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Bio-Fertilizer Improved Oil Palm Seedling Growth

Gabriel Ddamulira, F. Masika, A. Asiimwe, L. Zubairi, M. Otuba

Horticulture & Oil Palm Program, National Crops Resources Research Institute, Kampala, Uganda
Email: gdamuli@gmail.com

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Abstract

In most farming systems newly introduced commercial fertilizers to be accepted, adopted and used by farmers, their effectiveness and appropriate application rates must be exhibited. This study was conducted to validate the effect and rates of a bio-fertilizer (super agric) on oil palm seedling growth. The trial was laid out in a randomized complete block design (RCBD) with three application rates of 0, 4 and 8 ml/L of water (treatments) replicated thrice. Following the application of super agric to oil palm seedlings for a period of six months, observations drawn from the analysis of growth data were as follows: Three months after treatment, super agric significantly ($P < 0.05$) increased the height and breadth of oil palm seedling compared to those which were not applied with super agric. The results also showed that when super agric was applied at a rate of 4 ml/L, the leaf length and breadth were higher compared to the control were super agric was not used. Furthermore, applications of super agric improved oil palm seedling nitrogen uptake by 31% in treatment groups as compared to the control which explained the height and breadth increase in the oil palm seedlings that were applied with super agric. On the other hand, the effect of super agric application on phosphorus uptake by seedlings was not significant. Although the height, breadth, leaf width and length were all significantly affected by super agric application, the number of oil palm leaves and spears were not affected for the period the experiment was conducted. Six months after application of super agric the growth of oil palm seedlings was favorably impacted, hence we recommend super agric to be promoted among oil palm seedling growers.

Keywords

Bio-Fertilizer, Seedling, Growth, Application, Rates, Super Agric

1. Introduction

Oil palm (*Elaeis guineensis* Jacq.) growing is increasingly becoming important in Uganda due to strong demand for vegetable oil and other bi-products. Kalangala district is one of the areas with favourable climate for commercial oil palm cultivation. On 11,484 hectares, Kalangala district produces about 45,000 MT of palm oil annually [1]. Other regions with traditional methods of oil palm production are Bundibugyo and Kanungu with few oil palm trees scattered in farmers' fields that cater for household vegetable oil needs. The demand for oil palm in Uganda now stands at 410,000 MT, however, the existing output from commercial and traditional methods of oil palm production cannot satisfy the current demand (Source: International Trade Center, 2020) [2]. Additionally, it is also a well-known fact that vegetable oils are a crucial component of the human diet, and their production protects the nation's foreign exchange earnings through import substitution [3]. Therefore, oil palm productivity needs to be improved in order to meet the continuously growing demand of vegetable oil [4] [5]. The use of fertilizers from nursery stage through development to maturity is one strategy that has been used to boost oil palm yield and productivity [6]. The fertilizers that are often utilized occur in both inorganic and organic forms. Each form used has its advantages and disadvantages. Because they act quickly after application, inorganic fertilizers are often used [7]. However, there have been instances where careless use of inorganic fertilizers has had a negative effect on the enviroment [8]. For instance, if the leacheates are not regulated, it has been estimated that around 50% of the inorganic fertilizers used in farmlands leach down into the soil and might contaminate water sources [9]. Much as inorganic fertilizers are associated with the challenges mentioned above when inappropriately applied in oil palm, there is a need to boost oil palm production to supply food, while protecting the environment. From nursery stage through maturity stage, nutrients must be available in appropriate and balanced amounts to increase oil palm output [10]. Inorganic fertilizers have historically been the primary source of nutrients for seedlings, but their ongoing usage drives up the expense of seedling care due to their high costs. Bio-fertilizers, on the other hand, include beneficial microorganisms that promote plant development, and make plants more resistant to pests and diseases [11]. According to [12], the role of soil microorganisms in agriculture's sustainable growth has been examined. Bio-fertilizers contain various microorganisms that when added to soil or plant surfaces colonize the rhizosphere or the interior of the plant and simulate growth by converting nutritionally essential elements (nitrogen, phosphorus) from unavailable to available forms through biological processes like nitrogen fixation and rock phosphate solubilisation [13]. Further, compared to chemical fertilizers, the long-term use of bio-fertilizers is more affordable, environmentally friendly, productive and accessible to marginal and small farmers [14]. According to [15], although bio-fertilizers are known to increase nutrient absorption and support higher plant development and production, their characteristics rely on the pace at which they are administered. Furthermore, bio-fertilizers assist in plant health as often used as bio-control agents and enhance organic matter degradation [16]. However, the benefits of bio-fertilizers vary depending on the crops and rates at which they are applied. Therefore it is important to assess how bio-fertilizers affect oil palm seedling development and identify the appropriate rates at which it can be applied to obtain the best results. Hence, the purpose of this study was to determine the effect and rates of bio-fertilizer (super agric) on the growth of oil palm seedlings at nursery stage.

