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UTILIZATION OF *NEPHROLEPIS BISERRATA* AS UNDERSTOREY TO IMPROVE THE PERFORMANCE OF OIL PALM YIELD IN SANDY SOIL

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ABSTRACT

Oil palm plantations in Indonesia have reached 16.31 million hectares, distributed over various types of soil, including sandy soil. Specific cultivation technology is needed to manage this soil to find profitable oil palm productivity. This study aims to reveal the role of *Nephrolepis biserrata* as understorey in the performance oil palm yield on sandy soil. The study was carried out in a 14-year-old oil palm plantation, the observations were conducted on mineral soil and sandy soils, both of which were overgrown with *N. biserrata*, and mineral soils without this vegetation, each trial represented by three estate blocks. Yield performance is indicated by the number of fresh fruit bunches (FFB), FFB weight, and total FFB weight. The results of the study revealed that FFB production in sandy soil + *N. biserrata*(2.089 ton/ha/month) is higher than mineral soil - *N. biserrata*(1.963 ton/ha/month). However, the yield rate is still below to mineral soil + *N. biserrata*(2.299 tons/ha/ month). However, the number and weight of FFB (0.858 FFB/palm/month and 18.032 kg/FFB) in sandy soil + *N. biserrata* showed no significant difference compared to mineral soil + *N. biserrata*(0.850 FFB/palm/month and 20.700 kg/FFB). It is also revealed that the use of *N. biserrata* can improve the stability of the oil palm yield performance between estate blocks on mineral or sandy soils.

Keywords: *N. biserrata, yield performance, sandy soil, oil palm, EFB.*

Introduction

Oil palm is a major estate commodity in Indonesia that has strategic value in terms of economic, social, environmental, and political roles. In the last decade, this country became the world's largest producer of palm oil. This palm is cultivated in a variety of diverse soil conditions, including sandy soil, which is generally classified as marginal soil. The world demand for palm oil is increasing along with the increasing the world's biofuels. Demand for palm oil increases with population growth and is used as raw material for biofuels [1]. Palm oil prices have fluctuated in recent years, tending to decrease. This can be a threat to the Indonesian palm oil business. Increasing productivity and efficiency has to become a high priority in plantation management. The basic principle is to estimate the total demand for oil palm and the availability of nutrients by the oil palm agroecosystem, outside the fertilizer component [2]. Application of soil organic matter periodically as a source of soil organic carbon is predicted as effective practices to maintain soil productivity. Practices such as organic fertilizer and retention of crop residues increase carbon input and can sustain soil organic matter [3 4].

Increased crop productivity in sandy soil is closed related to an increase in water holding capacity of this soil. Sandy soils have a lower water holding capacity than clay one so they cannot compensate for water losses due to evapotranspiration for a longer period [5]. The water available to plants is the result of the interaction between soil properties and rainfall. Meanwhile, projected a decline in palm oil production in Southeast Asia, around 18% in 2050, and 30% in 2100 due to the influence of Global Warming [6]. Sandy soil has low organic matter content and cation exchange capacity. Organic matter in the soil is easily oxidized that decreasing fertilizer efficiency because it is easily leaching. The role of organic matter is fundamental in improving the soil properties, the potential for soil productivity, and the sustainability of the agricultural system in this land [7]. Sandy soil has a low vegetation coverage. It caused the increasing soil temperature; low clay content caused the bad structure of the soil, water deficit caused by rapid drainage [8].

Agronomic practices of sandy soil management must be based on economic potential (site potential) and following the principles of Sustainable Palm Oil. In addition to solving various environmental problems, waste composting can also improve soil quality and production of fresh fruit bunches for sustainable palm oil production [9]. The application of organic matter can improve the properties of sandy soil, especially its aggregation and water retention. Empty bunches are by-product biomass from oil palm mills; each ton of CPO produces one ton of empty bunches [10]. Application of 37.5 tons/ha/year empty bunches in path together with N and K fertilizer (0.735 kg N and 1.750 kg K per tree per year) can increase the N and K content of leaves, a number of bunches, bunch weight, and yield of oil palm bunches. On mineral soils, empty bunches as mulch can also reduce the use of N and K fertilizers [11].

Above-ground vegetation can improve the physical properties of sandy soil and reduce the negative effects of climate, such as erosion [12]. Ground cover plants have fast growth so that they can suppress weed growth. Understorey vegetation in oil palm trees can play a role as a ground cover, generally dominated by ferns that can function as ground cover. *N biserrata* plants as beneficial soil cover, such as small ferns or legume species form nodules and can bind nitrogen from the air, can be cultivated to minimize erosion and retain water. [13]. Many species of Nephrolepis that grow and spread in various ecosystem in Indonesia, *N. biserrata*(Sw.) Schott is reported as the most dominant species, especially in oil palm plantations [14]. Nephrolepis is a shade-tolerant that can be used as a cover crop for oil palm plantations [15]. This comparative study is to reveal the benefits of N. *biserrata* and the application of empty fruit bunches (EFB) in managing sandy soils in oil palm plantations, including in reducing the impact of drought on production.

