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[1.]Viktor József VOJNICH

EFFECT OF MAGNESIUM TREATMENT ON HYDROPONIC LETTUCE

[1.]PallaszAthéné University, Faculty of Horticulture and Rural Development, Kecskemét, HUNGARY

ABSTRACT: The use of modern technology on hydroponic lettuce (*Lactuca sativa*convar. *capitata* L.) enables the cultivation throughout the year. The plant is a significant vegetable, rich in vitamins. The lettuce grown without soil may have several favourable properties such as faster growth, higher yields, balanced growth, well-automated, environmentally friendly technology and does not require significant manual labour. The experiments of hydroponic cultivation were carried out in the greenhouse of PallaszAthéné University, Faculty of Horticulture and Rural Development (Hungary). The plants were placed into stone wool, where the submersible pump provided proper moisture and nutrients to the roots. In the course of our experiments $Mg(NO_3)_2$ treatments were used (50-, 100-, 150-, 200-, and 250 mg/L). The highest biomass weight was measured in the control group, while the lowest biomass was measured after the 250 mg/L $Mg(NO_3)_2$ treatment. Increasing magnesium content depressed the growing of lettuce and antagonism with potassium and calcium was supposed as well. The average height of lettuce head reached 20 cm.
Keywords: hydroponic, lettuce, $Mg(NO_3)_2$ treatment, glasshouse, biomass

1. INTRODUCTION

The species of lettuces are grown in extraordinary wide variety nowadays. Lettuce turned from a seasonal vegetable into an all-year grown food. Modern technologies, by using hydroponic lettuce growing, permit continuous cultivation of lettuce for 12 months every year. The average consumption of the plant increased during the previous decade, so it can be inserted into modern healthy nourishment. Lettuce (*Lactuca sativa*convar. *capitata* L.) is a significant vegetable, rich in vitamins and minerals as well. Growing in hydroculture has several beneficial advantages compared to the soil growing as regard of: faster development, higher average of yield, balanced and schemed development. Furthermore, growing can be automated by electric technologies, in an environmentally friendly way, and the production does not require significant manual labour [1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23].

By the use of an automated (electronic technology) system, the nutrient solution can circulate several times a day in the hydroculture channel system.

Magnesium is a central component of chlorophyll, which has a unique role in photosynthesis; magnesium is an essential metal in the plant metabolism, protein biosynthesis, and collaborates as a metallic catalyst in take and release of energy [24,25,26,27,28].

The aim of this research was to determine the optimal nutrient concentration of magnesium and to quantify the proper fertilizer concentration for hydroponic lettuce cultivation in the aspect of biomass production.

2. MATERIALS AND METHODS

Our hydroponic experiment was conducted in the greenhouse of the Faculty of Horticulture and Rural Development at the PallaszAthénéUniversity. The plants were placed into stone wool (grodane), where the submersible pump provided proper moisture and nutrients to the roots. During the course of the experiment, the magnesium supplements were added in the form of $Mg(NO_3)_2$ The following doses of magnesium were added to the standard nutriment solution in our experiment: 50-, 100-, 150-, 200-, 250 mg Mg/l solution. In the control treatment plants were grown with the use of standard nutriment solution without magnesium supplement.

The necessary nutrient solution was made from the following water-soluble fertilizers: 666.7 gFerticarekomplex (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%); 100ml 60 m/V% H_3PO_4 added to 1000 liters of water.

We filled the hydroponic tanks of 28 liters (Fig. 1) with a new nutrient solution every week. Only highly soluble fertilizers were used. In the hydroponic production watering with the nutrient solution was done using an automated pump system, two times a day for 15 minutes. On the main switch we configured when the submersible pump should be active. The circulation of the nutrient solution started at 10 and 14 o'clock.

Figure 1. The 28 ltanks

The nutrient solution was pumped into the gravity cup (Figure 2), then with the help of gravity it got into the channel through the pipe network.

