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ESTIMATION OF NITROGEN CONTENT IN SUGARCANE USING GREEN NORMALIZED DIFFERENCE VEGETATION INDEX (GNDVI)

ESTIMASI KANDUNGAN NITROGEN MENGGUNAKAN METODE GREEN NORMALIZED DIFFERENCE VEGETATION INDEKS (GNDVI) DI TANAMAN TEBU

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ABSTRACT

Sugarcane is one of the main plantation crops in Kapanewon Sedayu, Bantul Regency, D.I. Yogyakarta. However, its production has declined because of the limited nitrogen. Nitrogen is an important element that improve crop growth, development, quality, and productivity of sugarcane. The GNDVI is very sensitive to chlorophyll content and is also applicable for estimating the nitrogen status in crop (45). The objectives of this study were to assess the relationship between GNDVI with sugarcane tissue N content from drone image, create a forecast model and map the N content. The study was carried out at the Gunong Ombo Plantation, Argomulyo, Sedayu, Bantul, Yogyakarta with quantitative descriptive method. Forty-five sampling points were set (30 for prediction, and 15 for reference). The leaves that were sampled are a representative of the way in which nitrogen is provided to the 5-month-old sugarcane, and the samples were submitted to the analysis of their nitrogen contents using the method of Kjeldahl. Correlation, linear regression and paired t-test were used to analyze the relationship between GNDVI and tissue nitrogen content. The high correlation (r = 0.89) between the results is obtained with a coefficient of determination (R^2 = 0.78), and regression equation y = 4.75x + 0.60. References for nitrogen and predicted and reference nitrogen were nonsignificant by paired t-test. This model can also assist precision agriculture in site-specific nitrogen management to enhance the efficiency and sustainability of fertigation.

Keywords: ***Drone, GNDVI, Kjeldhal, Nitrogen, Sugarcane***

ABSTRAK

Tanaman tebu merupakan salah satu komoditas perkebunan yang banyak dibudidayakan di Kapanewn Sedayu, Bantul. Namun, produksi tebu mengalami penurunan diduga akibat kekurangan unsur nitrogen. Nitrogen diperlukan tanaman tebu dalam pertumbuhan, perkembangan, dan peningkatan kualitas. GNDVI merupakan indeks vegetasi yang peka terhadap kandungan klorofil. Penelitian ini bertujuan untuk mengetahui korelasi GNDVI dengan kandungan N jaringan tanaman tebu berdasarkan analisis citra *drone*, membangun model estimasi kandungan N jaringan, serta menghasilkan peta estimasi N jaringan pada tanaman tebu. Penelitian dilakukan di Kebun Gunung Ombo, Argomulyo, Sedayu, Bantul, D.I Yogyakarta dengan metode deskriptif kuantitatif. Terdapat 45 titik sampel (30 titik untuk prediksi dan 15 titik sebagai acuan). Sampel daun diambil pada pelepah ketiga pada tanaman tebu yang berusia 5 bulan. Semua sampel kemudian dianalisis untuk mengetahui kandungan nitrogen jaringan menggunakan metode Kjeldahl. Hubungan antara indeks vegetasi GNDVI dengan nilai nitrogen jaringan dilakukan uji korelasi *Pearson Product Moment*, uji regresi, dan Uji-t. Hasil penelitian menunjukkan bahwa GNDVI berkorelasi sangat kuat dengan nitrogen jaringan tanaman tebu (r = 0,896). Nilai koefisien determinasi atau (R^2) diperoleh sebesar 0,7891 dengan persamaan regresi y = 4,7507x + 0,6012. Hasil uji-t nilai prediksi nitrogen jaringan tanam tebu dengan nilai acuan nitrogen jaringan tanaman tebu menunjukkan tidak beda nyata. Hasil peta estimasi dapat digunakan sebagai pendukung manajemen pemupukan nitrogen pada tanaman tebu di daerah penelitian.

Kata kunci: ***Drone, GNDVI, Kjeldahl, Nitrogen, Tebu***

INTRODUCTION

Sugarcane (*Saccharum officinarum L.*) is the main ingredient in the sugar industry as a source of carbohydrates. According to data from the (Central Statistics Agency, 2023), sugarcane production in the Special Region of Yogyakarta decreased 273 tons in 2022-2023. Bantul Regency, the largest contributor, also saw a 13% decline compared to the previous year, including Sedayu District, whose production decreased 161.32 tons in 2023. This decline in production was influenced by various factors, such as pests and diseases, natural disasters, suboptimal fertilizer management and the type of soils, which typically have low total nitrogen (Koli et al., 2021).

