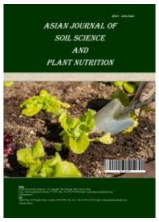

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The Effect of Microbe Plus and Phosphorus Fertilizers on the Vegetative Growth of Oil Palm (*Elaesis guineensis*, Jacq.) Seedlings

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The main objective of this study was to improve the growth of oil palm seedlings by using microbe plus to enhance phosphorous availability from rock phosphate under oil palm nursery was evaluated at Oil Palm Research Institute of Ghana, Kade-Kumasi. The study consisted of 16 treatments replicated 3 times in a 4 × 4 factorial experiment arranged in Randomize Complete Block Design. The factors tested were: Phosphate fertilizers (Phosphate only, triple superphosphate, super rock phosphate and Togo rock phosphate) and microbe plus rates (0, 50, 100 and 150%). Data was collected on leaf area, leaf area index and dry matter production. All data obtained were subjected to analysis of variance (ANOVA) using GENSTAT Version 11.1 (2008). The results showed that the P fertilizers and microbe plus applied alone or their interactions had no significant (P=.05) effect on leaf area and leaf area index values, however, dry matter produced was significantly (P=.05) different from each other. $TSPMP_{150}$ treated seedlings

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produced significantly (P=.05) the highest dry weight; 42% increase over the control (No phosphate and microbe plus). The complementary use of microbe plus with triple superphosphate or Senegal rock phosphate proved to be the best options in terms of the parameters measured than the triple superphosphate. Microbe plus can therefore be used in combination with rock phosphate to improve phosphate availability. Field experiment is suggested to validate the effect of microbe plus and these rock phosphates on the performance of oil palm, whereas, additional studies with different application rates, both at nursery and at the field, are recommended.

Keywords: Oil palm; phosphorous; rock phosphate; micro plus; triple superphosphate.

1. INTRODUCTION

Oil palm, *Elaesis guineensis*, Jacq., is a perennial crop and the world's leading source of vegetable oil with a potential oil yield of 6 to 7 tons/ha [1,2]. It is the second most important tree crop in the Ghanaian economy after cocoa, being one of the leading cash crops in the rural economy in the forest belt on Ghana [3].

Currently, Ghana has a total of 305,758 ha of oil palm of which more than 80% are cultivated by private small-scale farmers [4]. Though 243,852 tons of oil palm is estimated to be produced, Ghana currently still has an unmet demand of 305,000 tons of palm oil [5]. To increase productivity, tropical soils often low in available phosphorus require addition of P fertilizer for optimum yield [6]. According to [7] a crucial aspect of improving and maintaining soil fertility is the application of deficient nutrients.

According to [8] N is one of the most limiting plant nutrient for crop production, however, in sub-saharan Africa, phosphorus has been found to be a major limiting factor in crop production with an average consumption of about 1.5 kg of P_2O_5 per hectare [9]. It is a common practice to supply phosphorus in a form of superphosphates and diammonium phosphate to oil palm seedlings [8] which according to [10] is the foundation on which healthy and vigorously growing transplantable seedlings can sustain fresh fruit bunches (ffb). However, the use of these inorganic phosphorous fertilizers is constrained by the availability and cost. Cheaper and effective source such as rock phosphate (RP) is being promoted [7,11]. However, the reactivity of P from RP is slow.

The search for alternative ways to enhance the breakdown of RP into plant-available P forms has led to an array of RP modification techniques. Over the last two decades, various innovative techniques to enhance RP solubility such as partial acidulation, heap leaching, thermal treatment, mechanical activation, as well as modification through biological processes have been investigated [12,13]. These approaches, however, involve additional costs [11]. Currently, there is increasing emphasis on application of P-solubilizing microorganisms for RP solubilization in soils [14,15,16,17]. Although there are several options for enhancing P availability from RP, the options for small-scale farmers are limited.

