# EFFECT OF DIFFERENT LEVELS OF PHOSPHORUS FERTILIZER APPLICATION ON ACID SOIL FERTILITY AND DEVELOPMENT OF RUBBER SAPLINGS DURING EARLY STAGES OF RUBBER GROWTH

**Esekhade, T.U., *Idoko, S.O., Igberase, S.O. and Egwu, S.O.**

*Rubber Research Institute of Nigeria, P. M. B. 1049, Benin City, Edo State, Nigeria.*

***Corresponding author's E-mail:** onuidoko@yahoo.com

## ABSTRACT

The effects of different levels of Phosphorous (P) fertilizer on some soils and rubber sapling growth characteristics on acid sand of Southern Nigeria was investigated in a greenhouse experiment at the Rubber Research Institute of Nigeria, Iyanomo, near Benin City. The experiment consisted of four levels of P fertilizer levels (0, 30, 60, and 90 kg $P_2O_5$ $ha^{-1}$) arranged in a RCBD with each treatment replicated three times. The result showed that the optimum P fertilizer levels had no significant effects on the soil pH, percentage organic carbon, nitrogen and exchangeable acidity. However, total N had gradual increases from 30 days after planting (DAP). Mean uptake of N and Mg were highest in rubber saplings that received 90 kg $P_2O_5$ $ha^{-1}$, while P and Ca were highest in rubber saplings that received 60 kg $P_2O_5$ $ha^{-1}$ and Na and K were highest in rubber treated with 30 and 0 kg $P_2O_5$ $ha^{-1}$ respectively. The P requirement for rubber samplings was 60kg $P_2O_3$ $ha^{-1}$ and the highest growth characteristics (girth, height and leaf area) of rubber sampling was achieved with 60 kg $P_2O_5$ $ha^{-1}$. The study revealed that the optimum P nutrient requirement for the growth and development of rubber sapling on acid sand soil of southern Nigeria is 60 kg $P_2O_5$ $ha^{-1}$. However further work need to be carried out on the field to verify this result.

**Keywords:** Rubber saplings, P fertilizer levels, nutrient uptake, growth characteristics, acid sand.

J. Agric. Prod. & Tech.2017; 6:11-18

## INTRODUCTION

Plant nutrition is one of the most important factors affecting growth and development of rubber especially at the early growth stages. Fertilizer applications are aimed at promoting vigorous growth that may lead to early attainment of maturity in rubber. Phosphorous (P) fertilization has been shown to be the single most important nutrient in the growth and development of rubber (Osedeke *et al*., 1993 and Onuwaje and Uzu, 1982). This is attributed to the relatively low status of P in the soil. Kalam *et al*., (1980) showed that P played an important role in the rate of development of rubber stem girth.

Studies has shown that P fertilizer applied to rubber was always in excess of plants immediate requirement, followed by a build up reserve which would be slowly released for uptake by the plant at maturity over an extended period of time (Owen, 1974 and RRIM, 1954). Phosphorus deficiency in the soil generally leads to stunted and retarded growth and development in rubber (Shorrocks, 1964). Hence, P fertilization leads to the advancement of various stages of development of crops (Mokwunye and Bationo 2002). The beneficial use of fertilizers in the cultivation of rubber at different stages of growth has been demonstrated in a number of studies (Guha and Yeow, 1966; Guha, 1975; Onuwaje and Uzu, 1982; Onuwaje, 1983). However, there is dearth of information on the actual P fertilizer levels requirement for optimum growth and development of rubber in rubber growing areas of Nigeria. Hence, this study aimed at determining the effect of different levels of P fertilizer application on the development of rubber saplings during early stages of rubber growth.

## MATERIALS AND METHODS

The experiment was conducted at the Rubber Research Institute of Nigeria, Iyanomo near Benin City located in the rainforest region of Southern Nigeria. Annual rainfalls during the two seasons of the experiment were 2352 and 2622. The area has a bimodal rainfall distribution. The temperature is high, with a mean of 29.0 – 32.1 $^0$C and 25.7 – 31.4 $^o$C in the first and second season respectively. Selected physicochemical properties of the soils before cropping shows that the soil was very strongly acidic (pH of 5.90 and 5.40 in $H_2O$ and KCl respectively), the organic carbon was at medium level (18.6 g $kg^{-1}$), total N was high (3.8 g $kg^{-1}$), available P was 4.0 mg P $kg^{-1}$ and ECEC of 3.08 Cmol $kg^{-1}$ while the texture of the area was loamy sand with percentage sand, silt and clay ranges of between 73.2 and 93.5, 1.4 and 3.4, and 9.4 and 25.4 percent respectively.

