

# Nitrogen, Phosphor, and Potassium Level in Soil and Oil Palm Tree at various Composition of plant species mixtures grown

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**Abstract.** In productive oil palm plantation areas, poor vegetation is generally caused by low light intensity. This condition causes excessive erosion and decreases soil fertility. One of the efforts for soil and water conservation at oil palm plantations is through increased vegetation diversity. The changes of soil and plant nitrogen, phosphorus, and potassium content, observed by planting two types of herbs under oil palm tree, with different compositions. Vegetation composition was set as: *Arachis glabrata* 100%; *Stenotaprum secundatum* 100%; *Arachis glabrata* 50% + *Stenotaprum secundatum* 50%; *Arachis glabrata* 75% + *Stenotaprum secundatum* 25%; *Arachis glabrata* 25% + *Stenotaprum secundatum* 75%. The shoot and root fresh/dry weight, nutrient content (nitrogen, phosphor, and potassium) of each cutting were measured at the end of the experiment. Ten of treatment plant were harvested and divided shoots and roots after washing out of soil. Biomass samples were dried at 70 °C for 48 h and weighed. The total N and its proportional concentration (N%) were analyzed with the micro-Kjeldahl method. Potassium analyzing with flamephotometry, and phosphor and from samples was determined by analyzing with spectrophotometry method. The results showed the highest shoot growth of *A. glabarata* if planting was mixed with *S. secundatum*, but the result was different with *S. secundatum* being superior if planted with monoculture system. Combination of interrow cultivation is more recommended for soil conservation and nutrient maintenance in palm oil trees were *A. Glabarata* 75% + *S. secundatum* 25%.

## 1. Introduction

The success of oil palm cultivation is generally determined by soil conditions and water availability which includes physical, biological, and chemical properties of soil. Productive oil palm (POP) plantation areas are different than young oil palm (YOP), one difference being the light intensity level on the ground. The young oil palm gets enough light intensity, but the POP is not. Light is one of the most important factors mediating plant growth [27] and is a vital regulator of numerous processes [5] Light is the energy source for photosynthesis, producing the ATP and NADPH to assemble carbon atoms into organic molecules. The limited incidence of light in POP interrow causes lowered soil fertility and productivity. This decreased number of plants under the crop will cause fertilizer effectiveness to be reduced. Increasing plant population in POP interrows would prevent the loss of



fertilizer applied. In addition, the rate of erosion (*run off*) will be reduced because the smaller root plants are capable of holding and binding the soil aggregates. Therefore, soil conservation efforts are needed to prevent erosion, improve damaged soil, and maintain soil productivity so the soil can be used sustainably. Water supply is a major limiting factor for the production of palm oil. Drought affects all aspects of palm oil, including the quality of the crops such as the oil [6] and sugar contents [17]. The decline in sugar content will result in the plant lacking the energy for growth and development. Inhibited seed filling rate is also one of the reasons for low crop production. Better soil conditions will affect the processes of water and nutrient uptake, root respiration as well as ease of maintenance and harvest.

Not all plants growing on the oil palm plantation area are weeds that should be exterminated. Clean weeding might invite pests, especially caterpillars, and reduce the soil moisture.

Some types of ferns such as *Neprolepis*, *Casiacubanensis*, and *Turnera subulata*, however, are worth keeping. *Neprolepis* ferns are useful for retaining soil moisture, and *Turnera* and *Casia* could serve as hosts for *Cantheconidea* (predator of caterpillar). Therefore, other plants that have the ability to survive under low light intensity are also necessary. These plants can be expected to have a dual function: top revert run-off rate and increase soil organic matter. Selection of plants is based on their ability to adapt at low light intensity, and its capability to produce relatively high and stable foliage year-round. Types of legume or shade-tolerant grasses are chosen alternative compared to other ground plants that are considered best for cover crops. One of these legumes is *A. glabarata* and *S. secundatum* for the grasses. Both of these are shade resistant and grow easily ([20]. Increasing the plant diversity will affect on soil fertility. Many researchers clarified numerous effects on nutrient concentration and status [12, 13, 31]. Palm oil trees need nitrogen, phosphorus and potassium in large quantities. Nitrogen deficiency is usually associated with topsoil erosion. It will result in general and stiffening of the pinnae which lose their glossy lustre, reduce the number of effective fruit bunches, as well as the bunch size. Phosphor deficient leaves are shorter than well-nourished ones. Bunch size and trunk diameters are reduced. Potassium deficiency symptoms were intensifies these spots turn orange, or reddish-orange, and dessication sets in, starting from the tips and outer margins of the pinnae. In soils with low water holding capacity potassium deficiency can lead to a rapid premature dessication of fronds ([http://ipipotash.org/udocs/Nutrient Management of the oil palm.pdf](http://ipipotash.org/udocs/Nutrient%20Management%20of%20the%20oil%20palm.pdf)). The availability of soil nutrients will affect to oil palm productivity.

