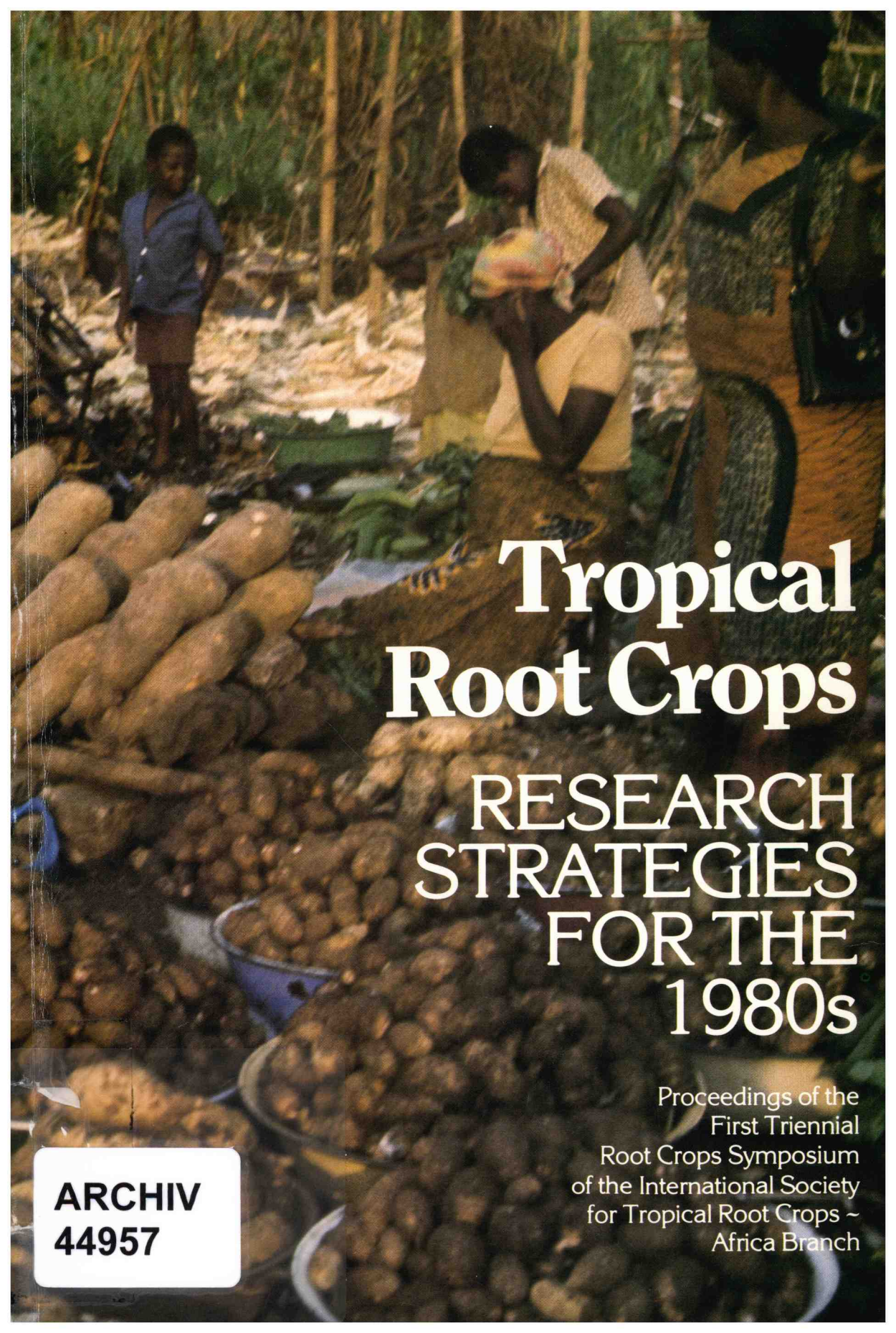




# Tropical Root Crops

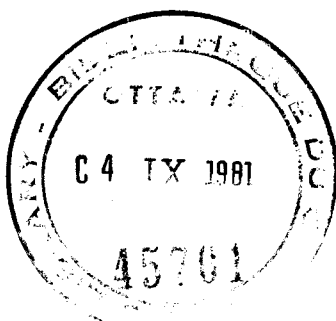
## RESEARCH STRATEGIES FOR THE 1980s

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## **TROPICAL ROOT CROPS: RESEARCH STRATEGIES FOR THE 1980S**

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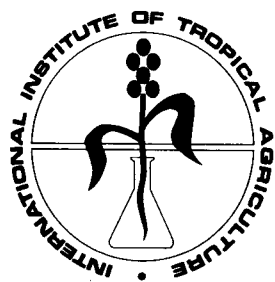
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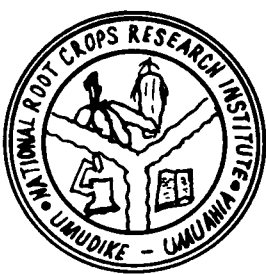
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# EVALUATION OF SOME MAJOR SOILS FROM SOUTHERN NIGERIA FOR CASSAVA PRODUCTION

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A pot trial was carried out with cassava and seven benchmark soils commonly used for cassava production in the forest and derived savanna of southern Nigeria. Soils from basement complex rocks from the forest zone (Araromi, Egbeda, and Apomu series) have higher potential for cassava production than those derived from sandy sedimentary rocks (Alagba, Onne, and Nkpologu series) or sandy soil from derived savanna (Shante series). Differential N, P, K, Mg, S responses and Zn deficiency were also observed among the seven soils. The data obtained can be used as a guide for fertilizer experiments.

Expérience de culture du manioc sur sept sols différents qui forment généralement la couche arable des forêts et savanes du sud du Niger où on produit cette plante-racine. Les sols de la zone forestière (Araromi, Egbeda et Apomu) produits par l'altération du socle rocheux ont un potentiel de production plus élevé que les sols de grès (Alagba, Onne et Nkpologu) ou les sols sableux des savanes (Shante). Les sept sols ont réagi différemment à l'apport de N, P, K, Mg et S et on a pu observer des carences en Zn. Ces données peuvent servir de base pour la conduite d'expériences sur les engrais.

