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# Effect of Cover Crops on Soil Properties and Oil Yield of Oil Palm (Elaeis *Guineensis* L) Grown on Utisol of Southern Nigeria

**Emmanuel Abiodun Awelewa[1], Okechukwu Chidiebube Umunnakwe[2]*, Emmanuel Bassey Effa[3], Bini Onen Ebri[4], Ozoemena Bernedette Bisong[5], and Inyang Ekpenyong Ekpenyoung[6]**

[1]JB Farms Oil Palm Plantation Ore, Ondo State, Nigeria.
[2]Department of Crop Science, Faculty of Agriculture, University of Calabar, Calabar, Nigeria.
[3]Department of Crop Science, Faculty of Agriculture, University of Calabar, Calabar, Nigeria.
[4]Department of Crop Science, Faculty of Agriculture, University of Calabar, Calabar, Nigeria.
[5]Department of Crop Science, Faculty of Agriculture, University of Calabar, Calabar, Nigeria.
[6]Department of Crop Science, Faculty of Agriculture, University of Calabar, Calabar, Nigeria.
*Corresponding author email: otitochiokey@yahoo.com

## ABSTRACT

*A field experiment was conducted from 2017 to 2022 at Oban in Akampa Local Government Area of Cross River State, Nigeria to evaluate the influence of leguminous cover cropping on soil properties and oil yield of oil palm. The experiment comprised three cover cropping treatments (Mucuna brateata, Pueraria phaseoloides and no cover crop) laid out in a Randomized Complete Block Design (RCBD) with twelve replications. Each replication measured 111.60 m x 33.72 m (3,763.52 $m^2$) comprising 3 uniform experimental units of 33.72 m × 37.20 m (1, 254.38 $m^2$). The gross plot measured 404.64 m × 446.4 m (180,631.296 $m^2$, equivalent to 18.06 hectares). Results indicated significant ($p < 0.05$) effect of treatment on soil properties and palm oil yield. The plots with cover crops showed significant improvement of the physical, chemical and biological properties of the soil which resulted in statistically higher oil yield. Mucuna brateata significantly enhanced soil properties and optimized palm oil yield more than Pueraria phaseoloides and the control, and is recommended for commercial oil palm production in Cross River State and areas with similar climates.*

***Keywords:*** *Mucuna, Pueraria, palm oil, oil palm, soil properties*

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## INTRODUCTION

The global demand for palm oil, derived from the oil palm (Elaeis guineensis L.), continues to increase significantly due to its extensive economic applications (Ritchie and Roser, 2021). Palm oil is a key ingredient in a wide range of food products, including bread, pizza, cookies, chocolates, and margarine. Additionally, it serves as a widely used cooking oil, making it the most consumed edible oil worldwide (USDA, 2019). Beyond its role in the food industry, palm oil is also a critical component in the manufacturing of various industrial and consumer goods, such as cleaning agents, cosmetics, soaps, and detergents (Murphy, 2014). Its versatility underscores its importance in both the food and industrial sectors, driving its increasing global demand.

Palm oil, along with kernel oil derived from the milling of oil palm, has traditionally been utilized as a fuel source for lighting lamps in local settings (Murphy, 2014). In modern industrial applications, biodiesel for powering vehicles is produced from methyl esters obtained through the conversion of palm oil (Rosillo-Calle et al., 2007). However, the current supply of palm oil remains insufficient to meet the growing demand across its diverse applications, presenting a significant challenge for industries reliant on this resource.

Currently, 72 million metric tonnes is the annual global turnover of palm oil. Indonesia currently has the highest annual palm oil turnover of 41 million metric tonnes which is 57 % of the total global output (Ritchie and Roser, 2021). This is followed by Malaysia with 20 million metric tonnes per annum accounting for 27 % of global output (Ritchie and Roser, 2021). Nigeria on the other hand, is the 5$^{th}$ highest global palm oil producer with 1.4 metric tonnes per annum which accounts for 1.9 % of the global output (Ritchie and Roser, 2021). Meanwhile, Nigeria was the highest palm oil producer across the globe before 1965, when it was producing over 43 % of the global oil output. Unfortunaly, today Nigeria is the 5$^{th}$ highest oil producing nation with a meager 1.4 million metric tonnes per annum which is regrettably less than 2 % of the global output (Shahbandeh, 2023). It has been reported that Nigeria's lead in world's palm oil production was lost majorly as a result of crude oil exploration, poor commitment to agricultural development, poor cultural practices and over dependent on inorganic fertilizers which often pose threats to soil health and the surrounding environment (Nnorom, 2012).

