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THE TREND IN FERTILIZER CONSUMPTION AND ITS IMPACT ON CROP OUTPUTS IN NIGERIA

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ABSTRACT
The study analyzed the consumption trend of fertilizers (nitrogen, phosphorus, potassium and total/composite fertilizers) and examined its relationships with selected crop outputs from 1962 to 2019 in Nigeria. Time-series data were used and were sourced from the World Bank and Food and Agriculture Organization. The descriptive statistics, correlation analysis and Cobb Douglas production function were applied to analyze the data collected. The results revealed that fertilizer consumption over time exhibited a high level of volatility in Nigeria. The average consumption rate of 7.17 kg/ha for composite fertilizer was far below the minimum rate of 50kg/ha declared in Abuja in 2006 by African countries. Furthermore, the study established significant correlations between fertilizers and selected harvested land yields and crop outputs in the country. This implies that fertilizers can significantly regulate the outputs of crop enterprises in the country. The empirical results revealed that fertilizers were irrationally utilized in the majority of selected crop enterprises as their elasticities were either negative or greater than unity. Moreover, the decreasing return to scale was confirmed for each crop enterprise denoting decreasing contribution of fertilizer inputs to crop outputs growth in Nigeria. Based on the findings, it is recommended that the Nigeria government should work towards achieving the Abuja declaration on fertilizer use.

Keywords: Crops, Fertilizer, Nigeria Policy, Trend.

INTRODUCTION
The Agricultural sector in Sub Saharan Africa will continue to be a critical sector and essential instrument for sustainable development, rural poverty reduction and a reliable source of self-food sufficiency in the region (Akpan *et al.*, 2012, Mukasa *et al.*, 2017; FAO, 2017). However, the agricultural productivity in the region has not been able to sustain the regions' economy adequately and has increased poverty and widespread underdevelopment (Jayne *et al.*, 2021). Agricultural productivity growth in Sub-Saharan Africa lags behind that of other regions in the World and is well below the threshold required to achieve food security and poverty goals (Binswanger and Townsend, 2000; Pfister *et al.*, 2011; Vibeke *et al.*, 2020). Many farmers in the region face declining crop yields due to low productivity of production factors, which has adverse effects on the region's economic growth (Hassan *et al.*, 1998). A prominent constraint to higher productivity among farmers in the region is tailored to "soil infertility" related mainly to the low nutrient status of the soils and continuous cultivation without planned replenishment of depleted soil nutrients (Wanyama *et al.*, 2009). Increasing agricultural productivity in Sub Saharan Africa especially in Nigeria is an urgent necessity; and one of the fundamental ways of improving agricultural productivity is through the introduction

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and optimal use of improved agricultural technologies (Olukunle, 2013; Kolawole and Omobitan, 2014; Olomola and Nwafor 2018; Akpan *et al.*, 2019).

Fertilizer is one of the most powerful productivity-enhancing technologies that is expected to contribute to the upsurge in agricultural outputs and productivity in the sub-Saharan Africa (SSA) region (Akpan et al., 2012b, Akpan *et al.*, 2012c, Tonny and Swaibu, 2019). Contrary to the expectation, literature has provided evidence that Africa is yet to catch up with other developing regions in fertilizer consumption (kilograms per hectare of arable land) (Minde *et al*., 2008; Druilhe and Barreiro-Hurlé 2012; FAO, 2021). For instance, in Nigeria, Food and Agriculture Organization (FAO) (2020) and World Bank (2020) reports on fertilizer use intensity among Nigeria's farmers revealed the consumption rate of 19.74kg/ha in 2018 compared to 29.4 kg/ha, 72.8 kg/ha, 74.9kg/ha, 393.2kg/ha and 304.7kg/ha in Ghana, South Africa, Morocco, China and Brazil, respectively. The reports further revealed that the fertilizer use rate among farmers in Nigeria and other African countries was far below the 50 kg/ha minimum target set by the Abuja Declaration on Fertilizer for the African Green Revolution in 2006 and 200kg/ha recommended by FAO for the sub-Sahara African countries. According to FAO (2020), in the 2015–2019 period Africa represented over 3.5% of the global agricultural use for nitrogen and phosphorus-based fertilizers, and a little above 2 percent for potassium-based fertilizer. The report also added that the share for SSA is generally less than 1%. In 2002, the average intensity of fertilizer use in Sub-Saharan Africa was only 8 kg/ha of cultivated arable land, and this was far lower than what was obtainable in other developing regions of the World.

