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Percentage of Available Nitrogen Content Based on Total Nitrogen Content in Peanut Plantations Before Harvest Using Organic Fertilizer Treatment

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Abstract

The study aims to determine the effect of organic fertilizers (chicken manure and burnt rice husks) on the percentage of NH_4^+ and NO_3^-, and to determine the correlation between total N with available N, as well as the correlation between the total percentage of available N with the yield of peanut plants (Arachis hypogaea L.). The study used a Randomized Block Design consisting of 3 treatment levels, namely: P0 = without organic fertilizer or control, P1 = 16 tons of organic chicken manure fertilizer ha^{-1}, and P2 = 16 tons of organic burnt rice husk fertilizer ha^{-1}. The results of this study indicate that only a small portion of the total N-in the soil is in the form of available N with the percentage of total available N only ranging from 0.028% - 0.063%. The total percentage of available N in chicken manure (0.053%) was higher than that of burnt rice husk fertilizer (0.048%) and the control (0.040%). There was a strong and very strong positive linear correlation between total N with available N, and there was a fairly strong positive linear correlation between the total percentage of available N with the number of pods and pod weight per plant.

Keyword: Total N, available N, organic fertilizer, peanuts

INTRODUCTION

Nitrogen (N) is essential for plants to grow and develop, as it's involved in vital processes like photosynthesis, making proteins, and enzyme reactions (Hawkesford et al., 2024). For peanut plants (Arachis hypogaea L.), getting enough nitrogen is key for good yields and quality, even though they can naturally get nitrogen from the air with the help of Rhizobium bacteria (Giller &

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Cadisch, 2023). However, simply knowing the total nitrogen in a plant doesn't tell us how much of it is actually available for the plant to use in its daily functions. The available nitrogen is a much better way to gauge a plant's health and its potential to produce.

The increasing emphasis on sustainable agricultural practices has led to a growing interest in organic fertilizers as an alternative to synthetic chemical fertilizers. Organic amendments, such as compost, manure, and biochar, contribute to soil fertility by enhancing soil organic matter, improving soil structure, and providing a slow-release source of nutrients, including nitrogen (Liu et al., 2023). However, the dynamics of nitrogen mineralization and availability from organic sources can be complex and are influenced by various factors, including soil type, microbial activity, climate, and the specific type of organic material applied (Smith & Jones, 2022). Understanding the conversion of total nitrogen into available forms in the plant is crucial for optimizing organic fertilizer application rates and timing, thereby reducing nutrient loss and environmental impact.

Despite the known benefits of organic fertilizers in peanut cultivation, there remains a knowledge gap regarding the precise percentage of available nitrogen content relative to total nitrogen content in peanut plants, particularly in the critical pre-harvest stage. This information is vital for fine-tuning nutrient management strategies and ensuring that plants receive adequate nitrogen during their peak demand periods. Previous studies have primarily focused on total nitrogen accumulation or the impact of organic fertilizers on soil nitrogen pools (Wang et al., 2021; Chen & Li, 2020), but direct quantification of the available N fraction in the soil, especially in relation to the available N in the soil before harvest, in organic fertilization regimes, remains poorly documented.

The study aims to determine the effect of organic fertilizers (chicken manure and burnt rice husks) on the percentage of NH_4^+ and NO_3^- based on the total N nutrient content, and to determine the correlation between total N with NH_4^+ and NO_3^-, as well as the correlation between the total percentage of N-available with the yield of peanut plants (*Arachis hypogaea* L.). This information will help develop more sustainable and accurate nutrient management advice for peanut farmers. Ultimately, our findings will improve understanding of nitrogen movement in organically farmed peanut systems and support optimizing organic fertilization to boost yields while reducing environmental impact.

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METHOD

Research Location

This research was conducted on agricultural land owned by farmers in Toto Utara Village, Tilongkabila District, Bonebolango Regency. Nitrogen nutrient levels (total N, NH_4^+, and NO_3^-) were analyzed at the Soil Fertility Laboratory of Hasanuddin University, Makassar.

