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Influence of climatic factors on soil reaction, nutrient application and yield outputs of oil palm

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Abstract

A study of the influence of Climatic factors on soil reaction, nutrient application and yield of oil palm in soils of oil palm belts (Edo State) in Nigeria was carried out in NIFOR (Nigeria Institute for Oil palm Research). The study compares oil palm fresh fruit bunches weight harvested on soils of the main station of the Institute and those from two oil palm estates on *Typic/rhodic paleudults* soil with climatic parameters such as solar radiation, rainfall and sunshine intensities, relative humidity, and temperature within past thirty years. Info-nutrient application data on recent fertilizer requirements for oil palm was arrived at from several fertilizer trials that were conducted in the Institute main-station and the two private oil palm estates (Okomu and Presco oil palm plantations). These were used in the various tables of correlations, which ranges from 0.45-4.5 kg palm-1, for macronutrient only. The Oil palm requirements of major fertilizers in oil palm belts of the South and marginal areas of Nigeria according to National Fertilizer Regulation Commission are given as follows; North Central areas requirement is Sulphate of Ammonia, 21.5-24.9 kg ha-1; Edo-Delta areas requirement is MOP, 90 kg ha-1mature and NK, 30 kg ha-1young at 20; 0; 20. While in the South Eastern states NK, 40 kg ha-1 mature at 20: 0: 20 and NK, 1: 1: 0.5 (N K + Ca, Mg, SO4 in 1: 1: 0.5). These were rates recommended and used for Oil palm in the 1960s to early 80s. Due to constant changes in weather resulting in climate change, fertilizer requirements and rates of application are being revisited based on current fertilizer trials conducted. A number of trials in this regard states as low as 0.45 kg/palm to as high as 4.5 kg/palm for different range of fertilizers since 1980 till date, even with the improved high yielding, early maturing and disease tolerant popularized Elite Hybrid Tenera known as the Extension Work Seed (EWS) by N.I.F.O.R.

Keywords: Climatic factors, Soil reaction, Nutrient, Oil Palm, Tenera.

INTRODUCTION

The impart of current global climate change in Agriculture is not restricted to atmospheric alteration in temperature and rainfall intensities rather has crept into soil nutrients status resulting in depletion and oil palm output decline. Similarly the nutrient pool in a field can be estimated as the amount of nutrient gained by the standing plants and the quantity of it applied to the soil less the amount lost by leaching, erosion, evaporation and plant removal processes (Henson et al, 2007). Experiments conducted by plant and Soil nutritionist in Nigeria Institute for Oil palm Research and Universities in Nigeria have shown that the quantity of nutrient element applied to a standing crop does not solely at anytime justifies the yield emanating from the field (NAR,1997). Reasons are partly due to environmental incursions that are traceable to climate changes on soil properties (EPA, 2012). Foster (1986) added that it might be due to yet unidentified complex interaction between the fertilizer requirements by oil palm stand, the micro environment in which the palm exists and the nutrients applied to the field. Hartley (1979) reviewed an early input to the oil palm development, when he added that unimproved variety of

