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THE EFFECT OF FERTILIZER DOSES ON VARIATIONS IN AGE OF PALM OIL PLANT

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ABSTRACT

To produce quality oil, proper plant care is essential, with fertilization being key to maintaining high productivity. As the plant ages, the required fertilizer quantity decreases, which can impact production outcomes. To assess the effects of reduced fertilization, observations were made on oil palm plants with decreased fertilizer quantities. These observations focused on plant health and oil palm production results. Analyzing plant health can be done in various ways, one of which is by using remote sensing technology. Remote sensing analysis of plant health can be conducted using Sentinel 2A satellite imagery, accessible and downloadable via Google Earth Engine. NDVI analysis is used on Sentinel 2A imagery to assess plant health. The analysis results show consistent health classification across different planting years. 72 to 1, indicate a very healthy classification, demonstrating that reducing the quantity of fertilizer does not affect the NDVI values in different planting years. However, reducing the quantity of fertilizer does impact the productivity of oil palm plants.

1. INTRODUCTION

The area under oil palm cultivation has seen substantial growth. For instance, in 2018, plantations occupied 3.4 million hectares (Amalia *et al*., 2022). By Mamuju Tengah Regency, the total area had expanded from 25,220 hectares in 2014 to 45,562 hectares in 2016 (Fatmasari *et al*., 2019). This expansion is driven by several factors, including global demand for vegetable oils and biofuels, which has led to a doubling of the oil palm area in Indonesia over the last decade (Afriyanti *et al*., 2016). The palm oil industry has been a major contributor to Indonesia's economy, generating significant revenue and creating job opportunities. The palm oil industry is a major source of foreign exchange for Indonesia. In 2017, palm oil exports were valued at USD 23 billion, and in 2018, they were valued at USD 21 billion (Purnomo *et al*., 2020). In 2020, the export value reached USD 18.44 billion, marking an 18.43% growth compared to the previous year (Adwiyah *et al*., 2023). This industry also contributes significantly to the country's gross domestic product (GDP) (Suryani *et al*., 2016).

The palm oil industry can provide employment opportunities for the community. The improvement of community welfare through palm oil can be felt by the community. This makes palm oil a superior commodity compared to other plantation crop commodities. The use of oil palm is increasing. Oil palm produces more oil per unit area than any other vegetable oil crop, making it highly efficient in terms of land use (Murphy *et al*., 2021). This high yield translates to lower production costs, making palm oil cheaper compared to alternatives (Meijaard *et al*., 2024). The advantages of oil palm are that it has a high carotene content, a low price, and a low cholesterol content. Oil palm contains carotenoids in the range of 600-1000 ppm (Leow *et al*., 2022). Alpha-carotene constitutes approximately 36.2% of the total carotenoids in oil palm. This is consistent with the high levels of both alpha- and beta-carotene found in red palm oil, which together account for more than 90% of the total carotene content (van Rooyen *et al*., 2008). These compounds are essential for human health, providing antioxidant properties and serving as pro-vitamin A (Ngamwonglumlert & Devahastin, 2019). Quality oil palm requires good quality raw materials (palm oil). To optimize oil palm growth under varying climate and soil conditions, agronomic adaptation strategies such as adjusting planting density, fertilizer application, irrigation, and pest management are essential (Abubakar *et al*., 2023).

Increasing oil palm productivity can be achieved through optimal air and nutrient management. The availability of air and nutrients in the soil greatly affects oil palm production. To ensure sufficient air supply, maintenance of air channels and drainage in oil palm fields is very important. Research shows that a combination of irrigation and fertilization can significantly increase fresh fruit bunch yields compared to treatments without irrigation or without fertilization. In addition, oil palm plant nutrient needs can be met through periodic analysis based on leaves and soil. Leaf analysis, especially on the 17th leaf stalk, as well as soil samples are used to determine plant nutrient needs and the right fertilizer dosage (Kamireddy *et al*., 2023). Fertilization according to the type and dosage needed by the plant is very important to achieve optimal growth and yield (Rhebergen *et al*., 2019).

Plants have a green leaf index that can be seen using remote sensing. Through the green leaf index, plant health can be seen. By using remote sensing, we can save costs. The use of remote sensing in monitoring plants can use various images that can be downloaded for free through sites on the internet. Several sites provide satellite imagery such as USGS and Google Earth Engine. On this website, you can download various satellite images in real-time such as Sentinel images, Landsat images, and others. Various analyses can be carried out to monitor plant health such as NDVI, SAVI, and LAI analysis. In this Final Project, NDVI analysis is used because the NDVI value correlates with plant health based on leaf chlorophyll (Chung *et al*., 2018). The NDVI value can show plant health through leaf chlorophyll. The use of this analysis can make it easier to control plant health through leaf chlorophyll so that it can determine the best care for palm oil plants.

