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Evaluation of growth and yield of organically-grown basil (*Ocimum basilicum* L.) in soilless culture

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Abstract

The effect of nutrient sources, organic manure and inorganic conventional nutrient solution in basil (*Ocimum basilicum* L.) production was evaluated in soilless culture. The experiment was designed to test two factors, cultivar (two local cultivars) and nutrient sources (inorganic nutrient solution, solid organic manure and organic nutrient solution) from February 2010 to July 2010 in an experimental greenhouse of Young Researchers Club of Islamic Azad University, Jahrom, Iran. Results showed that there was no significant difference between yields of cultivars. The highest yield was obtained in inorganic nutrient solution and the lowest one in solid organic manure. Comparison between inorganic nutrient sources and organic nutrient solution indicated that there was no remarkable difference among them. So, organic manure can be used in solution as a nutrient source for production of organic basil in soilless culture.

Key words: Hydroponic, herb, nutrition, poultry manure, organic production, yield.

Introduction

In recent years basil (*Ocimum basilicum* L.) production has increased due to its high value, popularity and demand. Only a few greenhouse in Iran are growing basil either hydroponically or organically, but none are doing both. In China, organic manure is widely used in substrate culture for plant production at commercial level and this technique is named as eco-organic soilless culture. This system is reported to be low cost compared to inorganic nutrient solution systems and is recommended for developing countries [18, 19]. Different composted organic wastes were also recommended as nutrient sources for plants grown in substrates [9-17]. Organic nutrient sources also proved to be successful in soilless culture production of cucumber [4], lettuce [1-3] and basil [6-16]. Although different organic nutrient sources exist for plant nutrition, poultry manure is among the most desirable natural fertilizers because of its high nutrient content [7, 8]. The general purpose of this research was to establish nutrition recommendations for the successful production of organic herbs in Iran. To achieve this goal the use of organic sources compared to inorganic nutrient solution was evaluated. Basil, a main herb of greenhouse production in the region, was chosen as the test plant.

Materials and Methods

This research was carried out in an experimental greenhouse of Young Researchers Club, Jahrom Islamic Azad University, Iran, from February, 2010 to July, 2010. The experiment was designed to test two factors; cultivar ([1] Green sweet and [2] Mikhaki), nutrient sources ([1] inorganic nutrient solution, [2] solid organic manure, [3] organic nutrient solution).

'Green sweet' basil is an annual herb that is used fresh and 'Mikhaki' basil is a perennial herb that is used extensively both fresh and dried as a spice. The organic nutrient source used both in solid organic manure and organic nutrient solution treatments was dried poultry manure in pellet form (Table 1). Its chemical composition was C 36.4, N 5.16, P 2.8, K 4.30, Ca 7.1, Mg 0.86, Na 0.69 and Fe 0.84% and Cu 79.80, Zn 380, Mn 353.4 and B 17.8 mg kg^{-1}.

Basil seeds were planted in complete randomized design with 3 replications (6 plants per replication) and 3 plants per pot (1.5 litre by volume) in a greenhouse with mean minimum and maximum temperatures of 22 and 35°C (72 and 95 F), respectively.

In treatments with organic nutrient source (solid organic manure and organic nutrient solution), poultry manure was mixed with perlite (Kimia, Pardis Production, Iran) as base dressing before planting at a rate of 10 kg m^{-3} substrate [4]. The solid organic manure treatment was side dressed under the drippers at a rate of 2 kg m^{-3}

Table 1. Some chemical properties of [z]poultry manure.

Fertilizer	EC ($dS.m^{-1}$)	pH	O.C (%)	N (%)	C/N	P (%)	K (%)
Poultry manure	8.94	7.37	36.43	5.16	7.06	2.8	4.30

[z]Locally available poultry manure in Shiraz, Iran.

substrate at 10 day intervals [4] throughout the experiment, however, the rate was increased to 6 kg m^{-3} after 65 days from seed planting due to faster plant growth and higher nutrient demand, and water requirements of the plants were covered by fresh water via drip irrigation system. On the other hand, in the organic nutrient solution treatment, a stock solution was prepared by dissolving the manure in the same amounts used as side dressings in solid organic manure treatment in a covered tank 3 days before each application period (10 days). Filtered and diluted organic nutrient solution with EC levels varying between 1.8 and 2.3 mS cm^{-1} was applied via drip irrigation system.

