THE PERFORMANCE OF MAIZE (Zea mays L.) AND COWPEA (Vigna unguiculata L.) VARIETIES IN SOILS FROM DIFFERENT AGROECOLOGICAL ZONES IN SOUTHWESTERN NIGERIA

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Abstract

.9 greenhouse soil culture experiment was carried out, using soil samples (0 -30cm) from uncultivated land in Osun, Ondo, Edo and Delta States in South-western Nigeria, to assess the adaptability of maize and cowpea varieties to the indigenous fertility of the soils. The maize varieties were TZEComp 3x4 (Early), TZPB-SR (Late) and Suwan 1-SR; while cowpea varieties were 84S-2246, TV_x3236 and IT86D-721. The heights, leaf areas and dry matter yields were determined at 82 days after planting.

The soil types were Entisols in the very wet Delta States, Oxisols and Ultisols in the wet Edo State, Ultisols in the less wet Osun and Ondo State. The soils are extremely acidic in Edo and Delta States, slightly acidic in Osun and Ondo States except at Ifetedo (pH 4.4) and Ipele (pH 7.5). Organic C and total N contents were in the medium ranges. The available P, ECEC, exchangeable cation and micronutrient contents were generally low. While exchangeable acidity was lower in the basement complex than in the sedimentary zone, the reverse was the case with base saturation and extractable Cu

While maize dry matter yields were significantly correlated with available $P(r=-0.99^{***})$ and exchangeable $K(r=-0.59^{*})$, those of cowpea were significantly correlated with extractable Zn ($r=0.91^{***}$), $Fe(r=-0.76^{**})$ and Cu ($r=-0.82^{**}$). Significant correlation ($r=0.83^{**}$) was also found between dry matter yields and leaf areas of the crops. These results show the importance of soil organic matter and micronutrients in determining the performances of maize and cowpea varieties in the soils formed over basement complex and sedimentary formations.

Introduction

The current high cost of commercial fertilizers poses a serious threat to agricultural production in Africa. Yet, great demands are being made on tropical soils to meet the needs for food and fibre of a rapidly expanding population (Harpstead, 1974). It is therefore necessary to

rationalize the use of inorganic fertilizers while planting crops that are compatible to specific soils in being able to exploit optimally their natural mineral nutrient resources. In a study of the adaptability of forage legumes to soil nutrient stress, Aduayi and Haque (1992) observed that the yield and quality parameters varied widely depending on stage of maturity, soil type, moisture content and climate. They stressed the importance of selecting crop varieties that are tolerant to the low soil fertility and P existing in vast areas of highly weathered, acid, sandy or clayey tropical soils. Obisanya (1987), in a similar vein found significant differences between twenty maize cultivars in terms of uptake of phosphorus and potassium. Even though cowpea has been found not to respond to N and P fertilizers in southwestern Nigeria, differential potentials to absorb nutrients as found for maize might be expected in cowpea too (Nangju,1973). Experience has shown, however that high imputs of synthetic fertilizers and pesticides are beyond the means of peasant farmers and are environmentally undesirable in most agroecological systems. In the natural state and absence of fertilizer applications, soil organic matter will be the major source of plant nutrients. It is therefore, the aim of this bionutritional investigation to assess the adaptability of maize and cowpea varieties in soils obtained from different agroecological zones in southwestern Nigeria by fitting crops to natural and uncultivated soils for maximum utilization of native soil nutrient resources before the need for additional fertilizer application.

Materials and Methods Soil Samples :

Soil samples were collected at a depth of 0 to 30cm at four sites located in different ecological zones in each of Osun, Ondo, Edo and Delta States in Southwestern Nigeria (Fig.1). The mean annual rainfall and temperatures in the four states are 750-1200mm, 750-1500mm, 1500-2000mm, and 2000-3000mm, 28-30°C, 27-30°C, 26-28°C and 25-28°C respectively. The bulk samples were airdried, screened through 2mm sieve and were employed for the greenhouse soil culture experiment.

