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FOLIAR CONTENT OF NUTRIENT ELEMENTS IN SUGARCANE GROWN AS A MONOCULTURE AT HAFT TAPPEH, IRAN[1]

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ABSTRACT

Analyses of sugarcane tissues for phosphorus, potassium, calcium, magnesium, Manganese, copper and zinc are reported. Continued cropping of irrigated cane producing heavy yields has reduced the potassium and the micronutrients. However, the calcium and magnesium levels have increased, and the phosphorus status has been improved by fertilization. Only phosphorus has thus far been required as a fertilizer. The foliar analyses are used to monitor the nutrient contents, to insure their adequacy and to set fertilizer practices to compensate for differential uptake related to soils and to cane variety.

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INTRODUCTION

Commercial sugarcane production is new to modern Iran. There is presently only one plantation, with an annual harvest from about 9200 ha, at Haft Tappeh in Khuzestan. Thus far, only two fertilizer elements are in regular use -- nitrogen and phosphorus -- although foliar applications of iron are also occasionally made. Since relatively high yields of cane (averaging 120 tons or more per ha) have been obtained for several years, it is important to insure that the other macro- and micronutrients are still being adequately supplied by the soil.

The advantages of analyses of sugarcane plant tissues, in contrast to soil analyses alone, for insuring that specific nutrients are not limiting crop production have been thoroughly discussed by Clements (3) and Samuels (9). The latter has detailed the various systems of foliar diagnosis in use as to the specific tissues, age of crop, number of samples, methods of analysis, etc. Some form of tissue analysis is now used by much of the sugar world (7), particularly where various soil types are farmed in the same locality.

From the first sugarcane crops at Haft Tappeh, the weekly or biweekly sampling of plants during the 24 weeks which include the period of grand growth (May to October) has been the basis for measuring growth and regulating irrigations and determining nutritional status and fertilizer applications.

Three questions should be asked of foliar analysis data: Are nutrient levels adequate? Are there important differences in respect to soil type and cane variety? What changes may be expected with time, under repeated cropping as a sugarcane monoculture?

Since expansion of sugarcane culture in Iran is planned, this paper presents some observations and interpretations of nutrient levels which may be of interest and use in farming this important crop.

MATERIALS AND METHODS

The data were obtained from sampling of the regular commercial crop and are based on more than 6500 determinations. The tissue sample consisted of 20 leaves, four leaves from each of 5 stalks harvested at different stations in 161 field blocks each representing about 50 hectares of the plantation. The sheaths of leaves numbered 3, 4, 5 and 6 (counting the unrolling spindle at the top as leaf No. 1), were separated from the blades, dried at 90 C to constant weight, ground and mixed, and dry-ashed at 550 C for analysis of the metals by atomic absorption spectrophotometry. Phosphorus was determined by a molybdovanadate colorimetric method adapted from Jackson (8) on separate samples of sheath tissue and in the second mature internode (usually below the point of attachment of leaf No. 7).

Copper, zinc and manganese have been expressed as parts per million dry weight of sheath. Calcium, magnesium and potassium are given as percentage sugar-free dry weight, the total sugar content of the sheath being subtracted in calculating Ca, Mg and K indices. Clements (4) found that expressing the potassium as a percentage of tissue moisture was generally more useful than the K-index alone in predicting response to potassium fertilization. Consequently, the K-H_2O has also been calculated from moisture determinations on the same sheath samples. At the same time, Clements advocated the use of the 5th mature internode of the stalk, in addition to the sheath, in obtaining the phosphorus index in the 2-year crop in Hawaii. However, the short growing season at Haft Tappeh precludes the use of the 5th internode. Our observations in numerous experiments has been that an amplified phosphorus index ("API"), as calculated from the phosphorus contents of the sheath and the 2nd mature internode, is useful (unpublished information).