Materials dan Tools

The materials used in the study were Kancil variety peanut seeds, organic chicken manure and burnt rice husks, and chemicals for nitrogen analysis. The tools used were hoes, machetes, shovels, plastic bags, measuring tape, cutters, digital cameras, water hoses, analytical scales, and nitrogen analysis tools.

RESEARCH METHODS

This study used a Randomized Block Design (RBD) consisting of 3 treatment levels, namely: P0 = without organic fertilizer or control, P1 = 16 tons of chicken manure organic fertilizer ha^{-1} equivalent to 3 kg $plot^{-1}$, and P2 = 16 tons of burnt rice husk organic fertilizer ha^{-1} equivalent to 3 kg $plot^{-1}$. Each treatment was repeated 4 times (U1, U2, U3, U4) so that there were 12 research plots in the field. Each research plot contained 25 plants with 7 plants as samples.

Research Procedures

The study was conducted on plots measuring 1.25 m long and 1.50 m wide, with a total of 12 plots. Prior to planting the peanuts, chicken manure and burnt rice husks were evenly mixed into each experimental plot according to the treatment. Peanuts were planted in each plot with a spacing of 25 cm x 30 cm. Peanut yields were observed to determine the correlation between total available nitrogen content and the number of pods and peanut seed weight per hectare. At the end of the experiment (prior to harvest), soil samples were taken from each experimental plot for soil property analysis, including:

- Total Nitrogen
- Available Nitrogen (NH_4^+ and NO_3^-)

Data Analysis

Data analysis was conducted descriptively to see the differences between treatment levels so that the treatment that provided the highest percentage of NH_4^+ and NO_3^- (available N) nutrient levels in the soil could be identified. Regression–correlation analysis was conducted to study the

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relationship between total N nutrient levels with NH_4^+ and NO_3^- and between the total percentage of available N nutrient levels with the number of pods and pod weight of peanut plants per planting.

RESULTS AND DISCUSSION

The average levels of N nutrients (total N and available N) and the percentage of available N (NH_4^+ and NO_3^-) in each treatment and each replication are presented in Table 1.

Table 1. Percentage of Available N (NH_4^+ and NO_3^-) Based on Total N in Peanut Plants with Organic Chicken Coop and Burnt Rice Husk Fertilizer Treatments

Treatment	Nutrient Content (ppm)			% NH_4^+ Based on N-total	% NO_3^- Based on N-total	Total % N available Based on N total
	N-total	NH_4^+	NO_3^-			
P0U1	2700	0,37	0,38	0,014	0,014	0,028
P0U2	1700	0,47	0,34	0,028	0,020	0,048
P0U3	2300	0,56	0,53	0,024	0,023	0,047
P0U4	2600	0,50	0,43	0,019	0,017	0,036
Rata-Rata	**2325**	**0,48**	**0,42**	**0,021**	**0,019**	**0,040**
P1U1	2800	0,80	0,95	0,029	0,034	0,063
P1U2	3300	0,91	0,80	0,028	0,024	0,052
P1U3	4200	0,85	0,89	0,020	0,021	0,041
P1U4	3500	0,88	0,93	0,025	0,027	0,052
Rata-Rata	**3450**	**0,86**	**0,89**	**0,026**	**0,027**	**0,053**
P2U1	2900	0,72	0,65	0,025	0,022	0,047
P2U2	2800	0,74	0,55	0,026	0,020	0,046
P2U3	2800	0,89	0,65	0,032	0,023	0,055
P2U4	3100	0,74	0,59	0,024	0,019	0,043
Rata-Rata	**2900**	**0,77**	**0,61**	**0,027**	**0,021**	**0,048**

The data in Table 1 presents a detailed analysis of nitrogen content and its available forms (ammonium and nitrate) in peanut plantations under various treatments, denoted as P0, P1, and P2, each with four replicates (U1-U4). Understanding the partitioning of total nitrogen into its available forms, particularly ammonium (NH_4^+) and nitrate (NO_3^-), is crucial for assessing soil

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nitrogen status and optimizing nutrient management strategies, particularly in the context of organic fertilization (Wang et al., 2024; Smith & Jenkins, 2023).

