Proceedings of the Indiana Academy of Science
(1988) Volume 98 p. 485-488.

SOIL AND PLANT ANALYSES RESEARCH IN SAHELIAN WEST AFRICA

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INTRODUCTION

The Sahelian zone of West Africa suffers from a very low level of food production. Low and variable annual rainfall (250-750 mm) during a 60- to 120-day rainy season is generally assumed to be the reason for the low food production. However, another major constraint to increasing food production in this region is the improverished soil characterized by low soil pH, organic matter (O.M.), fertility, and cation exchange capacity (Jones and Wild, 1975; Ohm and Nagy, 1985). Extremely variable plant growth usually is associated with these soils.

In 1979, Purdue University initiated a USAID supported farming systems project in Burkina Faso (then Upper Volta) to develop technology for increasing food production in this region of West Africa. As this farming systems project progressed, it became apparent that very little data existed in this region, concerning the mineral nutritional status of soils and plants. Thus, in 1984, a study was initiated to analyze some of the soils and cereal plants involved in the farming systems project to identify mineral deficiencies.

The major objective of this investigation was to analyze cereal crop plants and associated soils from the Sahel Region of Burkina Faso for the primary purpose of determining the mineral nutritional status of these crops. There is a great need for these data particularly in Burkina Faso.

MATERIALS AND METHODS

Soil and plant samples were collected during the 1984 growing season from farmer-managed experiments at five locations in Burkina Faso, which were a part of an USAID funded Farming Systems Project. The five locations were selected on the basis of soil type and geographic distribution. Corn, sorghum, and millet leaves were obtained, when the plants were near anthesis, dried, and sent along with soil samples to the Purdue Soil Testing Laboratory.

Plant mineral analysis was conducted by means of an emission spectrograph. Soil samples were analyzed for organic matter, pH, extractable P (Bray P_1), exchangeable K, Ca, and Mg, cation exchange capacity (CEC), and percent base saturation according to procedures outlined by Dahnke (1988). Sulfur analysis of soil samples was conducted at the University of Wisconsin Soil Testing Laboratory.

RESULTS AND DISCUSSION

Mineral composition of plants. Table 1 shows the ranges from low to high among the cereal leaf samples from the five locations in Burkina Faso. In order for these data to be meaingful, it is necessary to compare them with known critical

TABLE 1. Ranges in mineral composition of corn, sorghum, and millet leaves sampled at anthesis on five farmer-managed experiments in Burkina Faso, 1984. Critical concentration values for corn ear-leaves at tasseling are presented for comparison.

Element	Corn Ear-leaf* Critical Values	Cereal		
		Corn	Sorghum	Millet
	%	Range in Percent		
N	3.00	2.01-4.23	1.25-4.48	1.20-4.21
P	0.25	0.12-0.32	0.10-0.35	0.10-0.30
K	1.90	1.59-3.84	1.20-3.70	1.84-3.51
Ca	0.40	0.21-0.53	0.17-0.68	0.20-0.83
Mg	0.25	0.12-0.35	0.08-0.36	0.06-0.32
S	0.20	0.14-0.28	0.09-0.30	0.09-0.25
	mg/kg	Range in mg/kg		
Mn	15	29-123	22-126	35-78
Fe	25	108-286	110-339	109-373
B	10	4-16	3-10	2-12
Cu	5	6-13	4-14	5-17
Zn	15	21-52	22-86	16-45
Al	—	100-768	149-788	195-875
Na	—	13-82	7-76	25-115

* Melsted, *et al.*, 1967.

TABLE 2. Ranges in soil test values of soil samples taken from five farmer-managed experiments in Burkia Faso, 1984.