Nigeria's government has prioritized fertilizer use in several periods and developed measures to increase production and consumption capacities in a sustainable manner (Olomola, 2015; Saweda *et al.*, 2010; Gisaor and Gisaor 2018; Michael *et al.*, 2018). Besides, the country had enunciated and implemented several fertilizer policies and programmes to tackle the low utilization rate of fertilizer among arable crop farmers but has often yielded unsustainable outcomes (Ayoola and Ayoola 2016; Alabi and Adams, 2020). For instance, the fertilizer subsidies, the Growth Enhancement Support Scheme (GESS) and the use of Electronic Wallet (e-wallet) approach to distributing fertilizer to the farmers as well as the import substitution policies including privatization and commercialization policies of the government collectively did not have a long-lasting positive effect on the outputs of agricultural commodities. Correspondingly, the country experienced sluggish positive and unsustainable growth rates in crop outputs and the triggering of food insufficiency among the majority of Nigerians. The spilt over effect stretches to a continuous increase in food import demand with a huge financial burden on the country. Though the agricultural sector's productivity traditionally does not hinge solely on the use of fertilizer, several reports have indicated that chemical fertilizers are instrumental in improving crop yields in Asia, Europe, and North America, among other areas in the World.

However, experts have asserted that one of the ways to tackle the issue of food insecurity is to intensify agricultural production (Akpan *et al.*, 2015a; Akpan *et al.*, 2015b). Besides Morris *et al.* (2007) opined that the intensification of crop-based agriculture has been associated with a sharp increase in the use of chemical fertilizer. However, fertilizer intensification in Nigeria is far below the desired threshold needed for sustainable agricultural production (FAO, 2021). To reverse the declining trends, intensification through fertilizers and other land augmenting technologies are essential. Currently, the country is experiencing soil fertility crises (Adekunle *et al.*, 2017, Ande *et al.*, 2017; Yusuf and Olowoake, 2019). This condition primarily arose from increasing soil fragmentation induced by an increase in

population whereby farmlands cultivation are intensified without planned replenishment of the depleted nutrients; diminishing fallowing system where the soil is not sufficiently allowed to regenerate naturally, increasing deforestation and land/soil pollution arising from various activities of human as well as mounting population densities and inefficient/low coverage irrigation system (Tan *et al*., 2010; Akpan *et al*., 2017, Olarinre and Omonona, 2018; Akpan and Monday, 2021).

The need to intensify agricultural production in the country using fertilizer is obvious considering the rapid annual population growth rate (3 to 4% per annum), the dependence of the majority of the population (about 50 to 70% of the population) on agriculture, mounting poverty and unemployment rate among others (Akpan and Ebong, 2021). Developing a sound policy package to address this issue of fertilizer intensification calls for an assessment of the trend in fertilizer use and its relationship with crop outputs in Nigeria. Though at the farm level and employing cross-sectional data many authors have established a mixed relationship between fertilizer use and outputs of crop enterprises (Akpan *et al.*, 2010; Akpan *et al.*, 2012d, Yipu *et al.*, 2020; Dania *et al.*, 2021). However, currently, there is no empirical literature that addressed this issue using macro or time-series information in Nigeria. This is another approach that needs to be explored. Beckoned on these assertions, the study addressed three fundamental issues concerning fertilizer use in Nigeria: examine the trend in Nitrogen, phosphorus, potassium and composite/total fertilizers use in Nigeria; establish the relationship between fertilizer use and crop outputs and yields in Nigeria, and estimate and examined the production parameters of crop outputs with respect to fertilizers used in Nigeria. The study will provide information to update the existing related literature on fertilizer consumption and open up new areas for exploration on the issues of fertilizer use in Nigeria.

MATERIALS AND METHODS

The Study Area

The study was conducted in Nigeria. The country is situated on the Gulf of Guinea in sub-Saharan Africa. It lies between 4^0 and 14^0 north of the equator and between longitude 3^0 and 15^0 east of Greenwich. The country has a total land area of about 923,769 km^2 (98.3 million hectares) with 853 km of coastline along the northern edge of the Gulf of Guinea and a population of around 200 million (National Population Commission, 2020). The country is gifted with significant agricultural, mineral, marine and forest resources. Its multiple vegetation zones, plentiful rain, surface water and underground water resources and moderate climatic extremes allow for the production of diverse food, tree and cash crops. Over 60 per cent of the population is involved in the production of food crops such as cassava, maize, rice, yams, various beans and legumes, sorghum, ginger, onions, tomatoes, melons and vegetables. Also, fishery, aquaculture and livestock production such as poultry, goat, sheep, pigs and cattle flourished very well in all regions of the country. The main cash crops are cocoa, cotton, groundnuts, palm oil and rubber (Federal Ministry of Environment, 2021).

Data source

Secondary data were used in the study. The data were sourced from the World Bank and Food and Agricultural Organization (FAO) as well as the Central Bank of Nigeria. Data covered the period from 1961 to 2019. The choice of the period was based on the availability of data.