## 2. Material and methods

The research was conducted in field experiments on 8-years old productive plants. Observation on light intensity under palm oil tree using a lux meter showed that light intensity level was about 40%. Before planting *Stenotaprum secundatum* and *Arachis glabarata*, soil fertility and plants that live in these area were analyzed. Vegetation analysis was done by creating seven plots, each measuring 1x1m. Vegetation analysis studies the composition (component type) of plant communities. Along the POP interrows were planted both *A. glabrata* grass and legume with the following composition: *A. glabrata* 100% ; *S. secundatum* 100%; *A. glabrata* 50% + *S. secundatum* 50%; *A. glabrata* 75% + *S. secundatum* 25%; and *A. glabrata* 25% + *S. secundatum* 75%. The shoot and root fresh/dry weight, nutrient content (nitrogen, phosphor, and potassium) of each cutting were measured at the end of the experiment. Ten of treatment plant were harvested and divided shoots and roots after washing out of soil. Biomass samples were dried at 70 °C for 48 h and weighed. The total N and its proportional concentration (N%) were analyzed with the micro-Kjeldahl method. Potasium analyzing with flamephotometry, and phosphor and from samples was determined by analyzing with spectrophotometry method.

## 3. Results and discussion

### 3.1. Analysis vegetation

Analysis vegetation is research approach for study of spatial patterns of vegetation. It seeks to understand the structure and variation of the vegetation of lanscape. The term gradient in space of variables on environmental factors, species population and characteristic of communities (Cajo and Braak, 1987). Vegetation analysis on POP crop before planting *Stenotaprum secundatum* and *A. glabarata* showed that Kilingia species has the highest growth, followed by *Asistasia* (Table 1).

**Table 1.** Vegetation analysis on POP area.

| VegetationType                  | ObservationPlot |     |     |    |    |    |     |
|---------------------------------|-----------------|-----|-----|----|----|----|-----|
|                                 | I               | II  | III | IV | V  | VI | VII |
| <i>Cyperus Kilingia</i>         | 26              | 38  | 37  | 19 | 4  | 28 | 0   |
| <i>Ageratum conyzoides</i>      | 12              | 6   | 13  | 16 | 0  | 18 | 20  |
| <i>Asistasia</i>                | 28              | 23  | 6   | 10 | 4  | 12 | 7   |
| (a) <i>Phyllanthus Niruri L</i> | 26              | 15  | 31  | 23 | 8  | 29 | 3   |
| (b) <i>Cyclosorus aridus</i>    | 0               | 1   | 0   | 2  | 0  | 2  | 0   |
| <i>Cyperaceae</i>               | 0               | 42  | 0   | 0  | 0  | 0  | 6   |
| <i>Axonopus compresus</i>       | 0               | 0   | 0   | 24 | 17 | 0  | 0   |
| <i>Broadleaf weeds</i>          | 0               | 0   | 0   | 0  | 43 | 0  | 0   |
| <i>Total</i>                    | 92              | 125 | 87  | 94 | 76 | 89 | 36  |

*Kilingia* (*Cyperus kilingia*) is a type of cyperaceae hat developed with its root and rhizome. It grows and multiplies rapidly, and can survive in low light intensity, making it the most dominant weed. Basic or under growth vegetation are also important components in an ecosystem, being able to support the life of other plant species. Basic vegetation is basic cover crop consisting of herbaceous ground cover, bushes or shrubs, lianas and ferns. The results showed that low diversity of plants on the POP area. Decline in biodiversity with land use change identified as one of the most important drivers. The lost of diversity has a significat on ecosystem functioning [33].

Shoot fresh and dry weight of Interrow Plants

*A. glabarata* that were planted individually or simultaneously showed that each treatment affected herb growth significantly (Table 2). The highest shoot fresh weight on treatment (*S. secundatum* 100%) was 53.56g. Higher fresh weight in *S. secundatum* is possibly caused by the vegetation's better ability to compete in absorbing resources.

