Journal of Horticultural Science & Ornamental Plants 6 (2): 82-89, 2014
ISSN 2079-2158

DOI: 10.5829/idosi.jhsop.2014.6.2.1141

Conventional Basil Production in Different Growing Media of Compost, Vermicompost or Peat-Moss with Loamy Soil

[1]Mohammed Hewidy, [2]Engy Sultan, [2]Maha Elsayed and [2]Mohamed A.A. Abdrabbo

[1]Department of Horticulture, Faculty of Agriculture, Ain Shams University, Cairo, Egypt
[2]Central Laboratory for Agricultural Climate, Agricultural Research Center, Doki, Giza, Egypt

Abstract: Experiment was conducted during two successive seasons 2012-2013 to study the effect of growing media on growth and oil production in greenhouse or in open field. Available soil (loam soil) from El-Bosaily Research Station was blended with (20, 40, 60 and 80% blends in volume of peatmoss) beside a 100% loamy soil. Other 6 growing media were prepared consist of 10, 20 or 30% of compost or vermicompost with loamy soil. Basil dry weight, plant height, chlorophyll and essential oil percentage and yield were measured. Compost application in the growing media enhanced plant height, dry herb and oil contents. Compost uses in growing media enhanced plant growth performance as compared with peat-moss or mixed media with vermicompost. Plants grown in compost showed 2-3 times greater shoot number than the other treatments. Different peat-moss media mixture and control showed notable reduction in chlorophyll content as compared with mixed media containing compost or vermicompost. The number of lateral stems increased (up to 2-4 times) in basil when compost added into substrate mixtures as compared to lowest value in both seasons and cuts.

Key words: Basil · Growing media · Vermicompost · Compost · Peat-moss

INTRODUCTION

Agriculture in northern region of Egypt suffers from major constrains of lake of water and soil salinity. However, the weather considered to be favorable for agriculture crops. Permanent cultivation of fruit trees having advantageous of reclamation in that type of land but herbaceous crop facing greeter level of stress. Fresh and dry medicinal and aromatic plants have great potential in the market. They are used as culinary herbs, or for oil production.

Sweet basil (*Ocimum basilicum*) is an essential oil crop belonging to *lamiaceae* family that can be used in food, perfumery and pharmaceutical industry. Since ancient time basil was cultivated as ornamental plant and to extract its oil. It can be produced on small-scale as culinary herbs as one of the major source of income [1]. However, most of basil cultivars are suitable for food industry, which were also correlated via agromorphological features. Basil growth and yield can be affected by major abiotic stress such as drought and salinity. Basil produced for dried leaf and fresh markets rank second and third, respectively [2]. Craker *et al*. [3] explored that, basil is commercially produced in the field, greenhouse and soilless system.

The same cultivars gene expression of key enzyme of biosynthetic pathways may alter genetic analysis of distinct essential oil profiles [4]. Rangappa and Bhardwaj [5] found that basil nitrogen requirement is 50-75 kg/ha. That may encourage uses of organic sources as N supply due to slow release properties.

One of the main strategies to face soil salinity is to alter the soil but in case of water deficiency commercial cultivation of basil in growing media shows better opportunity to evitate them. Using good substrates is essential to increase yield, quality and profits in crops. Peat moss is widely used as stand-alone medium or as an ingredient in growing media [6]. Commercial production of different plants is mainly based on peat moss and perlite. Changing growing media composition by adding local compost or vermicompost showed large interest in order to enhance plant production and reduce depletion

Corresponding Author: Mohammed Hewidy, Department of Horticulture,
Faculty of Agriculture, Ain Shams University, Cairo, Egypt.

of natural resources [7,8]. Composted media proved better growth for basil seedling than medium without compost [7]. Plant nutrients provided by compost are not sufficient for growing cycle of plant that force the grower to use some additives [9]. However, Cull [10] concluded about the absence of full alternative to peat moss but partial substitution. Moreover, total replacement of peat by vermicompost was possible while Lazcano *et al.* [8] found that doses of compost higher than 50% caused plant mortality.