Microbe plus is a fusion of biological and conventional NPK fertilizers with comprehensive suite of bacteria and fungi which converts the nutrients into plant available form. Currently, no studies have been done to evaluate the potential of microbe plus to improve P availability from RP in Ghana. The content of P (P_2O_5?) in Togo Rock Phosphate and Senegal Rock Phosphate ranges from 5% to 33%

The main objective of this study therefore was to improve the growth of oil palm seedlings by using microbe plus to enhance P availability from RP.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was carried out at the Agronomy Nursery of Oil Palm Research Institute, Ghana (OPRI), Kade –Kusi, in the Eastern Region (latitude 0.6°00' N and longitude 0.01°45' W). The area falls within the semi deciduous forest zone and is characterized by bi-modal rainfall with mean annual rainfall of 1600 mm. Day temperatures range from a mean minimum of 20°C to a mean maximum of 31°C with relative humidity ranging from 95% in the rainy season to 40% in the dry season.

2.2 Experimental Design and Treatment

The experiment was a 4 × 4 factorial arrangement in Randomized Complete Block Design with three replicates. Each treatment had 20 seedlings planted in a 70 × 70 × 70 cm triangular planting design. The treatments were 4 levels of phosphorus fertilizers and 4 levels of microbe plus as follows: Phosphorus sources were at 4 levels of No phosphate fertilizer (Po), Triple superphosphate (TSP), Togo Rock Phosphate (TRP), and Senegal Rock Phosphate (SRP), whereas, Microbe plus (MP) rates were also at 4 levels of Zero% MP (MP_0), 50% MP (MP_{50}), 100% (MP_{100}) and 150% MP (MP_{150}) (Table 1). A basal dressing of 6 g Urea (N) and 6 g Muriate of Potash mixture was applied/ palm/month.

2.3 Pre-nursery

Mini polybags (black) of dimensions 10 × 19 cm were filled with top soil. The soil used was Ferric PlinthicAcrisol [18]. The lower third of the bags were perforated to enhance drainage of excess water. Germinated oil palm seed nuts of Dura × Pisifera (D × P) were sown singly in the polybags for four months.

2.4 Main Nursery

Maxi polybags of dimension 35 × 45 cm were filled with 10 kg topsoil and arranged in triangular planting design of distance 70 × 70× 70cm. Pre-nursery seedlings at four month or four leaf stage were transplanted into each of the maxi polybags and mulched with palm kernel shells.

2.5 Agronomic Practices

Watering of seedlings was done as and when necessary using the drip irrigation system after 3 days of no rain. Fertilizers were applied monthly as specified in the various treatments (Table 1). Weeding (hoeing in-between polybags and hand picking within the polybags) was carried out manually as and when necessary. Prophylactic fungicide (diathane) and insecticide (actellic) were sprayed every two weeks and monthly respectively when necessary in controlling pest and diseases. Data collection on vegetative growth was undertaken when seedlings attained five leaves at 5 months after transplanting (MAT) and continued monthly until seedlings reached 12 MAT.

2.6 Growth Parameters Measured

Vegetative growth responses were measured on leaf area, leaf area index and biomass dry weight. Leaf area (LA) was calculated after the plants were 12 months old and had developed leaflets on the third leaf from the top opened leaf. Three leaflets were taken from the centre of each side of the frond and the width and length were measured with a ruler. The means of the length and width of the leaflets obtained were put into the formula to estimate the LA: Leaf area (LA) = b (n x LW), where n = number of leaflets; LW = mean of length x mid-width for a sample of the leaflets b = the correction factor of 0.55 [19]. Leaf area index (LAI) was thus estimated as: LAI = Leaf area/Plant density, where Plant density = Ground area ($\frac{1}{2}\ \Delta^2\sqrt{3}$); Δ = planting distance. Destructive method was used to estimate the dry matter production of the leaf, root and stem. The plants were sampled at the end of the experiment and each plant was divided into leaves, butt and roots.

