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Effect of Substrate Culture System and Growing Media Type on Growth, Yield and Quality of Soilless Cultured Lettuce (cv. Green Star)

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ABSTRACT

This study was carried out at Soilless Culture Unit, Agric Faculty., Mansoura Univ., Egypt, from 2018 to 2020, to study the impact of three substrate culture systems (PVC pipes 4" in diameter with circular holes, slit PVC pipes 4" and slit PVC pipes 8") in A shape units and three growing media (peat moss, vermiculite and peat moss:vermiculite 1:1, v/v) and their interactions on growth and productivity of lattuga lettuce cv. Green Star grown soilless cultured. The experiment was designed as strip-plot design. The obtained results showed that, all studied traits as parameters of growth (plant height, foliage diameter/plant and leaves number and area/plant), yield (foliage and leaves fresh weights/plant and yield/unit) and leaves chemical composition (chlorophylls, N, P, K, …) significantly affected by all tested factors and their interactions. Concerning effect of substrate culture system, PVC pipes 4" with holes achieved the best significant means for all traits as compared to slit PVC pipes 8". Regarding influence of growing media, the mixture of peat and vermiculite gave the best significant values for all traits compared to vermiculite only. Respecting impact of combination treatments, the interaction treatment of PVC pipes 4" with circular holes+peat and vermiculite mixture had significant impacts on all forecited traits as compared to interaction one between slit PVC pipes 8"+vermiculite. Hence, it could be recommended that soilless culture of lettuce in PVC pipes 4" with holes+mixture of peat and vermiculite in A shape units is the best choice to achieve maximum growth and productivity of lettuce.

Keywords: Lattuga lettuce (Green Star cultivar), soilless substrate growing media cultures, PVC plastic pipes, growth, yield and quality.

INTRODUCTION

Lettuce (*Lactuca sativa* L.) belongs to Compositae (Asteraceae) family and it is one among the most widely raw consumed popular vegetables across the world because of its worldwide popularity, its contribution to the creation of jobs and income and as a nutritious and aperitif vegetable. Lettuce is also significance due to its beneficial effects on human health and nutrition, which arises from its important as a good source of dietary fibers, minerals (Fe, K, P, Ca and Mn), vitamins (A, B_1, B_6, C and K), omega-3 fatty acids that are essential for normal growth and development (Oh *et al*., 2009 and Belitz *et al*., 2009) and that also contains various other health-beneficial bioactive compounds such as phenolics, ascorbate, tocopherol and lignans, thus, lettuce has great medicinal properties as anti-inflammatory, cholesterol-lowering, and anti-diabetic activities (Kim *et al*., 2016).

Vegetables grown in soil contaminated with environmental toxicant or heavy metal pesticide addition have higher mineral components as well as toxic heavy metals and if accumulated in their tissues will cause potential health risk to human (Asaduzzaman *et al*., 2015). Food quality is an aspect of nutrition and food safety that is connected not only to production and availability of food, but also to improve the health of consumers. For food to be considered safe it must be free from any chemical components or products that may be detrimental to humans (Martins *et al*., 2017). In addition, global climate change is expected to increase the hazard of frequent water deficit. Agriculture is in a phase of great change around the world, as traditional soil culture systems suffer from serious problems such as; reducing arable areas due to severe urban sprawl, also poor soil fertility and its secondary salinity, scarcity of irrigation water suitable for agriculture, as well as the excessive use of fertilizers and chemical pesticides that cause serious damage to the environment and human health, as well as increase production costs, in addition to the problems of salinity, alkaline, weed seeds, and pathogens born in soil. In future, it would be difficult task to provide a fresh and clean food supply for the fast-growing population using traditional agriculture. Under these circumstances, the technique of soil-less culture is an alternative technology to adapt effectively to the current challenges in the agricultural sector in general and in the field of vegetable production in particular.

The plants cultivation is nowadays moving from traditional culture system (TCS) in mineral soil to soilless culture system (SCS) relying on growing media and fertigation system. The objectives of this transition are to realize higher qualitative and quantitative yields, to standardize cultivation techniques and to decrease both production costs and prejudicial environmental effects. SCS represents a valid substitute to conventional cultivation techniques attributed to the full control of the inputs that it supplies and it is a well technique to cultivate

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plants achieving guarantees of quality to the market. SCS allows to produce clean material at harvest, and therefore to decrease numerous washing treatments. As well, the short growing season of the soilless-grown vegetables decrease chances of parasite attacks and disease spread throughout the crop, and employing minimum inorganic nutrients in the form of balanced nutrient solution and sterile growing media with a low environmental influence may be a replacement to the procedure of soil disinfection. In several studies TCS to SCS were compared, showing that SCS allowed to increase earliness and to decrease nitrate content of leafy vegetables such as lettuce, spinach, celery, rocket and others. SCS is a valid alternative to TCS to prevent soil-borne diseases and to control mineral plant nutrition for standardizing qualitative characteristics of the final product (Nicola *et al*,. 2015).

