Influence of Different Substrate on Nutrients in Lettuce

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Abstract: The need for fast nitrogen releasing organic fertilizer, being allowable and economically accessible for organic farming is high. So authors have studied the growth of lettuce plants on different substrates (rock-wool, sheep wool and soil) and its influence on mineral content of lettuce plants grown in hydroponic system.

Regardless the fact that there were significant differences in the plant growth- seedlings in sheep wool grew faster, there were no significant difference in fresh weight at harvest, but faster growing plant had heavier dry weight of roots. Mineral contents didn't show important consequences, although we would expect it at least for potassium. So we cannot conclude sheep wool is more efficient substrate than rock wool or soil, but considering the fact that plants grew faster in it with similar nutrients content, it still seems like an optimal choice.

Keywords: Nutrients, lettuce, hydroponics, substrate, sheep wool.

1. INTRODUCTION

Nowdays, consumers are more and more concerned about staying healthy and eating correctly. Leafy vegetables generally are a rich source of potent antioxidants and are a valuable part of the diet owing to their nutritive values [1].

Apart from the product quality, the sustainable production plays important role when foods are purchased, where economic, social and ecological aspects are considered in the purchase decision [2].

From both perspectives, increased interest in organic farming seems rational choice. But organic farmers face many constraints, one of which is prohibition of the use of synthetic fertilizers. The result is often a lack of fertilizer with easily accessible nitrogen. Organic fertilizers contain a lot of organic nitrogen, but it is not mineralized fast enough to meet the needs of the plants during critical periods. Therefore, the need for fertilizer to fill this gap and at the same time being allowable and economically accessible for organic farming is high [3].

On the other hand, in Europe, high amounts of uncleaned sheep wool are available [4]. There are increasing trends of sustainable waste use, such as wool silt fence, wool erosion control blankets [5-7]. But because of the high amount of nutrients - especially nitrogen -, sheep wool gains an increasing interest also in agriculture.

There are few reports on the use of wool as a feedstock for composting as much for weed control and on the use of composted wool as a nitrogen source for plants. However, composting results in loss of nutrients, especially N [8].

Sheep wool can be used as multi-functional fertilizer in vegetable and flower cultivation or as a substrate in hydroponic system. In both cases un-purified sheep wool should be used, since high concentration of K in wool is due to suint (a wool grease excreted from the roots of the wool fibers) [9], while higher content of nitrogen (N) should be caused by fasces and urine [2]. These residues were washed out by fertilization during the experiments.

Reports are mostly in favor of sheep wool use [3, 4, 8, 9]. Although its use should be moderate, since increasing amount of wool-waste additions indicates greater N losses (the amount of N not being used by plants) [9].

Although hydroponics is not permitted in organic agriculture, growers might be interested. Especially because the growing medium is often disposed after one culture period. Therefore, the use of environmentally friendly growing substrates, which are, for example, biodegradable or can be used over several years, may reduce the waste flow under protected growing conditions [2].

Several researches have been conducted on vegetables cultivation on different organic and inorganic media under various soil less production techniques have mentioned high quality and better

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yield outcomes [10-12] although not for every culture– f.e. not for tomato production [2].

This could be, as already said due to higher nutrients values, especially K and N, but could also be due to the influence of the physical properties of different substrates used for hydroponic systems on the accumulation of primary and secondary metabolites [2].

The experiment reported in this article studied the growth of lettuce plants on different substrates. The objective of this study was to determine the effect of various substrate (rock-wool, sheep wool and soil) on mineral content of lettuce plants grown in hydroponic system.

2. MATERIALS AND METHODS

Plants of *Latuca sativa* cv. Comice (Cornus) were grown from the seedlings in three separate NTF hydroponic systems with continuous flow rate of $3m^3/h$. Roots were fully submerged and water level was kept constant by daily monitoring. Plants were exposed to natural day/ night light conditions, daily and night average temperature were 28 and 22°C respectively.

27 seedlings have been divided in three sets: 9 have been put into the hydroponic system in the small pots they have been bought in, while for others, soil has been removed first and than substrate (unwashed sheep's wool or washed rock wool) has been put around roots to give seedlings adequate support.

For the experiment, commercial nutrients were used according to the manufacturer's instructions; EC has been kept between 1,6 and 2,4mS/cm.