The Nigerian civil war of 1967 – 1970 has also been alleged to have contributed immensely to the decline in palm oil production turnover in Nigeria, however, recent stuidies have shown that inadequate infrastructure, unfavourable government policies, poor funding, lack of modern farm practices, land tenureship, poor soils and need for environmental protection are some of the major setbacks trailing the Nigerian oil palm industry (Ohimain *et al.,* 2014).

Utisols are characteristically poor structured with low aggregate stability, which makes them vulnerable to environmental degradation on exposure to the agents of denudations (Yulnafatmawita and Adrinal, 2014). Commercial oil palm plantations use heavy machinery that causes tense exposure of these soils to heavy runoffs and soil erosions leading to very high environmental degradation risks (Waran *et al*., 2019). There is total decline in soil fertility and productivity arising from the heavy washing off and transportation of the rich soil organic matter and nutrients (Awelewa and Ogban, 2015; Gmach *et al*., 2020). Cultivated soil also implies more nutrients removal through continous absorption by plants than being replenished unlike what is obtainable in natural and uncultivated lands. Nutrient depletion is a key factor in soil fertility decline (Ogeh & Osiomwan, 2012; Gmach et al., 2020). While inorganic fertilizers are commonly used, they pose environmental risks, and organomineral options remain rare and costly. To combat soil fertility challenges like weed competition, runoff, erosion, nutrient fixation, and compaction from heavy machinery, integrating leguminous cover crops in commercial oil palm plantations offers an effective solution. This practice reduces nutrient loss while improving soil health and sustainability (Michael et al., 2020).

Oil palms can enjoy a non competitive coexistence with leguminous cover crops. The legumes grow vigorously and could have a quick ground cover that could provide a needed cover to bare soil exposed to the agents of erosion by the activities of the heavy machines used in oil palm plantations (Samedani *et al*., 2014). The functions of the leguminous cover crops coexisting as an intercrop with oil palm has been listed to include reduction of the evaporation rate of soil water, improvement of soil structure, enhancement of soil organic matter content, symbiotic nitrogen fixation, prevention of runoff, prevention of nutrient leaching and soil erosion, promotion of nutrient recycling, improvement and maintenance of soil fertility (Adetunji *et al*., 2020; Freidenreich *et al*., 2022; Koudahe *et al*., 2022) and promoting the activities of soil organisms (Cloutier *et al*., 2020). Cover cropping system generally reduces the risk of soil compaction through the addition of organic materials to the soil which increases the buffering capacity of the soil, improves the workability of the soil, increases the cation exchange capacity of the soil, enhances soil aeration and good water infiltration by the improvement of soil structure (Goh *et al*., 2014; Gong *et al*., 2021). Leguminous cover crops promote biological fertility. The presence of complex organic residues underneath cover crops triggers the activities of several species of micro-organisms involved in transforming the organic matter into the component mineral nutrients (Borrell *et al*., 2016). This microbial activity is not only influenced by the volume of residual organic material, but also by the promotion of optimum aeration, temperature and humidity that favours the proliferation of benefitial microbes (Hallama *et al*., 2019). Freidenreich *et al.* (2022) had earlier averred that in the absence of biological fertility the soil becomes sterile and will lack the capacity to support plant growth. There is dearth of information on the use of leguminous cover crops as component crops in oil palm plantations in Nigeria; therefore this research is conducted to evaluate the effects of leguminous cover crops on soil properties and palm oil yield.

