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Release of Ammonium-N (NH_4^+) and Nitrate-N (NO_3^-) by Different Leguminous Cover Crops (LCCs) Planted in Peat Soils

Muhammad Rahmat Abdul Rahman, Nur Qursyna Boll Kassim

***Abstract**: Peat soils is renowned for the low mineral-N concentration which is crucial for crop's growth. One of the effective and conserving method to improve the soil mineral-N concentration is by planting leguminous cover crop (LCC) which is common in oil palm plantation area. However, different LCCs was found to release different concentration of mineral-N into the soils. Hence, this study aims to determine the concentration of soil mineral-N in form of soil ammonium-N (NH_4^+) and soil nitrate-N (NO_3^-) by different types of LCCs namely Mucuna bracteata, Calopogonium mucunoides, Pueraria javanica and Centrosema pubescens as well as to evaluate the effects on physico-chemical properties of peat soils. Results showed most of the LCCs can survive in acidic peat condition whilst improving the concentration of mineral-N in the soils. Mucuna bracteata was found to release a significant amount of mineral-N into the soils and shows a vigorous growth compared to others during the study period. However, it should be noted that different LCCs required distinct time to fix N since the maturity for different LCCs is different. Hence, prolonged studies on release of mineral N into the soil by LCCs are recommended.*

Keywords: ammonium, LCC, mucuna bracteate, nitrate, peat

I. INTRODUCTION

Malaysia, which consists of Peninsular Malaysia, Sabah and Sarawak, covers approximately 2.5 million hectare of peat soils area. A significant portion of the total peat area is contributed by Sarawak which covers about 1.6 million hectare whereas Peninsular Malaysia and Sabah supports about 0.85 million hectare and 0.08 million hectare, respectively [1]. Large distribution of peat soils in Malaysia offers a medium for various agricultural purposes through a proper soil management. The tropical peat soils which classified under oligotrophic group [2][3] is known for its poor nutrient content and acidic characteristics [2]. Low soil nutrient availability especially the macronutrients namely the N, P, K and Ca resulted in limited potential use of peat soil for agricultural purposes specifically under low input management [4]. For this reason, higher fertilizer input is required for cropping system to establish on peat soils. Since the management of N resources is critical especially in peat where acidic condition dominated, it becomes the focus of this study. Although total N in peat soils is considerably high, the availability of mineralized-N for plant uptake is crucial and low mineral-N concentration in peat soil is often restricted the crop's growth [2]. This is due to its poor chemical properties with low soil pH combined with anaerobic condition that restricted the peat decomposition. Peat decomposition is highly dependent on types of organic materials in peat build-up, the environmental conditions and the types of decomposers that were existing in the soil. All of these factors interacted with one another and makes the estimation on rate of decomposition become difficult [5]. Thus, the fluctuating amount of mineral-N released in peat soils under natural condition which involved alternate aerobic and anaerobic condition is expected [6]. Apart from the fertilizer application and slow decomposition resulted from microbial processes in order to supply the nutrients, one of the natural and conserving method to improve the soil mineral-N concentration is by planting leguminous cover crops (LCC) which is common in oil palm plantation area [7]. LCCs are benefited in peat soils by retaining the soil moisture, minimize the subsidence, prevent the occurrence of irreversible drying as well as lowering the risk of peat fire. Common LCCs planted in oil palm plantation include *pueraria javanica, pueraria phaseoloides, centrosema pubescens, calopogonium caeruleum and calopogonium mucuinodes.* Even so, different LCC was found to release different concentration of mineral-N into the soils [8]. Hence, this study aims to determine the concentration of mineral-N in form of ammonium-N (NH_4^+) and nitrate-N (NO_3^-) released by different types of LCCs namely *mucuna bracteata, calopogonium mucunoides, pueraria javanica* and *centrosema pubescens* planted in peat soils as well as to evaluate the effects on physico-chemical properties of the soil.