The term 'growing medium' is amongst others used to define the substance employed in a container to culture a plant (Olle *et al.,* 2012). Soilless culture growing media are materials, other than soils in situ, in which plants are cultivated. These can contain organic materials such as peat; coconut coir, compost, saw dust, tree bark, or inorganic substances such as vermiculite, perlite, pumice, expanded clay (Grunert *et al.*, 2008 and Vaughn *et al.*, 2011), rock wool and glass wool, or mixtures such as peat and perlite; peat and vermiculite, peat and sand, compost and sand, coir and sand, etc., (Nair *et al.,* 2011). Soilless growing media have three main roles for plants: 1) provide water, nutrients and aeration 2) allow for maximum root system growth and 3) supply physical support for the plant. Soilless media should have big particles with sufficient pore spaces between the particles (Bilderback *et al.*, 2005). Proper particle size selection or combination is crucial for a light and fluffy (well-aerated) medium that enhance rapid seed germination, strong root system growth and suitable water drainage. Several ingredients have been employed to make growing media for vegetable production. Worldwide, the raw materials utilized vary depending on their regional availability (Schmilewski, 2009). Such raw materials can be organic or inorganic, however growing media are often formed from a blend of various raw materials to attain the accurate balance of water and air holding capacity for the plants to be developed in addition for the long-term stability of the medium (Bilderback *et al.,* 2005). A good soilless growing media should supply typical growth circumstances for a plant to develop as water rationalization, good aeration, good water and nutrients retention capacity, resistance to decomposition and sanity and high structural stability.

Consequently, the aims of this investigation were to study the influence of different substrate culture systems and soilless growing media types on growth, yield and quality of Lattuga lettuce cv. Green Star.

MATERIALS AND METHODS

The current study was carried out in Soilless Culture Unit, Research Vegetable Farm, Vegetables and Ornamentals Dept., Faculty of Agric., Mansoura Univ., Egypt during two winter seasons of 2018/2019 and 2019/2020 to investigate the influence of three substrate culture systems (*i.e.*, PVC plastic pipes 4 inches in diameter and 3 meters in length with circular holes of 2.5" in diameter, PVC plastic pipes 4 inches in diameter and 3 meters long, the top third of which is cut lengthwise and slit PVC plastic pipes 8 " in diameter and 3 meters in length, cut in lengths into two identical halves) in A shape style and three growing media (peat moss, vermiculite and peat moss : vermiculite at 1:1, v/v) and their interactions on growth, yield and quality of lattuga lettuce (*Lactuca sativa* L. cv. 'Green Star') grown soilless cultured.

Well prepared growing media were added according to experiment treatments in A-shaped soilless culture unit pipes in appropriate quantities. Then uniform lettuce transplants (35 days old) were planted on 28th of October in both cultivation seasons inside PVC planting tubes filled with wetted growing medium in hills spaced 25 cm apart from each other in one row at a rate of 12 transplants per each planting tube and 108 transplants per each A-shaped soilless culture unit. Each A-shaped soilless culture unit consisted of 9 white-colored PVC plastic pipes, either with a full diameter of 4 inches or two-thirds of a diameter of a 4-inch pipe, or an 8-inch pipe radius (Figure 1: A-C). All pipes used, whether full or slit were 3 meters long and 4.7 mm wall thicknesses. The area of each planting unit was 6 m^2 (4 m length and 1.5 m width).

A B C

Figure: 1 (A-C): Substrate culture systems used; (A) PVC plastic pipes 4 inches in diameter with circular holes, (B) slit PVC plastic pipes 4 inches in diameter and (C) slit PVC plastic pipes 8 " in diameter.

Each growth unit was supplied with full strength Cooper's solution from 200 L PC4R Tank through drip irrigation system consisted of black, no-drip polyethylene hoses (16 mm in diameter) manifold to lateral black polyethylene hoses (16 mm in diameter) which contained inline drippers spaced 25 cm apart. Each dripper discharge was 4 L h^{-1}. Cooper's solution nutrients were prepared in the form of two separate concentrated stock solutions, the first of which contained only calcium nitrate, while the second solution contained the rest of the salts of the macro and micro nutrients. The stock solutions are 100 times stronger than the diluted solution which given to plants.

When feeding plants, the two stock solutions are diluted within nutrition tank by mixing them with water to make the diluted solution that the plants are supplied with and that achieves the full strength of Cooper's nutrient solution. The prepared diluted nutrient solution is pumped from the nutrition tank to the growth units throughout the growing season via the drip irrigation system by a half horse power water pump. The concentrations of macro and micro nutrients of the applied Cooper' nutrient solution were N: 200 ppm (NO_3-N= 170 ppm, NH_4-N= 30 ppm), P: 60 ppm, K: 300 ppm, Ca: 175 ppm, Mg: 50 ppm, S: 68 ppm, Fe: 12 ppm, Mn: 2 ppm, B: 0.3 ppm, Zn: 0.1 ppm, Cu: 0.1 ppm and Mo: 0.2 ppm. Each plant received about 150-250 cm^3 of the nutrient solution twice a week according to its growth stage, then a small amount of fresh irrigation water is pumped after each feeding process to wash the drip irrigation network and to avoid blockage of the drippers.