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planting materials are serious setback to yield outputs from the industry. Hence the discovery and emergence of the popularized elite hybrid tenera variety and the subsequent use of the Extension Work Seed (EWS) in the institute was aimed at solving this problem permanently. In NIFOR, Nigeria to be precise the limitation of soil testing and era for examination of the soil for presence or absence of a single nutrient element for oil palm growth should be considered inadequate. This is consequent on the effects of climate change that is advancing acute soil problems to the industry these include drastic increases in rainfall intensity and duration leading to flooding. (NOAA, 2011). Scientist and program leaders in the soil and environmental industry reported that climate change is likely to affect agriculture and the oil palm industry in the short run in areas of alteration in timing of seed planting and nutrient application, decline in Organic decay and nutrient status, others are the likely alteration in soil testing results in the long run (Maclead, 2005, GGMPCM, 2006). This however had spur scientists in NIFOR to become pro-active being aware early enough; that the oil palm requires a collaboration of some basic nutrient elements for growth and yield performance. This gave rise to a fertilizer programmed that was initiated early in 1960 to address some basic oil palm nutrient deficiency problems in fields planted to oil palms in the country. Experiments were conducted in various ecological zones with climatic peculiarities and soil characterization to fertilizer requirement and the effects of trace elements to the oil palm growth and development. These experiments were meant to cover the oil palm growing belts and to further examined the rate of application of these fertilizers starting from as low as 0.45kg/palm/yr to as high as 5.6kg/palm/yr (Omoti, et al., 1986). Apart from the fertilizer requirements by oil palm investigated, experiments were conducted at various times in the institute to ascertain forms of fertilizers and their effects on the oil palm growth and yield in various established oil palm estates apart from those done at the main station. (These experiments could be found in NIFOR ninth Annual Report, 1960/61) and (NIFOR ninth Annual Report, 1960/61; NIFOR year report, 2001-2008). It may be true to say that efforts had been thoroughly expended as was required, warranting scientist in the institute to digressed into experiments to determine uptake and responses by oil palm to various nutrients and their sources. Results of findings across the country were compared to a sister oil palm producing nation Malaysia; conducting experiments on an inland soil in Malaysia. Meunier, (1989) gave a different response to various sources of nitrogen application in an oil palm experiment across three countries namely; Brazil, Colombia and Central America. In a similar experiment under Nigeria environment, several studies to determine the effects of different nutrient elements on oil palm and forms of nutrients available in different parent materials have been concluded and several others are on going in Nigeria Institute for Oil palm Research, (Okpamen, 2009, Okpamen et al, 2011). Research in oil palm growth performances and development has further advanced into info-crop nutrient modeling to meet with the current demand in oil palm growing nations of the world. To this end, a data management and transformation project on nutrient and moisture demand of Oil palm is on going in the institute in Nigeria this was a follow up to advancing climate changes reported by NRC, (2010) on soil and atmospheric moisture dearth in the long run. It was also asserted by Foong, (1993) that irregular pattern of factors of climate with ages of palms in soils of Malaysia, and deep drainage (DD) losses are linked with percentage of rainfall effects at different sites and plantations, reiterating the negative impart of climate change on Malaysia agriculture. Stressing, the impact of climate change is likely to become the major factor of nutrient loss in oil palm management in the future, Hence a pragmatic approach to examining the influence posed by climatic factors on Soil reaction, nutrient application and Oil palm Output in the area become very important.

MATERIALS AND METHODS

Study Area and Soil Characterization

This study was carried out in NIFOR, an agricultural research institute located in Edo State, Southern Nigeria in the heart of the oil palm belt region. It is on latitude $06^{0}33^{1}$N and longitude $05^{0}37^{1}$E and on altitude 149.4m. And the study reviewed information on the effects of climatic factors on Soil reaction, Oil palm nutrient application on Soils of the zone and yield turnover as it affects oil palm on soils in the main station, Nigeria Institute For Oil Research on *Typic/rhodic paleudults*, Presco and Okomu Oil palm plantations on *Rhodic paleudults* and *Rhodic paleudalfs (*FAO/UNESCO, 1994) soils of Edo state. Influences of some climatic parameters were used to assess the effects of climate change on soil reaction and yields of FFB of oil palm in the institute main station and two oil palm estates within the same climatic zones sequel to long history of application of fertilizers. Age of palms investigated fall within 3-12years, Table 1, 2 and 3 represent records of soil ph, K and Mg fertilizers application to the soils in four different fields or plantations. Yields of FFB harvested are compared with the climatic variables; such as sunshine, relative humidity, temperature and solar radiation. Table 1 represent K and Mg application in four levels with K; 1.5, 2.5, 3.5 and 4.5 (Kg) and Mg; 0.0, 0.8, 1.7, 2.6 (Kg). Table 2 represents also the records of soil ph with K and Mg applications, K and Mg are applied in five levels with K; 0.0, 1.5, 2.5, 3.5, 4.5 (Kg) while Mg; 0.0, 0.8, 1.7, 2.6, 3.0 (Kg). Table 3 represents effects of Mg, Soil ph and climatic elements on FFB weights harvested. Mg was applied in three levels; 0.8, 1.7 and 2.6 (Kg). Info-nutrient

