PLANT NUTRIENT DEFICIENCIES AND RELATED TISSUE COMPOSITION OF TANNIA (XANTHOSOMA SAGITTIFOLIUM)

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Deficiency symptoms have been described for tropical plantation crops but for many important food crops such symptoms have yet to be described. A series of studies is now underway to produce and record the symptoms of deficiency of food crops of importance to the West Indies. The results of studies on Pigeon Pea (Gungo pea) *Cajanus cajan* (Nichols 1964) and Sweet potato *Ipomoea batatas* (Spence and Ahmad 1967) have already been published.

This paper deals with the symptoms produced by lack of the major plant nutrients: nitrogen, sulphur, phosphorus, calcium, potassium, magnesium and iron on tannia, *Xanthosoma saggitifolium*. The authors have not been able to find any previous record in the literature of deficiency symptoms in this crop.

MATERIALS AND METHODS

Culture technique.

The sand culture technique used was modified from methods reported by Hewitt (1952) and was described in detail in a previous paper (Spence and Ahmad 1967). It consisted essentially of a series of clay pots, 20 cm. in diameter, coated inside with bituminous paint and filled with acid washed (10% hydrochloric acid) beach sand. Watering with nutrient solution was accomplished automatically by means of an air pressure pump controlled by a time switch. The solution was forced by air pressure from winchester flasks under each pot up a polythene tube passing through the centre of the pot, so that it was sprayed on to the surface of the sand.

The nutrient solutions were taken from Machlis and Torrey (1959) and the concentrations of the major elements in the control solution were (in milligram equivalents per litre of ions or radicals): Ca 10.0; K 6.0; Mg 4.0; NO_3 15; PO_4 3.0; SO_4 4.0. In the deficient solutions Na replaced K , Ca and Mg ;and Cl replaced SO_4 , NO_3 and PO_4 at equivalent concentrations. Plants were obtained by placing ½ inch thick slices of mother corms in sand in a plant propagator and allowing the buds to grow. After sprouting of the buds the sprouts were removed from the corm slices and kept in sand until they were properly established as independent plants. Watering was carried out with distilled water only. The plants were then transplanted to the sand culture pots and watered with the appropriate nutrient solutions.

Each treatment was replicated three times and there was one plant per pot.

Preparation and chemical analysis of tissue

After eight weeks symptoms had developed markedly and the plants were harvested for tissue analysis.

At harvest, sand was washed off the root systems in the greenhouse and the whole plants were brought to the laboratory for further preparation. Leaves and petioles, roots and corms were separated, prior to analysis. Samples were bulked for each treatment and washed in one percent detergent solution (Teepol) and then rinsed successively in three lots of distilled water, the water being renewed after every five washings. Samples were then dried at 80°C. and ground in a stainless steel micro-hammer mill. Fresh weight and dry weight of the separate parts were rocorded.

For total nitrogen and phorphorus determinations 0.1000 gm of the ground sample was digested with sulphuric acid and hydrogen peroxide; nitrogen was estimated by the micro-kjeldahl method and phorphorus by the molybdo-vanadate method (Jackson, 1960). Potassium, calcium, magnesium and iron were determined on samples ashed at 450°C.; the soluble residue was taken up with dilute hydrochloric acid and the solution was analysed for the various elements. Potassium was determined by the flame photometer, calcium and magnesium by the versenate method and iron by the thiocyanate method (Jackson 1960). Sulphur was determined on samples pre-treated with a 10 percent solution of magnesium nitrate and ashed at 450°C. Sulphur was precipitated as barium sulphate and determined gravimetrically.

RESULTS AND DISCUSSION

Tissue Analysis

The tissue analysis was not intended as a guide to nutritional status but rather as a check on the symptoms in relation to shortage of particular elements. However attention is drawn to certain trends which may provide interest for further study.

Results of tissue analysis of leaves and petioles, roots and corms are presented in Table 1.

Nitrogen, phosphorus and potassium occurred in lowest concentration in the corms. Calcium, magnesium, sulphur and iron were generally highest in the roots with leaves and petioles next.

Minus nitrogen was associated with low values for total nitrogen throughout the plant. This treatment resulted in low values for phosphorus and calcium in the corms and increased accumulation of sulphur in the leaves and petioles.

Minus phosphorus resulted in low tissue content of this element particularly for tubers. Nitrogen content was depressed for the leaves and petioles and corms but not for roots. Calcium was also depressed throughout the plant but iron accumulated in the roots.

