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Comparative Study between Effect of some Growth Media on the Productivity and Quality of Lettuce and Red Cabbage Yields

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ABSTRACT

Two pot experiments were conducted at Soil Improvement and Conservation Research Dep. at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, North Nile Delta, Egypt during winter season 2018/2019. The factorial experiments were carried out in a complete randomized block design (CRBD) to study the effect of peat moss, compost, vermiculite, compost+ peat moss (1:1), peat moss + vermiculite (1:1), compost + vermiculite (1:1) and compost+ peat moss+ vermiculite (1:1:1) on growth, productivity and quality of lettuce (*cv .Beqbal*) and red cabbage (*cv.Naden*). The obtained results showed clear variation in the chemical and physical properties of different media after plants harvesting. The chlorophyll content, plant height and head diameter of lettuce and red cabbage values were significantly affected by different growth media. The highest values of these parameters were obtained by the mixture of compost+ peat moss+ vermiculite, while the lowest values were observed in plants grown in vermiculite. On the other hands, the mixture between compost+ peat moss+ vermiculite increased the valid, fresh and dry weights/plant of lettuce by 330.4, 336.8 and 109.8%, respectively, while the corresponding increases of these parameters in red cabbage were 216.4, 173.1 and 43.0%, respectively comparing to vermiculite. Also, this mixture achieved the highest values of NPK percentage for lettuce and red cabbage. In contrast, the lowest values of NPK were recorded with vermiculite media.

Keywords: Substrates; lettuce; red cabbage; growth; productivity; peat moss; compost; vermiculite.

INTRODUCTION

Lettuce and cabbage are the most important leafy vegetables in Egypt as it is flavor and lovely from most Egyptian People. Leafy vegetables have an important role in human nutrition and are a good source of minerals.

Decreasing cultivated area, rising population, water scarcity, need for recycling different organic wastes and climate change exert pressure on agricultural producers, moving from soil to soilless culture systems.

Soilless culture is defined as the cultivation of plants in systems without soil (Gruda *et al.,* 2016). These can include organic materials such as peat, compost, tree bark, coconut (*Cocos nucifera L.*), coir, poultry feathers, or inorganic materials such as clay, perlite, vermiculite, and mineral wool (Grunert *et al.,* 2008; Vaughn *et al.,* 2011) or mixes such as peat and perlite; coir and clay, peat and compost (Nair *et al.,* 2011). Peat is the main component of the current growing media used in substrate cultivation (Barrett *et al.,* 2016); however, this material is imported, very expensive and non-renewable. Compost is organic sources in Egypt which may play the role of peat moss. Compost is the material that results when recycled plant wastes, bio solids (like manure), fish, and other organic materials decompose aerobically through the action of microorganisms that live in the presence of air. Ceglie *et al.,* (2015) observed that the highest values of total length of lettuce; number of leaves and fresh and dry weights of seedlings aerial part were obtained with green compost+ peat+ perlite (45%+45% + 10% perlite by volume) as compared with peat or green compost alone. El- Moula *et al.,* (2016) revealed that the highest values of dry weight/plant, fresh weight, stem diameter, length, leaf area, number of leaves and NPK content of lettuce and cabbage were obtained with the mixture of 50% peat moss and vermiculite substrate and 50% rice straw compared with the traditional peat moss and vermiculite 1:1 (v/v). Hernández-Rodríguez *et al.,* (2017) showed that semi compost, vermicompost mixed in different proportions with peat moss significantly improved seed germination, as well as the development of lettuce and tomato seedlings, emphasizing the poor performance of peat moss alone. Thus, these organic fertilizers are appropriate for their use in the production of lettuce and tomato seedlings under greenhouse conditions.

The objective of this investigation is to assess the effects of some growth substrates composition on the productivity and quality of lettuce (*lactuca sativa*) and red cabbage (*Brassica oleracea var. capitata f. rubra*).

MATERIALS AND METHODS

Experimental description and treatments:

Two pot experiments were conducted at Soil Improvement and Conservation Research Dept., Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, North Nile Delta, Egypt (31° 5' 38.98" latitude N and 30°56' 53.69" longitude E) during winter season 2018/2019. The experiment aimed to study the effect of some growing substrates on growth, productivity and quality of lettuce *(lactuca sativa*) and red cabbage (*Brassica oleracea var. capitata f. rubra*).