Table 1. Treatment used

Treatment	Amount applied/palm/month
T1	Absolute control (PoMPo)
T2	TSP was applied at 6 g/palm/month. The standard practice recommended by OPRI of CSIR, Ghana.
T3	*SRP was applied at 8.2g/palm/month.
T4	*TRP was applied at 7.5 g/palm/month.
T5	MP_{50}. 25 ml of MP was dissolved in 1 liter of water and 50 ml of the mixture was applied.
T6	$TSPMP_{50}$. 6 g of TSP and 50 ml ofMP_{50}
T7	$SRPMP_{50}$. 8.2 g of SRP and 50 ml of MP_{50}
T8	$TRPMP_{50}$. 7.5 g of TRP and 50 ml of MP_{50}
T9	MP_{100}. 50 ml of MP was dissolved in 1 liter of water and 50 ml of the mixture was applied.
T10	$TSPMP_{100}$. 6 g of TSP and 50 ml ofMP_{100}
T11	$SRPMP_{100}$. 8.2 g of SRP and 50 ml ofMP_{100}
T12	$TRPMP_{100}$. 7.5 g of TRP and 50 ml of MP_{100}
T13	MP_{150}. 75.5 ml of MP was dissolved in 1 liter of water and 50 ml of the mixture was applied.
T14	$TSPMP_{150}$. 6 g of TSP and 50 ml of MP_{150}
T15	$SRPMP_{150}$. 8.2 g of SRP and 50 ml MP_{150}
T16	$TRPMP_{150}$. 7.5 g of TRP and 50 ml of MP_{150}

2.7 Physico-Chemical Properties of Medium used

Soil samples were air dried and passed through a 2 mm mesh sieve. Soil pH was determined using a HI 9017 microprocessor pH meter. The Walkley and Black procedure as modified by [20] which is used to assess the organic C content in the soils. Total N was determined by Kjeldahl digestion method. The available P was extracted with a HCl: NH4F mixture method as described by [21] and determined colorimetrically using the molybdenum blue method at the wavelength of 636nm. Exchangeable bases (calcium, magnesium, potassium and sodium) in the soil were determined in 1.0 M ammonium acetate extract whiles exchangeable acidity (hydrogen and aluminium) was determined in 1.0 M KCl extract. The Effective Cation Exchange Capacity (ECEC) was calculated as the sum of exchangeable bases and exchangeable acidity (Table 2). Soil particle size was determined by using the hydrometer method [22]. The P_2O_5content of the P fertilizers used for the trial was 46%, 37% and 33.5% for TSP, TRP and SRP respectively

2.8 Statistical Analysis

The data collected were analyzed using the one-way analysis of variance (ANOVA) with the aid of GENSTAT Version 11.1 (2008) [23] according to previously described [24] and the treatment means were separated by the least significant difference (LSD) to determine which of the treatments has significance difference or not at 5% probability level.

Table 2. Initial physico-chemical properties of the soil used

Soil property	Value
pH (1:2.5 H_2O)	5.1
Organic carbon (%)	0.76
Total nitrogen (%)	0.08
Exchangeable cations ($cmol_c$/kg)	
Ca	1.87
Mg	0.53
K	0.17
Na	0.05
Exch. Acidity ($cmol_c$/kg)	0.45
Available P (mg/kg)	4.70
Sand (%)	46.76
Silt (%)	31.44
Clay (%)	21.80
Texture	Loam

3. RESULTS AND DISCUSSION

3.1 Leaf Area and Leaf Area Index of Seedlings

The P fertilizers and microbe plus rates had no significant (P=.05) effect on the LA and LAI of seedlings (Table 3a). SRP recorded the highest LA and LAI with 7 and 21% respective increase over the P_o for P fertilizers. The highest LA in terms of MP rates was recorded by MP_{100}, which gave 7% increase over the MP_o, however, MP_{150} recorded the highest LAI with 2% increase over the MP_o. The data recorded in Table 3b showed no significant (P=.05) combined effect on LA and LAI. LA recorded by P_oMP_{100} and $SRPMP_o$ was higher than the other combinations with 35% increase over the control and 25% increase over the standard practice ($TSPMP_o$). This was closely followed by SRP + MP_{100} with 31% increase over the control. Moreover, LAI recorded by P_oMP_{100}, $SRPMP_o$ and $SRPMP_{100}$ was higher compared to the other combinations and represented 32% increase over the control and 26% increase over the $TSPMP_o$. This was followed by $TSPMP_{150}$ which also gave 30% increase over the control (Table 3b).