Nitrogen (N) is a necessary macronutrient responsible for vegetative growth of sugarcane, and contributes most to the formation of leaves, stems, roots and tillers. This is an element that is essential in the production of chlorophyll for photosynthesis, amino acids and protein. However, N fertilizer application must be precisely targeted, based on soil or leaf analysis (Peraturan Menteri Pertanian No. 53, 2015). Nitrogen fertilization is commonly carried out using fertilizer packages available on the market. The doses provided in these packages are based on national recommendations and soil plant tissue analyses conducted every five years (Cavill et al., 2015). Nevertheless, type of fertilizer packages are ineffective the actual nutrient demand for the crop and will be either in excess or deficit as compared to plant’s requirement (Endrizal and Bohihoe, 2004). This requires a yearly test of the required amount of fertilizer to be spread in order to best suit field specifics. Traditional methods such as soil and leaf based analysis are costly, time-consuming and labor intensive but cover very small area (Mahajan et al., 2016). Consequently, these methods are unsuitable for large scale plantations management.

In recent year, the development of technology has made drones and GNDVI (Green Normalized Difference Vegetation Index) analysis a alternative method. This technique is non-destructive and can be used to scan large areas with crop condition data near real-time. GNDVI is an ‘index indicative of crop greenness or photosynthetic capacity’, which uses bands that are very sensitive to the green (Gitelson et al., 1999). According to Cheng et al. (2025), GNDVI has a strong positive relationship with leaf nitrogen due to the fact that N is the main factor affecting chlorophyll concentrations, which in turn modifies green and NIR reflectance sensed by the index. It is reportedly more sensitive to leaf greenness of chlorophyll compared to the NDVI (Armita et al., 2022). Based on Hagn et al. (2025), sensors and; remote sensing – based (sensor) monitoring allow for site-specific N fertilizer management (VRA), with rates being adjusted to field-scale spatial variations thereby increasing the obvious efficiency of in comparison to a uniform application. However, research on uav-based gndvi to estimate nitrogen in sugarcane under Indonesian field conditions is limited. Accordingly, this research aimed to determine the level of Nitrogen substance content in sugarcane plants by using remote sensing technique with drone and GNDVI measurements at Gunung Ombo Plantation, Argomulyo, Sedayu, Bantul, DIY. The conclusion of this study can offer good guidance to help farmers in resorting to N-status of plant, provide a reference for current fertilization practices and lay the foundation to utilize RS technology in specific agriculture sector.

MATERIALS AND METHODS

The research was carried out from April 2025 to June 2025, at Gunung Ombo Plantation, Argomulyo Village, Sedayu Sub-district, Bantul Regency of Special District of Yogyakarta. Laboratory analyses were carried out at the Soil Resources Laboratory, Universitas Pembangunan Nasional "Veteran" Yogyakarta.

The tools used in this study included a drone DJI Phantom 4 Pro v2, mobile phone, GPS device, knife, plastic bags, markers, soil auger, icebox, laptop, ArcGIS 10.8 software, SPSS Statistics 26, soil sieve, oven, grinding machine, 0.5 mm filter paper, digital balance, and fume hood. The materials used leaf samples, soil samples, concentrated sulfuric acid (H_2SO_4) p.a., concentrated hydrogen peroxide (H_2O_2, 30%) p.a., and distilled water.

This study employed a quantitative descriptive method consisting of two stages: a pre-survey and the main survey. The pre-survey was conducted to collect supporting data through interviews with farmers and to determine sampling points using a systematic grid method based on field homogeneity with a total of 45 points (Figure 1), comprising 30 regression points and 15 reference points, with a spacing of 30 m between points.

