

ARTICLE

Nutrient content in leaves of hydroponic lettuce (*Lactuca sativa* convar. *capitata* L.) on higher magnesium and nitrogen nutrient treatment

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ABSTRACT The aim of this study was to assess how the steadily increasing concentration of a physiologically important element, magnesium, can affect the content of certain nutritional elements in the leaves of the hydroponic cultivated lettuce (*Lactuca sativa* convar. *capitata* L.). The nutrient elements nitrogen, magnesium and calcium were determined in the leaves of lettuce after supplementation with magnesium. Increasing magnesium concentration in the nutrient solution caused decrease of nitrogen content of dry matter in the leaves from 4.94 m/m% to 4.39 m/m%. The concentration of magnesium increased from 0.303 m/m% to 0.571 m/m%, and that of calcium decreased from 0.723 m/m% to 0.358 m/m%, in the average of 4 repetitions. Increasing concentration of magnesium can be the consequence of increased amounts of magnesium supplemented while decrease of nitrogen and calcium can be explained by the phenomenon of attenuation.

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KEY WORDS

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Introduction

Lettuces are grown in extraordinary wide range of varieties, and by now turned from a seasonal vegetable into an all-year-round grown food. Modern technologies, such as hydroponic growing, permit continuous cultivation of lettuce for 12 months of the year. Average consumption of this plant increased during the previous decade because it fits into modern healthy nutrition. Lettuce (*Lactuca sativa* convar. *capitata* L.) is a significant, vitamin-rich vegetable. In growing without soil, lettuce shows several advantages such as faster development, higher average yield, balanced and scheduled development; furthermore, growing can be automated which is environment friendly and does not require significant manual labour (Morgan 1999).

Magnesium is a central component of chlorophyll, which has an essential role in photosynthesis; magnesium is also an essential metal in the plant metabolism, protein biosynthesis, and collaborates as a metallic catalyst in take and release of energy (Somos et al. 1980; Somos 1983; Terbe and Fehér 2000; Terbe et al. 2001; Terbe 2007; Terbe et al. 2011).

The temperature and humidity of the greenhouse can be easily controlled with the automated system. The nutrient solution can also be circulated multiple times a day. The ad-

vantage of the technology is that the plants grow at the same rate and the heads are harvested at the same time. Harvesting is a short and smooth process, so it makes an efficient use of human resources. This method can be used repeatedly, allowing continuous production throughout the year. Lettuce can be grown as much as six times on rock wool in a year.

Materials and Methods

Hydroponic experiment was conducted in the greenhouse of the Faculty of Horticulture of Kecskemét College (Hungary) at the end of September 2014. The lettuce seedlings were placed into rock wool cubes and put into hydroponic growing channels. In the experiment, the standard nutrient solution was supplemented with magnesium, in form of $Mg(NO_3)_2$ solution, in the doses of 50, 100, 150, 200 and 250 mg/l. In the control, plants were grown with standard nutrient solution.

The standard nutrient solution was made from the following water-soluble fertilizers (only highly soluble fertilizers were used): 666.7 g Ferticare komplex (N 14%, P_2O_5 11%, K_2O 25%); 733.3 g $Ca(NO_3)_2$ (N 15%, CaO 26%); 66.7 g KH_2PO_4 (P_2O_5 54%, K_2O 32%); 100 ml 60 m/v% H_3PO_4 added to 1000 l of water. The standard solution contained both magnesium and microelements: 14.7 g MgO; 0.67 g Zn, Cu, Fe, Mn; 0.13 g B; 0.013 g Mo per 1000 l of solution.

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Table 1. Lettuce head weight measured after Mg supplementation. Results are means \pm SD of five measurements. For statistical analysis Tukey HSD test was used.

Treatments	Mean (g)	Standard deviation	Significance level
Control	285.93	21.106	-
50 mg/l	231.79	31.123	0.000
100 mg/l	257.61	20.058	0.001
150 mg/l	205.18	30.804	0.000
200 mg/l	217.57	24.309	0.000
250 mg/l	203.86	23.418	0.000

The hydroponic tanks of 28 l volume were filled with fresh nutrient solution every week. In the hydroponic system watering with the nutrient solution was done using an automated pump. Circulation of the nutrient solution was started for 15 min at 10 and 14 o'clock.

Experimental plants were propagated by seeding. Seedlings were transplanted to multi-cell transplant raising trays on 3rd September, and the lettuce seedlings were placed into rock wool cubes, and put into hydroponic growing channels on 17th September. Each channel of the closed nutrient system had a separate container with a separate submersible pump to ensure adequate circulation of the nutrient solution for plants. The number of plants per plot was 28. The experimental design was a randomized blocks with 4 repetitions. Temperature in the greenhouse was between 15 and 20 °C. No chemicals or herbicides were applied. The first harvest took place on 14th November, and the biomass was recorded by measuring 7 plants from each treatment group.

Analytical tests were performed in the Soil and Plant Testing Laboratory of Faculty of Horticulture and Rural Development (Pallasz Athéné University, Kecskemét, Hungary). Standard analytical methods were used. Lettuce leaves were dried in LTE-OP-250 drying oven at 70 °C for 48 h and then were homogenized and digested by wet destruction. Total amount of nitrogen was tested by Kjeldahl method. Magnesium and calcium content of the samples were analyzed by optical emission spectrometer (ICP-OES method) (Mindak et al. 2014).

