ADVANCES IN AGRICULTURAL AND FOOD RESEARCH JOURNAL

Original Research Article

Effect of Different Nitrogen Rates and Harvesting Periods on Lemongrass Performance

Ahmad Arif Ismail[1,2], Furzani Pa'ee[1]*, Muhamma Naim Fadzli Abd Rani,[3] Azlan Azizi bin Mohd Noh,[4] Zafrul Arif bin Radhi,[5]

[1]Faculty of Applied Sciences and Technology, UniversitiTun Hussein Onn Malaysia Pagoh, KM1, JalanPanchor, 84600 Muar, Johor, Malaysia

[2]MARDI Kluang. Industrial Crop Research Centre, 86000, Kluang, Johor, Malaysia

[3]MARDI Seberang Prai, Rice Research Centre, 13200, Kepala Batas, Penang, Malaysia

[4]MARDI Cameron Highland, Soil and Fertilizer Research Centre, 39000, Tanah Rata, Pahang, Malaysia

[5]MARDI Serdang, Soil and Fertilizer Research Centre, Serdang, 43400, Selangor Malaysia

*Corresponding author: Furzani Pa'ae Faculty of Applied Sciences and Technology, UniversitiTun Hussein Onn Malaysia Pagoh, KM1, JalanPanchor, 84600 Muar, Johor, Malaysia; furzani@uthm.edu.my

Abstract: Lemongrass is a perennial lawn crop. Generally known as *serai makan* in Malaysia. It has various uses, from table consumption to essential oil and ornamental and pharmaceutical products. However, the use of medicinal crops can be characterized by several approaches such as harvesting period, climatic factors, moisture, light exposure, plant parts, logistics, storehouse, drying process, and other post-harvest processes. One way to enhance lemongrass herbage yield is by manipulating the N rate. Department of Agriculture (DOA) Malaysia recommends using 400 kg/ha of NPK green 15:15:15 for 6–8 months, but this is a generalized blanket recommendation and not nutrient-specific. Therefore, a study was carried out on the effect of N and the harvesting period. The experimental design was a Randomized Complete Block Design (RCBD) with factorial. Analysis suggests that SPAD chlorophyll reading, slip number, and leaf blade number were significantly affected by N, harvesting period and interaction between N and harvesting period. SPAD readings at 150 and 180 days after transplant (DAT) only show significant improvement at 300 Kg N/ha. For slip numbers, the response at 210 DAT only showed significant improvement when at least 200 kg N/ha were applied, and the subsequent increment at 300 kg N/ha was at par. Leaves blade number response was unique for each harvesting period. Nevertheless, leaf blade numbers began to show a significant increment at 100 kg N/ha, and the increment of leaf blades between 200 to 300 kg N/ha was non-significant for all harvesting periods. These parameters exhibit significant positive linear responses towards N; some may have significantly unique responses to their harvesting period. Herbage yield was significantly affected by both N and the harvesting period, but there was no significant interaction between them. Herbage yielded the highest significant reading when 300 kg N/ha was applied, while the harvesting period contributed the highest significance at 240 DAT, while subsequent increment at 270 DAT was non-significant. Present findings may suggest that further study needs to be carried out to improve the current production manual, and consideration must be given to soil type, location, and climate conditions.

Keywords: SPAD chlorophyll; slip number; leaf blade; nitrogen; harvesting period

Received: 23rd March 2023

Accepted: 23rd February 2024

Available Online: 16th June 2024

Published: 20th November 2024

Citation: Ismail, A. A., Pa'ae, F., Abd Rani, M. N. F., *et al*. Effect of Different nitrogen rates and harvesting periods on lemongrass performance. *Adv Agri Food Res J* 2024; 5(2): a0000505. https://doi.org/10.36877/aafrj.a0000505

1. Introduction

Between 2017 and 2021, there has been an inconsistent fluctuating trend of *Cymbopogon citratus* production in West Malaysia, as recorded by Department of Agriculture (DOA) statistics. The Malaysian government has outlined production projections through the National Agrifood Policy (NAP) of herbs and spices to reach 11 7000 metric tons by 2020 (MOA, 2011). High-yielding *C. citratus* can be obtained through fertilizer rate manipulation; hence, the optimum fertilizer rate for C. citratus must be established.

Nitrogen is the most essential nutrient for plants' growth development, and it plays a role in biochemical and physiological processes to produce better yield quality (Leghari *et al*., 2016). It is compulsory to ensure crop yield enhancement and food quality (Ullah and Moore, 2009). According to Clarkson and Marschner (1995), nitrogen is the most critical modifier for crop production. *C. citratus* can achieve optimum growth with adequate nitrogen without excess (Hawkesford *et al*., 2012).

