positions on a stem at Tokyo and Miyazaki. *Japanese Journal of Crop Science*, 57(3), 431-437.
10. Kephart K. D. and Buxton D. R. (1993). Forage quality responses of C3 and C4 perennial grasses to shade. *Crop Sci*. 33(4), 831-837.
11. Kiyothong K. (2014). *Miracle grass is seen to boost local dairy productio*n. Retrieved November 26, 2015
12. Knorr, D., and Vogtmann, H. (1983). Quality and quantity determination of ecologically grown foods. In: *Sustainable Food Systems*. Knorr D (Ed). AVI Publishing Co, Westport, Connecticut pp 352-381.
13. Korol Y., Khokthong W., Zemp D. C., Irawan B., Kreft H., and Hölscher D., (2021). Scattered trees in an oil palm landscape: Density, size and distribution. *Global Ecology and Conservation*, 28,
14. Lopes, M. J., Dias-Filho, M. B., Castro, T. H., Gurgel, E. S., & Silva, G. B. (2021). Efficiency of biostimulants for alleviating shade effects on forage grass. *Journal of Agricultural Studies*, 9(3), 14.
15. Malaysia Palm Oil Board, (2023). *Oil Palm Planted Area (Hectares) – 2023*. https://prestasisawit.mpob.gov.my/en/plantations-area
16. Mohammed, I., Abakr, Y., Kazi, F., Yusuf, S., Alshareef, I. and Chin, S. (2015). Comprehensive Characterization of Napier Grass as a Feedstock for Thermochemical Conversion. *Energies*, 8(5), 3403-3417.
17. Muhtarudin, Sari, W. P., Desi, S., Farida, F., Erwanto, Liman, Agung, K. W., Ahmad, D., and Kusuma, A. (2020). Effect of Grass Variety and Shade under Palm Oil Plantation on Production and Proportion of Stems, Leaves and Nutrition Content of Grass. *Journal of Biological Sciences*, 20(3): 116-122.
18. Pitaksinsuk, C., J. Boonjaracha and J. Wongpipat. (2010). Data collection of fodder nutritive. Bureau of Animal Nutrition, Department of Livestock Development. 77p.
19. Poudel, S., Pent, G., and Fike, J. (2024). Silvopastures: Benefits, Past Efforts, Challenges, and Future Prospects in the United States. *Agronomy*, 14(7),1369.
20. Rusdy, M. (2016). Elephant grass as forage for ruminant animals. *Livestock Research for Rural Development*. 28 (4).

21. Siti Syahirah Safiah, M., Nurul Aini, K. and Ting Jia Yee (2022). Study on chemical composition of Napier Pak Chong (*Pennisetum purpureum* × *Pennisetum glaucum*) harvested at different growth stages. *Journal of Agrobiotechnology*, 13(1S), 24–30.
22. Taufan, P. D., Arliana Y. and Eko, W. (2014). Potensi hijauan di perkebunan kelapa sawit sebagai pakan sapi potong di Kabupaten Kutai Kartanegara. *Pastura,* 3(2), 94-98.
23. Tiwana, U., Singh, S., Goyal, M., Kingra, P.K., & Singh, A.K. (2020). Forage Production Potential and *Nitrate Nitrogen* in Napier Bajra Hybrid as Influenced by Nitrogen Dose under Shaded and Un-Shaded Environments. Internationalgrasslands.org
24. Widodo, S., Suhartanto, B. and Umami N. (2019). Effect of shading and level of nitrogen fertilizer on nutrient quality of Pennisetum purpureum cv Mott during wet season. *IOP Conf. Series: Earth and Environmental Science*, 247, 1-5.
25. Yammuen, S., Sutarmjam, A., & Seepai, A. (2017). Fermentation Quality and Chemical Composition of Napier Pakchong 1 Silage Supplemented with Lactic Acid Bacteria. Conference on International Research on Food Security, Natural Resource Management and Rural Development; 20-22 September, 2017.
26. Yang, H., Dong, B., Wang, Y., Qiao, Y., Shi, C., Jin, L., *et al.* (2020). Photosynthetic base of reduced grain yield by shading stress during the early reproductive stage of two wheat cultivars. *Sci. Rep*., 10(1), 14353.

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