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# Effect of Irrigation Volume and Fertilzer on Nutrient Losses as Affected by Mulching on Oil Palm Seedlings (Elaeis Guineensis Jacq) in the Screen house

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**ABSTRACT**

*Nutrient leaching is one of the major causes of surface and indeed a potential source of groundwater pollution. Nutrients applied as fertilizers are subjected to losses in the dissolved form via surface run off, erosion, leaching and fixation in the soil. Hence, this research was conducted to assess the effect of mulch (empty fruit bunch of oil palm) in mitigating leaching losses from NPKMg fertilizer application to oil palm seedlings. A 2 x 3 x 3 factorial experiment with three (3) replicates fitted to a Completely Randomized Design (CRD) was used. Treatments includes: A = NPKMg at two levels (0 kg ha$^{-1}$ and 37.5 kg ha$^{-1}$) per 5 kg soil, B= Shredded empty oil palm fruit bunch (EFB) as mulch at three levels (0, 37.5 and 75 kg ha$^{-1}$), C = Irrigation Volume at three levels (50,100 and 200 % Field capacity) respectively. Results showed that the leaching loss of N, P, K and Mg were highest when 200% field capacity of irrigation volume was used. Similarly, application of 37.5 kg ha$^{-1}$of NKPMg fertilizer combined with 167.4 g EFB mulch and irrigation volume at 100% Field capacity significantly minimized nutrient losses and enhanced seedlings performance.*

***Keywords:*** *Irrigation volume, Mulching, nutrient leaching, Fertilizer and Oil palm seedlings.*

## INTRODUCTION

Nutrient losses are one of the main environmental problems and indeed a potential cause of ground water pollution (Blomback *et al*., 2011). Nutrient content of soil is an important soil chemical property and different soils have different properties (Brye *et al.,* 2004). The extent at which it occurs in agricultural soils depends on the climate characteristics, soil type (Hesketh and Brookes 2000), and of course the nutrients characteristic (Mengel and Kirkby, 2001). Nutrients applied as fertilizers are subjected to losses in the dissolved form via surface run off, erosion, and fixation in the soil. For example, high rate of fertilizer application per unit area (within the palm circle) encourage nutrient losses in an oil palm ecosystem (Corley and Tinker, 2003). Fertilizers accounts for 50-70% (Calima *et al*., 2012) and about 25% of the total cost of oil palm production (Shamshuddin and Anda, 2012). However, frequent application of large amount of chemical fertilizers coupled with high rainfall intensity tends to increase the risk of nutrient loss and reduced crop productivity (Beaudoin, *et al*, 2005). Approaches to improve crop nutrient use efficiency have been proposed (Prasad, 2009). Mulching oil palm in the nursery helps improves seedlings growth, enhances soil moisture conservation, provides nutrients and improves soil structure (Isenmila, 2005). Various researchers have found that the application of empty fruit bunches raised oil palm yield by 65% (Ziukang Wang *et al*., 2018). Considering the importance of oil palm empty fruit bunch in the overall productivity of the palm, there is paucity of research information on the use of oil palm EFB as mulch in mitigating losses due to leaching arising from NPKMg fertilizer on an Ultisol cultivated with oil palm under screen house condition. Therefore, the objectives of this study were to:

Assess the effect of irrigation volumes on nutrient leaching and growth of oil palm seedlings

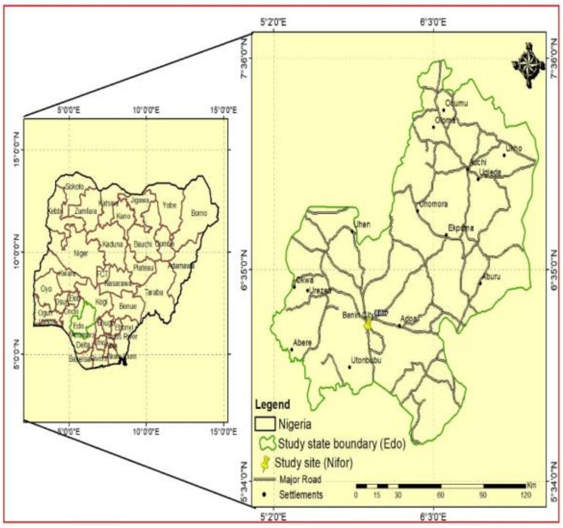
Evaluate the interaction effects of NPKMg fertilizer, EFB mulch and irrigation volume on losses due to leaching for sustainable oil palm seedling production

MATERIALS AND METHODS

Location and Soils of the study

This study was conducted between November, 2018 and March, 2019 in the screenhouse behind Tissue Culture Division of the Nigerian Institute for Oil palm Research (NIFOR) Benin City Edo State. The study area is located on latitude $6^0$ 33' 32.41" N and longitude $5^0$ 37'16.68" E with elevation of 156 m above sea level and falls within the rainforest agro-ecological zone of Nigeria. Humid tropical climate prevails with average annual rainfall of 2000 - 2500 mm (Ogeh and Adeoye, 2012). In the rainy season, the rainfall pattern is bimodal and falls between April and October, while the dry season is between November and April. The mean air temperatures ranged between 22 ºC and 31° C.