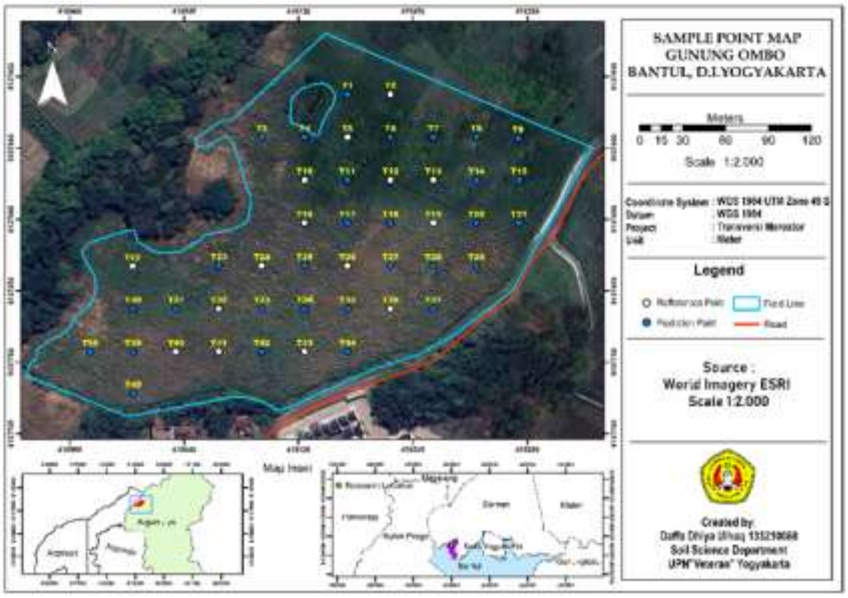

Figure 1. Map of Sampling Points in the Research Area

The main survey involved aerial photography and leaf sampling. Leaf samples were collected from the third sheath of five-month-old sugarcane plants at the predetermined sampling points, and nitrogen content in plant tissue was subsequently analyzed in the laboratory using the Kjeldahl method.The leaf vegetation index was calculated using the Green Normalized Difference Vegetation Index (GNDVI), derived from drone DJI Phantom 4 Pro v2 (RGB Camera) taken at an altitude of 80 m by combining green and red spectral bands to measure leaf chlorophyll levels.

$$GNDVI = \frac{(Green - Red)}{(Green + Red)} \quad (1)$$

Description
GNDVI = Green Normalized Difference Vegetation Index
Green = Reflectance value of the green band
Red = Reflectance value of the red band

Laboratory data were then used in a correlation test to evaluate the strength of the relationship between GNDVI values and nitrogen content using SPSS-26.

$$r = \frac{n \sum xy - (\sum x)(\sum y)}{\sqrt{\{n \sum_x 2 - (\sum x)^2\}\{n \sum_y 2 - (\sum y)^2\}}} \quad (2)$$

Description
R = Pearson correlation
n = Number of paired data (X and Y)
$\sum x$ = Total value of variable X
$\sum y$ = Total value of variable Y
$\sum x^2$ = Squared total value of variable X
$\sum y^2$ = Squared total value of variable Y
$\sum xy$ = Total product of variable X and variable Y

The GNDVI values and the results of tissue nitrogen (N) analysis were used in a linear regression to determine the extent of the influence of GNDVI on nitrogen content as the basis for prediction.

$$y = a + bx \quad (3)$$

Description
a = Constant
b = Regression coefficient (positive or negative effect)
y = Dependent variable
x = Independent variable

A paired t-test was used to examine the significance of differences between the reference values and the predicted nitrogen values.

$$t = \frac{\overline{D}}{\frac{SD}{\sqrt{N}}} \quad (4)$$

Description
t = Calculated t-value
$\overline{D}$ = Mean difference between paired samples 1 and 2
SD = Standard deviation of paired samples 1 and 2
N = Number of samples

RESULTS AND DISCUSSION

A. General Situation of the Area

Kemusuk Kidul located in Argomulyo Village, Sedayu Sub-district, Bantul Regency, Special Region of Yogyakarta. Cooordinates between 110° 16′ 48″ E and 7° 47′ 33″ S. The sub-district covers an area of 85.14 hectares at an elevation of 82.64 m above sea level. The area is bordered by Kemusuk Lor Hamlet and Tiwir Hamlet to the north, Gubug Hamlet to the east, Karanglo Hamlet and Panggang Hamlet to the south, and Srontakan Hamlet to the west. Analysis of rainfall data over the past ten years (2015–2024) according Badan Pusat Statistik (2025) shows an average of 1,671.06 mm/year with a rainfall coefficient (Q) of 1.16, classifying the area as climate type E (semi-dry) according to Schmidt-Ferguson. This climatic condition is characterized by a longer dry season compared to the wet season, leading to limited groundwater availability. Nevertheless, the average rainfall and air temperature of approximately 26°C remain suitable for sugarcane growth.