The sampling scheme has been thoroughly validated as to macronutrients and is adequate for fertilization control at the plantation level. However, Gowing (6) showed that the sample coefficient of variation for micronutrients is substantially higher than for elements regularly applied as fertilizers in Hawaii, and a similar observation was made by Gosnell and Long in Rhodesia (5). This is apparently related to the natural distribution of micronutrients in the field. Thus, the sample size is minimal for assessment of these elements, but will probably be useful until the tissue contents eventually more nearly approach the critical values for nutrient deficiency. The coefficient of variation of the laboratory procedures in wet chemistry and atomic absorption has been established with chemical standards and standard tissue samples (unpublished work) as being well within that of field sampling variation.

There were sometimes differences in the tissue levels of an element related to month of sampling (June, July and August) and hence to growth of the plant. The three sets of determinations have been averaged in this report (nine weekly sets in the case of phosphorus). The two major commercial varieties, NCo 310 and CP 48-103, were represented by 40 and 100 fields respectively. There were only 16 fields sampled for CP 57-614, 4 for NCo 376, and 1 for Q 58. Modern commercial sugar cane varieties are genetically mostly interspecific hybrids of various forms of *Saccharum officinarum* with *S. spontaneum* and less often with S. sinense and *S. robustum*, according to Arceneaux (2). Since the crop is planted from cuttings, the varieties are internationally well-known, established entities.

The Haft Tappeh plantation area was previously a semidesert pasture, or in part farmed in the traditional shifting agriculture of the region. There are three main soil types (10, 11): Shush Soil Series, mainly clay loams; Haft Tappeh Soil Series, largely sandy clay loams; and the lighter and coarser Dez Flood Plain Soils. The Central Section of the plantation produced its fourteenth annual commercial crop in 1974-75, and has all three soil types in about a 10:5:1 ratio. The North Expansion, of Shush Soil Series only, and the South Expansion of Haft Tappeh Soil Series only have been cropped for one, two, or three years, in increments as the plantation has been doubled in field area. Hence, the comparison of the analyses from fields of the Expansion Areas, with analyses from the 5500 hectares of the Central Section, gives information on the changes which may occur in the course of time. The fields were initially somewhat salinized and most fields required leaching prior to planting sugarcane (10).

RESULTS AND DISCUSSION

A brief inspection of the data of Table 1 will show nearly all nutrients to be at adequate levels under the current criteria (3, 9). Although these are average values, thus far no field has consistently shown a level requiring fertilization with any item listed except phosphorus, and field experiments with potassium and micronutrient applications have shown no response.

When the plantation was started in the Central Section, regular application of phosphate was required to maintain acceptable levels of tissue phosphorus. Increasingly heavy cane yields have required applications of 200 kg P_2O_5 per hectare at planting, and 100 kg P_2O_5 after each harvest in most fields. In the newer Expansion Areas, the API values are still somewhat lower than in plants on the corresponding soils of the Central Section. Hence, phosphate fertilizer trials have more regularly shown response in the Expansion Areas than in the Central Section in recent years.

There is evidence also of differences between varieties in tissue phosphate levels, particularly in the newer fields. In the older fields, which have been fertilized for several years according to the requirements of the tissue analyses, these differences have been minimized. Thus, Variety NCo 310 in the North Expansion showed an average API of 2919 for 23 fields, and CP 48-103 showed an API of 2153 from 22 fields. In the Central Section, the comparison was 2937 vs. 2924.

Variety Q-58 (one field only, North Expansion) has shown increases in yields in a phosphate fertilizer experiment: 138, 147 and 151 tons of cane per ha and API levels of 669, 1212 and 1576. In addition, tissue levels of zinc were apparently depressed by phosphate application in this test and in one other, out of eight trials. Although it is clear that we do not regularly see this effect, it has been reported several times, e.g., by Ambler and Brown (1). Perhaps, like so many such interactions, it is most noticeable and important when one or the other nutrient is at critically low levels.

Table 1. Nutrient contents* of leaf sheaths of sugarcane, Haft Tappeh, Iran, 1974.