Electrical conductivity of the nutrient solutions was measured by laboratory EC-meter (type ORION 3Star) on 13th October in two repetitions, in two growing channels, respectively. Statistical analysis was done with SPSS v19 software (Huzsvai 2004). The mean difference was regarded significant at the 0.05 level ($P \leq 0.05$).

Results

For our statistics calculations we compared the growth of the Mg-treated lettuce to that of the control plants. Data about

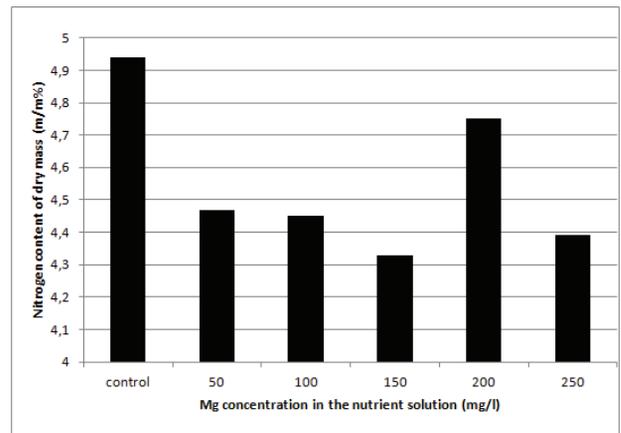


Figure 1. Nitrogen content of dry matter in the lettuce leaves (m/m%) after supplementation with Mg.

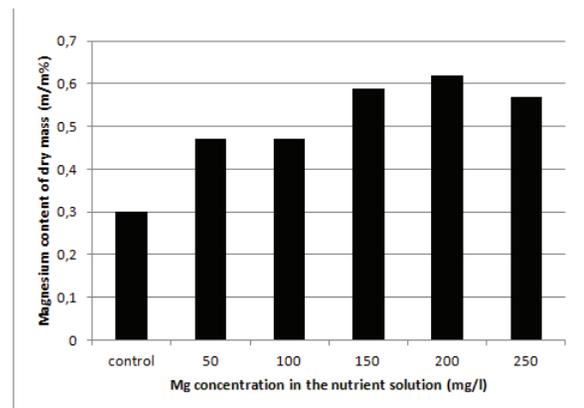


Figure 2. Magnesium content of dry matter in the lettuce leaves (m/m%) after supplementation with Mg.

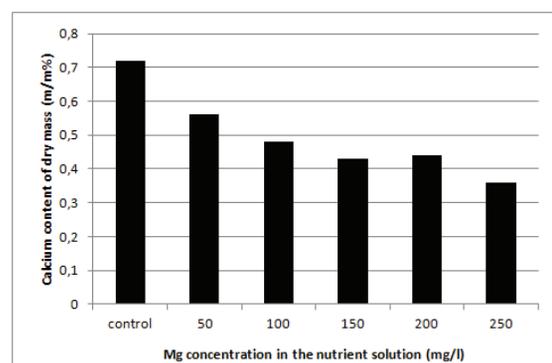


Figure 3. Calcium content of dry matter in the lettuce leaves (m/m%) after supplementation with Mg.

lettuce head mean weight are shown in Table 1.

We measured 28 plants from each treatment area. Minimum and maximum mass can be found in Table 1. The maxi-

imum weight was found in the control group, while the minimum was among the 150 mg/l and 250 mg/l treatments.

Nutrient element concentrations of nitrogen, magnesium and calcium were determined in the leaves of lettuce. Increasing magnesium concentration in the nutrient solution caused decrease of nitrogen content of dry matter in the leaves from 4.94 m/m% to 4.39 m/m% (Fig. 1). Magnesium concentration increased from 0.303 m/m% to 0.571 m/m% (Fig. 2), and calcium decreased from 0.723 m/m% to 0.358 m/m% (Fig. 3), in the average of 4 repetitions. Increasing concentration of magnesium can be the consequence of magnesium supplementation, while decrease of nitrogen and calcium concentrations can be explained by the phenomenon of dilution effect.

Discussion

Lettuce was grown using hydroponic cultivation in our study. Their growth was steady, but there was a great deviation in head weight, that is, magnesium treatment led to a significant decrease in head weight compared to control. The heaviest heads were found among the control plants (285.93 g), and the second heaviest, in the 100 mg/l treatment (257.64 g). Applying 200 mg/l magnesium led to 24% decrease, and 50 mg/l, to 19% decrease of lettuce head weight compared to the control. The effect of 250 mg/l and 150 mg/l was similar to each other.

Possibly due to a kind of antagonism, magnesium concentration blocked potassium uptake and thus led to the large differences in mass. Potassium is a mobile, translocating element and so the deficiency symptoms were first observed on the older leaves. Potassium deficient plants have reduced disease resistance, chlorosis and necrosis often occurs later in lettuce. Calcium deficiency symptoms were also noticeable. The roots had insufficient growth, the apices were mucous, turned brown, and subsequent necrosis was observed. In some

cases the growth of the plants failed to begin as the lettuce did not take up the nutrients at a proper rate.

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