A considerable amount of the plant nutrients needed in the substrate for the initial six weeks of plant growth was found to be supplied by the herbage compost. However, nutrient contribution of compost should be considered in order to avoid excessive vegetative growth and/or salinity effect. Compost slow release nutrient demonstrates an advantage for plant growth. The production of aromatic plants in container is highly competitive business and a way to avoid soil troubles. Compost and vermicompost application in growing media of plant production did not take so much attention due to its limitation on seedling production. Different growing mixtures using loam soil with compost and vermicompost as substitution to peat-moss was examined to determine the best growing mixture for basil production.

MATERIAL AND METHODS

The experiment was carried out in a completely randomized design in three replicates inside unheated glasshouse and outside at El-Bosaily experimental farm, Rashid, Egypt, located at the latitude of 31°27'15" N, longitude 30°23'23" E (temperature: max 25.7 ± 6.8 °C, min 25.7 ± 6.8 °C; RH (%):max 93.5 ± 1.9, min 74.8 ± 4.1) with alternate-day watering by manual irrigation.

One seedling/ pot of sweet basil was transplanted after appearing of 3-5 true leaves. The pot experiment ran from the 1st of March to 24th of June 2012 and in second 5th of March to 24th of June 2013. Plastic pots were 30 cm in diameter and 19 cm in height. First harvest was done in 20th of May and second harvest was taken 4 weeks after then the experiment was concluded in both years.

Treatments: Cultivation of basil was in the two successive seasons. Seeds were cultivated in nursery then transferred to 11 different mixtures of growing media as follow:

- T1 _ Control (loam soil 100%)
- T2 _ Loam soil 80% + Peat moss 20%
- T3 _ Loam soil 60% + Peat moss 40%
- T4 _ Loam soil 40% + Peat moss 60%
- T5 _ Loam soil 20% + Peat moss 80%
- T6 _ Loam soil 90% + Compost 10%
- T7 _ Loam soil 80% + Compost 20%
- T8 _ Loam soil 70% + Compost 30%
- T9 _ Loam soil 90% + Vermicompost 10%
- T10 _ Loam soil 80% + Vermicompost 20%
- T11 _ Loam soil 70% + Vermicompost 30%

Local source of soil chemical and physical properties were analyzed and summarized in Table (1). As these were qualitative study to see whether the compost/vermicompost discourage plant, no control of fertilized pots were studied. Compost was punctuated by organic green wastes collected from farmyard of El-Bosaily Research Station. Green wastes were kept till drying then crashed into small pieces then processed into compost. Compost pile was 3m wide of 1m high of 5m long. The piles were regularly turned and waters over 90 days period to ensure appropriate composting conditions. Vermicompost was processed in constructed system filled with crashed farm wastes materials then inoculated with earthworms that work on composting process.

Plant height (cm), number of branches and chlorophyll were determined at harvest time of vegetative growth. Chlorophyll was estimated by SPAD instrument (SPAD-502, Konica, Minolta). During growing season two harvest of fresh herb were collected then air dried and herb dry weight (g plant^{-1}) estimated. Essential oil percentage was estimated in dry herb. Final oil yield was estimated by multiplying oil percentage by final dry weight of plant.

Statistical Analysis: The experiment was carried out through two years. Data were tested for normality and then subjected general linear model GLM. Significance among mean values was determined using LSD at 5% [11]. Statistical analyses were performed using STATGRAPHICS centurion version 15.2.06.

RESULTS AND DISCUSSION

Plant Height and Branches Number: Plant height was estimated from growing media surface to shoot tip of main stem (Table, 2). As well branches number was determined. Greenhouse affects plant height and giving tender and tall plants due to deficit in light intensity and

Table 1: Soil chemical and physical characteristics of the El-Bosaily site.