In the traditional bush fallow system, cassava is usually grown as the last crop because of its ability to produce a reasonable yield on low fertility soils. However, cassava can produce high yields when grown on fertile soils or with judicious fertilization. In minikit trials carried out in East Central State, Nigeria, Ezeilo (1977) reported large and economic root yield increases ranging from 21 to 181% with NPK application. A number of investigators have reported responses to N, P, and K in cassava in various cassava-growing areas in southern Nigeria (Irving 1956; Amon and Adetunji 1973; Obigbesan

1977; Obigbesan and Fayemi 1976; Kang et al. 1980). As part of the Nigerian government's effort to increase food production in the country, emphasis has been given to the use of fertilizers to increase cassava yield. For this purpose, more and better data are needed about the responses of cassava to the nutrients contained in the soils of the major cassava-growing areas of the country. As one of the initial steps for obtaining the needed information, we carried out a greenhouse trial to assess the nutrient status of seven benchmark soils widely used for cassava production in southern Nigeria.

Table 1. General information on the seven soils used in the experiment.

| Soil order | Soil series | Location     | USDA classification   | Vegetation and land use      |
|------------|-------------|--------------|-----------------------|------------------------------|
| Alfisol    | Alagba      | Ikenne       | Oxic paleustalf       | Bush regrowth in forest area |
| Entisol    | Apomu       | IITA, Ibadan | Psammentic ustorthent | Grass fallow in forest area  |
| Alfisol    | Egbeda      | IITA, Ibadan | Oxic paleustalf       | Secondary forest             |
| Entisol    | Shante      | Ogbomosho    | Psammentic ustorthent | Derived savanna              |
| Alfisol    | Araromi     | Ishoya       | Oxic paleustalf       | Grass fallow in forest area  |
| Ultisol    | Nkpologu    | Umudike      | Typic paleudult       | Grass fallow in forest area  |
| Ultisol    | Onne        | Onne         | Typic paleudult       | Bush regrowth in forest area |

Table 2. Physical and chemical properties of soils used in the experiment.