The factorial experiments were carried out in a complete randomized block design (CRBD) with three replications. Pots were divided into 2 groups (21 pots for each) for lettuce and red cabbage. Circular plastic pots with 25 cm diameter and 25 cm depth (valium, 12.27 L) were used for lettuce, while pots with 25 cm diameter and 35 cm depth (volium, 17.18 L) were used for red cabbage. The pots in both groups were filled by peat moss, compost, vermiculite, peat moss + compost (1:1), peat moss + vermiculite (1:1), compost + vermiculite (1:1) or peat moss + compost + vermiculite (1:1:1).

Cultural practices:

Lettuce seedling (*cv Beqbal.*) with 3 to 4 green leaves (nearly30 days old) were obtained from Faculty of Agriculture, Kafr Elsheikh (Horticulture Dept), and transplanted into the pots on October, 22nd 2018 and harvested on February, 2nd, 2019 after full maturity. While red cabbage seedling (*cv. Naden*) with 3 to 4 green leaves (nearly 40 days old) were obtained from the same department and transplanted into the pots on October, 22nd,

2018 and harvested on March, 13th, 2019 after full maturity. All agricultural practices for lettuce or red cabbage were performed as recommended by Ministry of Agriculture and Reclamation.

Each pot was irrigated three times a week in the first state (one by nutrient solution and 2 times by water) and then after 25 days it irrigated twice a week (one by nutrient solution and one by water). 84 L nutrient solution for each pot (0.5 L /week) was prepared according to Cooper (1979) as follow:

Reagent	Formula	Amount (g/1000 L)
Potassium dihydrogen phosphate	KH_2PO_4	263
Potassium nitrate	KNO_3	583
Calcium nitrate	$Ca(NO_3)_2•4H_2O$	1003
Magnesium sulfate	$MgSO_4•7H_2O$	513
EDTA iron	$[(CH_2\text{-}N(CH_2.COOH)_2]_2FeNa$	79
Manganous sulfate	$MnSO_4•H_2O$	6.1
Boric acid	H_3BO_3	1.7
Copper sulfate	$CuSO_4•5H_2O$	0.39
Ammonium molybdate	$(NH4)6Mo_7O_{24}•4H_2O$	0.37
Zinc sulfate	$ZnSO_4•7H_2O$	0.33

This formula gives the following essential element concentrations in the solution:

Major Elements	Element Concentration, mg/L (ppm)
Nitrogen (N)	200
Phosphorus (P)	60
Potassium (K)	300
Calcium (Ca)	170
Magnesium (Mg)	60
Micronutrients	
Boron (B)	0.3
Copper (Cu)	0.1
Iron (Fe)	12.0
Manganese (Mn)	2.0
Molybdenum (Mo)	0.2
Zinc (Zn)	0.1

Growth media analyses:

Electrical conductivity and pH were determined in media: water (1:10 *w/v*) as described by Smith and Hughes (2002). Soluble cations and anions were determined as described by Jackson (1973). Total nitrogen was determined by Kjeldahl method according to Bremmer and Mulvaney (1982). Phosphorus (%) was determined colorimetrically at 550 mm as described by Ranganna (1979). Potassium (%) was determined by flame photometer as described by Jackson (1973). Fe, Zn and Mn were determined using atomic absorption spectrophotometer as described by Chapman and Pratt (1961). Total organic carbon (TOC) was determined by the dry combustion method at 540 °C for 4 h according to Abad *et al.,* (2002). Total organic matter was measured by multiplying Total organic carbon (TOC) * 1.724. Bulk density (BD) and soil moisture content of the growth media were tested according to the method presented by Verdonck and Gabriels (1992). Some chemical and physical properties of these media are shown in Tables (1and 2).

Table 1. Some chemical properties of growth media before cultivation

Properties	Media	Peat moss	Compost	Vermiculite
pH (1:10 substrate: water)		5.35	7.58	7.80
EC dS m^{-1} (1:10 substrate: water)		2.42	4.02	0.18
Cations and anions (Meq/l)	Na^+	21.5	28.3	0.05
	K^+	0.2	0.4	-
	Ca^{++}	1.8	8.4	0.23
	Mg^{++}	0.9	2.9	1.04
	Cl^-	22.3	14.0	0.5
	SO_4^-	2.1	22.0	1.2
Total macronutrients (%)	N	0.68	14.0	0.004
	P	1.1	1.10	0.01
	K	2.4	1.30	0.003
Available micronutrients ($mg\ kg^{-1}$)	Fe	2.14	1215	0.8
	Mn	11.3	56.0	-
	Zn	3.7	31.0	-

Table 2. Some physical properties of each growth media before cultivation

Properties / Substrate	Moisture content (%)	Bulk density ($g\ m^{-3}$)	Organic matter (%)	Organic Carbon (%)	C/N Ratio
Peat moss	32.50	0.07	66.55	38.51	56.63
Compost	16.70	0.57	26.96	15.60	11.14
Vermiculite	26.80	0.17	1.11	0.64	160

Plants analysis:

Chlorophyll content was measured after 70 days from transplanting; while plant height, head diameter, total fresh weight, valid weight and dry weight were measured after harvesting.