## MATERIALS AND METHODS

### *Study area*

A field experiment was conducted from 2017 to 2022 at Oban (latitudes 5$^{O}$20$^{1}$ and 5$^{O}$21$^{1}$ North and longitudes 8$^{O}$37$^{1}$ and 8$^{O}$38$^{1}$ East) in Akampa Local Government Area of Cross River State, Nigeria. The area is situated in the rainforest belt of Southern Nigeria. It is marked by two distinct seasons; the dry season, which lasts from November to March, and the wet season, which lasts from April to October. The mean annual rainfall range between 2,500mm – 3,000mm with a mean annual temperature range of 26$^{O}$C – 27$^{O}$C as well as mean relative humidity of 80 – 90 per cent during the rainy season peak period (Akpan-Idiok, 2012).

### Experimental design and layout

The experiment comprised three cover cropping treatments (*Mucuna brateata*, *Pueraria phaseoloides* and no cover crop) laid out in a Randomized Complete Block Design (RCBD) with twelve replications. Each replication measured 111.60 m x 33.72 m (3,763.52 $m^2$) comprising 3 uniform experimental units of 33.72 m × 37.20 m (1,254.38 $m^2$). The gross plot measured 404.64 m × 446.4 m (180,631.296 $m^2$, equivalent to 18.06 hectares).

### Field establishment of the test crop and the cover crops

The experimental site was in secondary vegetation following a six-year fallow period having been previously used for cassava and maize mixed cropping. The vegetation was predominantly shrubs with a few creeping herbs, grasses and other low growing plants that included *Calapogonium mucunoides* Desv., *Triumfetta rhomboidae* Jacq, *Panicum maximum* Jacq and *Euphorbia heterophylla* L. The vegetation was cleared using bulldozer. An 8.43 m x 7.44 m triangular spacing were lined and pegged to mark the oil palm planting points giving a total of 20 palms stand per 1,254.38 $m^2$ treatment unit and 160 palms stand per hectare. Ten months old oil palm seedlings of Cirad genotype were neatly planted into 45 cm x 43 cm holes dug using spade, corresponding to the size of the main nursery polybag where the seedlings were raised. Seeds of the cover crops were introduced in between the palms according to treatment units at 8.43 m x 7.44 m spacing resulting in one cover crop to one palm. The control plot was not sown cover crop. Manual weeding using hoe was carried out eight weekly up to the 72nd week when the cover crops fully covered the blocks.

### Data collection and analysis

On the 4th year of study, soil samples were taken randomly 10 meters apart using soil auger at 0 – 15 cm and 15 – 30 cm depths and composited separately for each treatment with twelve replications. Sub-sample was removed from the composite samples obtained, for microbiological analysis and the remaining was air-dried, ground and sieved through a 2 mm sieve and closed in plastic bags for physico-chemical analyses following the procedures described by Udo et al. (2009). Crop yield data was collected from six middle palms per plot over a period of three years from the 3rd year when the palms started full fresh fruit bunch (FFB) production to the 5th year. All data were subjected to analysis of variance (ANOVA) procedures for randomized complete block design (RCBD) using the GenStat Package Version 8.1 of 2015. Means were compared using Fisher's least significant difference (FLSD) method at 5% level of probability as described by Wahua (2010).

## RESULTS AND DISCUSSION

### Effect of cover cropping on soil physical properties at 15 cm and 30 cm depths

The physical properties of utisol of southern Nigeria at different depths as influenced by leguminous cover crops are presented in (Table 1). Results indicated significant ($P \leq 0.05$) effect of cover cropping on soil bulk density at 15 cm and 30 cm depths, and sand particles at 30 cm depth only. Both clay and silt particles were not significantly ($P > 0.05$) affected by cover cropping at all depths measured. The highest bulk density was observed on the control plot while the lowest was observed on the soil grown *M. brateata*. Soils grown *M. brateata* had significantly ($P \leq 0.05$) lower sand particles compared to those grown *P. phaseoloides* and those not treated with cover crop. The sand particles in the soil grown *P. phaseoloides* and those not treated with cover crop were statistically ($P > 0.05$) similar.

