p-ISSN 1410-5659 e-ISSN 2621-5144
Published by:
Unpad Press

Jurnal Ilmu Ternak Universitas Padjadjaran, March 2025, 25(1):75-87
DOI: 10.24198/jit.v25i1.53762
Available online at http://jurnal.unpad.ac.id/jurnalilmuternak

STUDY OF NITROGEN NUTRIENT ABSORPTION AND FORAGE PRODUCTION IN CALOPO PLANTS *(Calopogonium mucunoides)*

Kustiawan Triputra[1, a], Mansyur[2], Iin Susilawati[2], and Irfan Dwi Aditya[1]
[1]*Alumnus, Faculty of Animal Husbandry, Universitas Padjadjaran, Sumedang.*
[2]*Department of Animal Nutrition and Feed Technology, Faculty of Animal Husbandry, Universitas Padjadjaran, Sumedang*
[a]*email:* ktriputra21@gmail.com

Abstract

This research aims to evaluate differences in soil nitrogen content, nitrogen absorption by plants, and forage production of *Calopogonium mucunoides* grown on Andosol and Ultisol soils during a 90-day planting period. The research method used was experimental, with treatment factors in the soil type Andosol and Ultisol. The parameters observed were soil's moisture, temperature, pH, nitrogen content, and the plant's nitrogen content and forage production. The results showed that Andosol's average soil moisture value (53.61%) was higher than Ultisol's (43.68%). The soil temperature of Ultisol (24.34°C) tended to be higher than Andosol (23.36°C). Andosol soil pH (5.04) exceeds Ultisol's (4.87). The soil nitrogen content in Andosol (4,838%) was higher than in Ultisol (4,058%). The nitrogen content in plant tissue in both soil types was relatively the same, namely (2.423%) for Andosol soil and (2.523%) for Ultisol soil. However, forage production on Andosol (42.65 g/pot fresh weight; 11.85 g/pot dry weight) was almost two times higher than Ultisol (21.75 g/pot fresh weight; 5.907 g/pot dry weight). Nitrogen uptake in Andosol soil was 0.247 grams/pot, higher than in Ultisol soil, 0.149 grams/pot. In conclusion, Andosol soil is more optimal for the growth of *C. mucunoides* in forage production.
Keywords: Andosol, *Calopogonium mucunoides*, Nitrogen, Forage Production, Ultisol

STUDI PENYERAPAN UNSUR HARA NITROGEN DAN PRODUKSI HIJAUAN PADA TANAMAN KALOPO (Calopogonium mucunoides)

Abstrak

Penelitian ini bertujuan untuk mengevaluasi perbedaan kandungan nitrogen tanah, penyerapan nitrogen oleh tanaman, dan produksi hijauan tanaman Calopogonium mucunoides yang ditanam pada tanah Andosol dan tanah Ultisol selama 90 hari masa tanam. Metode penelitian yang digunakan adalah eksperimental dengan faktor perlakuan berupa jenis tanah (Andosol dan Ultisol). Parameter yang diamati meliputi kelembaban tanah, suhu tanah, pH tanah, kandungan nitrogen tanah, kandungan nitrogen tanaman, dan produksi hijauan tanaman. Hasil penelitian menunjukkan bahwa nilai rata-rata kelembaban tanah Andosol (53.61%) lebih tinggi daripada Ultisol (43.68%). Suhu tanah Ultisol (rata-rata 24.34°C) cenderung lebih tinggi dibandingkan Andosol (23.36°C). pH tanah Andosol (rata-rata 5.04) juga lebih tinggi dibandingkan Ultisol (4.87). Kandungan nitrogen tanah pada Andosol (4.838%), lebih tinggi dibandingkan Ultisol (4.058%). Kandungan nitrogen dalam jaringan tanaman pada kedua jenis tanah relatif sama yaitu sebesar (2.423%) untuk tanah Andosol dan (2.523%) untuk tanah Ultisol. Namun, produksi hijauan tanaman pada Andosol (42.65 g/pot berat segar; 11.85 g/pot berat kering) nyata lebih tinggi hampir dua kali lipat dibandingkan Ultisol (21.75 g/pot berat segar; 5.907 g/pot berat kering). Serapan nitrogen pada tanah Andosol adalah 0.247 gram/pot lebih tinggi daripada tanah Ultisol yaitu 0.149 gram/pot. Kesimpulannya, Andosol lebih optimal untuk pertumbuhan C. mucunoides ditinjau dari produksi hijauan yang dihasilkan.
Kata kunci: Andosol, Calopogonium mucunoides, Nitrogen, Produksi Hijauan, Ultisol

INTRODUCTION

Increasing forage production and good nutrient content for ruminant livestock is important to ensure livestock health and productivity. One aspect that needs to be considered in this effort is nitrogen availability in the soil, an essential element for the continued growth of forage plants (Sagala, et al., 2022).