The inorganic nutrient treatment prepared from soluble grade commercial fertilizers (Growmore) consisted of complete plant nutrients with a chemical composition of (%): N 20, P 20, K 20, Mg 50, S 0.20, Fe 0.1, Mn 0.05, Cu 0.05, Zn 0.05, B 0.052 and Mo 0.0005 (Grow More, Inc, U.S.A.). The EC of the inorganic nutrient solution ranged between 1.6 and 2.2 mS cm^{-1}. The pH of solution was maintained at 5.5-6.0 by adding 1 M nitric acid when necessary.

Data were collected related to plant growth characteristics, yield and elemental composition. Upper fully expanded leaves were sampled on May 21st and analyzed according to the standard methods for their total N by Kjeldahl method, P by colorimetry, K and Ca by flame photometry and Mg, Cu, Fe, Mn and Zn by atomic absorption spectrophotometry [7]. Data were analyzed statistically using MSTAT-C program. Differences between means of the treatments were compared by the Tukey's test.

Results and Discussion

Plant growth characteristics: The assessment of some plant growth characteristics showed that number of internodes was significantly affected by the treatments; cultivars and nutrient sources ($p < 0.01$) (Table 2). The comparison between organic and inorganic solution were not significant, but the differences between these two factors with solid organic manure were completely significant. Plants grown in organic and inorganic solution had more internodes compared to solid organic manure. Plant length and chlorophyll content were significantly affected by different cultivars, but nutrient sources had no significant effect on them, although, these values were higher in plants grown in inorganic treatment. Similar result has been reported by Gül *et al.*[4].

Table 2. The assessment of some biometric indices of basil growth in different substrates.

Experimental factors	Number of internodes	Plant length (cm)	Chlorophyll content (mg/g)
Cultivars			
Green sweet	19 [b1]	43 [b]	4.39 [b]
Mikhaki	21 [a]	47 [a]	4.88 [a]
Nutrient sources			
Inorganic nutrient source	22 [a]	48 [a]	4.68 [a]
Organic nutrient solution	21 [a]	46 [a]	4.67 [a]
Solid organic manure	18 [b]	44 [a]	4.56 [a]

[1]Means with similar letters in each column are not significantly different at 1% level of Tukey's test.

The result showed that 'Mikhaki' had more internodes, plant length and chlorophyll content compared to 'Green sweet' cultivar. Gül *et al.* [4] reported that vigorous cultivars might be more suitable for growing in soilless culture with organic and inorganic nutrient sources.

Yield: Plants were harvested weekly from April 10th to July 25, 2010. Dry leaves on the weekly harvesting were weighed from April 25 to July 25, 2010. The effect of nutrient sources was statistically significant in dry weights ($p < 0.01$) (Table 3). The differences between cultivars were also significant in dry weight ($p < 0.05$). Comparison between cultivars showed that 'Mikhaki' had more dry weight than 'Green sweet'. The highest dry weight was related to 'Mikhaki' grown in inorganic treatment. Interactions between these experimental factors were also significant ($p < 0.05$).

Total yield values were registered by weekly harvesting of fresh leaves from April 10th to July 25th, 2010. The effect of nutrient sources was statistically significant in total yield ($p < 0.01$). The comparison between inorganic nutrient solution and organic nutrient solution showed no significant differences (Table 3), but the differences between inorganic nutrient solution and solid organic manure were completely significant. Yield-nutrient source relations showed a reduction of 18.30% when solid organic manure was used compared with the inorganic nutrient solution (Table 3). Similar results have been reported by several authors [4, 5]. Gül *et al.* [5] reported that mixing the recommended amounts of organic manure into substrate prior to planting could be a sufficient nutrient source for lettuce plants, however, the results of another study showed that solid manure application was not adequate for crops with high nutrient demand and long vegetation period as cucumber [4].

Table 3. Total yields and leaves dry weight.