2. Materials and Methods

2.1. Study Site

The research was carried out on the main oil palm nursery at National Crop Resources Research Institute (NaCRRI), Namulonge in Uganda, for six months (January to June 2022) coinciding with three months of dry season and three months of rain season. Namulonge is located at 1150 meters above sea level, between 0˚ 32" and 32˚ 37" North and East. The area has a bimodal rainfall pattern with average rainfall of 1270 mm with lowest and highest temperatures of 15.9˚C and 28.4˚C respectively. The nursery was stationed on an open field irrigated twice a week using sprinklers.

2.2. Experiment Layout

The study was superimposed on four-month-old oil palm seedlings that had been transferred from the pre-nursery to the main nursery at (NaCRRI), Namulonge. The oil palm seedlings were placed in polybags 70 cm apart and arranged in triangular pattern in the open space. The experiment was set up in a Complete Randomized Block Design (CRBD) with three replicates. A group of 15 seedlings planted close together formed a single plot to which separate treatment were given Vemipro Limited's Super agric a bio-fertilizer (*L. plantarum* and *L. acidophilus* as the active components) was diluted at varying rates to provide two distinct treatments. Super agric was diluted at a rate of 4 ml in 1Litre of water for treatment one (T1), and 8 mls in 1Litre of water for treatment two (T_2). Each bio-fertilizer composition was sprayed on soil surface on polybags in two distinct plots, and bio-fertilizer composition was used in the third plot (control).

2.3. Oil Palm Seedling Management

Hand hoeing was done three times a month to suppress weeds growing between polybags and weeds growing in polybags were handpicked. Using drip irrigation system, 48 mm of water was applied to each seedling every three days. During the rainy season, 16 mm of water was provided to each seedling after three days as supplementary irrigation. Ridomil was sprayed at rate of 2.5 ml/L every two weeks to suppress fungal infections. Furthermore, scouting for pests' assault on seedlings was performed every two weeks and spraying with cypermethrin at a rate of 1.2 ml/L was performed when scouting and findings revealed pest infestation above the economic threshold observed.

2.4. Plant Analysis

To determine the nutrient content of palm leaves, a frond adjacent to the spear was selected from each treatment plot's 10 plants. To avoid contamination, the leaves were cleaned with alcohol and grown in sterile water. The 10 plant leaf samples were combined into one composite sample per treatment. The materials were oven-dried, crushed and tested for nitrogen (N) using the Kjeldahl technique [17] and phosphorus (P) by a spectrophotometer, and potassium (K) tested with a flame photometer [18].

2.5. Growth Data Collection and Analysis

The growth parameters including plant height, breadth, leaf length and width, and number of leaves and spears were measured. The data was taken six months following the super agric treatment at 30 day interval**.** Plant height and length were measured with a tape measure with the zero (cm) end put in the polybag at the soil level and measurements made at the plant's tip Similarly, leaf length and width were measured using a measuring tape from the leaf attachment onto the stem to the leaf apex and leaf width was measured from the leaf margin end across the midrib to the opposite margin end of the same leaf. Growth data collected was subjected to analysis of variance (ANOVA) using Genstat software version 11 [19], with the findings represented as mean values. Treatment means significances were calculated using the least significant difference (LSD) at $\alpha < 0.05$.

3. Results

Oil palm height is one of the factors that influence its growth. The experimental results showed a significant (P > 0.05) difference in oil palm plants subjected to different treatments/applications of the bio-fertilizer four months after application. The control (where the bio-fertilizer was not applied) showed the lowest height when compared to other treatments (**Figure 1**). Furthermore, there was no significant difference in height of oil palm trees treated with super agric of different dilution levels.