Analytical/Theoretical Framework

The study adopted a simple framework based on the theory of production. Generally, the theory of production depicts the unilateral relationship between the physical outputs of firm

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and physical inputs or factors of production. Explicitly a two-input production function can be expressed as thus:

$$Q = f(K, L) \quad \ldots (1)$$

where; Q is output and K and L are capital and labour inputs, respectively. The volume of Q of a firm at any time depends on the quantities of K and L that are utilized by that firm. Assuming a constant return to scale, the Cobb Douglas production was specified and production parameters estimated. The parameters were used to study the relationship between output and inputs specified.

Models Specification

a) To calculate the growth rate in fertilizer consumption over the years, a linear growth rate specification was used:

$$GT_t = \frac{(X_{t+1} - X_t)}{(X_t)} * 100 \quad \ldots (2)$$

where; 'GR_t' is the growth rate at period t and X's are annual fertilizer consumption.

b) To establish relationships between fertilizer, use and crop outputs and yields, a Pearson correlation analysis was carried out. The formula is described below in equation 3:

$$r_{xy} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}} \quad \ldots (3)$$

where; "r_{xy}" is the Pearson correlation coefficient that shows the linear and symmetric relationship between variable X and Y. The correlation coefficient ranges from -1 (strong negative relationship) to +1 (strong positive relationship).

c) To estimate the production parameters of selected crop enterprises with respect to fertilizers use, a Cobb Douglas production function was specified as in equation 4:

$$CP_t = b_o + b_1 NT_t + b_2 PH_t + b_3 KO_t + b_4 TF_t + u_t \quad \ldots (4)$$

Note, variables are expressed in logarithm.

where;

CP_t = is the output of crops (tons)

NT_t = Annual average Nitrogen-based fertilizer consumed in kg/ha

PH_t = Annual average phosphate-based fertilizer consumed in kg/ha

KO_t = Annual average potash-based fertilizer consumed in kg/ha

TF_t = Annual average total fertilizer consumed in kg/ha

RESULTS AND DISCUSSION

The descriptive statistics of variables used in the study are presented in Table1. The result showed a high degree of volatility in the consumption of all forms of fertilizers in the country. For instance, about 80.78%, 89.12%, 88.64% and 79.47% coefficients of variability were observed in nitrogen, phosphorus and potassium-based fertilizers as well as the total fertilizer respectively in the period used in the study. This implies that the rate of consumption of these fertilizers varies across time significantly and the variations were relatively similar within the specified period. The distribution of the fertilizers consumption marginally skewed to the right side of the normal curve, implying that in most periods, fertilizer use among farmers increase marginally but in a persistent manner.

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Table 1: The descriptive statistics of variables

Variable	Min.	Max.	Mean	Std. deviation	Coefficient of variability	Skewness
Nitrogen Fertilizer in kg/ha	0.0100	11.190	3.4776	2.8091	0.80776	0.72748
Phosphate fertilizer in kg/ha	0.0300	4.400	1.4495	1.2918	0.89121	0.72877
Potash K2O in kg/ha	0.0100	3.360	1.1088	0.9828	0.88638	0.79138
Total Fertilizer	0.0589	21.060	7.0483	5.6010	0.79466	0.58020

Source: Computed by the authors and data from World Bank.

Among the single nutrient-based fertilizers, nitrogen-based fertilizer was the most consumed among farmers in the country. Average consumption rates of 3.48 kg/ha, 1.45 kg/ha and 1.11 kg/ha were obtained for nitrogen, phosphate and potash-based fertilizer respectively. However, about 7.05 kg/ha of fertilizer consumption was found for the total fertilizer consumption in the country for the period under consideration. The data presented showed gross inadequate fertilizer consumption among farmers in the country.

The Growth Rates and Trends in Fertilizer Consumption in Nigeria

The linear growth rate of fertilizer consumption in Nigeria is shown in Table 2 and Table 3. The study period was divided into the range of ten years for easy analyses. The result revealed that the rate of fertilizer consumption was low from the early 1960s' to 1970. This was the period of early independence and commercial agriculture was evolving. During this period government policies on fertilizer consumption were rooted in the regional governments. The country mineral fertilizer consumption was limited to a few imported quantities mostly to areas with export potentials. The fertilizer consumption during this period assumed a sluggish progressive growth rate that averaged at 0.19 kg/ha at a 21.21% growth rate. As shown in figure 1, the period 1962 to 1970 witnessed the lowest trend in mineral fertilizer consumption or demand in Nigeria. The result showed that both single nutrient and composite fertilizers demand was low and assumed a similar trend within the period.