Table 1. Influence of Climatic Elements on Soil pH, K, Mg Fertilizers Rates and Oil Palm Bunch Weight (Wt/ha) 148palms/ha in Fields of NIFOR (main station)

soil pH	K (kg/Palm)	Mg (kg/Palm)	Bunch wt (kg)	Rainfall (mm)	S/s days/yr	R/H%/yr	Temp ℃/yr	Solar R/yr
5.19	1.50	0.00	12,140	2135.80	54.20	883.20	386.40	4446.90
5.19	1.50	0.80	9,887	2135.80	54.20	883.20	386.40	4446.90
5.19	1.50	1.70	14,383	2135.80	54.20	883.20	386.40	4446.90
5.19	1.50	2.60	10,192	2135.80	54.20	883.20	386.40	4446.90
5.23	2.50	0.00	13,402	1703.00	53.70	903.80	386.40	4405.80
5.23	2.50	0.80	12,469	1703.00	53.70	903.80	386.40	4405.80
5.23	2.50	1.70	15,596	1703.00	53.70	903.80	386.40	4405.80
5.23	2.50	2.60	15,178	1703.00	53.70	903.80	386.40	4405.80
5.34	3.50	0.00	11,014	1928.80	45.50	887.80	383.50	4353.60
5.34	3.50	0.80	12,839	1928.80	45.50	887.80	383.50	4353.60
5.34	3.50	1.70	10,481	1928.80	45.50	887.80	383.50	4353.60
5.34	3.50	2.60	10,360	1928.80	45.50	887.80	383.50	4353.60
5.32	4.50	0.00	16,819	1595.00	57.00	864.00	381.90	4970.00
5.32	4.50	0.80	12,821	1595.00	57.00	8640.00	381.90	4970.00
5.32	4.50	1.70	15,017	1595.00	57.00	864.00	381.90	4970.00
5.32	4.50	2.60	10,360	1595.00	57.00	864.00	381.90	4970.00

NIFOR Annual Report, 2005.Nigeria ,R /H - relative humidity, S/s - Sunshine, R - radiation, wt - weight, mm - millimeters, yr - year, K -potassium, Mg - magnesium, ^{0}C - degree Celsius,% - percentage.

Table 2. Influence of Climatic Elements on Soil pH, K, Mg Fertilizers Rates and Oil Palm Bunch Number (148palms/ha) in Fields of NIFOR (main station)

Soil pH	K (kg/Palm)	Mg (kg/Palm)	Bunch wt (kg)	Rainfall (mm)	S/s days/yr	R/H%/yr	Temp ℃/yr	Solar R/yr
5.19	1.50	0.00	1,140.00	2135.80	54.20	883.20	386.40	4446.90
5.19	1.50	0.80	1,074.00	2135.80	54.20	883.20	386.40	4446.90
5.19	1.50	1.70	890.00	2135.80	54.20	883.20	386.40	4446.90
5.19	1.50	2.60	1,184.00	2135.80	54.20	883.20	386.40	4446.90
5.19	1.50	3.00	765.00	2135.80	54.20	883.20	386.40	4446.90
5.23	2.50	0.00	981.00	1703.00	53.70	903.80	386.40	4405.80
5.23	2.50	0.80	1,072.00	1703.00	53.70	903.80	386.40	4405.80
5.23	2.50	1.70	1,013.00	1703.00	53.70	903.800	386.40	4405.80
5.23	2.50	2.60	1,228.00	1703.00	53.70	903.80	386.40	4405.80
5.23	2.50	3.00	906.00	1703.00	53.70	903.80	386.40	4405.80
5.34	3.50	0.00	880.00	1928.80	45.50	887.80	383.50	4335.60
5.34	3.50	0.80	839.00	1928.80	45.50	887.80	383.50	4335.60
5.34	3.50	1.70	1,065.00	1928.80	45.50	887.80	383.50	4335.60
5.34	3.50	2.60	885.00	1928.80	45.50	887.80	383.50	4335.60
5.34	3.50	3.00	1,313.00	1928.80	45.50	887.80	383.50	4335.60
5.32	4.50	0.00	1,025.00	1595.00	57.00	864.00	381.90	4970.00
5.32	4.50	0.80	1,339.00	1595.00	57.00	864.00	381.90	4970.00
5.32	4.50	1.70	1,068.00	1595.00	57.00	864.00	381.900	4970.00
5.32	4.50	2.60	1,256.00	1595.00	57.00	864.00	381.90	4970.00
5.32	4.50	3.00	830.00	1595.00	57.00	864.00	381.90	4970.00