Mature leaves were taken for analysis when plants have reached the diameter approximately 20cm in the period of 10 days. Leaf analyzes have been performed after incineration of leaf sample at 550°C. Ashes have been diluted in 0.3M hydrochloric acid (ISO 6869). Potassium, magnesium, calcium, manganese, iron, copper and zinc have been determined with atomic absorption according to ISO 6869. The same method was used for determination of the nutrients in wool. Statistics has been performed by Gnumeric.

3. RESULTS AND DISCUSSION

Visually, plants on sheep's wool have grown much faster than the ones in soil, while those in rock wool in-between. This could be explained by higher nitrogen in sheep's wool, but not for rock wool, so the more rational explanation seems physical. According to Dannehl [2], a low water retention capacity in substrates probably influences transpiration and consequently a yield reduction based. But in our experiment, highest water retention (soil) has caused the slowest growth, so it looks like it is only a part of the explanation. We have considered another possibility: when soil is removed from the seedling before putting it into substrate, it could damage the roots to some extent, which might even encourage plant growth. So we have removed the soil, washed the seedling and then put them in the soil again. It definitely didn't encourage the growth, since those plants grew slower (data not shown).

Furthermore, Guo-Jing *et al*. found a relation between physical parameters and the temperature behaviour inside the substrates, where growing media with a high air volume and a low volume of EAW tend to a faster warming [2]. It is in agreement with our results: sheep's wool is susceptible to faster warming which might encourage faster growth. Although it should be taken into account that some organic

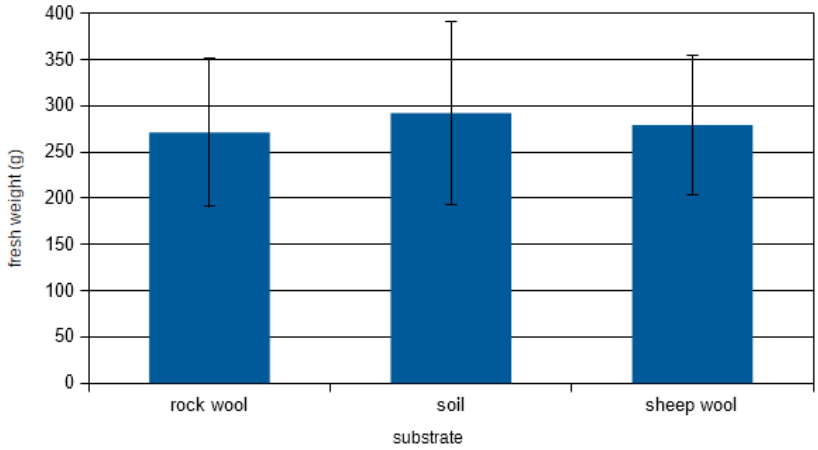

Figure 1: Lettuce fresh weight grown in different substrate.

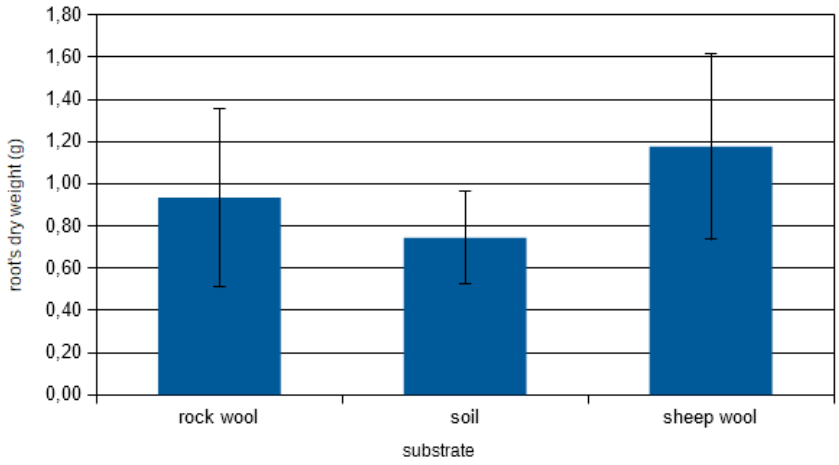

Figure 2: Root's dry weight at optimal maturity for plants grown in different substrates.

substrates are susceptible to shrinkage due to the decomposition [2], which might affect also temperature behavior, therefore additional research would be needed. (Figure **1** and **2**)

Regardless the fact that seedlings in sheep wool grew faster, there were no observable change in fresh weight at harvest, when lettuce's head has reached approximate diameter of 20cm.