Experimental design:

The experiment was laid out as strip-plot design with 3 replications. Where, the vertical plots were allocated to three substrate culture systems, whereas the horizontal ones were allotted to three growing media.

Recorded data:

After 9 weeks of planting date, fifteen lettuce plants were randomly cropped from each treatment to estimate the following parameters:

1- Vegetative growth parameters:

Plant height, foliage diameter/plant, leaves number/plant and leaves area/plant were measured.

2- Yield and its components:

Foliage fresh weight/plant, leaves fresh weight/plant, yield/PVC plastic pipes unit and yield/fed were calculated.

3- Leaves chemical composition:

Chlorophyll a, chlorophyll b, total carotenoids and vitamin C (VC) content and TSS and total acidity percentages were estimated in lettuce fresh leaves and analyzed according to AOAC (1990). Also, the percentage of N, P, K, protein and dry matter and nitrate (NO_3) content were determined in leaves dry matter according to AOAC (1990).

Statistical Analysis:

Data were treated by analysis of variance (ANOVA) method as described by Gomez and Gomez (1984). The treatment averages were compared employing the least significance differences (LSD) test at 5 % probability rate manner as mentioned by Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

Results

1- Vegetative growth parameters:

The impact of substrate culture system (PVC plastic pipes 4" in diameter with circular holes as first system, slit PVC plastic pipes 4 inches in diameter as second system and slit PVC plastic pipes 8" in diameter as third system), soilless growing media (peat moss, vermiculite and peat moss: vermiculite at 1:1, v/v) and their interaction on plant height, foliage fresh weight/plant, leaves no/plant and leaves area/plant of soilless cultured lettuce were presented in Table (1). Concerning the effect of substrate culture system, data listed in Table (1) and shown in Figures 2 (A-C) and 3 (A-D) indicate that all previous parameters had been affected significantly by all different substrate culture systems in both successive seasons, respectively. The highest values in this respect were achieved with the first substrate culture system, whereas the lowest values were recorded with the third one.

Table 1. Effect of substrate culture system and growing media type on vegetative growth parameters of soilless cultured lettuce during 1st (2018) and 2nd (2019) seasons.

Characters		Plant height (cm)		Foliage diameter/plant (cm)		Leaves No. /plant		Leaves area (cm^2/plant)	
Treatments		**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**
Substrate culture system									
First		32.4	32.1	12.0	11.5	47.9	47.6	6586	6568
Second		27.7	27.9	10.6	10.3	42.5	43.6	6145	6095
Third		25.5	25.0	9.8	9.3	39.0	39.3	5745	5720
LSD 5%		1.0	0.6	0.7	0.4	1.8	0.5	453	298
Growing media type									
Ver		26.8	26.5	10.2	9.8	41.5	41.5	5644	5650
Peat		27.9	27.5	10.7	10.4	43.1	43.3	6294	6235
Ver + Peat		30.9	30.9	11.5	11.0	44.8	45.6	6539	6498
LSD 5%		1.1	1.0	0.5	0.4	0.8	1.0	399	386
Interaction between substrate culture system and growing media type									
First	Ver	29.3	29.4	11.5	11.1	46.4	46.4	6176	6161
	Peat	30.8	30.4	11.7	11.4	48.4	46.8	6682	6664
	Ver + Peat	36.9	36.6	12.8	12.0	48.8	49.4	6900	6879
Second	Ver	26.6	26.3	10.1	9.7	40.6	40.6	5543	5556
	Peat	28.0	28.2	10.5	10.4	42.4	44.8	6375	6322
	Ver + Peat	28.5	29.1	11.2	10.8	44.4	45.4	6519	6407
Third	Ver	24.6	23.9	9.2	8.6	37.4	37.4	5213	5233
	Peat	24.8	24.0	9.8	9.2	38.4	38.4	5824	5720
	Ver + Peat	27.2	27.1	10.4	10.1	41.2	42.0	6197	6206
LSD 5%		2.0	2.1	0.9	0.7	1.6	2.2	681	579

First: PVC plastic pipes 4" in diameter with holes, Second: PVC plastic pipes 4" in diameter (slit) , Third: PVC plastic pipes 8" in diameter (slit)
Ver: Vermiculite , Peat: Peat moss ,Ver + Peat: Vermiculite + Peat moss