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II. RESEARCH METHODOLOGY

A. Field Sampling

Peat soil samples were collected from Parit Yusof, Muar, Johore at 0-15 cm depth using a soil auger. The sampling was taken using a random sampling technique. From the field observations, the soil was black in color (10YR 2/1) read using Munsell Soil Color Book with a bulk density of 0.55g/cm3. The data on bulk density was taken using a core ring method. The soils collected from the field were then filled into polybags for field experiment.

B. Field Experiment

The experiment was conducted in a greenhouse located at UiTM Jasin, Melaka using a completely randomized design (CRD). A total of 60 samples were applied with different treatments. The treatments applied were different types of legume cover crops namely *mucuna bracteate* (MB), *calopogonium mucunoides* (CM), *pueraria javanica* (PJ) and *centrosema pubescens* (CP). A non-planted peat soils is used as a control. Each of the treatments have three replications and destructive sampling methods were applied biweekly for 8 weeks.

C. Sample and Data Analysis

The soil samples were analyzed for soil pH, soil ammonium-N and soil nitrate-N while the plant samples were collected and measured for plant height, number of leaves, length of roots as well as the fresh and dry weight. Soil pH was measured using pH meter with a standard 1:10 (sample: water ratio). Soil ammonium-N and nitrate-N was analyzed using the steam-distillation techniques [9]. The data collected were statistically analyzed using SPSS software for analysis of variance (ANOVA) and the significant value was compared using Tukey's test and the correlation within parameters were also observed.

III. RESULTS AND DISCUSSIONS

A. Effects of LCCs Growth on Soil pH

The nutrient availability in peat is often hindered by the strong acidic condition [10]. In peat soils, the average soil pH is between pH 3 - pH 4.5 [2]. However, most of the nutrients will become available in soil when the soil pH is between pH 5.5 - pH 7.5 [7]. Planting of *pueraria javanica* (PJ) on peat soils had slightly improved the soil pH from pH 3.85 to pH 3.86. Even though the soil pH is still acidic, a slight increment may enhance the release of availability of the nutrients in soil [11]. In contrast, other LCCs shows a decreasing of soil pH from pH 3.85 to pH 3.84 (*mucuna bracteate*), pH 3.83 (*calopogonium mucunoides*) and pH 3.80 (*centrosema pubescens*). One of the reasons for the high acidity in peat soils is the abundance of hydrogen ion (H^+) [2]. This H^+ is found mostly in living organic materials, dead organic material on or above the soil surface as well as in the soil water [10].

Upon decomposition of these organic materials, much of H+ was released into the soils, accompanied by slight concentration of nutrients [12]. Thus, it is suggested that the organic matter degradation in peat soils contribute towards slight decrement of soil pH [13] [2] in the treatment plots as the difference in value is not significant ($p<0.05$). During the degradation process of organic materials, the release of organic acids may contribute to slight decrement of soil pH accompanied by the availability of some nutrients in the soil [7]. In addition, previous research also shows that the nitrification process contributing towards lowering the soil pH [8] which reflects the higher amount of soil ammonium-N in the treatment plots followed by the release of soil nitrate-N (Fig. 4).

B. LCCs Growth Performance

Fig. 1 shows the mean growth performance of different LCCs planted on peat soils over 8 weeks. The results showed that *mucuna bracteate* has the highest height compare to others due to its vigorous growth while the best rooting system was developed by *calopogonium mucunoides* represented by longest root length.

From the figure, the finding shows that all LCCs developed a vigorous growth of roots which is almost triple compared to the height of the plants even though the soil pH is acidic. The function of the roots nodule to fixed nitrogen is found effective for *mucuna bracteatea* even though the roots are shorter than those of *calopogonium mucuinodes*. This is reflected by the amount of soil ammonium-N fixed throughout the studied weeks (Fig. 4). The same case goes to *centrosema pubescens* where in form of the physiological growth, the roots and height is slightly shorter compare to other LCCs. However, the amount of soil ammonium-N produced in the soil planted with *centrosema pubescens* is higher compare to *pueraria javanica* and *calopogonium mucuinodes*.