According to the soil type map published by the Badan Perencanaan Pembangunan Daerah Istimewa Yogyakarta (2022) at a scale of 1:100,000 (2022), the dominant soil type in Kemusuk Kidul is grumusol, formed from the weathering of limestone, tuff, alluvial deposits, and volcanic ash. It is gray to black in color and fertile, but it has detrimental shrink-swell characteristics due to its abundance of 2:1 clay minerals. Grumusols are typically slightly to moderately acidic (pH 6–8.2), relatively low in organic C (1.7–2.31%) and low-medium in nitrogen status (Rovira et al., 1989). The land appears to be vulnerable from erosion, suffers from slow water movement, and forms cracks when the dry period ensues (Nursyamsi et al.,2017).

B. Results of GNDVI and Plant Tissue Nitrogen Analysis

1. Land Management

Sugarcane crops at Gunung Ombo Farm have been managed since 2012 on an area of approximately 5 hectares. At the time of the study, the sugarcane was 5 months old. Based on the 2024 assessment, sugarcane production at Gunung Ombo Farm amounted to 725 quintals/ha. Land management at the research site varied. Based on interviews with local farmers, land cultivation was divided into east and west blocks, as shown in Figure 2.

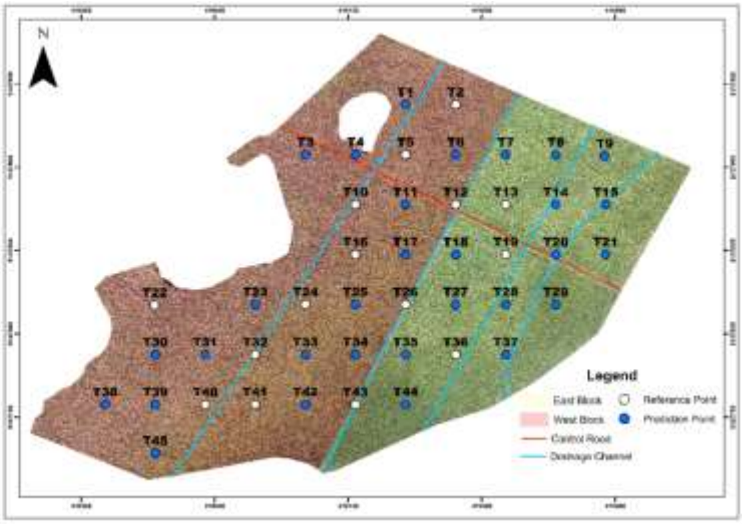

Figure 2. Block Division in the Research Area

The most distinguishing treatment is the creation of drainage channels in each block. In the east block, the drainage channels are optimally constructed, while in the west block, the drainage channels are not yet optimal, causing the soil to become waterlogged. This is because the east block is closer to the irrigation source. Planting distance also differs between blocks, the east block has a distance of 1.1 m, while the west block has a planting distance of 1 m. Fertilizer is applied twice: the first application as base fertilizer is given before planting, and the second application is given when the plants are approximately 1.5–3 months old. The fertilizers used are ZA and Pelangi.

2. Green Normalized Difference Vegetation Index Value

Aerial imagery was captured on May 7, 2025, using a drone at 80 m altitude, generating 588 photographs processed to calculate GNDVI values. The GNDVI analysis results were then classified based on vegetation greenness levels within the study area, with vegetation index values ranging from –0.098 to 0.428 (Figure 3). Values below 0 were interpreted as non-vegetation objects such as water bodies and roads, while values between 0 and 1 were interpreted as vegetation (Table 1).