				Chemical characteristics meq /l							
				Cations				Anions			
Depth	SP	pH	EC (dS m^{-1})	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	CO_3^{--}	HCO_3^{-}	SO_4^{--}
30 cm	33	7.75	1.25	2.80	2.15	6.69	0.9	4.50	-	1.90	6.14
60 cm	33	7.75	1.50	4.00	2.37	7.15	1.50	6.75	-	1.33	6.94
90 cm	32	7.70	1.40	3.20	4.00	5.93	0.88	5.85	-	1.90	6.26

Physical characteristics	30 cm	60 cm	90 cm
Coarse Sand (%)	11.5	9.2	11.6
Fine Sand (%)	29.5	30.9	30.4
Silt (%)	40.6	42.4	40.6
Clay (%)	18.4	17.5	17.4
Texture	Loamy	Loamy	Loamy
Field capacity (%)	17	17	16.5
Wilting point (%)	8	7.5	7.5
Soil reaction pH	7.75	7.75	7.7
Organic matter (%)	0.3	0.3	0.2
Bulk density	1.21	1.26	1.24
E.C. (dS m^{-1})	1.25	1.50	1.40

Table 2: Influence of different growing media mixtures on plant height and shoot number per plant in two harvest / cultivation season under field and greenhouse conditions.

	Plant height				Shoot number/ plant			
	1st cut		2nd cut		1st cut		2nd cut	
Treatments	GH	Field	GH	Field	GH	Field	GH	Field
1st Season								
Loam soil (LS)	52.3	34.7	55.3	26.0	9	11	10	12
80% (LS) + 20%peat	57.0	31.3	61.3	33.3	10	9	11	11
60% (LS) + 40%peat	65.0	36.0	67.0	27.7	11	10	12	11
40% (LS) + 60%peat	51.3	36.0	52.3	34.0	5	20	5	20
20% (LS) + 80%peat	64.0	36.0	63.0	38.0	12	14	12	18
90% (LS) + Com10%	67.3	36.0	72.7	38.7	14	30	14	30
80% (LS) + Com20%	68.7	47.3	71.0	43.0	13	34	13	34
70% (LS) + Com30%	74.0	52.7	79.0	55.3	15	40	16	39
90% (LS) + Verm10%	64.0	33.7	64.0	33.0	13	9	13	10
80% (LS) + Verm20%	60.3	33.0	64.0	33.3	8	10	8	10
70% (LS) + Verm30%	53.0	32.0	56.7	29.3	7	8	5	11
$LSD_{0.05}$	5.3	3.0	3.2	3.3	2.6	4.3	2.4	4.6
2nd Season								
Loam soil (LS)	57.3	37.7	54.0	28.3	11	11	13	11
80% (LS) + 20%peat	63.0	30.7	66.7	30.0	10	13	11	15
60% (LS) + 40%peat	69.0	36.0	72.7	34.0	14	10	15	12
40% (LS) + 60%peat	54.0	34.0	56.3	33.0	7	16	9	18
20% (LS) + 80%peat	67.7	37.3	72.7	36.3	13	17	16	22
90% (LS) + Com10%	71.0	36.7	74.0	38.0	12	29	13	27
80% (LS) + Com20%	73.3	44.7	78.0	44.3	13	35	15	34
70% (LS) + Com30%	80.0	53.7	80.7	56.0	15	41	19	45
90% (LS) + Verm10%	65.0	31.0	66.7	29.3	14	9	16	9
80% (LS) + Verm20%	63.3	31.3	71.7	35.0	10	11	13	8
70% (LS) + Verm30%	64.3	30.7	66.0	30.7	8	9	8	10
$LSD_{0.05}$	3.6	2.5	3.1	2.8	2.8	4.0	2.0	3.5

GH = Greenhouse; Field = Open field; $LSD_{0.05}$ = Least significant difference at $P < 0.05$