Table 2: Linear growth rates of Fertilizer consumption in Nigeria

	1962 – 1970		1971 – 1980		1981 – 1990		1991 – 2000	
	Av. qty. (kg/ha)	Growth rate (%)	Av. qty. (kg/ha)	Growth rate (%)	Av. qty. (kg/ha)	Growth rate (%)	Av. qty. (kg/ha)	Growth rate (%)
Nitrogen fertilizer	0.08	36.98	1.33	70.17	4.91	6.57	3.92	-6.49
Phosphate fertilizer	0.08	21.76	0.84	46.19	3.27	5.55	1.73	-2.51
Potash fertilizer	0.02	29.63	0.43	52.13	2.10	14.35	1.59	-6.32
Total fertilizer	0.19	21.21	3.01	54.27	11.87	6.91	8.37	-7.11

Source: Computed by the authors and data from World Bank.

The second era ranged from 1971-1980. This period was characterized by a massive accumulation of foreign reserves following crude oil exploitation. The import substitution policy was introduced and implemented in the country during this period. Emphasis was channeled to the establishment of fertilizer production companies to enhance domestic production and reduce the importation of fertilizer. There was remarkable improvement in fertilizer consumption as nitrogen, phosphorus and potassium, as well as composite fertilizers, witnessed an increase in both average quantity use and the corresponding growth rate. In this period, the average quantity of fertilizer uses and growth rate increase by 3.01 kg/ha and 54.27%, respectively. The result is consistent with the gradual shooting of the fertilizer trends

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in Figure 1. The trend in the second era showed the dominancy of nitrogen fertilizer consumption over other single-nutrient fertilizers. However, the average fertilizer consumption was low compared to other African countries and the recommended rate for the sub-Saharan countries.

The third and the fourth dispensations covered the periods 1981 to 1990 and 1991 to 2000, respectively. This period encompasses the pre-structural adjustment policies, structural adjustment and post-structural adjustment policies. The key policy target of this era on fertilizer sub-sector was the introduction of privatization and commercialization of fertilizer companies owned by the Nigerian government. The fertilizer subsidy programme was birthed during this era and various tariff policies were introduced to regulate fertilizer importation and encourage domestic production. The implementation of these policies was faulted following unsustainable growth rates in fertilizer consumption in the country. For instance, nitrogen-based fertilizer declines from 4.91kg/ha in the 1981 – 1990 period to 3.92kg/ha in the 1991 – 2000 period. Similarly, the composite fertilizer consumption shrinks from 11.87kg/ha in 1981 – 1990 to 8.37kg/ha in 1991 – 2000. Similar trends were replicated for the phosphate and potash-based fertilizers in the country. The problem of low fertilizer consumption was still a topical issue in the agricultural sector during these periods.

Table 3: Linear growth rates of Fertilizer consumption in Nigeria

	2001 – 2010		**2011 – 2019**		**Overall**	
	Av. qty. (kg/ha)	**Growth rate (%)**	**Av. qty. (kg/ha)**	**Growth rate (%)**	**Av. qty. (kg/ha)**	**Growth rate (%)**
Nitrogen fertilizer	3.75	26.68	7.26	11.40	3.54	24.22
Phosphate fertilizer	0.94	31.05	1.87	24.45	1.47	21.01
Potash fertilizer	0.93	22.25	1.64	30.67	1.13	23.56
Total fertilizer	6.67	**20.34**	12.76	11.20	7.17	17.86

Source: Computed by the authors and data from World Bank.

The periods 2001-2010 and 2011-2019 are the post SAP policies era. During this period, the government laid most emphasis on an increase in private investments in the fertilizer sub-sector. The liberalization of the sub-sector and provision of incentives were the major focus of the government. In 2019, the National Fertilizer Quality Control Act was enacted to safeguard and protect the interest of the entire Fertilizer value chain players such as manufacturers, producers, blenders, importers, distributors and the end-user farmers in Nigeria. Poor implementation of fertilizer policies and volatility in macroeconomic fundamentals among others were the factors hindering the increase in the fertilizer consumption rate in the country. The average single nutrient fertilizer and the composite fertilizer consumption rate shrink in the period 2001-2010 compared to the previous period.

