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Effect of seaweed concentrate on the growth and mineral nutrition of nutrient-stressed lettuce

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Abstract

The effects of the seaweed concentrate 'Kelpak' on the growth and mineral nutrition of lettuce plants grown under conditions of varying nutrient supply were investigated. Kelpak significantly increased the yield and the concentration and amounts of Ca, K and Mg in the leaves of lettuce receiving an adequate supply of nutrients, but had little effect on nutrient stressed plants. Results are discussed in relation to the physiological mechanisms that have been proposed to explain the beneficial effects of seaweed concentrate on plants.

Introduction

The application of commercial seaweed preparations has many beneficial effects on plants (Metting *et al.*, 1990). One explanation for these effects is that seaweed concentrates promote nutrient uptake. For example, workers have reported increased uptake of nitrogen (Booth, 1966; Cairozzi *et al.*, 1968; Senn & Kingman, 1978; Beckett & van Staden, 1989, 1990a); phosphorus (Booth, 1966; Caiozzi *et al.*, 1968; De Villiers, 1983); potassium (Booth, 1966; Beckett & van Staden, 1989); calcium (Senn & Kingman, 1978; De Villiers, 1983); manganese (Blunden, 1972); magnesium (Senn & Kingman, 1978), iron (Booth, 1966; Castillo, 1966) and zinc (Beckett & van Staden, 1990b). Precisely how seaweed concentrates promote nutrient uptake is uncertain. However, the organic molecules present in seaweed concentrates, e.g. organic acids and methionine, may chelate at least some nutrients thus increasing their bioavailability (Lynn, 1972). In addition, concentrates can increase root size, thus increasing the volume of soil sampled by a plant (Nelson & van Staden, 1984).

Apart from the brief study of Abetz and Young (1983), little is known about the effects of seaweed concentrates on lettuce. The aim of the present study was to use lettuce as a model system to determine whether seaweed concentrates can promote the uptake of Ca, K and Mg by plants. We predicted that if seaweed concentrates increase yield by increasing nutrient uptake, then their effect should be greatest when the plants are nutrient stressed.

Material and methods

Growth of plants

Seeds of lettuce (*Lactuca sativa* L. cv. Winter Crisp) were germinated in petri dishes and then planted in acid washed sand, one per 450 cm^2 plastic pot. Plants were grown in a glass house under natural lighting and temperatures. The mean minimum and maximum daily temperatures were 7.0 °C and 25.1 °C, respectively. Each treatment comprised eight pots arranged in a randomized block design. Watering, with minor variations, was with 100 ml of half, single or double strength Hoagland's nutrient solution (Hewitt, 1967) on the first day, 100 ml of distilled water on the second day and nothing on the third day of a three-day cycle.

Seaweed concentrate

The seaweed preparation used was 'Kelpak'. Kelpak is prepared from *Ecklonia maxima* (Osbeck) Papenfuss by a cold, cell-burst process. This process does not involve the use of heat, chemicals or dehydration, which could affect some of the organic components of the concentrate (Featonby-Smith, 1984). Plants received a root flush of 100 ml of distilled water, 0.20% Kelpak or 0.40% Kelpak per pot 15, 45 and 75 days after planting.

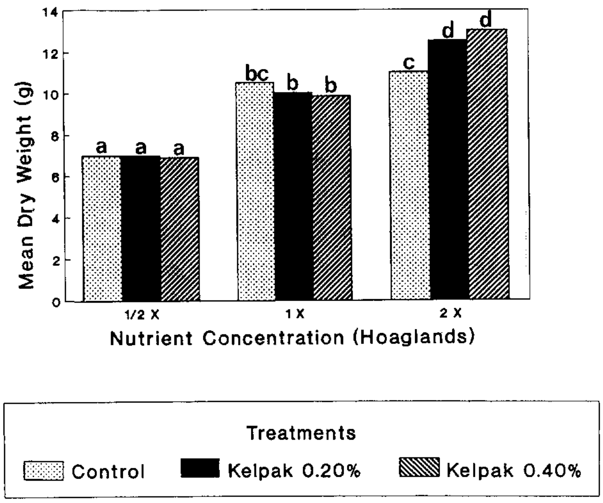

Fig. 1. Effect of nutrient supply and seaweed concentrate on the total dry weight of mature lettuce plants. Bars with the same letter on top are not significantly different using Duncan's Multiple Range Test ($P > 0,05$).