Greenhouse Experiment

Two Kilogramme (2kg) portions of soil from each sampling site were weighed into plastic pots perforated and plugged with cotton wool at the bottom to ensure adequate aeration. Each pot was maintained at 70% of the field moisture capacity throughout the 82 days in which the experiment lasted. Two seeds of each variety of maize and cowpea were sown per pot and replicated four times. The varieties were obtained from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

The maize varieties were TZEComp 3x4 (Early), TZPB-SR (LATE) and Suwan I-SR (Suwan) while the cowpea varieties were 84S-2246, TV x 3236 and IT86D-721. The seedlings were later thinned to one per pot at two weeks after planting. The pots were arranged in a completely randomised design.

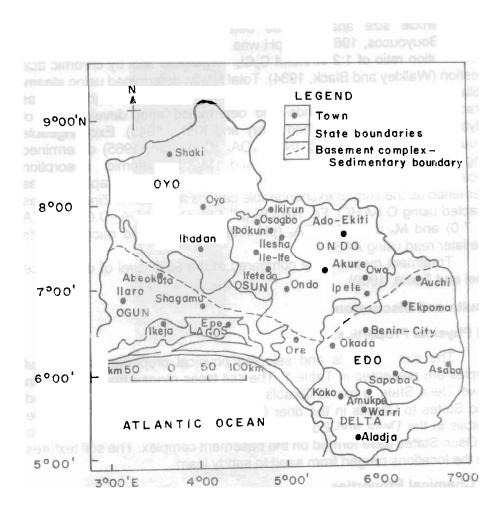


Fig. 1: Map Of South Western Nigeria Showing Selected Sampling Locations

Morphological Characteristics

Leaf area and plant height were taken at harvesting at 82 days after planting. The shoots were cut at the soil level while the roots were seived out of the pots, washed and added to the respective shoots in paper bags. The tissues were oven-dried to constant weight at 70°C for dry matter determination.

Soil Physical and Chemical Analyses

Particle size analysis was determined using the hydrometer method (Bouyoucos, 1962). Soil pH was determined potentiometrically in a soil solution ratio of 1:2 in 0.0IM C_aCl_2 . Organic C was by chromic acid digestion (Walkley and Black, 1934). Total N was determined using steam-distillation technique (Bremner and Keeney, 1966). Available P was extracted in dilute acid-fluoride and determined after development of molybdenum blue color method (Bray and Kurtz, 1945). Exchangeable catious were extracted using IN NH₄OA_c (Chapman, 1965) determined using flame photometry, Ca and M_g by atomic absorption spectrophotometry (AAS). Effective cation exchange capacity was determined as the sum of exchangeable cations and acidity. Zinc (Zn) was extracted using O.IM HCl, Fe NH₄OA_c(p^H 4.8), C_u NH₄OA_c-O.OIM EDTA (pH 7.0) and M_n using NH₄OA_c (pH 7.0). The extracted micronutrients were later read using AAS.

Treatment means were compared at the 95% level of confidence (Steel and Torrie, 1960).

Results and Discussion

Soil Physical Properties:

The classifications and selected physical properties of the soil samples are presented in Table 1. The soil types ranged from Entisols in the wet Delta State, a mix of Oxisols and Ultisols in the less wet Edo and Ondo States to Ultisols in the drier Osun State (Ojo-Atere, 1984). While the soils in the Delta and Edo States were sedimentary, those of Ondo and Osun States were formed on the basement complex. The soil textures in all the locations ranged from sand to sandy loam.

Soil Chemical Properties

Table 2 shows the chemical properties of the soil samples obtained at different agroecological sites in southwestern Nigeria. The soils from Edo and Delta States were extremely acidic in reaction (pH 4.10-4.70); those from Osun and Ondo States, were in the medium to strongly acidic range (pH 5.10-5.70) except at Ifetedo and Ipele where the values were extremely acidic (pH 4.40) and neutral (pH 7.50) respectively.