Plant samples were taken at booting and harvesting growth stages for chemical analysis, dried at 70 °C for 48 hrs, ground, mixed and wet digested using hot sulfuric acid with repeated additions of sulfuric –per chloric acids mixture (1:1) as described by Peterburgski (1968). Nitrogen concentration was determined by micro-Kjeldahl method according to Jackson (1973), phosphorus concentration was determined by using hydroquinine method according to Snell and Snell, (1967) and potassium concentration was determined by using flame photometer according to Jackson (1973).

Statistical analyses:

The obtained results were subjected to analyses of variance and LSD test at 0.05 level of probability according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Chemical characteristics for the growth media after plant harvesting:

Data illustrated in Table (3) showed that the highest value of EC was obtained by compost (3.92 dS m^{-1}) while the lowest value was observed with vermiculite (0.16 dS m^{-1}).

The total N, P and K of the different growth media are presented in Table (3). The highest NPK contents (17.06, 1.26 and 2.65 %) were achieved in growth media of compost+ peat moss+ vermiculite, followed by compost+ peat moss. The lowest NPK contents (0.01, 0.09 and 0.02 %) were found in vermiculite media.

Physical characteristics of different growth media after plant harvesting:

The results presented in Table (3) showed obvious variations in bulk density, organic matter and moisture content of the studied growth media. The maximum bulk density (0.62 g m^{-3}) was noticed in compost+ peat moss+ vermiculite followed by compost (0.59 g m^{-3}), while the minimum value (0.08 g m^{-3}) was found in peat moss. The maximum organic matter (66.4 %) was noticed by peat moss, but the minimum value (1.1%) was found in vermiculite media. On other hand, the maximum moisture content (32.65 %) was recorded in compost+ peat moss+ vermiculite, while the minimum value (16.70%) was found in compost media.

Table 3. Some chemical and physical characteristics of the growth media after harvesting

Properties / Substrate	EC dS m^{-1}	Total macronutrients (%)			Bulk density (g m^{-3})	Organic Matter %	Moisture Content (%)
		N	P	K			
Peat moss (P)	2.36	1.46	1.6	2.9	0.08	66.4	32.50
Compost (C)	3.92	16.2	1.19	1.84	0.59	26.89	16.70
Vermiculite (V)	0.16	0.01	0.09	0.02	0.19	1.1	26.80
P+ C	2.84	16.9	1.24	2.41	0.41	45.6	26.34
C+ V	1.98	1.54	0.18	1.01	0.36	18.4	22.4
P + V	1.13	0.26	0.12	0.067	0.12	31.95	28.75
C+ P+ V	2.06	17.06	1.26	2.65	0.62	49.3	32.65

Chlorophyll contents of lettuce and red cabbage:

Results presented in Fig (1) indicted that significant difference in chlorophyll contents of lettuce and red cabbage was observed with different growth media in this study. The highest values of chlorophyll content for lettuce and red cabbage (54.57 and 75.13, respectively) were achieved with growth media of compost+ peat moss+ vermiculite as compared to the other growth media. While the lowest values for lettuce and red cabbage (13.33 and 57.50, respectively) were obtained with vermiculite media. This trend may be due to that vermiculite media is poor in the nutrient elements comparing to other growth media as shown in Table (1).

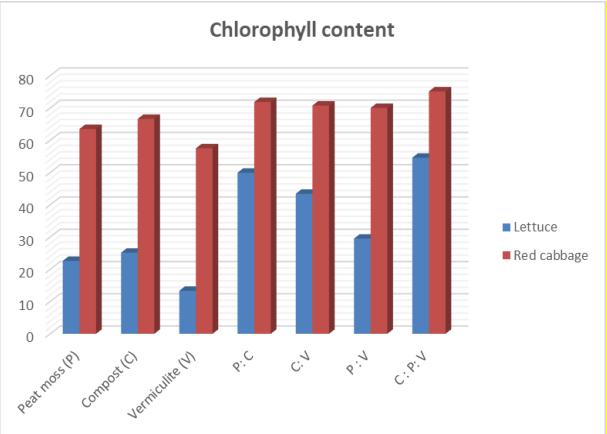

Fig. 1. Effect of different growth media on chlorophyll content of lettuce and red cabbage.