Fertilization is one of the most important things in maintaining high productivity of palm oil plants. Mistakes in fertilization can cause major losses. Fertilization mistakes can lead to inconsistent yields (Thakur *et al*., 2023). Meanwhile, Inefficient use of fertilizers not only increases costs but also reduces the economic viability of plantations (Uttran *et al*., 2023). Fertilization is also influenced by the age of the palm oil plant. Plants that are more than 25 years old generally have their fertilizer quantity reduced because they have entered the rejuvenation period. This reduction in fertilizer can have an impact on production results. Therefore, this article will discuss the impact of reducing fertilizer doses on mature plants.

2. MATERIALS AND METHOD

2.1 Location and Time of Research

The research was conducted in Tapung Hilir District, Kampar Regency, Riau Province. The research was conducted from September 2023 to January 2024.

2.2 Materials and Tools

The materials used include primary data, namely Sentinel 2A imagery (September 2023) and NDVI analysis data and secondary data, namely 2022 fertilization data and palm oil production data. The tools used in the observation were a laptop, Google Earth Engine, Arcmap 10.8, and Microsoft Excel.

2.3 Research Procedures

The observed samples were 25 blocks consisting of mature palm oil plants with planting years of 1993, 1994, 1995, 2002, and 2021. The plants observed were in mineral soil areas. Observations were made through available production data that had been permitted for use in research. Observations through satellite imagery were carried out using the Normalized Difference Vegetation Index (NDVI) analysis. The following are the stages in the NDVI analysis are downloading Sentinel 2A imagery using Google Earth Engine, the downloaded imagery is Sentinel band 4 (RED) and band 8 (NIR). The downloaded image is then processed in Arcmap with a raster calculator to calculate the NDVI value using the following equation (Priambodo *et al*., 2023):

$$\mathrm{NDVI} = (\mathrm{NIR} - \mathrm{RED})/(\mathrm{NIR} + \mathrm{RED}) \tag{1}$$

Note: NIR is the digital number value in the near infrared channel and RED is the digital number value in the red channel.

Taking NDVI samples each planting year with five samples per block using an identifier so that the NDVI value is visible for each sample in each block.

2.4 Observed Parameters

The study was conducted by observing plant health from the greenness of the leaves and the production results of palm oil plants on plants with reduced fertilizer doses. The fertilizer dose given will be compared with the fertilizer recommendations sourced from PPKS. Plant health will also be seen through leaf greenness using satellite imagery. The satellite image used is the Sentinel 2A satellite image. With this image, NDVI analysis will be carried out. Then an analysis of the production results of oil palm plants is carried out. The following is a classification of plant health based on leaf greenness using NDVI analysis in Table 1.

The following is the program code for downloading Sentinel 2A band 4 and band 8 imagery:

```
function maskS2clouds(image) {
var qa = image.select('QA60');

// Bits 10 and 11 are clouds and cirrus, respectively.
var cloudBitMask = 1 << 10;
var cirrusBitMask = 1 << 11;

// Both flags should be set to zero, indicating clear conditions.
var mask = qa.bitwiseAnd(cloudBitMask).eq(0)
.and(qa.bitwiseAnd(cirrusBitMask).eq(0));

return image.updateMask(mask).divide(10000);
}

var image = ee.ImageCollection('COPERNICUS/S2_SR_HARMONIZED')
.filterDate('2023-09-01', '2023-09-30')
// Pre-filter to get less cloudy granules.
.filter(ee.Filter.lt('CLOUDY_PIXEL_PERCENTAGE',40))
.map(maskS2clouds)
.median()
.clip(NSAE);

var nir = citra.select('B8'); // NIR band
var red = image.select('B4'); // Band Red

// Export bands to Google Drive in GeoTIFF format
Export.image.toDrive({
image: nir,
description: 'NIR_band',
folder: 'Citra Band Sentinel 2A',
region: NSAE,
scale: 10, // Spatial resolution
fileFormat: 'GeoTIFF', // File format
});

// Export bands to Google Drive in GeoTIFF format
Export.image.toDrive({
image: red,
description: 'Red_band',
folder: 'Citra Band Sentinel 2A',
region: NSAE,
scale: 10, // Spatial resolution
fileFormat: 'GeoTIFF', // File format
});
```

Table 1. NDVI Values for Plant Health

Plant Health	NDVI value
Bad	0.11 - 0.22
Normal	0.22 - 0.42
Good	0.42 - 0.72
Very good	0.72 - 1

Source: (Arini *et al*., 2022).