For the number of leaves, highest number of leaves were produced by *pueraria javanica* due to its rapid leaves' growth compared to other LCCs (Fig. 2). Most of smaller leaves LCCs will produce higher quantities of leaves compared to those of broader leaves during the initial growth performance stage. The stages of growth are much likely depending on the physiological characteristics of the plant itself and in this case, *centrosema pubescens* indicates a slower growth performance compare to other LCCs (Fig. 2). However, the acidic condition of peat soils slightly affects the growth performance of the LCCs, and it is suggested that *centrosema pubescens* showed slower leaves production when planted in peat soil.

Highest weight of plant biomass was produced by *mucuna bracteate* compare to other LCCs as shown in Fig. 3, believed to be due to broader leaves and vigorous growth in form of plant height. As compare to other LCCs, the size of leaves of *mucuna bracteate* is almost double to triple the size of other LCCs leaves. Hence, this difference in leave size reflects to the higher fresh weight of *mucuna bracteate* compare to other LCCs. For the dry weight of the LCCs, it is found that most of the LCCs weight consist almost 30-50% of water. This reflects the loss of weight of the fresh LCCs upon drying.

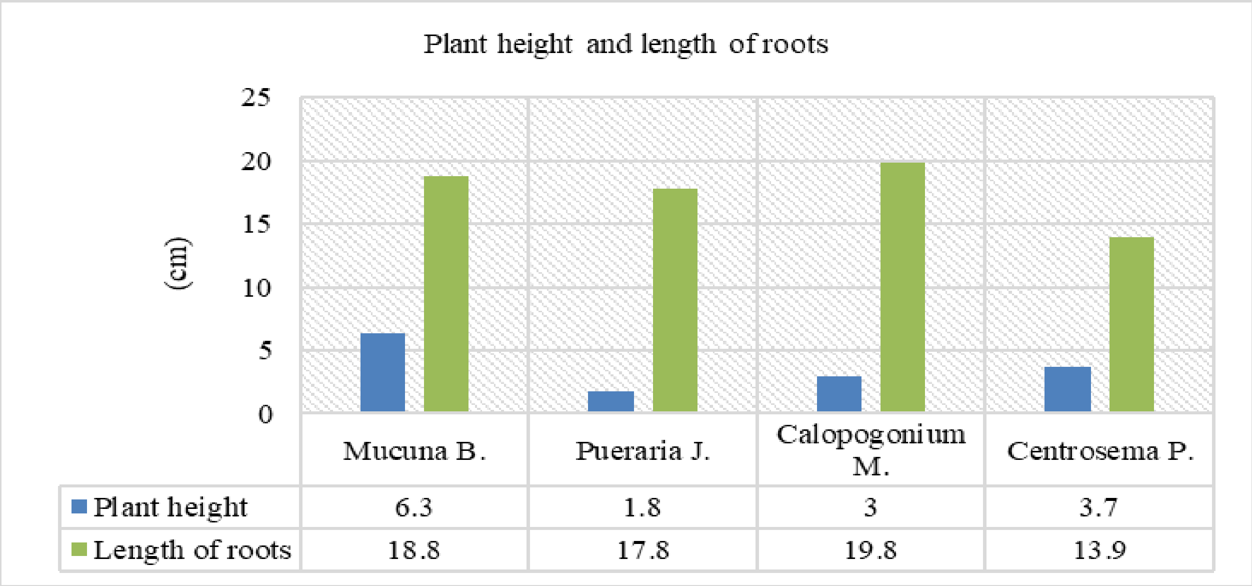

Fig. 1: Growth performance of LCCs (plant height and length of roots)

