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Influence of Substrate Types and Mulch Application on Growth, Yield and Quality of Lettuce Plants (*Lactuca sativa* L.)

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ABSTRACT

This experiment was carried out at screened greenhouse to investigate the effects of substrate types and mulch application on the growth, yield and quality of lettuce. Five types of substrate (sand, sand + husk, perlite, perlite + peat moss and peat moss) and two cultivation systems (compost mulch and un-mulch) were conducted on (*Lactuca sativa* cv. Iceberg) at Central Laboratory for Agricultural Climate (CLAC), during two autumn seasons 2015/2016 and 2016/2017. The treatments were set up in a split plot design with four replications. Results indicated that substrate types, mulch application and there interaction had a significant effects on vegetative growth parameters (plant height, number of leaves and fresh and dry weights of leaves), chemical components of leaves (N, P and K %) and yield and its components (head diameter, ascorbic acid and total yield). Moreover, sand + husk substrate increased almost all parameters compared to other substrate types. Applied compost mulch had greater parameters values compared to un-mulch treatment.

INTRODUCTION

Lettuce (*Lactuca sativa* L.), an annual plant of the Asteraceae family, is one of the most important commercial vegetables and a popular salad crop in the world. The plant is full of vitamins and minerals with lots of fibers (Moreira *et al*., 2014).

Soilless culture is defined as growing plants in either organic or inorganic substrate and compensate by nutrient solution for nourishment. It is characterized as intensive, efficient system that maximizes the use of resources and yield. It is also considered one of the most intensive forms of vegetables production on a commercial scale (Robertson, 1993; Paradossi *et al*., 2002 and Grillas *et al*., 2001). Many authors proposed soilless culture as an alternative to traditional field production for high-value vegetables especially under greenhouses (Asao, 2012 and Dorais *et al*., 2007). Soilless growing media is more suitable growing environment in terms of drainage control as well as soil born diseases control when compared with soil culture (Bilderback *et al*., 2005 and Mastouri *et al*., 2005).

Soilless culture media may include inert organic and inorganic substances either alone or in mixture. Most common organic substrates include sawdust, coco peat, peat moss, woodchips, fleece, marc, bark. Inorganic substrates can be either naturally or artificially created. Naturally coexisted inorganic substrates include perlite, vermiculite, zeolite, gravel, rock wool, sand, glass wool, pumice, expanded clay, volcanic tuff while synthetic substrates may include hydrogel, foam mates (polyurethane) and oasis (plastic foam) etc. (Olle *et al*., 2012; Ehret and Helmer, 2009).

Using local substrates such as sand and vermicompost instead of peat moss and perlite reduces the cost and increase the sustainability of the substrate culture (Asaduzzaman *et al*., 2015). Worldwide many raw materials have been used as a growing media in vegetables production under soilless culture systems. Despite these many benefits, there is currently very little information available concerning the influence of substrate type on plant growth and nutrient uptake in many crops, including leafy vegetables.

Mulching is defined by the use of organic material to cover the soil and is more common in horticulture and very useful in root protection from different environmental conditions that might harm plant development. Mulch plant protection is not only limited to temperature mitigation but also prevents weed growth and spread due to the release of some allelopathic compounds (White *et al*., 1989; Teasdale, 1993). In many cases, mulch attributes to crop earliness, yield, and quality (Yoo-Jeong *et al*., 2003; Bhardwaj and Kendra, 2013; Kumar *et al*., 2014).

Mulch can be used anywhere, but it is favorable where there is no need to remove the mulch so often and does not require extra labor costs (Bhardwaj, 2011). The term organic mulch means the use of plant or animal materials for the soil cover. These materials include sawdust, wood chips, plant leaves, ash, straw, compost and animal manures. It is recommended to apply mulch immediately after seeds germination or transplanting to achieve the best benefits from the mulch.

Mulch is useful in plant nutrition. It reduces nutrient leaching (Relf, 2009), and improves soil characteristics. Moreover, when mulch decays, it supplies the soil with organic materials, which enhance the soil physical properties to sustain the soil biological macro fauna (Mayer and Hartwig, 1986; Hooks and Johnson, 2003; Blanchart *et al*., 2006; Muhammad *et al*., 2009; Sarolia and Bhardwaj, 2012; Kumar *et al*., 2014).

The objective of this present study is to evaluate the effects of five deferent commercial substrate types and two mulch applications to determined better substrate type and mulch application on yield and quality of lettuce.

MATERIALS AND METHODS

Experimental layout:

This experiment was carried out at screened greenhouse located at the Dokki Protected Cultivation Experimental site, CLAC, Agricultural Research Center (ARC), Ministry of Agriculture and Land Reclamation. Experiment comprised five different commercial substrate types: (1) sand, (2) sand + husk (1:1 v/ v), (3) perlite, (4) perlite + peat moss (1:1 v/ v) and (5) peat moss, and two mulch applications (1) mulch: Nile compost, by 5 cm thickness, and (2) un-mulch. Physical and chemical characteristics of the substrates and Nile compost according manufacturer, are shown in Tables (1 and 2; respectively).

Table (1): Physical and chemical characteristics of five commercial substrates.

Items	Peat moss	Perlite	Sand	Husk
Organic matter (%)	82.00	-----	-----	-----
N ($mg \cdot L^{-1}$)	10.90	0.10	-----	0.20
P ($mg \cdot L^{-1}$)	0.62	0.001	-----	-----
K ($mg \cdot L^{-1}$)	2.00	0.016	-----	-----
pH	3.0-4.0	6.32	7.7	6.32
EC ($mS \cdot cm^{-1}$)	0.80	0.03	0.62	-----
C/N ratio	53.00	-----	0.9	204.30

Lettuce (*Lactuca sativa* cv. Iceberg) seedlings were transplanted at 15th of October during two autumn seasons, 2016 and 2017, after emergence, at Styrofoam planting boxes.

Each substrate was arranged in three rows on a greenhouse trough in plastic pots, 6 L capacity. Each 1m^2 included 12 plants. Each planting pots was irrigated using 2 L/h pressure-compensating drip emitters. Irrigation was controlled by a timer and averaged 20 to 30% drainage (leaching fraction) at each application. Nutrient solution was applied daily by fertigation, from transplanting to the day before harvest. Compost mulch (5 cm thickness) was covered on half of pots and others haven't mulch.

Table (2): Physical and chemical properties of Nile compost used in this study.

Compost properties	Values
Density as wet basis (kg/m^3)	600 - 750
Density as dry basis (kg/m^3)	450 - 560
Moisture content (%)	25 - 30
pH in 1 : 10 extract	5.5 - 7.5
EC in 1 : 10 extract (dS/m)	3.5 - 5.5
Water holding capacity (%)	200 - 300
Organic matter (%)	40 - 45
Organic carbon (%)	23.2 - 26.1
C/N ratio	14.5 : 1 - 16.5 : 1
Total nitrogen (%)	1.4 - 1.8
Phosphorus (%)	0.4 - 0.8
Potassium (%)	0.6 - 1.2
Iron (ppm)	1500 - 2000
Copper (ppm)	160 - 240
Manganese (ppm)	100 - 150
Zinc (ppm)	40 - 80

Source: Egyptian company for agricultural residues utilization (ECARU).

Measurements:

Four plants were selected at random from each unit plot after 80 days from transplanting. The following parameters were recorded from sample plants: plant height, number of leaves, fresh and dry weights of leaves and total yield. Total N, P and K contents of leaves were determined for each treatment according to distillation in a Macro-Kjeldahle apparatus (Black, 1983) and atomic absorption spectrophotometric (Helrich, 1990) methods. Ascorbic acid (vitamin C) was determined in the fresh heads by using the 2,6Dichlorophenolindophenol method described in Association of Official Analytical Chemists (AO A C) (1990).

Substrate temperature was determined as average for (maximum + minimum) per month from transplanting until end of experiment using a digital thermometer Art.No.30.5000/30.5002 produced by TFA, Germany.

Economic evaluation:

Total cost determined by the cost of substrate (calculated in 5 years) + plastic pots (calculated in 5 years) + seedling + mulch+ nutrient solution.