Based on the data in Table 1. shows that a small portion of the total N-in the soil is in the form of available N with a total percentage of available N only ranging from 0.028% - 0.063%. The average percentage of available N (NH_4^+) in the control (P0) and cow manure (P2) tends to be higher (0.021% and 0.027%) compared to NO_3^- (0.019% and 0.021%), while in the chicken manure treatment (P2), the percentage of NH_4^+ and NO_3^- is almost the same, namely 0.026% and 0.027%. The tendency for a higher average percentage of NH_4^+ in the control compared to NO_3^- is caused by several factors, including immobilization, adsorption and leaching factors. NH_4^+ tends to be more easily immobilized by microorganisms due to its positively charged structure so that it can be adsorbed on soil colloids, while negatively charged NO_3^- is more easily leached from the soil profile causing NO_3^- to be lower compared to NH_4^+. In the cow manure treatment, the average percentage of NH_4^+ tends to be higher than NO_3^- because after cow manure is applied to the soil, organic nitrogen in cow manure must go through a mineralization process by soil microorganisms to be converted into an inorganic form that can be absorbed by plants. The first step of this mineralization process is ammonification, where organic nitrogen is converted into ammonium (NH_4^+) and this process occurs relatively quickly after the manure is applied.

Ammonium (NH_4^+), being a positively charged ion, has a strong affinity for negatively charged sites on soil colloids, such as clay particles and soil organic matter (Wang et al., 2024; Smith & Jenkins, 2023). This adsorption largely immobilizes NH_4^+ within the soil matrix, making it less prone to leaching than NO_3^-. Furthermore, NH_4^+ is readily assimilated by soil microorganisms through a process known as microbial immobilization (Peters & Grant, 2023). Microorganisms rapidly take up NH_4^+ from the soil solution to meet their metabolic demands, incorporating it into their biomass (e.g., proteins, nucleic acids). This process effectively "locks up" nitrogen in organic forms, temporarily reducing its availability for plant uptake but also preventing its loss from the system (Davies & Clarkson, 2024). In systems with high microbial activity or readily decomposable organic carbon, microbial immobilization can be a dominant pathway for NH_4^+ retention, leading to its higher proportion relative to NO_3^-.

The average percentage of NH_4^+ (0.025%) is almost the same as NO_3^- (0.026%) with the chicken manure treatment because the soil system is in a relatively balanced condition in terms of the nitrogen cycle. The impact of the balance between NH_4^+ production (from ammonification) and NH_4^+ consumption to form NO_3^- (by nitrification) will result in a relatively balanced concentration of both forms of inorganic N in the soil solution. When chicken manure is applied, the initial rapid release of NH_4^+ through ammonification fuels the subsequent nitrification process.

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The relative equilibrium between NH_4^+ and NO_3^- observed in your P1 treatment indicates that the rate of NH_4^+ production from ammonification is closely matched by its consumption for NO_3^- formation through nitrification. This leads to relatively stable concentrations of both inorganic N forms in the soil solution, making them consistently available for plant uptake (Yarafert, 2024; MDPI, 2022). The amount of available N nutrients (NH_4^+ and NO_3^-) in the soil is related to the total N nutrient content dan yield production. The relationship between total N nutrient levels and the average of NH_4^+ and NO_3^- is presented in Figure 1.