Analysis	Range*
Soil pH	5.0-8.0
P, ppm	0.5-120
K, ppm	45-499
O.M., %	0.29-4.05
Ca, ppm	140-3,000
Mg, ppm	36-530
S, ppm	0.5-16.5
CEC, meg/100 g	1-14
Base Sat., %	34.2-96.1

* A total of 141 soil samples.

values for these nutrient elements. Critical values for corn leaves at tasseling for the United States are also presented in Table 1 (Melsted, *et al.*, 1967). These comparisons reveal that deficiencies exist for all nutrient elements in the investigation except Mn, Fe, and Zn. No critical values are presented for Al and Na as these are not essential elements for plants.

The lowest leaf concentration of N is 1.20%, which is extremely deficient. However, this is not surprising, when one considers that a soil organic matter

content (the principal source of N) as low as 0.29% was observed in this study (Table 2). Also, low rates of nitrogen fertilizer and/or animal manure are traditionally applied by farmers in Burkina Faso. It is interesting to note that some high N concentrations were also observed, with the highest value being 4.48. Soil organic matter content in excess of 4% (Table 2) was also found in this study.

The low P values in leaves were not unexpected, as most soils in this region are known to be low in P. It is a common practice for farmers of this region to apply P fertilizer or animal manure in order to alleviate P deficiencies.

Table 1 shows the ranges in mineral composition found in corn, sorghum, and millet leaves. In general, the mineral concentrations in corn tend to be the highest, and millet mineral concentrations tend to be the lowest. This is to be anticipated because corn is less tolerant of low fertility soils than millet and sorghum. Consequently, farmers in this region grow corn only on the most fertile soils, and millet is relegated to the least fertile soils.

Soil analyses. The extremes in values of the various soil analyses are presented in Table 2. Although soil pH ranged from 5.0 to 8.0, most soils tend to be acid. Some soils tested very low in P, which is not uncommon for unfertilized soils of this region.

The lowest K soil test was 45 ppm exchangeable K and indicates a low K level using a standard for the Cornbelt. However, soil and plant analyses for K would indicate that it is not one of the most limiting nutrient elements, especially at the low yield levels common to the Sahel Region. The extremely high K soil test of 499 ppm exchangeable K is from a corn plot adjacent to a housing unit and indicates the use of "night soil," especially the urine fraction.

Soil organic matter content as low as 0.29% is a result of the very hot, dry climate and the resulting low total plant yields, along with a crop utilization program which often results in the removal of all, or nearly all, of the organic matter produced by the cereal crops.

Wide variations were found in exchangeable Ca and Mg values. The lowest Mg soil test of 36 ppm indicates a low level of Mg in the soil as values below 50 ppm are considered low. These low levels of exchangeable Ca and Mg are reflected in very low concentrations of Ca and Mg in the cereal leaves obtained from these plots (Table 1).

The wide range is S soil tests reflects the organic matter content of the soil, since S, as with N, in the soil is contained primarily in organic matter.

All CEC values tended to be low, ranging from 1 to 14 meg/100g. These values are not unexpected, since CEC is dependent upon the organic matter content as well as the type and content of clay.

The low base saturation values reflect the low levels of bases found in many of the soils of the Sahel Region.

SUMMARY

Soil and plant analyses from the Sahel Region of Burkina Faso strongly indicate that numerous mineral deficiencies exist in the commonly grown cereal crops. Lowest mineral levels were observed in millet plants, which are grown on the least fertile soils. Extremely low organic matter content and CEC would

suggest very low levels of availability of various nutrients, especially N and S. Based on the results of this survey study, it is obvious that greater emphasis should be placed on the soil fertility aspect of agronomic experiments conducted in the Sahel Region.

ACKNOWLEDGMENTS

This research was conducted by the Purdue University Farming Systems Unit (FSU) under the Semi-Arid Food Grain Research and Development Project (SAF-GRAD), P.O. Box 1783, Ouagadougou (Burkina Faso) and Contract AFR-C-1472 between the Agency for International Development and International Programs in Agriculture (IPIA), Purdue University, Lafayette, Indiana, U.S.A.

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