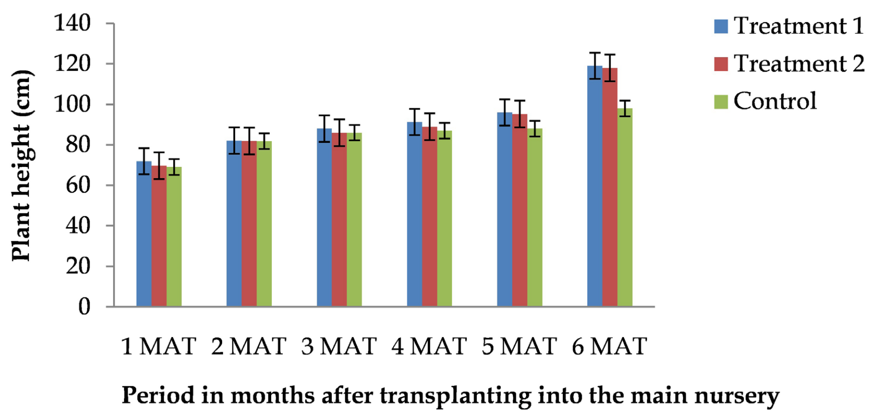


Figure 1. Effect of super agric on the height of oil palm seedlings at nursery stage [Treatment 1 = 4 mls/L water; Treatment 2 = 8 mls/L water; Control = no super agric was applied; MAT = months after transplanting].

3.1. Plant Breadth

There was no significant variation in plant breadth over the first three months after application of super agric. However, by the fourth month, a significant difference ($P < 0.05$) in breadth was noted with application rate of 4 mls/L of water providing the greatest breadth while the control provided the least. The observations were the same in the fifth and sixth months for the same treatment (**Figure 2**).

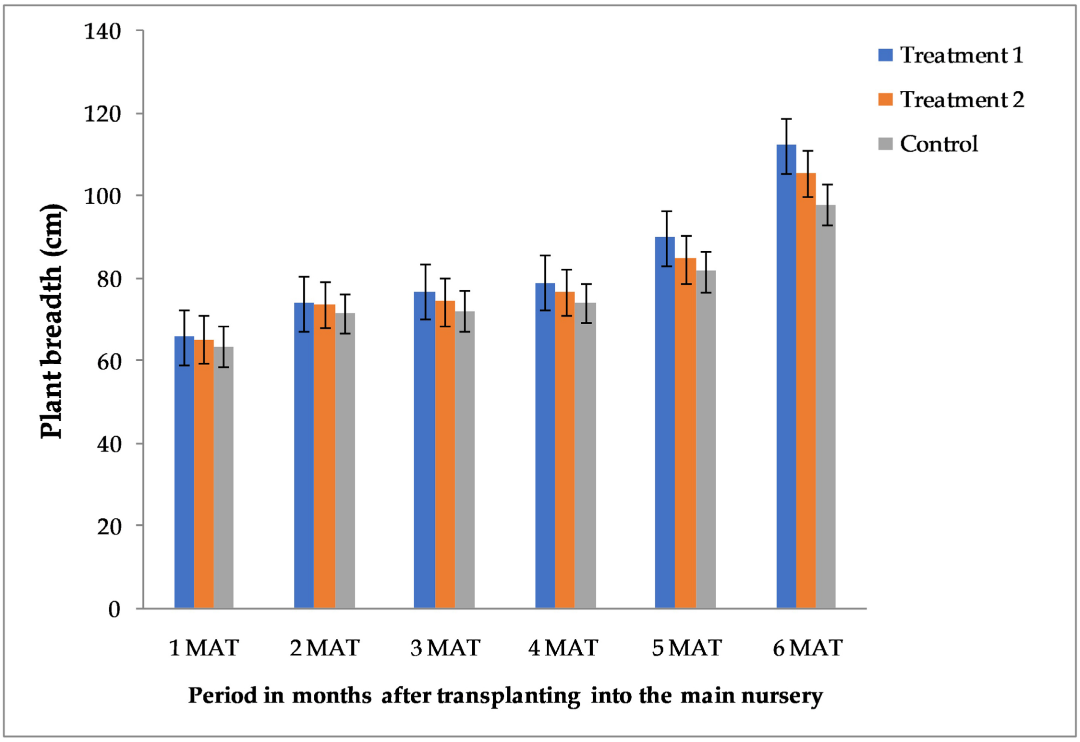


Figure 2. Effect of super agric on oil palm seedling width at nursery stage [Treatment 1 = 4 mls/L water; Treatment 2 = 8 mls/L water; Control = no super agric was applied; MAT = months after transplanting].