**Table 1:** Soil physical properties at 15cm and 30cm depth as influenced by cover cropping.

| Treatments | Clay % | Silt % | Sand % | Bulk density g/cm$^3$ |
|---|---|---|---|---|
| **Surface soil (15 cm)** | | | | |
| Control | 6.83 | 16.93 | 75.23 | 1.40 |
| *Mucuna brateata* | 10.40 | 17.07 | 72.53 | 1.11 |
| *Pueraria phaseoloides* | 7.67 | 15.40 | 76.93 | 1.16 |
| $FLSD_{(0.05)}$ | NS | NS | NS | 0.12 |
| **Subsurface soil (30 cm)** | | | | |
| Control | 9.07 | 16.03 | 74.90 | 1.46 |
| *Mucuna bracteata* | 13.57 | 16.33 | 70.10 | 1.16 |
| *Pueraria phaseoloides* | 10.43 | 15.47 | 74.10 | 1.18 |
| $FLSD_{(0.05)}$ | NS | NS | 2.04 | 0.13 |

### Effect of cover cropping on soil chemical properties at 15 cm and 30 cm depths

The effect of leguminous cover cropping on the chemical properties of utisols of southern Nigeria at different depths are presented in (Table 2). Results indicated significant ($P \leq 0.05$) effect of cover cropping on all the chemical properties of southern utisol at all depths, except sodium (Na) at all depths and hydrogen radicals at 30 cm. Significantly ($P \leq 0.05$) higher values of pH, organic carbon (OC), total nitrogen (TN), available phosphorous (P), calcium (Ca), magnesium (Mg), potassium (K), effective cation exchange capacity (ECEC) and base saturation (BS) were observed on the soil grown *M. brateata* at all depths, followed by *P. phaseoloides* at 15 cm depth, while the lowest values at all depths were observed on the control plot without cover crop.

**Table 2:** Soil chemical properties at 15cm and 30cm depth as influenced by cover cropping.

| Treatments | pH | Org C % | TN % | Avail P mg/kg | $Ca^{2+}$ cmol/kg | $Mg^{2+}$ cmol/kg | $K^{+}$ cmol/kg | $Na^{+}$ cmol/kg | $Al^{3+}$ cmol/kg | $H^{+}$ cmol/kg | ECEC cmol/kg | BS % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Surface soil (15 cm)** | | | | | | | | | | | | |
| Control | 5.55 | 1.45 | 0.08 | 5.93 | 1.71 | 0.40 | 0.13 | 0.11 | 0.54 | 0.55 | 3.44 | 64.64 |
| *Mucuna brateata* | 6.12 | 2.80 | 0.31 | 9.08 | 3.06 | 0.74 | 0.27 | 0.11 | 0.30 | 0.20 | 4.68 | 89.38 |
| *Pueraria phaseoloides* | 5.98 | 1.98 | 0.18 | 8.70 | 2.48 | 0.65 | 0.25 | 0.10 | 0.31 | 0.26 | 4.06 | 85.95 |
| $FLSD_{(0.05)}$ | 0.10 | 0.37 | 0.05 | 1.28 | 0.53 | 0.17 | 0.04 | NS | 0.10 | 0.33 | 0.72 | 4.66 |
| **Subsurface soil (30 cm)** | | | | | | | | | | | | |
| Control | 5.72 | 1.02 | 0.11 | 5.35 | 1.71 | 0.33 | 0.12 | 0.11 | 0.48 | 0.53 | 3.28 | 69.70 |
| *Mucuna bracteate* | 6.16 | 2.26 | 0.30 | 9.45 | 2.95 | 0.84 | 0.27 | 0.11 | 0.22 | 0.21 | 4.60 | 90.70 |
| *Pueraria phaseoloides* | 6.01 | 1.69 | 0.19 | 8.03 | 2.38 | 0.57 | 0.25 | 0.10 | 0.34 | 0.28 | 3.92 | 84.10 |
| $FLSD_{(0.05)}$ | 0.31 | 0.79 | 0.04 | 1.76 | 0.57 | 0.26 | 0.04 | NS | 0.04 | NS | 0.71 | 8.06 |