NIFOR Annual Report, 2005.Nigeria, AR /H - average relative humidity, S/s - Sunshine, R - radiation, wt - weight, mm - millimeters, yr - year, K - Potassium, Mg - magnesium, ^{0}C - degree Celsius,% - percentage.

Table 3. Influence of Climatic Elements on Soil pH, K, Mg Fertilizers Rates and Oil Palm Single Bunch Weight (148palms/ha) in Fields of NIFOR (main station)

Soil pH	Mg (kg/Palm)	S/FFB wt (kg/palm)	Rainfall (mm)	S/s (days/yr)	R/H (%/yr)	Temp (°C/yr)
5.19	0.80	12.52	2135.80	54.20	883.20	386.40
5.19	1.70	12.48	1703.00	54.20	883.20	386.40
5.19	2.60	12.43	1928.80	54.20	883.20	386.40
5.23	0.80	12.82	1703.00	53.70	903.80	386.40
5.23	1.70	12.59	1703.00	53.70	903.80	386.40
5.23	2.60	13.70	1703.00	53.70	903.80	386.40
5.34	0.80	12.82	1928.80	45.50	887.80	383.50
5.34	1.70	12.59	1928.80	45.50	887.80	383.50
5.34	2.60	13.70	1928.80	45.50	887.80	383.50
5.32	0.80	15.89	1595.00	57.00	864.00	381.90
5.32	1.70	15.98	1595.00	57.00	864.00	381.90
5.32	2.60	16.64	1595.00	57.00	864.00	381.90
5.43	0.80	17.40	1972.90	45.80	901.10	386.40
5.43	1.70	17.53	1972.90	45.80	901.10	386.40
5.43	2.60	18.90	1972.90	45.80	901.10	386.40
5.01	0.80	16.95	2036.50	70.40	835.50	369.40
5.01	1.70	18.07	2036.50	70.40	835.50	369.40
5.01	2.60	16.90	2036.50	70.40	835.50	369.40
4.73	0.80	20.85	1648.60	59.00	844.50	393.80
4.73	1.70	20.88	1648.60	59.00	844.50	393.80
4.73	2.60	20.84	1648.60	59.00	844.50	393.80

and yield data were sourced from both past and present yield records as documented in the Institute's library while climatic studies were carried out in the institute climatologic research unit. This is a pragmatic assessment of climatic study on soil inputs as it affects yield of oil palm within the ecological zone or the oil palm belts of Nigeria.

Statistical Analysis of Data

The data on rainfall, sunshine, solar radiation, humidity and yield were collated for statistical analysis and correlation of climatic factors and parameters whose influence imparted on the work were carried out with SPSS version 16 statistical package to assess possible relationships with soil nutrient uptake and nutrient applications.

RESULTS AND DISCUSSION

The influence of rainfall, sunshine, relative humidity, temperature and solar radiation were used to examine the probable effects climate change would have on soil reaction, nutrient application rates and yields of Fresh Fruit Bunches of oil palm in NIFOR main station and in two oil palm estates within the same climatic zones. Table 1 and 2 represent records of soil pH, K and Mg fertilizer application to the soils in four different fields or plantations, with yields of FFB harvested compared in weights and numbers with climatic variables; while table 3 represents result from seven fields.

Impact Assessment of K and Mg Fertilizer Trial

Table 1 explains the effects of two treatments K and Mg on the number of fresh fruit bunch harvested in the experimental year 2006 in some fields in NIFOR. It is a four years impact assessment of K and Mg fertilizer trial results are computed statistically in Table 1 above, the magnesium fertilizer was applied at a constant rate of 0.0 to 2.6 kg/palm while the potassium fertilizer was applied in varying amounts ranging from 1.5 to 4.5 kg/palm.