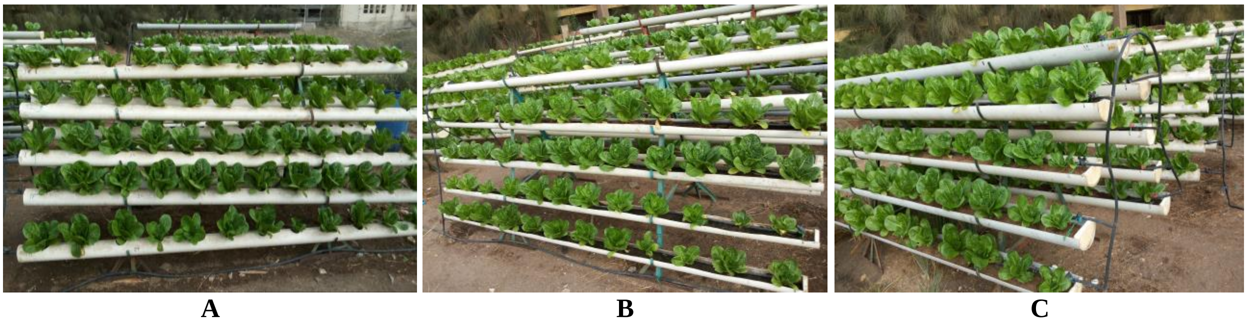

Figure 2 (A-C): Development of soilless cultured lettuce plants growth 6 weeks after planting of transplants within different substrate culture systems used; (A) PVC plastic pipes 4 inches in diameter with circular holes, (B) slit PVC plastic pipes 4 inches in diameter and (C) slit PVC plastic pipes 8 " in diameter.

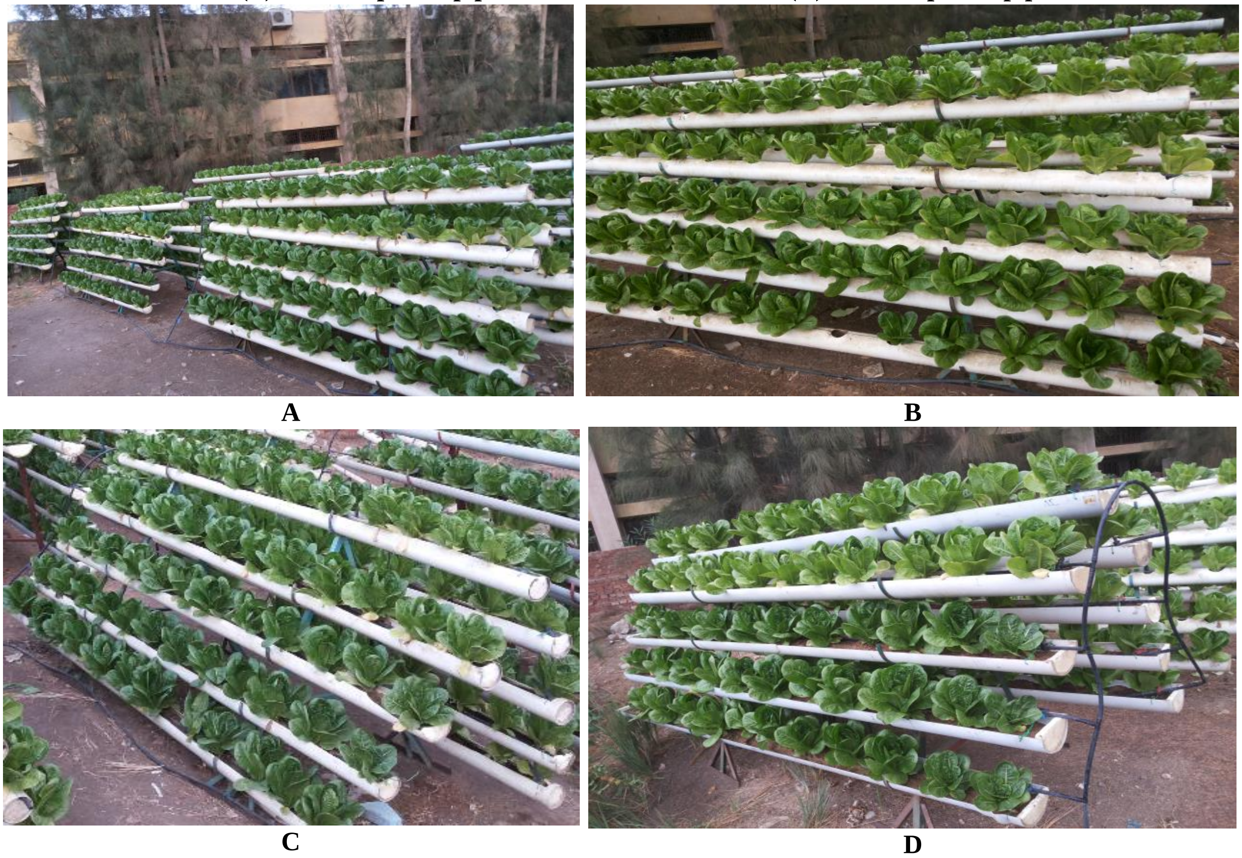

Fig. 3(A-D): Development of soilless cultured lettuce plants growth 9 weeks after planting of transplants within different substrate culture systems used; (A) general view for substrate culture systems, (B) PVC plastic pipes 4 inches in diameter with circular holes, (C) slit PVC plastic pipes 4 inches in diameter and (D) slit PVC plastic pipes 8 " in diameter.

