## Calcium Requirements of Higher Plants

The Hoagland nutrient solution for growing plants calls for the use of 0·004 or 0·005 M calcium and 0·002 M magnesium[1]. Plants grown in such solutions contain about the same amount of calcium as plants grown in soil. In the present investigation corn and tobacco plants have been grown with calcium levels 1/50 or less than that of Hoagland solutions. To accomplish this it was necessary to ensure that the copper level of the solutions was 200 p.p.b. or less, that unchelated iron was less than 0·5 p.p.m., that manganese was 0·5 p.p.m. or less, that zinc was 0·1 p.p.m. or less, and that magnesium was $5 \times 10^{-4}$ M or less. There were some variations due to plant species.

Calcium is required by some algae and other micro-organisms in micro-nutrient quantities only[2] and perhaps also for a gymnosperm[3]. Higher plants seemingly require relatively large quantities of it. The concentration of it in leaves of higher plants generally ranges from 0·2 to more than 5 per cent of dry weight[4]. There are a large number of experiments which indicate that higher plants benefit from the high levels of calcium which they contain.

Calcium-levels in leaves of from 200 to 800 p.p.m. of dry weight appear to be sufficient under some conditions (Tables 1 and 2). The magnesium-level simultaneously must be relatively low since high magnesium-levels can be very toxic under low calcium-levels[5]. The calcium and magnesium assays were made from wet digested samples with an atomic absorption flame spectrophotometer.

There is some indication also that with proper balance the magnesium requirement is also in the same magnitude as that of calcium. The lower limit of sufficient magnesium cannot be less than its need in chlorophyll. This amounts to a need of about 0·03 per cent magnesium on the dry weight basis. The co-factor requirements for magnesium in enzymatic reactions add roughly an additional 0·03 per cent to the magnesium requirement. This is based on a concentration of about 1 mM in the plant liquid. The total magnesium requirement, therefore, would be about 600 p.p.m. of dry weight. Critical magnesium levels for plants generally have been reported as from 0·2 to 0·3 per cent of dry weight for different plant species. This is around three times the postulated level. The difference has never been reconciled and may be related to the calcium-levels, which are usually high. The data in Table 1 indicate that the need for magnesium in tobacco may be from 800 to 1,200 p.p.m. of dry weight.

The plants grown without added calcium as described in Table 1 did have some indications of calcium deficiency as indicated by yields and by appearance of growing tips. When neither calcium nor magnesium was supplied the new leaves had an unnatural curl. The new leaves of these plants contained 80–90 p.p.m. calcium on the dry weight basis, which under the conditions of the experiment was slightly too low for maximum yield. Although these plants were decreased in yields by about 30 per cent they looked reasonably healthy. The relatively high calcium-levels of the old leaves on the plants was due to a pretreatment complete nutrient solution together with no retranslocation of calcium from old to new leaves.

Table 1. Yields and Calcium and Magnesium Contents of Tobacco Plants grown in Complete Nutrient Solutions except for Calcium and Magnesium

| Plant part | Differential treatments | | |
|---|---|---|---|
| | No calcium, no magnesium | 5 mM calcium, no magnesium | 5 mM calcium, 4 mM magnesium |
| | Dry weight/plant (g) | | |
| Shoot | 11·6 | 17·3 | 15·4 |
| Root | 1·7 | 2·1 | 2·3 |
| Whole plant | 13·3 | 19·4 | 17·7 |
| | Calcium (percentage of dry weight) | | |
| New leaves | 0·009 | 0·63 | 0·44 |
| New mature leaves | 0·008 | 0·57 | 0·39 |
| Remainder of shoot | 0·41 | 1·26 | 1·14 |
| Root | 0·048 | 0·44 | 0·23 |
| | Magnesium (percentage of dry weight) | | |
| New leaves | 0·08 | 0·08 | 0·22 |
| New mature leaves | 0·03 | 0·03 | 0·17 |
| Remainder of shoot | 0·12 | 0·10 | 0·28 |
| Root | 0·22 | 0·12 | 0·44 |

Table 2. Yields and Calcium Contents of Corn and Tobacco grown in Nutrient Solutions at Two Calcium Levels

| Calcium (p.p.m.) | Yield (g) | Leaf calcium (percentage of dry weight) |
|---|---|---|
| | Corn | |
| 2 | 5·1 | 0·011 |
| 5 | 4·8 | 0·020 |
| | Tobacco | |
| 2 | 18·6 | 0·08 |
| 5 | 18·6 | 0·10 |

The plant species have been grown in a number of nutrient solution cultures to test their need for calcium. They grew well at the low calcium-levels (Table 2). These data were obtained with 1 mM magnesium, 20 p.p.b. copper and chelated iron and indicate that from 100 to 200 p.p.m. calcium in corn leaves on the dry weight basis is sufficient and that not more than 800 is sufficient for tobacco.

There is considerable evidence that plants do not require all the calcium they ordinarily contain and the present investigation indicates that published critical levels do not reflect the direct need of plants for calcium. They reflect the ability of calcium to prevent injury from excesses of magnesium, copper, iron, manganese, zinc, and possibly other ions.

Corn and tobacco plants grew well in nutrient solutions at calcium-levels lower than 1/50 of that of Hoagland solution provided that levels of copper, iron, manganese, zinc and magnesium were in proper balance. The implication is that beyond ameliorating toxicities of other ions, the role of calcium in higher plants is that, or nearly that, of a micro-nutrient.

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## Introduction and Exchange of Coconut Planting Material

The presence of cadang-cadang, lethal yellowing, red ring and other serious diseases in important coconut growing areas, coupled with an awareness of genetic differences in palms in different parts of the world, has stimulated an interest in disease resistance testing. The occurrence of known resistance to lethal yellowing disease in Jamaica has served to emphasize the possibilities.

Pollen introductions greatly speed up the production and testing of hybrids between local and exotic material, but do not eliminate the necessity for seed importations[1]. Coconut seed often has low viability following shipment by sea, and the need for research on collection and dispatch has recently been emphasized[2]. Preparatory to survey and collection of coconut planting material[3], air freight and fumigation tests were therefore undertaken.

Short distance air freight (return trip to Miami from Jamaica) did not affect seed germination, and good germination was also obtained with samples introduced from Wallis Island and with seed exported to West Africa.

Germination of seed nuts with the husk removed is a standard procedure in Jamaica for the production of coconut seedlings for investigations of disease transmission. In a long-distance air freight experiment (Jamaica–England–Jamaica; at high altitude) equal