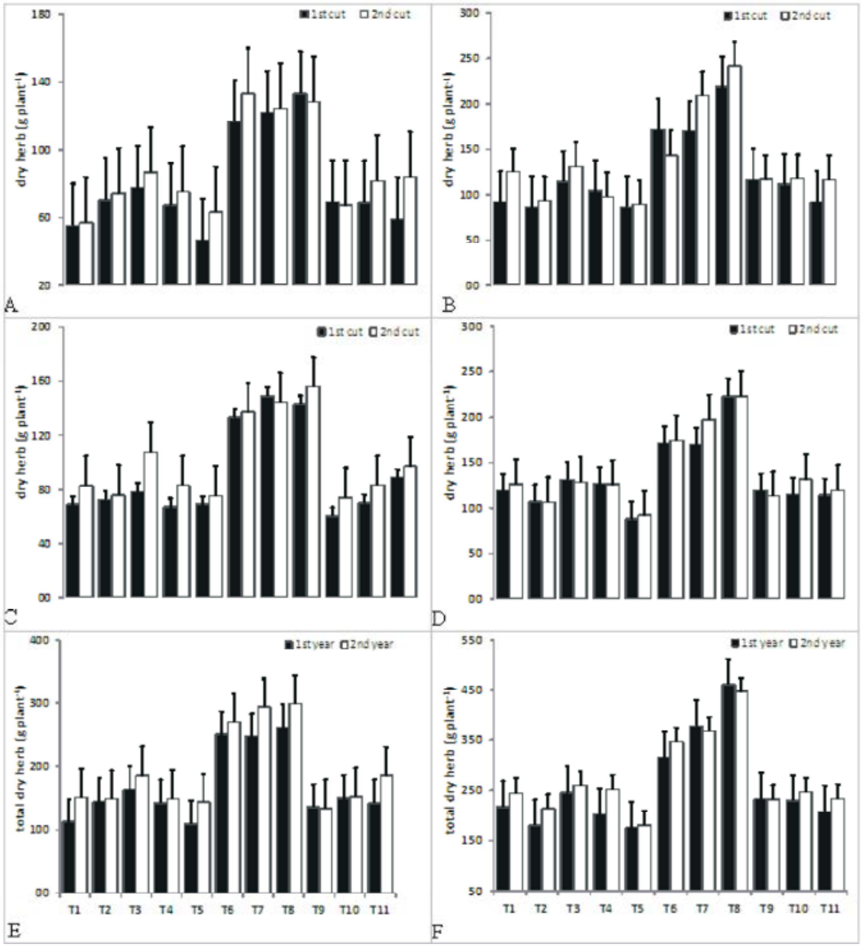

Fig 1: Basil dry weight growing in different media structure.
A, C & E cultivation in greenhouse, B, D & F cultivation in open field, A and B first year and C and D second year, E and F accumulative yield per plant.
Vertical bar present LSD value at P < 0.05.

increment of temperature compared to open field. In both seasons and cuts the plant height in the greenhouse values varied from 74 to 80 cm. On the other hand plants were grown outside showed robust and compacted growth of small plants. In both years and harvest application of 30% compost in media gave the tallest plant 74 cm compared to other mixtures with slight significant or no significant effect with other two compost integrated media. Control, different peat moss mixtures and vermicompost showed no relevant difference among them. Though, compost had a supportive action to grown plants, which might be due to availability and holding capacity of plant nutrition. Vermicompost application improves plant growth compared to control but without relevant significant difference. Construct the main structure of growing media. Compost's effect on plant height was in consisting with Atiyeh *et al*. [12] on marigold. Moreover, impact of compost was beneficial on basil and distinct than the impact of vermicompost, on the contrary of what was observed on *Crossandra undulaefolia* by Gajalakshmi and Abbasi [13]. Different observations were found on branches number in which greater number of branches produced in the open field than greenhouse. Branches number showed distinct difference between compost integrated media as compared with the other growing media. Compost application gives the tallest and more ramificated plants. Increment of compost percentage in growing media has showed positive effect on plant weight and branches number.