According to Singh (2008), 100–150 Kg N/ha application contributed to optimum growth for *C. martini*. Parameters such as clump mass, tiller number, height, branches and slip diameter are significantly higher than control's. However, excess amounts of nitrogen could be unfavourable. According to Joyce *et al*. (2015), *C. Palmarosa* showed yield reduction when excess nitrogen was applied exceeding 160 kg N/ha. Another study by Sasikala *et al.* (2016) points out that applying vermicompost with higher N concentrations contributed to significantly higher heights, tillers, and herbage yields. Therefore, it is essential to calibrate the optimum nitrogen rate for *C. citratus* production.

Furthermore, the use of medicinal plants can be characterized by several approaches consisting of cultivation, harvest period, climatic factors, humidity, brightness, plant parts, transportation, storage, drying process and extraction process (Callixto, 2000). *Cymbopogon citratus* slip can be harvested for fresh consumption, whereas the leaves can be used for essential oil production through hydrodistillation (Sahadevan, 1987).

The Department of Agriculture (DOA) recommends using 400 kg/ha NPK green 15:15:15 with a 6 to 8-month harvesting period. The application was to be applied through equal splitting at one, third and fifth months after transplant. Hence, a study on *C. citratus* nitrogen fertilizer application with multiple harvesting periods was investigated to understand better the relationship between nitrogen rate and harvesting period on *C. citratus.*

2. Materials and Methods

The experimental design used for this experiment was RCBD with factorial with three replications (Ismail *et al*., 2014). Two factors investigated were nitrogen rate and harvesting periods. Four nitrogen levels comprising 0, 100, 200, and 300 kg/ha. The nitrogen used in this study was urea. Four applications were made at 30, 60, 90, and 120 days after transplant (DAT) with equal splitting. Five harvesting periods were implemented: 150, 180, 210, 240, and 270 days after transplant (DAT). A total of 60 experimental units were erected, each consisting of 32 hills experimental units of 4 m x 4 m. For the SPAD meter reading, the slip with the longest leaf blade was sampled from 4 hills per experimental unit (Gewaily *et al*., 2018). Slip number and leave number parameters were measured from 4 hills selected randomly from each experimental unit. For each experimental unit, 9 m^2 of area was harvested to evaluate herbage yield. This study was conducted in Ladang 2, MARDI Kluang, Johor, Malaysia. Means were subjected to Analysis of Variances (ANOVA). Duncan Multiple Range Test (DMRT) was employed if there was any significant effect. Data analysis was computed using statistical analysis software (SAS 9.4)

3. Results and Discussions

Analysis of Variance (ANOVA) results indicate that nitrogen rate (N), harvesting period, and the interaction of nitrogen rate and harvesting period had a significant impact on SPAD chlorophyll reading, slip number, leaf number, and leaf weight (Table 1). The harvesting period was the only factor that significantly impacted plant height. Both harvesting and N rate considerably impacted herbage yield.

Table 1. ANOVA mean square analysis for the effect of nitrogen rate and harvesting period on *C. citratus* performance.

Source of variance	Parameter			
	SPAD	**Slip number**	**Leaf number**	**Herbage yield**
Rep	2.63	0.84	4060.99	10084.11
Nitrogen (N)	25.34**	36.12**	8955.35**	275073.34**
Harvesting period (Hvp)	5.11*	129.44**	16642.17**	350113.63**
N x Hvp	6.27*	6.94*	14.07**	28234.82
Grand mean	36.4	28.5	265	1128.8
C.V. (%)	3.73	8.43	4.78	20.72

Note: mean followed by * indicates a significant difference at 0.05; mean followed by ** indicate a significant difference at 0.01

3.1 SPAD Chlorophyll Reading.

The significant interaction between the N rate and harvesting period implied that each has its unique response. At 150 DAT, the SPAD chlorophyll reading shows a significant positive linear response (Figure 1). Specifically, the addition of N from 0 to 200 kg/ha at this period increased the reading but exhibited minimum impact. A significant increment can be observed only at 300 kg/ha of N. The difference would at least amount to 17.32%