A hybride *Tenera* variety developed by NIFOR popularly known as Extension work seed (EWS) was used as a test crop. The soils of NIFOR main station used for this study have been reported to belong to the Orlu series and classified as Rhodic Paleudult (USDA) and Dystric Nitosols (FAO/UNESCO) under the soil order they are classified as Ultisol (Ogunkunle, 1983). The geographical map of the study area is presented in Figure 1. The meteorological data including maximum temperature ($^0$C), minimum temperature ($^0$C), rainfall (mm), wind speed (m/s), maximum relative humidity (%) and minimum relative humidity (%) were observed for the entire period of the experiment from NIFOR meteorological station located at 6 km from the experimental site.




Coordinates: Latitude $6^0$ 33' 32.41" N and Longitude $5^0$ 37'16.68" E

Figure 1: Map of Edo State, showing NIFOR and other major towns

Source: Edo State ministry of land and survey (2016).

Soil sampling

Representative soil samples were collected at the onset of the experiment using soil auger from 0-20, 21-40 and 41-60 cm depths respectively from NIFOR main station in field 9 and bulked separately to form composite sample which were used for routine laboratory analysis.

Fertilizer application

The NPKMg 12:12:17:2 compound fertilizer was applied using the ring method at 7 cm from the stand of seedlings following the procedure described by (Corley and Tinker, 2009).

Mulching

Shredded empty oil palm fruit bunch (EFB) mulch was applied at three levels 0, 83.7 and 167.4 g (based on field application rate of 0, 37.5 and 75 kg ha$^{-1}$) as recommended by Lim and Zaharah (2000).

Soil physical and chemical properties

Particle size analysis of the soil was determined by hydrometer method (IITA, 2012). Bulk density was determine from undisturbed soil sample by core sampling method at (3) depths 0 - 20, 21 - 40 and 41 - 60 cm, oven dried for 24 hours at 105 ° C and determined using the formula of (Al-Shammary et al, 2018). $\boldsymbol{Bulk}\ density = \frac{Wd}{Vc}$ ...

Where, pb is soil bulk density (g/cm$^3$), Wd is weight of dry soils (g) and Vc is volume of soil (cm$^3$); Total porosity *(Pt)*: the percentage of bulk volume not occupied by solids was calculated from the bulk density value assuming a particle density (Pd) of 2.65 gcm$^{-3}$. Total porosity (Pt) = 1- Bd., Where, Bd is the bulk density and (pd) is the particle density = 2.65 g cm$^3$; Saturated hydraulic conductivity, $K_{sat}$ was calculated using formula proposed by Rattan and

Shukla (2005). $K_{sat} = \frac{Q}{At} \bullet \frac{L}{\Delta H}$. Where, $K_{sat}$ = saturated hydraulic conductivity (cm/hr), Q = volume of water per unit time ($cm^3$/mins), L = length of soil column (cm), A = cross sectional area of the soil column ($cm^2$), ΔH = change in hydraulic head (dimensionless) and t = time of flow (mins). Soil pH was determined with a pH meter at a ratio of 1:2 soil to distilled water suspensions (Thomas, 1996) Organic carbon was analyzed by the dichromate oxidation procedures (Walkley and Black, 1934) method. Total nitrogen was determined by the regular macro-Kjedahl digestion method (AOAC, 2003). Available phosphorus (P) was extracted using Bray-1 method (Ubi *et al.,* 2012). Exchangeable cations were extracted using $NH_4OAC$ buffered at pH 7.0 (Adamu *et al*, 2015), Potassium (K) and Sodium (Na) were determined with a flame photometer while Exchangeable calcium (Ca) and Magnesium (Mg) were determined using Atomic Absorption Spectrophotometer (AAS) Perkin Elmer 403. The Elemental content of leachate (N P K Mg) were determined as follows:

$$\text{Leached amount of N} = \frac{\textit{Concentration of N in the leachate}}{\textit{Total leachate volume}}$$

This formula was used to calculated leachate concentrations for each individual element

Determination of field capacity

Prior to transplanting, the field capacity of soil was determined by the gravimetric method Souza *et al.* (2000), from three (3) undisturbed soil samples collected from the soil pit in a core sampler at a depth interval of 0-20 cm, 21-40 cm and 41- 60 cm respectively. Core samples were saturated for one day and a pressure of 1/3 bar (field capacity) was exerted until no more change in weight of sample was observed as described by Mbah, (2012).

Experimental Design and Treatments

Treatments consisted of three factors namely: NPKMg 12:12:17:2 fertilizer, at two levels and irrigation volume at three levels.

A = NPKMg fertilizer at two (2) levels 0 g and 0.084 g per 5 kg soil (based on application rate of `0 kg $ha^{-1}$ and 37.5 kg $ha^{-1}$) as recommended by Chude *et al.* (2011).

B = Shredded empty oil palm fruit bunch (EFB) as mulch at three levels 0, 83.7 and 167.4 g (based on field application rate of 0, 37.5 and 75 kg $ha^{-1}$) as recommended by Lim and Zaharah (2000).