3.2 Seedlings Dry Matter Production

As shown in Table 4, there was no significant (P=.05) effect on dry matter produced by the P fertilizers and the microbe plus rates at the end of the experiment. However, dry weight of butt produced by TSP was 23% higher over the P_o. This corresponded to a higher frond dry weight of 123.33 g which was 23% higher than the P_o. More so, MP_{150} treated seedlings produced higher dry weight of butt and fronds which were 34% higher in butt dry weight and 42% higher in frond dry weight over the MP_o. The trend of biomass produced by P fertilizers was TSP > SRP > P_o> TRP and MP_{150}> MP_{100}> MP_{50}>MP_o by microbe plus rates. The combined use of P fertilizers and microbe plus rates significantly (P=.05) improved dry matter partitioning only the in roots at the end of the experiment (Fig. 1).

3.3 Discussion

3.3.1 Leaf Area (LA) and Index (LAI)

The observed increases in LA and LAI (Table 3a and 3b) affirmed the assertion by [25] that increasing nutrient supplied to seedlings increases leaf area and directly affect leaf area index of the seedlings. The lack of significance among the treatments indicated that P and MP were not the major limiting nutrients in the growth medium. The superior effect of SRP on LA and LAI in relation to P fertilizers was contrary to the general notion that soluble P fertilizers will have superior effect over RP's. The marginal increases in LAI values after the application of MP_{150} could be attributed to the release of more nutrients into the medium as a result of the higher rates. Complementary use of P_oMP_{100}, $SRPMP_o$ and $SRPMP_{100}$ gave the higher LA and LAI (Table 3b), due to more nutrient released ability which also improved the nutrient use efficiency of the seedlings. Similar work by [26] using P fertilizers amended with organic residues explained that organic fertilizers fortified with it enhanced the rate of nutrients released into the rhizosphere for quick absorption by plants. LA and LAI values of all the treatments were lower than 1.0. According to [27] LA remained below 1.0 for some time since the total LA of the young seedling is negligible in relation to the land it occupies. Besides, LA could be used as selection criteria in 9 months old seedlings as it correlated highly with yield [28].

3.3.2 Dry matter production

The differences in seedlings dry matter produced among the various nutrient inputs could be attributed to the differences in the formulations. The superior effect of TSP fertilizer on total biomass produced could be ascribed to high solubility of phosphate in TSP [7]. The, higher biomass produced by MP_{150} could be due to higher rate of MP applied although this was contrary to the observation made by [29] and [30] that rates higher than the prescribed rates had no positive effect on RP utilization. The observed higher dry matter produced in $TSPMP_{150}$ (Fig. 1) could be associated with increased rates of MP and its utilization in the metabolic processes of the seedlings. This agreed with the observation made by [11] in dry matter yields of aerobic rice. Their study showed that P fertilizers inoculated with PSB16 recorded significantly higher dry matter than PSB9 inoculated and the control.

This observation is supported by [31] who asserted that biofertilizers worked to increase plant nutrient uptake and improve the nutrient use efficiency; and that there were no advantages in the use of sole biofertilizers in the promotion of plant growth [32]. However, the selection of appropriate biofertilizer according to [33] is therefore critical as growth effect could vary widely based on the different active organisms used in the formulation of the products. Studies by [34] showed inhibited root growth as resulted from low P supplied, whereas, [35] reported that in P-deficient plants, shoot growth was found to be more affected than root growth due to assimilate partitioning towards the root which led to a decrease in the shoot: Root dry matter ratio. Contrarily, the result obtained in this study was not in support of the above authors as shoot: root growth of MP treated seedlings performed favourably with the P treatments, as well as, their interactions (Fig. 1).