Leguminous plants, such as calopo (*Calopogonium mucunoides*) are important in meeting soil nitrogen needs (Sulok, et al., 2014). Apart from that, this plant has high forage production potential because it can grow well on less fertile land and is tolerant of unfavorable environmental conditions (Chen & Aminah, 1997). Plants need sufficient nutrients to ensure their growth cycle. One nutrient element that is very important for plants and whose availability in the soil really needs to be considered is nitrogen. Nitrogen is a nutrient which availability is very abundant in the atmosphere but very low in the soil (Purba, et al., 2021). Leguminosaurs such as calopo have the ability to collaborate with rhizobia bacteria to form root nodules, which fix nitrogen in the atmosphere into a usable molecule for plants (Taisa et al., 2021). Therefore, research on soil nitrogen levels and nitrogen uptake by legume plants such as calopo is very relevant.

The planting media used are Andosol soil and Ultisol soil. Andosol soil was chosen as a planting medium and obtained from Lembang, an area famous for its soil fertility. On the other hand, the choice of Ultisol soil is a type of soil that is very widely distributed in Indonesia. Ultisol soil is used as a comparative planting medium to assess which one is more optimal for the growth of calopo plants*, based on* the nitrogen content and forage production.

Previous studies have often focused on the effects of various soil types on plant growth, but many have not specifically compared Andosol and Ultisol soils. For instance, research by Enggalmulia et al. (2024) indicated that Andosol soils generally provide better nutrient availability for certain crops, aligning with this study's findings, which show higher nitrogen content and moisture levels in Andosol compared to Ultisol.

The urgency of this research lies in the urgent need to improve food security and implement sustainable agricultural practices amidst the increasing global demand for food. By providing insights into how soil types, particularly Andosols and Ultisols affect the growth and production of *Calopogonium mucunoides* forage crop, this study can assist farmers and stakeholders in selecting optimal soil types to improve yield and feed quality. Furthermore, the findings highlight the importance of sustainable soil management to maintain soil health and fertility, and provide opportunities for further research on crop rotation and intercropping strategies that can enhance agricultural productivity. Thus, this study not only contributes to scientific knowledge but also provides practical solutions to current agricultural challenges.

MATERIALS AND METHODS

This study used materials and equipment to activate nitrogen absorption in *Calopogonium mucunoides*. The materials used included 10 grams of calopo seeds, and two types of soil: Andosol (100 kg from Lembang) and Ultisol from the land of the Faculty of Animal Husbandry, Padjadjaran University. The equipment used included a hoe, watering can, plant scissors, envelope paper (24.5 x 34.5 cm), a modem for connecting the Blynk IoT application, 40 plastic pots (capacity 5 kg), a smartphone to display measurement results, a soil test tool to measure soil nutrient elements, scales (10 kg and 3 kg), seedling trays (50 holes), and bamboo poles (100 cm) for plant propagation media.

The research procedure began by soaking the seeds in water at 25-30°C for 24 hours, then sowing in a tray for 30 days. After that, the soil was put into a labelled pot and its nutrient content was measured using a soil test tool. The sown seeds were transferred into pots, with maintenance including watering (300 ml per day) and weeding. Nutrient measurements were carried out every week for 90 days. Harvesting was carried out after 90 days, by cutting the stems and weighing the leaves, stems, and roots that had been separated from the soil. The harvested plants were dried in an oven at 60°C for 48 hours before measuring the dry weight. Total nitrogen was analyzed using the Kjeldahl method in the laboratory. The research method used was experimental, with data analysis using descriptive statistical analysis and t-test to assess significant differences between soil nitrogen content and forage production in both types of soil. The variables observed included humidity, temperature, pH, soil nitrogen content, total plant nitrogen content, and forage production during the 90-day planting period.

RESULTS AND DISCUSSION

Soil Moisture

The data in Table 1, can be interpreted that the soil moisture planted with calopo *plants* on Andosol and Ultisol soils was different at the 1% level. The average soil moisture in Andosol was 53.611%, while the average soil moisture in Ultisol was 43.679%.

This difference in soil moisture can be caused by the nature and characteristics of the soil. Andosol soil has better physical properties than Ultisol soil. It has a crumbly soil structure, high infiltration capacity, and better drainage. This causes Andosol soil to be able to store more water than Ultisol soil. Andosol, which has a fine grain structure due to the decomposition of volcanic material, shows optimal water retention capacity.