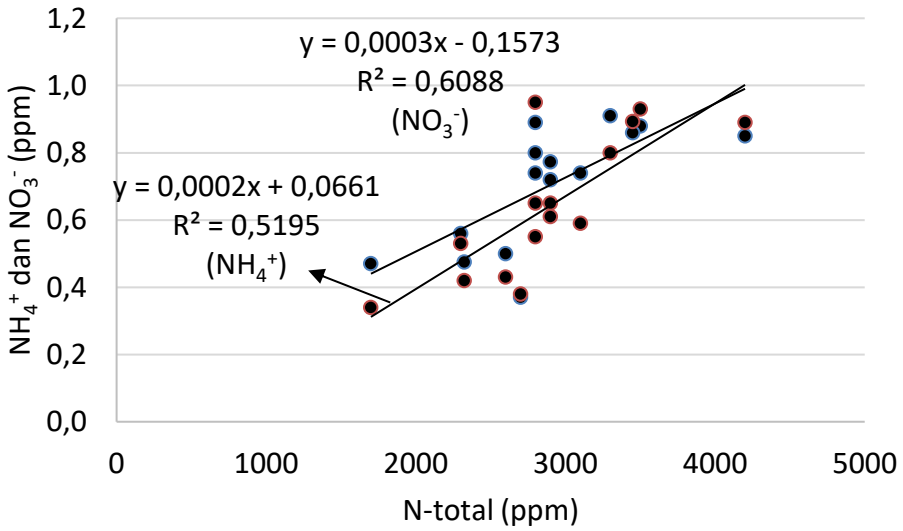


Figure 1. Relationship between Total N Nutrient Content and Available N Nutrient Content

The regression line equation Y = 0.0002X + 0.0661 explains that every 1 ppm increase in total N nutrient levels will result in an increase in available N nutrient levels (NH_4^+) of 0.0002 ppm and NO_3^- of 0.0003 ppm. The coefficient of determination R2 = 0.5195 and 0.6088 means that 51.95% of the variation in available N in the form of NH4+ and 60.88% of the variation in available N and NO_3^- can be explained by the presence of total N. The correlation coefficient values derived from the coefficient of determination values of 0.7208 and 0.7803 respectively indicate a strong and very strong positive correlation between total N nutrient levels and available N levels NH_4^+ and NO_3^-.

The Relationship Between total Nitrogen and available Nitrogen in Soil-Plant Systems In agricultural and ecological contexts, understanding the relationship between total nitrogen (N-total) and available nitrogen is fundamental for optimizing plant nutrition and minimizing environmental losses. While N-total represents the entire nitrogen pool within a system (whether

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soil or plant tissue), only a fraction of this total is immediately accessible and utilized by plants. Total nitrogen in the soil primarily exists in organic forms, often comprising over 90-98% of the total N (Hill Labs, n.d.; GRDC, 2013). This organic N is integrated into soil organic matter, microbial biomass, and plant residues. Similarly, within plant tissues, total nitrogen includes all nitrogen incorporated into proteins, nucleic acids, chlorophyll, and other organic compounds (Hawkesford et al., 2024). While essential as a long-term reservoir, organic nitrogen is unavailable for direct plant uptake (UMinnesota Extension, n.d.). It must first undergo transformations to become available. Measuring N-total in soil provides an indicator of the soil's overall nitrogen fertility and long-term potential to supply N, but it does not reflect the immediate supply to crops (AgroCares, 2023).

The relationship between the total percentage of available N nutrient content and the number of pods and seed weight of peanut plants is presented in Figure 2.