| Soil series | Mechanical analysis (%) |      |      | pH  | Organic C (%) | Total N (%) | Bray-1 P (ppm) | Extractable cations (me/100g) |      |      | Extractable Zn (ppm) |
|-------------|-------------------------|------|------|-----|---------------|-------------|----------------|-------------------------------|------|------|----------------------|
|             | Sand                    | Silt | Clay |     |               |             |                | K                             | Mg   | Ca   |                      |
| Apomu       | 85                      | 7    | 8    | 6.0 | 1.13          | 0.18        | 6.0            | 0.25                          | 1.07 | 2.90 | 3.3                  |
| Alagba      | 81                      | 9    | 10   | 6.0 | 1.40          | 0.18        | 1.8            | 0.08                          | 2.00 | 3.20 | 2.4                  |
| Shante      | 91                      | 5    | 4    | 6.4 | 1.10          | 0.08        | 6.0            | 0.33                          | 0.07 | 1.70 | 0.8                  |
| Egbeda      | 70                      | 15   | 15   | 6.4 | 1.60          | 0.29        | 3.0            | 0.60                          | 2.40 | 4.10 | 6.8                  |
| Araromi     | 51                      | 19   | 30   | 6.0 | 2.50          | 0.39        | 6.3            | 1.20                          | 2.50 | 8.70 | 23.1                 |
| Nkpologu    | 87                      | 5    | 8    | 4.9 | 1.40          | 0.13        | 6.9            | 0.08                          | 0.50 | 1.20 | 0.7                  |
| Onne        | 81                      | 7    | 12   | 4.1 | 1.03          | 0.14        | 41.7           | 0.21                          | 0.23 | 0.38 | 1.5                  |

Table 3. Effect of fertilizer application and soil type on height (cm) of cassava variety TMS 30395 at 5 WAP.<sup>a</sup>

| Fertilizer treatment | Egbeda | Apomu | Alagba | Araromi | Onne | Nkpologu | Shante | Fertilizer mean |
|----------------------|--------|-------|--------|---------|------|----------|--------|-----------------|
| Control              | 19.8   | 21.8  | 13.0   | 18.8    | 15.8 | 17.0     | 14.0   | 17.1            |
| NPKSMg               | 21.5   | 19.8  | 20.8   | 17.8    | 17.5 | 17.3     | 15.3   | 18.5            |
| NPKS                 | 20.0   | 18.5  | 21.8   | 16.0    | 18.5 | 14.5     | 16.0   | 18.5            |
| NPKMg                | 19.8   | 17.8  | 23.8   | 15.5    | 13.5 | 17.5     | 14.0   | 18.3            |
| NPSMg                | 21.5   | 19.0  | 19.8   | 17.3    | 20.3 | 16.5     | 16.3   | 18.6            |
| NKSMg                | 15.8   | 17.5  | 14.8   | 18.0    | 18.3 | 14.0     | 16.0   | 16.3            |
| PKSMg                | 21.5   | 19.0  | 18.8   | 20.3    | 15.3 | 13.5     | 15.0   | 17.6            |
| Soil mean            | 20.0   | 19.3  | 18.9   | 17.9    | 17.0 | 15.8     | 15.5   |                 |

<sup>a</sup>Soil type: SE =  $\pm 0.72$ ; LSD 5% = 2.2; WAP = weeks after planting.Table 4. Effect of soil type and fertilizer application on plant dry weight (g) at 12 WAP.<sup>a</sup>

| Fertilizer treatment | Araromi | Egbeda | Apomu | Alagba | Onne | Nkpologu | Shante | Fertilizer mean |
|----------------------|---------|--------|-------|--------|------|----------|--------|-----------------|
| Nil                  | 20.0    | 16.4   | 13.8  | 11.8   | 15.4 | 9.6      | 10.5   | 13.9            |
| NPKSMg               | 23.9    | 19.7   | 21.4  | 20.4   | 15.7 | 16.2     | 14.5   | 18.8            |
| NPKS                 | 21.4    | 18.3   | 19.9  | 18.4   | 16.1 | 14.0     | 10.6   | 17.1            |
| NPKMg                | 18.8    | 15.1   | 15.7  | 17.3   | 14.3 | 14.5     | 9.9    | 15.1            |
| NPSMg                | 19.7    | 22.5   | 16.0  | 16.0   | 12.6 | 14.5     | 13.3   | 16.4            |
| NKSMg                | 19.0    | 13.3   | 15.1  | 14.5   | 13.9 | 14.6     | 14.2   | 14.9            |
| PKSMg                | 24.1    | 16.3   | 15.9  | 12.6   | 12.5 | 11.9     | 10.9   | 14.9            |
| Soil type mean       | 21.1    | 17.4   | 16.8  | 15.9   | 14.4 | 13.6     | 12.0   | 15.9            |