Nutrient:	Phosphorus API	Calcium index	Magnesium index	Potassium index	Potassium $K\text{-}H_2O$	Manganese, ppm	Copper, ppm	Zinc, ppm
Adequate level:	1800-2500	0.15	0.10	2.25	0.425	10	3	8
Varieties:								
NCo 310	2883	0.35	0.18	2.68	0.48	42	18	10
CP 48-103	2381	0.31	0.20	2.61	0.49	31	20	11
CP 57-614	2790	0.38	0.21	2.99	0.51	38	22	13
NCo 376	2388	0.37	0.22	2.17	0.37	48	16	10
Q-58	1940	0.37	0.22	3.30	0.53	42	19	8
Location:								
Central Sect.	2792	0.35	0.24	2.39	0.43	37	18	11
F.P. Soil	2622	0.35	0.20	2.79	0.48	32	21	13
Shush Soil	2957	0.35	0.24	2.20	0.42	38	17	11
H.T. Soil	2346	0.34	0.24	2.15	0.43	34	16	9
North Expansion								
Shus Soil	2527	0.30	0.15	3.36	0.53	30	21	10
South Expansion								
H.T. Soil	2019	0.29	0.17	3.23	0.55	34	21	11

* Dry weight basis. The Ca-, Mg-, and K-Index values are percentages of the sugar-free dry weight. The $K\text{-}H_2O$ is potassium as a percentage of tissue moisture. The API -- amplified phosphorus index -- is calculated from the phosphorus content of the sheath and the second mature internode.

We have found no field symptoms of zinc deficiency as yet at Haft Tappeh, although we do not consider the tissue levels to be more than adequate. This is one element to be closely watched.

As to the other two micronutrients determined, the levels of copper were adequate and those of manganese above critical value, although CP 48-103 was consistently lower in manganese than the other varieties and NCo 376 (4 fields only) was somewhat higher. Seven years ago, in a survey of 20 fields of the Central Section, these micronutrients and a few others were determined by chemical methods in leaf sheaths (10). No field was critically low and the averages for zinc, copper, manganese, boron, molybdenum and sulfur were 16, 12, 50, 2.9, 0.92 and 2800 ppm compared with adequate levels of 8, 3, 10, 1.5, 0.15 and 1500 ppm, respectively. The lower values obtained in the present study may indicate some decrease under our high-intensity cropping.

We also occasionally observe a chlorosis in certain places where the crop has not promptly resumed growth after harvesting -- owing to cool weather, delayed first irrigation, etc. This can be corrected by foliar applications of 1% ferrous sulfate as needed, but the chlorosis usually disappears when the new crop has set its own root system and becomes well established.

In respect to the calcium and magnesium indices, these were well above the deficiency levels. Interestingly, they seemed higher in the older Central Section fields than in the newer Expansion Areas. Continued cropping to sugarcane contributes annually some 10-20 tons of organic matter from the old root mass, and there are annual increments of nitrogen and phosphorus fertilizer, and particularly calcium and magnesium in the irrigation waters. Perhaps these features have created a more favorable soil environment and cation exchange ratios for uptake of these nutrients than has been historically available in the Expansion Areas. This is presently under study.

In contrast, both measures of potassium status show the Central Section fields to be distinctly lower than in the Expansion Areas, approaching levels where potassium fertilizer may be called for, e.g., in Variety NCo 376. There has been much less contribution of potassium from the Dez River irrigation water (0.03 meq/ as compared to calcium at about 2.5 meq/ and magnesium at about 1 meq/). However, in two experiments in the older fields of the Central Section, no response to potassium fertilizer was obtained in yields of cane or sugar. The experiment sites were selected where the K-H_20 values had been low but adequate in the previous planting. Perhaps no response would have been expected in these trials in this year, since the tissue levels in the unfertilized controls were 2.55 and 2.21 for the K-indices, and 0.48 and 0.45 for the K-H_20 in the two locations.

The points above are illustrative of the principles of foliar diagnosis, demonstrate that detectable changes can occur with continued farming, that the need for corrective measures can be forecast, and that varietal differences do occur, but can be minimized when this is important or desirable.

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