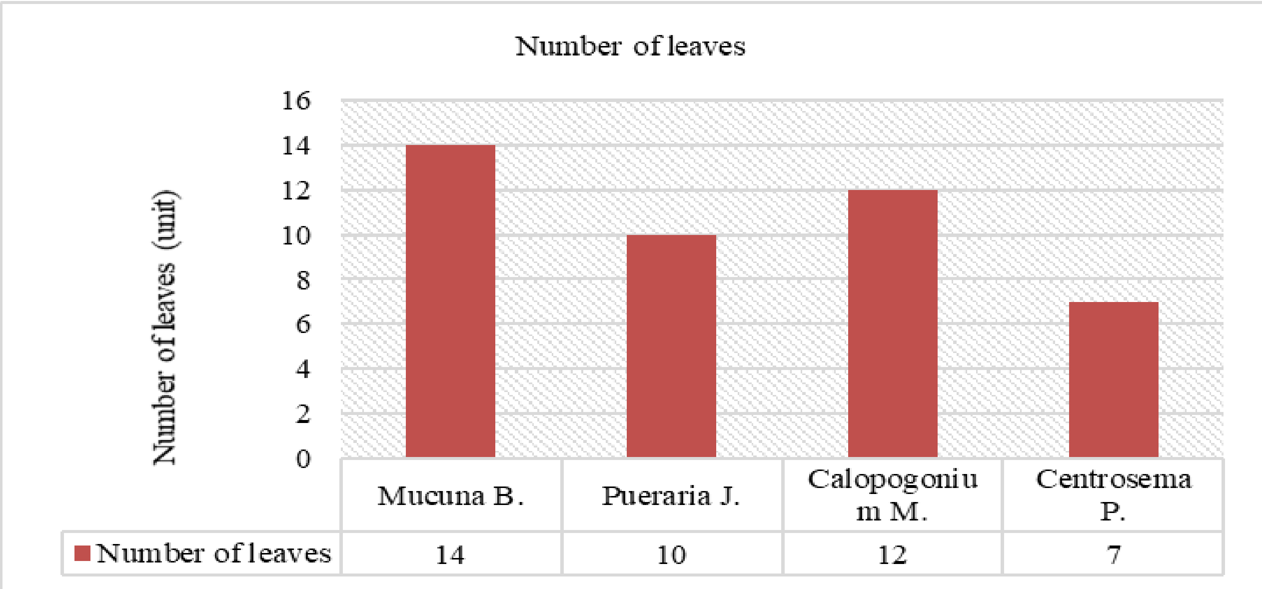

Fig. 2: Number of leaves

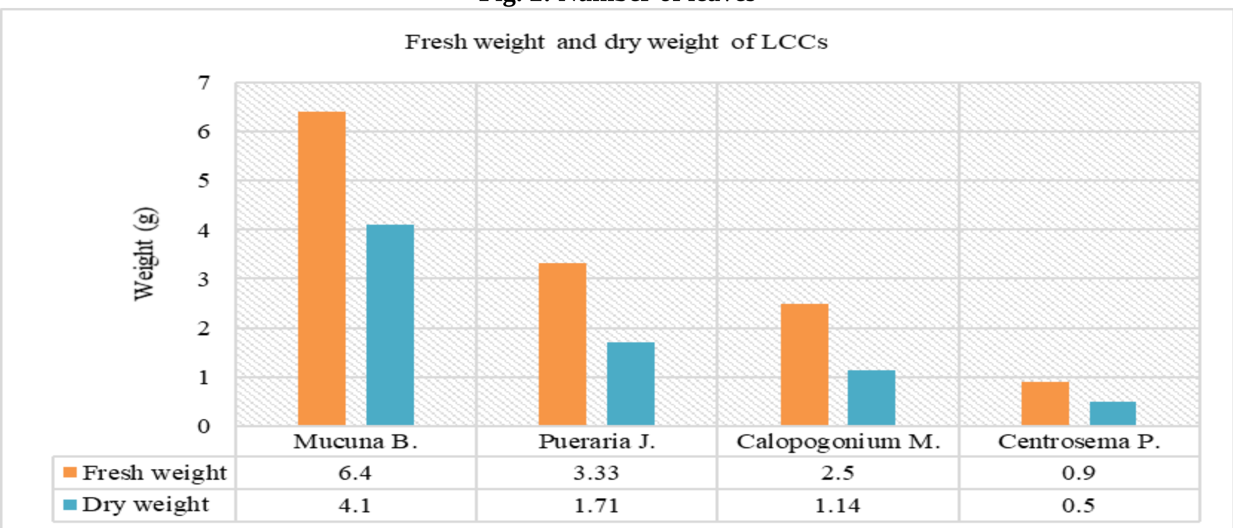

Fig. 3: Fresh weight and dry weight of LCCs

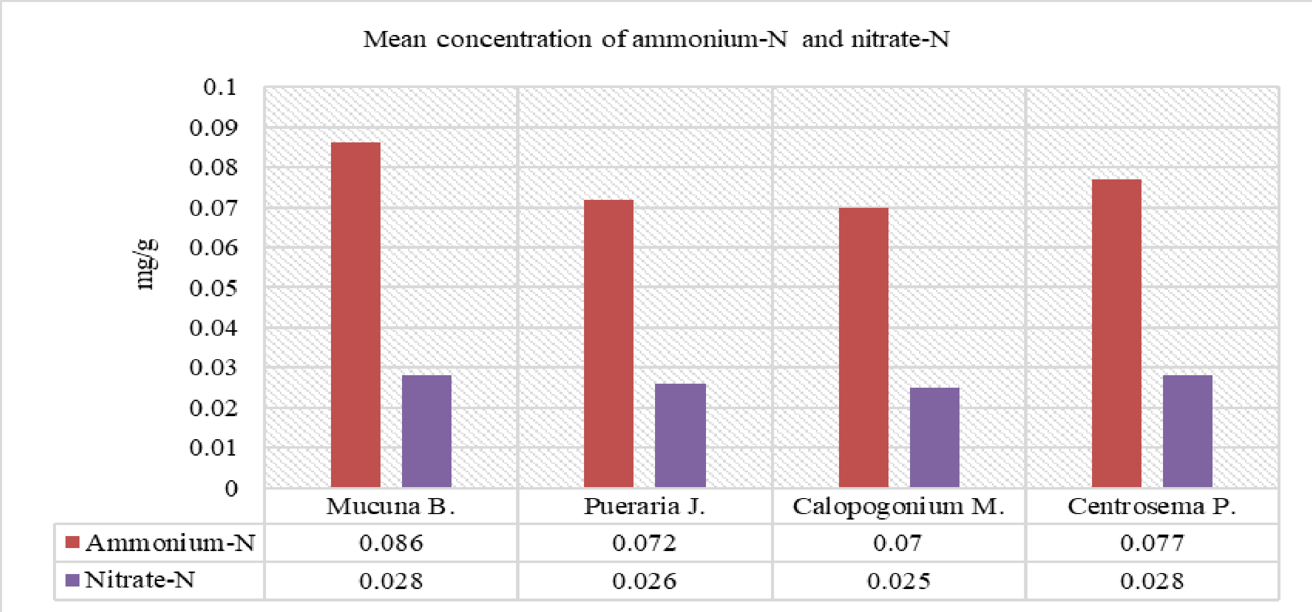

Fig. 4: Mean concentration of Soil Ammonium-N (NH_4^+) and Nitrate-N (NO_3^-)

C. Release of Soil Ammonium-N (NH_4^+) and Nitrate-N (NO_3^-)

Much of soil ammonium-N as well as nitrate-N were released by *mucuna bracteate* compare to other LCCs, as shown in Fig. 4.

Even though the rooting system of *calopogonium mucunoides* shows an aggressive growth, much of the ammonium-N was fixed by *mucuna bracteate* under acidic soil condition. It is suggested that the release pattern of nitrate-N is following the soil ammonium-N input from the LCCs [14] (Brady, 2008). Hence the amount of nitrate-N produces in the soil planted with *mucuna bracteate* is higher compared to other LCCs. Under aerobic condition, much of the soil-N is in contact with oxygen resulting in the nitrification activity by microbes (John, Samuel, James, & Werner, 2005) [15]. In addition, increase of nitrification process has led to the decrease in soil pH (Supriyadi et al., 2017) which further restricted the microbial activities in the soils (John et al., 2005) [11]. Even though the concentration is in small amount, the increasing pattern of mineral-N released by different LCCs shows the positive endurance in acidic peat soils.