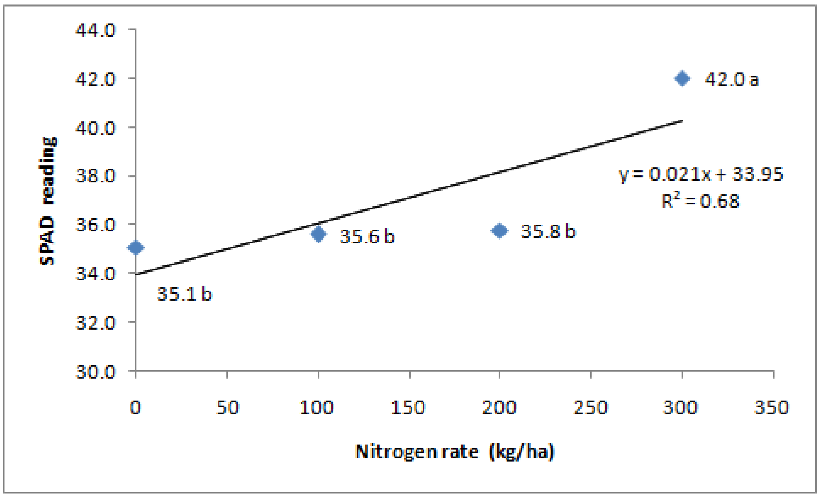


Figure 1. Effect of nitrogen rate on SPAD reading at 150 days after transplant (DAT). Data were analyzed from 3 replications with four hills per individual treatment plot. Mean followed by different alphabet indicate significant differences ($p \leq 0.05$)

For SPAD reading at 180 DAT, a similar significant positive linear response was observed (Figure 2). The least significant reading, 35.3, came from 0 kg N/ha. The SPAD measurement was raised to 36.2 by an increase to 100 kg N/ha, although this was not significantly different from 0 kg N/ha. The difference was 2.55%. Subsequent N increment to 200 kg N/ha significantly increased the SPAD reading to 36.2 and shares parity with 100 kg N/ha. 1.11% of a difference was measured. The maximum significant reading was obtained with the final N increment of 300 kg N/ha, which was 39.9. The difference was 9.02% compared to 200 kg N/ha. The response for subsequent 210, 240 and 270 DAT shows no significant difference.

Applying 300 kg N/ha at 150 DAT resulted in the greatest significant reading with a value of 42.0 when considering the various responses of SPAD reading toward nitrogen rate at various harvesting periods (Table 2). This may imply that 150 DAT is the ‘photosynthetic maturity of *C. citratus* since it exhibits the highest chlorophyll reading in younger plants compared to 180 DAT, and this is attributed to factors such as photosynthetic activity, stomatal conductance and transpiration rate across plant growth period (Sestak, 1963).

The growth of plants' photosynthetic organs depends mostly on chlorophyll since it contains N (Bassi *et al.*, 2018). Most C4 grasses convert 30% of their available leaf nitrogen (N) into chlorophyll, and their concentration rises in the presence of abundant N. In contrast to older plants, younger plants should be considered more when they are "photosynthetically mature," which occurs after reaching their maximum chlorophyll content. This is because of several factors, including photosynthetic activity, stomatal conductance, and transpiration date throughout the plant growth period (Sestak, 1963).

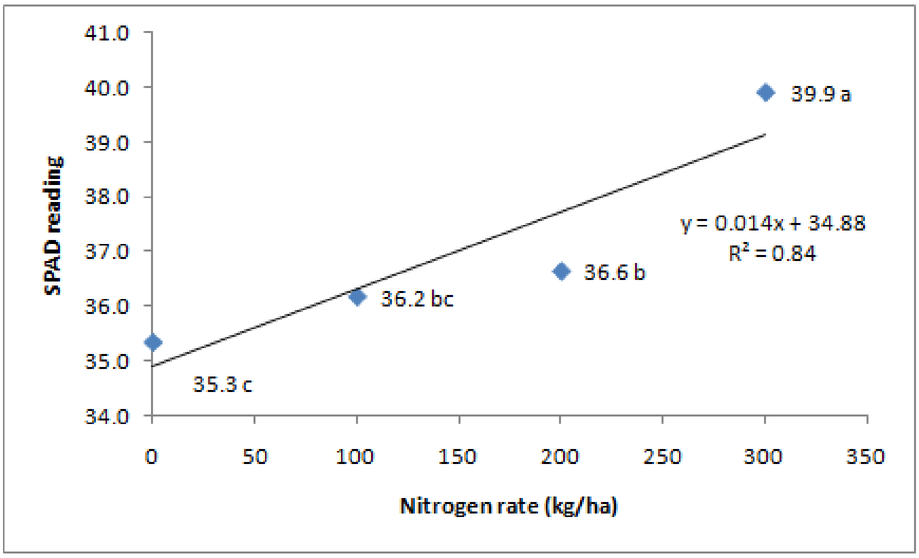


Figure 2. Effect of nitrogen rate on SPAD reading at 180 days after transplant (DAT). Data were analyzed from 3 replications with four hills per individual treatment plot. Mean followed by different alphabet indicate significant differences ($p \leq 0.05$)

3.2 Slip Number

Slip number was significantly impacted by the interaction between the N rate and harvesting period, much as SPAD chlorophyll reading (Table 1). Despite the variation in observation, 150, 180 and 270 DAT contributed to no significant impact. N rate has a lesser or less impact during these particular harvesting periods.