Mineral content such as kaolin, allophane, and ferrihydrite also contribute to the chemical properties that support high soil moisture, and low density contributes to water-holding capacity (Shoji et al., 1978). In contrast, Ultisols, which tend to have a coarse structure and contain heavy clay, exhibit lower water retention. Mineral content such as kaolinite, iron oxide, and aluminum oxide are the main factors in this soil's ability to drain water more quickly.

Other aspects, such as climate, vegetation, and soil management practices, also play an important role in shaping variations in soil moisture conditions in the two types of soil. (USDA, 2023). Apart from that, there is also a relationship between soil temperature and soil moisture, namely that at high soil temperatures, soil moisture tends to be low, and vice versa, at low soil temperatures, soil moisture tends to be high (Kartasapoetra, 2005).

Most plants can thrive in soil with humidity ranging from 20-60% (Ilamsyah, et al. 2022). In legume plants, the nodulation process can occur at soil moisture ranging between 25-45% (Oguis, et al. 2019).

Soil Temperature

Based on Table 2, the temperature of the soil planted with calopo varied significantly, both between weeks and between types of soil. In general, the soil temperature of Andosol was lower than the temperature of Ultisol. The average soil temperature of Andosol is 23,361 ˚C, while the average soil temperature of Ultisol is 24,342˚C. This difference in soil temperature is caused by climatic factors and the physical and chemical properties of Andosol and Ultisol soils. Kartasapoetra (2005) states that there are two factors that cause changes in soil temperature, namely external factors involving solar radiation, cloud conditions, rainfall, wind, and air humidity, as well as internal factors including soil texture, soil structure, soil color, organic content, and soil water content.

The relationship between soil temperature and soil moisture is that soil moisture tends to be low at high soil temperatures, and vice versa, at low soil temperatures, soil moisture tends to be high. According to Hawari et al. (2022), An increase in soil temperature can occur because the soil absorbs a lot of sunlight and high air temperatures, and the dry season results in a lack of rain. In addition, soil temperature is influenced by organic matter content through its influence on cation exchange capacity, specific heat, biological activity, and water storage capacity (Onwuka & Mang, 2018). Andosol is a soil that is rich in organic matter, so it has a high field capacity. This causes the Andosol soil temperature to be more stable and not change easily. Ultisol, on the other hand, is a type of soil that is poor in organic matter and has low field capacity.

From the soil temperature measurement data in Table 2, the highest temperature occurred in the 6th week; the soil temperature was 29,508 ˚C and Ultisol soil was 27,865 ˚C. Meanwhile, the lowest temperature for Andosol soil, namely 19,466 ˚C, occurred in the 8th week, and for Ultisol soil, it occurred in the 9th week, namely 20,340 ˚C. According to Chen and Aminah (1997), calopo plants will grow optimally at daily temperatures ranging from 24 ˚C - 32 ˚C with a maximum limit of 36 ˚C and a minimum limit of 18 ˚C. Plant growth is influenced by temperature, and each type of plant has a different optimum, minimum and maximum temperature range. If plants grow below optimal temperatures, their growth will be stunted. Temperatures below the optimum value can reduce the growth rate and metabolic processes of plants, while temperatures above the maximum value can also inhibit growth and even result in plant death (Karmila & Andriani, 2019) .

If the soil temperature is too low or too high, it will seriously impact plant growth and production results. High temperatures can accelerate soil water evaporation, reduce plant health, and cause temperature stress on plant bodies (Niska et al., 2023). On the other hand, if the temperature is low, it can inhibit the development of plant roots and will impact production results. A decrease in soil temperature also causes a decrease in the amount of nitrogen fixed, which then impacts chlorophyll production and inhibits the photosynthesis process (Anderson & Markham, 2021).

Degree of Acidity (pH)

Based on the data presented in Table 3, the pH of the soil in pots planted with calopo plants decreased significantly from week to week. In the 0^{th} week, the soil pH of Andosol and Ultisol was 5,711 and 5,875, respectively. At week 12, the soil pH of Andosol and Ultisol was 4,898 and 4,193, respectively. High pH values for both Andosol and Ultisol soil occurred in week 0, namely 5.771 and 5.875. Meanwhile, the lowest pH value for Andosol soil was 4.838 and Ultisol soil was 3.783, both of which occurred in the 10th week. These conditions are quite good conditions for calopo plants to grow. Calopo effectively thrives in acidic soil. The optimal pH range for this plant is between 4.0 to 5.0 (Chen & Aminah, 1997). Its ability to cope with low pH was demonstrated when calopo was grown in clay soil with a pH range of 4.5–5.0 (Heuzé et al., 2016).