<sup>a</sup>Soil type: SE =  $\pm 0.82$ ; LSD 5% = 2.45; fertilizer: SE =  $\pm 0.72$ ; LSD 5% = 2.00; fertilizer treatment within soil type: SE =  $\pm 1.89$ ; LSD 5% = 5.3.

## MATERIALS AND METHODS

The list of soil samples used in the experiment is given in Table 1. Soil texture was measured by the hydrometer method; a 1:1 soil: water ratio was used in pH measurements with glass electrode; organic carbon was determined by a modified version of the Allison wet digestion method; total nitrogen was determined by the Kjeldahl method;

extractable phosphorus was determined with a Bray no. 1 extractant; exchangeable cations were extracted by 1 N ammonium acetate; and extractable zinc was measured after extraction with 0.1 N hydrochloric acid.

Plant samples were digested in a Tecator model 40 aluminum digestion block; the reagents were nitric, perchloric, and hydrochloric acids. Phosphorus was measured by means of a Technicon

autoanalyzer; potassium, by means of an EEC flame photometer; and zinc, with a Perkin Elmer model 403 atomic absorption spectrophotometer. Nitrogen was measured by a micro-Kjeldahl distillation method.

The greenhouse trial was a split-plot design with four replications. The seven soil types constituted the main plots; five fertilizer treatments were applied to subplots: NPKSMg, NPKS, NPKMg, NPSMg, NKSMg, PKSMg, and control (no fertilizer). N, P, and K were added at 100 ppm each and Zn and S added at 20 ppm each. Five kilograms of air-dried soil was used in each pot. Fertilizers were thoroughly mixed with soil, and the pots watered to field capacity. Four stakes of cassava variety TMS 30395 were planted in each pot and thinned after 2 weeks to two plants/pot. A top dressing with 25 ppm N was made at 5 WAP (weeks after planting). Plants were harvested at 12

WAP. Index leaf samples were collected at 8 WAP for Zn determination.

## RESULTS AND DISCUSSION

### SOIL ANALYSIS

Some of the characteristics of the soils used in the study are shown in Table 2. Except for the Araromi soil, which was sandy clay loam, all the soils were coarse, ranging from loamy sand to sandy loam. The Araromi soil, which is derived from amphibolitic rocks, showed the highest nutrient status; the Onne soil, which is derived from marine sediments, exhibited the lowest. Except for the Onne soil, the soils were low in extractable P; the soils derived from sandy sedimentary materials (Ikenne, Nkpologu, and Onne) were also low in exchangeable K. Also noteworthy is the high acid-

Table 5. N, P, K concentrations (%) in index leaf blade as affected by fertilizer and soil type (12 WAP).