3.2. Leaf Length

Unlike the previous growth metrics, recorded leaf length did not change significantly until the third month following treatment with super agric. However, after the third month, there was a significant ($P > 0.05$) difference in oil palm seedling leaf length was observed. Seedlings treated with super agric at 4 ml/IL of water had the highest length while the control had the lowest leaf length (**Figure 3**).

3.3. Leaf Width

In the first two months, the width of oil palm seedling did not differ substantially across treatments. However, significant ($P < 0.05$) changes in leaf width were detected across treatments after the third month. Seedlings treated with 4 mls/1L of water had the greatest width, whereas in control, seedlings had the least width (**Figure 4**). Furthermore, the leaf width of seedlings treated with 4 ml/1L of super agric in water was significantly ($P < 0.05$) different from seedlings treated with 8 ml/1L of super agric in water.

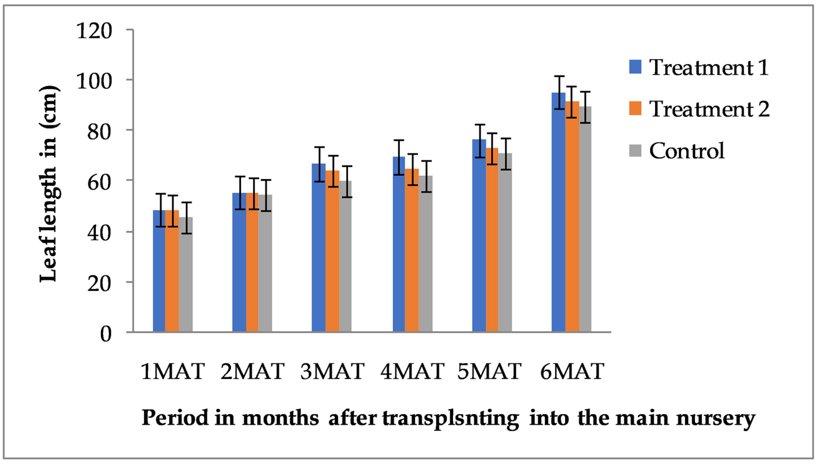


Figure 3. Effect of super agric on leaf length of oil palm seedlings [Treatment 1 = 4 mls/L water; Treatment 2 = 8 mls/L water; Control = no super agric was applied; MAT = months after transplanting].

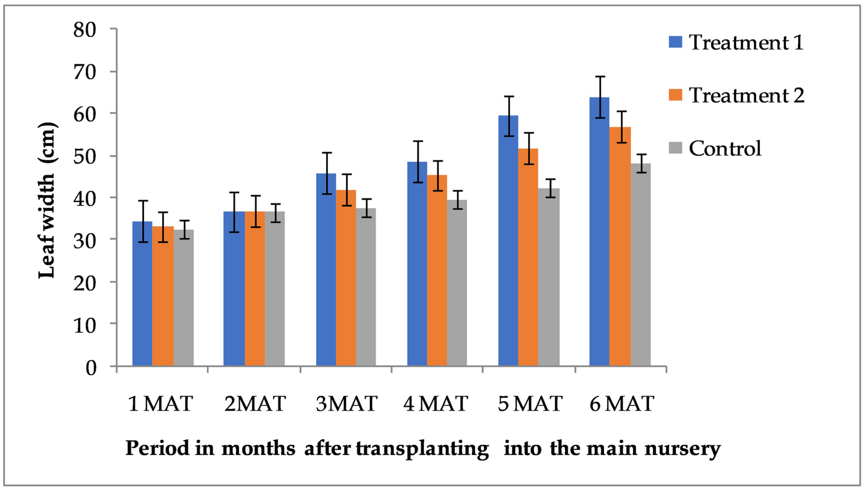


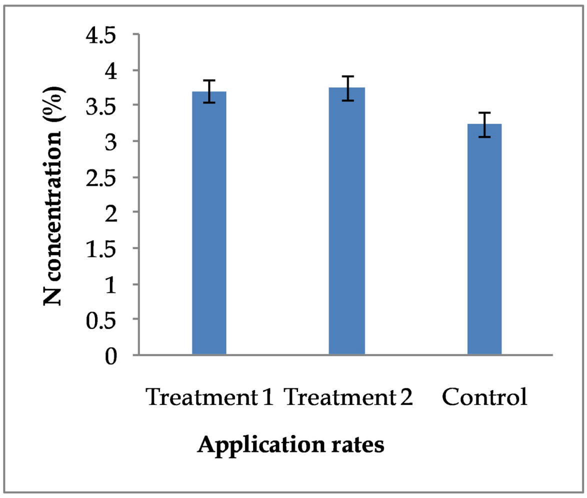
Figure 4. Effect of super agric on leaf width of oil palm seedlings [Treatment 1 = 4 mls/L water; Treatment 2 = 8 mls/L water; Control = no super agric was applied; MAT = months after transplanting].

