Chemical characteristics of material deposit in axil part of oil palm

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Abstract. Information of chemical characteristics of materials deposit in the axil is needed to achieve high fertilization effectiveness and efficiency through the axil part. Research survey has been carried out on 11- years oil palm plantations at PT Bumitama Gunajaya Agro, West Kalimantan, Indonesia, from October to December 2018 using the nested design method. Three cropping locations were selected, namely the edge, inside and center In each location three sample plants were determined and each plants were selected for the upper, middle and lower axil to take the material buried in it and then analyzed the chemical content. The results showed that the organic matter content ranged from 29.79 - 48.14% with organic C between 17.12-24.85% and C / N ratio 6.26-9.44%. The highest content was found in plants that are in the inside location. Cation exchange capacity ranges from 96.65 - 106.88cmol / kg, it means as high . The pH of material was relatively same in three locations, ranged 5.76-5.98. The total N content 2.5-2.75% were classified as high valued. Highest content was in plants in the inner location. The total P and total K were classified as medium valued 0.16-0.19% and 0.32-0.53% respectively.

1. Introduction
The oil palm fertilization is usually done through the roots [1]. [2] states that the application of oil palm fertilization through roots is less effective during the growth period, because the dosage, time, and nutrient composition absorbed are very dependent on the local land conditions. Under certain conditions fertilizers undergo evaporation, leaching, erosion, and fixation, [3]. On tidal land, swamp land, sandy land, peat land, the fertilization response is very low due to obstacles to nutrient absorption, [3]. The higher the plant, the longer it takes to translocate nutrients from the roots to the leaves and other parts. Using the analogy of fertilizing through leaves, the idea of fertilizing through the leaf axils appeared. In addition, the application of fertilization through the leaf axils is also inspired by previous studies [4] which axillary applies fungicides to control leaf disease in coconut plants [4] used the base of the midrib as a place to take boron fertilizer to overcome Boron
deficiency in coconut and oil palm plants. Fertilization through the base of the leaf axils were influenced by various things, one of which was the condition of those own leaf axils. In the oil palm leaf axils there was material consisting of most of the oil palm litter in the form of leaves, fruit, dried male flower or leaf sheath and so on. The litter is still intact but most of it has been decomposed into organic matter. [5], states, in the leaf axils there were a number of organic materials whose decomposition is aided by Arthropods. The abundance of organic matter is also influenced by the presence of ferns (epiphyt) as has been studied by [4] [5].

Decomposed organic matter contains a number of macro and micro nutrients. The sources of organic material present in oil palm plantations can come from trimmed leaves and leaflets, empty bunches, dried stems, dried male flowers, [5] [6]. There have not been many studies on organic matter in the leaf axils of oil palm fronds. So far, the study was more on the role of insects in the process of decomposition of organic materials, or wild plants that can thrive in the sheath of the midrib [5]. Therefore, this research was conducted with the aim of supporting fertilization efforts through leaf axils. Information on the chemical properties of organic material in the leaf axils where the fertilizer is placed is very necessary.

2. Materials and Methods

2.1. Samples

This research was conducted from October to December 2018 in two places, namely the oil palm plantation of PT Bumitama Gunajaya Agro, Ketapang, West Kalimantan, Indonesia for sampling organic material from the leaf axils and ICBB-Bogor Laboratory, West Java, Indonesia for nutrient content analysis. Sampling of plants carried out in stratified randomly using nested designs [7]. The block of 11-year oil palm plantation area is divided into 3 locations, namely the edge, inside and center. The edge was a location that was two plants away from the edge of the garden road, the inside location was the distance between two plants from the edge location and the center location was two plants away from the inside location. At each location three sample plants were determined, and in each sample plant three leaf axils were determined which organic material would be taken. The first leaf axil was located at the bottom of the canopy that has not been pruned. The second one was the leaf axil in the 4th spiral after the first one and the third were the leaf axil in the 8th spiral after the first one. The location of the leaf axil sample is shown in figure 1.

![Figure 1. Determination of leaf axils sample in each plant](image)

2.2. Taking organic material in the leaf axils

After the leaf axil points were determined, all deposits of organic material taken in each of the leaf axil were taken out. Previously, each leaf axils was measured in depth, midrib base width, midrib
angle and relative temperature and humidity. The material obtained was separated between the three leaf axils. Samples of organic material from that place were included in plastic bags to analyze their chemical characteristics in the laboratory.