Regarding the influence of growing media type, data of the same Table (1) clearly reveal that the forecited parameters had significantly been impacted by all growing media in the first and second seasons. The maximum means were obtained with the mixture of peat moss + vermiculite. While, the minimum means were registered with vermiculite medium only.

Respecting the impact of interaction treatments, data shown in Table (1) also mainly indicate that the above parameters were significantly had been influenced by all different combination treatments in two growing seasons. The best records in this connection were attained with the combination treatment of the first substrate culture system + the mixture of peat moss + vermiculite. Whereas, the worse records were realized with the interaction treatment of third substrate culture system + vermiculite alone. The rest combination treatments gave values between these two extremes.

2. Yield and its components:

Data presented in Table (2) elucidate that, substrate culture system had significant effects on the characters of soilless cultured lettuce yield and its components (foliage fresh weight, leaves fresh weight/plant, yield/PVC plastic pipes unit and yield/fed). In this regard, the first substrate culture system gave the highest values for all mentioned parameters in both consecutive seasons, respectively. While, the lowest values for all previous parameters were recorded with the third substrate culture system.

As for the impact of growing media type, data given in Table (1) obviously indicate that aforementioned traits had been affected significantly by divers growing media used. The mixture of peat moss + vermiculite growing medium achieved the maximum means for all above traits, followed by peat moss one. Whereas, the vermiculite growing medium alone recorded the minimum means in this respect.

As to the influence of interaction treatments, data presented in the same Table (2) also distinctly show that the forecited attributes had significantly been impacted by all diverse interaction treatments in both growing seasons. The highest values in this connection were obtained with the combination treatment of peat moss + vermiculite as a mixture of growing medium with the first substrate culture system. While, the lowest values were registered with the combination treatment of third substrate culture system plus vermiculite only. However, the rest interaction treatments recorded values between these two extremes.

Table 2. Effect of substrate culture system and growing media type on yield and its components of soilless cultured lettuce during 1st (2018) and 2nd (2019) seasons.

Characters		Foliage FW*/plant (g)		Leaves FW*/plant (g)		Yield/PVC P unit (kg)		Yield/fed(ton)	
Treatments		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Substrate culture system									
First		392.02	389.27	350.00	339.21	42.338	42.041	29.637	29.429
Second		348.00	348.37	310.47	309.16	37.584	37.624	26.308	26.337
Third		294.86	301.35	259.77	270.51	31.845	32.546	22.291	22.782
LSD 5%		7.05	12.55	12.31	4.23	0.761	1.355	0.533	0.949
Growing media type									
Ver		312.30	318.77	278.51	284.18	33.728	34.427	23.610	24.099
Peat		343.56	338.65	303.05	303.93	37.104	36.574	25.973	25.602
Ver + Peat		379.02	381.57	329.69	330.77	40.934	41.210	28.654	28.847
LSD 5%		9.24	10.63	9.77	10.92	0.998	1.148	0.698	0.803
Interaction between substrate culture system and growing media type									
First	Ver	373.76	372.49	340.06	335.23	40.340	40.229	28.238	28.160
	Peat	378.76	374.75	343.15	336.74	40.906	40.473	28.634	28.331
	Ver + Peat	423.78	420.57	366.78	345.65	45.769	45.422	32.038	31.795
Second	Ver	309.75	313.17	275.98	276.96	33.453	33.822	23.417	23.676
	Peat	361.59	363.06	312.17	322.49	39.052	39.211	27.336	27.448
	Ver + Peat	372.65	368.88	316.25	328.04	40.246	39.839	28.172	27.887
Third	Ver	253.62	270.64	219.48	240.36	27.391	29.230	19.174	20.461
	Peat	290.32	278.12	253.83	252.56	31.355	30.037	21.949	21.026
	Ver + Peat	340.63	355.27	306.03	318.61	36.788	38.369	25.751	26.859
LSD 5%		18.73	17.64	18.16	15.68	2.023	1.905	1.416	1.333

FW: Fresh weight PVC P unit: Poly vinyl chloride pipe unit

3. Leaves chemical quality:

The effect of substrate culture system, growing media and their interaction on lettuce fresh leaves chemical quality parameters (contents of chlorophyll a, chlorophyll b, total carotenoids and VC and percentage of TSS and total acidity) presented in Table (3). Pertaining impact of substrate culture system, results shown in Table (3) indicate that all substrate culture systems had significant effects on all former parameters in two growing seasons. In this regard, the best results for all previous traits were obtained with the first substrate culture system (PVC plastic pipes 4" in diameter with circular holes), followed by the second one (slit PVC plastic pipes 4 inches in diameter) as compared to the third one (slit PVC plastic pipes 8 " in diameter), which gave the worst results in this connection.

Table 3. Effect of substrate culture system and growing media type on photosynthetic pigments, vitamin C, TSS and total acidity contents of fresh leaves of soilless cultured lettuce during 1st (2018) and 2nd (2019) seasons.