Minus potassium resulted in low levels of potassium throughout the plant. This treatment led to high levels of calcium and magnesium and an accumulation of iron in the roots and corms. The relatively high level of potassium in this treatment (2.5 percent) and its association with severe deficiency symptoms indicate a high requirement of this crop for this nutrient.

No calcium led to low levels of calcium in the whole plant, but particularly in the roots and corms. High levels of nitrogen, phosphorus and potassium were

associated with lack of this nutrient in all parts of the plant. Sulphur accumulated in the roots and to a lesser extent in the corm.

Minus magnesium resulted in low levels of magnesium throughout the plant. Accumulation of phosphorus, potassium and calcium took place in the leaves and petioles and corms but not in the roots.

Lack of sulphur resulted in low levels of sulphur in the entire plant. Considerable accumulation of potassium took place in the leaves and petioles. Phosphorus reached a high level in this treatment for leaves and petioles and roots. Low values for iron occurred in the leaves and petioles and corms.

The no iron treatment was associated with low levels of iron in the plant, and particularly in the leaves. This treatment resulted in an increase in nitrogen in the leaves and petioles and roots but a slight depression in the corms.

It should be noted that in this plant there is a high proportion of petiole to lamina and this may be responsible for certain features of the tissue analysis data.

The data presented for a field sample of tannia leaf and petiole showing severe magnesium deficiency symptoms is of some interest here. This soil (Brasso Clay, Trinidad) has a low level of available magnesium and citrus growing on it shows magnesium deficiency symptoms associated with low levels of magnesium in the tissues (C.C. Weir, Peronal Communication). The level of magnesium in the tannia tissue was as low as for the minus magnesium treatment in the pot experiments.

Another interesting feature of the data was the very high levels of potassium and phosphorus especially in the leaves, petioles, and roots where these elements had been supplied. A high level of potassium was also noted in the sample of petioles and leaves taken from the field (Table 1).

Table 1

Results of Chemical analysis of leaves and petioles, roots and corms of the tannia plant

Treatment	N	P	K	Ca	Mg	S	Fe
			percent				(ppm)
			Leaves and Petioles				
— N	1.81	0.59	9.00	1.17	0.32	0.53	204
— P	2.85	0.31	9.40	1.44	0.34	0.15	227
— K	5.24	1.80	2.50	1.98	0.72	0.28	190
— Ca	4.22	0.69	12.40	0.55	0.56	0.26	256
— Mg	3.68	0.72	11.40	2.00	0.07	0.23	176
— S	3.85	1.27	14.20	1.60	0.58	0.13	100
— Fe	3.89	0.49	9.80	2.51	0.26	0.25	45
Control	3.57	0.47	8.90	1.97	0.20	0.20	152
*Field Sample	3.73	0.45	9.00	2.00	0.09	0.18	152
			Roots				
— N	1.48	0.69	9.38	1.92	2.00	0.12	550
— P	3.58	0.20	7.80	1.30	0.77	0.16	960
— K	3.22	0.53	1.20	3.40	1.32	0.49	800
— Ca	3.32	0.85	9.00	0.28	3.12	0.95	360
— Mg	3.36	0.59	8.40	1.32	0.22	0.35	696
— S	3.86	1.11	8.63	2.40	1.14	0.16	470
— Fe	3.86	0.65	6.30	2.95	0.92	0.55	190
Control	3.07	0.56	8.50	1.75	0.34	0.18	742
			Corms				
— N	0.52	0.37	1.42	0.20	0.27	0.14	214
— P	1.35	0.05	1.84	0.28	0.28	0.26	113
— K	4.21	1.35	0.40	1.15	0.57	0.44	400
— Ca	3.42	0.81	2.45	0.20	0.76	0.33	214
— Mg	2.50	0.65	2.70	0.56	0.20	0.25	214
— S	1.94	0.63	1.46	0.47	0.40	0.10	152
— Fe	1.94	0.43	2.00	0.62	0.47	0.18	155
Control	2.21	0.42	1.77	0.42	0.34	0.14	175

* Plant showing severe magnesium deficiency symptoms grown on Brasso Clay, Central Trinidad.

Deficiency Symptoms

(i) *Leaf*

Growth in complete nutrient solution

In the complete nutrient solution growth was vigorous and large leaves were produced. The laminae were a moderately dark green colour.

Growth in nutrient deficient solutions

Nitrogen: Growth was severely restricted and leaves with very small laminae and short petioles were produced. The leaves were pale green in colour.