Key: Org C = organic carbon, TN = total nitrogen, Avail P = available phosphorus, $Ca^{2+}$ = calcium, $Mg^{2+}$ = magnesium, $K^{+}$ = potassium, $Na^{+}$ = sodium, $Al^{3+}$ = aluminum ion, $H^{+}$ = hydrogen ion, ECEC = effective cation-exchange capacity, BS = base saturation

**Table 3:** Soil biological properties at 15cm and 30cm depth as influenced by cover cropping.

| Treatments | BAC_POP ($x10^{6}$ $cfug^{-1}$) | FUN_POP ($x10^{-3}$ $cfug^{-1}$) | MB ($MgCO_2^{-1}$) | PMC ($MgCO_2$-C) | PMN ($MgCO_2$-N) |
|---|---|---|---|---|---|
| **Surface soil (15 cm)** | | | | | |
| Control | 29.30 | 9.00 | 1.97 | 5.67 | 1.00 |
| *Mucuna brateata* | 71.40 | 25.33 | 3.33 | 16.93 | 2.65 |
| *Pueraria phaseoloides* | 60.20 | 20.33 | 2.40 | 15.00 | 1.97 |
| $FLSD_{(0.05)}$ | 8.92 | 3.16 | 0.49 | 1.28 | 0.32 |
| **Subsurface soil (30 cm)** | | | | | |
| Control | 20.10 | 5.00 | 1.13 | 4.83 | 0.93 |
| *Mucuna bracteata* | 48.00 | 19.00 | 2.27 | 9.00 | 1.71 |
| *Pueraria phaseoloides* | 33.50 | 11.50 | 1.87 | 6.93 | 1.37 |
| $FLSD_{(0.05)}$ | 18.94 | 8.76 | 0.67 | 4.98 | 0.73 |

Key: BAC_POP = Bacterial population, FUN_POP = Fungal population, MB = Microbial biomass, PMC = potentially mineralizable carbon, PMN = potentially mineralizable nitrogen

### *Effect of cover cropping on soil biological properties at 15 cm and 30 cm depths*

The effect of leguminous cover cropping on the biological properties of utisols of southern Nigeria at different depths are presented in (Table 3). Results indicated significant ($P \leq 0.05$) effect of cover cropping on all the biological properties measured at all depths. Bacterial population, Fungal population, Microbial biomass, potentially mineralizable carbon (PMC) and potentially mineralizable nitrogen (PMN) were significantly ($P \leq 0.05$) higher in the soil grown *M. brateata* at all depths, followed by *P. phaseoloides* while the lowest at all depths were observed on the control plot without cover crop.

### *Effect of cover cropping on oil yield of oil palm*

The effect of leguminous cover cropping on oil yield of oil palm grown on utisols of southern Nigeria is presented in (Table 4). Results showed significant ($P \leq 0.05$) effect of cover cropping on the oil yield of oil palm across the first three production years of the palms. Palms in the plot treated *M. brateata* produced the highest annual oil yield across the three years with 0.74, 0.95 and 1.69 metric tonnes/ha for 2020, 2021 and 2022 production years, respectively followed by *P. phaseoloides* with 0.59, 0.81 and 1.37 t/ha for 2020, 2021 and 2022 production years, respectively while the lowest oil yield was observed on the control plot without cover crop with 0.48, 0.67 and 0.92 metric tonnes per hectare for 2020, 2021 and 2022 production years, respectively.