However, at 210 DAT, the slip number has a substantial linear response to the N rate (Figure 3). Slip number increases by 3.98% as the N rate is increased from 0 to 100 kg N/ha. The difference between these two intervals, however, was not significant. The subsequent increase from 100 to 200 kg N/ha significantly increased the slip number by 19.92% compared to 100 kg N/ha. Finally, increasing the N rate to 300 kg N/ha resulted in a 0.31% decrease in slip rate. There was no significant increment between these two intervals of 200 and 300 kg/ha.

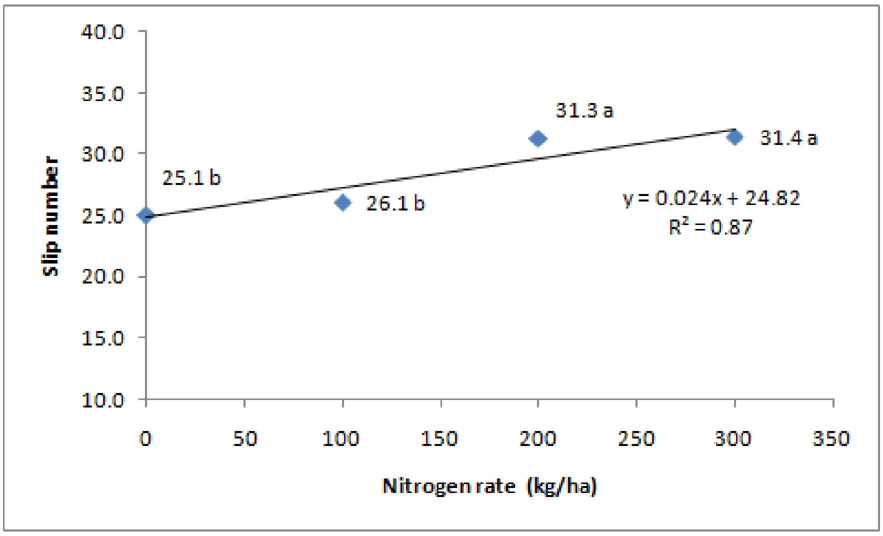


Figure 3. Effect of nitrogen rate on slip number at 180 days after transplant (DAT). Data were analyzed from 3 replications with four hills per individual treatment plot. Mean followed by different alphabet indicate significant differences ($p \leq 0.05$)

At 240 DAT, the slip number showed the same significant positive linear response to the N rate (Figure 4). The addition of N between 100 and 300 kg/ha was discovered to be significantly higher than 0 kg/ha. Slip number increased by 17.23% between 0 and 100 kg/N/ha. Slip number increases by 4.47%, further rising from 100 to 200 kg N/ha. Finally, increasing the N rate to 300 kg N/ha did not result in any increase. The slip numbers under 100, 200, and 300 kg N/ha exhibit no significant variation.

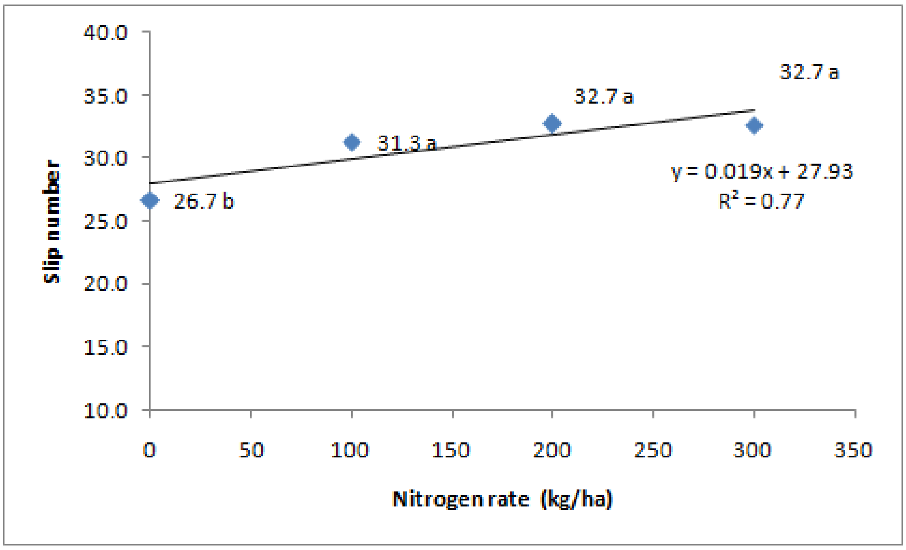
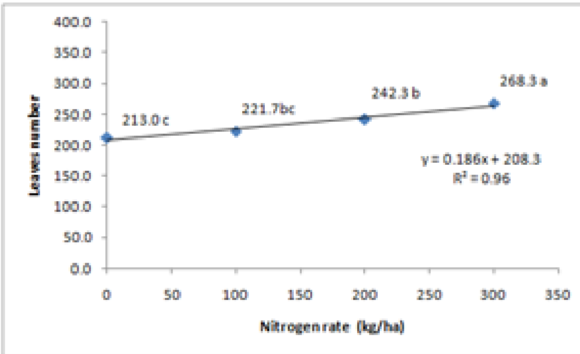