Sulphur: Growth was somewhat restricted and leaves with relatively small laminae and short petioles were produced though the effect was not as severe as with nitrogen shortage. The leaves were uniformly pale green to pale yellow in colour.

Phosphorus: Growth was also affected by lack of phosphorus, small leaves with short petioles being produced. The colour of the leaves was unaffected. However, the leaves had a more shiny appearance lacking the bloom of control plants.

Calcium: Shortage of calcium produced restricted growth,smaller laminae and shorter petioles than in control plants. The laminae appeared thicker than in control plants and were somewhat leathery to the touch. As symptoms progressed the youngest leaf became distored with irregular chlorotic and necrotic patches. Leaves senesced rapidly at this stage, very small distorted leaves were produced and the plants finally died.

Potassium: Somewhat smaller leaves with shorter petioles were produced in comparison with control plants but the effect was not as great as with lack of nitrogen, sulphur or phosphorus. However, a distinct symptom appeared in the older leaves. Narrow water-soaked areas appeared at three or four points at the margin of the laminae, these areas rapidly drying to give thin papery grey to brown patches. Further, such areas developed on the margin until a narrow band of necrotic tissue existed from the tip to the shoulders of the laminae, the band penetrating for a short distance towards the centre of the leaf between the main veins. A narrow yellowish band occurred adjacent to the inner edge of the necrotic band.

Observations in early morning suggested an association between the appearance of the water-soaked areas and guttation. Guttation drops occured at the water-soaked points and in some instances a bladder had formed which later in the day dried out to give the characteristic dry papery patch.

Magnesium: Magnesium deficiency produced striking leaf symptoms, a bright orange colour appearing between the main veins, starting first towards the half of the lamina towards the tip and spreading over the whole surface of the lamina. Dark green bands remained along the main veins and first order secondary veins and also for some time along the marginal vein. The interveinal areas towards the tip then dried out and the leaves rapidly senesced. The sequence of symptoms on successive leaves was very regular, the orange colour appearing on the second open leaf just as the third leaf senesced. Thus usually only one leaf at a time showed these symptoms which progressed rapidly until the leaf senesced. The size of leaves was not affected but fewer leaves occurred than on control plants.

Very similar symptoms were observed on plants growing in a citrus field and as mentioned earlier, tissue analysis (Table 1) of such plants showed very low levels of magnesium.

Iron: Relatively mild symptoms or iron deficiency were obtained. Growth was not affected and an interveinal pattern of a lighter green colour appeared.

Narrow dark green bands remained on the main and first and second order secondary veins. It is intended to undertake further trials in an attempt to produce more severe iron deficiency symptoms.

(ii) *Roots and corms*

In the treatments lacking nitrogen, sulphur and phosphorus, a smaller root system was produced than in control plants and a fair size corm in relation to growth of the whole plant. The comparatively larger size corm in relation to leaves was most marked in the minus nitrogen treatment and was similar to effects of the same treatment given to sweet potato plants (Spence and Ahmad 1967) where a very restricted leaf area allowed development of a fair-sized tuber.

In the minus calcium treatment there was severe dying back of roots so that as marked leaf symptoms appeared there was little root system left and death of the whole plant occurred rapidly. The size of corm in relation to leaves was similar to the control plants.

Lack of potassium resulted in a small root system and magnesium deficiency was associated with dying back of roots. The minus iron treatment produced a root system similar to the controls.

SUMMARY AND CONCLUSIONS

Characteristic and severe symptoms of deficiency were produced by lack of the major plant nutrients nitrogen, sulphur, phosphorus, potassium, magnesium and calcium and mild symptoms with lack of iron.

Tissue analysis indicated low contents of the plant nutrients in relation to treatment. This analysis further indicated a high level of potassium in leaves and petioles and in roots, except where this nutrient was omitted.

The association of onset of potassium deficiency symptoms with guttation deserves further investigation.

A related edible aroid, *Colocasia antiquorum,* is reported to secrete up to 400 ml per day of almost pure water (Bennet-Clark, 1959). If, as appears to be the case for tannia, potassium deficiency upsets this system of secretion then further investigation may throw light on the symptom development and/or the mechanism of secretion.

Also of interest were the characteristic magnesium deficiency symptoms and the occurrence of such symptoms in the field in association with low magnesium content in leaf tissue of both tannia and citrus. This suggests the possibility for use of tannia as an indicator plant for magnesium deficiency.

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