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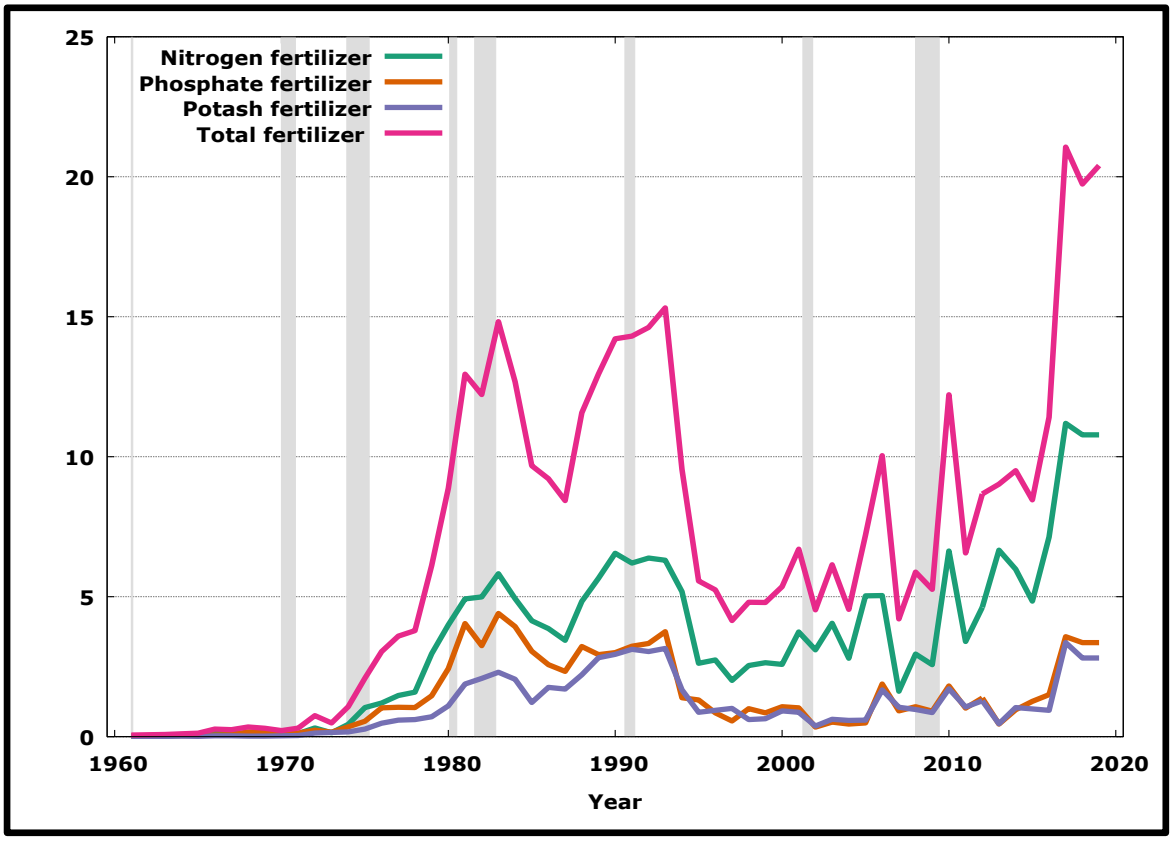

Figure 1: *Trends in nitrogen, phosphate, potash and total fertilizers.*

However, from 2011 – 2019, the country witnessed marginal growth in both single nutrient and composite based fertilizers. The average nitrogen-based and composite fertilizer stood at 7.26kg/ha and 12.76kg/ha respectively. Despite this marginal improvement in fertilizer consumption, it was still far below the required standard needed for sustainable growth in the food sector of the country. The overall analysis of fertilizer consumption from 1962 to 2019 revealed that nitrogen, phosphorus and potassium, as well as composite fertilizer consumption, averaged at 3.54kg/ha, 1.47 kg/ha, 1.13kg/ha and 7.17kg/ha, respectively.

The Relationship between Fertilizer use and Crop outputs in Nigeria

The Pearson correlation coefficients were estimated to investigate the relationship between fertilizer use and crop outputs in Nigeria. The results of Pearson's estimates are presented in Table 4. The findings revealed that an increase in the outputs of cassava, coconut, fruit, groundnut, maize, oil palm, pineapple, rice, rubber, tomatoes, vegetables, wheat, sugarcane, yam, potato, sorghum, soybeans and cocoa have a significant positive linear relationship with the nitrogen-based fertilizer usage in the country. The result implies that as the use of nitrogen-based fertilizer increases, the annual outputs of these crops also increase. The findings suggest that nitrogen-based fertilizer is necessary as soil enhancing material needed for the increase in the outputs of these crops. Similarly, the outputs of fruit, rice and sugarcane have a significant positive correlation with the use of phosphorus-based fertilizer in the country. By implication increase in the use of phosphorus-based fertilizer is associated with an increase in the outputs of these crops.