Figure 4. Effect of nitrogen rate on slip number at 240 days after transplant (DAT).Data were analyzed from 3 replications with four hills per individual treatment plot. Mean followed by different alphabet indicate significant differences ($p \leq 0.05$)

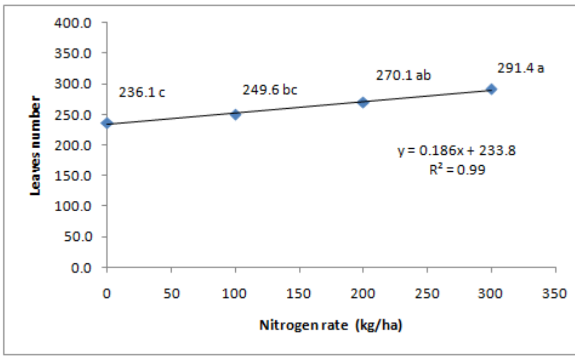
At 5.5 months, or roughly 165 DAT, *C. citatus* clumps were still growing to create new slips, producing 2–3 tillers, according to Tajidin *et al*. (2012). Each tiller then produced an additional 4–5 leaves. According to the current investigation, there was no significant increase in the slip number toward the nitrogen rate between 150 and 180 DAT. However, it was apparent that the number of slips harvested at 180 DAT was higher than those harvested at 150 DAT. This may indicate that the morphological mechanism described by Tajidin *et al*. (2012), rather than nitrogen, was the cause of the rise in slip number during this particular period. Between 210 and 240 DAT, slip numbers recently began to respond to the N rate significantly. Jimayu *et al* (2016) also discovered that slip number increases with the harvesting period. Their study found an increment as early as 60 DAT, increasing until 105 DAT.

3.3 Leaves Number

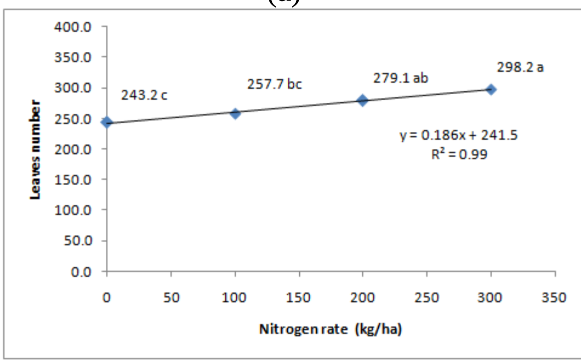
Interaction between the N rate and harvesting period considerably impacts the number of leaves. In other words, the leaves number reacted differentially to the N rate at each harvesting period.



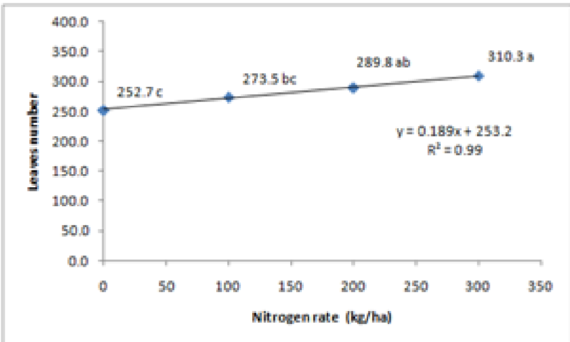
(a)



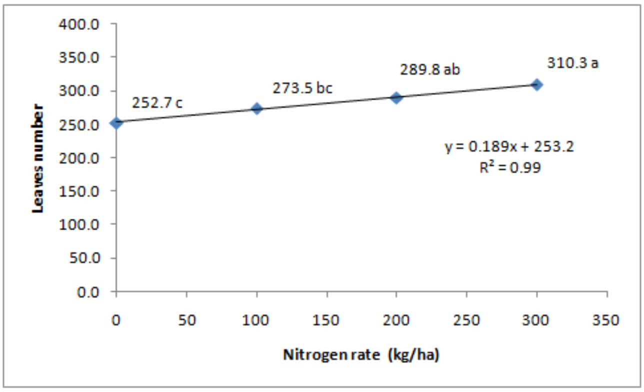
(b)



(c)



(d)



(e)

Figure 5. Effect of nitrogen rate on leaves number **(a)** 150 DAT, **(b)** 180 DAT, **(c)** 210 DAT, **(d)** 240 DAT, **(e)** 270 DAT. Data were analyzed from 3 replications with four hills per individual treatment plot. Mean followed by different alphabet indicate significant differences (p≤0.05)

At 150 DAT, the number of leaves responded linearly. The number of leaves increases by 4.08% with an increment in N rate from 0 to 100 kg N/ha (Figure 5a). The increment still does not represent a significant difference at this point. The number of leaves increases by 9.29% after the subsequent 200 kg N/ha, significantly higher than 0 kg N/ha. Although leaves number increases from 100 to 200 kg N/ha, they display statistical parity. The largest significant leaf number was contributed by the final N of 300 kg N/ha, with a value of 268.3, 10.73% more than 200 kg/ha.