Seeds for the pre-nursery establishment were collected from a multi-clonal plantation close to the nursery unit in RRIN, Benin City. The seeds were pre-germinated in nursery beds and transferred to the ground nursery. The seedlings were green budded to NIG 805 clone after six months. Healthy and equal sized budded stumps were selected for planting and harvested bare rooted for planting in the poly bags in the green house.

Soil samples for the poly bags were collected from the experimental area at 0 – 15 cm depths. The soil were air-dried and passed through a 2 mm sieve. Each poly bag had a lay-flat dimension of 55 x 30 cm and 400-guage thickness and filled with 8 kg soil. The budded stumps were planted immediately after lifting into the poly bags to which treatments have been applied and allowed to equilibrate for 48 hours.

The experiment was arranged in a randomized complete block design with each treatment replicated thrice. The treatments consisted of four levels of P fertilizer (0, 30, 60, and 90kg $P_2O_5$ $ha^{-1}$) using Single Super Phosphate (SSP) fertilizer as source. Basal nutrient were applied according to Onuwaje (1983).

Soil samples were collected from the poly bags at an interval of 30 days at the time of destructive harvest of rubber saplings for analysis. The samples were subjected to physiochemical analysis by using standard analytical procedures while the sampled plants were partitioned into leaf, stem and root. The samples were thoroughly washed with clean water and oven-dried at 80$^o$C to a constant weight. The dried samples were ground and processed for analysis by dry ashing at 550$^o$C for 3 hours. Nitrogen was determined using Auto Analyzer, P was by the Vanadomolybdate method colorimetrically through UV/visible spectrophotometer; and K and Ca was by the Flame Photometer while Mg and Na was determined in a Perkin-Elimer 703 Atomic Absorption Spectrophotometer (AAS).

Morphological growth parameters of rubber saplings were measured at interval of 30 days. Girth was determined using Venire Calliper and the diameter obtained multiplied by 3.142 to give the girth of each rubber saplings. Plant heights were obtained using flexible tape. Leaf area meter was used to determine the leaf areas of rubber. The number of leaf was by simple counting.

All the data generated were analysed using the Analysis of variance (ANOVA) statistics and the means separated using the Least Significant Differences (LSD) at 0.05 level of statistical significance.

## RESULTS

Effects of different levels of Phosphorus fertilizer application on soil nutrient status in the greenhouse is as shown in Figures 1 and 2; and Tables 1 and 2 below.

There were no significant effect of P levels on soil pH, total N and exchangeable acidity (Table 1). However, soil pH values were highest in soils in which 30 kg $P_2O_5$ was applied. It was further observed that organic carbon and total N increased gradually from 30 DAP to 360 DAP. Soil with 0.0 kg $P_2O_5$ $ha^{-1}$ level had the highest organic carbon values of 33 g $kg^{-1}$ soil at 360 days after planting. Exchangeable acidity did not follow any particular trend. But the soil with 0 kg $P_2O_5$ $ha^{-1}$ level had the highest exchangeable acidity value of 0.8 Cmol $kg^{-1}$ soil, while soils with 60 kg $P_2O_5$ $ha^{-1}$ level had the lowest value of 0.5 Cmol $kg^{-1}$ soil at 360 DAP respectively.