Characters		Chl. a (mg/100g FW*)		Chl. b (mg/100g FW*)		T. carot. (mg/100g FW*)		VC (mg/100g FW*)		TSS (%)		T. acidity (%)	
Treatments		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Substrate culture system													
First		70.8	72.2	33.3	33.9	23.7	24.3	4.4	4.3	5.8	5.7	0.25	0.26
Second		63.7	69.5	29.9	32.6	21.3	23.2	3.7	3.6	4.8	4.7	0.16	0.17
Third		53.4	55.6	24.0	26.0	17.0	18.5	2.9	2.8	4.0	3.9	0.40	0.42
LSD 5%		1.5	2.8	1.3	1.2	0.9	0.6	0.4	0.7	0.1	0.3	0.06	0.05
Growing media type													
Ver		60.2	64.2	27.5	30.1	19.6	21.5	3.4	3.3	4.6	4.4	0.25	0.27
Peat		62.6	65.5	29.1	30.7	20.7	21.8	3.7	3.6	4.8	4.7	0.27	0.28
Ver + Peat		65.1	67.5	30.6	31.7	21.8	22.7	4.0	3.9	5.2	5.1	0.28	0.30
LSD 5%		3.0	1.1	1.2	0.6	0.8	0.5	0.4	0.5	0.3	0.2	0.12	0.12
Interaction between substrate culture system and growing media type													
First	Ver	68.1	71.1	32.0	33.4	22.7	23.9	4.2	4.0	5.5	5.5	0.21	0.22
	Peat	70.6	71.9	33.2	33.8	23.6	24.3	4.4	4.2	5.7	5.7	0.25	0.26
	Ver + Peat	73.8	73.5	34.6	34.5	24.7	24.9	4.7	4.6	6.1	5.9	0.28	0.30
Second	Ver	62.9	68.0	29.5	31.9	21.0	22.8	3.4	3.3	4.4	4.3	0.14	0.13
	Peat	63.4	70.1	29.8	32.9	21.2	23.2	3.7	3.7	4.7	4.5	0.16	0.17
	Ver + Peat	64.9	70.3	30.5	33.0	21.7	23.5	4.0	3.9	5.3	5.3	0.19	0.21
Third	Ver	49.8	53.4	21.0	25.0	14.9	17.8	2.6	2.6	3.7	3.7	0.42	0.47
	Peat	53.7	54.6	24.3	25.4	17.3	18.0	2.9	2.9	4.1	3.9	0.40	0.42
	Ver + Peat	56.6	58.8	26.6	27.6	18.9	19.6	3.1	3.0	4.3	4.2	0.37	0.38
LSD 5%		4.6	3.5	2.6	1.7	1.9	1.2	0.6	0.8	0.3	0.3	0.17	0.18

Chl. a: Chlorophyll a , Chl. b: Chlorophyll b , T. carot.: Total carotenoids , T. acidity: Total acidity , FW*: Fresh weight

In relation to the influence of growing media type, it is quite clear from the results presented in Table (3) that all growing media employed significantly affected all the forecited characters in both seasons. The maximum values on that score, except total acidity one, were recorded with the growing media mixture of peat moos plus vermiculite, followed by peat moss one. Whereas, the minimum values in this respect were registered with vermiculite alone.

Concerning the effect of interaction treatments, results of the same Table (3) clearly state that all combination treatments had significant impacts on all mentioned parameters during both seasons. The highest means of all preceding characters were achieved with the interaction between the first substrate culture system and mixture of peat moss + vermiculite as growing medium, followed by the combination treatment of first substrate culture system + peat moss only. While, the lowest of all above mentioned characters were recorded with the combination between the third substrate culture system and vermiculite alone. But, the rest combinations gave means between these two extremes.

4. Leaves chemical constituents:

The influence of substrate culture system, growing media type and their combination on N, P, K, protein and dry matter percentage and NO_3 content of dry leaves of soilless cultured lettuce were listed in Table (4). Concerning the impact of substrate culture system, data presented in Table (4) distinctly revealed that the forecited parameters had significantly been affected by all different substrate culture systems in both seasons, consecutively. The first substrate culture system achieved the best values for all tested parameters followed by the second one in this connection. On the contrary, the third one recorded the lowest values for all studied parameters in this respect.

Regarding the effect of growing media type, data shown in the same Table (4) mainly indicate that the aforementioned characters significantly had been impacted by all growing media used in the first and second seasons. The mixture of peat moss + vermiculite gave the maximum means for most above characters and the minimum NO_3 content, followed by peat moss growing medium. On contrast, the vermiculite growing medium registered the minimum means for most previous characters and the maximum ones for NO_3 content.

Respecting the influence of combination treatments, data of the same Table (4) clearly show that the above mentioned traits had been affected significantly by all interaction treatments between substrate culture system and growing media in two growing seasons. The highest values of all above traits, except NO_3 content, were attained with the combination treatment of the first substrate culture system plus the growing media mixture of peat moss + vermiculite. On the other hand, the lowest values for all mentioned attributes, except NO_3 content, were realized with the interaction treatment of the third substrate culture system + vermiculite growing medium only. The rest combination treatments gave values between these two extremes.