- Net return = Total return - Total cost

$$\text{Rate of capital gains (\%)} = \frac{\text{Net return}}{\text{Total cost}} \times 100$$

- Return of pound spent on operating costs= Net return / Total variable costs.

The price of lettuce head was calculated depending on the sorting of head size.

Experimental design and analysis:

The experiment was carried out in split plot design with four replicates. The mulching application was arranged in the main plots, whereas, the substrate types were arranged in the subplots. Data of all measured parameters were analyzed statistically by SAS statistical software. Also, Duncan's Multiple Range Tests (DMRT) was used to compare treatment means at a probability level of 0.05.

RESULTS AND DISCUSSION

1. Soil temperature profile:

Data in Figures (1, 2) showed the average substrate temperature at Dokki site. The greatest values of substrate type's temperature were, in general, detected in October followed by November. However, the lowest substrate type's temperature was found at January.

Data from the same figures (1, 2) indicated that, in general, applied compost mulch lead to increase average different substrate types temperature more than other substrate types un-mulched. Moreover, perlite substrate without compost mulch application recorded the lowest average temperature compared to other substrate types. While sand + husk substrate with compost mulch recorded the highest average temperature.

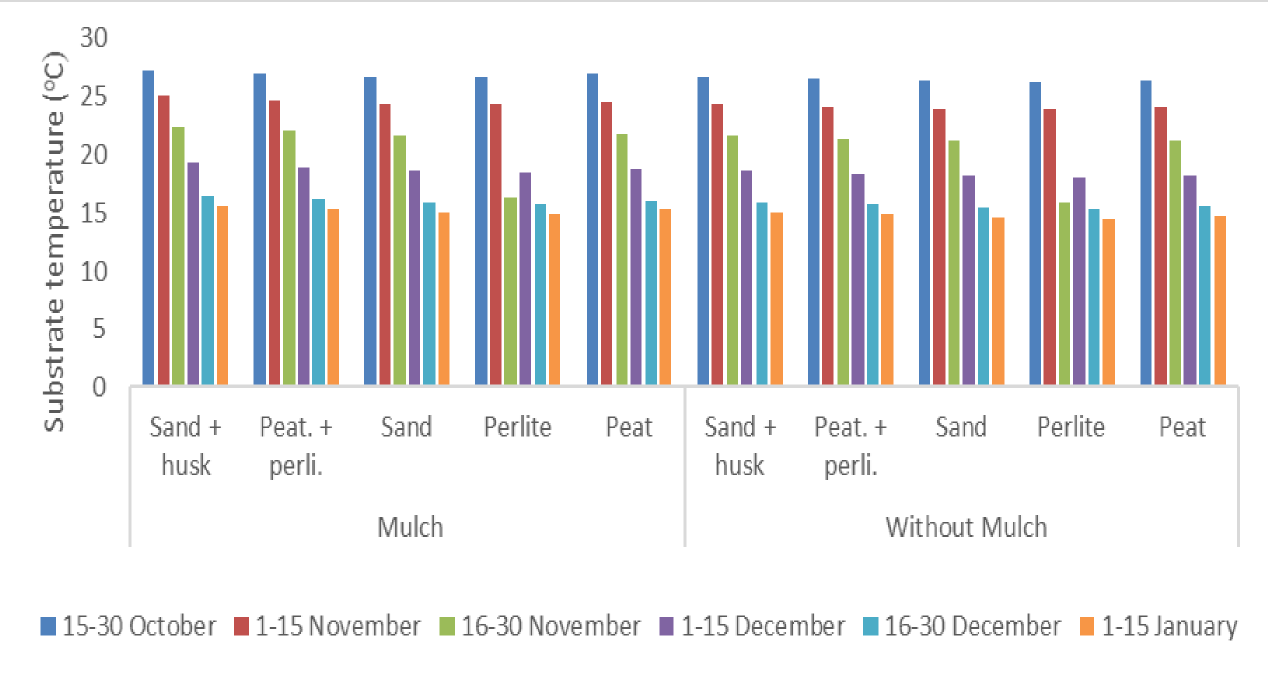

Figure (1): Average substrate temperature mulched or un-mulched during season during season 2015/2016.

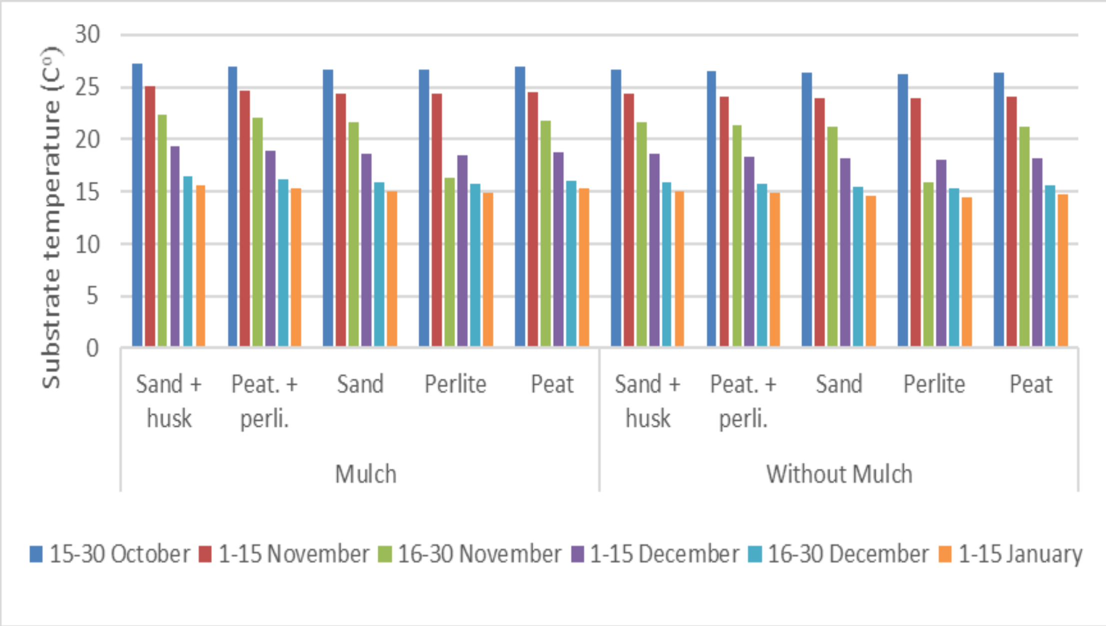

Figure (2): Average substrate temperature mulched or un-mulched during season 2016/2017.

This trained of soil temperature was noticed by many authors. They mentioned that soil mulching with organic material is one method for helps maintain a constant soil temperature within the root system of crops (Kosterna, 2014).

2. Vegetative growth:

2.1. Plant height:

Data presented in Table (3) showed the effect of substrate types and application of comopst mulch on plant height of lettuce plants during autumn 2015/2016 and 2016/2017 seasons.

Tallest plant was obtained with substrate (sand + husk), while lowest plant height was recorded with substrate (peat moss). In other words, the most favorable treatment for stimulating the plant height was the substrate (sand + husk), in general, all over the tested seasons.

Results also showed that plants cultivated in compost mulch treatment were taller than plants cultivated in un-mulch treatment, regardless substrate types.

Significant effect was detected for the interaction between substrate types and compost mulch. Applied substrate (sand + husk) plus compost mulch gave highest values of plant height compared with other treatments. While, peat moss followed by perlite substrates with un-mulch treatment gave the lowest values of plant height without any significant differences between them.

Table (3): Effect of substrate types and compost mulch on plant height (cm) of lettuce plants during 2015/2016 and 2016/2017 seasons.

