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Variability of Maize Yield and Some Soil Properties in an Exhaustively Cultivated Field in the School of Agriculture, Ikorodu

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ABSTRAK

Perubahan pengeluaran jagung dan sifat sesetengah tanah di kawasan yang ditanam rapi di Sekolah Pertanian, Ikorodu dikaji menggunakan variasi yang koefisien dan analisis regresi pelbagai langkah bijak selama dua tahun (1990 dan 1991). Perubahan ciri-ciri tanah dan pengeluaran jagung secara individu seperti yang ditunjukkan oleh perbezaan nilai cv yang meluas. Ciri-ciri kimia tanah (ex, Ka, Ex, Avail.P dan Zink) berubah lebih daripada ciri-ciri fizikal tanah (kapasiti pegangan air dan pasir). Perubahan ciri-ciri sesetengah tanah dan pengeluaran jagung berkemungkinan jelas dipengaruhi oleh penggunaan tanah sebelumnya dan aktiviti pengurusan lain di sekeliling kawasan tersebut. Pada tahun 1990, 18 ciri tanah menerangkan 92.51% variasi dalam pengeluaran jagung di kawasan tersebut. Berbanding 87.29% pada tahun 1991, setiap ciri tanah menggunakan pengaruh berlainan ke atas pengeluaran jagung. Ciri-ciri tanah menggunakan pengaruh berlainan ke atas pengeluaran jagung. Ciri-ciri tanah yang menggunakan pengaruh kuat ke atas pengeluaran jagung dalam kawasan tanaman yang mengandungi P, potasium yang boleh berubah, jirim organik, kapasiti pegangan air, kalsium yang boleh berubah, pasir dan zink. Kajian ini menekankan perubahan besar jumlah tanah dan kadar pengeluaran jagung yang boleh wujud dalam kawasan kecil yang ditanam rapi. Pendekatan yang digunakan dalam kajian ini kelihatan munasabah untuk memperbaiki pengeluaran tanaman di kawasan tersebut. Pendekatan ini mungkin berguna dalam memilih ciri-ciri tanah untuk kajian penilaian kesuburan tanah.

ABSTRACT

The variability of maize yield and some soil properties in an exhaustively cultivated field in the School of Agriculture, Ikorodu was examined using a coefficient of variation and stepwise multiple regression analysis for two years (1990 and 1991). The variability of individual soil properties and maize yield as indicated by cv values differed widely. Soil chemical properties (ex, Ca, Mg, Ex, Avail. P and zinc) varied more than the physical properties of the soil (sand and water holding capacity). Variability of some soil properties and maize yield were likely to have been markedly influenced by previous landuse and other management practices around the exhaustively cultivated field. In 1990, 18 soil properties explained 92.51% of the variation in the yield of maize on the exhaustively cultivated field. Compared to 87.29% in 1991, each of the soil properties exerted a different influence on the yield of maize. Soil properties which exerted stronger influences on the yield of maize within the cultivated field were available P, Exchangeable Potassium, organic matter, water holding capacity, Exchangeable calcium, sand and zinc. This study has highlighted the tremendous amount of soil and maize yield variability that may exist within a small exhaustively cultivated field. The approach used in this study seems reasonable for improving crop yield on the field. It would be useful for selecting different soil properties for land and soil fertility evaluation studies.

INTRODUCTION

Much of the existing information on soil variability, including the few on tropical soils (Tomlinson 1970; Areela 1982), concentrates on variability. This is the component of total variability observed over a considerable distance of between two distinctly different units such as parent materials or land facets (Van Wambeke and Dual 1978). Far less attenttion has been given to the microvariability component, which pertains to the local and often recurrent variations on the scale of a single field (Meerman and Kang 1978).

Research reported by Kang (1977 and 1978) has shown that the effect of soil variability on the growth and performance of crops in the inter tropical areas can be pronounced. In addition, the experience of researchers as a result of the effect of considerable microvariability on agricultural experiments can be very frustrating. A knowledge of the degreee of microvariability of the soil over an area and the factors responsible for this variability is therefore essential for both practical and experimental agriculture.