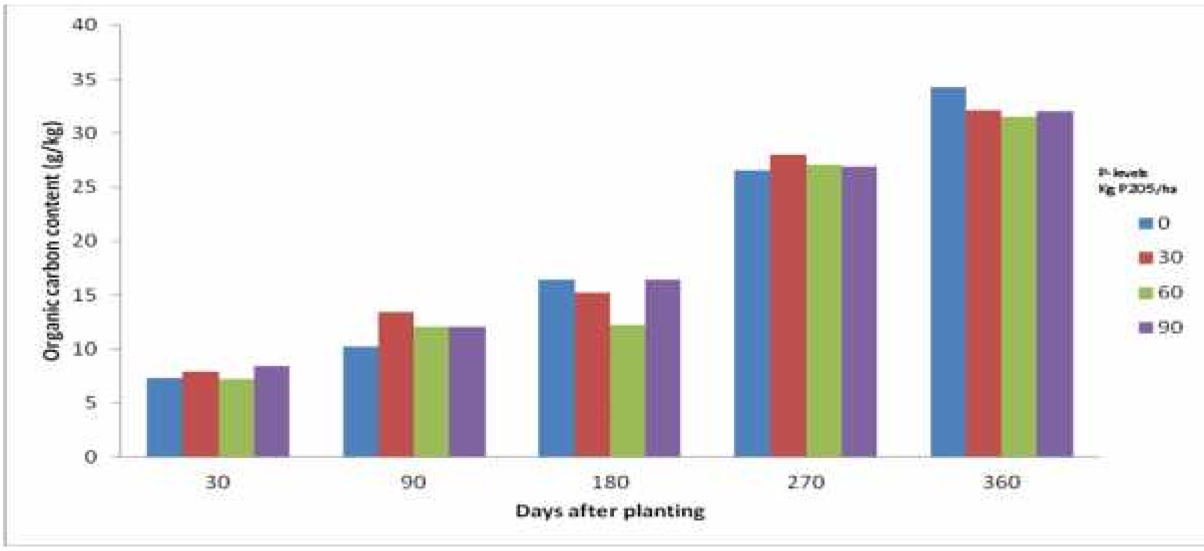


**Figure 1: Effect of levels of phosphorous on organic carbon**

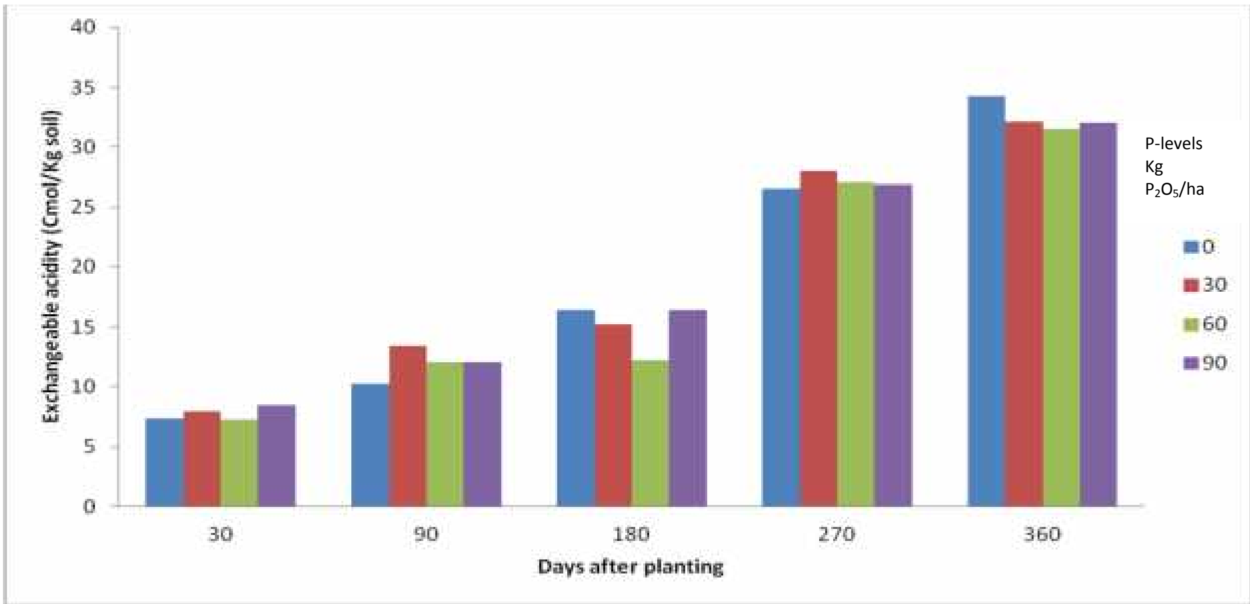


**Figure 2: Effect of levels of phosphorous on Exchangeable acidity**

The effects of different levels of Phosphorus fertilizer application on uptake of other nutrients by rubber saplings is as shown in Figures 3-6 below. The effects of P on the contents of major nutrients in rubber saplings are presented in Table 2. Mean percentage N and Mg were highest in rubber saplings that received 90 kg $P_2O_5$ $ha^{-1}$ level. Mean P and Ca were highest in rubber saplings to which 60 kg $P_2O_5$ $ha^{-1}$ were applied, while Na and K were highest in rubber saplings treated with the 30 and 0 kg $P_2O_5$ $ha^{-1}$ respectively.

The effect of different levels of P on growth parameters of rubber saplings is as shown in Figures 3 – 6 below. The results showed that P levels significantly ($p \leq 0.05$) influenced the growth parameters such as girth (Figure 3), height (Figure 4), leaf area (Figure 5) and number of leaves (Figure 6) of rubber saplings. The results also showed that the effect of P levels on the growth parameters of rubber saplings only became significant from 180 DAP (Figures 3 – 6). Rubber saplings to which P was applied at the 60 kg $P_2O_5$ $ha^{-1}$ level consistently had the highest values of rubber sapling growth parameters (girth, height, leaf area and number of leaves).