Herb Dry Weight: Plants in the open field accumulate more dry weight than plants inside the greenhouse in both years (Fig. 1). Compost application enhanced basil biomass accumulation inside and outside the green house. Increasing compost percentage to 30% assumes better accumulation of basil biomass. Peatmoss and vermicompost application did not improve soil capacity compared to control treatment. Slight insignificant increase in the accumulated biomass had been observed in the second cut compared to first one. Compost and vermicompost has showed positive impact on herb dry weight thanks to organic matter of and their contents of nutrient. In the second year compost application gave better yield 460 g plant^{-1} than the first year 266 g plant^{-1} cumulative weight of both cuts. Peat moss based and control growing media gave the lowest value in the first year 46.6 – 86.6 g plant^{-1} respectively. Between the lowest and highest value the difference fluctuated between 1.3 and 1.96 depend on the year and harvested cut. Vermicompost revealed poor nutrient supply than compost and that was in accordance with Anonymous [14].

Chlorophyll Content and Essential Oil Percentage: Chlorophyll was measured by SPAD, data showed the lowest coefficient of variability among values (Table, 3). However, 30% compost addition to the growing mixture gave the highest chlorophyll contents. Application of vermicompost did not give promising result. Plants grown in the open field showed higher chlorophyll contents than that one grown inside the greenhouse. That finding is in accordance with Kopsell *et al*. [2] who find reduction in basil leave pigments under green house condition. They had showed increase irradiance followed by increase in chlorophyll content in basil leaves. That was in accordance with Kurasova *et al*. [15] on barley and Behera and Choudhury [16] on wheat. The difference between the highest and lowest chlorophyll content was 7-10%. Inconsistent variability among treatments has explored that media structure does not provide clear image for chlorophyll contents. However, 30% compost application had showed the best chlorophyll contents

Table 3: Influence of different growing media mixtures on chlorophyll content and essential oil percentage in two harvest / cultivation season in field and greenhouse.

	Chlorophyll				Oil (%)			
	1st cut		2nd cut		1st cut		2nd cut	
Treatments	GH	Field	GH	Field	GH	Field	GH	Field
1st Season								
Loam soil (LS)	31.1	34.3	31.0	34.4	0.495	0.548	0.490	0.542
80% (LS) + 20%peat	31.4	34.7	31.3	34.8	0.392	0.520	0.465	0.521
60% (LS) + 40%peat	32.0	35.1	31.9	35.4	0.354	0.387	0.353	0.456
40% (LS) + 60%peat	32.1	32.1	32.1	32.4	0.250	0.255	0.250	0.265
20% (LS) + 80%peat	32.4	33.1	32.8	33.8	0.410	0.407	0.435	0.415
90% (LS) + Com10%	32.6	34.3	32.9	34.7	0.270	0.278	0.275	0.266
80% (LS) + Com20%	32.4	34.6	32.6	35.1	0.312	0.333	0.318	0.335
70% (LS) + Com30%	33.4	35.4	33.3	35.7	0.431	0.587	0.426	0.453
90% (LS) + Verm10%	32.7	35.1	33.1	34.9	0.667	0.596	0.675	0.582
80% (LS) + Verm20%	32.0	34.1	31.8	34.1	0.447	0.548	0.440	0.614
70% (LS) + Verm30%	32.2	34.2	32.3	34.5	0.583	0.620	0.585	0.618
LSD0.05	0.6	0.4	0.4	0.3	0.075	0.179	0.035	0.144
2nd Season								
Loam soil (LS)	31.2	34.6	31.7	34.8	0.510	0.546	0.490	0.554
80% (LS) + 20%peat	31.7	34.4	32.1	34.4	0.475	0.517	0.383	0.519
60% (LS) + 40%peat	32.2	35.2	32.8	35.6	0.357	0.510	0.353	0.391
40% (LS) + 60%peat	32.8	32.3	33.1	33.2	0.245	0.260	0.265	0.285
20% (LS) + 80%peat	32.8	33.6	33.2	34.1	0.405	0.418	0.475	0.421
90% (LS) + Com10%	33.1	34.6	33.5	34.8	0.285	0.268	0.275	0.293
80% (LS) + Com20%	34.0	34.9	34.5	35.1	0.327	0.339	0.322	0.345
70% (LS) + Com30%	33.4	35.1	33.6	35.5	0.427	0.454	0.455	0.442
90% (LS) + Verm10%	31.9	35.1	32.4	35.2	0.665	0.662	0.675	0.482
80% (LS) + Verm20%	32.4	35.1	33.1	35.0	0.465	0.570	0.435	0.627
70% (LS) + Verm30%	32.8	35.2	33.3	35.3	0.589	0.634	0.580	0.643
LSD0.05	0.6	0.2	0.4	0.4	0.024	0.08	0.065	0.050

