International Journal of Vegetable Science

Nutrient Solutions on Yield and Quality of Basil and Cress

J. A. Olfati a, S. A. Khasmakhi-Sabet b & H. Shabani a

a University of Guilan, Horticultural Department, Rasht, Iran
b Azad University, Science and Research Branch, Tehran, Iran

Available online: 19 Jun 2012


To link to this article: http://dx.doi.org/10.1080/19315260.2011.642475

PLEASE SCROLL DOWN FOR ARTICLE
Nutrient Solutions on Yield and Quality of Basil and Cress

J. A. Olfati,1 S. A. Khasmakhi-Sabet,2 and H. Shabani1

1University of Guilan, Horticultural Department, Rasht, Iran
2Azad University, Science and Research Branch, Tehran, Iran

Hydroponics is a common culture method for production of herbs. It is necessary to determine optimal ranges of elements in nutrient solutions. Four nutrient solutions, with different total nitrogen concentrations and ammonium-to-nitrate ratios were used to determine effects on yield and quality of basil (Ocimum basilicum L.) and cress (Lepidium sativum L.). Increasing ammonium benefited cress but not basil. Increasing nitrate positively affected basil. Cress and basil do not appear to need high levels of nutrients for production using hydroponics.

Keywords Ammonium, Leafy vegetables, Soilless culture, NFT, Nitrate, Nitrogen.

Herbs contain vitamins, minerals, and cellulose that are important to human health (Peyvast, 2009). Greenhouse production can provide high-quality products because weather conditions are not factors (Dorais et al., 2001; Mairapetyan, 1999). The use of hydroponics increases absorption and root metabolic activities, which increase plant growth (Dorais et al., 2001; Mairapetyan, 1999; Manukyan et al., 2004). In order to provide appropriate levels of nutrient elements for plants, adequate nutritional programs must be used (Van Iersel and Kang, 2002). Concentrations of nutrient solutions are used based on fertilizer recommendations and selected on the basis of experience, plant species, cultivar, and growth stage (Schwarz et al., 2002).

Improved growth and yield of basil (Ocimum basilicum L.) was obtained with a full or half concentration of a nutrient solution (Suh et al., 1999). Concentrations of nutrient solution on salvia (Salvia splendens L.) affected plant root and shoot dry weights (Kang and Van Iersel, 2004). Udagawa (1995) compared concentrations of nutrient solution on dill (Anethum graveolens L.) and thyme (Thymus vulgaris L.) and found that high concentrations of nutrient solution increased plant fresh and dry weight but oil content was reduced.
Nitrogen is essential for plant growth. As a macro-element, it is part of the protein structure and participates in metabolic processes and energy transfer. It is absorbed by the plant as ammonium ($\text{NH}_4^+$) or nitrate ($\text{NO}_3^-$) ions. The form in which N is absorbed is, in part, dependent on pH (Trejo et al., 2008). In hydroponics, nitrate and ammonium forms are used in nutrient solutions. A balance between ammonium and nitrate favors plant growth and the degree of benefit varies among crops (Mengel and Kirkby, 1987).

Nitrogen content in nutrient solutions and ammonium and nitrate levels significantly affect absorption of other ions by plants (Salardini, 1993; Zornoza et al., 1985). Increasing ammonium concentrations from 14 to 112 mg·L$^{-1}$ reduces concentrations of potassium, calcium, magnesium; increases concentrations of ammonium in plants (Jose and Wilcox, 1984; Wilcox et al., 1985); and increases absorption of phosphorus and some micro-elements related to antagonistic ammonium effects (Ben and Kafkafi, 2002). Increasing ammonium in nutrient solution causes ascorbic acid to decrease depending on the ammonium level (Mozafar, 1993). The negative effect of ammonium salts is in response to the synthesis of vitamin C and is not associated with catabolism rate in plant tissue (Mozafar, 1993).

Basil and cress provide significant amounts of nutrients essential to the human diet (Peyvast, 2009). Field production of basil and cress is limited due to unfavorable environmental conditions during part of the year. Hydroponic greenhouse culture of these plants can help alleviate seasonal shortages of these crops. This project was undertaken to determine the best nutrient solution for production of basil and cress in a hydroponic system.