3.4. Number of Oil Palm Seedling Leaves and Spears

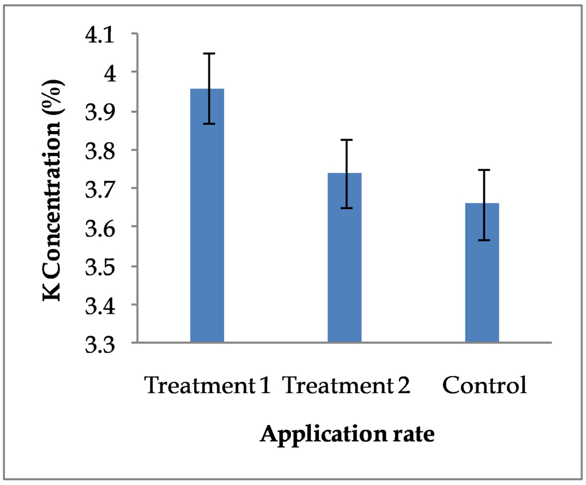
Based on the data obtained on leaves and spears, the results indicated no statistical difference in the number of leaves and spears between treatments and the control.

3.5. Oil Palm Nutrient Content in Oil Palm Seedling Leaf Samples

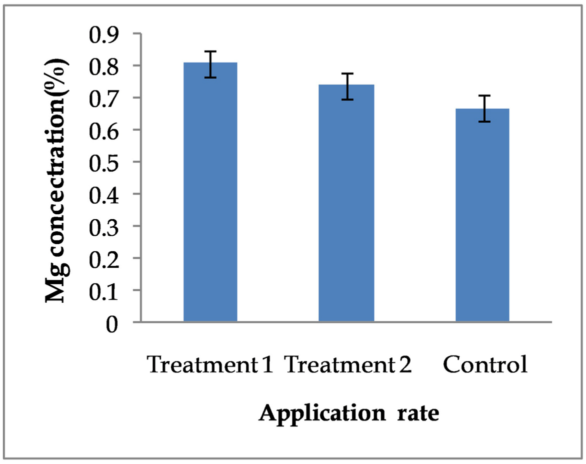
The concentration of N, P, and Mg significantly ($P < 0.05$) varied among seedlings treated with different super agric rates. Nitrogen levels were higher in seedlings applied with 4 ml/1L compared to the control, but N levels were not significantly different between seedlings applied with 4 ml/1L and 8 ml/1L. Similarly, K and Mg were highest in seedlings applied with 4 ml/1L when compared to the control (Figure 5).



(a)



(b)



(c)

Figure 5. N, K and Mg concentration in the oil palm leaf samples at nursery stage [Treatment 1 = 4 mls/L water; Treatment 2 = 8 mls/L water; Control = no super agric was applied].

Based on the plant nutrient analysis, the results obtained were compared to the conventional critical nutrient values for oil palm which are classified as insufficient, good, and excess (Table 1). Apart from phosphorus, which was below the insufficient levels in all treatments, other nutrients found were over the essential levels of being declared deficient in oil seedlings.

Table 1. Nutrient concentrations (%) of oil palm seedlings applied with varying levels of super agric applied.

Nutrients	Observed nutrients in leaf sample	Deficient	Good	Excessive
			Standard critical nutrient values	
N, P, K & Mg concentrations (%) in oil palm seeding applied with 4 ml/1L super agric				
Nitrogen (N)	**3.75**	<2.50	2.6 - 2.90	>3.10
Phosphorus (P)	**0.11**	<0.15	0.16 - 0.19	>0.25
Potassium (K)	**3.96**	<1.00	1.10 - 1.30	>1.80
Magnesium Mg)	**0.74**	<0.20	0.30 - 0.45	>0.70
N, P, K & Mg concentrations (%) in oil palm seeding applied with 8 ml/1L super agric				
Nitrogen (N)	**3.71**	<2.50	2.6 - 2.90	>3.10
Phosphorus (P)	**0.12**	<0.15	0.16 - 0.19	>0.25
Potassium (K)	**3.74**	<1.00	1.10 - 1.30	>1.80
Magnesium Mg)	**0.81**	<0.20	0.30 - 0.45	>0.70
N, P, K & Mg concentrations (%) in oil palm seeding applied with no super agric				
Nitrogen (N)	**3.24**	<2.50	2.6 - 2.90	>3.10
Phosphorus (P)	**0.12**	<0.15	0.16 - 0.19	>0.25
Potassium (K)	**3.66**	<1.00	1.10 - 1.30	>1.80
Magnesium Mg)	**0.67**	<0.20	0.30 - 0.45	>0.70