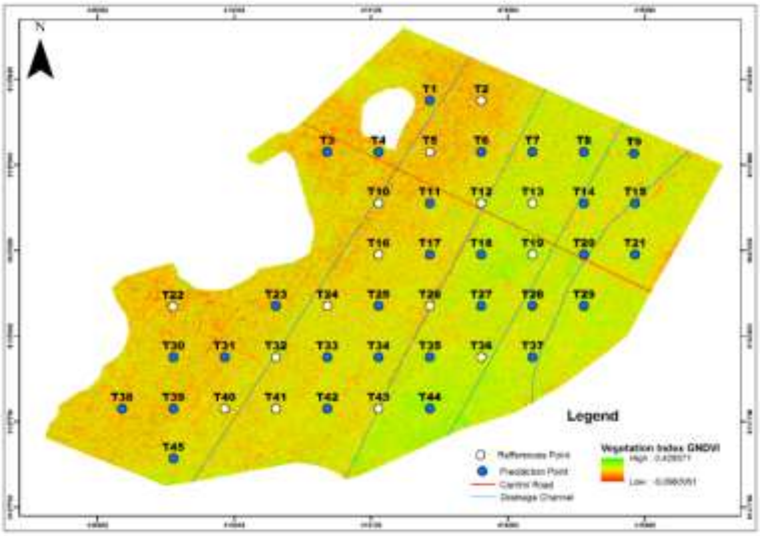

Figure 3. GNDVI Processing Results

Table 1 Class Division Based on GNDVI Values

Indication	Value
Inanimate objects such as roads, buildings, and soil	<0
Unhealthy Plants	0 – 0,33
Healthy Plants	0,33 – 0,66
Very Healthy Plants	0,66 – 1

Source : Dronedeploy (2017)

Based on the results of the GNDVI vegetation index classification at the sample points (Table 2), it was found that the sugar cane fields in Kemusuk Kidul Hamlet were dominated by the "Unhealthy Plants" class at 69% and "Healthy Plants" at 31%. Most of the domination in Figure 2 is done by the east block for "Unhealty Plants" and west block (Figure 2) is interested by plants, which are healthy.This condition offers a considerable variation in sugarcane plant health at the study location and should be useful as a tool for evaluating sugarcane field-plant growth conditions and for treatment consideration on more proper fertilizing schedule and land utilization.

Table 2 Results of GNDVI and Nitrogen Content in Plant Tissue

Sample Point	Indeks Vegetation Value	Classification*[1]	Plant Tissue Nitrogen (%)	Category*[2]
1	0.111	Stressed Plant	1.40	Low
2	0.117	Stressed Plant	1.40	Low
3	0.09	Stressed Plant	0.85	Low
4	0.126	Stressed Plant	1.67	Low
5	0.16	Stressed Plant	1.83	Low
6	0.149	Stressed Plant	1.80	Low
7	0.338	Healthy Plant	2.16	Medium
8	0.42	Healthy Plant	2.98	High
9	0.42	Healthy Plant	2.92	High
10	0.31	Stressed Plant	1.99	Medium
11	0.13	Stressed Plant	1.03	Rendah
12	0.37	Healthy Plant	2.26	Medium
13	0.42	Healthy Plant	2.92	High
14	0.32	Stressed Plant	2.01	Low
15	0.31	Stressed Plant	1.95	Low
16	0.12	Stressed Plant	1.43	Low
17	0.07	Stressed Plant	1.22	Low
18	0.38	Healthy Plant	2.37	Medium

19	0.39	Healthy Plant	2.57	Medium
20	0.22	Stressed Plant	1.85	Low
21	0.30	Stressed Plant	1.79	Low
22	0.12	Stressed Plant	1.22	Low
23	0.11	Stressed Plant	1.18	Low
24	0.15	Stressed Plant	1.31	Low
25	0.17	Stressed Plant	1.28	Low
26	0.2	Stressed Plant	1.70	Low
27	0.29	Stressed Plant	1.78	Low
28	0.36	Healthy Plant	2.03	Medium
29	0.41	Healthy Plant	2.43	Medium
30	0.14	Stressed Plant	1.24	Low
31	0.14	Stressed Plant	1.26	Low
32	0.19	Stressed Plant	1.29	Low
33	0.24	Stressed Plant	1.40	Low
34	0.29	Stressed Plant	1.31	Low
35	0.33	Healthy Plant	2.42	Medium
36	0.414	Healthy Plant	2.70	High
37	0.42	Healthy Plant	3.22	High
38	0.12	Stressed Plant	1.24	Low
39	0.147	Stressed Plant	1.24	Low
40	0.2	Stressed Plant	1.25	Low
41	0.318	Stressed Plant	1.85	Low
42	0.25	Stressed Plant	1.79	Low
43	0.36	Healthy Plant	2.15	Medium
44	0.39	Healthy Plant	2.27	Medium
45	0.203	Stressed Plant	1.32	Low

*[1]) Source : Dronedeploy, (2017)

*[2]) Source : Bryson and Milis, (2015)

3. Nitrogen Content in Plant Tissue

According to Table 1 the nitrogen content of sugarcane plant tissue were more in "Low" with 64.45% (29 samples), whereas, in other two classes was 32 ug sample-1 and those number is also been found in medium class as well but other five samples were placed on the high class for nitrogen. And the determination results were displayed as Nitrogen Distribution Map in plant based on ArcGIS 10.8. The map of distribution of N is shown in Figure 4.