**Table 4:** Oil yield of oil palm as influenced by cover cropping.

| Annual oil yield (t/ha) | | | |
|---|---|---|---|
| Treatments | Production year | | |
| | 2020 | 2021 | 2022 |
| Control | 0.48 | 0.67 | 0.92 |
| *Mucuna brateata* | 0.74 | 0.95 | 1.69 |
| *Pueraria phaseoloides* | 0.59 | 0.81 | 1.37 |
| $FLSD_{(0.05)}$ | 0.06 | 0.13 | 0.30 |

## DISCUSSION

The lower bulk density observed on *M. brateata* treated plot suggests reduction on soil compaction and better soil aggregation which may possibly be as a result of organic matter addition to the soil by the decomposition of fallen leaves and dead branches from the mucuna. Celik *et al.* (2004) averred that increasing the organic matter composition of the soil results in a lower bulk density, reduces the degree of compaction, improvement of aggregation, enhancement of porosity, improves hydraulic conductivity, and resistance to erosion. In the same vein, Martinez and Zinck (2004) stated that a decline in the organic matter content of the soil results in soil compaction. On the other hand, the higher bulk density recorded on the control plot suggests a higher soil compaction. The significantly lower sand particles observed at 30 cm soil depth in the plot treated MB may be attributed to a high foliage production observed on the cover crop which forms a high organic matter on decomposition. As noted by Celik *et al*. (2004), since organic matter has low bulk density and higher porosity, the decomposition of crop residues adds organic matter to the soil which improves the physical properties. Koudahe *et al.* (2022) avered that soil organic matter is quite essential to soil health as its accumulation under cover crops deters soil compactibility by decreasing soil bulk density while enhancing soil structure. Celik *et al*. (2010) reported improved soil physical properties as a result of increase in soil organic matter content following organic manure application.

The higher pH values (lower soil acidity) observed in the plots treated with leguminous cover crops relative to the control without cover crop suggests increase in macronutrients availability. The work of Nweke (2016) on influence of different leguminous crop on the ultisol that had been continuously cropped to cassava /maize for over six years, showed increase in soil pH in the plots treated with cover crops which he attributed to soil nutrient enhancement by the activities of the symbiotic microbes inhabiting the roots of the leguminous cover crops. Leguminous crops such as centrosema, cowpea, mucuna pruriens and Bambara groundnut create symbiotic microclimates that promote the activities of beneficial micro - and macro-organisms which improve soil physico-chemical properties (Lal *et al*., 2008; Wilson *et al*., 2012). Increase in pH by legumes was also reported by Degu *et al*. (2019) and Michael *et al*. (2020). On the other hand, the higher soil acidity (lower pH) observed on the control suggest that the soil in that treatment was exposed to extreme environmental conditions such as torrential rainfall which might have resulted in heavy leaching of the macronutrients.

According to Fageria and Nascente (2014), heavy rainfall contributes to the leaching of macronutrients, which in turn leads to increased soil acidity. The elevated organic matter content observed in plots treated with leguminous cover crops can be attributed to the substantial foliage production by these legumes, which subsequently enhances the soil's organic matter.

Sharma et al. (2018) and Michael et al. (2020) observed that organic matter under cover crops was higher than bare soil treatment. Soil organic matter enhancement by legumes was also reported by Nascente and Stone (2018). The higher total nitrogen observed in the plots treated with leguminous cover crops may be attributed to the fixing of atmospheric nitrogen into the soil by symbiotic bacteria inhabiting the root nodules of the legumes. As noted by Kumar *et al.* (2013), Rhizobia spp that live in symbiotic association with legumes have intrinsic capacity to fix atmospheric nitrogen.

In consonance with this observation are the reports of Lal *et al*. (2009), Wilson *et al*. (2012) and Degu *et al.* (2019) which showed increase in soil nitrogen content by leguminous cropping. Available phosphorus was higher with leguminous cover crops which could be attributed to several factors. Phosphorus in the tissues of the cover crops may have been recycled back to the soil through the decomposition of the dead leaves.

The pool of beneficial microorganisms attracted by the microclimate created by the dense canopy of the legumes may have included phosphorus solubilizing bacteria and fungi. Similarly, increase in acid phosphatase and b-glucosidase enzyme activity with cover crop treatment in North Carolina and Tennesse, USA, were reported by Kirchner *et al*. (1993) and Mullen *et al*. (1998), respectively. Indigenous arbuscular mycorrhizal fungi, recognized for their ability to enhance phosphorus uptake (Umunnakwe et al., 2022), are known to establish symbiotic associations with the roots of leguminous plants. Studies conducted by Lehman et al. (2014), Njeru et al. (2014), and Hontoria et al. (2019) have demonstrated an increase in fungal colonies in soils where leguminous cover crops are present. These findings underscore the critical role of leguminous plants in fostering beneficial microbial communities, improving soil fertility, and facilitating efficient nutrient cycling within agricultural systems.