Experimental plants were propagated by seeding and subsequent transplant raising in greenhouse. Seedlings were transplanted to multi-cellular transplant raising trays on 3th of September 2014. The lettuce seedlings were placed into rock cotton cubes, and put into hydroponic growing channels on 17th of 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. The temperatures in glasshouse were between 15-20 °C. No chemicals or herbicides were applied. The first harvest took place on 14th of November 2014, when the biomass was recorded. In each treatment 7 plants were measured.

Electrical conductivity in nutrient solutions was measured by laboratory EC-meter (type ORION 3Star) on 13th October in two repetitions, in two growing channels, respectively.

Figure 2. The gravitycup

The statistical analysis was accomplished with SPSS v19 software [29]. The mean difference is significant at the 0.05 level. Following harvest, the leaves of lettuce were dried in a LTE-OP-250 drying oven in the laboratory. In the course of the experiment, the nutrient element concentrations nitrogen, magnesium and calcium were determined in the leaves of lettuce.

3. RESULTS

The lettuce grew at a proper rate in the stone wool. The leaves turned yellow and brown when using solutions of higher concentrations. For our statistics calculations we compared the growth of the Mg-treated lettuce to that of the control plants. The development of the lettuce head weight is shown in Table 1, Table 2 and Table 3.

We measured 28 plants from each treatment area. The minimum and maximum mass can be found in Table 1. The maximum weight was found in the control group, while the minimum was among the 150mg/l and 250mg/l treatments.

Table 1. Tukey HSD test of lettuce. Values of the five treatments were measured in 2014 (Parameter: lettuce head weight)

Treatments	Mean (g)	N	Standard Deviation	Minimum	Maximum
Control	285.93	28	21.106	246	312
50 mg/L	231.79	28	31.123	162	268
100 mg/L	257.61	28	20.058	201	296
150 mg/L	205.18	28	30.804	161	256
200 mg/L	217.57	28	24.309	176	253
250 mg/L	203.86	28	23.418	167	251

Table 2. Tukey HSD test of lettuce. Values of the five treatments were measured in 2014 (Parameter: lettuce head weight). *The mean difference is significant at the 0.05 level.

Treatments (A)	Treatments (B)	Mean difference (A-B)	Standard Error	Significance level
Control	50 mg/L	54.1428*	6.8179	0.000
	100 mg/L	28.3214*	6.8179	0.001
	150 mg/L	80.7500*	6.8179	0.000
	200 mg/L	68.3571*	6.8179	0.000
	250 mg/L	82.0714*	6.8179	0.000

The magnesium treatment led to significant decrease in each case (Table 2). The average mass homogenity is shown in Table 3.We took samples from the hydroponic tanks to test their EC. Changes in the electrical conductivity are shown in Figure 3 and Figure 4. The control had the lowest EC values (1.95 and 2.05 mS/cm) and the 250 mg/l the highest (3.68 and 4.00 mS/cm). The EC values increased along with the magnesium concentration.

Table 3. Tukey HSD test of lettuce. Means for groups in homogeneous subsets are displayed auses Harmonic Mean Sample Size = 28.000.

Treatments		N	Subset for alpha = 0.05			
			1	2	3	4
Tukey HSD[a]	250 mg/L	28	203.86			
	150 mg/L	28	205.19			
	200 mg/L	28	217.57	217.57		
	50 mg/L	28		231.79		
	100 mg/L	28			257.61	
	Control	28				285.93
	Significant		0.340	0.300	1.000	1.000

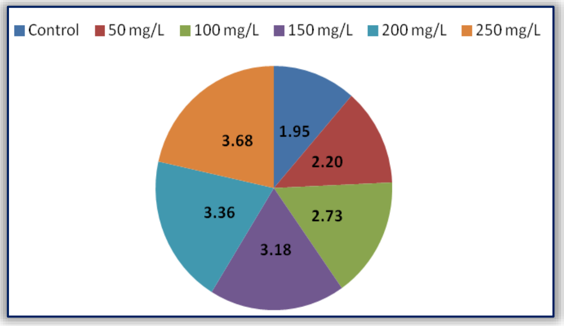

Figure 3. EC of the nutrient solutions in the treatment groups of I[st] repetition