Presently, there is a lack of information about soil variability and its effects on maize yield around the study area. In view of the proximity of Lagos to the study area where capital or intensive farming is accessible, it is necessary to generate adequate information on landuse or soil management, so as to maximise the use of the land: crop rotation is now difficult in Lagos State because of pressure on the land for industrial and commercial activities within the state. This predisposes the few available areas to be put under heavy use with the aid of fertilizers.

It is therefore necessary to monitor crop yield on such land so as to determine to what extent it has been altered. This will offer information regarding measures to guarantee optimal use of such areas.

Soil exhibits tremendous variations both laterally and vertically. The results of previous soil veritability studies (Ogunkunle 1986) have revealed very high variations between soil properties of two closely spaced spots 10 cm apart on a uniform terrain.

It has also been established that, for most arable crops, the control of crop performance is mainly in the plough layer (0-20cm), where most of the roots are concentrated. Similarly, Sopher and McCracken (1973) found that 70% of corn yield variation was due to soil properties of the plough layer. Lal *et al.* (1975) also observed that the removal of 2.5cm and 7.5cm of the topsoil, respectively resulted in 50 and 90 per cent reductions in maize yield.

This study examined the degree of variation in some soil properties and yield of maize on an exhaustively cultivated field. This study will no doubt furnish some information on the variation of some soil properties and yield of maize, which we hope will be a useful guide to farmers and other landusers. Hence, the information on the topsoil properties controlling yield variation will be very useful for improving food production.

Study Area

The studies were conducted in the experimental farm of the School of Agriculture, Ikorodu. The location is about 15km from Lagos and 30km from Sagamu. The area lies roughly between latitudes 5° 7°N and 5° 10°N and longitudes 3°16 and 5° 18° ease of Greenwich Meridian. It has an altitude of about 50 km above sea level.

The climate is humid tropical with two distinct seasons – the dry (November to March) and the wet (April to October). Mean annual rainfall is at least 132 mm with a maximum in July and September. Mean daily temperature ranges from 25 to 28°C. The humidity is high throughout the year and reaches its peak during the wet season. The mean relative humidity is never below 65%.

The soil has been mapped as Alfisols with Typic Paloustalf as the modal profile (Fasina 1989). It is derived from sedimentary parent material (Moss 1957) with sandy loam and sandy clay texture in the surface and subsoil, respectively. The soil has been exhaustively cultivated with vegetables and maize in the past. This means the continuous planting of the field with vegetables and maize without allowing it to fallow.

MATERIALS AND METHODS

Field studies were conducted for two years (1990 and 1991) during the wet season. TZSR-Y maize needs variety were planted on plots of 0.1ha with inter and inter-row spacings of 90cm and 30cm respectively. NPK (15-15-15) compounded fertilizer and urea were applied at the rate of 200kg/ha and 100kg/ha two weeks after planting respectively. Leaving out the guard rows, 20 maize stands were randomly selected from the middle of the 0.1ha plots for the two year study. At tasselling, 5 surface (0-15cm) core soil samples were taken from around each of the selected stands to form a composite sample for laboratory analysis. The maize cobs were harvested at maturity (15% moisture content) from these stands and the yield per stand (weight of grains in grams) was determined. All experimental procedures were the same for both years.

Laboratory Analysis

Particle size distribution was done using the Bouyoucos hydrometer method (Day 1965) and pH was measured in water (1:1, soil:water). The exchangeable cations (Ca, Mg, Na and K) were extracted in IN NH_4OAC and Na and K were determined by a flame photometer and Ca and Mg on an atomic absorption spectrophotometer. The exchangeable acidity (A1 and H^+) was determined by titration of the soil solution with IN KCL and organic carbon was determined by the Walkey-Black method (Allison 1965).

Available P was extracted by Bray's PI solution (Bray and Kurtz 1945) and determined following the Murphy and Rilley method (Murphy and Rilley 1962). Total N was determined by the macro-kjeldahl method (Bromner 1960) and moisture content (%) by gravimetrics. The dicronutrients were leached out with 0.1m NHCI (Wear and Sammer 1948) and were read on the atomic absorption spectrophotometer.

Statistical Analysis

Yield and laboratory data were statistically analysed from plots for variations (mean (X), standard deviation (sd). The coefficient of variation (cv) and the stepwise regressions of yield on soil properties were measured using the SPSS computer program of Lagos State, Agricultural Development Project, Lagos.