Table 4. Effect of substrate culture system and growing media type on N, P, K, protein and NO_3 contents of leaves dry matter of soilless cultured lettuce during 1st (2018) and 2nd (2019) seasons.

Characters		N(%)		P(%)		K(%)		Protein (%)		NO_3(mg/kg DW)		DM(%)	
Treatments		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Substrate culture system													
First		5.02	4.94	0.469	0.486	5.73	5.61	28.9	28.4	83.7	97.2	6.55	6.67
Second		4.47	4.50	0.418	0.443	5.10	5.24	25.7	25.9	104.4	123.3	6.21	6.28
Third		3.58	3.94	0.335	0.388	4.09	4.70	20.6	22.6	117.4	127.6	5.72	5.76
LSD 5%		0.18	0.06	0.017	0.006	0.21	0.07	1.1	0.4	4.3	3.3	0.39	0.38
Growing media type													
Ver		4.14	4.13	0.387	0.407	4.72	4.94	23.8	23.8	107.2	121.0	6.01	6.07
Peat		4.35	4.42	0.406	0.435	4.96	5.14	25.0	25.4	101.6	115.1	6.16	6.24
Ver + Peat		4.58	4.81	0.429	0.474	5.23	5.47	26.4	27.7	96.7	112.0	6.30	6.40
LSD 5%		0.13	0.16	0.012	0.016	0.14	0.19	0.7	0.9	2.9	3.4	0.27	0.29
Interaction between substrate culture system and growing media type													
	Ver	4.88	4.88	0.456	0.480	5.57	5.55	28.0	28.0	92.5	104.9	6.45	6.54
First	Peat	4.92	4.90	0.460	0.482	5.62	5.57	28.3	28.2	85.1	95.7	6.59	6.67
	Ver + Peat	5.26	5.03	0.492	0.495	6.00	5.72	30.2	28.9	73.6	91.0	6.62	6.79
	Ver	4.39	4.03	0.410	0.397	5.01	4.96	25.2	23.2	106.0	127.0	6.07	6.15
Second	Peat	4.48	4.69	0.419	0.462	5.11	5.34	25.7	27.0	104.7	122.2	6.24	6.33
	Ver + Peat	4.53	4.77	0.424	0.470	5.17	5.43	26.1	27.4	102.6	120.7	6.31	6.38
	Ver	3.15	3.50	0.294	0.344	3.59	4.30	18.1	20.1	123.0	131.0	5.51	5.52
Third	Peat	3.64	3.67	0.340	0.362	4.15	4.52	20.9	21.1	115.1	127.6	5.66	5.73
	Ver + Peat	3.96	4.64	0.370	0.457	4.52	5.27	22.8	26.7	114.0	124.3	5.98	6.02
LSD 5%		0.26	0.23	0.024	0.022	0.29	0.27	1.5	1.3	5.9	5.2	0.47	0.44

DM: Dry matter

Discussion

It is quite clear from the forecited presentation of the acquired results connected to the impact of substrate culture system, growing media type and their combinations on the characteristics of vegetative growth, productivity and quality of soilless cultured lattuga lettuce plants that there are generally significant positive influences of both these tested factors on all of the estimated characters.

Regarding the effect of substrate culture system, the obtained results are in agreement with those found by Frezza *et al.* (2005); Fallovo *et al.* (2009a) and Kim *et al.* (2016) on lettuce, Böhme *et al.* (2001) on cucumber, Fontana *et al*. (2003) on corn salad, Nicola *et al.* (2005), Nicola *et al*. (2005) and Fontana and Nicola (2009) on rocket, Valenzano, *et al*. (2008) on tomato plants, Jafarnia, *et al*. (2010) on strawberry.

The positive increments in the growth, yield and quality characters of the soilless cultured lettuce plants due to different substrate culture system can be ascribed to the first planting system (The 4" diameter PVC plastic pipes with circular holes) providing a better growth environment for the growing lettuce plants compared to the other second (PVC plastic pipes 4 inches in diameter and 3 meters long, the top third of which is cut lengthwise) and third (slit PVC plastic pipes 8" in diameter) cultivation systems. Since, the growing medium as a ground environment in the first system are slightly exposed to external climatic conditions through the circular holes of the growth tubes, which are completely closed after the plants age and increase their vegetative growth, which leads to the failure of the rapid drying of the growing medium and the retention of an adequate amount of moisture and nutrient solution needed to growing plants for the longest period throughout the growing season to ensure the best growth, yield and quality compared to the third cultivation system in particular. On the other hand, the growing medium in the third system is completely exposed to the external climatic conditions that leads to its rapid drying and failure to retain an adequate amount of moisture for growing plants for a long period of the growing season, which leads to an increase in the concentration of salts in them and exposing the plants to salt stress that cause a remarkable decrease in vegetative growth, yield and quality rates of growing plants.