MATERIALS AND METHODS

Stock solutions (Table 1) were used to produce treatment solutions with four nitrogen levels and four ammonium-to-nitrate ratios (Table 2). Seed of basil and cress were germinated in sponges and transferred to aluminum rails in hydroponic production using a nutrient film technique apparatus after

<table>
<thead>
<tr>
<th>Compound</th>
<th>Milligrams per liter in irrigation solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>($\text{NH}_4$)$_6\text{Mo}·7\text{O}_2/4\text{H}_2\text{O}$</td>
<td>0.05</td>
</tr>
<tr>
<td>$\text{H}_3\text{BO}_3$</td>
<td>1.5</td>
</tr>
<tr>
<td>$\text{MnSO}_4·4\text{H}_2\text{O}$</td>
<td>2</td>
</tr>
<tr>
<td>$\text{CuSO}_4·5\text{H}_2\text{O}$</td>
<td>0.25</td>
</tr>
<tr>
<td>$\text{ZnSO}_4·7\text{H}_2\text{O}$</td>
<td>1</td>
</tr>
<tr>
<td>Sequesteren Fe 136</td>
<td>10</td>
</tr>
</tbody>
</table>
Table 2: Macronutrients used in nutrient solutions.

<table>
<thead>
<tr>
<th>Solution</th>
<th>KNO₃</th>
<th>KH₂PO₄</th>
<th>NaCl</th>
<th>Ca(NO₃)₂</th>
<th>MgSO₄</th>
<th>NH₄NO₃</th>
<th>K</th>
<th>NH₄⁺</th>
<th>NO₃⁻</th>
<th>N</th>
<th>NO₃:NH₄⁺ ratio</th>
<th>Total salt</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.2</td>
<td>3.3</td>
<td>0.2</td>
<td>5.3</td>
<td>1.5</td>
<td>1</td>
<td>3.6</td>
<td>1</td>
<td>8.5</td>
<td>9.5</td>
<td>89.47 : 10.53</td>
<td>13.5</td>
</tr>
<tr>
<td>2</td>
<td>3.2</td>
<td>3.3</td>
<td>0.2</td>
<td>5.2</td>
<td>1.5</td>
<td>0.1</td>
<td>4.6</td>
<td>0.1</td>
<td>8.5</td>
<td>8.6</td>
<td>98.8 : 1.2</td>
<td>13.5</td>
</tr>
<tr>
<td>3</td>
<td>1.1</td>
<td>1.65</td>
<td>0.1</td>
<td>2.65</td>
<td>0.75</td>
<td>0.5</td>
<td>1.8</td>
<td>0.5</td>
<td>4.25</td>
<td>4.75</td>
<td>89.47 : 10.53</td>
<td>6.75</td>
</tr>
<tr>
<td>4</td>
<td>1.6</td>
<td>1.65</td>
<td>0.1</td>
<td>2.6</td>
<td>0.75</td>
<td>0.05</td>
<td>2.3</td>
<td>0.05</td>
<td>4.25</td>
<td>4.3</td>
<td>98.8 : 1.2</td>
<td>6.75</td>
</tr>
</tbody>
</table>

- **a** Total concentration of NH₄⁺ in salts in solutions.
- **b** Total concentration of NO₃⁻ in salts in solutions.
- **c** Nitrogen equivalent as sum of NO₃⁻ and NH₄⁺.
- **d** Refers to salt concentrations in nutrient solution presented in the first six columns containing compounds.
14 d. Conditions of growth included a 16:8 h light:dark cycle with light supplied by high-pressure sodium vapor lamps (70-W power consumption; model 5000 E, Hoklartherm, Nuremberg, Germany). Temperatures during the experiment were 22°C during the day and 18°C at night. The experiment was arranged in a completely randomized design with four replications. Total yield was determined from a single harvest of cress and several harvests of basil. After harvesting, a subsample from each replication was obtained and sample dry weights were determined after drying in an electric oven at 75 ± 5°C until constant weight (Association of Official Analytical Chemists, 1984) was reached.

Ascorbic acid was quantitatively determined using 2,6-dichlorophenolindophenol dye (Ranganna, 1997). Ascorbic acid was extracted by grinding 10 g of fresh sample in a mortar with pestle with 3% metaphosphoric acid (v/v) as a protective agent. The extract was made up to a volume of 100 mL and centrifuged at 3000 g for 15 min at room temperature. Ten milliliters was titrated against 2,6-dichlorophenolindophenol dye, which had been standardized against ascorbic acid.

Chlorophyll a and b and carotenoids were calculated after extraction by N,N-di-methyl formamide using the colorimetric method of Inskeep and Bloom (1985). Data were subjected to analysis of variance in SAS (ver. 9.1, SAS Institute, Inc., Cary, N.C.). Means were separated using Tukey’s test.