4. Discussion

Oil palm height, breadth, leaf length, and width are all important parameters to consider when assessing oil palm growth. The results showed exponential rise of these parameters indicating that the super agric used favorably contributed to the observed oil palm seedling growth. The *L. plantarum* in super agric is known to promote plant growth and resilience to water stress [20]. *L. plantarum* frequently promotes plant development by producing growth hormones auxin, indole-3-acetic acid (IAA), cytokinins, and minerals [21]. Similarly, previous studies indicated that L. *plantarum* gradually introduced into plant rhizospheri c soil altered plant physical attributes to enhance plant development [22]. This has also been observed in the rice where rice seeds coated with *L. plantarum showed* significantly enhanced plant height and leaf length [23]. Furthermore, *L. plantarum* significantly boosted cabbage growth considerably [24]. Based on prior studies on *L. plantarum*, it may be concluded that the increase in oil palm seedling development (height & breadth) achieved with super agric was due to growth boosting hormones found in *L. plantarum*. On the other hand, the limited growth in height and breadth of oil palm seedlings not applied with super agric was most likely due to a lack of growth stimulating hormones.

The bacteria which are active components in super agric are known to fix nitrogen into the soil The nitrogen fixation capabilities of *L. plantarum* possibly availed more nitrogen for oil palm seedlings. This bacteria's nitrogen fixation capacity promotes nitrification process which avails nitrogen for the plants [20]. This method of fertilizer application probably explained the elevated nitrogen content observed in oil palm seedlings treated with super agric vs seedlings not applied. This was consistent with previous study by [25] which found that bacterial-based bio-fertilizer like super agric enhanced crop growth and expedited nitrogen absorption. However, unlike nitrogen and potassium, phosphorus content within oil palm seedlings was found to be low, despite the fact that phosphorus is likewise a critical nutrient in terms of require uptake quantities in plants [26] [27]. Phosphorus is fairly insoluble in soils depending on the type and circumstances [28] which affect is absorption by plants like oil palm, and hence its usage in oil palm nurseries has been reliant on the administration of artificial phosphorous fertilizers. However, when applied as fertilizer to soil, a portion of phosphorus becomes insoluble and thus unavailable to plants [29] [30], so there is a need to improve the performance of super agric by incorporating phosphorus solubilizing bacteria [31] [32] such as *Flavobacterium*. This will give the three basic macro nutrients required by oil palm, hence increasing the efficacy of super agric.

The absence of influence effect of super agric on seedling development during the first three months was partly attributed to L. *plantarum*'*s* delayed growth in natural habitats [33]. Nutrient availability in natural ecosystems is extremely low and varies over time. *L. plantarum* live a "feast and famine" existence in such environments with resources allocated to growth, when circumstances are favorable, and resources committed to survival/maintenance when nutrients are few [34]. Because of the early nutrient restriction in the soil, there may have been less energy available for growth-related activities, resulting in sluggish or no growth seen in the first three months following application. Similar work by [35] found out that maintenance energy in the plant increased from 13 to 94 % of the total ATP produced over the first 31 days of *L. plantarum* development at an early stage. As a result of the rapid development, *L. plantarum* will be able to produce growth hormones at an early stage. It may be recommended for super agric users to apply quicker nutrient release fertilizers to provide for seedling nutrient demands during the first three months.

5. Conclusion

According to the data, three months after its application, super agric improved oil palm growth (height, breadth, leaf length, and width). Nitrogen and potassium uptake by oil palm seedlings treated with super agric improved, but phosphorus uptake remained low; hence, super agric treatment needs to be supplemented with phosphorus sources for better seedling growth. Increasing the super agric application rate from 4 ml/1L of water to 8 ml/1L of water showed no influence on oil palm seedling development; however, a lower dose of 4 ml/1L of water offered improved growth outcomes.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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