2.5 Data Processing Methods

The data obtained from the observation activities will be analyzed quantitatively so that the effect of reducing fertilizer doses on producing plants is known. Data processing is carried out using Microsoft Excel to compare fertilizer reduction data, NDVI analysis, and production data.

3. RESULT AND DISCUSSION

The data used are 2022 plantation fertilization data, production data in September, and also satellite imagery data. The following are fertilization data and fertilizer recommendations. As can be seen in Table 2, plants with planting years 1993, 1994, and 1995 experienced a reduction in fertilizer. Plants with planting years of 1994 experienced the largest reduction in fertilizer doses. These plants were fertilized with a total of 1.08 kg of fertilizer/plant per year.

A large reduction in fertilizer doses also occurred in plants with planting years 1993 and 1995 with 1.97 and 1.13 kg/plant per year, respectively. Plants from 1993-1995 have entered the rejuvenation period considering that they are more than 25 years old, plant height above 13 m, annual production of less than 14 tons/ha, and the stand per hectare less than 100 trees/ha. The three plants are already 25 years old and above which is the optimal age for rejuvenation (Mariyah *et al*., 2018) so fertilizer dose reductions are carried out. Plants with planting years 2002 and 2021 also experienced a reduction in fertilizer doses. The reduction in fertilizer dose related to leaf greenness is shown in Figure 1.

Table 2. Fertilizer Dosage in 2022

Planting Year / Plant Age	Fertilizer Dosage per Year (kg/plant)					Total Fertilizer (kg/plant)
	Urea	TSP	MOP	Dolomite	Borax	
>20 Years*	2.50	1.75	2.25	2.25	0.075	8.83
1993**	0.00	0.67	1.25	0.00	0.050	1.97
1994**	0.00	0.67	0.00	0.36	0.050	1.08
1995**	0.00	0.67	0.00	0.36	0.100	1.13
2002**	1.50	0.84	1.75	0.18	0.075	4.34
3-4 Years*	2.50	1.50	2.50	2.25	0.100	8.85
2021**	1.43	0.95	1.15	0.25	0.100	3.88

Information : * = Pusat Penelitian Kelapa Sawit (2020).

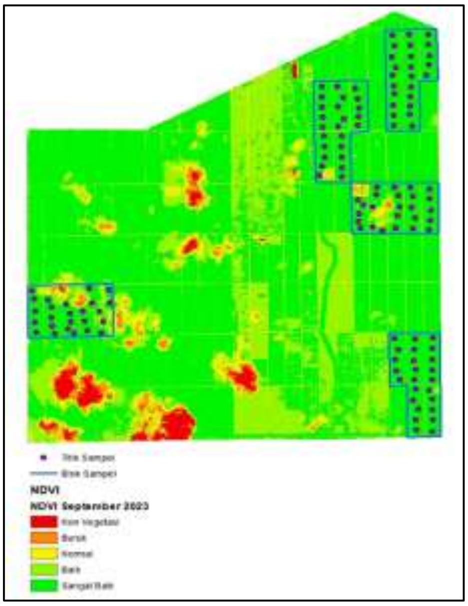

Figure 1. Results of Normalized Difference Vegetation Index Analysis with Arcmap 10.8