The significant difference in pH values between week 0 and week 12 showed that the Calopo plant had quite an influence on soil pH. Calopo plants are known to have the ability to absorb nutrients from the soil, including acidic nutrients. According to Mosaic (2020), one of the causes of soil pH values changing is the type of plants planted. Leguminous plants contain more cations than anions, causing H ions to be released from plant roots to maintain electrochemical balance in the tissues, resulting in increased soil acidity. Apart from that, regular watering can also influence the pH of the soil to become more acidic. Watering can cause soil pH to drop, including dissolution of minerals, transfer of exchangeable cations, and decomposition of organic matter due to watering. These processes can cause mineral leaching, acid release, and disruption of the soil's pH balance. Ultimately, these processes will cause the soil pH to decrease gradually (USDA, 2023).

The research results on Calopo showed that this plant could grow well in acidic soil with a high level of aluminum saturation. Additional studies on Calopo found that when this plant was grown in vermiculite and given nutrient solutions adjusted to pH 4.0, 5.5, and 7.0, impacts on nodulation and biological nitrogen fixation were seen (Ferreira et al., 2016). This indicates the ability of this plant to adapt to variations in different pH levels. Therefore, the optimal pH for calopo growth is in the acidic range, indicating the tolerance of this plant to varying levels of soil acidity. Overall, the pH value of Andosol soil was higher than that of Ultisol soil, and during the planting period, the pH value of both types of soil fluctuated. The pH range of Andosol soil varied, ranging from 3.4 to 6.7. The most common pH range in Indonesia is between 4.5 and 5.5, while the pH concentration, which is also quite significant, is in the range of 5.5 to 6.5. Meanwhile, Ultisol soil is often found in Indonesia, commonly with a low or acidic pH of 3.1 – 5.0 (Prasetyo et al, 2006). According to the Ministry of Agriculture's annual report, Ultisol soil is included in the Red and Yellow Podzolic soil category, which is generally acidic. Low acidity levels in the soil can affect the availability of nutrients for plants.

Soil Nitrogen

Based on Table 4, it was found that the nitrogen content in Andosol and Ultisol had a significant difference. The nitrogen content in Andosol soil was generally higher than in Ultisol soil. This can be seen from the average nitrogen content of Andosol 4,838%, while Ultisol soil was 4,058%.

In the first 6 weeks, the soil nitrogen content of Andosol was higher than that of Ultisol. This is supported by Andosol's higher soil moisture, lower temperature and more alkaline pH compared to Ultisol in the same period. Andosol soil nitrogen content decreased drastically starting in the 7^{th} week, while Ultisol was relatively stable. The decrease in nitrogen in Andosol soil is related to a decrease in humidity, pH and an increase in soil temperature which triggers an increase in the rate of decomposition of organic matter.

During the planting period, the N content of Andosol soil tended to decrease, while the N content of Ultisol soil fluctuated. Conditions that occurred in the soil during the planting period could be caused by several factors, such as humidity, temperature, pH, microorganisms, nitrogen absorption by plants, and evaporation. The decrease in both types of soil was caused by the absorption of nitrogen by plants. This was in accordance with Purba et al (2021), which stated that plants need nitrogen to grow and develop.

The activity of microorganisms in the soil can also affect the availability of nitrogen, as most of the nitrogen can be absorbed by plants or even lost to the atmosphere in the form of nitrogen gas. According to Taisa et al., (2021), the unavailability of nitrate and ammonium elements to be absorbed by plants can be caused by a competition between plants and microorganisms in obtaining N. Plants can take nitrogen from the soil in two ionic forms, namely NH_4^+ and NO_3^-. However, because nitrification commonly occurs in agricultural soils, most nitrogen is absorbed as nitrate. Nitrates move freely towards plant roots during water absorption. After entering the plant, NO_3^- is converted into the NH_2 form and integrated to produce more complex compounds (Muratore et al., 2021). According to Sarief (1989), in the vegetative phase of plants, nitrogen absorption will be high because it is very necessary for the growth of leaves, stems and roots.

Temperature can increase microbial activity and respiration, reducing the amount and quality of organic matter in the soil. Rising temperatures can affect the mineralization rate and nitrogen availability, while cold climates inhibit microbial activity and slow the nitrogen mineralization rate. (Janna et al., 2005). The decrease in nitrogen content in Andosol was influenced by an increase in soil pH, which was less than optimal for soil microbial activity. Meanwhile, the increase in nitrogen in Ultisol was supported by a decrease in soil pH, which is more optimal for nitrogen mineralization and soil microbes (Geng et al., 2017).