The leaves number responded linearly to the N rate at 180 DAT (Figure 5b). An increase in N rate from 0 to 100 kg N/ha resulted in a 5.72% increase in leaves number (Table 2). The increase was, however, insignificant. After increasing N by 200 kg /ha, there was an 8.21% rise in leaves. This increase was far more significant than 0 kg N/ha, yet it was still equal to 100 kg N/ha. The final increase to 300 kg N/ha results in an increase in leaves number of 7.89%, which is much higher than 100 kg/ha but on par with 200 kg/ha.

A similar positive linear response may be seen in leaf number 210 DAT (Figure 5c). Production of leaves increases by 5.96% when the N rate is increased from 0 to 100 kg N/ha. At this specific period, the increase does not significantly differ. The production of leaves increases by 8.3% with a subsequent increment in nitrogen rate to 200 kg N/ha, equal to 100 kg N/ha but noticeably more significant than 0 kg N/ha. The production of leaves increases by 6.84%, with the final subsequent increase in N rate of 300 kg N/ha. This increment was significantly greater than 0 and 100 kg N/ha but equal to 200 kg N/ha.

Leaves number at 240 DAT shows identical positive linear responses (Figure 5d). The output of leaves number increases by up to 6.9% when the N rate is increased from 0 to 100 kg/ha. However, this increase was comparable to 0 kg N/ha. The number of leaves increased by 7.59% with the subsequent N rate increment from 100 to 200 kg N/ha, which was much greater than the initial N rate of 0 kg/ha but on par with 100 kg/ha. The output of leaves increased by 7.07%, with the final increment in N rate being 300 kg N/ha, which was significantly greater than 100 kg N/ha but comparable to 200 kg N/ha.

A similar trend can be observed for leaf production at 270 DAT under multiple N rates (Figure 5e). The number of leaves increases by 8.23% when the N rate is increased from 0 to 100 kg N/ha, although there is no recognizable difference between these two intervals. Leaves number was further increased by 5.96% when the N rate was increased to 200 kg/ha; this is significantly higher than those at 0 kg/ha but statistically equal to that at 100 kg/ha. Leaves number kept increasing by 7.07% with the final N rate increment of 300 kg/ha, which was significantly greater than 100 kg N/ha but on par with 200 kg N/ha.

3.4 Herbage Yield

Herbage yield is significantly influenced by nitrogen rate (kg N/ha) and harvesting period, and both variables showed substantial linear responses (Figure 6). There is no significant interaction between N rate and harvesting time on herbage yield. Herbage yield is increased by 1.59% when the N rate is increased from 0 to 100 kg N/ha. Herbage yield increased by 9.94% with a subsequent N rate addition of 200 kg N/ha, significantly more significant than 0 and 100 kg N/ha. The final N rate increment to 300 kg /ha enhances herbage yield by 12.08% compared to 200 kg N/ha. The increment between 200 to 300 kg N/ha significantly increased herbage yield.

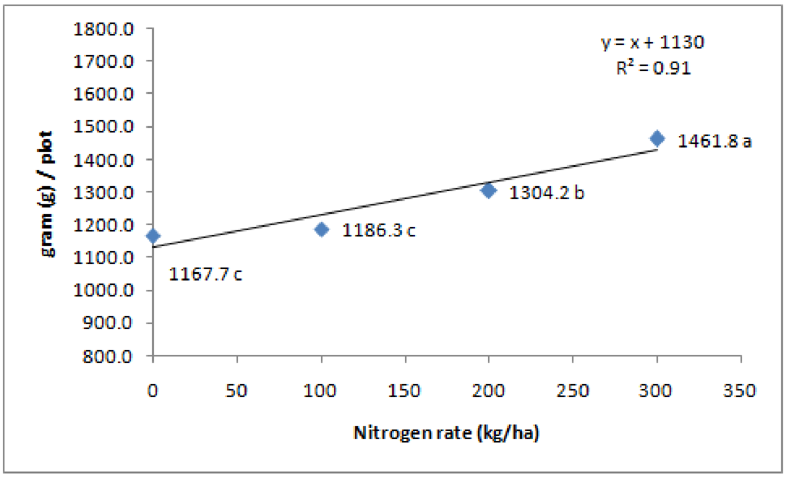


Figure 6. Effect of nitrogen rate on herbage yield. Data were analyzed from 3 replications with four hills per individual treatment plot. Mean followed by different alphabet indicate significant differences ($p \leq 0.05$)