On the other hand, which plants have grown faster has could be observed also at harvest: faster growing plants had heavier roots, although the differences were not significant:

If we compare the mineral content in the mature leaves, there are no significant differences between the substrates, but there are some interesting findings. It is surprising that potassium levels are lowest for sheep wool, although it was used unwashed and should consequently have higher levels of potassium [9].

There is a similar trend in magnesium: higher values in rock wool than in sheep wool, but opposite for

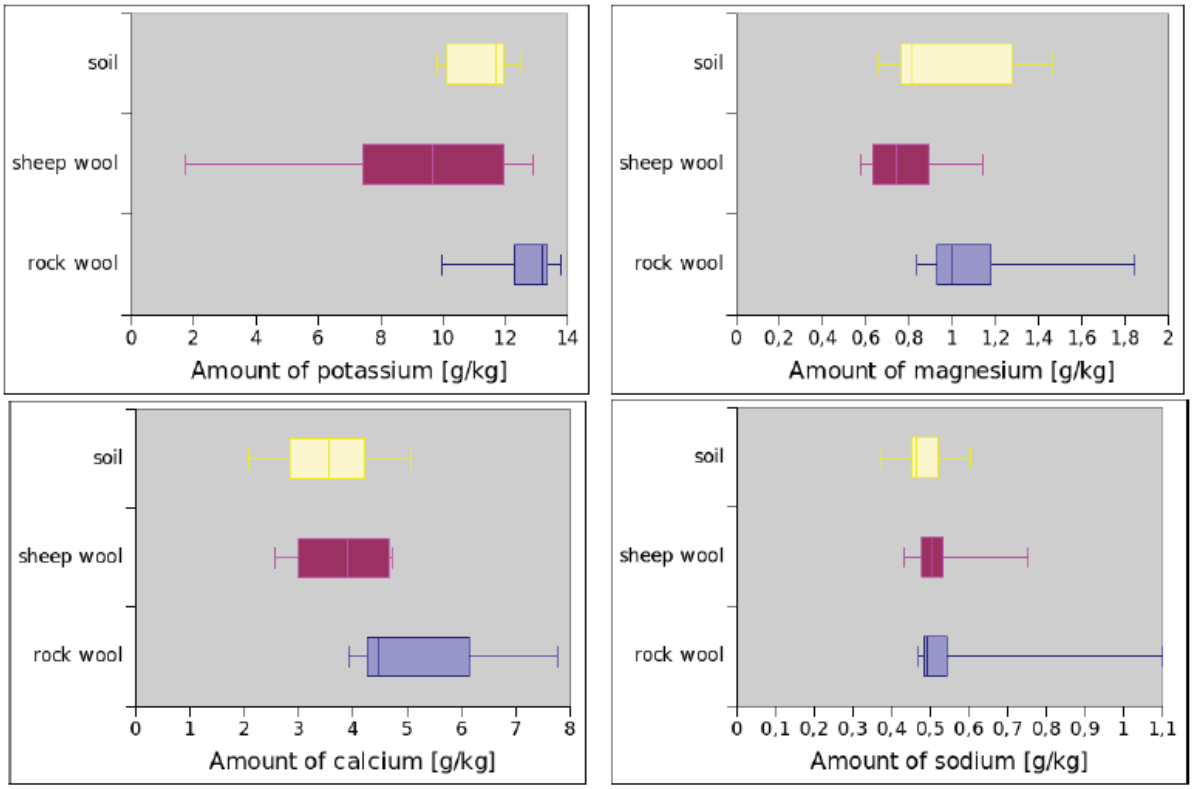

Figure 3: Minerals (macronutrients) in dry leaves for plants grown in different substrates.