C = Irrigation Volume at three (3) levels (50 % Field capacity, 100 % Field capacity and 200 % Field capacity).

The experimental design was a 2 x 3 x 3 factorial experiment with three (3) replicates fitted to a Completely Randomized Design (CRD). A total of 18 treatments combination were evaluated. Treatments were assigned randomly using the balloting method as showed below:

Treatment combination for screenhouse experiment
T1= 50 % FC
T2 = 100% FC
T3 = 200 % FC
T 4= 83.7g EFB + 50% FC
T5 = 83.7g EFB + 100% FC
T 6 = 83.7g EFB + 200% FC
T7 = 167.4g EFB + 50% FC
T8 = 167.4g EFB + 100% FC
T9 = 167.4g EFB + 200% FC
T10 = 0.084g NPKMg + 50% FC
T11 = 0.084g NPKMg + 100% FC
T12 = 0.084g NPKMg + 200% FC
T13 = 0.084g NPKMg + 83.7g EFB+ 50% FC
T14 = 0.084g NPKMg + 83.7g EFB + 100% FC
T15 = 0.084g NPKMg + 83.7g EFB+ 200% FC
T16 = 0.084g NPKMg + 167.4g EFB+ 50% FC
T17 = 0.084g NPKMg + 167.4g EFB+ 100% FC
T18 = 0.084g NPKMg + 167.4g EFB+ 200% FC

**Planting**

The oil palm seedlings were sourced from the Nigerian Institute for Oil Palm Research (NIFOR), Benin City. The oil palm seedlings of 2 to 3 leaf stage healthy, vigorous and of uniform growth were selected and transplanted singly by hand into the plastic bucket. The 54 plastic buckets were used for the experiment. All the transplanted seedlings were watered when necessary for a period of two weeks in order to obtain good emergence before treatments were applied. Manual weeding was carried out regularly to control weeds.

**Agronomic parameters**

Plant height which is the distance from the soil surface to the tallest leaf was measured with a meter rule at one inch ($m^2$) above the surface. Leaf production was assessed by counting all fully opened leaves on each palm. Stem circumference was measured from the soil surface with a thread that was held tightly round the base of the seedlings and thereafter spread along a meter rule to determine the exact width (Corley and Tinker, 2009). The leaf area was measured as the product of the length from the base to the tip and the maximum width with a meter rule and the formula

Leaf area = Max. Length × Max. Width × a constant (×) was used to determine the area of each leaf. The constant (×) varies for each crop, for oil palm is 0.05 (oil palm leaf calibration factor) (Mannan, *et al*, 2019). Measurements were taken every month for the period of five (5) months.

Statistical Analysis

**RESULTS AND DISCUSSION**

The results of the soil physical and chemical properties of soil used in the screen house experiment are presented in Table 1

The texture of the soil was sandy clay loam with relative high proportion of sand fraction over the mineral particles and decreased with increasing soil depth. This may be due to the sandy nature of the soils as observed in the area. This observation corroborates the findings of Osayande *et al*. (2013) who reported that the parent material of the coastal plain sand soils of Nigerian Institute for Oil Palm Research (NIFOR) may have influence the texture of the soils in the study area. The clay content increased with increasing soil depth. The low pH, total N, available P, exchangeable K, Ca, Mg, Na and organic matter content confirmed the soil to be low in fertility. The low CEC values may be attributed to the low clay and organic matter contents of the Soils. Singh (2002) reported that, soil with low organic matter content is expected to have low CEC than soil with high organic matter. The result of this study further conforms to the findings of Akanbi and Togun (2002) who reported that most tropical soils are low in nutrient content. The soil reaction in the study area is extremely to moderately acid with pH values ranged from 4.2 to 4.6 between 0-20 and 40-60 cm depth. The low pH observed in the study area however, did not limit oil palm cultivation, this observation corroborates earlier findings by Ikyaahemba *et al*, 2015 who reported that oil palm can cope with a pH as low as 4.4.

Table 1: Some physical and chemical properties of soil used in the screen house experiment

| Soil physical characteristics | Soil depth (cm) | | |
|---|---|---|---|
| | 0 – 20 | 21 – 40 | 41 -60 |
| Sand (g/kg) | 685 | 621 | 588 |
| Silt (g/kg) | 56 | 32 | 26 |
| Clay (g/kg) | 259 | 347 | 386 |
| Textural class | Sandy clay | Sandy clay | Sandy clay |
| Bulk density (g/cm$^3$) | 1.48 | 1.43 | 1.32 |
| Total porosity (%) | 44 | 46 | 50 |
| $K_{sat}$ (cm /hr) | 1.42 | 1.39 | 0.21 |
| Chemical characteristics | | | |
| Soil pH ($H_2O$) 1:2 | 4.6 | 4.4 | 4.2 |
| Organic carbon (g/kg) | 0.34 | 0.32 | 0.30 |
| Total N (g/kg) | 1.2 | 1.1 | 1.0 |
| Available P (mg/kg) | 27 | 23 | 22 |
| Exch. acidity (cmol/kg) | 0.4 | 0.2 | 0.2 |
| Exchangeable Bases | | | |
| Calcium (cmol/kg) | 0.33 | 0.32 | 0.32 |
| Magnesium (cmol/kg) | 0.39 | 0.37 | 0.34 |
| Potassium (cmol/kg) | 0.53 | 0.49 | 0.46 |
| Sodium (cmol/kg) | 0.25 | 0.24 | 0.22 |