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Table 4: Pearson bivariate correlation between Fertilizers and crop outputs in Nigeria

Crop outputs	Nitrogen fertilizer	Phosphorus Fertilizer	Potassium Fertilizer	Composite Fertilizer
Cashew	0.1169	-0.1739	-0.0404	0.0249
Cassava	0.6626*	0.1370	0.3403*	0.5078*
Coconut	0.5752*	0.0672	0.2550	0.4221*
Coffee	-0.2089	-0.1013	-0.1620	-0.1852
Fruit, fresh	0.4857*	0.3006*	0.4230*	0.4500*
Groundnut	0.4243*	-0.1443	0.0694	0.2386
Maize	0.7196*	0.2397	0.4706*	0.5896*
Millet	-0.0683	-0.0652	0.0510	-0.0536
Oil palm	0.5076*	-0.0204	0.2070	0.3457*
Pineapple	0.7408*	0.2423	0.3973*	0.5949*
Rice	0.8068*	0.3341*	0.5173*	0.6791*
Rubber	0.5991*	0.1240	0.4100*	0.4737*
Cotton	0.2430	-0.1639	0.0784	0.1210
Tomatoes	0.6210*	0.1121	0.2499	0.4613*
Vegetables	0.6146*	0.0615	0.2520	0.4435*
Wheat	0.3989*	0.1958	0.2839*	0.3449*
Sugarcane	0.7161*	0.4435*	0.5155*	0.6529*
Yam	0.6440*	0.0849	0.2961*	0.3491*
Potato	0.5917*	0.0557	0.2048	0.4432*
Sorghum	0.4064*	0.0367	0.2214	0.1632
Soybeans	0.5948*	0.0666	0.2577*	0.3911*
Cocoa	0.3154*	-0.1778	0.0803	0.3263*

Note: * represents 5% critical value (two-tailed) = 0.2564 for n = 59.
Source: Computed by the author

The bivariate Pearson estimates also revealed that potassium-based fertilizer has a significant positive association with the outputs of cassava, fruit, maize, pineapple, rice, rubber, wheat, sugarcane, yam and soybeans. The results indicate that increase in the use of potassium-based fertilizer as soil enhancing additive would likely increase the outputs of some crops in Nigeria. In a similar vein, the composite fertilizer has a significant positive relationship with the annual outputs of cassava, coconut, fruit, groundnut, maize, oil palm, pineapple, rice, rubber, tomatoes, vegetables, wheat, sugarcane, yam, potato, soybeans and cocoa,

The Relationship between Fertilizer use and Crop Yields in Nigeria

The relationship between fertilizer uses and crop yields was also determined using the Pearson coefficient. The estimated correlation coefficients of fertilizer use concerning crop yields in Nigeria is shown in Table 5. The crop yield is the ratio of the respective crop output to harvested land area and is measured in kg/ha. The essence of the estimation was to assess the relationship between land productivity and the use of fertilizer in the country.

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Table 5: Pearson bivariate correlation between Fertilizer use and crop yields in Nigeria

Crop Yields	Nitrogen fertilizer	Phosphorus Fertilizer	Potassium Fertilizer	Total fertilizer
Cashew	0.0869	-0.1947	-0.0828	0.2026
Cassava	-0.1747	-0.0159	0.0552	-0.1281
Coconut	0.6255*	0.0843	0.2664	0.3033*
Coffee	0.5493*	0.0586	0.2800	0.4392*
Fruit, fresh	0.6660*	0.3947*	0.4260*	-0.1618
Groundnut	0.4246*	0.1723	0.3468*	0.4188 *
Maize	0.5447*	0.2703*	0.3528*	0.3600*
Millet	0.2984*	0.4265 *	0.3475 *	0.5036*
Oil palm	0.3364*	0.2163	0.4027*	0.3491*
Pineapple	0.7374*	0.3494*	0.5357*	0.1641
Rice	0.3726*	0.6189*	0.5244*	0.3052*
Rubber	-0.2688*	0.2146	-0.0299	-0.0036
Cotton	0.2668*	-0.1336	0.0968	0.3291*
Tomatoes	-0.5089 *	0.0171	-0.1275	-0.2349
Vegetables	0.6107*	0.0815	0.2599*	0.2325
Wheat	-0.4014*	0.0141	-0.1731	0.2559
Sugarcane	-0.3311*	0.2438	0.0704	-0.1660
Yam	-0.0463	-0.2347	-0.0221	-0.2262
Cocoa	-0.1142	-0.2812*	-0.0643	-0.1368
Potato	-0.5842*	-0.2737	-0.3707*	-0.4963*
Sorghum	0.6342*	0.5604*	0.5228*	0.6465*
Soybeans	0.4126*	-0.1211	0.0625	0.1916

Note: * represents 5% critical value (two-tailed) = 0.2564 for n = 59.
Source: Computed by the author

The result showed that nitrogen-based fertilizer use has a significant positive correlation with the harvested land productivity or yield of coconut, coffee, fruit, groundnut, maize, millet, oil palm, pineapple, rice, cotton, vegetables, sorghum and soybeans. The result implies that as nitrogen-based fertilizer use is increased, the yield of these crops increases correspondingly. On the contrary, the result found a significant negative association between nitrogen fertilizer use and yields of rubber, tomatoes, sugarcane and potato.