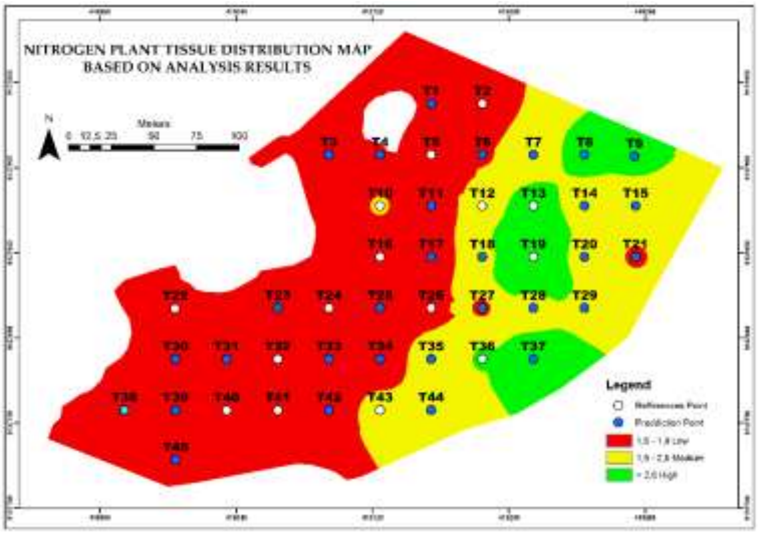

Figure 4. Distribution of Plant Tissue Nitrogen Based on Laboratory Analysis

The low nitrogen concentration in sugarcane is due to many reasons. First, nonuniform spacing is present among blocks (eastern block = 1.0 m apart vs western block = 1.1 m) of the rows studied in these two experiments. Plants grown closer together compete for light, water, and nutrient resources and may impact N uptake. Arif et al. (2016) found that wider spacing have a significant effect on stem diameter, number of tillers, internodes length and leaf area and Harjadi (1991) underlines the interspace causes competition on drought and nutrients plant uptake which has an impact on growth and yield. It is also important with regard to spacing of the male plants. The drainage in the eastern block was relatively good, while in the western block several channels were buried with soil and therefore did not allow water to flow through. Drainage is crucial for preserving water availability of nutrient in vegetation, especially during the dry season when clay soils can show a tendency to crack and impair root growth (Ardiansyah, 2015).

The variation in use of seedlings in the Block seems to be another cause for Nitrogen. The eastern block was planted with new seedlings with higher energy and nutrient reserves, while ratoon seedlings that were grown from the remaining roots of previous crops which had limited supply of nutrients were used in the western block (Paul, 2013 in Maharani, 2024). Ratoon regime is relatively more economical as it eliminates the need to purchase seedlings and perform land preparation, though with reduced productivity. Too frequent ratooning reduces both; yield and sugarcane quality, which might have national level consequences on sugar production-related parameters. As a consequence, ratooning is only recommended for up to the third generation (Kadarwati et al., 2015). Therefore, low nitrogen content in Gunung Ombo Plantation was due to interaction of the technical cultivation with the drainage condition and seedling type.

4. Correlation Test

The analysis using SPSS 26 and the Pearson Product Moment method revealed a correlation coefficient of r = 0.896 (Table 3) which is in the category of “very strong” (Sugiyono, 2014). The positive value of the coefficient, however, means that with increase in GNDVI values, higher will be the nitrogen content in the plant tissue of sugarcane. These findings harmonize with Mahrus (2020) that reported GNDVI has a high relation to nitrogen content of nutrients. Earlier study by Gholizadeh et al. (2015) also highlighted a good relationship between the GNDVI vegetation index and chlorophyll, whereas Gitelson et al. (1996) emphasized that GNDVI is a better index in detecting chlorophyll concentration than NDVI, which was directly related to nitrogen. Hence, results of this study further buttress the evidence that GNDVI can serve as a potent proxy for estimating N concentrations in sugarcane.