The effects of potassium and magnesium fertilizers on fresh fruit bunch weight and numbers were determined using co-efficient of correlations as the statistical tool for comparison.

Investigation and results showed a sharp response of K at 4.0kg/palm to fresh fruit bunch weight than Mg, while the combination of both fertilizers had no significant mean response on fresh fruit bunch weight in the experiment (r = -0.165, 0.269) The results show influences of climatic

elements on soil reactions, nutrient application rate (K and Mg) and FFB weights and numbers. Results revealed that there were significant relationship in the yields response to sunshine and solar radiation r=0.887 and 0.691 respectively. While a negative significant linearity was established with rainfall amounts across the periods investigated. Most other elements did not correlated significantly with yield especially the soil reaction, relative humidity, applied nutrients and temperature.

While a negative significant linearity was established with rainfall amounts across the periods investigated. Most other elements did not correlated significantly with yield especially the soil reaction, relative humidity, applied nutrients and temperature. The effect of K and Mg on oil palm bunch weight in Kg/ha was investigated during the experimental year of 2005/2006 with the impression that the effects of Mg fertilizer was not significantly pronounced as that of K fertilizer. There was a corresponding increase in bunch weight as a total of 4.5kg application was made per palm, leading to an accumulated weight of 16,819kgwt/ha from the field see table1 above while a total of 1,025 to 1,339 bunches were harvested per hectare (Table 2.) The correlation of climatic variables of the environment with soil reaction and yield output from the study reported in Table 1, 2 and 3 reveals the following; yield of FFB in the experimental year did not correlate with soil properties such as soil ph, the K and Mg applied had no significant contribution to the yield within the period. However the following climatic factors did impacted positively on yield namely; sunshine, r = 0.887* and solar radiation, r= 0.691 while rainfall affected yield negatively but significantly at (r=-0.745). Average relative humidity and temperature revealed no significant effect on yield of FFB harvested.

The application of nutrients K and Mg on the soil in the experiments did not correlates with yield even at 0.01 and 0.05 respectively. ($r=0.269^{ns}$ and 0.268^{ns}). This findings is in line with Omoti et, al, (1986) which stated that experiments conducted by plant and Soil nutritionist in NIFOR have shown that the quantity of nutrient element applied to a standing crop does not solely at anytime justifies the yield emanating from the field adding that yield output is affected by interplay of soil and environmental factors. They also adduced managerial potentials available as being indispensible in the crop industry. However the correlation of nutrients with soil reaction gave a positive significant result on yield as K application correlates with soil ph effectively r=0.901, while Mg application was r=0.899 these factors did not correlate with climatic variables considered except temperature with significant positive correlation of r=0.608 In the study, rainfall which is one important determinant of the climate of the oil palm belt had significant negative correlation with yield of FFB harvested, meaning that rainfall effects on the oil palm might be positive only to the extent of affecting growth rate. It may also suggests that it is an equilibrating factor to optimizing the positive effects of both sunshine and solar radiation which were positively correlated with yield r= 0.887 and 0.691. From this finding it is true that sunshine and solar radiation are significant climatic factors to maximizing output of FFB in the rainfall belts. It has been proven that the oil palm would require more of sunshine and solar radiation to maintain optimal yield of FFB production.

CONCLUSION

The influence posed by the rapid changes in climatic elements in the Oil palm producing belts of Nigeria is currently an issue for most researchers in the industry today. Almost 90 percent of the factors impeding oil palm development in Nigeria are weather related and could only be addressed when all stakeholders in the research circle channel in their synergies towards ameliorating these snags from the industry. Thus correlation of soil inputs such as soil reactions, soil amendment levels and yields outputs from oil palm fields with some influencing weather parameters in the environment of the palm will probably throw some light to solving these problems. This work has conceptualized and bring to fore the relationship that exists between some basic climatic parameters and soil factors such as pH and fertilizer application to soil in NIFOR, Okomu and Presco plantations in Edo State, Nigeria. Establishing the that oil palm performance in terms of growth and yield is significantly dependent on Sunshine and solar radiation with the soil factors inexcusably tied to nutrient utilization by oil palm.

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