Treatments	Without mulch	With mulch	Mean B
		First season	
Sand + husk	14.72 c	20.10 a	17.41 A
Peat moss + perlite	10.30 g	17.60 b	13.95 B
Sand	12.92 d	14.80 c	13.86 B
Perlite	11.20 f	14.60 c	12.90 C
Peat moss	11.00 f	12.20 e	11.60 D
Mean A	12.03 B	15.86 A	
		Second season	
Sand + husk	14.23 e	22.50 a	18.37 A
Peat moss + perlite	12.50 h	18.50 b	15.50 B
Sand	13.50 f	17.10 c	15.30 B
Perlite	11.60 i	15.90 d	13.75 C
Peat moss	11.83 i	13.17 g	12.50 D
Mean A	12.73 B	17.43 A	

2.2. Number of leaves per plant:

Data in Table (4) show significant differences in the number of leaves per plant obtained as a result of substrate types and application of compost mulch during two growing seasons. Cultivated plants in sand + husk substrate produced the highest number of leaves compared to other types of substrate.

It was noticed also that there were significant differences in leaf numbers between the two studied mulch applications. Compost mulch application increased number of leaves per plant more than without mulch treatment, during the two growing seasons.

Cultivated plants in substrate (sand + husk) with the application of compost mulch led to the increase in leaves number compared to other treatments. While, peat moss substrate plus non-mulch application showed the lowest values of leave numbers during the two growing seasons.

Table (4): Effect of substrate types and compost mulch on number of leaves per plant of lettuce plant during 2015/2016 and 2016/2017 seasons.

Treatments	Without mulch	With mulch	Mean B
		First season	
Sand + husk	44.80 b	49.73 a	47.27 A
Peat moss + perlite	30.30 e	45.23 b	37.77 C
Sand	36.40 d	42.87 c	39.63 B
Perlite	36.03 d	35.90 d	35.97 D
Peat moss	26.40 f	29.60 e	28.00 E
Mean A	34.79 B	40.67 A	
		Second season	
Sand + husk	50.80 c	55.50 a	53.15 A
Peat moss + perlite	40.50 f	51.23 b	45.87 C
Sand	44.57 e	48.60 d	46.58 B
Perlite	37.40 h	39.70 g	38.55 D
Peat moss	30.57 j	34.80 i	32.68 E
Mean A	40.77 B	45.97 A	

2.3. Fresh and dry weigth of leaves:

Data presented in Tables (5, 6) showed the effect of substrate types and compost mulch application on fresh and dry weight of leaves. Results indicated that the cultivated in sand + husk substrate obtained the greatest values of fresh and dry weight of leaves compared to other types of subatrate, spcialy peat moss substrate which showed the lowest values, except dry weight at second season, the perlite and peat moss substrates obtained the lowest dry weight values without any significant difference between them.

As for mulch application, mulched plants produced more fresh and dry weight of leaves than those of un-mulched in both tested seasons.

Concerning the interaction, significant differences were detected in fresh and dry weight of lettuce leaves in both autumn seasons. Cultivated plants at sand + husk substrate plus applied compost mulch increased the fresh and dry weights of lettuce leaves. Furthermore, at second season, sand + husk substrate plus compost mulch application, sand + hush substrate with un-mulch treatment and peat moss + perlite substrate with compost mulch treatment increased dry weight of leaves without significant differences.

Table (5): Effect of substrate types and compost mulch on fresh weight (gm) of leaves per plant of lettuce plant during 2015/2016 and 2016/2017 seasons.

Treatments	Without mulch	With mulch	Mean B
	First season		
Sand + husk	459.00 b	489.00 a	474.00 A
Peat moss + perlite	367.00 d	392.00 c	379.50 B
Sand	295.00 f	319.33 e	307.17 C
Perlite	254.00 h	275.00 g	264.50 D
Peat moss	215.00 j	230.00 i	222.50 E
Mean A	318.00 B	341.07 A	
	Second season		
Sand + husk	489.87 b	512.30 a	501.08 A
Peat moss + perlite	388.60 d	422.30 c	405.45 B
Sand	308.67 g	375.53 e	342.10 C
Perlite	298.23 h	344.30 f	321.27 D
Peat moss	275.80 i	295.20 h	285.50 E
Mean A	352.23 B	389.93 A	

Table (6): Effect of substrate types and compost mulch on dry weight (gm) of leaves per plant of lettuce plant during 2015/2016 and 2016/2017 seasons.

Treatments	Without mulch	With mulch	Mean B
	First season		
Sand + husk	41.27 b	46.50 a	43.88 A
Peat moss + perlite	34.90 c	39.40 b	37.15 B
Sand	26.30 e	31.50 d	28.90 C
Perlite	21.40 f	28.40 e	24.90 D
Peat moss	18.50 g	21.53 f	20.02 E
Mean A	28.47 B	33.47 A	
	Second season		
Sand + husk	43.40 a	48.50 a	45.95 A
Peat moss + perlite	35.70 bc	42.57 ab	39.13 B
Sand	27.53 d	33.50 c	30.52 C
Perlite	23.47 g	30.50 e	26.98 D
Peat moss	20.70 fg	23.80 ef	22.25 D
Mean A	30.16 B	35.77 A	

Our investigation showed that cultivated at different substrate types with applied compost mulch had a positive effect on the lettuce vegetative growth parameters through both tested seasons. The greatest values of those parameters observed with substrate sand + husk plus compost mulch application. These results are in harmony with (Cantliffe *et al.*, 2007; Tzortzakis and Economakis, 2008; Gordon *et al.*, 2008; Wadas *et al.*, 2009; Gorbe and Calatayud, 2010; Cecatto *et al.*, 2013; Christoulaki *et al.*, 2015). They mentioned that vegetable production can be improved by using various substrates of soilless culture.

Therefore, the important vegetable crop, lettuce (*Lactuca sativa* L.) is being grown extensively all over the world in different growing media. Also, reported the favorable effect that organic materials have on plant growth. These effects are direct, such as absorption by the plants of the humic compounds that affect membrane permeability and certain enzymatic activities, or indirect, such as stimulation of microbiological activity, and increased Cation Exchange Capacity (CEC) in plants. Moreover, application of mulch increased plant height due to higher soil moisture conservation and reduced water stress. Plants cultivated on mulched soil were higher than plants from the control plot; however, treatments consisting of mulch and row covers produced significantly higher plants than treatments without row covers. A higher soil temperature under covers provide better conditions for plants immediately after planting and allow them to produce a higher mass of above-ground parts. Furthermore, FontanettiVerdial *et al*. (2001) and khazaei *et al*. (2013) studied effect of mulch on Iceberg lettuce. They reported that mulch had the highest averages of head weight and dry matter of head and leaf number. Such conclusion was matched with illustrated data in Tables (4, 5 and 6).

3. Chemical components of leaves:

The effects of substrate types, application of compost mulch and their interaction on nitrogen, phosphorus and potassium contents, in lettuce leaves, during the autumn seasons are shown in Tables (7, 8, 9).

Data indicated that substrat types had significant effects on chemical components of leaves during two autumn growing seasons. Plants which cultivated in sand + husk substrate had the highest nitrogen and phosphorus contents in their leaves. Althought, potassium content of leaves was increased in plants which cultivated in sand substrate. Whereas, those cultivated at peat moss substrate showed the lowest values, except nitrogen content in second season, peat moss + perlite substrate, gave the lowest values.

As for the effect of mulch application, the content of N, P and K in the leaves showed that there were significant differences in N, P and K between mulched plants and un-mulched plants. Mulched plants contained higher N, P and K compared to un-mulched.These results held true in both seasons.

The interaction effect of substrate types and application of compost mulch on N, P and K was significant in both growing seasons. The best treatment for increasing N or P was sand + husk substrate with applied compost mulch treatment. While, plants cultivated in sand substrate plus compost mulch treatment, increased K content. On other hand, plants cultivated in peat moss substrate with un-mulch treatment had lowest leaves contents of N, P and K.

These finding are in agreement with those of (Haynes and Naidu, 1998; Goyel *et al*., 1999; Sikora and Enkiri, 1999; De Neva and Hofman, 2000; Trinsoutrot *et al*., 2000; Tejada and Gonzalez, 2003; Borthakur *et al*., 2012). They noticed that maintenance of soil organic matter is important for the long term productivity of agro-eco systems. For this reason, the application of organic waste rich in organic matter to the soil, such as animal manure, compost or crop residues are current environmental and agricultural practices for maintaining soil organic matter, reclaiming degraded soil and supplying plant nutrients.