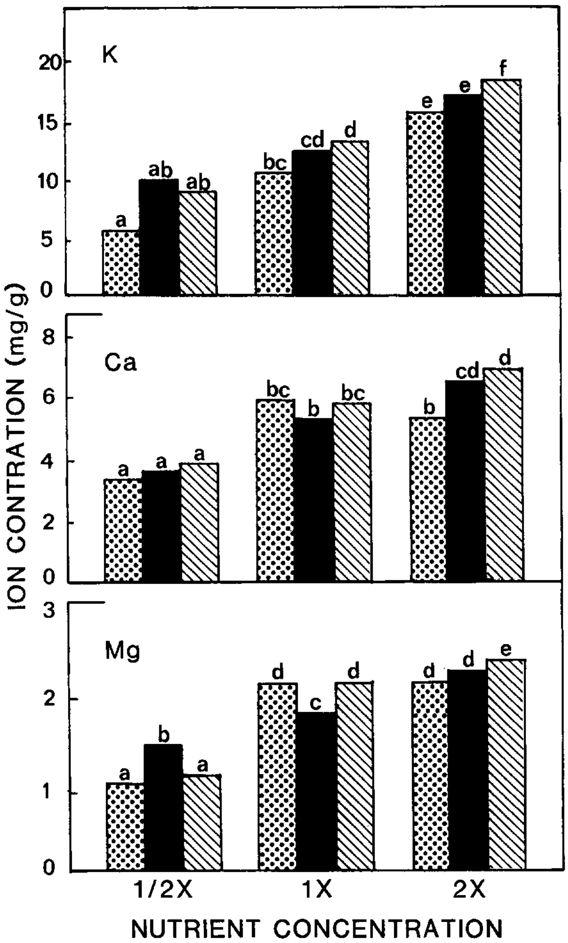

Fig. 2. Effect of nutrient supply and seaweed concentrate on the concentrations of potassium, calcium and magnesium in lettuce leaves. Bars with the same letter on top are not significantly different using Duncan's Multiple Range Test ($P > 0,05$).

Harvesting and cation analysis

Plants were grown to maturity (85 days), leaf surface area measured using a LiCor 3100 leaf area meter, and the leaves and roots dried at 80 °C and weighed. The Ca, K and Mg contents of the leaves were determined by atomic absorption spectrophotometry in an air/acetylene flame.

Results

Kelpak had little effect on plants receiving half or single strength nutrient solution, but significantly increased the yield of plants receiving double strength nutrient solution (Fig. 1). The concentrations of Ca, K and Mg in the lettuce leaves increased with increasing nutrient supply (Fig. 2). Kelpak significantly increased the concentrations of Ca, K and Mg in lettuce treated with double strength nutrient solution, but had little effect on plants that received a lower nutrient supply (Fig. 2). Although Kelpak slightly increased the concentrations of K and Mg in the low nutrient plants (Fig. 2) any increases in concentration were offset by lower yields (Fig. 1). As a result, calculations showed that Kelpak had little effect on the total amount (i.e. concentration multiplied by yield) of K and Mg in these plants.

Discussion

Results presented confirm the results of Abetz and Young (1983) showing that seaweed concentrates can improve the yield of lettuce. In plants receiving double strength Hoaglands nutrient solution, 0.4% Kelpak increased yields by 14% (Fig. 1) and leaf surface area by 11% (results not shown). Kelpak increased the amount of Ca in the leaves by 52%, the amount of K by 46% and the amount of Mg by 37%. Kelpak increased both the concentration and amounts of nutrients, strongly suggesting that stimulated nutrient uptake may, at least in part, explain the increases in yield.

Contrary to predictions, Kelpak had no effect on plants receiving a sub-optimal nutrient supply. It is difficult to explain why Kelpak only increased the yield and mineral nutrition of plants receiving an adequate supply of nutrients. Calculations show that the extra amounts of Ca, K and Mg taken up by plants treated with double strength nutrient solution and with 0.4% Kelpak were about ten times greater than that contained in the Kelpak. The implies that the Kelpak-induced increase in growth was not simply a fertilizer effect. Furthermore, if Kelpak were acting as a fertilizer, then it should have had its greatest effect on the nutrient stressed plants, which it did not. Kelpak did not increase the root to shoot ratio of the lettuce at any level of nutrient supply (results not shown), so increased root size cannot explain the increase in nutrient uptake in this instance.

It is interesting that Francki (1960a,b) found that the leaves of tomato plants treated with seaweed meal and foliar spray had taken up more manganese than was supplied in the seaweed itself. One possible explanation for this result and ours could be that, as discussed in the Introduction, the many organic molecules present in seaweed concentrates may chelate at least some nutrients, thus increasing their bioavailability (Lynn, 1972). Some workers (e.g. Blunden & Wildgoose, 1977) have suggested that the plant hormones present in seaweed concentrates are responsible for most of the improved growth and vigour of the plants. Increasing evidence exists that nutrient uptake and movement within plants is under hormonal control (Glass, 1989). Possibly the application of low concentrations of plant hormones can improve growth and nutrient uptake. While the physiological mechanisms responsible for the beneficial effects of seaweed concentrates on plants remains uncertain, this should not discourage their use. Results presented here show that Kelpak can significantly increase the yield and nutritional quality of lettuce. Kelpak will be most effective when applied to crops receiving an adequate nutrient supply.

Acknowledgements

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