2.3. Analysis of the chemical properties of leaf axils deposit

The leaf axils deposit is analyzed consisted of percent organic matter, organic C content, total nitrogen, phosphate content, total K content, cation exchange capacity and pH. The organic C content was analyzed using the Walkley & Black method, 1934. Total Nitrogen levels were analyzed using the Kjeldhal method, total P and total K were analyzed by the HClO₄ HNO₃ method, cation capacity (CEC) was measured using the N NH₄Oac method and pH was measured using a pH meter.

2.4. Data analysis

All data on the chemical properties of the material taken from each oil palm leaf axils were analyzed using Analysis of Variance for the Nested Design with a 5% of confidence level [7]. To test the differences between locations and plants used the Least Significant Difference (LSD) method at the 5% level of confidence.

3. Results and Discussion

3.1. Organic matter, C/ N ratio, N, P and K total

In three different locations the content of organic matter, organic C, total N, P and K were varied. But with a statistical test all parameters measured did not show significant differences between locations or between plants in the location (Table 1.). Figure 2. shows that the organic material, organic C content and N material deposit content are relatively higher than total P and total K content. From the three locations, it can be seen that the inside area has a relatively higher chemical content than the one at the edge and center locations. The content of organic matter is influenced by the type of constituent material [8]. The deposit of material in the oil palm leaf axils was mostly in the form of litter originating from oil palm plants such as dried leaves, dried male flowers, remaining leaves and female flowers, fruit bunches and a small portion of airborne dust [9]. At the location of plants inside the garden, these organic matter deposits were higher (48.14%) than those on the edge (34.72%) and in the middle (29.79%), although statistically not significantly different. The environmental conditions in the garden are relatively darker, the light intensity under the canopy leaves was lower. This condition can cause dried leaves of the lower leaves which eventually fall and partially fill the space between the base of the midrib with the stem or often called the leaf axils, [5]. In addition to litter derived from oil palm plants, organic material that accumulates in the leaf axils also originates from epiphytic plant litter which grows on oil palm trunks [9]. On the contrary, this epiphytic plant thrives on the media of organic matter in the leaf axils. The deposit of material with relatively high organic matter content in this location is also followed by higher organic C content as well (Figure 2 and Table 1.), while in the edge and middle locations it was relatively lower. [10], argues that organic matter is all carbon from plant residues or dead plants and animals. So it was normal that the organic C content follows the amount of organic matter. Based on the criteria for evaluating the results of soil analysis [11], the organic C content > 5% is classified as very high. The high content of C deposit material is due to almost 100% material is organic matter. The higher organic C content in this location is also followed by a higher C / N ratio (figure 3) (9.44), while the lowest is in the middle location (6.25), although both of these values are already low. This means that the organic material has been decomposed properly, [6].

The total nitrogen content in the deposit of organic material measured by oil palm leaf axils were between 2.5 - 2.75% (Table 1, Figure 2). In the three locations the total N content were relatively the same and is classified as very high. According to the assessment criteria for the results of soil analysis [11], N total percentage > 0.75 classified as high. [6], said leaf sheets of palm oil
decomposed contribute a very high amount of nutrients except Potassium, compared to leaf bones. This is consistent with the fact that the litter that fills the axils was mostly leaf sheets, very little or almost no leaf bone enters it.

Phosphorus and Potassium are two types of nutrients whose contents in organic materials were rarely high, [12]. Although potassium is an important nutrient for oil palm and fertilization of potassium in oil palm is based on its content in leaves, potassium is almost 72% stored in stems and leaf bones, [13].

The potassium content in organic material in this study ranged from 0.32% - 0.53%, and the inside garden was relatively highest. This percentage is classified as very low. Similarly, phosphorus content, only ranges from 0.14% - 0.19%. According to [13], phosphorus is the most limiting nutrient in the process of decomposition of litter in tropical forests. This low P presence can also be caused by a low average pH, around 5.7 - 5.98 (Table 1 and Figure 5). In conditions of low pH, nutrient P is firmly fixed so that it is not available, [6].