This trend is in line with the finding that acidity is prevalent in areas experiencing high rainfall (Oguntoyinbo et al., 1994). Both the organic C (1.43-3.31%) and total N (0.12-0.28%) contents of all the soils were in the medium ranges (Sobulo and Adepetu, 1987). The available P (1.34-7.39mg/kg), ECEC (3.65-9.32 cmol/kg), exchangeable Ca, Mg, K and Na contents with ranges of 2.02-7.82, 0.12-0.88, 0.07-0.40 and 0.12-0.60 cmol/kg, respectively ere low. In line with the neutral pH, the Ca content (55.60 cmol/Kg) at Ipele was high leading to high ECEC of 56.92 cmol/Kg. The exchangeable acidity in the soils obtained from the sedimentary areas were much higher (0.99-1.23 cmol/kg) than in soils formed over basement complex (0.11 - 1.11 cmol/kg). The reverse was the case with respect to % base saturation values of 66-87% and 80 - 99% in sedimentary and basement complex soils, respectively. The contents of micronutrients in all the soils were generally very low. The soils from the sedimentary parent material were particularly very low in Cu. This was attributed to the very sandy nature of the soils.

Table 1: Physical properties and classification of soils sampled from different agro-ecological zones in southwestern

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Sampling Location	Soil Type	Particle size analysis			Textural Class
		Sand	Silt	Clay	
Basement Complex Osun State					
lkirun	Ultisols	76	12	12	Sand loam
Ibokun	Ultisofs	72	13	15	Sand loam
Ile-Ife	Ultisols	84	12	4	Loam sand
Ifetedo	Ultisols	88	7	5	Sand
Ondo State					1
Ado-Ekiti	Ultisols	86	13	1	Sand
Ondo	Ultisols	91	8	1	Sand
Ore	Oxisols	83	11	6	Loam sand
Ipele	Ultisols	88	10	2	Sand
Sedimentary Zone Edo State					
Ekpoma	Ultisols	91	6	3	Sand
Ozalla	Ultisols	89	6	5	Sand
Benin	Oxisols	95	3	2	Sand
Okada	Oxisols	84	9	7	Loam Sand
Delta State		1 1 1 1			
Koko	Entisols	91	6	3	Sand
Aladja	Entisols	76	18	6	Sand loam
Sakpobe	Entisols	94	-4	2	Sand
Amukpe	Entisols	86	13	H (100	Sand

Some chemical properties of soils sampled from different ecological zones in south-western Nigeria.