Table 3a. Effect of P fertilizers and microbe plus rates on Leaf Area (LA) and Leaf Area Index (LAI) of seedlings

P fertilizers	LA (m^2)	LAI
P**o**	0.30	0.57
TSP	0.30	0.65
SRP	0.32	0.69
TRP	0.27	0.59
Pr	0.48	0.13
Lsd (0.05)	0.53	
Microbe plus		
MP_0	0.30	0.65
MP_{50}	0.27	0.59
MP_{100}	0.32	0.61
MP_{150}	0.30	0.66
Pr	0.497	0.640
Lsd (0.05)	0.065	0.117
Pr P fert.* MP	0.700	0.373
CV (%)	26.29	22.44

Table 3b. Interaction effect of P fertilizers and microbe plus rates on LA and LAI of seedlings

P fertilizers + MP	LA (m^2)	LAI
$PoMP_0$	0.26	0.57
$PoMP_{50}$	0.26	0.57
$PoMP_{100}$	0.35	0.75
$PoMP_{150}$	0.32	0.71
$TSPMP_0$	0.28	0.60
$TSPMP_{50}$	0.30	0.64
$TSPMP_{100}$	0.30	0.64
$TSPMP_{150}$	0.33	0.74
$SRPMP_0$	0.35	0.75
$SRPMP_{50}$	0.31	0.69
$SRPMP_{100}$	0.34	0.75
$SRPMP_{150}$	0.27	0.58
$TRPMP_0$	0.30	0.66
$TRPMP_{50}$	0.21	0.45
$TRPMP_{100}$	0.28	0.62
$TRPMP_{150}$	0.28	0.61
Lsd (0.05)	0.13	0.23
Pr	0.70	0.37
CV (%)	26.3	22.4

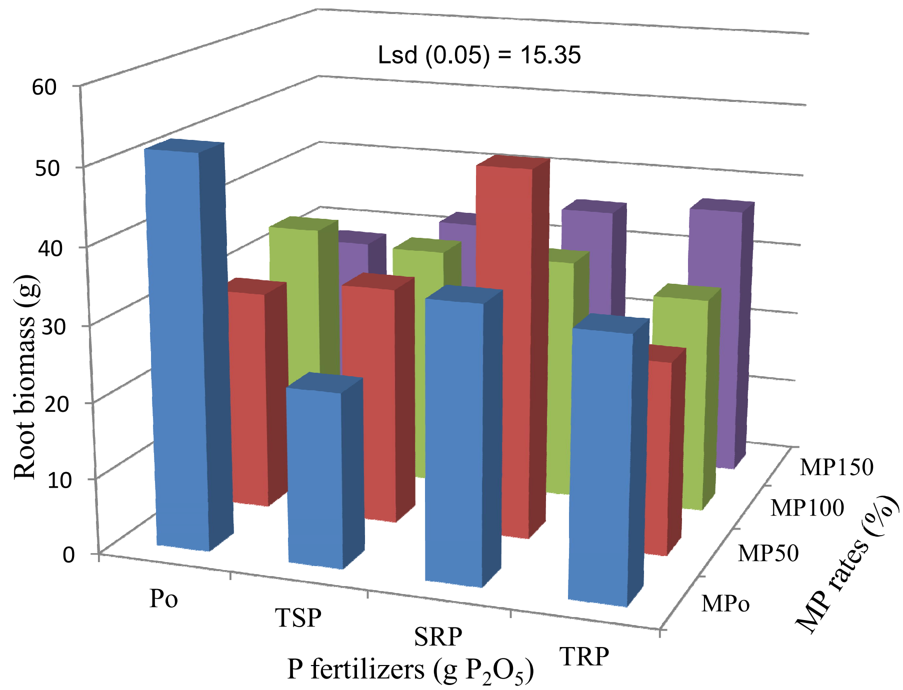

Fig. 1. Interaction effect of P fertilizers and microbe plus on root biomass at 12 MAT