**Table 2.** Shoot fresh and dry weight of interrow plants at various planting composition.

| Population Percentage     | Shoot fresh weight | Shoot dry weight |
|---------------------------|--------------------|------------------|
| <i>A. glabrata</i> 100%   | 19,46e             | 11.45g           |
| <i>S. secundatum</i> 100% | 53.56a             | 43.61a           |
| <i>A. glabrata</i> 50%    | 18.46e             | 10.48g           |
| <i>S. secundatum</i> 50%  | 44.66c             | 30.82d           |
| <i>A. glabrata</i> 75%    | 28.49d             | 21.85e           |
| <i>S. secundatum</i> 25%  | 47.74b             | 38.56b           |
| <i>A. glabrata</i> 25%    | 19.01e             | 13.61f           |
| <i>S. secundatum</i> 75%  | 43.54c             | 33.41c           |

Note: The number followed by repeated letter in the same column is insignificant according to Duncan average test (DMRT) at 5% level.

This herb is also shade-tolerant and able to grow under limited light intensity, also found an increase in the growth of *S. secundatum* planted under shade [28]. This grass also has ability to adapt to saline soil [16]. The results of this study indicated that *S. secundatum* have adaptability under limited light intensity. This ability is thought to be caused by its high growth rate, making it excel in competition. *S. secundatum* is a plant belonging to the group of C4 metabolism [24]. This group has a higher CO<sub>2</sub> utilization, water use, and higher radiation use efficiency [26]. Therefore C4 producing more assimilates, and higher nitrogen use efficiencies because it will require less Rubisco and hence less nitrogen.

Planting one plot with one type of plant (*S. secundatum* 100%) also made it grow better (Table 2). This is because it didn't have to share its nutrients with other plants. The number of plant population per hectare is also an important factor to obtain maximum yield. Higher plant density will create higher competition between plants for nutrient absorption. *Arachis glabarata* has a higher wet and dry weight average in mixed-population plots (*A. glabarata*75%+*S. secundatum* 25%) compared to single-type plots.

In a monoculture, the obtained dry weight was 11.45 but in mixed-population plots it increased to 21.85 (Table 2). This result indicated an increase in *A. glabarata* by mixing the diversity of the vegetation in a plot. Planting more than one type of plant in an area had proven to increase nutrient enrichment condition [7, 18, 23, 30], water and reduce the effects of plow pan. Thus output per unit area increases with many fold returns to the growers. Increased diversity in one area will affect the micro climate [29], reduce soil hardening effect [32], improvement of soil structure and organic matter content. The effects of such practices on the range of interactions within the plant-soil system are manifest via plant interspecific competition, pest and disease attenuation, soil community composition and structure, nutrient cycling, and soil structural dynamics. Soil biotic communities are affected by plant diversity, which can increase abundance, diversity and activity of functional groups. Attendant rhizosphere located processes can facilitate nutrient uptake between component crops [11]. Differences to monocultures derive from: (i) interplant competitive interactions, which can lead to complementary resource use in time, space and form [10,15]; (ii) mobilisation and transfer of nutrients to component crops within the system [2]; (iii), increase in organic matter inputs [1, 22]. Rhizodeposition transfers energy and recycles organic matter and nutrients between crops, microorganisms and the soil and thus is important for crop productivity [34].

#### Root fresh and dry weight of Interrow Plants

Various compositions of interrow planting showed significant effect on its root fresh and dry weight. The results in Table 3 showed the highest fresh weight in treatment (*A. glabarata* 75% and *S. secundatum* 25%). The results of this study indicated a complementary interaction between *A. glabarata* with *S. secundatum* if planted in a mixed system (mixcropping). The most commonly accepted reason explaining why it is possible to obtain better yields with crop mixtures is that the component crops differ in their growth requirements.

**Table 3.** Root fresh and dry weight of interrow plants in various compositions.

| Population Percentage     | Root Fresh Weight | Root Dry Weight |
|---------------------------|-------------------|-----------------|
|                           | ..... g.....      |                 |
| <i>A. glabarata</i> 100%  | 13.11c            | 9.82c           |
| <i>S. secundatum</i> 100% | 4.39e             | 1.09g           |
| <i>A. glabarata</i> 50%   | 29.42b            | 17.32b          |
| <i>S. secundatum</i> 50%  | 4.22f             | 1.68g           |
| <i>A. glabarata</i> 75%   | 37.19a            | 21.49a          |
| <i>S. secundatum</i> 25%  | 12.56c            | 4.03e           |
| <i>A. glabarata</i> 25%   | 11.61d            | 7.11d           |
| <i>S. secundatum</i> 75%  | 3.09f             | 2.88f           |

Note: The number followed by repeated letter in the same column is insignificant according to Duncan average test (DMRT) at 5% level.