|           | Eg-beda | Alag-ba | Apo-mu | Shante | Nkpologu | Onne | Araromi | Fertilizer mean |
|-----------|---------|---------|--------|--------|----------|------|---------|-----------------|
| N(%)      |         |         |        |        |          |      |         |                 |
| Control   | 4.5     | 3.5     | 3.9    | 3.2    | 3.1      | 4.4  | 6.0     | 4.1             |
| NPKSMg    | 5.0     | 4.2     | 5.4    | 4.4    | 4.9      | 5.3  | 5.5     | 5.0             |
| NPKS      | 5.2     | 3.8     | 5.2    | 4.9    | 3.4      | 6.4  | 5.9     | 5.0             |
| NPKMg     | 5.0     | 3.8     | 5.2    | 5.1    | 4.5      | 5.6  | 5.5     | 5.0             |
| NPSMg     | 5.2     | 4.0     | 5.0    | 4.6    | 3.6      | 5.3  | 5.7     | 4.0             |
| NKSMg     | 5.8     | 3.9     | 3.3    | 4.5    | 3.4      | 6.0  | 5.1     | 4.6             |
| PKSMg     | 4.5     | 3.6     | 4.5    | 3.4    | 3.1      | 4.9  | 5.0     | 4.1             |
| Soil mean | 5.0     | 3.8     | 4.6    | 3.8    | 3.7      | 5.4  | 5.5     |                 |
| P(%)      |         |         |        |        |          |      |         |                 |
| Control   | 0.14    | 0.22    | 0.18   | 0.25   | 0.15     | 0.16 | 0.17    | 0.18            |
| NPKSMg    | 0.30    | 0.28    | 0.20   | 0.32   | 0.24     | 0.23 | 0.20    | 0.25            |
| NPKS      | 0.20    | 0.13    | 0.30   | 0.32   | 0.22     | 0.24 | 0.22    | 0.23            |
| NPKMg     | 0.23    | 0.22    | 0.32   | 0.32   | 0.16     | 0.24 | 0.21    | 0.24            |
| NPSMg     | 0.30    | 0.20    | 0.31   | 0.26   | 0.24     | 0.30 | 0.34    | 0.28            |
| NKSMg     | 0.16    | 0.18    | 0.19   | 0.18   | 0.18     | 0.16 | 0.13    | 0.17            |
| PKSMg     | 0.32    | 0.30    | 0.30   | 0.39   | 0.23     | 0.21 | 0.28    | 0.29            |
| Soil mean | 0.24    | 0.22    | 0.26   | 0.29   | 0.20     | 0.22 | 0.22    |                 |
| K(%)      |         |         |        |        |          |      |         |                 |
| Control   | 2.60    | 1.10    | 1.30   | 1.64   | 1.30     | 1.33 | 2.94    | 1.74            |
| NPKSMg    | 2.90    | 1.39    | 2.63   | 3.15   | 1.50     | 2.00 | 3.10    | 2.38            |
| NPKS      | 2.90    | 0.85    | 2.60   | 2.46   | 1.54     | 3.10 | 2.60    | 2.29            |
| NPKMg     | 2.90    | 1.30    | 2.50   | 2.46   | 2.86     | 2.45 | 2.60    | 2.44            |
| NPSMg     | 2.11    | 0.75    | 1.77   | 1.10   | 1.12     | 1.35 | 2.20    | 1.49            |
| NKSMg     | 2.97    | 2.17    | 2.10   | 2.33   | 1.51     | 2.01 | 2.90    | 2.28            |
| PKSMg     | 1.40    | 1.41    | 1.26   | 1.77   | 1.60     | 2.49 | 2.79    | 1.82            |
| Soil mean | 2.54    | 1.28    | 2.03   | 2.13   | 1.63     | 2.10 | 2.73    |                 |

Table 6. Zn levels (ppm) in cassava leaf blades at 8 and 12 WAP.

| Fertilizer treatment | Egbeda |        | Alagba |        | Apomu |        | Shante |        | Nkpologu |        | Onne  |        | Araromi |        |
|----------------------|--------|--------|--------|--------|-------|--------|--------|--------|----------|--------|-------|--------|---------|--------|
|                      | 8 WAP  | 12 WAP | 8 WAP  | 12 WAP | 8 WAP | 12 WAP | 8 WAP  | 12 WAP | 8 WAP    | 12 WAP | 8 WAP | 12 WAP | 8 WAP   | 12 WAP |
| Control              | 27     | 62     | 20     | 31     | 23    | 62     | 24     | 54     | 29       | 56     | 30    | 54     | 33      | 64     |
| NPKSMg               | 32     | 40     | 27     | 38     | 32    | 39     | 18     | 16     | 30       | 32     | 41    | 44     | 41      | 55     |
| NPKS                 | 35     | 44     | 23     | 40     | 29    | 38     | 20     | 43     | 26       | 29     | 32    | 44     | 32      | 44     |
| NPKMg                | 38     | 32     | 26     | 37     | 39    | 43     | 21     | 22     | 26       | 69     | 38    | 42     | 38      | 45     |
| NPSMg                | 29     | 31     | 29     | 43     | 27    | 54     | 21     | 35     | 24       | 64     | 36    | 39     | 36      | 30     |
| NKSMg                | 39     | 56     | 23     | 44     | 36    | 61     | 26     | 48     | 26       | 67     | 33    | 44     | 33      | 60     |
| PKSMg                | 27     | 38     | 23     | 33     | 23    | 55     | 24     | 57     | 20       | 59     | 34    | 41     | 35      | 49     |
| Mean                 | 32     | 43     | 24     | 38     | 30    | 50     | 22     | 39     | 22       | 54     | 35    | 44     | 35      | 50     |

ity of the Onne and Nkpologu soils. In another study, the Onne soil was shown to have high levels of extractable aluminum.