RESULTS AND DICUSSION

Variations in Soil Properties and Maize Yield

Variability of individual soil properties and maize yield as indicated by cv values differed widely (Table 1). The exhaustively cultivated field was more uniform in those soil properties which are genetically and morphologically important such as sand, while those properties which are ephemeral and which are related to management (Ex, Ca, Mg, Avail.P, Ex K) were more variable (Table 1). These are the properties that most control maize yield on the field. The cv data obtained for the two year experiment seems to be

TABLE 1
Variability of maize yield and soil properties

	1990			1991		
Property of Maize Yield	x	Sd	CV%	X	SD	CV%
Maize yield (kg)		0.24	1.08	37	126.75	44.83
35.11						
Soil p^H	6.76	0.22	3	6.78	0.13	1.91
Organic carbon %		1.41	0.11	8	3.16	0.45
14.2						
Total N %	0.12	0.01	8	0.32	0.05	15.62
Available Phosphorus Cmol kg^{-1}	52.49	28.43	54	73.99	53.44	72.22
Calcium (ca) Cmol kg^{-1}	2.47	0.92	37	2.60	0.74	28.46
Magnesium (mg) Cmol kg^{-1}	1.15	0.18	16	1.23	0.15	12.19
Sodium (Na) Cmol kg^{-1}	0.27	0.05	17	0.31	11	35.48
Potassium (K) Cmol kg^{-1}	0.17	0.09	54	0.20	0.07	35.0
Exchangeable acidity Cmol kg^{-1}	0.24	0.08	33	0.28	0.12	52.55
Cation Exchanged Capacity Cmol kg^{-1}	4.44	1.03	5	2.69	0.29	11
Base saturation (BS) %	94.55	2.56	3	93.55	3.00	3.20
Manganese (Mn) - Cmol kg^{-1}	69.37	5.33	8	71.58	8.62	12.04
Iron (Fe) - Cmol kg^{-1}	21.68	4.60	21	21.03	3.89	18.49
Copper (Cu) - Cmol kg^{-1}	1.48	0.19	13	1.56	0.15	9.67
Zinc (Zn) - Cmol kg^{-1}	6.67	2.48	37	6.87	2.99	43.52
Sand - %	0.79	2.38	3	76.15	2.50	3.28
Silt - %	9.00	1.54	17	9.30	1.77	19.03
Clay - %	12.40	2.01	16	14.55	2.55	17.52
Water Holding Capacity (WHC) %	35.61	5.01	14	36.72	1.77	4.82

uniform. Also, the cv values obtained for soil properties in this study were not at variance with what other workers have observed in the past (Beckett and Webster 1971; Chickezie 1984; Unwni 1985; Fasina 1986). The cv values of some chemical properties appeared to be less variable than others. Soil pH base saturation, CEC, total N, manganese and organic carbon were less variable while available P, Ex, Ca, K, Zn, Ex acidity, Fe were more variable on the exhaustively cultivated land. The observed differences in the variability of the chemical properties for the whole area as shown by the cv values (Table 1) could be due to variations imposed by cultivation and management practices employed in the study area.

It has also been shown (Beckett and Webster 1971) that in cultivated areas, contrasting crops, soil amelioration and addition of fertilizers superimposed differences between fields on the variation already present in the native soil. The variation in these chemical properties in the soil would result in variations in the yield of crop cultivated on the field as in the case of this study. This is in accordance with Talukdar and Barthakur (1986) and Gbadegesin (1987). The variations observed in these chemical properties could also be caused by land clearing and preparation that the exhaustively cultivated field has been subjected to over the years. The cv values obtained from maize yield and soil properties in the study when grouped by the method of Wilding and Drees (1978) (Table 2) has put pH, Org C, Total N, base sat Mn, Sand, Cu, ECE, as the least variable properties (CV 15%). Ex.Mg, Ex Na, acidity Fe, silt and clay are moderately variable properties (CV 15-35%) while maize yield, available P, Ex. Ca, Ex K and zinc are extremely variable properties (CV 35%). The result of this grouping agreed with the results obtained by Wilding and Drees (1978) and also with results obtained elsewhere in Nigeria (Fasina 1986; Ogunkunle 1986).