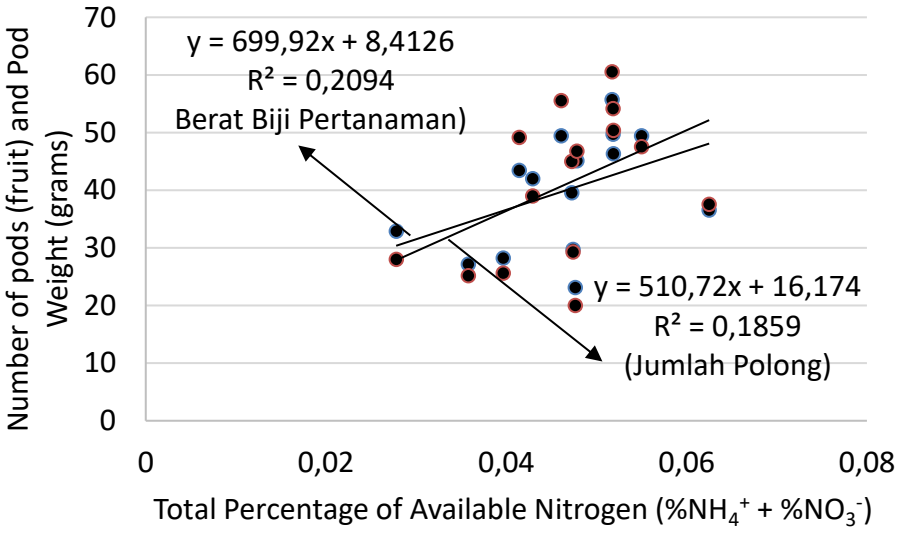


Figure 2. Relationship between Total Percentage of Available N Nutrient Content (NH_4^+ and NO_3^-)

The regression line equation Y = 699.92X + 8.4126 explains that every 0.01 unit increase in the Total Percentage of Available N Nutrient Content (NH4+ and NO3-) will result in an increase in the number of pods by 6.99 and seed weight by 5.11 grams. The coefficient of determination R2 = 0.2094 and 0.1859 means that 20.94% of the variation in seed weight per crop and 18.59% of the variation in the number of pods can be explained by the total percentage of available N in the soil. The correlation coefficient values derived from the coefficient of determination values of

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0.4576 and 0.4312 respectively indicate a fairly strong positive correlation between the total percentage of available N nutrient content with the number of pods and seed weight per crop of peanut plants.

The number of pods per plant is a major yield component in peanuts, directly influencing overall productivity. An adequate supply of available nitrogen during critical growth stages, particularly from flowering through pod initiation and development, is crucial for maximizing pod set. Sufficient available N promotes robust vegetative growth, leading to a larger plant canopy and more branches, which provide a greater number of potential flowering sites (Bell and Wright, 2023). A well-developed vegetative structure acts as a "source" for assimilates that are later translocated to the developing "sink" organs, the pods. Studies have consistently shown a positive correlation between early-season N availability and subsequent branching and flowering intensity in peanuts (Gao et al., 2024; Smith & Jones, 2023).

Adequate N ensures the optimal development of flowers and subsequent pegs (gynophores), which penetrate the soil to form pods. Nitrogen plays a vital role in the synthesis of proteins, enzymes, and hormones necessary for these complex reproductive processes (Hawkesford et al., 2024). Insufficient available N can lead to flower abortion and poor peg formation, ultimately reducing the number of pods.

Beyond the number of pods, the weight of individual pods (often reflecting seed size and fullness) is another critical determinant of peanut yield and quality. Available nitrogen significantly influences the partitioning of assimilates and the overall metabolic efficiency required for pod filling. Nitrogen is a key component of chlorophyll and enzymes involved in photosynthesis. Higher available N levels often translate to more efficient photosynthesis, leading to greater production of carbohydrates (sugars) in the leaves (source organs) (Miller & Weaver, 2023). These carbohydrates are then translocated to the developing pods (sink organs) for seed development and oil synthesis, contributing directly to pod weight (Chen & Wang, 2024). Adequate available N facilitates the efficient translocation of other essential nutrients (like phosphorus and potassium) from vegetative tissues to the developing pods. Nitrogen's role in protein synthesis is crucial for the formation of transport proteins that move these nutrients throughout the plant (Liu et al., 2024). During the pod-filling stage, high demand for nitrogen supports the synthesis of storage proteins and oils within the developing seeds, directly impacting their size and weight. A sustained supply of available N throughout this period is essential to prevent premature senescence and ensure complete pod filling (J. Exp. Bot., 2023). Insufficient available N during this critical phase can lead to smaller, shriveled kernels and reduced pod weight, even if the pod number is high.

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CONCLUSION

Based on the research results, it can be concluded that only a small portion of the total N in the soil is in the form of available N (ranging from 0.026% to 0.063%). The total percentage of available N in chicken manure (0.053%) was higher than that in burnt rice husk fertilizer (0.048%) and the control (0.040%). There was a strong and very strong positive linear correlation between total N and NH_4^+ and NO_3^-, and a fairly strong positive linear correlation between the total percentage of available N and the number and weight of pods per plant.

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