Nutrient source	Leaves dry weight (g/pot)		Total yield (g/plant)	
	Cultivar		Cultivar	
	Mikhaki	Green sweet	Mikhaki	Green sweet
Inorganic nutrient source	214[a2]	201[ab]	468 [a]	450 [a]
Organic nutrient solution	183[ab]	149[ab]	458 [a]	411 [ab]
Solid organic manure	145[ab]	132[b]	395 [b]	355 [c]
Mean	181[A]	161[B]	440.3 [A]	405.3 [B]
[1]Significance	*		**	

[1]Means are separated by Tukey's test. Treatment effects were significant at the 1% level (**), 5% level (*) and non significant (ns). [2]Capital letters between mean values in cultivars, small letters between nutrient source values.

Leaf nutrients: The effect of nutrient sources showed that plants grown in inorganic nutrient solution had higher concentrations of leaf nutrients compared to plants grown in organic treatments (Tables 4 and 5). Differences between cultivars were significant and 'Mikhaki' had more nutrition value compared to 'Green sweet' (Table 6). There were no significant differences between cultivars and nutrient sources related to leaf nutrient contents except B, Cu and Pb. Leaf analyses showed that all of the essential elements were within the adequate ranges in the inorganic nutrient solution treatment except P and Ca were more than sufficient (0.2-0.4%) according to Succop [16]. In organic treatments the amount of Fe was lower than optimum range (100 mg kg^{-1}) for basil and Ca was higher than the ranges cited as optimum in mineral nutrient sufficiency values [16].

Table 4. Main effects of nutrient sources on leaf macronutrient contents.

Nutrient source	%				
	N	P	K	Mg	Ca
Inorganic nutrient source	2.89[a1]	0.53[a]	1.37[a]	0.76[a]	3.05[a]
Organic nutrient source	2.88[a]	0.38[b]	1.59[a]	0.74[a]	2.62[ab]
Solid organic manure	2.55[a]	0.33[b]	1.68[a]	0.60[b]	2.17[b]

[1]Means with similar letters in each column are not significantly different at 1% level of Tukey's test.

Table 5. Main effects of nutrient sources on leaf micronutrient contents.

Nutrient source	mg kg^{-1}				
	Fe	Zn	Mn	Cu	B
Inorganic nutrient source	114.0^{a1}	34.0^{b}	61.0^{a}	6.0^{a}	54.5^{a}
Organic nutrient source	97.5^{b}	60.0^{a}	53.5^{b}	4.2^{b}	40.5^{b}
Solid organic manure	88.0^{c}	20.0^{c}	52.5^{b}	3.3^{c}	36.0^{c}

[1]Means with similar letters in each column are not significantly different at 1% level of Tukey's test.

Table 6. Comparison between cultivars in order to their leaf nutrient contents.

Cultivar	%					mg kg^{-1}				
	N	P	K	Mg	Ca	Fe	Zn	Mn	Cu	B
Mikhaki	2.99^{a1}	0.45^{a}	1.69^{a}	0.70^{a}	2.84^{a}	102.0^{a}	39.0^{a}	56.3^{a}	4.70^{a}	45.7^{a}
Green sweet	2.54^{b}	0.39^{a}	1.40^{a}	0.70^{a}	2.38^{a}	98.0^{b}	37.0^{a}	55.0^{a}	4.33^{b}	41.7^{b}

[1]Means with similar letters in each column are not significantly different at 1% level of Tukey's test.

Both basil cultivars had acceptable plant nutrient values and yield in this organic soilless culture method, but 'Mikhaki 'was more compatible in soilless culture with organic manure. Similar results have been reported by Gül *et al.* [4]. Mengel and Kirkby[8] stated that potential nutrient uptake of plants is dependent on root development and vigour [8]. The use of solid manure reduced plant growth and yield compared to inorganic nutrient solution. Reductions in plant growth and yield in organic manure treatment may be attributed to the lower uptake due to the lower availability and slower release of nutrients from organic sources. Low availability of nitrogen in the composition of organic matter is very well known. Similarly, the amount of nutrients which contacts directly with the plant roots is rather small within the overall nutrient demand [8]. Therefore, transportation of nutrients towards the rhizosphere and root surface by mass flow and diffusion are more important than interception.