Besides nitrogen rate, harvesting time was discovered to impact herbage yield considerably. Herbage output improved by 9.90% when harvesting was delayed from 150 to 180 DAT, which was noticeably significant (Figure 7). Herbage yield increased by 0.56% with a further delay in harvesting to 210 DAT; however, this gain was not statistically significant compared to 180 DAT. Since the increase in herbage productivity between these two periods was so little, it was not noteworthy. Herbage yield increases by 18.11% with an additional delay of 240 DAT, significantly greater than at 210, 180, and 150 DAT. Finally, a further delay in harvesting to 270 DAT enhances herbage yield by 5.43% and shows statistical parity with 240 DAT.

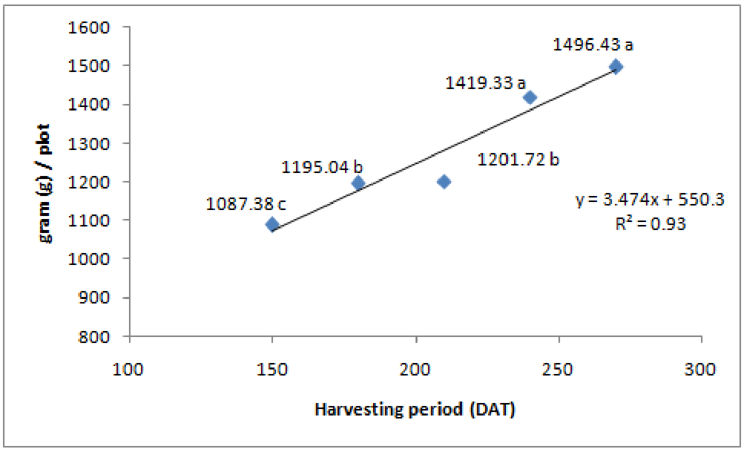


Figure 7. Effect of harvesting period harvesting period and herbage yield. Means with different alphabets indicate significant differences. Data were analyzed from 3 replications with four hills per individual treatment plot. Mean followed by the same letters indicate no significant difference ($p \geq 0.05$)

According to Jimayu *et al*. (2016), the harvesting period and variety substantially impacted the fresh herbage yield of *C. citratus*. The variety Lomisar-UA has a 105-day growth cycle and produces the most considerable herbage yield. According to Marco *et al*. (2006), *C. winterianus* Jowit's total dry matter (kg/ha) increases from 4 to 8 months, with the sixth and eighth months exhibiting statistical parity. The present study points out statistical parity between the seventh and eighth months.

3.4 Correlation Analysis Between SPAD, Leaves Number, Slip Number And Herbage Yield.

Analysis suggests that herbage yield has a significant positive association with leaves and slip numbers (Table 2). This may imply that any drop slip number and leaves number could significantly drop herbage yield and vice versa. However, the SPAD reading shows no significant positive association with the rest of the parameters. SPAD may not be a valuable tool for evaluating the performance of *C. citratus*.

Table 2. Correlation analysis

	SPAD	**Leaves number**	**Slip number**	**Herbage Yield**
SPAD	1	0.21 ns	0.2 ns	-0.09 ns
Leaves number		1	0.61 **	0.68 **
Slip number			1	0.69 **
Herbage yield				1

Note: mean followed by * indicates a significant difference at 0.05; mean followed by ** indicate a significant difference at 0.01

4. Conclusions

In conclusion, almost all significantly affected parameters show linear responses towards the nitrogen rate or harvesting period. The interaction between the harvesting period and nitrogen rate significantly affected SPAD chlorophyll reading and slip number. Uniquely, leaves and slip numbers share a positive association with herbage yield. This may imply that any increment in these two parameters can potentially increase the overall performance of herbage yield. Herbage yield was significant in terms of both nitrogen level and harvesting period, but no significant interaction was established. This may indicate that further study should be carried out to investigate the effect of nitrogen on other locations with different soil fertility levels.

Author Contributions: Conceptualization: Ahmad Arif Ismail; Methodology: Furzani Pa'ee; Plot maintenance: Muhamma Naim Fadzli Abd Rani; Data analysis: Azlan Azizi Mohd bin Mohd Noh and Zafrul Arif bin Radhi

Funding: No external funding provided for this research

Acknowledgements: The authors would like to thank En Mohd Noh bin Yusof for providing technical expertise at field.