IV. CONCLUSIONS

From this study, it is suggested that all the LCCs namely *mucuna bracteata*, *calopogonium mucunoides*, *pueraria javanica* and *centrosema pubescens* can survive in acidic peat condition whilst improving the concentration of mineral-N in the soils. However, it should be noted that different LCCs required distinct time to fix N since the maturity for different LCCs is different. Hence, prolonged studies on release of mineral N into the soil by LCCs are recommended.

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REFERENCES

1. P. Maltby, E. and Immirzi, "Carbon dynamics in peatlands and other wetlands – regional and global perspective," *Chemosphere*, vol. 27, pp. 147–154, 1993.
2. J. P. Andriesse, "Nature and management of tropical peats," in *FAO Soils Bulletin*, FAO, Rome, 1988, p. 165.
3. K. Yonebayashi, M. Okazaki, and J. Pechayapisit, *Coastal Lowland Ecosystem in Southern Thailand and Malaysia*. Showado-Printing, Sakyoku, Kyoyo, 1992.
4. F. Shinya, Y. Koyo, F. S. Jong, and C. O. K. Ernest, "Nutritional environment of tropical peat soils in Sarawak, Malaysia based on soil solution composition," *Soil Sci. Plant Nutr.*, vol. 42, no. 4, pp. 833–843, Dec. 1996.
5. R. Laiho, "Decomposition in peatlands: reconciling seemingly contrasting results on the impacts of lowered water levels," *Soil Biol. Biochem.*, vol. 38, no. 8, pp. 2011–2024, 2006.
6. A. Y. Nur Qursyna Boll Kassim, "Effects of Liming, Urea and NPK Fertilizers on Availability and Movement of Mineral Nitrogen in Peat Soils under Aerobic and Anaerobic Condition," *J. Appl. Sci. Agric.*, vol. 9, no. 11, pp. 292–299, 2014.
7. N. C. and R. R. W. Brady, *The Nature and Properties of Soils 14th edition*. 2008.
8. Supriyadi, Sudaryanto, Purwanto, and A. Safrudin, "Management of Legume As Land Cover Crop and Empty Bunch for the Nitrogen Efficiency in Inceptisols At Oil-Palm Plantation," *J. Soil Sci. Agroclimatol.*, vol. 13, no. 2, pp. 51–59, 2017.
9. Soil Survey Staff, "Soil survey field and laboratory methods manual. Soil Survey Investigations Report No. 51, Version 2.0.R. Burt and Soil Survey Staff (ed.)," 2014.
10. A. D. Robson and L. K. Abbott, "The effect of soil acidity on microbial activity in soils," in *Soil Acidity and Plant Growth*, Academic Press, 1989, pp. 139–165.
11. L. H. John, L. T. Samuel, D. B. James, and L. N. Werner, *Soil Fertility and Fertilizers*, Seventh Ed. Pearson Prentice Hall, 2005.
12. H. T. Kim, *Principles of Soil Chemistry*, 4th ed. CRC Press, 2011.
13. R. E. Lucas, *Organic soils (Histosols). Formation, distribution, physical and chemical properties and management for crop production*. Michigan State University Agricultural Experiment station, 1982.
14. T. Rutting, P. Boeckx, C. Muller, and L. Klemedtsson, "Assessment of the importance of dissimilatory nitrate reduction to ammonium for the terrestrial nitrogen cycle," *Biogeosciences*, vol. 8, pp. 1779–1791, 2011.
15. J. I. Prosser, "Microorganisms cycling soil nutrients and their diversity," in *Modern Soil Mirobiology*, CRC Press, Boca Raton, 2007, pp. 237–261.

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