Table (7): Effect of substrate types and compost mulch on nitrogen (%) of leaves for lettuce plant during 2015/2016 and 2016/2017 seasons.

Treatments	Without mulch	With mulch	Mean B
	First season		
Sand + husk	2.43 bc	2.76 a	2.60 A
Peat moss + perlite	2.38 bcd	2.69 a	2.54 AB
Sand	2.23 d	2.66 a	2.45 B
Perlite	2.16 e	2.47 b	2.32 C
Peat moss	1.93 f	2.36 cd	2.15 D
Mean A	2.23 B	2.59 A	
	Second season		
Sand + husk	2.80 a	2.82 a	2.81 A
Peat moss + perlite	2.35 f	2.11 h	2.23 E
Sand	2.40 e	2.75 b	2.58 B
Perlite	2.22 g	2.52 c	2.37 C
Peat moss	2.10 i	2.44 d	2.27 D
Mean A	2.37 B	2.53 A	

Table (8): Effect of substrate types and compost mulch on phosphorus (%) of leaves for lettuce plant during 2015/2016 and 2016/2017 seasons.

Treatments	Without mulch	With mulch	Mean B
		First season	
Sand + husk	0.43 c	0.55 a	0.49 A
Peat moss + perlite	0.41 cd	0.51 b	0.46 B
Sand	0.39 d	0.48 b	0.44 B
Perlite	0.35 e	0.44 c	0.40 C
Peat moss	0.31 f	0.37 de	0.34 D
Mean A	0.38 B	0.47 A	
		Second season	
Sand + husk	0.46 b	0.56 c	0.51 A
Peat moss + perlite	0.43 d	0.53 a	0.48 A
Sand	0.40 e	0.51 b	0.46 B
Perlite	0.37 f	0.44 c	0.41 C
Peat moss	0.34 g	0.42 e	0.38 D
Mean A	0.40 B	0.49 A	

FontanettiVerdial *et al*. (2001) and khazaei *et al*. (2013) found that mulch had the highest average for the nitrogen concentration in the aerial part of the plant. Also, mulch promoted higher average values for the total amounts of N and P due to a higher dry matter weight in the plants. Finally, they explained that the treatments without mulch had lower average values for total quantities of nutrients when compared to the treatments using mulch.

Regarding to Blanchart *et al*. (2006), during the mineralization process of the mulch, small amounts of nutrients become available for plants, which could be the reason for better plant development.

In the time, favorable physiochemical properties like pH, EC and nutrient availability are observed in tea wastes along with rice husk, tree bark + rice husk and peat + perlite (El-Naggar and El-Nasharty, 2009; Abouzari *et al*., 2012).

Table (9): Effect of substrate types and compost mulch on potassium (%) of leaves for lettuce plant during 2015/2016 and 2016/2017 seasons.

Treatments	Without mulch	With mulch	Mean B
		First season	
Sand + husk	2.46 d	2.67 b	2.57 B
Peat moss + perlite	2.35 e	2.56 c	2.46 C
Sand	2.27 f	2.97 a	2.62 A
Perlite	2.02 g	2.32 e	2.17 D
Peat moss	1.87 h	2.25 f	2.06 E
Mean A	2.19 B	2.55 A	
		Second season	
Sand + husk	2.51 c	2.75 b	2.63 AB
Peat moss + perlite	2.40 d	2.77 b	2.59 B
Sand	2.33 ef	2.99 a	2.66 A
Perlite	2.11 g	2.37 de	2.24 C
Peat moss	2.00 h	2.29 f	2.15 D
Mean A	2.27 B	2.63 A	

4. Yield and its components:

4.1. Head diameter:

Results in Table (10) showed that substrate types affected head diameter of lettuce plants, which increased with sand + husk substrate, while, reduced with peat moss substrate.

On the other hand, compost mulch had higher value of head diameter than un-mulch treatment.

Regarding the interaction, significant effects on head diameter was noticed with both mulching applications. The most favorable treatment for increasing lettuce head diameter was sand + husk substrate plus organic mulch application.

Table (10): Effect of substrate types and compost mulch on head diamtere (cm) of lettuce plant during 2015/2016 and 2016/2017 seasons.

Treatments	Without mulch	With mulch	Mean B
		First season	
Sand + husk	30.80 b	33.55 a	32.18 A
Peat moss + perlite	28.60 d	29.44 c	29.02 B
Sand	25.90 h	28.09 e	27.00 C
Perlite	24.50 i	27.30 f	25.90 D
Peat moss	23.70 j	26.31 g	25.00 E
Mean A	26.70 B	28.94 A	
		Second season	
Sand + husk	31.60 b	34.95 a	33.28 A
Peat moss + perlite	29.40 d	31.60 b	30.50 B
Sand	27.50 f	29.70 c	28.60 C
Perlite	25.90 h	27.95 e	26.93 D
Peat moss	25.00 i	26.95 g	25.97 E
Mean A	27.88	30.23 A	

4.2. Ascorbic acid:

Result in Table (11) showed that different substrate types significantly affected ascorbic acid contents in lettuce head. The most effective substrate type in enhancing this character was sand + husk substrate compared to other substrate types, specially, peat moss substrate which reduced ascorbic acid contents.

Results in Table (11) also indicated that applied compost mulch produced lettuce heads having greater values of ascorbic acid contents compared to un-mulch treatment.

The interaction between substrate types and mulch application reflected a significant effect on ascorbic acid content. Sand + husk substrate plus compost mulch showed the highest values of ascorbic acid than other treatments.

4.3. Total yield:

Results presented in Table (12) indicated that the highest total yield resulted from sand + husk substrate. While, the lowest total yield obtained from peat moss substrate. The differences among the five substrates were significant in both seasons.

Concerning mulching application, compost mulching gave higher total yield of lettuce than un-mulched treatment. In other words, compost mulch was favorable for produce greatest lettuce yield.

Table (11): Effect of substrate types and compost mulch on ascorbic acid (mg/100g fresh weight) of lettuce plant during 2015/2016 and 2016/2017 seasons.

Treatments	Without mulch	With mulch	Mean B
		First season	
Sand + husk	25.10 b	25.40 a	25.25 A
Peat moss + perlite	24.87 c	25.20 b	25.03 B
Sand	24.30 e	24.50 d	24.40 C
Perlite	24.00 f	24.20 e	24.10 D
Peat moss	23.00 h	23.50 g	23.25 E
Mean A	24.25 B	24.56 A	
		Second season	
Sand + husk	25.20 c	25.60 a	25.4 A
Peat moss + perlite	24.80 d	25.40 b	25.10 B
Sand	24.30 f	24.60 e	24.45 C
Perlite	23.80 g	24.40 f	24.10 D
Peat moss	23.60 i	23.00 h	23.30 E
Mean A	24.34	24.60	

Table (12): Effect of substrate types and compost mulch on letuuce yield (Kg) per m^2 during 2015/2016 and 2016/2017 seasons.

Treatments	Without mulch	With mulch	Mean B
		First season	
Sand + husk	5.508 b	5.868 a	5.688 A
Peat moss + perlite	4.404 d	4.704 c	4.554 B
Sand	3.540 f	3.832 e	3.686 C
Perlite	3.048 h	3.300 g	3.174 D
Peat moss	2.580 j	2.760 i	2.670 E
Mean A	3.816 B	4.093 A	
		Second season	
Sand + husk	5.878 b	6.148 a	6.013 A
Peat moss + perlite	4.663 d	5.068 c	4.868 B
Sand	3.704 g	4.506 e	4.105 C
Perlite	3.579 h	4.132 f	3.855 D
Peat moss	3.310 j	3.542 i	3.426 E
Mean A	4.227 B	4.679 A	

The interaction between substrate types and mulch application had a significant effect on total yield of lettuce plants. The best yield was obtained with sand + husk substrate and applied compost mulch which significantly was more than any other interaction treatments. This was true in both growing seasons.