The data generated were subjected to Analysis of Variance (ANOVA) using GENSTAT edition 2012 software package. Treatments means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

Table 2: Main effect of NPKMg, EFB and irrigation volume on leached nitrogen under oil palm seedlings in the screenhouse

| Treatments rate | Leached nitrogen (g/L) | | | | |
|---|---|---|---|---|---|
| | 1 MAT | 2 MAT | 3 MAT | 4 MAT | 5 MAT |
| No fertilizer | 31.13b | 21.54b | 36.48b | 48.32b | 52.93b |
| NPKMg 0.084g | 205.6a | 170.9a | 241.6a | 189.6a | 156.3a |
| LSD (0.05) | 4.002 | 5.124 | 3.008 | 9.016 | 10.061 |
| | | | | | |
| No EFB mulch | 275.4a | 254.8a | 321.6a | 352.8a | 268.4a |
| EFB 83.7 g | 55.94b | 59.71b | 55.29b | 69.03b | 71.31b |
| EFB 167.4 g | 19.82c | 16.39c | 14.28c | 15.21c | 18.12c |
| LSD (0.05) | 11.007 | 10.006 | 9.0043 | 6.042 | 8.005 |
| | | | | | |
| IR.V 50% | 15.24c | 25.56c | 21.59c | 22.41c | 21.65c |
| IR.V 100% | 30.26b | 39.54b | 40.41b | 29.35b | 41.41b |
| IR.V 200% | 360.5a | 339.6a | 433.7a | 412.9a | 420.2a |
| LSD (0.05) | 8.120 | 9.005 | 7.143 | 9.015 | 8.027 |
| Interaction | | | | | |
| NPKMg x EFB | 0.0299 | NS | NS | NS | NS |

Means with the same letter (s) within the column are not significantly different at 5% level of probability using Least Significant Different (LSD), NPKMg = inorganic fertilizer (12:12:17:2), EFB = oil palm empty fruit bunch, IR. V = irrigation volume at 50,100 and 200% field capacity, NS= not significant, MAT = months after transplanting

The high leaching loss of N, P, K and Mg (Table 2, 4, 6 and 8) as observed in the screenhouse with the application of NPKMg fertilizer may be attributed to the ready availability of mineral elements present in the fertilizer. Comparatively, the low leaching of N, P, K and Mg (Table 2, 4, 6 and 8) as observed with increasing rate of EFB mulch may be due to enhanced water-holding capacity of the EFB mulch thereby reducing the amount of nutrient loss. The result of this study is in line with Liang and Wang, (2002) who noted that, mulch materials could have decomposed to release nutrient, enhanced soil microbial activity, improved soil water retention capacity and consequently reduce nutrient loss. Previous studies (Aribe, 2003) had established improvements of soil physical properties by the application of organic materials.

The interactions between NPKMg fertilizer and EFB mulch on leached nitrogen was only significant ($p<0.05$) at 1MAT as shown in Table 3.

Table 3: Interaction effect of NPKMg and EFB mulch on leached nitrogen under oil palm seedlings in the screenhouse

| Treatments rates | | Leached nitrogen (g/L) |
|---|---|---|
| NPKMg | EFB | 1 MAT |
| | 0 g | 19.98a |
| 0 g | 83.4 g | 13.62b |
| | 167.4 g | 5.881c |
| | 0 g | 16.03a |
| 0.084g | 83.4 g | 10.61b |
| | 167.4 g | 4.325c |

Means with the same letter within the column are not significantly different at 5% level of probability using Duncan Multiple Range Test, NPKMg= inorganic fertilizer (12:12:17:2), EFB= oil palm empty fruit bunch, MAT= month after t

The main effect of NPKMg, EFB mulch and irrigation volume on leached phosphorus under oil palm seedlings in the screenhouse is presented in Table 4.