Methods

This survey compares oil palm production on sandy soils + N. *biserrata*(Nb), mineral soils + Nb, mineral soils. Three garden blocks represent each treatment. The area of each block is 30 hectares, with a tree age of 14-16 years. The yield component observed was the number of fresh fruit bunches, fresh fruit bunch weight, and yield (tonnage) of fruit with 10-day crop rotation. Yield and rainfall data are taken for one year (2017). All blocks are given empty fruit bunches (EFB) at a dose of 50 tons per hectare per year by spreading them out into a single layer of dead storage (to avoid egg laying rhino beetles). In addition to empty fruit bunches, oil palm tree are given an organic fertilizer as much as 1.96 kg of Urea; 3.44 kg MOP; 2.29 kg rock phosphate; 0.10 kg HGF; 0.03 CuSO4 (in 2015) and 1.69 kg of Urea; 0.08 kg MOP; 1.25 kg rock phosphate.; 0.07 kg HGF; 2.35 kg Kieserit; 0.12 kg of CuSO4 (in 2016). Parameter data on yield of FFB, number of FFB, and weight of FFB are analyzed by using variance analysis (ANOVA) and DMRT test at a 5% confidence level [16 17 18].

Result and Discussion

Oil palm yields, which consist of the weight of the fresh fruit bunches (FFB), the number of FFB, and bunch tonnage, showed fluctuations in locations and time. Likewise, each component of the results shows various responses between time and location. The use of Nb as understorey vegetation in mineral soils produces varying FFB weight between blocks compared to blocks in mineral soils without Nb (Figure 1). Sandy soil blocks with Nb vegetation showed smaller FFB variations compared to mineral +Nb soil blocks. The weight of FFB is determined by the number of flowers at the spikelet, the number and weight of the fruitlet. Fresh fruit bunches need six months from anthesis to harvest. During this time, FFB is vulnerable to water and nutrient influences and sink competition. The drought period can affect the flowering ratio of males and females, affecting the number of bunches and production. The water problem for oil palm is a result of climate change, which reduces rainfall and increases the dry season [19].

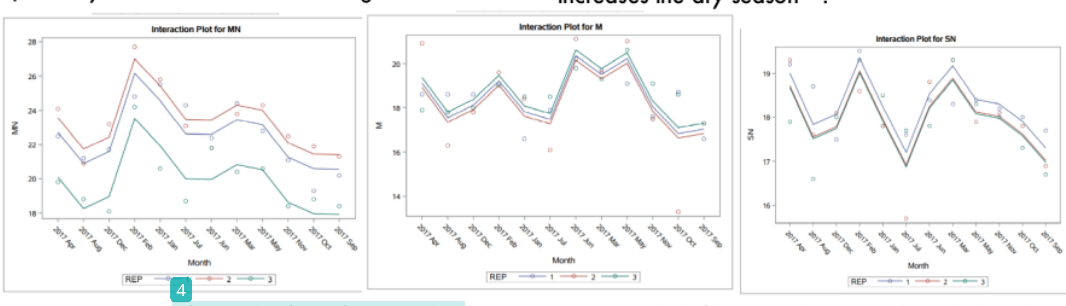

Figure 1. Weight of oil palm fresh fruit bunches on mineral soil +Nb (left), mineral -Nb soil (middle), and sand +Nb (right)

Monthly weight fluctuations in FFB in all observation blocks are a response to factors of production (especially water) that take place during fruitlet and FFB growth and development. These fluctuations tend to have the same pattern, as shown in Figure 2.

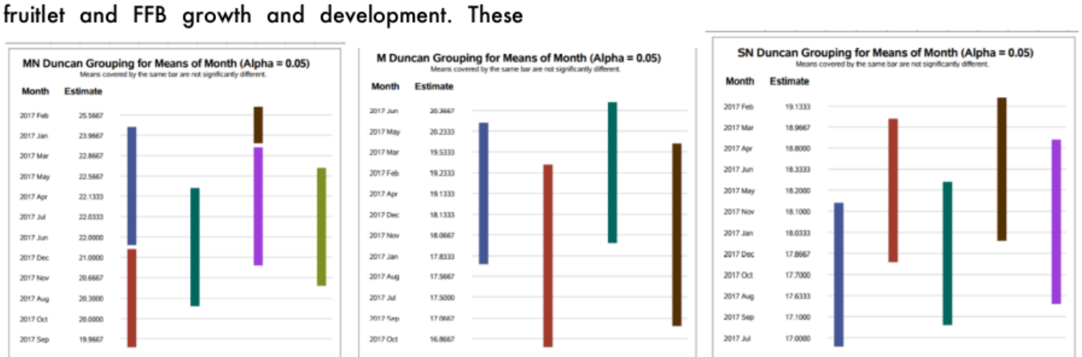

Figure 2. Heavy cluster of oil palm fresh fruit bunches on mineral soil + Nb (left), mineral-Nb soil (middle), and sandy soil + Nb (right) based on Duncan's test at 95% confidence level.