![Figure 2. Organic material content, C organic, N, P, K total of material deposit in the 11-year oil palm leaf axils in three locations](image-url)
3.2. Cation Exchange Capacity

The value of the cation capacity (CEC) of material in the palm leaf midrib armpit obtained in this study averaged 97.77 cmol / kg at the edge location, 96.65 cmol / kg at the insider location and 106.88 cmol / kg at the middle location (Fig. 4). These values are very high according to the criteria for evaluating the results of soil analysis [10]. The amount of CEC value is influenced by the content of clay, organic matter, organic C and pH, [6]. Humus and high organic matter have a high cation exchange capacity (100 = 300 me / 100g), while inorganic colloids have low values (3-150 me / 100g), [2]. High organic C in this study is closely related to high CEC values.
3.3. pH

The pH of organic material collected in the palm oil leaf axils in this study averaged between 5.76 in the inner location, 5.89 at the edge location and 5.98 in the middle location (Figure 5). This value is relatively close to the value of 6. pH is closely related to cation exchange capacity and decomposition of organic matter. The organic material which has been decomposed further is characterized by a low C/N ratio, resulting in a relatively higher pH of the material compared to the still raw organic material. Decomposition of organic matter results in available nutrients as a result of increased pH, [14]. The decomposition rate of organic matter was influenced by environmental conditions such as temperature and humidity. Table 2 shows the same average temperature and humidity at the three observation locations. The air temperature is relatively high (30.07 °C) and relatively high humidity (> 71%). The higher the temperature and humidity the faster the organic matter decomposes.

![Figure 5. pH of material deposit in 11-year oil palm leaf axils in three locations](image)

A summary of the chemical properties analysis results of the material deposits in oil palm leaf axil is shown in Table 1.

**Table 1.** The chemical properties of material deposit in the 11 years old of oil palm leaf axils

| Chemical properties | Location         | Plant 1 | Plant 2 | Plant 3 | Plant 1 | Plant 2 | Plant 3 | Plant 1 | Plant 2 | Plant 3 |
|---------------------|------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Org. matter (%)     | Edge             | 33.95\(^p\) | 29.63\(^p\) | 50.67\(^p\) | 31.90\(^p\) | 61.85\(^p\) | 30.30\(^p\) | 34.62\(^p\) | 36.66\(^p\) |
|                     | Average in location | 34.72\(^a\) | 48.14\(^a\) | 29.79\(^a\) |
| C-Organic (%)       | Edge             | 16.96\(^p\) | 18.28\(^p\) | 15.15\(^p\) | 17.31\(^p\) | 18.88\(^p\) |
|                     | Average in location | 17.36\(^a\) | 24.85\(^a\) | 17.12\(^a\) |
| C/N Ratio (%)       | Edge             | 7.13\(^p\)  | 7.43\(^p\)  | 5.91\(^p\)  | 6.18\(^p\)  | 6.68\(^p\)  |
|                     | Average in location | 6.94\(^a\)  | 9.44\(^a\)  | 6.26\(^a\)  |
| CEC (%)             | Edge             | 92.87\(^p\) | 98.27\(^p\) | 109.71\(^p\) | 107.97\(^p\) | 102.95\(^p\) |
|                     | Average in location | 97.24\(^a\) | 107.00\(^p\) | 106.88\(^a\) |
| pH                  | 5.83\(^p\)  | 5.87\(^p\)  | 5.93\(^p\)  | 5.87\(^p\)  | 5.76\(^p\)  | 5.98\(^p\)  |
| N Total (%)         | 2.35\(^p\)  | 2.52\(^p\)  | 2.62\(^p\)  | 2.95\(^p\)  | 2.68\(^p\)  | 2.57\(^p\)  | 2.70\(^p\)  | 2.83\(^p\)  |
Average in location 2.50ᵃ 2.75ᵃ 2.70ᵃ 2.50ᵃ 2.75ᵃ 2.70ᵃ 0.13ᵇ 0.18ᵇ 0.17ᵇ 0.23ᵇ 0.21ᵇ 0.14ᵇ 0.13ᵇ 0.15ᵇ 0.14ᵇ

Average in location 0.16ᵃ 0.19ᵃ 0.23ᵇ 0.45ᵇ 0.28ᵇ 0.45ᵇ 0.63ᵇ 0.51ᵇ 0.33ᵇ 0.32ᵇ 0.56ᵇ 0.32ᵃ 0.53ᵃ 0.40ᵇ