Concerning the impact of soilless growing media type, the results are in harmony with the findings of Karimaei *et al*. (2004); Anjana and Iqbal (2007), Fandi *et al*. (2008), Coronel *et al.* (2009), Fallovo *et al.,* (2009a), Bhat *et al*. (2013) and Makhadmeh *et al.* (2017) on lettuce, Gruda, and Schnitzler (2004a and 2006), Galbiatti *et al.*, (2007), Fontana and Nicola (2009) on corn salad and rocket plants and Olle *et al*. (2012). The stimulatory impact of growing media mixture may be attributed to that mixing coarse inorganic materials such as vermiculite with organic ones as peat moss has resulted in a better plant growth and higher yield and quality probably owing to increasing water-holding capacity and good aeration of the sufficiently loose growing media mixture used, leading to a strong and effective root system formation that absorbs the needs of the upper plant parts with high efficiency, resulting in achieving the highest characteristics of growth, yield and quality of soilless cultured lettuce plants.

CONCLUSION

Regarding the forecited results, it could be concluded that using the first substrate culture system (PVC plastic pipes 4" in diameter with circular holes) + the mixture of peat moss and vermiculite (1:1, v/v) as a growing media type is considered the best treatment for obtaining maximum growth, high quantitative and qualitative production of soilless cultured lattuga lettuce cv. Green Star under Dakahlia Governorate circumstances.

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تأثير نظام مزارع البيئات الصلبة ونوع بيئة النمو على نمو ومحصول وجودة الخس صنف جرين ستار المنزرع لأرضياً

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أجريت هذه الدراسة الحالية بوحدة الزراعة بدون تربة، قسم الخضر والزينة، كلية الزراعة، جامعة المنصورة، مصر خلال الفترة من 2018 إلى 2020 م، لدراسة تأثير ثلاثة أنظمة مزارع بيئات صلبة (مواسير PVC بلاستيكية قطر 4 بوصة ذات فتحات دائرية علوية على مسافة 25 سم من بعضها البعض، مواسير PVC بلاستيكية قطر 4 بوصة مقطوع ثلثها العلوي طولياً و أنصاف مواسير PVC بلاستيكية قطر 8 بوصة مشقوقة طوليا) في وحدات ذات شكل A، وثلاثة بيئات نمو (بيت موس، فيرميكيوليت، وخليط بيت موس : فيرميكيوليت بنسبة 1:1، حجم/حجم) وتفاعلاتهم على نمو وإنتاجية خس اللاتوجا صنف جرين ستار المنزرع بطريقة الزراعة بدون تربة. صممت التجربة في تصميم الشرائح المتعامدة في 3 مكررات. بينت النتائج المتحصل عليها أن جميع الصفات المدروسة كصفات النمو (إرتفاع النبات، قطر النمو الخضري/نبات وعدد الأوراق والمساحة الورقية/نبات)، والمحصول (الأوزان الطازجة للنمو الخضري/نبات، الوزن الطازج للأوراق/نبات، والمحصول/وحدة زراعة، والمحصول/فدان)، والتركيب الكيماوي للأوراق (محتوى كلورفيل أ، ب، والكاروتينيدات الكلية، و % لفيتامين ج، والمواد الصلبة الذائبة بأوراق الخس الطازجة، هذا بالإضافة إلى النسب المئوية لكل من النيتروجين، والفوسفور، والبوتاسيوم، والمادة الجافة ومحتوى النترات بأوراق الخس الجافة) قد تأثرت معنويا بجميع العوامل المدروسة وتفاعلاتها. ففيما يتعلق بتأثير نظام مزارع البيئات الصلبة، نجد أن مواسير الـ PVC البلاستيكية قطر 4 بوصة ذات الفتحات الدائرية العلوية قد حققت المتوسطات الأفضل معنويا لجميع الصفات مقارنة بأنصاف مواسير الـ PVC البلاستيكية قطر 8 بوصة المشقوقة طوليا. وفيما يتعلق بتأثير بيئات النمو، نجد أن خليط بيئتي البيت موس والفيرميكيوليت بنسبة 1:1، حجم/حجم قد أعطى القيم الأفضل معنويا لجميع الصفات مقارنة ببيئة الفيرميكيوليت بمفردها. وفيما يتعلق بتأثير معاملات التفاعل بين أنظمة مزارع البيئات الصلبة و بيئات النمو، نجد أن معاملة التفاعل بين مواسير الـ PVC البلاستيكية قطر 4 بوصة ذات الفتحات الدائرية العلوية وخليط بيئتي البيت موس والفيرميكيوليت ذات تأثيرات معنوية على جميع الصفات سابقة الذكر مقارنة بمعاملة التفاعل بين مواسير الـ PVC البلاستيكية قطر 8 بوصة المشقوقة طوليا وبيئة الفيرميكيوليت منفردة. لذلك، يمكن التوصية بأن زراعة خس الرومين صنف جرين ستار لأرضيا في وحدات هرمية الشكل لمواسير الـ PVC البلاستيكية قطر 4 بوصة ذات الفتحات الدائرية العلوية المملوءة بخليط مناصفة من بيئتي النمو البيت موس والفيرميكيوليت يعتبر الخيار الأفضل لتحقيق النمو والإنتاجية القصوى للخس.