Increased nutrient content in both soils. Both types of soil may have high nitrogen content. This can be attributed to increased soil moisture, which can increase the activity of microorganisms and biogeochemical processes in the soil, which in turn can impact nitrogen availability. When environmental conditions support the activity of microorganisms, biogeochemical processes such as mineralization and nitrification can increase nitrogen availability in the soil (Stark and Firestone, 1995). Plant-microorganism interactions in soil and small changes in nitrogen content indicate that soil nutrition is always changing and can be influenced by many factors. Factors such as soil properties, climate, and microbial bioactivity influence soil nutrient dynamics. Microorganisms in soil play an important role in plant mineral nutrition through nutrient acquisition and conversion of unavailable nutrients into forms beneficial to plants. (Richars et al., 2017).

Nitrogen levels in soil can increase due to various factors, including nitrogen fixation by legume plants, decomposition of organic matter by microbes, and leaching of nitrogen compounds. According to Purba et al. (2020), Legume plants, such as calopo, have the capacity to capture nitrogen from the air, thereby increasing the total nitrogen content in the soil even without fertilization. The microbial decomposition process of organic material also plays a role in increasing the availability of nitrogen in the soil. In addition, leaching of nitrogen compounds, such as nitrates, can occur without fertilization, which can ultimately lead to a decrease in the nitrogen content in the soil. Therefore, natural processes and microbial activity significantly affect fluctuations in soil nitrogen levels (Taisa et al., 2021).

Andosol and Ultisol are two types of soil that show differences in characteristics and nutrient content. Andosol, which comes from volcanic ash, has a high ability to retain water and nutrients due to the presence of minerals with less regular crystal structures (USDA, 2023). Andosols generally tend to have higher levels of total N, available P, total P, and exchangeable K (Hifnalisa et al., 2022). This is related to the type of Andosol, which is fertile soil obtained from mountainous areas with a high organic material content, making it very suitable for agriculture. In contrast, Ultisols, which are found in semiarid to humid environments, typically exhibit more moderate weathering and soil development. This soil tends to have low nutrient content, making it less productive (Nurdin, 2010). One study reported that the nitrogen content of Ultisol soil ranged from 0.30 – 1.16% (Sagiarti et al., 2020).

Soil Phosphorus

Data on Table 5, shows that the average soil phosphorus levels in weeks 0-6 were lower than in weeks 7-12. This indicates an increase in soil phosphorus levels over time. Overall, the average phosphorus content in Andosol soil was higher than in Ultisol, which was significantly different at the 5% level.

The difference in phosphorus levels in the two types of soil was caused by the physical and chemical properties of the soil. Ultisol generally reacts sourly and lacks essential nutrients including phosphorus. Meanwhile, Andosol soil is generally fertile because of its high organic and mineral content.

Andosol has a higher cation exchange capacity (CEC), so it is able to absorb and store phosphorus better than Ultisol. Phosphorus will be firmly bound to soil colloids so that it is not easily leached.

The increase in phosphorus levels occurred due to several factors, such as soil mineralization of organic matter and weathering. Soil mineralization contains a certain amount of phosphorus. Over time, organic material will be decomposed by soil microorganisms (mineralization), which can release phosphorus into available forms (Sari et al., 2017). Some minerals, such as apatite and other natural phosphates, will naturally decay to form more readily available organic phosphorus compounds. Weathering is influenced by climate factors, temperature, and biological activity.

Soil Potassium

Based on Table 6, Andosol soil potassium levels were on average higher than Ultisol at weeks 0-6, and at weeks 7-12 were relatively the same for both types of soil. There was a very significant decrease in potassium levels in both soil types from weeks 0-6 to weeks 7-12. On average, the overall potassium in Andosol and Ultisol soils was relatively the same.

The potassium content of Andosol was higher than that of Ultisol because the volcanic parent material in Andosol supported minerals that provide potassium, such as feldspar and mica (Baumgarten & Dörner, 2013). Andosol's high CEC capacity allows the prevention of potassium leaching, and the high organic material content plays a role in providing potassium through mineralization.

The decrease in potassium levels that occurred was due to potassium uptake by plants and fixation by clay minerals in Ultisol, which were slow to release available K. Meanwhile, the increase in potassium levels occurred because the rate of mineralization of organic matter and release of K from binders increased at high temperatures and high-water content, and there was a dynamic balance of plant K uptake and K release from the soil.