Table 3. Correlation Test Result

		Correlation GNDVI	Nitrogen Content Plant
GNDVI	Correlation Coefficient	1	0.896
	Sample Size	45	45
Nitrogen Content Plant Tissue	Correlation Coefficient	0.896	1
	Sample Size	45	45

The relationship of GNDVI (x) to plant tissue nitrogen content (y) was highly positive, as the outputs indicated, as reflected by an R^2 value 0.7891. According to Chin (1998), the value can be classified as “strong”, indicating that 78.91% of the variation of nitrogen content in sugarcane can be explained by GNDVI. Mahrus (2020) who reported an even hidger coefficient of determination (R^2 = 0.93) derived from drone imagery. Therefore, the present findings substantiate of effectiveness of GNDVI as an accurate tool for nitrogen estimation in sugarcane through remote sensing technologies.

5. Paired Sample T-Test

A paired sample t-test was applied in this study to determine whether there was a significant difference between the predicted plant tissue nitrogen values and the reference values. The test was conducted at a 5% significance level (α = 0.05), where the decision criterion was that H_0 is accepted if the significance value is greater than 0.05 and rejected if it is less than 0.05 (Ghozali, 2016). The results of the t-test (Table 4) showed a significance value of 0.509, which is greater than 0.05.

Table 4 Paired Sample T-Test

Sample Point	Predicted Plant Tissue Nitrogen (%)	Reference Plant Tissue Nitrogen (%)
T2	1,15	1,40
T5	1,36	1,83
T10	2,07	1,99
T12	2,37	2,26
T13	2,59	2,92
T16	1,17	1,43
T19	2,45	2,57
T22	1,17	1,22
T24	1,31	1,31
T26	1,5	1,70
T32	1,50	1,29
T36	2,5	2,70
T40	1,55	1,25
T41	2,11	1,85
T43	2,31	2,15
Mean	1,81	1,86
Standard Deviation	0,551	0,562
Standard Error of the Mean	0,143	0,145
Significance Value	0,509*	
α	= 0,05 (5%)	

Thus, H_0 is accepted and Ha is rejected, which means that there is no significant difference between the average plant tissue nitrogen content obtained from prediction and the reference values. This indicates that the regression model y = 4.7507x + 0.6012 is valid and feasible to be used for estimating nitrogen content in sugarcane, as the predicted results did not differ significantly from the reference data.

6. Development of Estimation Model

Prediction map of sugarcane plant tissue nitrogen was created by substituting the values obtained in equation 4.7507x + 0.6012 into ArcGIS with raster calculator. This conversion resulted in estimate for nitrogen content of sugarcane plant tissue in the field. Results of the modeling show that nitrogen in the plantation followed min-max distribution with a range between 0 and 5.35 and had coefficient of determination (R^2) 0.7891. This means that about 78.91% of the variation can be explained by GNDVI values, and the rest variation is affected by other factors not included in the model. The spatial distribution map showed a large variation with most regions at low to medium nitrogen levels and only small portion filled of high nitrogen levels (Figure 6).