It has been shown that in experiments where specific treatments were applied, variability as high as cv 99% may invalidate the results even with a high degree of replication (Ogunkunle 1988). This shows the importance of calculating the variations in yield data obtained in an experiment.

The variation in the maize yield also signified the variation in soil properties of the exhaustively cultivated field. The variations in soil properties and the type of management systems adopted are thus among the causes of variations in yield parameters observed on the field.

Yield Prediction

In order to have an idea of the contributions of each of the individual soil properties to the variations in the yield of maize on the exhaustively cultivated land, a further analysis of the data was carried out using a stepwise regression model.

The stepwise regression of the maize yield (dependent variable) on the soil properties (independent variables) reveal that 18 soil properties contributed significantly (P 0.01) to the prediction of maize yield in the study area (1990- R^2 value of 92.51%, 1991 – R^2 value of 87.29%) (Table 3). With 8 soil properties in regression, 72% of the variations in maize yield were explained in 1990 while it was 75% for 1991. The regression analysis also revealed that the soil variables were not equal as far as their influence on the yield of the crop was concerned. The soil chemical properties seemed to exert a stronger influence on the yield of the crop in the study area.

For instance, for the two year study Ex Ca and organic carbon were among the first two relevant soil properties (Table 3) that contributed significantly to the yield of maize. The regression values obtained for Available P and Ex Ca (R^2 = 10% - 1990, R^2 = 4% - 1991) and (R^2 = 10% R^2 – 13% - 1991) tend to support the

TABLE 2

Grouping of maize yield and soil properties using CV values for the exhaustively cultivated fields

Group of Properties	Range of CV Values	Soil Property and Maize Yield
Least Variable	15%	pH, org C, total N, Base Saturation, Mn Sand, Cu, CEC
Moderately Variable	15 – 35%	Ex. Mg. Ex Na. Ex. Acidity Fe, Silt and Clay
Extremely Variable	35%	Avail P, Ex Ca, Ex K and Zinc, Maize yield

TABLE 3(a)
Yield prediction (R^2) with increasing number of properties in regression (1990)

No. of Soil Properties in Regression	List of Properties	R^2	R^2%
1	Av.P	24	-
2	Av. P. Ca	34	10
3	Av. P^2Ca, org. C	41	7
4	Av. P. Ca. org C, WHC	48	7
5	Av. P. Ca. org C. WHC, Na	55	7
6	Av. P, Ca, org C, WHC, Na, K	62	7
7	Av.P, Ca, org C, Whc, Na K, Base Sat.	68	6
8	Av.P. Ca, org C, WHC, Na, K, B. Sat. Silt	72	4
9	Av.P. Ca, org L, WHC, Na, K, Bsal	76	4
10	Av.P, Ca, org C, WHC, Na K.B. Sat Silt, Zn, Fe	79	3
11	Av.P, Ca, org C, WHC, Na, K.B. Sat, Silt Cu, Fe, Sand	82	3
12	Av.P, Ca, org C, WHC, Na, K, B.Sat, silt, Zn, Fe, Sand, Cu	85	3
13	Av.P, Ca, org C, WHC, Na, K,B.Sat, Silt, Zn, Fe, sand, Cu, Mn	88	3
14	Av.P, Ca, org C, WHC, Na, K.B.Sat, silt, Zn, Fe, Sand, Cu, Mn, CEC	90	2
15	Av.P, Ca, org C, WHC, Na, K,B.Sat, Silt, Zn, Fe, sand, Cu, Mn, CEC, Ph	91	1
16	Av.P, Ca, org C, WHC, Na, K.B.Sat, Silt, Zn, Fe, Sand, Cu, Mn, CEC, PH Total N	91.6	0.6
17	A.P, Ca, org C, WHC, Na, K, B.Sat, Silt, Zn, Fe, Sand, Cu, Mn, CEC, PH, Total N, Mg	91.85	0.25
18	Av.P, Ca, org C, WHC, Na, K, B.Sat, Silt, Zn, Fe, Sand, Cu, Mn, CEC, PH Total N, Mg Ex ac	92.51	0.66