GH = Greenhouse; Field = Open field; LSD0.05 = Least significant difference at $P < 0.05$.

Table 4: Influence of different growing media mixtures on oil yield (ml plant-1) in two harvest / cultivation season in field and greenhouse.

	1st cut		2nd cut		Total oil yield /plant	
Treatments	GH	Field	GH	Field	GH	Field
			1st Season			
Loam soil (LS)	0.272	0.630	0.277	0.677	0.549	1.307
80% (LS) + 20%peat	0.276	0.507	0.349	0.433	0.624	0.939
60% (LS) + 40%peat	0.216	0.522	0.301	0.596	0.518	1.118
40% (LS) + 60%peat	0.158	0.226	0.191	0.245	0.348	0.471
20% (LS) + 80%peat	0.215	0.339	0.264	0.371	0.479	0.711
90% (LS) + Com10%	0.290	0.530	0.364	0.379	0.655	0.910
80% (LS) + Com20%	0.327	0.683	0.393	0.749	0.720	1.431
70% (LS) + Com30%	0.625	1.446	0.533	1.009	1.158	2.455
90% (LS) + Verm10%	0.371	0.757	0.456	0.675	0.827	1.432
80% (LS) + Verm20%	0.279	0.614	0.359	0.718	0.637	1.332
70% (LS) + Verm30%	0.314	0.666	0.471	0.716	0.784	1.382
LSD0.05	0.149	0.228	0.029	0.198	0.150	0.313
			2nd Season			
Loam soil (LS)	0.342	0.674	0.424	0.733	0.765	1.407
80% (LS) + 20%peat	0.351	0.522	0.293	0.544	0.644	1.066
60% (LS) + 40%peat	0.357	0.638	0.407	0.489	0.764	1.126
40% (LS) + 60%peat	0.191	0.319	0.221	0.363	0.412	0.682
20% (LS) + 80%peat	0.237	0.387	0.363	0.404	0.600	0.791
90% (LS) + Com10%	0.383	0.499	0.377	0.546	0.760	1.045
80% (LS) + Com20%	0.527	0.492	0.513	0.677	1.040	1.169
70% (LS) + Com30%	0.637	1.004	0.736	1.123	1.373	2.127
90% (LS) + Verm10%	0.452	0.699	0.503	0.594	0.955	1.294
80% (LS) + Verm20%	0.372	0.659	0.355	0.858	0.726	1.517
70% (LS) + Verm30%	0.548	0.736	0.577	0.675	1.125	1.410
LSD0.05	0.054	0.080	0.121	0.140	0.139	0.418

GH = Greenhouse; Field = Open field; LSD0.05 = Least significant difference at $P < 0.05$.

Table 5: Coefficient of correlation among plant treats and oil %.