Location	(CalCl ₂)		%	()	mg/kg	-	Excha	Exchangeable bases and acidity	ases and a	cidity	ECE	BS%			Minnon	1 / 1
						Ca	Mo	X	<u> </u>		C				and di	microfidulettis (IIIg/kg)
Basement Complex								7	Na	7			Zn	Fe	C	Mn
Osun State																
Ikirin	1												ŀ		ľ	
I Ni di	5.4	1.57	0.14	11.2	7.39	7.82	.48	.13	.25	-1	8 79	00 0	3			
IDOKUN	5.7	1.43	0.12	11.9	3.36	8.06	.82	09	2	:	, ,	99.0	1.3	1.1	1.5	12.3
lle-lfe	5.4	2.80	0.24	11.7	3.53	6.46	An is	3 3	124		9.32	99.0	1.7	1.8	2.1	4.9
lfetedo	4.4	2.89	0.25	11.5	2.69	3 79	3 5	.46	3 3	1.11	7.74	98.0	2.2	1.4	1,0	23.8
Ondo State	,					00		-	.22	1.11	5.56	80.0	1.2	2.8	0.6	9.3
Ado-Ekiti	5.1	2.64	0.23	11.5	3.66	6.57	0.32	3	14	5	72.					
Ondo	5.5	2.08	0.18	11.6	4.87	6 73					1.51	99.0	1.7	0.2	0.1	12.0
Ore	5.5	2.44	0.21	11.6	3.35	5.76	3 3			11	7.17	98.0	3.9	0.7	0.7	7.3
lpele	7.5	2.64	0.23	11 5	3 80	55.00	1 1	=	.12	111	6.52	98.0	1.9	1.5	0.4	6.2
Sedimentary Zone					1.00	22.60	· /a	.15	.24	.15	56.92	99.0	1.6	2.2	1.3	2.7
Edo State	<i>y</i>														-	
Ekpoma	4.7	1.60	0 14	111	3 80											
Ozalla	45	1 80			000	0.08	&	.16	.25	.99	7.97	87.0	2.3	œ. 3	0.1	8.8
	5	- 50	0.14	11.4	1.34	4.62	.28	.13	.25	1.07	6.35	84.0	1.7	0.4	03	130
Benin	4.3	2.90	0.25	11.6	6.82	3.66	30	3	2					0	:	10.0
Okala	4.6	3.31	0.28	11.8	3 84	4 60	3	; ;	į	- 5	5.54	79.0	5.7	1.5	0.1	4.3
Delta State				1		1.00	.30	.12	.22	1.03	6.42	84.0	1.2	0.5	0.1	7.8
Koko	4.4	1.88	0.16	11.8	2.69	3 10	3	3								
Aladja	4.3	2.49	0.21	+	454	3 3		.00	.22	1.11	4.92	77.0	2.0	3.1	0.1	2.7
Sakpoba	4.1	+	0.17	4	3 53	3 0	12	11	.60	1.15	5.13	77.0	1.2	3.0	2	1.4
Amukpo	4.3	+	+	\perp	30 00	20.2	1 . 1 .	.07	21	1.23	3.65	66.0	1.1	1.9	0.2	2.4
		ŀ	L	L	7.60	0.0	.22	.07	2	1 15	7 10	70 0		-		

Table 3: The performance of maize (*Zea mays L.*) varieties in soils from different agroecological zones in southwestern Nigeria.

Treatments	Heights (cm)	Leaf area (cm²)	Dry matter yield (g)	Dry matter yield (mg/cm)
OS ¹ M1 ²	80.75f ³	183.65b	4.60g	57.30e
ONM1	100.50b	169.00cd	5.97de	54.30f
EDM1	96.55bcd	184.25b	5.90de	61.20c
DEM1	89.65e	175.30bcd	6.10de	68.05bcde
OSM2	91.90cde	174.55bcd	4.99fg	54.30e
ONM2	109.05a	222.45a	8.20a	75.15abc
EDM2	98.05bc	211.45a	6.32cd	64.50cde
DEM2	89.10e	181.75bc	6.54cd	73.35abcd
OSM3	95.0bcd	177.45bc	5.37f	56.50e
ONM3	95.45bcde	171.70bcd	7.63ab	79.90a
EDM3	94.55cde	163.30d	5.99de	63.35de
DEM3	91.80cde	210.35a	6.98bc	76.05ab
SE±	1.91	4.02	0.25	3,38
Mean	94.36	185.43	6.22	65.33

- 1. States: 0S, Osun; ON, Ondo; ED, Edo; DE, Delta;
- 2. Maize varieties M1 = TZE comp 3x4 (Early); M2=TZPB-SR(Late); M3 = Suwan 1-Sr
- 3. Means followed by the same letters are not significantly different (P=0.05, DMRT).