TABLE 3(b)
Yield prediction (R^2) with increasing number of properties in regression (1991)

No. of Soil Properties in Regression	List of Properties	R^2	R^2%
1	WHC	15	-
2	WHC, Ca	28	13
3	WHC, Ca, Org C	38	10
4	WHC, Ca, Org C, Silt	47	9
5	WHC, Ca, Org C, Silt, EC	55	8
6	WHC, Ca, Org C, Silt, Ec, Cu	63	8
7	WHC, Ca, Org C, Silt, Ec, Cu, Sand	71	8
8	WHC, Ca, Org C, Silt, Ec, Cu, Sand, Av.P	75	4
9	WHC, Ca, Org C, Silt, Ec, Cu, Sand, Av.P, PH	79	4
10	WHC, Ca, Org C, Silt, Ec, Cu, Sand, Av.P, PH, Fe	82	3
11	WHC, Ca, Org C, Silt, Ec, Cu, Sand, Av.P, PH, Fe Na	84.5	2.5
12	WHC, Ca, Org C, Silt, Ec, Cu, Sand, Av.P, PH, Fe Na	85.5	1
13	WHC, Ca, Org C, Silt, Ec, Cu, Sand, Av.P, PH, Fe Na, K, Zn,Mg		
14	WHC, Ca, Org C, Silt, Ec, Cu, Sand, Av.P, PH, Fe, Na, K, Zn, Mg	86.84	0.34
15	WHC, Ca, Org C, Silt, Ec, Cu, Sand, Av.P, PH, Fe, Na, K, Zn, Mg, Mn	87.07	0.23
16	WHC, Ca, Org C, Silt, Ec, Cu, Sand, Av.P, PH, Fe, Na, K, Zn, Mg, Mn, Total N	87.20	0.13
17	WHC, Ca, Org C, Silt, Ec, Cu, Sand, Av.P, PH, Fe, Na, K, Zn, Mg, Mn, Total N, CEC	87.26	0.06
18	WHC, Ca, Org C, Silt, Ec, Cu, Sand, Av.P, PH, Fe, Na, K, Zn, Mg, Mn, Total N, CEC, Ex ac	87.29	0.03

results of the coefficient of variation for these two properties in the study area (Tables 1 and 3). The regression also showed the importance of different soil properties in predicting the yield of maize in the field. The differences observed in the yield predictions might be due not only to the individually soil properties but to a combination of crop and soil factors.

Application of Data to Land and Soil Fertility Evaluation Studies

The soil properties observed to be controlling the yield from the exhaustively cultivated field for the two year experiment (Available P, Ex Ca, Ex K, organic matter and water holding capacity, sand and zinc)can be used to evolve a reasonable land evaluation report (sutiability/land capability classification) for the area of study. These soil properties, when combined with other permanent properties of the soil like slope, depth, texture, structure and degree of management can be used for proper landuse and fertility evalution studies.

The results of the regression analysis can also be useful in soil fertility evaluation studies – in terms of artificial soil nutrient requirements(optimum levels of nutrients), and the expected performance and crop yields. This would then make the study more relevant for crop production.

CONCLUSION

Variability of individual soil properties and maize yield as indicated by cv values differed widely. Soil chemical properties were more variable than the physical properties of the soil. The variability of some soil chemical properties and maize yield were likely to have been markedly influenced by past land-use activities and some other management practices around the study area. It was also observed from the study that variations in some soil properties especially chemicals (Available phosphorus, Ex Ca, Calcium and Potassium) properties might lead to variations in maize yield on the field.

With 18 soil properties in regression in 1990, 92.51% of the variations in yield of maize was explained, while for 1991 the same 18 soil properties explained 87.29% in maize variation. The two most relevant soil properties that contributed significantly to the yield of maize were Ex ca and organic carbon for the two year study. The soil chemical properties exert stronger influence on the yield of crop in the study area.

The soil properties found to be relevant to maize yield in this study, if combined with the more permanent characteristics (slope, depth, drainage), may produce reliable landuse classes. Also, the results can be useful in soil fertility evaluation studies – determining optimum levels of nutrients and concentrating more on the most relevant soil properties, thereby saving cost on fertilizer use.

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