Figure 2 reveals that FFB-based clusters are more heavily on mineral + Nb soils than indicated by mineral-Nb soils and sandy + Nb soils. These results reveal the contribution of Nb depends on the type of soil. The growth of Nb biomass in mineral soils is more abundant, and it caused nutrient competition with oil palm. Meanwhile, on mineral soil Nb, routine application of empty fruit bunches can replace the role of Nb. At the same time, the use of empty fruit bunches + Nb in sandy soils produce FFB weight (18.029 kg /FFB), which is the same as mineral-Nb soil (18.032 kg / FFB) although both are lower than mineral soil + Nb (20.701 kg / FFB).

Oil palm yield is influenced by the number of FFB harvested. The number of FFB is determined by rainfall and groundwater status, nutrient balance, canopy conditions, and source-sink relations, and palm age. These factors influence the determination of sex that lasts 12-18 months before FFB is harvested [20, 21]. Monthly fluctuations in the number of FFB observed in sandy soil + Nb and mineral soil - Nb is higher than mineral + Nb soils (Figure 3). These results reveal that the contribution of Nb to sandy soils in reducing environmental influences (especially the dry season) has a shorter duration than in mineral soils so that the management of Nb as lower vegetation is more intensive in oil palm plantations. On the other hand, Nb population growth on mineral soils needs to be controlled to avoid competition in nutrient uptake with oil palm trees.

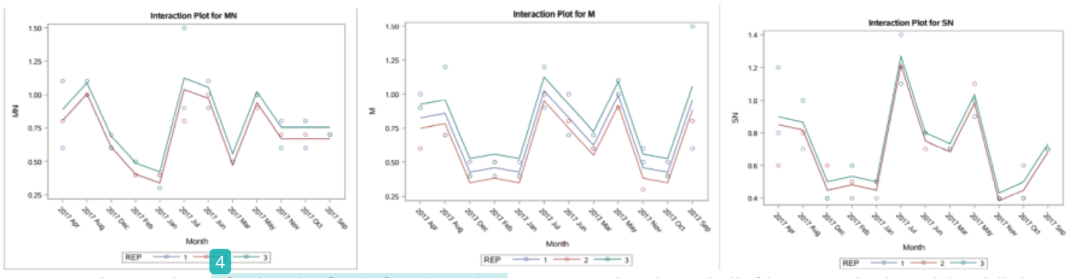

Figure 3. The number of oil palm fresh fruit bunches on mineral soil + Nb (left), mineral-Nb soil (middle), and sand + Nb soil (right).

Monthly fluctuations in the number of FFB in response to external and internal conditions during sex determination have a marked effect on FFB tonnage fluctuations compared to the impact of FFB weight. A decrease in the number of FFB tends to occur in sandy soil + Nb and mineral soil - Nb. Figure 4 reveals that cluster based on the number of FFB in mineral soils and sandy soils which covered Nb as lower vegetation than mineral soil-Nb. In other words, the amount of FFB harvested is more stable on mineral soils - Nn. Therefore, managing the density of Nb vegetation needs to get priority, especially on mineral soils that have been given empty bunches. Although, the number of FFB in sandy soils and mineral soils (0.858 and 0.850 FFB / harvest) which have lower vegetation than mineral-Nb soils (0.810 FFB / harvest)

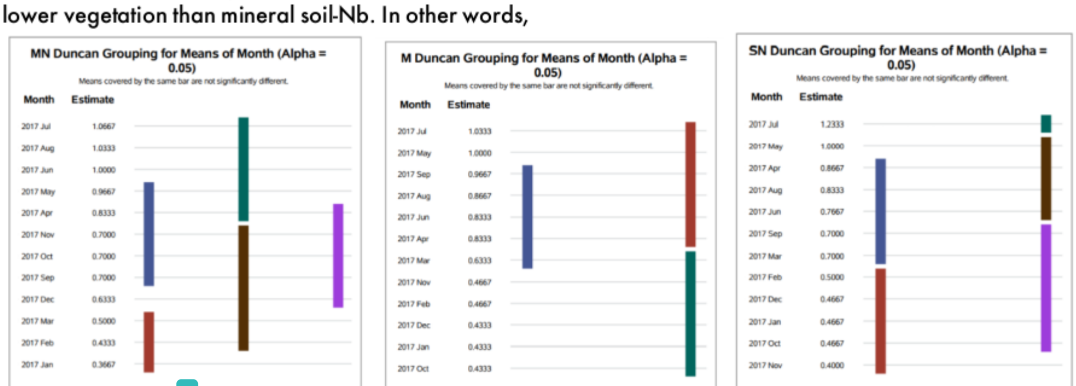

Figure 4. Clusters of oil palm fresh fruit bunches on mineral soil + Nb (left), mineral-Nb soil (middle), and sandy land + Nb (right) based on Duncan's test at 95% confidence level.