Nitrogen in Plant Tissue

Nitrogen is the main macronutrient and is very important for plant growth. Plants absorb nitrogen in the form of NO_3—or NH^{4+} ions. The average nitrogen content in plant tissue is 2-4% of its dry weight (Mukherjee, 1986). The results of research on the N content of calopo plants planted on two different types of soil are presented in Table 5.

Calopo planted in Ultisol soil was 2.523%, while the nitrogen content in plants planted in Andosol soil was 2.423%. However, statistically, the results show that there is no significant difference. These results indicate that the ability of calopo plants to absorb nitrogen in both types of soil is relatively the same. This is due to the plant's ability to fix nitrogen from the air. This ability is supported by plant root nodules, which contain rhizobium that can bind nitrogen from the air and convert it into a usable form by plants (Mahmud et al., 2020). Andosol has a higher soil nitrogen content than Ultisol. However, the nitrogen content in plant tissue was not significantly different, indicating that calopo plants have the ability to fix nitrogen from the air in sufficient quantities to meet their needs.

Forage Production

Forage production refers to the amount of forage plants produced for use as animal feed. Table 6 presents data on the average production of calopo forage planted on two different types of soil during the 90-day planting period.

Based on the data in Table 6, the fresh forage of calopo planted in Andosol and Ultisol soil was 44,650 grams/pot and 21,750 grams/pot respectively. Meanwhile, the dry weight of calopo planted in Andosol and Ultisol soil was 11.846 grams/pot and 5.907 grams/pot respectively. These results are higher than Susilawati et al. (2011) the fresh weight of calopo grown in pots for 3 months was 33.55 grams/pot.

The difference in forage production between Andosol and Ultisol soils was caused by a combination of several factors: soil nitrogen content, soil physical and chemical characteristics, and climate factors. Plants need nitrogen to produce protein, which is an important component in plant growth and development. A higher soil nitrogen content will give plants more nitrogen to grow and develop. (Sagala et al., 2022). Andosol soil has a looser texture, which makes it easier for plant roots to penetrate, and its high organic matter content makes the soil more fertile (Sukarman & Dariah, 2014).

The availability of water in the soil, which can be seen in the soil moisture level, will support the root system of plants. Healthy plant roots will be better able to absorb water and nutrients so that plants grow and develop well. Insufficient soil moisture can result in stunted growth and less than optimal crop yields (Vennam et al., 2023). Meanwhile, the right humidity level can support the development of the plant's root system, which in turn increases the absorption of plant nutrients (Flynn, et al. 2023).

According to Budianta (2022), the main absorption of nitrogen usually occurs through plant roots, using mass flow, diffusion and root interception mechanisms. In the process of absorption through mass flow, the moisture level in plant roots becomes crucial, while in absorption through diffusion, the concentration of nutrients in soil water plays a major role. In the root interception mechanism, direct contact between roots and nutrients plays a significant role, and the wider the plant roots, the greater the support for absorption efficiency.

Nitrogen Uptake

Table 10 shows the results of the T test on the forage production of calopo plants on the two types of soil showed significantly different results. This result was caused by the N uptake of both types of soil. The nitrogen uptake of calopo plants in Andosol soil was 0.247 grams/pot, which was higher than the nitrogen uptake in Ultisol soil, namely 0.149 grams/pot. The value of nitrogen in plant tissue s proportional to forage production or plant biomass. This is natural because nitrogen is a primary macro nutrient that plants really need for growth and development such as the formation of leaves, stems and roots. In contrast, plants grown on Ultisol have lower nitrogen content, which means lower forage production and nitrogen uptake.

Table 1. Andosol and Ultisol Soil Moisture t Test Results

Week	Soil Moisture		
	Andosol	Ultisol	T-count
	……………………………%……………………………		
0	51,745±5,167	46,630±4,528	3,330**
1	51,948±5,153	30,958±4,504	13,717**
2	57,793±8,193	44,663±5,203	6,050**
3	52,299±4,890	43,548±3,458	6,534**
4	51,655±7,196	42,750±4,539	4,681**
5	55,103±7,067	41,590±6,824	6,151**
6	52,869±5,636	47,050±4,304	3,670**
7	55,291±8,841	45,528±4,266	4,448**
8	49,505±6,016	44,033±4,163	3,345**
9	58,220±9,486	54,543±6,418	$1,436_{tn}$
10	49,078±8,925	43,355±6,740	2,288*
11	66,068±37,244	47,783±6,303	2,165*
12	45,375±10,817	35,403±7071	3,451**
Average	53,611±5,136	43,679±5,738	4,650**

note: *= significantly different at the 5% level of significance;
**= significantly different at the 1% level of significance; tn: not significantly different