Table 4. Effect of P fertilizers and MP rates on seedling dry matter production

P fertilizers	Fronds	Butt	Roots	Total
Po	100.1	45.4	35.7	181.2
TSP	123.3	55.9	29.7	208.9
SRP	99.0	55.5	38.1	192.6
TRP	90.3	49.3	31.3	170.8
Lsd (0.05)	30.9	12.7	7.68	
Pr	0.18	0.28	0.12	
Microbe plus				
MP_0	87.4	44.5	36.1	167.9
MP_{50}	89.7	46.5	33.7	170.0
MP_{100}	111.2	55.3	31.9	198.4
MP_{150}	124.4	59.8	33.1	217.3
Pr	0.06	0.06	0.73	
Lsd (0.05)	30.8	12.7	7.68	
Pr P fert.* MP	0.07	0.08	0.03	
CV (%)	35.9	29.6	27.3	

4. CONCLUSION

Root dry matter yield, was significantly (P=.05) affected by the applied inputs. TSP applied alone and MP at rates of 100 and 150% and their interactions, elicited higher growth response in the parameters measured. Microbe plus can therefore be used in combination with RP's to improve P availability. Field experiment is suggested to validate the effect of MP and these RP's on the performance of oil palm, whereas, additional studies with different application rates, both at nursery and at the field, are recommended.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Cochard B, Adon B, Kouame KR, Durand-Gasselin T, Amblard PH. Intérêts des semences commerciales améliorées de palmier à huile (*Elaeisguineensis* Jacq.). OCL. 2001;8:654-658.
2. Oil world annual report; 2008.
3. Ofosu-Badu K, Sarpong D. Oil palm industry growth in Africa: A value chain and smallholder study for Ghana, In: Rebuilding West Africa's Food Potential, A. Elbehri (ed.). FAO/IFAD; 2013.
4. Ministry of Food and Agriculture, MoFA. Programme for the Promotion of Perennial Crops in Ghana; 2013.
   Available:www.mofa.gov.gh
5. Ministry of Food and Agriculture, MoFA. Brief on the Oil Palm Sector in Ghana; 2014.
   Available:www.mofa.gov.gh
6. Omoti U. Fertilizer use economy in the oil palm in Nigeria through nutrition recycling. Proceeding of the International Conference on Palm and Palm Products, NIFOR. 1989;218-231.
7. Imogie AE, Oviasogie PO, Udosen CV, Ejedegba BO, Nwawe A. Evaluation of some locally sourced phosphate rocks for oil palm production. Journal of Soil Science and Environmental Management. 2011;2(6):153-158.
8. Sangakkara UR, Richner W, Schnelder MK, Stamp P. Impact of intercropping beans (*Phaseolus vulgaris L.*) and sun hemp (*crotalaria juncea L.*) on growth, yields and nitrogen fixation of maize (*Zea mays* L.) grown in the humid and tropics during the minor season. Maydike. 2003;48:233-238.
9. Mutert E, Esquìvez AS, De-los-santos OA, Cervantes EO. The oil palm nursery: Foundation for high production. Better Crops International. 1999;13(1):39-40.
10. International Atomic Energy Agency, (IAEA), Assessment of Soil Phosphorus Status and Management of Phosphatic Fertilisers to Optimise Crop Production. (IAEA-TECDOC-1272); 2002
11. Panhwar QA, Radzia O, Zaharah AR, Sariah M, Mohd-Razi I. Role of phosphate solubilizing bacteria on rock phosphate solubility and growth of aerobic rice. J. Environ. Biol. 2011;32:607-612.
12. Singh CP, Amberger A. Solubilization of rock phosphate by humic and fulvic acids extracted from straw compost. *Agrochimica.* 1998;41:221-228.
13. VanStraaten PV. Rocks for crops. Agro minerals of Sub-Sahara Africa. 2002;7.
14. Rodríguez H, Fraga R. Phosphate solubilizing bacteria and their role in plant growth promotion. Biotechnol. Advance. 1999;17:319-339.
15. Whitelaw MA. Growth promotion of plants inoculated with phosphate solubilizing fungi. Adv. Agron. 2000;69:99-144.
16. Vassilev N, Vassileva M, Fenice M, Federici F. Immobilized cell technology applied in solubilization of insoluble inorganic (rock) phosphates and P plant acquisition. Bioresour. Technol. 2001;79: 263-271.
17. Arcand MM, Schneider KD. Plant-and microbial-based mechanisms to improve the agronomic effectiveness of phosphate rock: A review. Anais da Academia Brasileira de Ciências. 2006;78(4):791-807.
18. FAO. Soil Map of the World- Revised Lengend, 4th Draft. FAO. Rome. Fertilizer Research. 1990;36:141–150.
19. Hardon JJ, Williams CN, Watson I. Leaf area and yield of oil palm in Malaysia. Expl. Agric. 1969;5:25-32.
20. Nelson DW, Sommers LE. Total carbon, organic carbon and organic matter In: Page AL, Miller RH, Keeney DR. (Eds.), Methods of soil Analysis, Part 2. Chemical and Microbiological Properties, 2nded. (Agronomy series no. 9) ASA, SSSA, Madison, Wis. 1982;539-579.
21. Bray RH, Kurtz LT. Determination of the total organic and available forms of phosphorus in soil. Soil Sci. 1945;599:39-45.
22. Bouyoucos GJ. Hydrometer method improved for making particle size analysis of soils. Agronomy Journal. 1962;53:464-465.
23. GenStat Release 12.1 ed. VSN International Ltd. UK, 2012.
24. Steel GD, Torrie JH. Principles and procedures of statistics. McGraw Hill Co. Inc. New York; 1980.
25. Mohd RMN, Mohd HH. The role of leaf area index in oil palm. Oil palm bulletin. Malaysian palm oil board Kuala Lumpur, Malaysia. 2004;48:11-16.