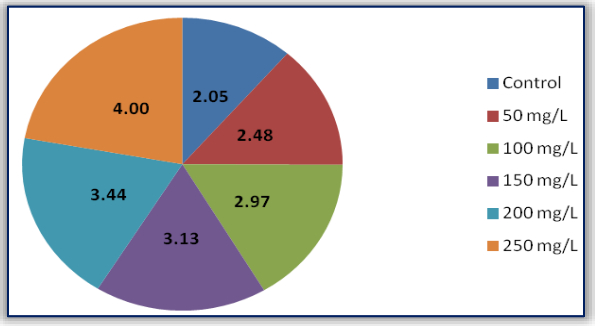

Figure 4. EC of the nutrient solutions in the treatment groups of II[nd] repetition

4. CONCLUSIONS

Despite the widely and commonly used traditional agricultural production technologies, hydroponic growing also has a great role nowadays and in the future as well. In the course of our experiment we found that the easily purchased materials (stone wool, medium raw material) can be used cost-effectively in the hydroponic cultivation.

Human labor is only needed for planting into stone wool, filling in the nutrient solution and harvesting. More work is needed for production on a field. In the case of hydroponic growing there is no need for weeding, fertilizing or groundwork. The leaves turning brown and rotting can be avoided with using adequate nutrient solutions. Higher salt concentration or excessive nutrient ratios may easily cause inadequate growing or disorders.

The lettuce was grown using hydroponic cultivation in our study. Their growth was steady, but there was a great deviation in head weight. While measuring the hydroponic lettuce we found that the magnesium treatment led to a significant decrease in head weight, compared to the control group.

We measured the heaviest mass among the control plants (285.93 g). The 250 mg/l and 150 mg/l plantations had similar results to each other. The 200 mg/l treatment led to a 24% decrease compared to the control. The second heaviest heads of lettuce were found in the 100 mg/l treatment (257.64 g). The mass of the 50 mg/l treatment was 19% less than that of the control group.

As a supposed result of some antagonism, the magnesium concentration blocked the 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. The potassium deficient plants have a 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 mucoid, they turned brown and subsequent necrosis was observed. In some cases the growth of the plants did not begin, as the lettuce did not take up the nutrients at a proper rate.

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 advantage 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 stone wool in a year.

References

[1.] BALÁZS, S., 1994, A zöldségtermesztőkkézikönyve. MezőgazdaKiadó, Budapest;

[2.] BALÁZS, S., 2000, A zöldséghajtatáskézikönyve. MezőgazdaKiadó, Budapest;

[3.] BALÁZS, S., FILIUS, I., HODOSSI, S., 1987, Zöldségkülönlegességek. MezőgazdaKiadó, Budapest;

[4.] BUDAI, CS., 2002, Növényvédelem a zöldséghajtatásban. MezőgazdaKiadó, Budapest;

[5.] BUDAI, CS.,CSÖLLE, I., TERBE, I., 1993, A hajtatottnövényektrágyázása. MezőgazdaKiadó, Budapest;

[6.] BUDAI, CS., CSÖLLE, I., TERBE, I., 1997, Primőrökvédelmében. MezőgazdaKiadó, Budapest;

[7.] GEISSLER, T.H., 1990, GemüseproductionunterGlas und Plaster - DeutscherLandwirtschaftsverlag, Berlin;

[8.] HODOSSI, S., KOVÁCS, A., TERBE, I., 2009, Zöldségtermesztésszabadföldön. MezőgazdaKiadó, Budapest;

[9.] KOVÁCS, A., 2000, Talajnélkülitermesztés. A zöldséghajtatáskézikönyve. MezőgazdaKiadó, Budapest;

[10.] KOVÁCS, A., 2000, Vízkultúráséskonténerestermesztés. MezőgazdaKiadó, Budapest;

[11.] KOVÁCS, A., 2005, Vízkultúráséskonténerestermesztés. In: Terbe, I.; Hodossi, S.; Kovács, A. Zöldségtermesztéstermesztőberendezésekben. MezőgazdaKiadó, Budapest;

[12.] LEDÓNÉ, D.H., 2012, Ahazaisalátatermesztésről. Zöldség – GyümölcsPiacésTechnológia, Budapest. 16(11-12), pp. 14-15.