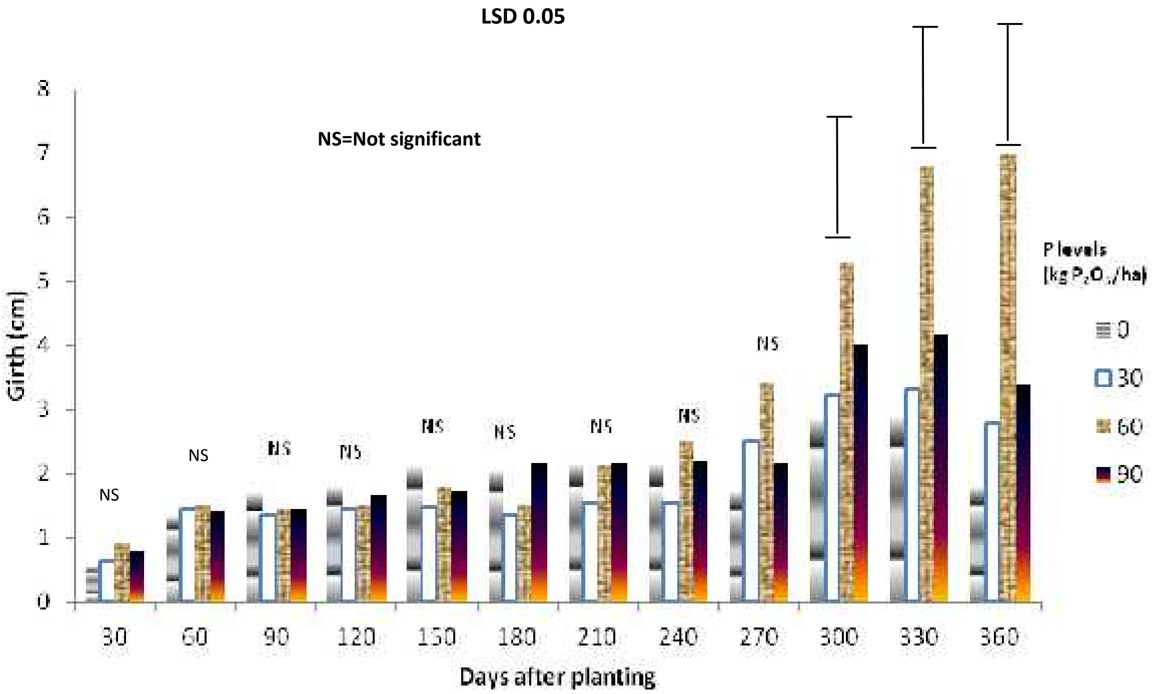


**Figure 3: Effects of levels of phosphorous on girth of rubber saplings in the greenhouse**

**Table 1: Effects of different levels of P on soil pH under rubber saplings in the greenhouse**

| **Levels of P (kg $P_2O_5$ ha$^{-1}$)** | **30** | **60** | **90** | **120** | **150** | **180** | **210** | **240** | **270** | **300** | **330** | **360** | **Mean** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **DAP** | | | | | | | | | | | | |
| 0 | 5.18 | 5.20 | 5.40 | 5.0 | 5.82 | 5.58 | 5.60 | 5.08 | 5.11 | 5.50 | 5.40 | 5.50 | 5.35 |
| 30 | 5.44 | 5.40 | 5.56 | 5.40 | 5.62 | 5.38 | 5.60 | 5.04 | 5.48 | 5.88 | 5.46 | 5.39 | 5.45 |
| 60 | 5.29 | 5.05 | 5.57 | 5.35 | 5.45 | 5.19 | 5.60 | 5.16 | 5.23 | 5.90 | 5.30 | 5.17 | 5.29 |
| 90 | 5.50 | 5.25 | 5.11 | 5.30 | 5.73 | 5.45 | 5.60 | 5.65 | 5.32 | 5.39 | 5.26 | 5.27 | 5.33 |
| **LSD (0.05** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |

**Table 2: Effects of P levels on mean contents of major nutrients in rubber saplings at 360 DAP in the greenhouse**

| **Levels of P (kg $P_2O_5$ ha$^{-1}$)** | Total N | K | Mg | Ca | Na | P |
|---|---|---|---|---|---|---|
| | | | | Cmol kg$^{-1}$ | | g kg$^{-1}$ |
| 0 | 1.19 | 0.05 | 0.20 | 0.60 | 0.76 | 0.12 |
| 30 | 0.98 | 0.54 | 0.21 | 0.76 | 0.82 | 0.06 |
| 60 | 1.34 | 0.42 | 0.24 | 0.95 | 0.65 | 0.13 |
| 90 | 1.36 | 0.42 | 0.29 | 0.95 | 0.66 | 0.08 |
| **Mean** | **1.22** | **0.48** | **0.24** | **0.77** | **0.72** | **0.10** |
| **S.E.** | **0.10** | **0.04** | **0.02** | **0.08** | **4.77** | **0.02** |
| **CV** | **14.4** | **15.0** | **17.2** | **18.7** | **11.4** | **33.9** |