Conclusions

According to the results of this experiment, nutrient solution derived from organic manure can be a promising technique compared to solid manure application for organic nutrition of herbs in soilless culture. This specific soilless culture technique was successfully used in basil, a main herb of greenhouse production and thus can be used also for other leafy vegetables.

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References

[1]Abd-Elmoniem, E. M., El-Shinawy, M. Z., Abou-Hadid, A. F. and Helmy, Y. I. 2001. Response of lettuce plant to feeding with unconventional sources under hydroponic system. Acta Hort. **559**:549-554.

[2]Atkin, K. and Nichols, M. A. 2004. Organic hydroponics. Acta Hort. **648**:121-127.

[3]El-Shinawy, M. Z., Abd-Elmoniem, E. M. and Abou-Hadid, A. F. 1999. The use of organic manure for lettuce plants grown under NFT conditions. Acta Hort. **491**:315-318.

[4]Gul, A., Kidoğlu, F. and Anaç, D. 2007. Effect of nutrient sources on cucumber production in different substrates. Sci. Hort. **113**:216-220.

[5]Gul, A., Öztan, F., Eroğul, D., Yağmur, B. and Ongun, A. R. 2003. The use of organic manure for iceberg lettuce plants grown in substrates. Acta Hort. **608**:53-57.

[6]Hochmuth, R. C., Davis, L. L. L., Laughlin, W. L. and Simonne, E. H. 2008. Evaluation of Organic Nutrient Sources in the Production of Greenhouse Hydroponic Basil. North Florida Res. and Education Center, Suwannee Valley. Res. Rep. 2003-08.

[7]Kacar, B. and Katkat, V. 1999. Gübreler ve Gübreleme Tekniğ i. Vıpas, A. Ş., Bursa, 345 p.

[8]Mengel, K. and Kirkby, E. A. 2001. Principles of Plant Nutrition. 5th edn. Kluwer Academic Publishers, The Netherlands, 849 p.

[9]Metzger, J. 2001. Vermicompost as an amendment for soilless media. Flower Technol. **4**(7):34-36.

[10]O'Brien, T. A., Barker, A. V. and Campe, J. 1999. Container production of tomato with food by-product compost and mineral fines. J. Plant Nutr. **22**(3):445-457.

[11]Premuzic, Z., Bargiela, M., Garcia, A., Rendina, A. and Iorio, A. 1998. Calcium, iron, potassium, phosphorus and vitamin C content of organic and hydroponic tomatoes. HortScience **33**(2):255-257.

[12]Premuzic, Z., Rios, A., Accorinti, C., Clozza, M., Viella, F. and Mirabelli, E. 2001. Influence of fertilisation on the production and vitamin C and sugar content of ''cherry'' tomatoes. Acta Hort. **559**:601-606.

[13]Raviv, M., Chen, Y. and Inbar, Y. 1986. Peat and peat substitutes as growth media for container-grown plants. In Chen, Y. and Avnimelech, Y. (eds). The Role of Organic Matter in Modern Agriculture. Martinus Nijhoff, Dordrecht, pp. 257-287.

[14]Ribeiro, H. M., Romero, .M., Pereira, H., Borges, P., Cabral, F. and Vasconcelos, E. 2007. Evaluation of a compost obtained from forestry wastes and solid phase of pig slurry as a substrate for seedlings production. Bioresource Technol. **98**:3294-3297.

[15]Salminen, M. S. 1997. Growth and yield of tomato cultivated in a substrate with organic fertilizers. In Proc. of the 9th Int. Cong. on Soilless Culture, Channel Island, pp. 409-415.

[16]Succop, C. E.1998. Hydroponic Greenhouse Production of Fresh Market Basil. Master's thesis, Department of Horticulture and Landscape Architecture. Colorado State University, 54 p.

[17]Wilson, D. P. and Carlile, W. R. 1989. Storage properties of peat based growing media containing worm worked duck waste. Acta Hort. **238**: 205-220.

[18]Xing, Y. X. and Meng, X. D. 1999. Development and prospect of hydroponics in China. Acta Hort. **481**:753-760.

[19]Zhang, Z. B. 1999. Update development of protected cultivation in mainland China. Chronica-Hort. **39**(2):11-15.