Table 4: Effect of NPKMg, empty oil palm fruit bunch and irrigation volume on leached phosphorus under oil palm seedlings in the screenhouse

| Treatments (g) | Leached phosphorus (g/kg soil) | | | | |
|---|---|---|---|---|---|
| | 1 MAT | 2 MAT | 3 MAT | 4 MAT | 5 MAT |
| No fertilizer | 10.95bc | 10.99cd | 15.57cd | 16.76ab | 13.61bc |
| NPKMg 0.084g | 13.42ab | 12.47bc | 18.82bc | 17.47ab | 14.03ab |
| No EFB mulch | 54.64a | 42.29a | 34.97a | 27.25a | 29.26a |
| EFB 83.7 g | 27.54b | 25.43ab | 22.14ab | 20.58b | 21.61b |
| EFB 167.4 g | 15.09ab | 16.08c | 14.52cd | 14.67bc | 12.59c |
| IR.V 50% | 6.203c | 7.139cd | 7.129d | 6.488d | 6.194d |
| IR.V 100% | 14.6ab | 16.71c | 13.63bc | 11.69c | 12.79bc |
| IR.V 200% | 47.76a | 33.77b | 28.91b | 29.84a | 31.08a |
| Interaction | | | | | |
| NPKMg x EFB | 0.802 | NS | 0.901 | NS | 0.749 |

Means with the same letter (s) in the same column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT). NPKMg = inorganic fertilizer (12:12:17:2), EFB = oil palm empty fruit bunch, IR. V = irrigation volume at 50,100 and 200% field capacity, NS= not significant, MAT = months after transplanting

Result indicated that sole application of NPKMg fertilizer had no significant ($P>0.05$) effect on leached phosphorus. Phosphorus losses decreased with increasing rate of EFB mulch compared to the control. However, excess irrigation volume at 200% field capacity increased nutrient loss. The interaction between NPKMg fertilizer and EFB mulch on leached Phosphorus was significant ($P<0.05$) at 1, 3 and 5 MAT as in shown in table 5.

Table 5: Interaction effect of NPKMg and EFB mulch on leached phosphorus under oil palm seedlings in the screenhouse

| Treatments combinations | | Leachate phosphorus (g/L) | | |
|---|---|---|---|---|
| NPKMg | EFB | 1 MAT | 3 MAT | 5 MAT |
| | 0 g | 0.831a | 0.681a | 0.512a |
| 0 g | 83.4 g | 0.611b | 0.521b | 0.321b |
| | 167.4 g | 0.422c | 0.235c | 0.112c |
| | 0 g | 0.631a | 0.512a | 0.433a |
| 0.084g | 83.4 g | 0.491b | 0.343b | 0.236b |
| | 167.4 g | 0.331c | 0.196c | 0.125c |

Means with the same letter within the column are not significantly different at 5% level of probability using Duncan Multiple Range Test, NPKMg= inorganic fertilizer (12:12:17:2), EFB= oil palm empty fruit bunch, The main effect of NPKMg, EFB mulch and irrigation volume on leached potassium is presented in Table 6.

Table 6: Main effect of NPKMg, EFB mulch and irrigation volume on leached potassium under oil palm seedlings in the screenhouse

| Treatments | Leached potassium (g/L) | | | | |
|---|---|---|---|---|---|
| Rates | 1 MAT | 2 MAT | 3 MAT | 4 MAT | 5 MAT |
| NPKMg (g) | | | | | |
| No Fertilizer | 41.56b | 34.71b | 53.37b | 42.86b | 45.17b |
| NPKMg 0.084 | 226.1a | 189.1a | 230.5a | 178.3a | 132.8a |
| EFB mulch (g) | | | | | |
| No EFB mulch | 520.4a | 466.9a | 505.5a | 380.6a | 350.5a |
| EFB 83.7 | 166.7b | 127.6b | 117.3b | 126.5b | 38.65b |
| EFB 167.4 | 63.43c | 55.54c | 51.37c | 45.23c | 26.63c |
| IR, Vol. (%) | | | | | |
| 50 | 40.29c | 56.88c | 45.68c | 39.91c | 26.01c |
| 100 | 127.7b | 146.6b | 109.5b | 133.7b | 142.3b |
| 200 | 470.1a | 346.5a | 322.4a | 488.5a | 595.2a |
| Interaction | | | | | |
| EFB x IR.V | 0.0128 | 0.0173 | NS | 0.0337 | 0.0361 |

Means with the same letter (s) in the same column are not significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT), NPKMg = inorganic fertilizer (12:12:17:2), EFB = oil palm empty fruit bunch, IR. V = irrigation volume at 50,100 and 200% field capacity, NS= not significant, MAT = months after transplanting

Table 7: Interaction effect of EFB and irrigation volume on leached potassium under oil palm seedlings in the screenhouse

| Treatments rate | | Leached potassium (g/L) | | | |
|---|---|---|---|---|---|
| EFB | Irrigation volume | 1 MAT | 2 MAT | 4 MAT | 5 MAT |
| 0 g | 50 | 0.395c | 0.380c | 0.281c | 0.252c |
| 83.4 g | 100 | 0.558b | 0.456b | 0.453b | 0.429b |
| 167.4 g | 200 | 0.630a | 0.627a | 0.627a | 0.603a |
| 0 g | 50 | 0.377c | 0.381c | 0.370d | 0.331c |
| 83.4 g | 100 | 0.455b | 0.473b | 0.462bc | 0.429b |
| 167.4 g | 200 | 0.634a | 0.621a | 0.623a | 0.614a |

Means with the same letter within the column are not significantly different at 5% level of probability using Duncan Multiple Range Test, EFB= oil palm empty fruit bunch, MAT= months after treatments

Result revealed that Application of 0.084 g NPKMg fertilizer significantly enhanced leaching of Potassium compared to control. In contrast, low values of K were recorded in the pot mulched with 167.4 g EFB followed by 83.7 g EFB mulch relative to the control.

