MINERAL DEFICIENCY IN THE MULBERRY, *Morus indica* L.

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ABSTRACT

Major element deficiencies in mulberry seedlings (*Morus indica* L.) have been studied in solution cultures. The visual symptoms as well as the results of chemical analyses have been presented. In the light of the results, the feasibility of using such deficient plants for silkworm nutrition studies has been discussed.

INTRODUCTION

So long as mulberry remains the food of choice for the silkworm, *Bombyx mori* L., the nutrition of the mulberry plant itself will continue to have a profound influence on the nutrition of the insect. Since different stages of deficiency of one or more elements are not infrequently encountered under field conditions, it is desirable to have a clear-cut idea of the responses in the insects fed on leaves from such plantations. With a view, therefore, to get as complete a picture as possible of deficiency states for specific elements in the plant, solution culture methods, which offer an ideal answer for inducing the deficiency of specific elements to any desired degree, were tried with mulberry seedlings.

As may be witnessed from a perusal of the literature upto date, the use of solution culture methods on mulberry plant (either water or sand culture) has been restricted. Agata[1] conducted experiments on the sand culture of mulberry. Sano[2] reported that, besides nitrogen, phosphorus was more important than potassium for the normal growth of mulberry. In the present investigation major element deficiencies have been studied in mulberry seedlings by the application of the water culture method. The purpose of this paper is to discuss the visual symptoms observed as well as to report the chemical composition of the leaves exhibiting deficiency of the elements studied.

EXPERIMENTAL

Two series of experiments were conducted.

In the first, two month old mulberry seedlings were placed in 50% strong Arnon and Hoagland[3] solution (complete with micro-nutrients) contained in polythene beakers (400 ml cap.) coated on the outside with black paint.

'Hylam' sheet covers with bakelite supports were used for holding the plants. Each beaker held one seedling. After one month the seedlings were transferred to nutrient solutions deficient in nitrogen, potassium, phosphorus, calcium, magnesium and sulphur. Appropriate controls were maintained by continuing to grow some of the plants in the complete nutrient solution. The composition of the deficient solutions were identical with those reported by Hoagland and Arnon[4] with this difference that in the present instance the solutions were only 60% as strong as the original. For all the solutions pH was adjusted between 5.5-5.8. The molar compositions of the deficient solutions are indicated in Table I. Four plants were used for each of the deficient treatments. Solutions were replaced twice in a week. The progress of the visual symptoms was recorded for $1\frac{1}{2}$ months, after which, the plants in all deficiencies were taken individually for fresh weight determination. The shoot and root weights were recorded separately.

TABLE I

Composition of nutrient solutions
[Expressed as milli moles per litre]

	Nitrate	Potassium	Phosphate	Calcium	Magnesium	Sulphate
No deficiency (complete nutrient)	8.4	4.2	0.6	2.4	1.2	1.2
Nitrogen deficiency	0.0	3.0	0.6	1.5	1.2	2.4
Potassium deficiency	6.0	0.0	0.6	3.3	1.2	1.2
Phosphorus deficiency	8.4	3.6	0.0	2.4	1.2	1.2
Calcium deficiency	3.0	3.6	0.6	0.0	1.2	1.2
Magnesium deficiency	8.4	6.0	0·6	2.4	0.0	0.9
Sulphur deficiency	10.8	4.2	0.6	2.4	1.2	0.0

In the second series, four month old seedlings were used for the experiments with six plants for each of the deficient treatments, the solution composition and other experimental details remaining the same as in the previous series. The deficiencies, however, were not allowed to progress far. At the end of 15 days, when the plants in the deficient series had just started showing chlorosis of the leaves, they (aggregate of the young as well as the mature) were collected and dried in an oven at 100°C. The dry samples were used for the determination of nitrogen, potassium, phosphorus, calcium, magnesium and sulphur.

Nitrogen was estimated by the micro-kjeldahl method. Potassium, phosphorus, calcium and magnesium were estimated in acid digests of 1 *g*

quantities of leaf powder (Snell and Snell[5]). Potassium was estimated as the silver cobaltinitrate complex which gives an emerald green colour with choline chloride and potassium ferrocyanide[6]. Phosphorus was estimated by the method of Fiske and Subba Row[7]. Calcium was precipitated as the oxalate[8] and estimated by titration against standard potassium permanganate. Magnesium was estimated colorimetrically with Titan yellow[9]. Sulphur was estimated in separate acid digests as benzidine sulphate[10].

RESULTS AND DISCUSSION

The onset of visual signs was rapidly manifest in plants suffering from phosphorus and nitrogen deficiencies. Marked reduction in growth and other signs of deficiency were evidenced (Table II). Deficiencies in calcium, potassium and sulphur appeared later in the order mentioned. The magnesium deficiency was also severe but in one instance was somewhat difficult for interpretation because of an accidental omission, for six days, of potassium sulphate from the medium. (It was, however, observed that the leaf samples at the end of the expt. contained normal levels of sulphur).