The phosphate-based fertilizer uses also showed a unique relationship with crop yields in Nigeria. It is found that fruit, maize, millet, pineapple and rice yields grow with an increase in phosphate-based fertilizer use. This means that increase in yields of these crops can be derived from increasing the use of phosphate-based fertilizer. Similarly, the use of potassium-based fertilizer has a significant positive correlation with the yields of fruit, groundnut, maize, millet, oil palm, pineapple, rice, vegetables and sorghum. Besides, the composite fertilizer correlates with the annual land productivity of coconut, coffee, groundnut, maize, millet, oil palm, rice, cotton, potato, and sorghum.

Effect of Fertilizer on the Selected Crop in Nigeria

Since the correlation coefficient does not depict causality, a simple Cobb Douglas production function was specified and estimated to assess the production parameters with respect to fertilizer use in the country. The estimates of the Cobb Douglas production function are presented in Table 6 for each of the selected crop enterprises. The findings revealed that the application of fertilizer did not have a significant effect on the production of cashew and fresh fruits crops in the country. The findings suggest that the production of these crops depend more on the natural soil ability or the use of organic matter.

The elasticity of production with respect to nitrogen fertilizer use is significant and positive as well as less than unity for coffee and sugarcane crop enterprises. This implies that nitrogen-based fertilizer is rationally utilized in the production of sugarcane and coffee as increased usage will significantly increase output. However, for the majority of crop enterprises specified, nitrogen-based fertilizer was irrationally utilized.

The regression estimates also revealed that increase use of phosphorus-based fertilizer decreases outputs of cashew, cassava, coconut, groundnut, maize, oil palm, pineapple, rice, rubber, cotton, tomatoes, vegetables, wheat, yam, cocoa, potato, sorghum and soybeans crop in the country. The negative elasticities of production with respect to the phosphorus-based fertilizer in these crop enterprises connote irrational use. Besides the outputs of coffee, fruit and sugarcane had a positive insignificant relationship with the use of phosphorus-based fertilizer in the country. Furthermore, the elasticity of production with respect to potassium-based fertilizer input responded positively and significantly to the outputs of millets, rubber, cotton and cocoa. The results indicate that the increased use of potassium-based fertilizer will correspondingly induce a rational increase in outputs of these crops.

The results further revealed a mixed impact of composite/total fertilizer on the annual outputs of crops in Nigeria. For instance, cassava, maize, rice, tomato, vegetables, potatoes and soybeans have positive significant elasticity of production with respect to composite fertilizer. Following the classical production theory, the utilization of the composite fertilizer in the production of cassava, maize, rice, tomato, vegetables, potatoes and soybeans is inadequate in the country. The findings imply that more composite fertilizer is needed than the quantity applied currently to produce the technically optimum level of sustainably annual outputs of cassava, maize, rice, tomato, vegetables, potatoes and soybeans. On the other hand, the production elasticity of composite fertilizer with respect to coconut, oil palm and pineapple is inelastic, positive and significantly established at the conventional levels of significance. This means that the use of the composite fertilizer in the production of coconut, oil palm and pineapple in the country is currently rational or sufficient whereas the rest of the crop enterprises specified are irrationally utilized. This result is highly contestable following the low average utilization rate in the country. It is suggested that the agronomical requirement and the natural fertility of the soil as well as the alternative soil enhancing materials applied may be responsible for these results.

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Table 6: Causality relationship between Types of Fertilizer and crop outputs in Nigeria