**RESULTS AND DISCUSSION**

**Basil**

Treatment affected all measured traits except dry matter and carotenoid content (Table 3). The lowest yield was from plants treated with solution 3. Values for ash in plants treated with solutions 1 and 2 were higher than those treated with solution 3; plants treated with solution 4 were intermediate. The

<table>
<thead>
<tr>
<th>Solution</th>
<th>Chlorophyll b (mg/100 g FW)</th>
<th>Chlorophyll a (mg/100 g FW)</th>
<th>Vitamin C (mg/100 g FW)</th>
<th>Ash (% dry matter)</th>
<th>Yield (g m⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>964.7 b</td>
<td>59.46 b</td>
<td>6.28 ab</td>
<td>16.52 a</td>
<td>258.60 a</td>
</tr>
<tr>
<td>2</td>
<td>1126.4 a</td>
<td>57.24 b</td>
<td>6.14 b</td>
<td>16.62 a</td>
<td>258.60 a</td>
</tr>
<tr>
<td>3</td>
<td>423.3 c</td>
<td>58.36 b</td>
<td>6.32 a</td>
<td>15.25 b</td>
<td>174.28 b</td>
</tr>
<tr>
<td>4</td>
<td>654.1 b</td>
<td>69.66 a</td>
<td>6.20 ab</td>
<td>15.47 ab</td>
<td>234.76 a</td>
</tr>
</tbody>
</table>

Values in a column followed by the same letter are not significantly different at \( P \leq 0.01 \) or \( P \leq 0.05 \), Tukey’s test.
vitamin C content was higher in plants treated with solution 3 than with solution 2. Plants treated with solutions 1 and 4 were intermediate. Chlorophyll a content was highest in plants treated with solution 4 and chlorophyll b content was highest in plants treated with solution 2. Dry matter averaged 7.8% and carotenoids averaged 0.46 mg/100 g FW. Unlike for cress, solution 3 was not the best choice for basil production using hydroponics. The best growth and yield in basil was obtained when a full or half concentration of the standard solution was used (Suh et al., 1999). Kang and Van Iersel (2004) and Udagawa (1995) reported that nutrient solution concentration of total salt affected root and shoot of dill and thyme dry weight. Their results do not correspond with those reported here for basil because total salt concentration did not affect basil.

**Cress**

Yield and contents of dry matter, ash, ascorbic acid, and chlorophyll b, but not chlorophyll a or carotenoids, were affected by treatment (Table 4). Plants treated with solution 2 did not produce yields equal to those treated with the other solutions. Plants treated with solution 1 produced plants with less dry matter than plants treated with solution 3. Dry matter for plants treated with solutions 2 and 4 were similar to both extremes. Plants treated with solution 3 produced more ash than those treated with the other solutions. Vitamin C content in plants treated with solution 2 was higher than in those treated with solution 3; plants treated with the other solutions were intermediate. Chlorophyll b content was highest in plants treated with solution 3. Chlorophyll a content averaged 445 mg/100 g FW and carotenoid content averaged 0.55 mg/100 g FW. Solution 3 appears to be as good as, or better than, the other solutions for production of cress and could probably provide the most benefit under hydroponic production. Similar results have been reported in basil (Suh et al., 1999). However, our results indicated that basil requires low concentrations of ammonium in the nutrient solution and responds better to NO₃ than NH₄. Mozafar (1993) reported that high levels of ammonium

<table>
<thead>
<tr>
<th>Solution</th>
<th>Chlorophyll b (mg/100 g FW)</th>
<th>Vitamin C (mg/100 g FW)</th>
<th>Ash (% dry matter)</th>
<th>Dry matter (%)</th>
<th>Yield (g m⁻²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>898.52 b</td>
<td>6.71 ab</td>
<td>15.49 b</td>
<td>4.58 b</td>
<td>126.80 a</td>
</tr>
<tr>
<td>2</td>
<td>815.53 b</td>
<td>6.76 a</td>
<td>15.27 b</td>
<td>5.00 b</td>
<td>66.99 b</td>
</tr>
<tr>
<td>3</td>
<td>1307.67 a</td>
<td>6.64 b</td>
<td>17.09 a</td>
<td>15.99 a</td>
<td>172.60 a</td>
</tr>
<tr>
<td>4</td>
<td>935.44 b</td>
<td>6.67 ab</td>
<td>15.75 b</td>
<td>8.43 ab</td>
<td>151.49 a</td>
</tr>
</tbody>
</table>

Values in a column followed by the same letter are not significantly different at *P* ≤ 0.01 or *P* ≤ 0.05, Tukey’s test.
decrease ascorbic acid concentration, indicating that the effects on vitamin C synthesis are not related to catabolism. The reason for this finding requires clarification.

Cress and basil responded differently to nutrient solutions. Ammonium positively affected cress but not basil. Nitrate positively affected basil. Cress and basil do not appear to need high levels of nutrients for production using hydroponics.

REFERENCES


Salardini, A. 1993. Soil fertility and fertilizer. Tehran University, Tehran, Iran.