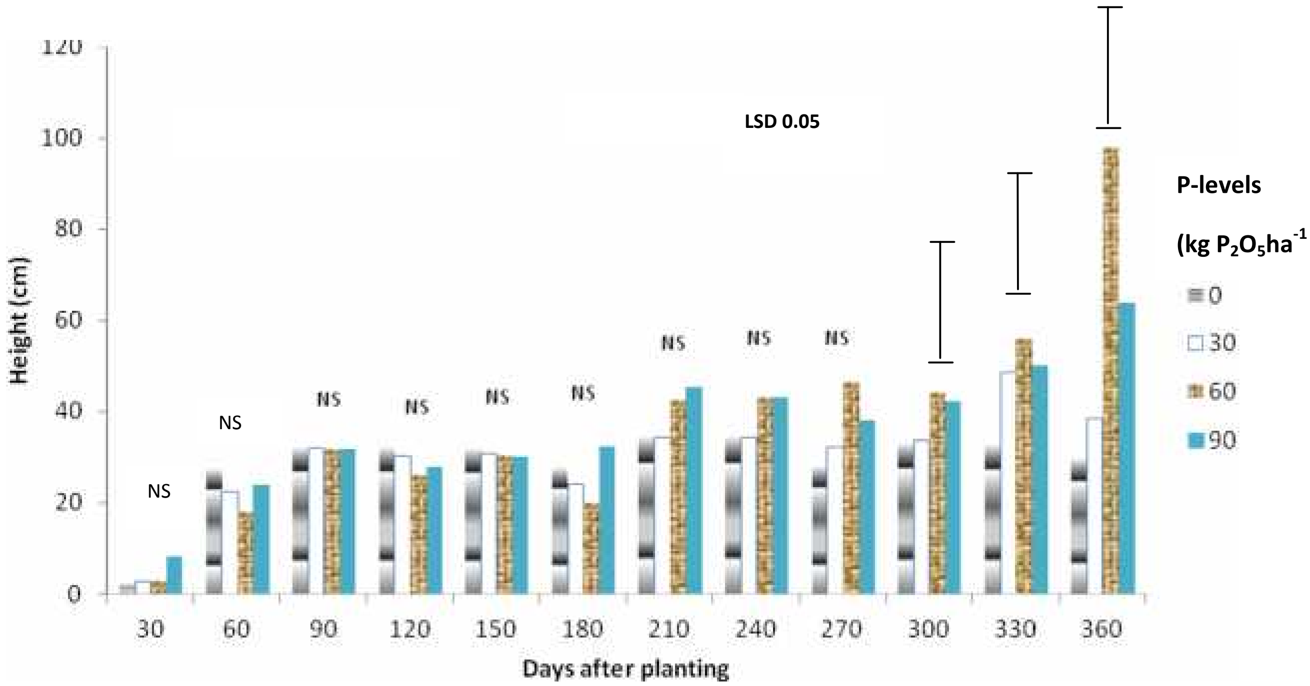


**Figure 4: Effects of levels of phosphorous on the height of rubber saplings in the greenhouse**

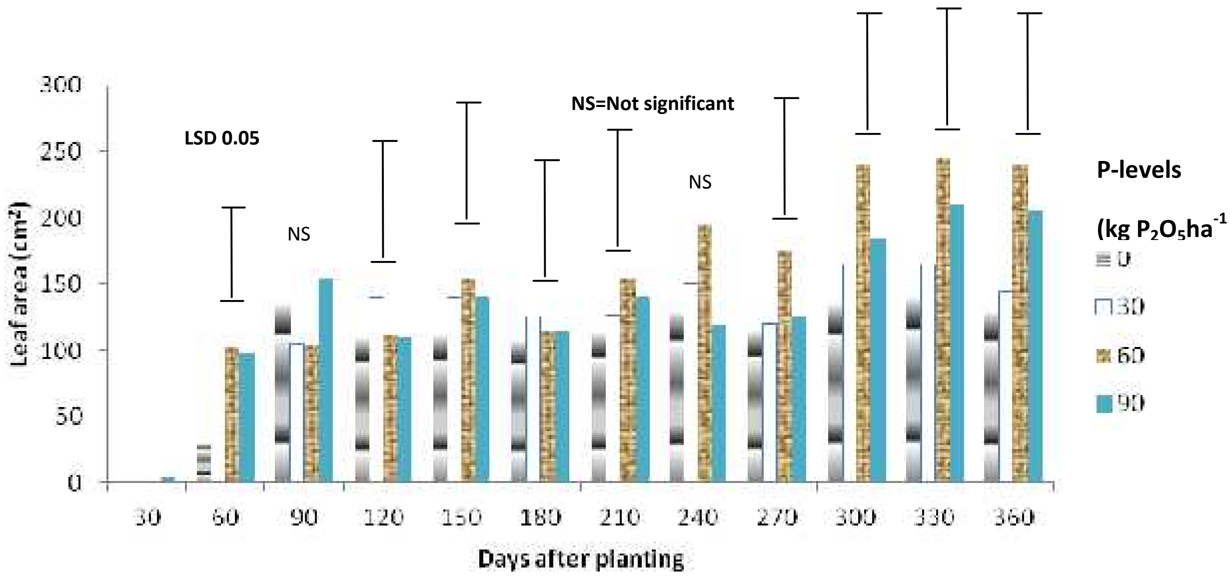


**Figure 5: Effects of levels of phosphorous on the leaf area of rubber saplings in the greenhouse**

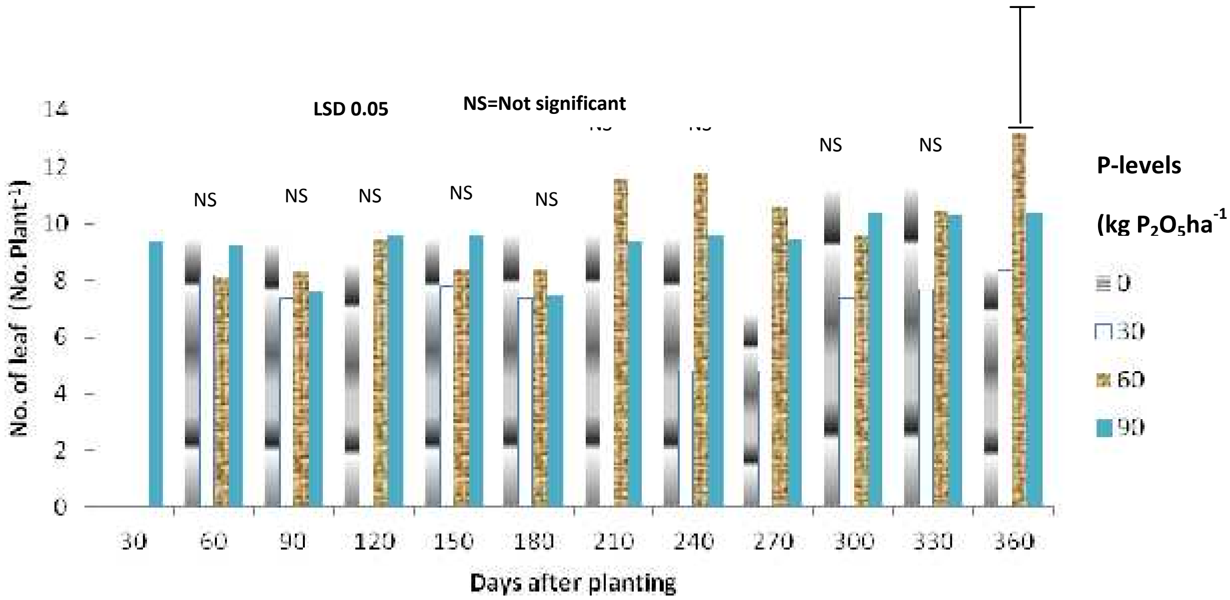


**Figure 6: Effects of levels of phosphorous on number leaf of rubber saplings in the greenhouse**

## DISICUSSION

The changes in the soil pH did not follow a definite pattern, which suggest that the different levels of P application to the soil had no effect on the pH of the soil, rather, it was the pH of the soil that influenced the availability of native and applied P as earlier reported by Idoko *et al*., (2006) and Tisdall and Nelson (1996). The gradual build-up of organic carbon from a mean of 7.0 g kg-1 soil at 30 DAP to 33.0 g kg -1 at 360 DAP in the soil is attributed to the addition of leaf litter during the period. Woomer *et al*., (1994) reported that crop residues might provide a significant organic input, and therefore could reduce soil carbon loss in tropical cropping