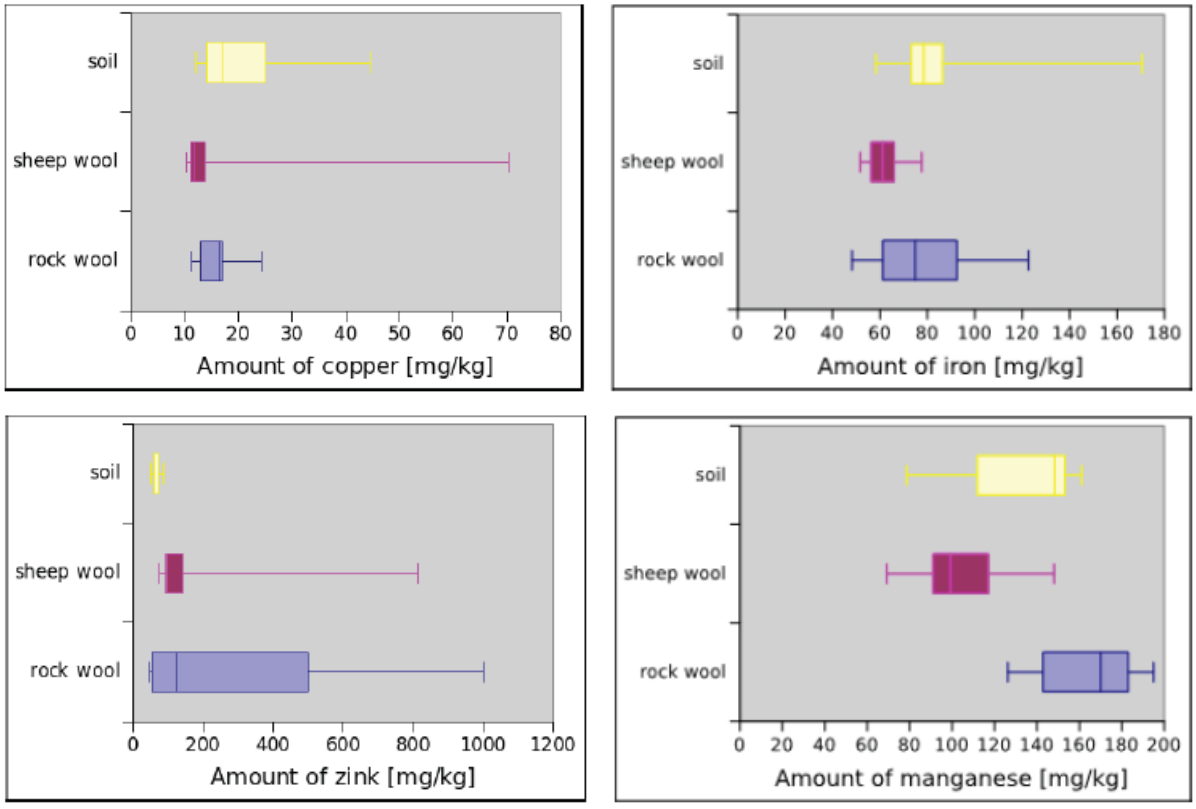

Figure 4: Minerals (micronutrients) in dry leaves for plants grown in different substrates.

calcium and sodium although the differences are only minor and might be only due to a natural variability. (Figure **3** and **4**)

There are no important differences in micronutrients content between substrates, as already reported for tomato [2]. On the other hand Zheljazkov [8] reported that wool waste addition might be an excellent soil amendment, since its use increased tissue P, K, Ca, S, Mn, Zn, and Na in basil, and increased tissue S and Mn but decreased tissue Mg and Na in thorn apple. Probably the length of growing seasons should be taken into account. We have observed that hidroponic solution in the system with rock wool is less microbiologically active than the other two (data not shown), which might play a visible role after longer period and should also be considered in the future.

Based on this experimental data we cannot conclude sheep wool is more efficient substrate than rock wool or soil, but considering the fact that plants grew faster in it with similar nutrients content, it still seems like an optimal choice.

CONCLUSIONS

Regardless the fact that there were significant differences in the plant growth - seedlings in sheep wool grew faster, there were no significant difference in fresh weight at harvest, but faster growing plant had heavier dry weight of roots. Mineral contents didn't show important consequences, although we would expect it at least for potassium. But it seems interesting subject for further research. Because even if we cannot conclude sheep wool is more efficient substrate than rock wool or soil, but considering the fact that plants grew faster in it with similar nutrients content, it still seems like an optimal choice.

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AUTHOR'S CONTRIBUTIONS

B. Slamic performed analytical part and data evaluation, while T. Jug performed literature search. They collaborated both in date interpretation and discussion.

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