Plant Growth

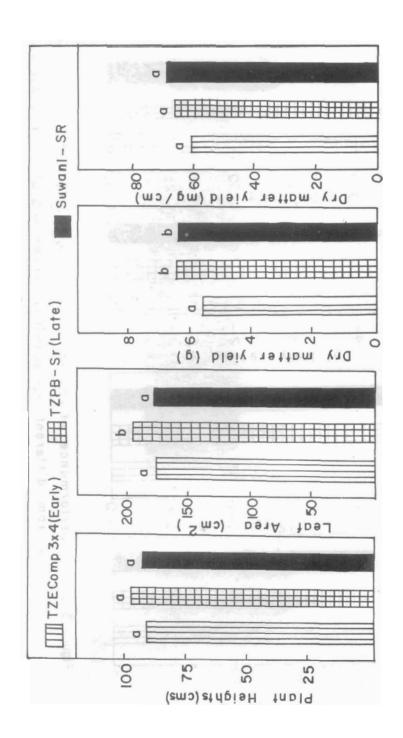
The maize and cowpea heights and leaf areas are presented in Tables 3 and 4. The values obtained for each variety at different sites within each state were averaged. The mean values for each variety over the four States are presented in Figures 2 and 3. While the three varieties of maize had the least growth in Osun State, both the early and late maize performed well in Ondo State. There was no significant difference in the growth of Suwan in the four States. Moreover, its leaf area was the highest in Delta State. This shows that Suwan is adaptable

to soils ranging from neutral to acidic reaction while early and late maize are somewhat sensitive to acidity. However, early and late maize had the highest leaf areas in Ondo and Edo States.

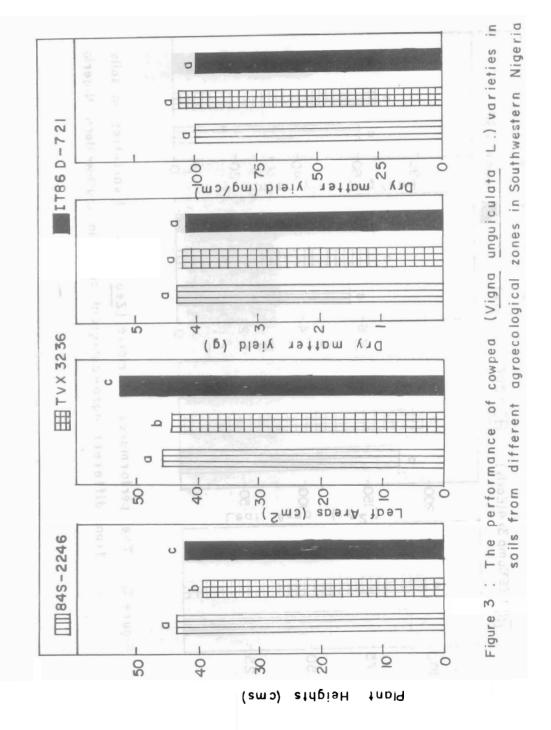
Table 4: The performance of cowpea (*Vigna unguiculata L.*) varieties in soils from different agroecological zones in southwestern Nigeria.

Treatments	Heights (cm)	Leaf area (cm²)	Dry matter yield (g)	Dry matter yield (mg/cm)
OS ¹ M1 ²	46.85a ³	41.55c	2.95e	62.95e
ONC1	47.05a	46.70bc	4.76b	101.05bc
EDC1	41.05bc	45.00bc	5.45f	132.70a
DEC1	40.20bc	47.60bc	4.37bc	108.70b
OSC2	40.60bc	39.95d	3.07c	75.60dc
ONC2	40.75bc	46.15bc	4.01cd	98.30bc
EDC2	42.35b	48.20b	6.25a	147.70f
DEC2	34.85e	46.55bc	3.55de	101.66c
OSC3	38.55cd	46.55bc	3.03e	78 5d
ONC3	46.05a	53.10a	4.14bcd	89.8 5cd
EDC3	47.10a	56.15a	6.23a	132.20a
DEC3	39.50de	54.40	3.30e	90.15cd
SE±	0.80	0.96	0.20	4.60
Mean	41.83	47.66	4.26	101.61

- 1. States: 0S, Osun; ON, Ondo; ED, Edo; DE, Delta;
- 2. Cowpea varieties C1 = 84S.2246; C2 = TVx 3236; C3=IT86D-721
- 3. Means followed by the same letters are not significantly different (P=0.05, DMRT)



from different agroecological zones in Southwestern Nigeria The performance of maize (Zea mays L.) varieties in soils Figure 2



On the average, while there was no significant difference in the heights of the three varieties, late maize had the highest leaf area (Fig. 2).