systems. Decomposition of dead roots within the closed system of the poly bag soil might also have led to the increased organic carbon observed in the soil. Total N in the soil followed the same trend as observed for organic carbon. The build-up of N in the greenhouse soil was due to the litter and dead roots decomposition and the urea fertilizer applied to the poly bag soils.

The response of rubber saplings to P fertilizer application at all levels were gradual except at the 0 kg $P_2O_5$ ha$^{-1}$ level, where rubber saplings maintained the highest growth characteristics up to 180 DAP. This was attributable to the conversion of applied-P into less available forms. Steele (1976) reported that there was usually a rapid adsorption of P on particle surfaces when P is applied to soils. The gradual uptake of P by rubber saplings could also be due to the low mobility of P in the soils. Thus, at 360 DAP P-uptake by rubber saplings at the four levels of P in the greenhouse were in the order 60 kg $P_2O_5$ ha$^{-1}$ > 90 kg $P_2O_5$ ha$^{-1}$ > 30 kg $P_2O_5$ ha$^{-1}$ > 0 kg $P_2O_5$ ha$^{-1}$. Nutrient concentration of rubber saplings' leaves showed that Ca and Mg contents were influenced by the different P levels. Mean percentage Mg were 0.20, 0.21, 0.24 and 0.29 percent in rubber leaf, while the mean percentage Ca were 0.60, 0.76, 0.95 and 0.95 percent for P applied at 0, 30, 60 and 90 kg $P_2O_5$ ha$^{-1}$ respectively. This was as a result of some synergistic effects. Onuwaje (1982) observed that significant N/K and P/K interactions, on growth response of rubber saplings were an indication that, the effect of K depended on the presence of N or P, and also that N/K interaction had a synergistic relationship in the nutrition of rubber. While P/K interaction was the result of the domineering effect of P on the seedlings. This result agreed with the findings at the Rubber

Research Institute of Malaysia on rubber nutrition and latex yield (RRIM, 1971). They reported that P application raised P and Ca levels and lowered those of Ca and Mg and Mg/P ratios. The high contents of P, the low Mg/P ratio and Mg + Ca/P ratio led to good latex stability, faster flow rates and increased yield. Ruer (1966) reported a similar observation for oil palm.