Table 2. T Test Results for Andosol and Ultisol Soil Temperature

Week	Temperature		
	Andosol	Ultisol	T-count
	……………………………… ˚C ………………………		
0	23,245±1,301	26,619±1,164	-8,645**
1	24,356±1,273	27,023 ± 1,607	-5,817**
2	23,865 ± 0.982	26,173±1,276	-6,410**
3	21,514±1,213	25,980±1,343	-11,036**
4	21,893 ± 1,083	21.585 ± 0.523	1,143tn
5	20.889±0.494	21.575 ± 0.551	-4,146**
6	29,508±1,887	27,865±1,292	3,212**
7	21.321 ± 0.686	22,340 ± 0.891	-4,051**
8	19.466 ± 0.533	20.593 ± 0.591	-6,331**
9	19.521±0.500	20,340±0.797	-3,889**
10	27,955±1,118	26,600±0.800	4,409**
11	21.689 ± 0.806	22,853±1,237	-3,651**
12	28,470±1,282	26.905 ± 0.639	4,885**
Average	23,361±3,352	24,342±2,799	-0.810tn

note: **= significantly different at the 1% level of significance; tn: not significantly different

Table 3. Results of Andosol and Ultisol Soil pH t Test

Week	Soil pH		
	Andosol	Ultisol	T-count
	…………………………………………………………		
0	5.771 ± 0.359	5.875±0.259	-1,048tn
1	5.384 ± 0.347	5.263 ± 0.598	0.784tn
2	4.983 ± 0.491	4,700±0.238	2,314*
3	4.909 ± 0.427	4.860 ± 0.205	0.460tn
4	4.871 ± 0.437	4.748 ± 0.223	1,128tn
5	4.854 ± 0.438	4.745±0.247	0.967tn
6	4.889 ± 0.365	4.535 ± 0.198	3,815**
7	4.975±0.476	4,590 ± 0.135	3,481**
8	5.156 ± 0.354	4.773 ± 0.238	4,021**
9	5.019 ± 0.517	4.243 ± 0.196	6,281**
10	4.838±0.633	3.783 ± 0.319	6,655**
11	5.015±0.413	4.098 ± 0.312	7,993**
12	4.898±0.439	4.193 ± 0.460	4,955**
Average	5.043 ± 0.264	4.646 ± 0.533	2,405**

note: *= significantly different at the 5% level of significance;
**= significantly different at the 1% level of significance; tn: not significantly different

Table 4. Andosol and Ultisol Soil Nitrogen t Test Results

Week	Soil Nitrogen		
	Andosol	Ultisol	T-count
	……………………… % ………………….		
0	6,125±2,913	3,300±0.497	4,276**
1	6,088±2,929	3,200±0.377	4,372**
2	6,500±3,138	4.325 ± 0.520	3,058**
3	6,163±2,914	4,200±0.410	2,983**
4	6,075±2,796	4.150 ± 0.489	3,033**
5	6,100±2,646	4.125 ± 0.425	3,295**
6	6,188±2,599	4,100±1,107	3,304**
7	4,638±1,657	4.425 ± 0.634	0.536tn
8	3,513±1,317	4.075 ± 0.438	-1,813tn
9	3,313±1,808	4.575±0.693	-2,916**
10	2,775±1,118	4.225 ± 0.595	-5,120**
11	2.875 ± 0.901	4.225 ± 0.638	-5,467**
12	2,550±0.724	3.825 ± 0.654	-5,884**
Average	4,838±1,585	4.058 ± 0.401	1,722*

note: *= significantly different at the 5% level of significance;
**= significantly different at the 1% level of significance; tn: not significantly different

Table 5. Andosol and Ultisol Soil Phosphorus T-test Results

Week	Soil Phosphorus		
	Andosol	Ultisol	T-count
	……………………… % ………………….		
0	8,513 ± 3,911	4.400 ± 0.528	4. 660 **
1	8,125 ± 3,890	4,150 ±0. 462	4. 539 **
2	8,713 ± 4,246	5.67 5 ± 0.674	3. 160 **
3	8,388 ± 4,321	5.6 00± 0.6 41	2,854 **
4	8,113 ± 3,810	5.650 ± 0.813	2,827 **
5	8.0 00 ± 3.661	5.5 5 0 ± 0.724	2,936 **
6	8,313 ± 3,601	5.775 ± 0.924	3,052 **
7	6,075 ± 2,211	5,600 ± 1,561	0 ,785 tn
8	4,563 ± 1,756	5.2 5 0 ± 0.69 8	-1. 627 tn
9	4,488 ± 2,216	6,000 ± 0.973	- 2,795 **
10	3.725 ± 1.409	5.650 ± 0.919	-5.1 17 **
11	3.8 00 ±0.992	5.55 0 ±0.74 2	- 6,318 **
12	3.55 0 ±0.958	4.975±0.924	- 4,786 **
Average	6,490 ± 2,140	5.363 ± 0.544	1,839*

note: *= significantly different at the 5% level of significance;
**= significantly different at the 1% level of significance; tn: not significantly different