Table 2. Average temperature and humidity of the location

|                | Edge   | Inside  | Center  |
|----------------|--------|---------|---------|
| Temperature (°C) | 30.07  | 30.07   | 30.2    |
| Humidity (%)    | 71.22  | 68.78   | 74.25   |

4. Conclusion

Based on the results of research and discussion about the chemical characteristics of deposit material in 11 years oil palm leaf axils, it can be concluded, the chemical character of the leaf axil material deposit consists of organic matter, organic C, C / N ratio, total N, total P, K total, CEC and pH. The value of each chemical character is not significantly different between the three observation locations, namely the edge, inside and center of the area. Organic matter content ranges from 29.79% - 48.14%, organic C 17.12% - 24.85%, C / N ratio 6.26 - 9.44, N total 2.5% - 2.75%, P total 0.14% - 0.19%, total K 0.32% - 0.53%, CEC 96.65 cmol / kg - 106.88 cmol / kg and pH between 5.76 - 5.98.

References

[1] Saadati, S., Moallemi, N., Mortazavi, S. M. H., & Seyyednejad, S. M. 2016. Foliar Applications of Zinc and Boron on Fruit Set and Some Fruit Quality of Olive. *Crop Research*, 2016.

[2] Ginting, Eko Noviandi; Suroso Rahutomo dan Edy Sigit Sutarta.2018. Efisiensi Serapan Hara Beberapa Jenis Pupuk Pada Bibit Kelapa Sawit. *J. Pen. Kelapa Sawit*, 2018, 26(2): 79-90.

[3] Broschat,Timothy K. 2011. Uptake and Distribution of Boron in Coconut and Paurotis Palms. *Hortscience* 46(12):1683–1686. 2011.

[4] Monteiro, Claryssa M.; Ediane S. Caron; Silvaldo F. da Silveira; Alexandre M. Almeida.,Gilberto R. Souza-Filho; Aleomar L. de Souza.2013. Control of foliar diseases by the axillary application of systemic fungicides in Brazilian coconut palms. *Crop Protection* 52 (2013) 78e83.

[5] Ganser,Dominik; Lisa H. Denmead; Yann Clough; Damayanti Buchori and Teja Tscharntke.2017. Local and landscape drivers of arthropod diversity and decomposition processes in oil palm leaf axils. *Agricultural and Forest Entomology* (2017), 19, 60–69.

[6] Tiemann, T. T., Donough, C. R., Lim, Y. L., Härder, R., Norton, R., Tao, H. H., … Oberthür, T. (2018). Feeding the Palm: A Review of Oil Palm Nutrition. Advances in Agronomy, 152, 149–243.

[7] Montgomery, Douglas C. 2005. Design and Analysis of Experiments. 6th editions.
[8] Moradi, A., Teh, C. B. S., Goh, K. J., Husni, M. H. A., & Ishak, C. F. (2014). Decomposition and nutrient release temporal pattern of oil palm residues. *Annals of Applied Biology*, **164**(2), 208–219.

[9] Nery Sofiyanti. 2013. The Diversity Of Epiphytic Fern On The Oil Palm Tree ISSN : 1410 5292.(Elaeis Guineensis Jacq.) In Pekanbaru, Riau. *Jurnal Biologi XVII* (2) : 51 –55.

[10] Munawar, A. 2011. Kesuburan Tanah Dan Nutrisi Tanaman. IPB Press. Bogor. 240 hal.

[11] Balai Penelitian Tanah.2009. Analisis kimia tanah, Tanaman, Air dan Pupuk. Balai Besar Litbang Sumberdaya Lahan Pertanian. Badan Penelitian dan Pengembangan Pertanian. Departemen Pertanian. 246p

[12] Bakker, Maartje Anne, Geovana Carren˜o-Rocabado, and Lourens Poorter. 2011. Leaf economics traits predict litter decomposition of tropical plants and differ among land use types. *Functional Ecology 2011*, **25**, 473–483

[13] Dubos, Bernard ; Wilmar Herna´n Alarco´n ;Jesu´ s Edgardo Lo´pez ; Jean Ollivier.2011. Potassium uptake and storage in oil palm organs: the role of chlorine and the influence of soil characteristics in the Magdalena valley, Colombia. *Nutrient Cycling in Agroecosystems*. March 2011.

[14] McCauley, Ann; Clain Jones; Jeff Jacobsen.2017. Soil pH and Organic Matter. Nutrient Management Module No. 8. Montana State University.