Table 3. NDVI Values Per Planting Year

Planting Year	Block	NDVI (Sample)				
		1	2	3	4	5
	F-39	0.820	0.816	0.801	0.792	0.807
1993	F-40	0.818	0.847	0.844	0.819	0.814
	G-38	0.824	0.848	0.838	0.841	0.809
	G-39	0.854	0.855	0.818	0.841	0.801
	G-40	0.845	0.833	0.848	0.836	0.838
1994	G-35	0.838	0.841	0.825	0.832	0.785
	G-36	0.844	0.816	0.817	0.837	0.796
	H-34	0.838	0.835	0.834	0.853	0.829
	H-35	0.817	0.840	0.821	0.824	0.835
	H-36	0.851	0.839	0.845	0.840	0.847
1995	C-53	0.766	0.795	0.813	0.808	0.813
	C-54	0.819	0.810	0.822	0.810	0.818
	C-55	0.804	0.820	0.848	0,800	0.813
	C-56	0.826	0.844	0.817	0.806	0.814
	C-57	0.816	0.821	0.827	0.799	0.814
2002	A-34	0.808	0.824	0.805	0.786	0.806
	A-35	0.811	0.822	0.805	0.821	0.807
	B-34	0.802	0.812	0.802	0.804	0.823
	B-35	0.823	0.835	0.827	0.810	0.835
	B-36	0.796	0.802	0.821	0.809	0.839
2021	E-63	0.806	0.825	0.805	0.799	0.792
	E-64	0.848	0.812	0.830	0.822	0.821
	E-65	0.858	0.852	0.819	0.845	0.843
	E-66	0.824	0.880	0.830	0.832	0.837
	E-67	0.872	0.831	0.813	0.884	0.844

Table 4. Production September 2023

Planting Year	Block	Ton	Ton/ha	Bunch	ABW
1993	F-39	40,79	1,38	1.805	22,60
	F-40	49,06	1,70	2.171	22,60
	G-38	50,42	1,58	2.231	22,60
	G-39	50,62	1,76	2.240	22,60
	G-40	69,15	1,97	3.060	22,60
1994	G-35	50,81	1,58	2.276	22,32
	G-36	56,79	1,89	2.544	22,32
	H-34	60,89	1,75	2.728	22,32
	H-35	58,62	1,60	2.626	22,32
	H-36	66,65	1,80	2.986	22,32
1995	C-53	26,93	0,87	1.177	22,88
	C-54	19,10	0,62	835	22,88
	C-55	25,26	0,80	1.104	22,88
	C-56	27,15	0,86	1.220	22,26
	C-57	25,77	0,92	1.158	22,26
2002	A-34	63,12	1,99	3.458	18,25
	A-35	60,60	1,87	3.320	18,25
	B-34	70,17	2,24	3.844	18,25
	B-35	62,19	1,94	3.407	18,25
	B-36	41,45	1,31	2.271	18,25
2021	E-63	16,36	0,51	4.519	3,62
	E-64	11,96	0,40	3.305	3,62
	E-65	9,72	0,32	2.685	3,62
	E-66	14,21	0,45	3.927	3,62
	E-67	12,01	0,53	3.317	3,62

In the image above, NDVI sampling was carried out on 25 blocks with different planting years. In each block, five NDVI samples were taken with different points in one block. Taking five samples in each block was done to increase the accuracy of the NDVI analysis results obtained. The following NDVI values for each sample are shown in Table 3. Table 3 shows the difference in NDVI values in each block in each planting year. The NDVI value for each planting year is in the classification of very healthy plants. Although the plants show good NDVI values, there are differences in values in each block in the same planting year. The difference in NDVI values in each planting year shows values that are not much different. The average sample NDVI values for the planting years 1993, 1994, 1995, 2002, and 2021 are 0.828, 0.831, 0.814, 0.813, and 0.833. The highest average NDVI value was in the 2021 planting year and the lowest average NDVI value was in the 2002 planting year. These values are still in the same range, namely 0.72-1 with a classification of very good plant health based on chlorophyll. From these results, the NDVI value does not show any significant difference in plant health so fertilizer reduction does not affect plant health based on chlorophyll. Based on the NDVI value, its influence on palm oil production can be seen in Table 4.

Table 4 shows the production results in September 2023. Differences in fertilizer quantity have an impact on the average bunch weight and also production results (Hasibuan *et al*., 2023). This impact affects the productivity of palm oil plants. The productivity of palm oil plants with planting years over 20 years is below its potential which can reach 2,75 tons/ha/month. In the 2002 planting year which was still optimally productive, only one block was able to achieve productivity >2 tons/ha/month and this productivity was still below its potential. While in other planting years over 20 years the productivity was lower. The difference in average bunch weight (ABW) and production results is also thought to be caused by differences in land suitability both in terms of soil pH, drainage, land height, and others as well as differences in the age of palm oil plants (Firmansyah, 2017).

4. CONCLUSIONS

The results of plant health research through Sentinel 2A satellite imagery calculations with Normalized Difference Vegetation Index (NDVI) analysis can show plant health based on leaf greenness. The results of the analysis show the same health classification in each planting year. Reducing the quantity of fertilizer has an impact on the average bunch weight and production results for each planting year which affects the productivity of palm oil plants.

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