Similar results were reported by (Cantliffe *et al*., 2003; Bilalis *et al*., 2009; Guzman-Pfeiffer and Ulrichs, 2011; Olle *et al*., 2012; Mokhtari *et al*., 2013). They found that the higher yields of various vegetables were found on different soilless growth media compared to those grown in the soil. In addition, cucurbit crops gave better yield when grown on coarse perlite, medium perlite and pine bark in greenhouse and high yield and quality of lettuce (*Lactuca sativa*) were observed when grown on the soilless substrates mixing rice husk, sand sawdust and gravel with different ratio. Also, Lettuce and tomato are grown well in organic floating system, there, showed highest vegetative growth and yield.

On the other hand, compost as a mulch showed the best clear and positive effects on plant (crop yield and crop quality) and on soil characteristics (Diacono and Montemurro, 2011; Trupiano *et al*., 2017). Furthermore, Organic mulch had a positive effect on the lettuce head diameter. The positive effect of compost as organic mulching, on lettuce head size and lettuce dry mass, may be due to an increase in the level of available potash with the turning down of the organic matter into the soil (Borthakur *et al*., 2012).

The present increasing in the lettuce head diameter and dry weight may be due to: secretion of phytohormones, nitrogen fixation, production of undefined signaling molecules that can interfere with plant metabolism, nitrite production, and the enhancement of mineral uptake by plants (Okon and Itzigsohn, 1995).

Mulching, due to its moisture retaining, temperature regulating properties, cannot only enhance plant growth and development but also create a congenial environment for the growth and multiplication of microorganisms.

Totally mulching causes better nutrition absorption and temperature adjacent in crown and improved lettuce growth and due to them total yield increased (khazaei *et al*., 2013). According to Ibarra-Jiménez *et al*. (2008), yield increments caused by mulching are partly due to an increase in soil temperature and photosynthesis.

Some studies have indicated that a low root temperature restricts water uptake and top growth plants, and may cause wilting and a long-term retardation of stem and leaf growth (Haapala *et al*., 2015). The lower root temperature may also decrease the yield (Lorenzo *et al*., 2005), whereas, a higher soil temperature has been observed to promote the stem and leaf growth.

According to many authors, a slower increase in soil temperature under mulches and also lower fluctuations of soil temperature in the plant growing period contribute to the better growth and development of plants (Kęsik and Maskalaniec, 2005; Dahiya *et al*., 2007;

Sinkevičienė *et al.*, 2009). In turn, some authors claim that natural organic mulch eventually breaks down and becomes a part of the soil and a source of plant nutrients (Bond and Grundy, 2001; Gruber *et al.*, 2008), which as a result improve plant growing conditions.

5. Economic evaluation:

Data in Table (13 a) showed the fixed costs for the production heads of Lettuce plants. The investment of fixed costs for these items: tank, irrigation system and pots were 25, 15 and 7.2 pounds, respectively. The total fixed costs were 47.2 L.E. and the percentage of each item mentioned before was 53%, 32%, and 15%, respectively, from total costs. Also, data obtained the distributed cost of each item according to working life per year, which was 1.25, 1.00 and 1.44 L.E. for tank, irrigation system and pots, respectively. The total installment of depreciation was 3.69 L.E. for each year.

From data in Table (13 b) indicated that investment cost of substrate was listed as follows: sand+ husk, peat moss + perlite, sand, perlite and peat moss (6, 30.65, 4.2, 42 and 63 L.E., respectively). Moreover, distributed cost for each substrate according to working life/years to illustrate the fixed cost per year was presented in table.

Table (13 a): Total fixed costs for supplies to produce Lettuce head.

Items	Investment cost (L.E.)	Investment cost (%)	Working life	Cost per year (installment depreciation)	Cost/year (installment depreciation) (%)
Tank	25.0	53	20	1.25	33.9
Irrigation system	15.0	32	15	1.00	27.1
pots	7.2	15	5	1.44	39.0
Total fixed costs	47.2	100		3.69	100.0

Table (13 b): Total fixed costs for different substrate types.

Items	Investment cost (L.E.)	Working life	Cost per year (installment depreciation) (%)
Sand + husk	6.00	5	1.20
Peat moss + perlite	30.65	5	6.13
Sand	4.20	5	0.84
Perlite	42.00	5	8.40
Peat moss	63.00	5	12.60

Data in Table (14) showed the variable costs to produce Lettuce heads. The variable costs items included seed, nutrient solution, mulch/un-mulch application and interest of capital 10 %. Variable cost for each item mentioned before was listed as follows: 6, 24, 2.4 or 0 and 3.24 or 3 L.E., respectively. The total variable cost was 29.16 L.E., when, applied compost mulch, while, it was 27 L.E., without mulch. The percentage of variable costs in ascending order were seed, nutrient solution, mulch/un-mulch, and interest of capital 10%, were represented as 3.24%, 18.52%, 74.07%, 7.41/0% and 10%, respectively.

Table (14): Variable costs to produce lettuce head.

Items	Without mulch		With mulch	
	Cost (L.E.)	Total variable costs (%)	Cost (L.E.)	Total variable costs (%)
Seed	6	22.22	6	18.52
Nutrient solution	24	88.89	24	74.07
Mulch	-----	-----	2.4	7.41
Interest at the capital 10%	3	10.00	3.24	10.00
Total variable costs	27	100	29.16	100

Data illustrated in Table (15) showed that, in the first season, price/revenues for substrate types without compost mulch application were 45.6, 39.9, 34.2, 34.2 and 14.25 for sand+ husk, peat moss + perlite, sand, perlite and peat moss substrates, respectively. Furthermore, total cost was about 32.25, 36.82, 31.53, 34.67 and 37.40 L.E., for sand + husk, peat moss + perlite, sand, perlite and peat moss substrates, respectively. While, net return reached about 13.35, 3.08, 2.67, -0.47 and -23.15 L.E., for sand+ husk, peat moss + perlite, sand, perlite and peat moss substrates, respectively.

In the second season, results showed the same trend. Price/revenues were 48.45, 45.6, 39.9, 37.05 and 34.2 L.E., for sand+ husk, peat moss + perlite, sand, perlite and peat moss substrates, respectively. While, total cost was 32.25, 36.82, 31.53, 34.67 and 37.40 L.E., for sand+ husk, peat moss + perlite, sand, perlite and peat moss substrates, respectively. On other hand, rate of net return for sand+ husk, peat moss + perlite, sand, perlite and peat moss substrates, reached about 16.2, 8.78, 8.37, 2.38 and -3.20, respectively

Table (15): Net return and revenues of Lettuce production without compost mulch application at 2015/2016 and 2016/2017 seasons.

Substrates	production per m^2	Losses 5%	production after losses	price/revenues (L.E.)	Total cost (L.E.)	Net return (L.E.)
	First season					
Sand + husk	12	0.6	11.40	45.60	32.25	13.35
Peat moss + perlite	12	0.6	11.40	39.90	36.82	3.08
Sand	12	0.6	11.40	34.20	31.53	2.67
Perlite	12	0.6	11.40	34.20	34.67	-0.47
Peat moss	12	0.6	11.40	14.25	37.40	-23.15
	Second season					
Sand + husk	12	0.6	11.40	48.45	32.25	16.2
Peat moss + perlite	12	0.6	11.40	45.60	36.82	8.78
Sand	12	0.6	11.40	39.90	31.53	8.37
Perlite	12	0.6	11.40	37.05	34.67	2.38
Peat moss	12	0.6	11.40	34.20	37.40	-3.20

Illustrated data in Table (16) indicated that, in the first season, price/revenues at mulched substrate types were 51.3, 42.75, 39.90, 37.05 and 34.20 L.E., with the five treatments: sand+ husk, peat moss + perlite, sand, perlite and peat moss substrates, respectively. Although, total costs for each substrate type arranged were about 34.05, 38.98, 33.69, 37.07 and 39.80 L.E., for the same treatments, respectively. While net return reached to17.25, 3.77, 6.21,-0.02and -5.60 L.E., for the same treatments, respectively.