DEFICIENCY SYMPTOMS

Nitrogen deficiency. This revealed itself as chlorosis of older leaves followed by a general paling and stunting of growth. The chlorotic old leaves were shed soon. Occasionally necrotic spots also were observed. The chlorosis of nitrogen deficiency was characterized by a mottled appearance on the leaves, severely chlorotic spots or areas appearing on the still green leaves, instead of the more common interveinal, generalized chlorosis. The plants hardly showed new growth.

Potassium deficiency. This was attended with the defoliation of older leaves but chlorosis was not pronounced. In two plants, the older leaves showed the characteristic marginal scorching and necrotic spots. The young leaves and buds tended to be deformed in advanced stages.

Phosphorus deficiency. The earliest sign noticeable was interveinal chlorosis of older leaves which spreads rapidly to the whole leaf. Marginal necrosis and defoliation soon followed. The plant did not produce new growth.

Calcium deficiency. Very characteristic symptoms appeared during calcium deficiency. It was marked by a deformation of the younger leaves (cupping). This was followed by necrosis along the veins. Slight paling of the leaves was also observed and as the deficiency progressed, the buds died out.

Magnesium deficiency. The effect manifested in the form of chlorosis of the older leaves. The effects during the later stages could not be considered

conclusive because of an inadvertant omission of potassium sulphate for a period of six days in the culture medium.

Sulphur deficiency. This was not evidenced clearly except as a general retardation in growth and the appearance of slight chlorosis. The roots of the plant tended to be long. Figs. I – VI show the deficiency effects in mulberry seedlings against the controls.

TABLE II

The shoot and root weight of mulberry seedlings in deficient solutions. (wts. in g; av. of 4)

Deficient Element	None	Nitrogen	Potassium	Phosphorus	Calcium	Magnesium	Sulphur
Shoot Weight	4.17	0.66	2.13	0.92	1.67	1.01	1.77
Root Weight	2.20	0.80	1.12	0.97	0.79	1.25	1.48

TABLE III

Effect of mineral deficiency of leaf composition.
[expressed as % of dry wt.]

	Nitrogen	Potassium	Phosphorus	Calcium	Magnesium	Sulphur
No deficiency (complete nutrient)	3 87	4.30	0.38	1.31	0.325	0.197
Nitrogen deficiency	2.96	3.43	0.38	0.97	0.351	0.380
Potassium deficiency	4.19	2.61	0.52	2.77	0.534	0.280
Phosphorus deficiency	3.78	3 16	0.24	1.54	0.360	0.277
Calcium deficiency	3.66	3.59	0.22	0.59	0.351	0.250
Magnesium deficiency	4.04	4.82	0.41	1.90	0.205	0.185
Sulphur deficiency	4.09	3.11	0.42	2.00	0.400	0.102

It may be observed from table III that complete withdrawal of the element from the solutions resulted in a drastic reduction in its concentration in the leaves. Slight variations in the concentration of the other components are also evident therein. Most of these variations can, however, be attributed to the concentrations used in the nutrient solutions (Table I).

A notable exception appears to be the low content of phosphorus in calcium deficiency although phosphate was provided at normal levels in the medium. Confirmation to the lowering in the phorphorus concentrations during calcium deficiency was also sought by analysing the leaf samples from the first series of experiments. Values of 0.53%, 0.30% and 0.425%, were

obtained for the control (grown in full nutrient), phosphorus deficient and calcium deficient plants respectively. From this it is evident that calcium has a role to play in the uptake of phosphorus by the plant. Supporting evidence for this view is available from the work of Tanada[11] who reported that phosphate uptake excised by roots was enhanced by calcium. Similar observations have been made by Legget.[12]

Although the leaves were taken for analysis before the appearance of visual symptoms, it is significant to observe the marked reduction in the concentration of the deficient element (Table III). Such leaves would seem to be ideally suited for studying the deficiency effects on the silkworm as at this stage the leaves might still supply other nutrients in adequate quantities particularly because the physiological damage is still not serious. The extent of damage caused to the insect will, however, depend on the insect's requirement for the element also. It has been found, for example, that 46% of the consumed nitrogen appears as larval nitrogen (calculated from Table II. Shyamala *et al*[13]). The corresponding figure for calcium, magnesium, phosphorus and potassium are 3.8, 17.1, 46.0 and 22.2% respectively (unpublished). It may be seen from these figures that whereas nitrogen and phosphorus are retained to the greatest extent the retention of calcium is low. This would mean that leaves deficient in nitrogen and phosphorus would limit the availability of the respective elements to the insect, whereas calcium deficient leaves would still supply adequate quantities of the element. However, since calcium deficiency is seen to affect phosphorus absorption, the leaves may still prove inadequate with respect to phosphorous. It is proposed to conduct further experiments to study the effect of deficiencies on the silkworms.

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