Interaction between EFB and irrigation volume was significant ($p<0.05$) at 1, 2, 4 and 5 MAT,

The main effect of NPKMg, EFB mulch and irrigation volume on leached magnesium is presented in (Table 8).

Table 8: Main effect of NPKMg, EFB mulch and Irrigation volume on leached magnesium under oil palm seedlings in the screenhouse

| Treatments | Leached magnesium (g/L) | | | | |
|---|---|---|---|---|---|
| Rates | 1 MAT | 2 MAT | 3 MAT | 4 MAT | 5 MAT |
| No Fertilizer | 65.48a | 49.21a | 53.45a | 64.10a | 34.76as |
| NPKMg 0.084g | 67.84a | 52.75a | 55.35a | 66.45a | 37.13a |
| No EFB mulch | 215.2a | 207.5a | 204.1a | 179.4a | 106.4a |
| EFB 83.7 g | 64.52b | 50.52b | 42.51b | 37.76b | 25.86b |
| EFB 167.4 g | 23.75c | 22.06c | 23.54c | 22.28c | 17.92c |
| LSD (0.05) | 4.013 | 5.014 | 3.015 | 5.013 | 4.056 |
| IR.V 50% | 27.53c | 42.61c | 34.47c | 25.71c | 28.42c |
| IR.V 100% | 54.28b | 70.41b | 64.28b | 59.65b | 43.99b |
| IR.V 200% | 132.4a | 107.6a | 124.5a | 125.4a | 102.5a |
| Interaction | | | | | |
| NPKMg x EFB x IR.V | NS | 0.0371 | NS | NS | NS |

Means with the same letter (s) in the same column are not significantly different at 5% level of probability using Least Significant Different (LSD), NPKMg = inorganic fertilizer (12:12:17:2)
EFB = oil palm empty fruit bunch, IR. V = irrigation volume at (50,100 and 200%) field capacity
NS= not significant, MAT = months after transplanting

The results showed that application of 0.084g NPKMg fertilizer had no significant ($p<0.05$) effects on leached magnesium throughout the period of the study. Mg losses decrease with increasing levels of EFB mulch in the order of 167.4 g EFB < 83.7 < 0 g EFB (Table 8). Similarly, irrigation volume at 200% Field capacity significantly increased Mg than 100% field capacity and 50% field capacity.

The interaction between EFB mulch and irrigation volume was significant ($p<0.05$) at 1, 2, 4 and 5 MAT,

Table 9: Interaction effect of NPKMg, EFB mulch and irrigation volume on leached Magnesium under oil palm seedlings in the screenhouse

| Treatment rates | | | Leached Mg (g/L) |
|---|---|---|---|
| NPKMg | EFB mulch | Irrigation volume | 2 MAT |
| | 0 g | 50 | 49.21c |
| 0 g | 83.4 g | 100 | 52.75b |
| | 167.4 g | 200 | 25.27a |
| | 0 g | 50 | 42.61c |
| 0.084 g | 83.4 g | 100 | 70.41b |
| | 167.4 g | 200 | 107.6a |

Means with the same letter within the column are not significantly different at 5% level of probability using Duncan Multiple Range Test, NPKMg= inorganic fertilizer (12:12:17:2), EFB= oil palm empty fruit bunch, MAT = month after treatments.