[13.] MORGAN, L., 1999, Hydroponic lettuce production. Casper Publications, Narrabeen, Australia;

[14.] TERBE, I., 2000, Levélzöldségfélék. DinasztiaKiadó, Budapest;

[15.] TERBE, I., HODOSSI, S., KOVÁCS, A., 2005, Zöldségtermesztéstermesztőberendezésekben. MezőgazdaKiadó, Budapest;

[16.] TERBE, I., 2005, Levélzöldségekhajtatása. MezőgazdaKiadó, Budapest;

[17.] TERBE, I., PAP, Z., 2008, Talajnélkülizöldséghajtások. MezőgazdaKiadó, Budapest;

[18.] TERBE, I., SLEZÁK, K., 2008, Talajnélkülizöldséghajtatás. MezőgazdaKiadó, Budapest;

[19.] TOMPOS, D., 2008, A fejessalátatalajnélkülitermesztése. MezőgazdaKiadó, Budapest;

[20.] Hüvely A., Buzás I., BorsnéPető J., TóthnéTaskovicsZs. 2011, Examination of the arsenic accumulating capacity of lettuce growing in aggregate hydroponics under the influence of arsenic polluted nutrient solution. 1stTransilvanian Horticulture and Landscape Sudies Conference, 2011. ápr. 8-9. Marosvásárhely, 35. p., ActaUniversitatisSapientiae. Agriculture and Environment, 3, 122–131.

[21.] TóthnéTaskovicsZs., Pető J., Hüvely A., Kovács A. 2014, The effect of some plant conditioning materials on the quality and quantity of green pepper. Proceedings of TEAM 2014 6th International Scientific and Expert Conference of the International TEAM Society 6(1) pp. 86-88. 10–11th November 2014, Kecskemét.

[22.] Ferencz Á. –Marselek S. (2008): Üzemtan. In: Zöldségtermesztésszervezéseésökonómiája. Szerk. Nábrádi A.-Pupos T.-TakácsnéGy. K., SzaktudáskiadóHáz Budapest, 88-115.p.

[23.] NótáriM. – Ferencz Á. (2013): Harmonizing quality criteria of regional horticultural products and customers' decision in Hungary. Procedia-Social and Behavioral Sciences (Elsevier) Vol. 81. pp. 672-677.

[24.] SOMOS, A., 1983, Zöldségtermesztés. AkadémiaKiadó, Budapest;

[25.] TERBE, I., FEHÉR, M., 2000, Levélzöldségek. In. Balázs, S., (Szerk.) A zöldséghajtatáskézikönyve. MezőgazdaKiadó, Budapest;

[26.] TERBE, I., SLEZÁK, K., KAPPEL, N., TÓTH, K., 2001, A termésminőségés a tápanyagellátásösszefüggése a zöldségtermesztésben. Integrálttermesztés a kertészetiésszántóföldikultúrákban XXII. Növény-ésTalajvédelmiKözpontiSzolgálat. 2001. Nov. 27. Budapest. pp. 83-93.

[27.] TERBE, I., 2007, Afejessalátatápanyagellátása. KertészetésSzőlészet, Budapest. Vol. 56. No. 10. pp.10-12.

[28.] TERBE, I., SLEZÁK, K., KAPPEL, N., 2011, Kertészetiésszántóföldinövényekfejlődésirendellenességei. MezőgazdaKiadó, Budapest;

[29.] HUZSVAI, L., 2004, Biometriaimódszerekaz SPSS-ben. SPSS alkalmazások. DebreceniEgyetem, MezőgazdaságtudományiKar, Debrecen;