## CONCLUSION

- The optimum P nutrient requirement for growth of rubber sapling in the green house was 60kg$P_2O_5$/ha. However further work need to be carried out in the field to test the effect of this rate on the growth and development of rubber sapling on acid soils of Southern Nigeria. .

## REFERENCES


Guha, M.M. 1975. Fertilizer response from mature rubber in Liberia, *Proceedings of International Rubber Conference*, Kuala Lumpur. pp. 108 –121.

Guha, M.M. and Yeow, K.H. 1966. Content of major nutrients in rubber growing soils of Malaysia, *Proceedings of the 2nd Malaysian Soil Conference.* Kuala Lumpur. pp. 171.

Idoko, S.O., Orimoloye, J.R., Uzu, F.O., Orimoloye, V.I. and Ugwa, I.K. 2006. Effects of rock phosphate and indigenous mycorrhizal fungi on cocoyam intercropped with matured rubber plantation. *Proceedings of the International Rubber Conference,* Vietnam. 30:236 – 245.

Kalam, M.A., Amma, M.K., Punnoose, K.I.P. and Potty, S.N. 1980. Effect of fertilizer application on growth and content of some important *Hevea* clones, *Rubber Board (India) Bulletin* 16:19 – 30.

Mokwunye, U. and Bationo, A. 2002. Meeting the phosphorous needs of the soils and crops of West Africa: The role of indigenous phosphate rocks. In: *Integrated Nutrient Management in Sub-Sahran-Africa* B. Vankuwe, J. Diels, N. Sanging and R. Merckx (eds) CAB 2002.

Onuwaje, O.U. 1983. Yield response of rubber *Hevea brasiliensis* to fertilizers on an ultisols in Nigeria. *Fertilizer Research* 4:357 – 360.

Onuwaje, O.U. and Uzu, F.O. 1982. Growth response of rubber seedlings to N.P.K. fertilizer. *Fertilizer Research* 3:169 – 175.

Osedeke, V.E., Asawalam, D.O.K., Kamalu, O.J. and Ugwa, I.K. 1993. Phosphorous sorption characteristics of some soils of the rubber belt of Nigeria.. *Communication in Soil Science and Analysis* 24(13 & 14):1733 – 1743.

Owen, F. 1974. Retention of phosphorous by Malaysian soil types. *Journal of Rubber Research Institute of Malaysia* 12:16 – 20.

RRIM (Rubber Research Institute of Malaysia), 1954. Mycorrhyza in *Hevea*. *Planters Bulletin*, 12:120 - 128.

RRIM (Rubber Research Institute of Malaysia), 1971. Nutrients and Rubber. *Planters Bulletin*, 114:127.

Ruer, P. 1966. Relation entire facteurs climatiques et nutrition mineral choz le Palmier a huile. *Oliqgineus* 21:143 – 148.

Shorrocks, V.M. 1964. Mineral deficiencies in *Hevea* and associated cover plants, *Rubber Research Institute of Malaysia Conference.* Pp. 18 – 22.

Steele, K.W. 1976. Effects of added P on the availability and forms of P present in two soils of Manawatu-Ramgitikei sand country. *New Zealand journal of Agricultural Research* 19:443 – 9.

Tisdall, S.L. and Nelson, W.L. 1996. *Soil Fertility and Fertilizer* Macmillan Company New York. pp. 209 – 211.

Woomer, P.L., Martins, A., Albrecht, A.,. Resck and H.W. Scharpensecel. 1994. The importance and management of soil organic in the tropics. In*: The Biological Management of Tropical Soil fertility* P.L. Woomer and Swift, M.J. (eds) 1994 Wiley-Sayce Publication pp. 47 – 79.