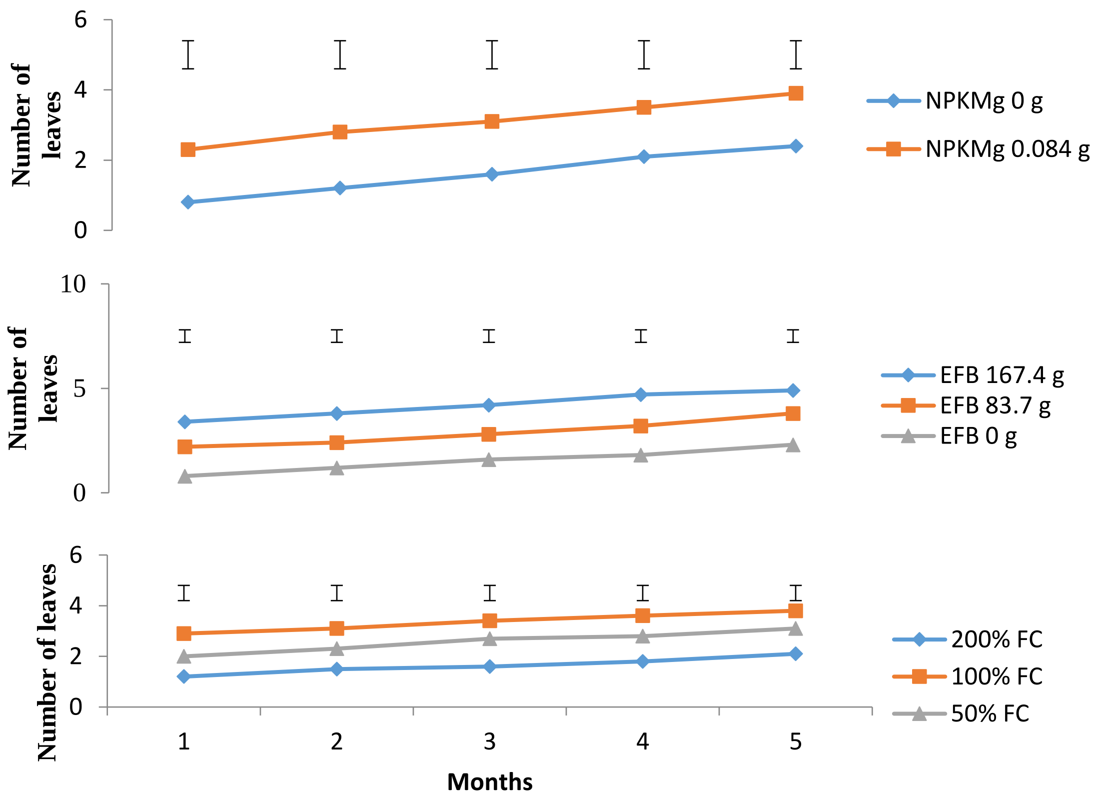



Figure 2: Effect of NPKMg, EFB and irrigation volume on number of leaves of the oil palm seedlings in the screenhouse
The vertical bars represent LSD $_{(0.05)}$ bar

The high leaching loss of N, P, K and Mg observed in this study with the application of NPKMg 12:12:17:2 fertilizers may be attributed to the ready availability of mineral elements present in the fertilizer. This is consistent with Adeniyan *et al*. (2011) who reported that nutrient in inorganic fertilizer is already in mineralized form and provides a ready source of nutrient to the soil. The leachate characteristics as examined in this study showed that EFB mulch significantly reduced leaching of N, P, K and Mg, this may be adduced to the fact that the EFB mulch enhanced water-holding capacity of the soil thereby reducing the amount of nutrient loss. This is in alignment with the findings of (Aribe, 2003) who reported that organic materials improves soil physical properties and enhance soil water retention. The result of this study conform with the findings by Liang and Wang, (2002) who noted that, mulch materials when applied decomposes to release nutrient, enhanced soil microbial activity, improved soil water retention capacity and consequently reduce nutrient loss. Comparatively excess irrigation at 200% field capacity increased nutrient loss. This observation is consistent with the findings by Walter *et al.* (2016) who compared the leaching losses of mineral fertilizer applied on sandy and clay soil under different irrigation regime and reported that the amount of nutrients leached were more on sandy soils under 200% irrigation regime compared to 50 and 150% irrigation regime on clay soil.

The growth parameters of the oil palm seedlings under screenhouse study are presented in Figures 2, 3, 4 and 5.

Generally, the oil palm seedling growth and physiology improved with the application of EFB mulch. Seedlings fertilized with 0.084 g NPKMg significantly ($P<0.05$) had higher number of leaves, and plant height; this was followed by increasing rate of EFB mulch in the order of 0 g EFB> 83.7 g EFB > 167.4 g EFB. This agreed with the findings of Bhatt and Kheral (2006) and Anikwe *et al.* (2007) who reported that mulch provides a better soil environment, moderate soil temperature and increase soil porosity. The decline in the growth parameters as observed with increasing levels of irrigation volume (50% > 100% > 200%) Field capacity may be due to the poor soil aeration and leaching of plant nutrients beyond the root zone. This observation is consistent with the findings of Jalota *et al.* (2006) who noted that different irrigation regime may show different effects on plant growth and crop yields under different soil conditions. There was a positive interaction between fertilizer and EFB mulch at 100% FC on the plant height, stem girth and leaf area of the oil palm seedlings (Fig. 3, 4 and 5).