Conflicts of Interest: The author declares no conflict of interest

References

Ismail, A. A., Che Haron, I., Wan Mamat, W. Z., *et al.* (2014). Pengaruh baja nitrogen (N) dan kalium (K) terhadap padi varieti MR 269 dan MR 284 di Sungai Nibong (PBLS). *Jurnal Teknologi*, *70*(6), 1–4.

Bassi, D., Menossi, M. & Mattiello, L. (2018). Nitrogen supply influences photosynthesis establishment along the sugarcane leaf. *Scientific Reports*, *8*, 1–13.

Callixto, J. B. (2000). Efficacy, safety, quality control, marketing, and regulatory guidelines for herbal medicines (Phytotherapeutic agents). *Brazilian Journal of Medical and Biological Research, 33*(2), 179–189.

D. T. Clarkson, Marschner H. 1995. Mineral nutrition of higher plants. second edition. 889pp. London: Academic Press, Annals of Botany, Volume 78, Issue 4, October 1996, Pages 527–528

Gewaily, E. E., Ghoneim, A. M., & Osman, M. M. A. (2018). Effects of nitrogen levels on growth, yield and nitrogen uese efficiency of some newly released egyptian rice genotypes. *Open Agriculture*, *3*, 310–318.

Hasan, M. N. (2018). The effect of spraying boron and seaweed extract (kelpak) on vegetative growth characteristics and concentration of some medicinally active substances from lemongrass (*Cymbopogon citratus* L.*). International Journal of Engineering & Technology 7*(4.37), 145–149.

Hawkesford, M.J., (2012). Improving Nutrient Use Efficiency in Crops, In: eLS. John Wiley & Sons, Ltd: Chichester. DOI: 10.1002/9780470015902.a0023734

Marco, C.A., Innecco, R., Mattos, S.H., *et al*. (2006). Influence of spacing, cut height, and harvest time on biomass yield, and essential oil content of citronella grass. *Revista Ciência Agronômica*, *37*(1), 32–36.

Jimayu, G., Gebre, A. & Mengesha, B. (2016). Response of lemongrass (*Cymbopogon Citratus* L) varieties for different intra and inter row spacing at Wondo Genet, Southern Ethiopia. *Academic Research Journal of Agricultural Science and Research, 4*(6),279–284.'

Joyce, B.L., Zheljazkov, V.D., Sykes, R., Cantrell, C.L., Hamilton, C., Mann, D.G.J., Rodriguez, M., Mielenz, J.R., Astatkie, T. and Stewart Jr, C.N. (2015). Ethanol and High-Value Terpene Co-Production from Lignocellulosic Biomass of Cymbopogon martini. PLoS ONE 10(10)

Leghari, S.J., Wahoco, N.A., Laghari, G.M., Hafeez Laghari, A., Mustafa Bhaban, G., Hussain Talpur, K. and Lashari, A.A., (2016). Role of Nitrogen for Plant Growth and Development. A Review. Advances in Environmental Biology, 10, 209-219

Kementerian Pertanian dan Industri Asas Tani Malaysia (MOA). (2011). *Dasar Agromakanan Negara 2011–2020*. Retrieved from https://pnc.upm.edu.my/upload/dokumen/menul320171013193808Dasar_Agromakanan_Negara_2011-2020.pdf

Sahadevan, N. (1987). *Green Fingers: A total commitment to the development of farming*. Sahadevan Publication.

Sasikala, P., Rattanathorn, I., Vijaya, M. *et al*. (2016). Impact of vermicompost on lemongrass (*Cymbopogon flexuosus* L) production and oil content. *Research Journal of Pharmaceutical, Biological and Chemical Sciences, 7*(3),870–877

Singh, M. (2008). Effect of nitrogen and potassium fertilizer on growth, herbage, oil yield of irrigated palmarosa (Cymbopogon martini [roxb.] wats. var. motia Burk). *Archives of Agronomy and Soil Sciences*, *54*(4), 395–400.

Sestak (1963). Changes in the chlorophyll content as related to photosynthetic Activity and age of leaves. *Photochem and Photobiol*, *2*, 101–110.

Tajidin, N., Ahmed, S.H., Rosenani, A.B., *et al*. (2012). Chemical composition and citral content in lemongrass *(Cymbopogon citratus*) essential oil at three maturity stages. *African Journal of Biotechnology,*. *11*(11), 2685–2693.

Ullah, S. & Moore, T.R. (2009). Soil drainage and vegetation controls of nitrogen transformation rates in forest soils. Southern Quebec. *Journal of Geophysical Research*, 114. https://doi.org/10.1029/2008JG000824

Yeshitila, W.S., (2019). Herbage and essential oil yield of two lemon grass (*Cymbopogon Citratus*) varieties as affected by harvesting cycle and number of tiller per planting slips at Wondo Genet, Southern Ethiopia. *International Journal of Research Studies in Agricultural Sciences (IJRSAS), 5*(2), 18–22.