		Shn	DW	Chlorophyll	Oil%	Oil yield/plant
Field	PH	0.86***	0.69***	0.21NS	-0.30**	0.48***
	Shn	---	0.73***	0.14NS	-0.50***	0.35***
	DW	---	---	0.42***	-0.24NS	0.70***
	Chlorophyll	---	---	---	0.40***	0.61***
	Oil%	---	---	---	---	0.50***
Greenhouse	PH	0.75***	0.69***	0.67***	-0.12NS	0.61***
	Shn	---	0.46***	0.44***	0.06NS	0.48***
	DW	---	---	0.67***	-0.37***	0.69***
	Chlorophyll	---	---	---	-0.19NS	0.50***
	Oil%	---	---	---	---	0.39***

PH = plant height, SHn = shoot number, DW = dry weight.
** = significant at $P < 0.01$; *** = significant at $P < 0.001$; NS = not significant.

although of greater plant growth. Leaves chlorophyll content in the second year was 10% higher than first year. On the contrary of other parameters, reduction in essential oil percentage was noticed for compost mixture media which came as a reason for dilution effect (Table 3). On the other hand, vermicompost media gave the highest value of essential oil percentage.

Essential Oil yield: Oil yield is mainly based on essential oil percentage and dry biomass (Table, 4). However the negative correlation observed between oil percentage and dry weight reduces differences among treatments. However, compost application at 30% gave greater biomass than difference in oil percentage reduction.

Correlations among Different Treats: Correlation coefficients were calculated among plant traits, chlorophyll and essential oil content (Table, 5). Positive correlation between and among plant traits were observed in green house environment. However, oil percentage reveal negative correlation with plant height; shoot number and dry weight in both cultivation conditions which reveal dilution effect based on weight increment. Chlorophyll content reveals positive correlation with oil percentage which can be taken as an indicator for oil content. Furthermore, accumulative oil yield per plant showed positive correlation with different plant traits. Kopsell *et al*. [2] found that sweet basil carotenoids are positively correlated with chlorophyll content which affected by environmental factors. Thus, chlorophyll content is in accordance with nutritional value of sweet basil.

CONCLUSION

Different studies showed importance of sweet basil due to level of essential oils, phenols and flavonoids which express antioxidant, antimicrobial and anticarcinogenic properties. It has been shown, that the amendment of soil with organic matter leads to increase in the sustainability of agricultural production because it possesses many desirable properties such as high water holding capabilities, cation exchange capacity, ability to sequester contaminants (both organic and inorganic), enhanced nutrient uptake, plant hormone-like activity and beneficial effects on the physical, chemical and biological characteristics of soil. However, peat-moss is one of non-renewable resources its consumption cause exploitation and degradation of highly valuable ecosystems like peatlands [17]. Cultivation condition affects growth and final yield of cultivated herbs. Herbs, plants that represent a vast group of aromatic and medicinal species are relatively minor horticulture crops. Sweet basil is a native to Mediterranean region and widely cultivated in its basin countries. It has many uses such as essential oil production, pharmaceutical and food. Growing of basil in non adapted or poor soil is limited due to sensitivity of the plant to abiotic stress. However, basil requires very low amount of nutrient and very productive in the mean time. Loam soil present good physical and chemical structure for plant growth. However, integration of peat-moss increases water holding capacity. Its poor nutrition supply reduces the ability of loam soil. Therefore, compost application enhanced physical and chemical structure. Ability of compost on nutrition supply and nesting beneficial microorganisms increase its eligibility for media structure. Vermicompost application was always lower than compost application. Organic matter amendment leads to increase in sustainability in agricultural production because it possesses many desirable properties such as high water holding capabilities, cation exchange capacity, enhanced nutrient uptake, plant hormone-like activity and beneficial effects on the physical, chemical and biological characteristics of the soil [18,19].

Different plant parameters showed stability in their response regarding different treatments. Compost application can form independent source for plant growth and development. Further studies can be carried out on other levels of compost and different types of composting materials. On the other hand, research in herb in vital for human health and commodity.