The number of FFB has a more significant contribution than the weight of FFB in influencing the oil palm yields, as indicated by fluctuations in FFB tonnage that was having the same pattern as the number of FFB (Figures 5 and 6). Generative growth cycles consist of primordia initiation of interest and sex determination, which affects the number of female flowers (sex ratio). Whereas to be harvested as FFB, female inflorescence must avoid abortion (occurring before the anthesis) and failed bunches (occurring up to 4 months after the anthesis). This generative cycle is very vulnerable to the influence of water and temperature changes during the dry season, so the agronomic practices of estate blocks is an important factor in anticipating climatic stress factor [22].

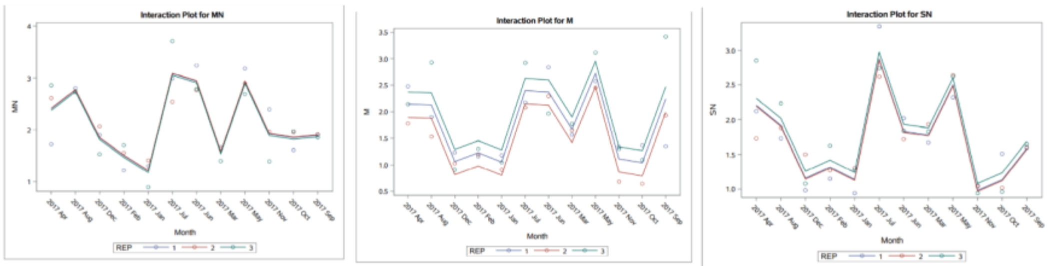

Figure 5. Palm oil yield tonnage on mineral soil + Nb (left), mineral-Nb soil (middle), and sand + Nb soil (right).

Figure 6 reveals the role of Nb as understorey vegetation to increased the productivity of sandy soils with a rate of 2.089 tons of FFB per month. It is also known that Nb in mineral soils produces 2.299 tons of FFB per month. Thus, Nb can provide higher yields than mineral soil-Nb (1.963 tons FFB per month).

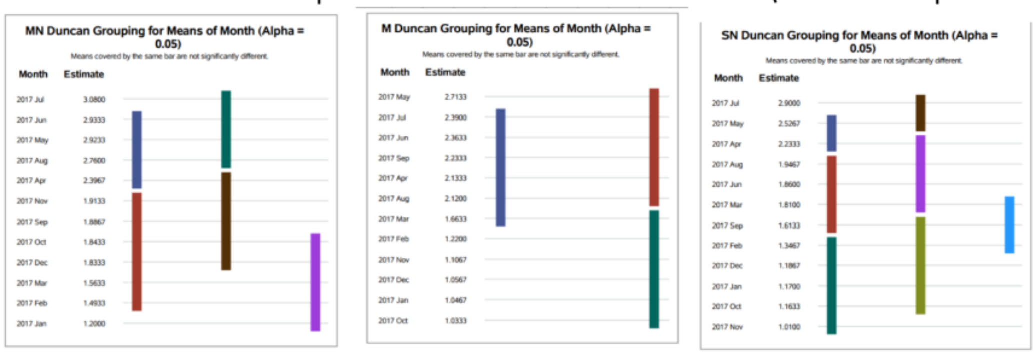

Figure 6. Palm oil yield tonnage cluster on mineral soil + Nb (left), mineral-Nb soil (middle), and sandy land + Nb (right) based on Duncan's test at 95% confidence level.

N biserrata as understorey vegetation reduces evaporation and maintains a microclimate that is conducive to the activity of the beetle pollinator *Elaeidobius camerunicus* so that it can increase fruit set and FFB tonnage harvest. On the other hand, amelioration on sandy soils can be done with the application of empty bunches or Nb vegetation management. Exudate and regeneration of Nb rooting can help maintain the sustainability of soil organic matter supply.

Conclusion

Sandy soils are vulnerable to the influence of environmental change conditions and have a significant impact on the stability of oil palm yields. N. *Biserrata* as vegetation downstairs can improve the stability and productivity of palm oil in sandy soil, which has been applied periodically to empty fruit bunches. Compost bunches of empty fruit can enhance the fertility of sandy soil, so that the growth of N. *Biserrata* become fertile and oil palm productivity increases. It is recommended that palm oil is applied to the empty fruit bunches and planting N. *Bisserata*

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