Crop output	R-squared	F-calculated	Constant (β_0)	Nitrogen (β_1)	Phosphorus (β_2)	Potassium (β_3)	Total fertilizer (β_4)	Return to Scale
Cashew	0.576	17.83***	9.04(4,90)***	0.11(0.15)	−2.04(−4.42)***	0.42(0.73)	1.47(1.04)	−0.04
Cassava	0.721	34.88***	15.03(21.42)***	−0.33(-0.89)	−1.07(−5.55)***	0.12(0.66)	1.40(2.34)**	0.12
Coconut	0.671	27.49***	10.88(25.10)***	−0.08(-0.36)	−0.61(−5.12)***	0.05(0.47)	0.68(1.83)*	0.04
Coffee	0.071	1.03	8.88(12.16)***	0.69(1.82)*	0.18(0.89)	0.04(0.22)	−0.95(−1.53)	−0.04
Fruit, fresh	0.414	9.54***	11.06(247.5)***	0.02(0.89)	0.01(0.67)	−0.02(-1.57)	−8.6e-05(-0.002)	0.05
Groundnut	0.395	8.827***	12.69(12.64)***	−0.20(−0.38)	−1.14(−4.12)***	0.02(0.07)	1.14(1.33)	−0.18
Maize	0.545	16.164***	12.69(9.96)***	−0.60(−0.91)	−1.43(−4.08)***	0.32(0.99)	1.85(1.70)*	0.14
Millet	0.149	2.374*	16.21(18.13)***	0.18(0.38)	−0.17(−0.68)	0.64(2.84)***	−0.69(−0.90)	−0.04
Oil palm	0.523	14.798***	15.14(56.50)***	−0.14(−0.97)	−0.38(−5.17)***	0.04(0.58)	0.46(2.03)**	−0.02
Pineapple	0.621	22.16***	12.50(30.40)***	−0.23(−1.07)	−0.44(−3.93)***	−0.06(−0.54)	0.82(2.33)**	0.09
Rice	0.816	59.82***	11.32(12.10)***	−0.57(−1.16)	−1.23(−4.78)***	0.16(0.69)	2.05(2.57)**	0.41
Rubber	0.576	18.32***	10.77(21.06)***	−0.13(−0.46)	−0.70(−4.97)***	0.26(1.98)*	0.57(1.30)	0
Cotton	0.490	12.98***	11.40(12.73)***	−0.19(−0.40)	−1.26(−5.11)***	0.54(2.39)**	0.76(0.99)	−0.15
Tomatoes	0.660	26.24***	10.02(9.33)***	−0.56(−1.01)	−1.42(−4.81)***	−0.24(−0.88)	2.40(2.62)**	0.18
Vegetables	0.667	27.01***	12.55(14.77)***	−0.31(−0.69)	−1.29(−5.50)***	0.10(0.47)	1.55(2.14)**	0.05
Wheat	0.534	15.46***	9.75(11.41)***	−0.04(−0.09)	−0.57(−2.4)**	0.11(0.52)	0.66(0.90)	0.16
Sugarcane	0.720	34.82***	13.89(31.44)***	0.58(2.51)**	0.14(1.13)	−0.05(−0.47)	−0.48(−1.27)	0.19
Yam	0.599	20.13***	15.13(14.99)***	0.25(0.47)	−1.13(−4.07)***	0.11(0.44)	0.79(0.92)	0.02
Cocoa	0.533	15.9***	12.46(28.79)***	0.10(0.46)	−0.57(−4.96)***	0.23(2.17)**	0.16(0.44)	−0.08
Potato	0.637	23.69***	6.21(3.36)***	−0.99(−1.03)	−2.52(−4.95)***	−0.33(−0.70)	4.06(2.57)**	0.22
Sorghum	0.242	4.32***	14.68(19.81)***	−0.25(−0.65)	−0.59(−2.88)***	0.18(1.02)	0.65(1.02)	−0.01
Soybeans	0.654	25.49***	9.34(8.58)***	−0.57(−0.99)	−1.71(−5.697)***	0.19(0.71)	2.14(2.31)**	0.05

Note: *, ** and *** represent 10%, 5% and 1% probability level of significance, respectively.
Source: computed by the author and data from FAO website.

The return to scale of the fertilizer inputs to each of the crop enterprises denotes decreasing return to scale. This means that the total increase in fertilizer use would result in a decrease in the output of crops. The estimates of the return to scale are extremely low and negative in some crop enterprises implying that fertilizers as factors of production do not contribute significantly to the growth of output of crop enterprises in the country. Similar results have been reported by the following authors using cross-sectional data; Akpan *et al.* (2010); Akpan *et al.* (2012d); Yipu *et al.* (2020); and Dania *et al.* (2021).

CONCLUSION AND RECOMMENDATIONS

The study established a mixed linear correlation between fertilizer use and annual crop outputs in the country. Similar relationships were confirmed between fertilizer use and crop yields (output/harvested area of land). This connotes those outputs and yields of crop enterprises can be regulated by varying quantities of nitrogen, phosphorus and potassium as well as composite fertilizers use. The impact of various forms of fertilizers on the output of crop enterprises in the country was estimated and the results revealed that the majority of crop enterprises had irrational or underutilization of fertilizer inputs. The findings however indicated that the use of fertilizer in the production of coconut, oil palm and pineapple was adequate which is highly contestable considering the average application rates in the country. The return to scale of the fertilizer inputs portrays decreasing return, implying that aggregate use of fertilizer contributes less to the growth of crop outputs in the country.

In conclusion, it was established that fertilizer use in the country is very low compared to the minimum standard required for sustainable crop production in the Sub Saharan region of Africa. Also, fertilizer has been proved to be one of the prerequisites for regulating outputs of crop enterprises in the country. The study further confirmed that fertilizer use has a significant impact on outputs of crop enterprises in the country, however, the return to scale of the fertilizer inputs indicates decreasing return to scale. Hence, the objective of attaining self–food sufficiency will be jeopardized if the fertilizer consumption is not enhanced at least to the minimum standard required as an urgent policy action. It is strongly recommended that the federal government of Nigeria should ensure the full implementation of the Abuja declaration on the fertilizer consumption rate of 50kg/ha adopted in 2006 for the continent.

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