In second season, noticed that, price/revenues had54.15, 51.30, 45.60, 39.90 and 37.05 L.E., sand+ husk, peat moss + perlite, sand, perlite and peat moss substrates, respectively. Moreover, total costs above to34.05, 38.98, 33.69, 37.07 and 39.80 L.E., for the same treatments, respectively. Whereas, net return for substrate type were 20.10, 12.32, 11.91, 2.83 and -2.75, for the same treatments, respectively.

Table (16): Net return and revenues of Lettuce production with compost mulch application at 2015/2016 and 2016/2017 seasons.

Substrates	production per m^2	Losses 5%	production after losses	price/revenues (L.E.)	Total cost (L.E.)	Net return (L.E.)
	First season					
Sand + husk	12	0.6	11.40	51.3	34.05	17.25
Peat moss + perlite	12	0.6	11.40	42.75	38.98	3.77
Sand	12	0.6	11.40	39.90	33.69	6.21
Perlite	12	0.6	11.40	37.05	37.07	-0.02
Peat moss	12	0.6	11.40	34.20	39.80	-5.60
	Second season					
Sand + husk	12	0.6	11.40	54.15	34.05	20.10
Peat moss + perlite	12	0.6	11.40	51.30	38.98	12.32
Sand	12	0.6	11.40	45.60	33.69	11.91
Perlite	12	0.6	11.40	39.90	37.07	2.83
Peat moss	12	0.6	11.40	37.05	39.80	-2.75

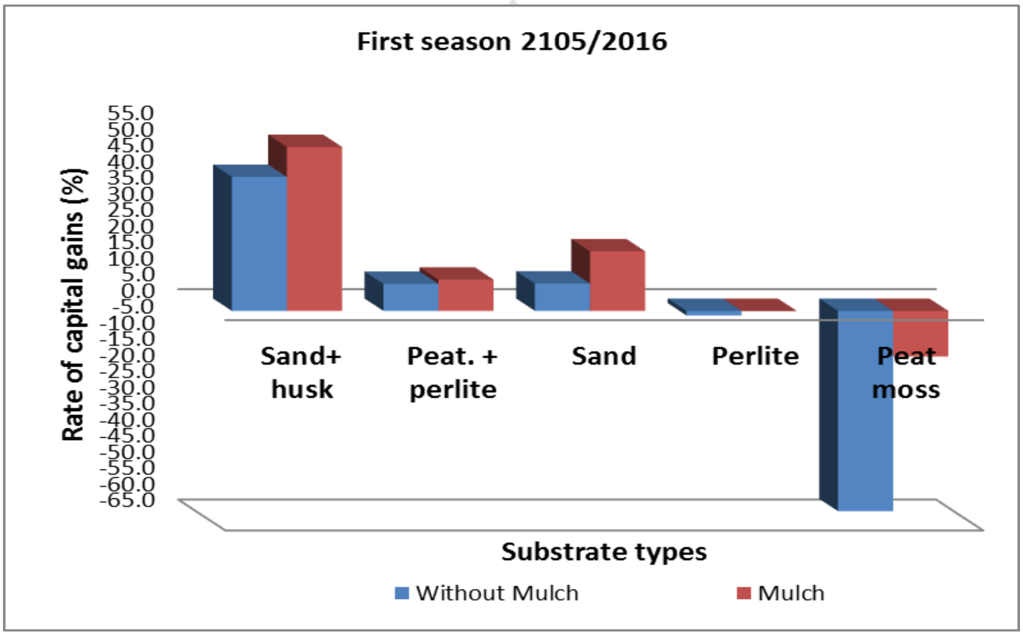

Figure (3 a): Rate of capital gains (%) during 2015/2016 season.

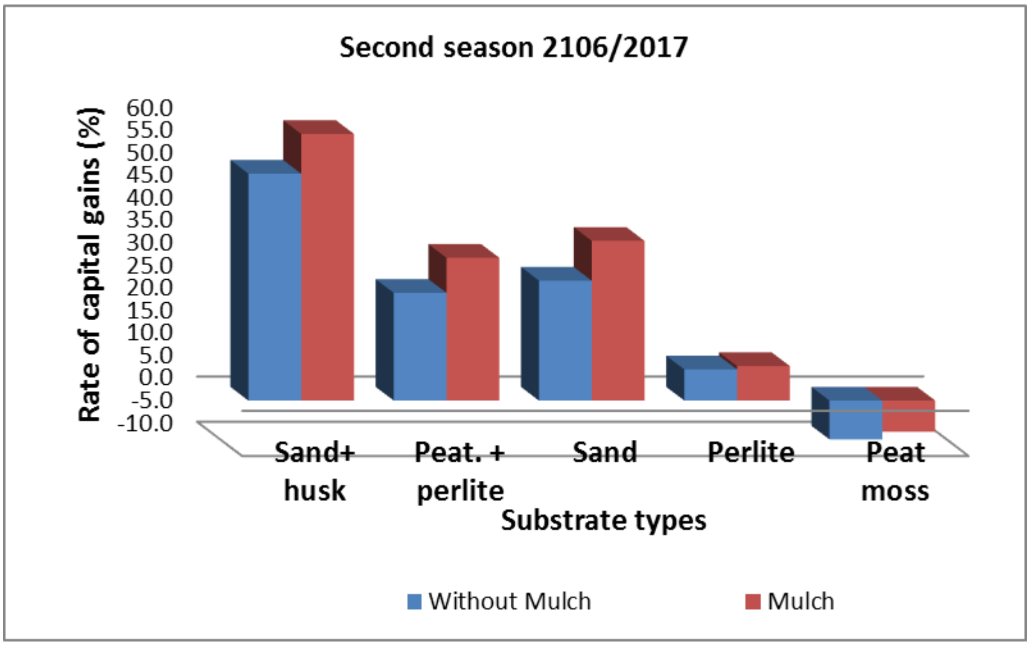

Figure (3 b): Rate of capital gains (%) during 2106/2017 season.

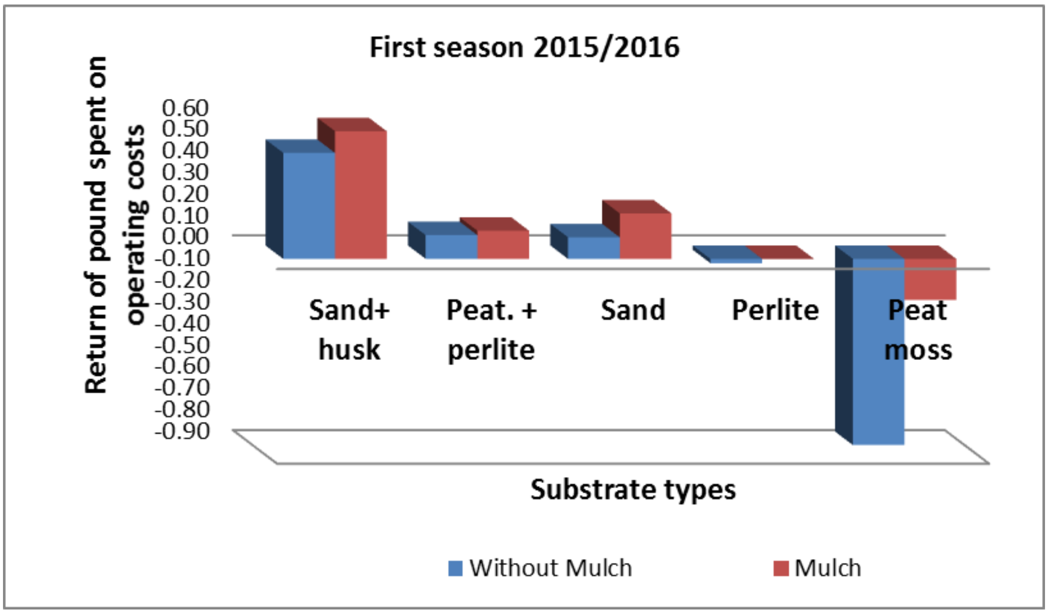

Figure (4 a): Return of pound spent on operating costs during 2015/2016 season.