The three cowpea varieties had the lowest heights in Delta State (Table 4). This trend could be attributed to the acidity and low Ca content prevailing in these sandy soils. Low pH and available Ca are factors known to lead to poor legume performance in soil (Alexander, 1977). The leaf areas were generally not significantly different except in Osun State. With the soils in Osun State being in the medium to strongly acidic range, and also classified by Sobulo and Adepetu (1987) as being in the high fertility classes with respect to N,P and K, it is not very clear the trend obtained in this state. However, high soil N content is known to have a depressive effect on N₂ fixation (Fernandez and Miller, 1986). In terms of heights and leaf areas, 84S-2246 and IT86D-721 were the most adaptable to varying soil conditions (Fig.3). Such conditions include acidity, low available P, Ca, K, Cu, ECEC and base saturation.

Dry Matter Yields

The dry matter yields and efficiencies of dry matter accumulations are presented in Tables 3 and 4. The three maize varieties had low dry matter yields in Osun State on the basement complex. The same general trend way obtained for the efficiency of dry matter accumulation. As earlier stated, the reason for this is not too clear. Late maize and Suwan had the highest yields in Ondo State. The lower yields of these varieties in the acidic soils of Edo and Delta States compared to the medium acid to neutral soils in Ondo State demonstrate their tolerance to the adverse effects of acidity. On the average, late maize and Suwan were the most adaptable in terms of dry matter yields (Fig. 2). However, the efficiencies of dry matter accumulation were not different amongst the varieties.

Except in Delta State in the sedimentary zone, the cowpea varieties had the least dry matter yields and efficiencies of dry matter accumulation in Osun State (Table 4). The reason for this is not clear as N_2 fixation is normally favoured at the pH values prevalent in Osun State except at Ifetedo (pH 4.4). As stated earlier however, this trend might be due to the relatively high fertility of the soils (Fernandez and Miller, 1986; Sobule and Adepetu, 1987).

The three varieties had the highest yields in Edo State in the sedimentary zone. Amongst these varieties however, 84S - 2246 had the lowest yield. The variety 84^S - 2246 however performed better than the other two in the more acidic soils of Delta State. On the average, the cowpea varieties had similar potential to accumulate dry matter (Fig.3).

Correlation Studies

Correlation analyses were carried out between the indices of growth of maize and cowpea, and also between indices of growth and soil nutrient contents. Significant correlations (r = 0.83 **) were found between dry matter yield and leaf areas of maize and cowpea. This is attributable to the fact that leaves are the sites for primary production during photosynthesis.

While maize dry matter yields were significantly correlated with available P (r= -0.99***) and exchangeable K (r= -0.59*), those of cowpea were significantly correlated with extractable Zn (r= -0.91**), Fe(r=-0.76**) and Cu (r=-0.82**). These findings indicate the importance of macronutrients and micronutrients in the nutrition of maize and cowpea respectively.

Conclusion

In terms of dry matter yields, the three maize and cowpea varieties generally performed poorly in Osun State on the basement complex. An improvement could have been achieved if basal rate of fertilizer was applied to maize and cowpea seeds inoculated with rhizobia. The soil factor that most strongly influenced the adaptability of these varieties was soil acidity which in turn affected the base saturation, macronutrient (P and K) and micronutrient (Zn Fe and Cu) contents. While the cowpea varieties were equally adaptable in the range of soils, the maize varieties were tolerant to soil acidity. For sustainability of crop yields under low-input agriculture, the assessment of the adaptability of improved crop varieties to the prevailing soil conditions is of paramount importance. Further work needs to be done in the field in order to be able to make more specific recommendations.

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