Plant height of lettuce and red cabbage:

The data in Fig (2) showed big variance in plant height of lettuce and red cabbage with different growth media. The highest plant heights of lettuce and red cabbage (14.33 and 18.33 cm, respectively) were recorded with compost+ peat moss+ vermiculite which increased in both plants by 50.88 and 27.91%, respectively as compared with vermiculite which gave the lowest values. The increases in plant height might be due to stability of cell walls with compost+ peat moss+ vermiculite, which stimulates formation of new leaves and increases the size and height of plant more than that with vermiculite. The obtained results are in agreement with those obtained by Ceglie *et al.*, (2015).

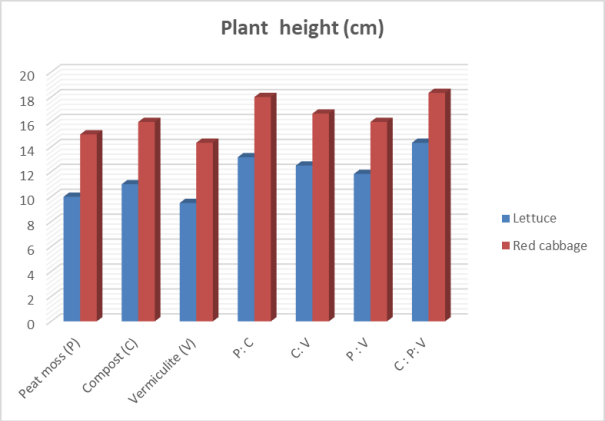

Fig. 2. Effect of different growth media on plant height of lettuce and red cabbage.

Head diameter of lettuce and red cabbage:

Regarding the effect of the studied growth media on head diameter, the data in Fig (3) cleared that the highest head diameter for lettuce and red cabbage (11.67 and 10.67 cm, respectively) were achieved with compost+ peat moss+ vermiculite, while the lowest values for both plants (6.67 and 7.33 cm, respectively) were observed with vermiculite. These results may be due to that vermiculite is poor in the nutrient elements comparing to other growth media which effect on plant growth and head diameter. However, no significant differences were observed between the effect of compost+ peat moss+ vermiculite and compost+ peat moss on head diameter of red cabbage. The obtained results are agreed in somewhat with Ceglie *et al.*, (2015).

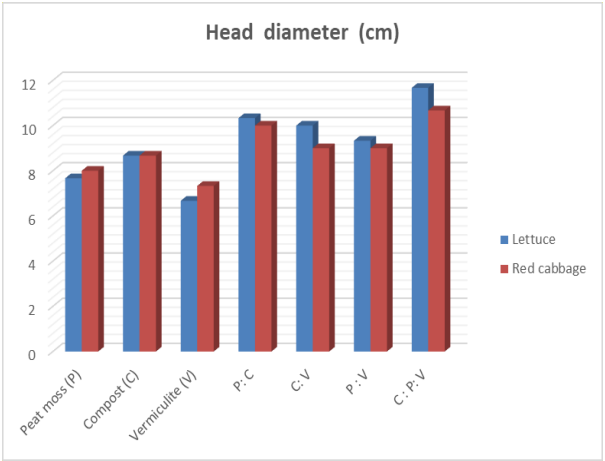

Fig. 3. Effect of different growth media on head diameter of lettuce and red cabbage

Valid, fresh and dry weights of lettuce and red cabbage:

Data illustrated in Table (4) revealed that the valid, fresh and dry weights were significantly affected by different growth media. The use of mixture from compost+ peat moss+ vermiculite (1:1:1) as a growth media led to a significant increase in valid, fresh and dry yields and produced the highest yields/plant from both crops followed by compost+ peat moss. Therefore, mixture of compost+ peat moss+ vermiculite increased these parameters by 330.4, 336.8 and 109.8% respectively in lettuce and 216.4, 173.1 and 43.0%, respectively in red cabbage as compared to the vermiculite media. On the other hand, vermiculite produced the lowest values of these parameters. The decline of the yield of both crops with vermiculite media may be due to lower nutrients contents and absorption capacity as compared to other media which increased the nutrients in the root zone of plants. These results are in agreement with those obtained by Ceglie *et al.,* (2015).