REFERENCES

1. Palada, M.C., A.M. Davis, S.M.A. Crossman, C. Robles and E.A. Chichester, 2002. Sustainable crop management practices for improving production of culinary herbs in the Virgin Islands. In *XXVI* International Horticultural Congress: The Future for Medicinal and Aromatic Plants, 629: 289-298.
2. Kopsell, D.A., D.E. Kopsell and J. Curran-Celentano, 2005. Carotenoid and chlorophyll pigments in sweet basil grown in the field and greenhouse. HortScience, 40(5): 1230-1233.
3. Craker, L.E., Z. Gardner and S.C. Etter, 2003. Herbs in American fields: a horticultural perspective of herb and medicinal plant production in the United States, 1903 to 2003. HortScience, 38(5): 977-983.
4. De Masi, L., P. Siviero, C. Esposito, D. Castaldo, F. Siano and B. Laratta, 2006. Assessment of agronomic, chemical and genetic variability in common basil (Ocimum *basilicum* L.). European Food Research and Technology, 223(2): 273-281.
5. Rangappa, M. and H.L. Bhardwaj, 1998. Nitrogen Fertilization of Basil. HortScience, 33(3): 481-481.
6. Bunt, A.C., 1988. Media and mixes for container-grown plants. (A manual on the preparation and use of growing media for pot plants) (Ed. 2). Unwin Hyman.
7. Rakocy, J.E., R.C. Shultz, D.S. Bailey, E. Pantanella and J.J. Danaher, 2009. Alternative Media Types for Seedling Production of Lettuce and Basil. In International Symposium on Growing Media and Composting, 891: 257-264.
8. Lazcano, C., J. Arnold, A. Tato, J.G. Zaller and J. Domínguez, 2009. Compost and vermicompost as nursery pot components: effects on tomato plant growth and morphology. Spanish Journal of Agricultural Research, 7(4): 944-951.

9. Eklind, Y., L. Salomonsson, M. Wivstad and B. Rämert, 1998. Use of herbage compost as horticultural substrate and source of plant nutrients. Biol. Agri. Hort., 16: 269-290.
10. Cull, D.C., 1981. Alternatives to peat as container media; organic resources in the uk. In Symposium on Substrates in Horticulture other than Soils In Situ, 126: 69-82.
11. Sendecor, C.W. and W.G. Cochran, 1982. Statistical methods. 7th Ed. The Iowa State Univ. Press. Ames. Iowa, USA.
12. Atiyeh, R.M., N. Arancon, C.A. Edwards and J.D. Metzger, 2002. The influence of earthworm-processed pig manure on the growth and productivity of marigolds. Bioresource Technology, 81: 103-108.
13. Gajalakshmi, S. and S.A. Abbasi, 2002. Effect of the application of water hyacinth compost/vermicompost on the growth and flowering of Crassandra undulaefolia and on several vegetables. Bioresource Technology, 85: 197-199.
14. Anonymous, 2013. Nutrient-rich compost versus nutrient-poor vermicompost as growth media for ornamental-plant production. http://onlinelibrary. wiley.com/resolve/doi?DOI=10.1002%2Fjpln.201200 325.
15. Kurasova, I., M. Cajanek, J. Kalina and V. Spunda, 2001. Analysis of qualitative contribution of assimilatory and non-assimilatory de-excitation processes to adaptation of photosynthetic apparatus of barley plants to high irradiance. Photosynthetica, 38(4): 513-519.
16. Behera, R.K. and N.K. Choudhury, 2003. High irradiance-induced changes in carotenoid composition and increase in non-photochemical quenching Chl a fluorescence in primary wheat leaves. J. Plant physiology, 160: 1141-1146.
17. Robertson, R.A., 1993. Peat, horticulture and environment. Biodivers Conserv., 2: 541-547.
18. Aggelides, S.M. and P.A. Londra, 2000. Effects of compost produced from town wastes and sewage sludge on the physical properties of a loamy and a clay soil. Bioresource Technology, 71(3): 253-259.
19. Weber, J., A. Karczewska, J. Drozd, M. Licznar, S. Licznar and E. Jamroz, 2007. Agricultural and ecological aspects of a sandy soil as affected by the application of municipal solid waste composts. Soil Biol. Biochem., 39: 1294-1302.