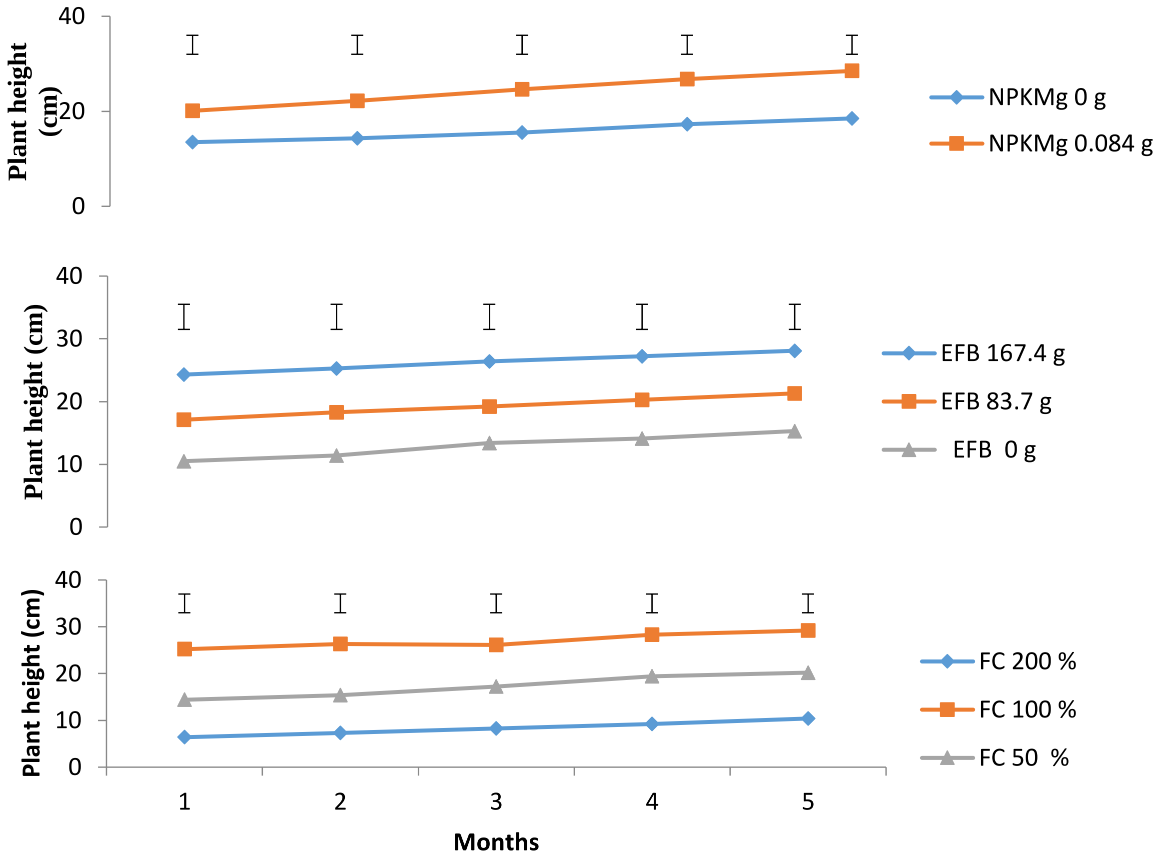



Figure 3: Effect of NPKMg, EFB and irrigation volume on plant height of the oil palm seedlings in the screenhouse

The vertical bars represent LSD $_{(0.05)}$ bar

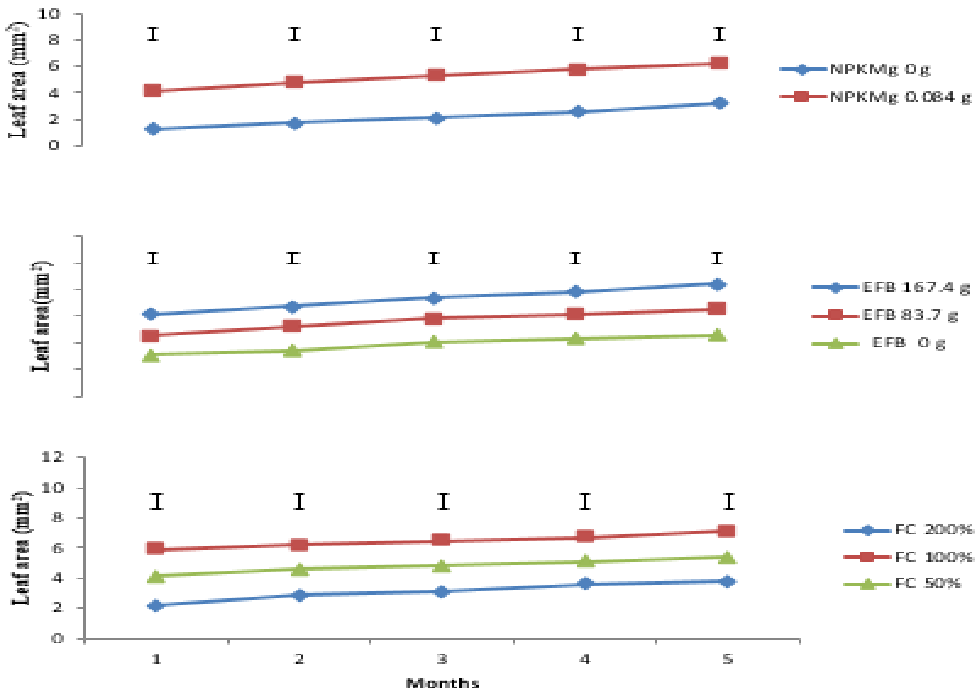



Figure 4: Effect of NPKMg, EFB and irrigation volume on leaf area of the oil palm seedlings in the screenhouse
The vertical bars represent LSD $_{(0.05)}$ bar

**CONCLUSION AND RECOMMENDATION**

Generally, the result of this investigation has demonstrated that application of 37.5 kg ha-1 NPKMg fertilizer combined with 167.4 g EFB mulch and irrigation at 100% field capacity significantly minimized nutrient losses and enhanced seedlings performance. Therefore, Nursery managers should consider combining EFB mulch at 167.4 g with 100% FC for optimal result.

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