The significantly higher cations $Ca^{2+}$, $K^{+}$ and $Mg^{2+}$ observed in the plots treated with leguminous cover crops relative to the control must have been as a result of the decomposition and mineralization of the dead branches and foliage from the cover crops. The legumes, especially Mucuna produced dense foliage that completely covered the soil surface. This observation agrees with earlier reports by Nweke (2016), Degu *et al*. (2019), Kim *et al.* (2020) and Michael *et al*. (2020). The higher ECEC and base saturation observed in the plots treated with cover crops relative to the control suggests enhancement of the fertility and productivity of the soil. This observation corroborates the reports of Stagno *et al.* (2011) who stated that leguminous cover crops increase soil fertility by enhancing the availability of essential soil nutrients.

The reduced exchangeable acidity observed in plots treated with leguminous cover crops can be attributed to the enhanced effective cation exchange capacity (ECEC) associated with these treatments, reflecting improved macronutrient availability in the soil. This finding aligns with the results of Michael et al. (2020), who reported lower exchangeable acidity in similar treatments, attributing it to increased soil essential nutrients and elevated pH levels.

Furthermore, the notable enhancement of microbial populations in plots with leguminous cover crops, compared to the control, suggests that these cover crops contribute to creating a more favorable microclimate in the rhizosphere, thereby promoting microbial activity and soil health.

The findings align with those of Stagno et al. (2011), Lupwayi et al. (2017), and Hontoria et al. (2019), emphasizing the positive impact of cover crops on soil organic matter content, which supports the proliferation of soil microorganisms. Studies by Borrell et al. (2016) and Detheridge et al. (2016) have highlighted that the incorporation of leguminous cover crops in cropping systems enhances the growth of soil saprotrophs due to an improved carbon-to-nitrogen (C/N) ratio resulting from the higher biomass of cover crop residues. Furthermore, significant increases in soil microbial biomass following the application of leguminous cover crops have been documented by Chavarría et al. (2016) and Gong et al. (2021).

Additional benefits of legume cover crops, such as the suppression of pathogenic organisms, enhancement of soil microbial diversity, contribution of plant residues, and reduction in synthetic fertilizer dependency, have been reported by Esmaeilzadeh-Salestani et al. (2021). These findings collectively underscore the ecological and agronomic advantages of incorporating leguminous cover crops into agricultural systems.

Higher oil yield was obtained from the LCC treated plots relative to the control which could be attributed to the enhanced physical, chemical and biological properties of the soil observed in those plots. Previously, Teoh and Chew (1980), Chiu and Siow (2007), Mathews and Saw (2007), and Samedani et al., (2014) had reported higher yield in oil palm when intercropped with leguminous covers relative to the control. The superior performance of M brateata to P. phaseoloides could be attributed to several factors. The luxuriant growth with quicker tendency to attain complete ground coverage within a short period of time observed with MB must have added extra benefits of moisture conservation, soil buffering from the impacts of raindrops and high intensity sunshine, temperature regulation and increase in organic matter from foliage litters.

This observation is in consonance with Mathews and Saw (2007) who reported higher fresh fruit bunch yield by MB treatment compared to other cover crops.

The results from this study have shown that intercropping oil palm with leguminous cover crops enhanced soil fertility by improving the soil physical, chemical and biological properties, thereby significantly increasing the oil yield of oil palm. Mucuna brateata showed superior soil properties and higher oil yield relative to P. phaseoloides and the control, and could therefore be recommended for commercial oil palm production in Cross River State and other tropical rainforest regions.

## Conflict of Interest

The authors declare that there are no conflict of interest associated with the study.

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