#### PLANT GROWTH

Plant height, as measured at 5 WAP, varied significantly with soil types (Table 3). The mean plant height was very much affected by soil type. Though there were no significant differences attributable to fertilizer treatment, best growth was observed with complete treatment (NPKSMg).

The plant dry weight determined at 12 WAP probably gives a better indication of the productivity of the soil than does the height of plants (Table 4). The mean dry weight was also very much affected by soil type. The Araromi soil, which had the highest nutrient status, gave the highest dry weight. Yields from control treatments were lower than those from soils that had a complete fertilizer mixture. The treatments without nitrogen and phosphorus gave the lowest yields, averaged over all soils.

A comparison of the effects of fertilizer treatments on the various soils indicates that the plants responded to nitrogen treatment on Alagba, Onne, Nkpologu, and Shante soils; to phosphorus on Araromi, Egbeda, Apomu, and Alagba soils; to potassium on Araromi, Apomu, Alagba, and Onne soils. Also, dry-matter yield increases were observed with sulfur addition on all soils, but particularly on Apomu and Shante soils, and magnesium application significantly increased dry-matter yield from the Shante soil.

#### PLANT NUTRIENT STATUS

The index leaf blades taken at 12 WAP indicated that the Araromi soil sustained plants with the highest nitrogen status; the amount ranged from 5 to 6% and was not appreciably affected by fertilizer treatment (Table 5). Plants on other soils showed

marked increases in leaf nitrogen levels with N addition, although the levels in plants on the Alagba, Shante, and Nkpologu soils were still below the critical N level indicated by Howeler (1978). This may mean that application rates of 125 ppm N are not sufficient for these soils.

Plants grown on all soils showed marked responses in leaf blade phosphorus with P application. In general the blade levels without P application were lower than the 0.2% critical value reported by Howeler (1978).

Potassium was highest in leaves from plants on Egbeda and Araromi soils and lowest for plants on Alagba, Nkpologu, and Onne soils, which showed good responses to K application.

Low zinc levels were observed in leaf blades at 8 WAP (Table 6). Zinc deficiency symptoms were observed on plants grown on Alagba, Nkpologu, and Shante soils. The levels in plants showing deficiency symptoms ranged from 18 ppm to 27 ppm, which are below the critical level of 35 ppm reported by Howeler (1978). Levels improved substantially by the 12th week without any Zn addition, and the deficiency symptoms were scarcely discernible.

The data clearly showed some relationship between soils, crop growth, and plant nutrient status. It also appears that soils derived from basement complex rocks in the forest zone (Araromi, Egbeda, and Apomu series) have higher potential for cassava production than those derived from sandy sedimentary rocks (Alagba, Onne, and Nkpologu series) or sandy soil from derived savanna (Shante series).

The nitrogen responses in the Apomu, Shante, Alagba, Onne, and Nkpologu soils (Table 4) were to be expected because of the low N and organic C status of these soils. These responses are a reflection of the vegetative cover (Table 1).

The phosphorus responses observed in this pot trial (Table 4 and 5) may be related to the limited

soil volume used. As indicated by Kang et al. (1980), cassava has low external P requirements, and responses for field-grown cassava are not common.

The sandy entisols (Apomu and Shante) and soils derived from sandy sedimentary rocks (Alagba, Onne, and Nkpologu soils) are potentially more subject to potassium deficiency than are the others. The Shante soil from the derived savanna also showed potential for magnesium and sulfur deficiencies.

Though early zinc deficiency on the Shante and Nkpologu soils was expected because of their low zinc levels (Table 2), it was not expected on the

Alagba soil, which had adequate zinc levels. The disappearance of zinc deficiency later (12 WAP) may be related to the ability of the older roots to explore the entire soil volume.

Data from this trial may be useful in the planning of field fertilizer trials in the major cassava-growing areas of southern Nigeria.

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