Table 4. Effect of different growth media on valid, fresh and dry weights of lettuce and red cabbage

Crop	Substrate type	Valid weight (g/plant)	Fresh weight (g/plant)	Dry weight (g/plant)
lettuce	Peat moss (P)	121.67	168.33	7.04
	Compost (C)	160.00	208.33	7.89
	Vermiculite (V)	93.33	126.67	4.99
	P+ C	328.33	405.00	9.60
	C+ V	228.33	321.67	9.16
	P + V	198.33	285.00	8.51
	C+ P+ V	401.67	553.33	10.47
	$LSD_{0.05}$	57.70	62.76	0.76
Red cabbage	Peat moss (P)	401.67	481.67	13.00
	Compost (C)	440.00	522.67	14.23
	Vermiculite (V)	295.00	353.33	12.40
	P+ C	848.33	860.00	16.30
	C+ V	661.67	680.00	15.77
	P + V	516.67	581.67	14.97
	C+ P+ V	933.33	965.00	17.73
	$LSD_{0.05}$	94.92	92.59	0.86

Nutrient concentrations of lettuce and red cabbage plants:

It is evident from the results in Table (5) that significant differences can be observed in NPK concentrations of lettuce and red cabbage plants grown in different growth media. The highest values of NPK concentrations were obtained by using the mixture of compost+ peat moss+ vermiculite, while the lowest values were recorded in plants grown in vermiculite media. However, no significant differences were found in P concentration in lettuce and red cabbage plants grown in compost+ peat moss+ vermiculite or that grown in compost+ peat moss media. This trend may be attributed to high nutrient contents in these mixtures over than vermiculite media as shown in Table (3). These results are in accordance with Manas *et al.*, (2009).

Table 5. Effect of different growth media on NPK concentrations of lettuce and red cabbage

Crop	Substrate type	N%	P%	K%
Lettuce	Peat moss (P)	2.31	0.109	1.24
	Compost (C)	2.68	0.114	1.44
	Vermiculite (V)	1.50	0.103	0.81
	P+ C	2.92	0.116	1.57
	C+ V	2.76	0.112	1.49
	P + V	2.31	0.111	1.24
	C+ P+ V	3.17	0.119	1.70
	$LSD_{0.05}$	0.19	0.004	0.10
Red cabbage	Peat moss (P)	2.61	0.130	2.04
	Compost (C)	3.19	0.135	2.49
	Vermiculite (V)	1.79	0.123	1.39
	P+ C	3.48	0.139	2.71
	C+ V	3.29	0.133	2.56
	P + V	2.76	0.132	2.15
	C+ P+ V	3.77	0.141	2.94
	$LSD_{0.05}$	0.28	0.004	0.22

CONCLUSION

Using compost alone or mixed with some materials as a growth media gave the highest vegetative yields of lettuce and red cabbage with high N, P and K concentrations. So, we can use it as a local renewable substrate instead of the imported substrates, which may play the same role of peat moss.

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دراسة مقارنة بين تأثير بعض بيئات النمو على إنتاجية وجودة محاصيل الخس والكرنب الأحمر

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أُجريت تجربتان الأصص في قسم بحوث تحسين وصيانة الأراضي- محطة البحوث الزراعية بسخا - محافظة كفر الشيخ - شمال الدلتا - مصر خلال موسم الشتاء 2019/2018 لدراسة تاثير انواع البيئات : البيتموس، الكمبوست ، الفيرميكوليت ، الكمبوست: البيتموس (1: 1) ، البيتموس : الفيرميكوليت (1: 1) ، الكمبوست + الفيرميكوليت (1: 1) والكمبوست+ البيتموس+ الفيرميكوليت (1: 1: 1) . علي انتاجية وجودة محصول الخس والكرنب الاحمر. واظهرت النتائج اختلافات فى الصفات الكيمائية و الطبيعية للبيئات محل الدراسة بعد الحصاد. ووجد ايضا اختلافات معنوية بين تأثيرالبيئات والمخاليط المختلفة علي محتوى الكلوروفيل وطول النبات وقطررأس ألخس و الكرنب الأحمر حيث كانت أعلى القيم مع مخاليط الكمبوست والبيتموس و الفيرميكوليت. بينما لوحظت أقل القيم مع الفيرميكوليت. و من ناحية اخرى ادى استخدام خليط الكمبوست+ البيتموس+ الفيرميكوليت (1: 1: 1) إلى زيادة فى قيم الوزن الطازج والوزن الصالح والوزن الجاف لنبات الخس بمقدار 330.36 ، 336.84 ، 109.75% ، على التوالى بينما كانت الزيادة لتلك الصفات لنبات الكرنب الاحمر 216.38 ، 173.11 ، 43.01%، على التوالى. أيضا ، تم الحصول على أعلى قيم لمحتويات النتيروجين والفوسفوروالبوتاسيوم باستخدام خليط الكمبوست و البيتموس و الفيرميكوليت. بينما كانت اقل القيم مع الفيرميكوليت.