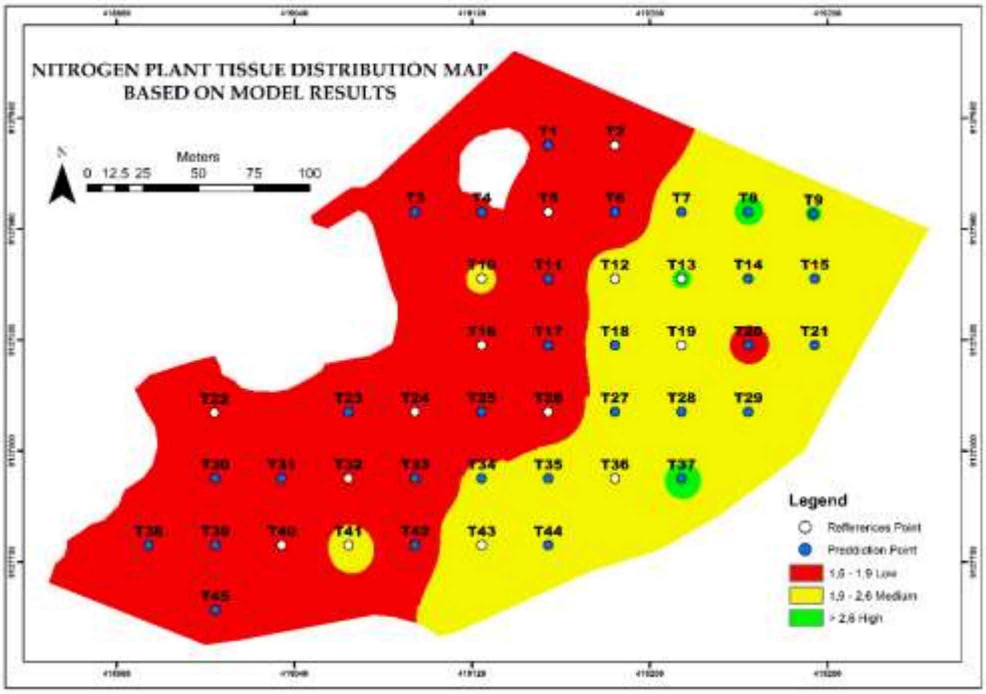

Figure 6. Map of Estimated Nitrogen Plant Tissue in Sugarcane

Based on the nitrogen status map, the field was divided into three types: low (1.6%–1.9%,24 sampling points), medium (1.9%–2.6%,17 sampling points) and high (>2.6%,4sampling points). Low-nitrogen zones, shown as red colors, were located from the western to central region of the field and should be fertilized with more N for better plant growth. Medium nitrogen zones were in the east to south, and maintenance fertilization was recommended, although high nitrogen zones seemed very restricted. Certain sample points such as 20 also fall within medium dominated areas but was rated low due to some stipulated environmental conditions like waterlogging which enhances loss of N, hence result in a lesser concentration when compared with the surrounding areas.

Differences between estimates produced by model and laboratory analysis were due to environmental factors known to confound image accuracy. For example, wet followed by dry weather may change soil humidity, visibility, and surface reflectance subsequently affecting characteristic of the drone-based data (Adzima et al., 2022). Also, depending on the flight altitude, image sharpness and resolution are influenced. The height at which the UAV was flown in this study was 80 m, although it is known that for evaluating crop status lower altitudes provide more detailed and higher depiction accuracy of landscape features (Muliadi et al., 2024). Therefore, weather changes and flight altitude are two reasons for a low R^2 value and differences between the prediction model outcomes and laboratory analysis.

7. Recommendation for Supplemental Fertilization

The recommendation of the additional fertilization applied was established by means of analysis of plant nitrogen content in sugarcane tissue obtained through the prediction model shown at field study. Under field condition, application rate of fertilizer in the Gunung Ombo plantation was applied at 1,200 kg/ha (n) divided by two times. The first fertilization was carried out prior planting using 400 kg of ammonium sulfate (ZA), and NPK Pelangi 200 kg. The second fertilizer application was applied at 2–3 month of the crop, also with 400 kg ammonium sulfate

Through it fertilization guidelines, the government suggests a standard recommendation of 180 kg N, 75 kg P_2O_5 and 75 kg K_2O per hactare. This recommendation is based on two times of application, at planting and before the second hilling-up. The first of two fertilizations applies one-third of the nitrogen requirement and the entire phosphate demand, while the second applies approximately two-thirds of the nitrogen required and all potassium demanded (BSIP, 2024). The discrepancy between application practices of the farmers and official recommendations suggest differences in nutrient management practices that have to be tailored according to specific soil and crop conditions.

Leaf analysis is one of the most valuable tools for assessing plant nutrient status because it provides an indication of the current crop situation. If the soil test results show that the level of nutrients in the profile is in the medium range, as observed by Memet (2006), an extra quantity of fertilizer must be applied to increase nutrient sufficiency. On the other hand, when a contaminant has high nutrient status, fertilization must be no more than maintenance needs. The recommendation for fertilization should therefore study tissue and leaf analysis to establish new parameters to make recommendations, promoting better precision in application and greater alignment with the real nutritional needs of its crops.

CONCLUSION

It was also found that GNDVI presented a very strong relationship with leaf N status in sugarcane, indicating GNDVI as the suitable substitute for diagnosis of crop N conditions. The GNDVI regression model showed strong predictive precision and statistical agreement with the reference measurements, which implies good validity. Spatial assessments showed that nitrogen status differed considerably over the site, with various support for variable- versus uniform-rate fertilizer application. In general, drone-based GNDVI measurements is a feasible decision-support agricultural practice for targeted nitrogen management at Gunung Ombo Plantation, Argomulyo, Sedayu, Bantul and Yogyakarta.

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