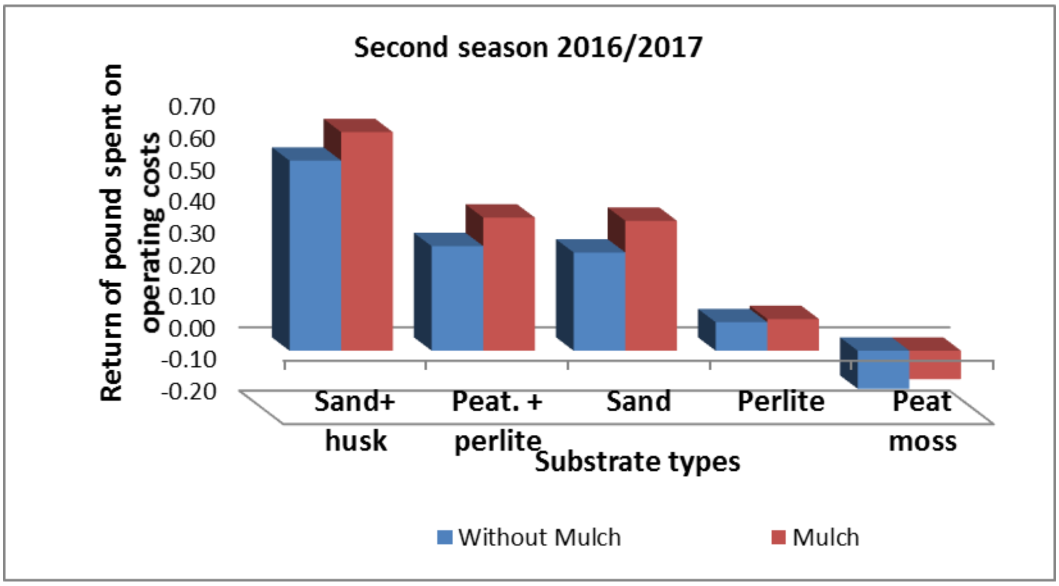

Figure (4 b): Return of pound spent on operating costs during 2106/2017 season.

Data illustrated in Figures (3 a, 3 b, 4 a, 4 b) showed the rate of capital gains and return of pound spent on operating costs for cultivation with different substrate types with/without compost mulch. The greatest value of rate of capital gains and return of pound spent on operating costs were obtained with sand + husk substrate with application compost mulch, while, peat moss substrate without mulch dressed those two items.

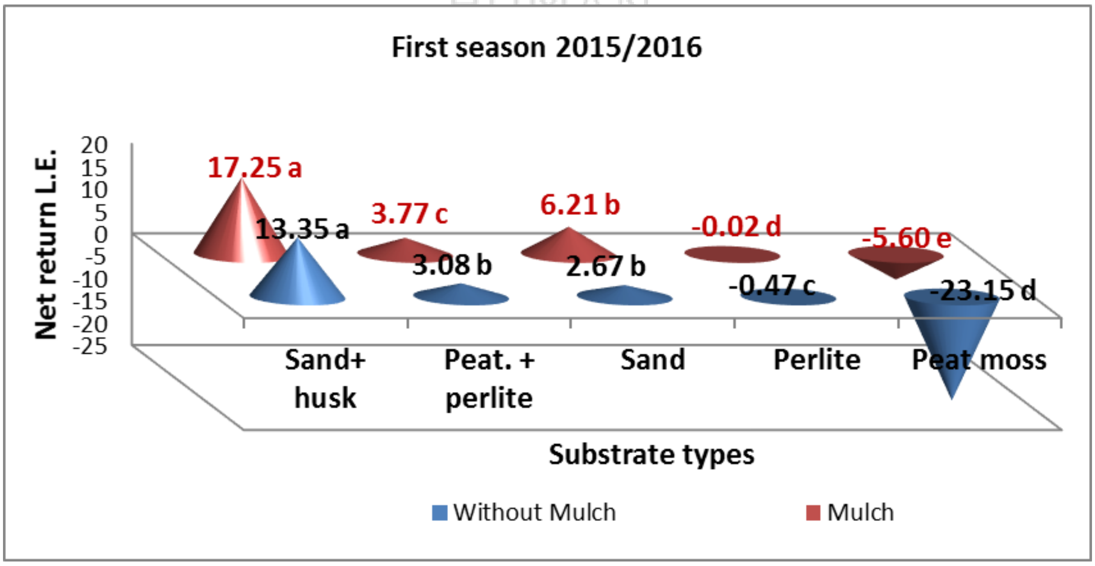

Figure (5 a): Net return of production lettuce heads at different substrate types with/without compost mulch during 2015/2016 season.

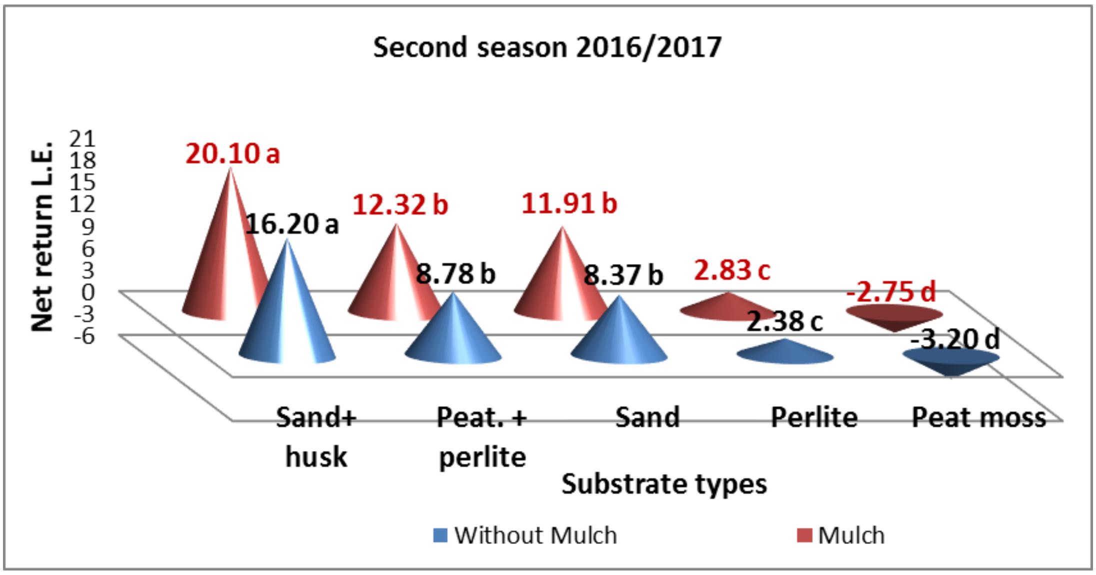

Figure (5 b): Net return of production lettuce heads at different substrate types with/without compost mulch during 2016/2017 season.

Statistical analyses of net return of the production of lettuce heads were presented in Figures (5 a, b). The greatest value of net return was, in general, detected in sand + husk substrate with compost mulch followed by sand + husk substrate without mulch. However, the lowest net return was found at peat moss substrate without mulch.

On other words, the highest total costs (fixed and variable costs) to produce lettuce heads were obtained with peat moss substrate which recorded (39.80, 37.40 L.E.) and followed by peat moss + perlite substrate (38.98, 36.82 L.E.) with mulch and un-mulch during the two growing seasons, respectively. The lowest total costs observed with sand + husk substrate (34.05, 32.25 L.E.) and followed by sand substrate (33.69, 31.53 L.E.) with mulch and un-mulch during both seasons, respectively.

Moreover, the greatest price/revenues and net return were found with production with sand + husk substrate plus compost mulch more than other substrate types with mulch or un-mulch. While, peat moss substrate without mulch obtained negative impact.

In the present instance the interaction of sand + husk substrate and composting mulch have created a favorable soil ecosystem leading to higher lettuce head diameter, fresh weight and dry matter content.

In the present instance the interaction of sand + husk substrate and composting mulch have created a favorable soil ecosystem leading to higher lettuce head diameter, fresh weight and dry matter content.