26. Bello WB, Ogunjinmi SO, Ajani AO. Comparative evaluation of different levels and types of Organo-mineral fertilizers on growth and performance of nursery palm (*Elaeis guineensis*. Jacq). Agric. Biol. J. N. Am., 2014;5(4):175-182.
27. Dwarko A. Effects of moisture and different shade regimes on two progenies of oil palm seedlings. MPhil theses submitted to the University of Ghana; 2001.
28. Subronto T, Taniputra B, Manurury M. Correlation between vegetative characteristics of oil palm in the nursery and yield. Bulletin-Perkebunan. 1989;20: 107-116.
29. Isenmila AE, Omoti U, Oviasogie PO. Development of alternative, cheap, easily available and affordable fertilizers from local rock minerals for the palms. The Journey sofar. Paper presented at NIFOR Seminar. 2006;1-20.
30. Abidemi A, Obigbesan GO. Response of polybag oil palm seedlings to rock phosphates in two benchmark soils. A paper presented at the annual conference of the Nigerian Soil Science Society Conference, held 5th-11th November, Benin City. 1999;1-16.
31. Vernieri P, Borghesi E, Ferrante A, Magnani G. Application of biostimulants in floating system for improving rocket quality. Journal of food, Agric. and Environ. 2005;3-4:86-88.
32. Albregts EE, Howard CM, Chandler C, Mitchell RL. Effects of biostimulants on fruiting of strawberry. Proc. Fla. State. Hort. Soc. 1988;101:370-372.
33. Fraser GA, Percival GC. The influence of biostimulants on growth and vitality of three urban tree species following transplanting. Arboricultural Journal. 2003;27(1):43-57.
34. Obigbesan GO, Akinrinde EA. Suitability of phosphate rocks for direct use as P sources for crop production. Nig. J. Soil Sci. 2000;12:88-99.
35. Goh KJ, Härdter R. In Fairhurst TH, Härdter R (Eds.), Managing oil palm for large and sustainable yields. PPI/PPIC-IPI, Singapore. 2003;191-230.

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