*A. glabarata* is a legume plant with deep root and many branches, shade tolerance [3], adapt to soil bad drainage, and has the symbiotic capability with the microbial. The adequacy of N in plants will influence the extraction of P which, in turn, will contribute to increased growth of *A. glabarata* roots. *A. glabarata* has high adaptability and shade tolerance which could produce high dry matter [3]. These support by the ability to adapt soil with either good or bad drainage.

### 3.2. Nitrogen (N), Phosphorus (P), and Potassium (K) contents in intercrops

The highest N content is showed in monoculture treatment of *A. glabarata*, while P and K levels can be seen in mixed planting (*A. glabarata*. 75% + *S. Secundatum* 25%) (Table 4). High potassium level in intercrops would affect the absorption and translocation of phosphorus nutrient. Potassium has an important role in both plant cells and membrane transport system (Table 4).

**Table 4.** Nitrogen (N), Phosphorus (P), and Potassium (K) contents in intercrops.

| Treatment   | Plant nutrient content |         |             |
|---|------------------------|---------|-------------|
|   | N (%)                  | P (ppm) | K (me/100g) |
| <i>Arachis g.</i> 100%)                           | 2.46                   | 0.250   | 1.832       |
| <i>Stenotaphrum s.</i> 100%)                      | 2.19                   | 0.294   | 2.043       |
| <i>Arachis g.</i> 50% + <i>S. secundatum</i> 50%) | 2.20                   | 0.322   | 1.649       |
| <i>Arachis g.</i> 75% + <i>S. secundatum</i> 25%) | 2.15                   | 0.332   | 2.660       |
| <i>Arachis g.</i> 25% + <i>S. secundatum</i> 75%) | 2.40                   | 0.319   | 1.574       |

Potassium is known to possess a variety of functions such as managing to cell expansion process [9]; nutrient movement and translocation [9]; and stomata behavior [8]. Phosphor and potassium of plant were highest in plantations with poly culture system, nitrogen was highest in *A. glabarata* monoculture (Table 4). The effectiveness of N microbial activity to fixation in extracting nitrogen is the cause of its level to be highest in *A. glabarata*.

### 3.3. Soil nitrogen, phosphorus and potassium analysis

Soil analysis performed before and after treatment of the composition of plant diversity is shown in table 5.

**Table 5.** Soil Nitrogen (N), phosphorus (P), and potassium (K) level with mixed vegetation treatment.

| Treatment  | Nutrient content |            |      |            |       |            |
|--|------------------|------------|------|------------|-------|------------|
|  | N                | Increase % | P    | Increase % | K     | Increase % |
| Without vegetation                                   | 0.18             | 0          | 4.00 | 0          | 0.38  | 0          |
| <i>A. glabarata</i> . 100%                           | 0.27             | 50         | 8.47 | 111.75     | 0.257 | - 47.85    |
| <i>S. secundatum</i> 100%                            | 0.18             | 0          | 8.51 | 112.75     | 0.643 | 69.21      |
| <i>A. glabarata</i> . 50% + <i>S. secundatum</i> 50% | 0.80             | 344.4      | 9.26 | 131.5      | 0.516 | 35.78      |
| <i>A. glabarata</i> 75% + <i>S. secundatum</i> 25%   | 0,62             | 244.4      | 8.60 | 115        | 0.622 | 63.68      |
| <i>A. Glabarata</i> 25% + <i>S. secundatum</i> 75%   | 0.54             | 200        | 7.63 | 90.75      | 0.548 | 44.21      |

Generally, increasing the diversity of the vegetation would make percentage change in soil nutrients with different percentage (Table 5). Highest nitrogen level reached 344.4% and phosphorus was 131.5% in mixed planting (*A.glabarata* 50% + *S.secundatum*50%). Potassium level percentage (69.21%), however, increased in a single-type plot. (*S.secundatum* 100%). Composition and diversity may affect soil fertility through differential species effect on nutrient inputs, may also affect fertility through differential species effect on nutrient retention. Soil nutrient heterogeneity interacted with nutrient availability and plant functional diversity to determine productivity and nutrient cycling responses. Above and below ground productivity increased under heterogeneous nutrient supply.

#### 4. Conclusion

1. *Growth of A.glabarata* was highest if planted in a mixed/polyculture system, while *S.secundatum* was highest in a monoculture;
2. The best root and shoot growth were obtained in mixed vegetation with treatment in *A. glabarata*75% + *S. secundatum* 25%;
3. The highest N level in treatment by *A.glabarata*, while phosphor and potassium in treatment by mixed vegetation *A. glabarata* 75% + *S.secundatum*. 25%;
4. Combination of interrow cultivation is more recommended for soil conservation and nutrient maintenance in palm oil trees were *A. Glabarata* 75% + *S.secundatum* 25%.

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