Table 6. Andosol and Ultisol Soil Potassium T-test Results

Week	Soil Potassium		
	Andosol	Ultisol	T-count
	……………………… % ………………………		
0	20,038 ± 8,974	12,300 ± 1,508	3,803 **
1	20,800 ± 10,048	11,200 ±0.97 9	4.25 3 **
2	22,625 ± 10,687	15,200 ± 1,601	3.07 3 **
3	21,325 ± 10,127	15,475 ± 1,617	2,551 **
4	20,713 ± 8,898	14,950 ± 1,919	2,831 **
5	20,850 ± 9,073	14,675 ± 1,688	2,992 **
6	21,913 ± 9,778	15,575 ± 1,583	2,861 **
7	15,725 ± 5,722	15,625 ± 2,133	0.073 tn
8	12,263 ± 4,322	13,700 ± 1,720	-1,382 tn
9	11,875 ± 5,672	16,075 ± 2,220	- 3,084 **
10	10,075 ± 3,529	15,250 ± 2,731	- 5,186 **
11	10,175 ± 2,456	14,975 ± 1,766	- 7,096 **
12	9,575 ± 2,148	13,225 ± 2,308	- 5,177 **
Average	16,825 ± 5,267	14,474 ± 1,450	1,552tn

note: *= significantly different at the 5% level of significance;
**= significantly different at the 1% level of significance; tn: not significantly different

Table 7. Calopo Plant Nitrogen t Test Results

Type of soil	Average …….%…….	T-Count
Andosol	2.423 ± 0.184	-1,129tn
Ultisol	2.523 ± 0.211	

note: *= significantly different at the 5% level of significance;
**= significantly different at the 1% level of significance; tn: not significantly different

Table 8. Fresh Weight t Test Results

Fresh Weight	Andosol	Ultisol	T-Count
	……. gram/pot ………		
Leaf	25,900 ± 4,315	12,500 ± 6,117	8,005**
Stem	18,750 ± 3,683	9,250 ± 5,524	6,339**
Root	28,050 ± 9,489	9,950 ± 5,491	7,383**
Fresh Weight of Forage (leaves + stems)	44,650±7,611	21,750±11,539	7,409**

note: *= significantly different at the 5% level of significance;
**= significantly different at the 1% level of significance; tn: not significantly different

Table 9. Dry Weight t Test Results

Dry Weight	Andosol	Ultisol	T-Count
	……. gram/pot ………		
Leaf	6,871 ± 1,507	3,367 ± 1,891	6,480**
Stem	4.9 75 ± 1.091	2,540 ± 1,427	6,064**
Root	5,757 ± 1,209	1.678 ± 0.870	12,245**
Dry Weight of Forage (leaves + stems)	11,846±2,599	5,907 ±3,318	6,303**

note: *= significantly different at the 5% level of significance;
**= significantly different at the 1% level of significance; tn: not significantly different

Table 10. Results of the T-test for Nitrogen Uptake of Calopo Plants

Type of soil	Average …..... grams/pot ………	T-Count
Andosol	0.247±0.033	4,182**
Ultisol	0.149±0.067	

note: **= significantly different at the 1% level of significance; tn: not significantly different

CONCLUSION

Based on the results and discussion it can be concluded that:

1. *Calopogonium mucunoides* planted in both types of soil have relatively similar plant nitrogen content, namely 2.423% for Andosol soil and 2.523% for Ultisol soil.
2. The production of fresh and dry forage *Calopogonium mucunoides* planted in Andosol soil was 44,650 grams/pot and 11,846 grams/pot. Meanwhile, the production of fresh and dry forage *for Calopogonium mucunoides* planted in Ultisol soil was 21,750 grams/pot and 5,907 grams/pot. The nitrogen uptake of *Calopogonium mucunoides plants* in Andosol soil is 0.247 grams/pot, higher than the nitrogen uptake in Ultisol soil, namely 0.149 grams/pot.
3. *Calopogonium mucunoides* plants can grow and produce better forage in Andosol soil.

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