CONCLUSION

This investigation has presented the positive role of some growing substrates on the performance and consequent upon the yield and quality of lettuce, which considered as an important horticultural crop. In the present experiment the combined treatment of sand + husk substrate and composting mulch, showed a positive effect on yield and plant parameters under study.

Further research study is needed to complete the exploitation of the positive use of rice husk and/or crop residues in substrate mixtures as pure or composted material, as well as improve physicochemical properties as substrate medium for grown crops.

REFERENCES

1. Abouzari, A., S. Rouhi, A. Eslami and B. Kaviani. 2012. Comparison of the effect of different soilless growing media on some growth characteristics of Benjamin Tree (*Ficus benjamina*). International Journal of Agriculture and Biology. 14(6):985-988.
2. O. A. C. 1990. Association of official methods of analytical chemists, official methods of analysis 15th ed. Washington, D. C., U.S.A.
3. Asao, T. 2012. Hydroponics –a standard methodology for plant biological researches. Rijeka: InTech.
4. Asaduzzaman, Md., Md. Saifullah, A. K. M. Salim Reza Mollick, Md. MokterHossain, G. M. A. Halim and T. Asao. 2015. Influence of Soilless Culture substrate on improvement of yield and produce quality of horticultural crops. http://dx.doi.org/10.5772/59708.
5. Bhardwaj, R. L. 2011. Benchmark survey on effect of mulching material on crop production.KrishiVigyanKendrs, Sirohi, MPUAT Udaipur. pp.12-15.
6. Bhardwaj, R. L. and K. V. Kendra. 2013 effect of mulching on crop production under rainfed condition - a review.Agri. Reviews. 34(3): 188-197.
7. Bilalis, D., P. Kanatas, S. Patsiali, A. Konstantas and K. Akoumianakis. 2009. Comparison between conventional and organic floating systems for lettuce and tomato (*Lactuca sativa* and *Lycopersiconesculentum*) seedling production. Journal of Food Agriculture and Environment. 7: 623–628.
8. Bilderback, T. E., S. L. Warren, J. S. Jr. Owen, J. P. Albano. 2005. Healthy substrates need physicals. HortTechnology. 15: 747-751.
9. Black, C. A. 1983. Methods of Soil Analysis.Parts 1 and 2. Amer. Soc. Agron. Jnc. Publ., Madison, Wisc., USA.
10. Blanchart, E., C. Villenave, A. Viallatoux, B. BarthŁs, C. Girardin, A. Azontonde and C. Fellera, 2006. Long-term effect of a legume cover crop (*Mucunapruriens* var. *utilis*) on the communities of soil macrofauna and nematofauna, under maize cultivation, in southern Benin.European Journal of Soil Biology. 42: 136-144.
11. Bond, W. and A. C. Grundy. 2001. Non-chemical weed management in organic farming systems. Weed Res. 41: 383-405.
12. Borthakur, P. K., S. W. Tivelliand and L.F.V. Purquerio. 2012. Effect of green manuring, mulching, compost and microorganism inoculation on size and yield of lettuce. ActaHorticulturae. 933: 165-171.

13. Cantliffe, D. J., J. Funes, E. Jovicich, A. Paranjpe, J. Rodriguez and N. Shaw. 2003. Media and containers for greenhouse soilless grown cucumbers, melons, peppers and strawberries. Acta Horticulturae. 614: 199-205.
14. Cantliffe, M. J., Z. C. Javier and A. Paranjpeshwin. 2007. Yield and quality of greenhouse- grown strawberries as affected by nitrogen level in coco coir and pine bark media. Proceedings of the Florida State Horticultural Society. 120:157-161.
15. Cecatto, A. P., E. O. Calvete, A. A. Nlenow, R. C. Costa, H. F. H. Mendonca, and A. C. Pazzlnato. 2013. Culture system in the production and quality of strawberry cultivars. Acta Scientiarum.Doi: 10.4025/ac.
16. Christoulaki, M., S. Gouma, T. Manios and N. Tzortzakis. 2015. Deployment of sawdust as substrate medium in hydroponically grown lettuce. Journal of Plant Nutrition.37:1304–1315.
17. Dahiya, R., J. Ingwersen and T. Streck. 2007. The effect of mulching and tillage on the water and temperature regimes of a loess soil: Experimental findings and modeling. Soil Tillage Res. 96(1): 52-63.
18. De Neva, W. and G. Hofman. 2000. Influence of soil compaction on carbon and nitrogen mineralization of soil organic matter and crop residues. Biol. Fertil. Soils. 30:544-549.
19. Diacono, M. and F. Montemurro. 2011. Long-term effects of organic amendments on soil fertility.Journal of Sustainable Agriculture.2: 761–786.
20. Dorais, M., C. Menard and E. Begin. 2007. Risk of phytotoxicity of sawdust substrate for greenhouse vegetables. ActaHorticulturae. 761: 589-594.
21. Ehret, D. L. and T. Helmer. 2009. A new wood fiber substrate for hydroponic tomato and pepper crops. Canadian Journal of Plant Science. 89(6): 1127-1132.
22. El-Naggar, A. H. and A. B. El-Nasharty. 2009. Effect of growing media and mineral fertilization on growth, flowering, bulbs productivity and chemical constituents of *Hippeastrumvittatu*, herb.American-Eurasian J. Agric. & Environ. Sci. 6(3): 360-371.
23. FontanettiVerdial, M., M. Santos de Lima, A. F. Morgor and R. Goto. 2001.Production of Iceberg lettuce using mulches. Scientia Agricola. 58(4): 737-740.
24. Gorbe, E. and A. Calatayud. 2010. Optimization of nutrition in soilless systems: A Review. Advances in Botanical Research. 53: 193–245.
25. Gordon, G. G., G. F. Wheeler, T. R. Stewart, J. E. Brown, E. Vinson and F. M. Woods. 2008. Plastic mulches and row covers on growth and production of summer squash. Int. J. Veg. Sci. 14(4): 322-338.
26. Goyel, S., K. C. Chadha and K. K. Kapoor. 1999. Influence of inorganic fertilizers and organic amendments on soil organic matter and soil microbial properties under tropical conditions. Biol. Fertil. Soils. 29:196-200.
27. Grillas, S., M. Lucas, E. Bardopoulou, S. Sarafopoulos and M. Voulgari. 2001. Perlite based soilless culture systems: Current commercial applications and prospects. ActaHorticulturae. 548: 105-114.
28. Gruber, S., D. Acharya and W. Claupein. 2008. Wood chips used for weed control in Organic Farming. J. Plant Dis. Protect. 21: 395-400.
29. Guzman-Pfeiffer, L. and C. Ulrichs. 2011. Eignung verschiedener Anbaumedien für den erdelosen Subsisten-zanbau in Iquitos (Peru) und deren Wirkung auf Wachstum und Qualität von Pflücksalat (*Lactuca sativa* L. var. crispa L.). Gesunde Pflanzen. 63: 19–26.
30. Haapala, T., P. Palonen, A. Tamminen and J. Ahokas. 2015. Effects of different paper mulches on soil temperature and yield of cucumber (*Cucumis sativus* L.) in the temperate zone. Agricultural and Food Science.24: 52–58.
31. Haynes, R. J. and R. Naidu. 1998. Influence of lime, fertilizer and manure application on soil organic matter content and soil physical condition. A review.Nutr.Cycl.Agro.Eco. Syst. 51:123-137.
32. Helrich, K.1990. Official methods of Analysis, 15th ed.; Association of Official Analytical Chemists (AOAC): Arlington, VA, USA.
33. Hooks, C. R. R. and M. W. Johnson. 2003. Impact of agricultural diversification on the insect community of cruciferous crops. Crop Protection. 22: 223-238.
34. Ibarra-Jiménez, L., A. Zermeño-González, J. Munguía-López, M. A. R. Quezada-Martin and M. de la Rosa-Ibarra. 2008. Photosyn-thesis, soil temperature and yield of cucumber as affected by colored plastic mulch. ActaAgriculturaeScandinavica, Section B - Soil & Plant Science. 58: 372–378.
35. Kęsik, T. and T. Maskalaniec. 2005. Effect of soil mulching on air and soil temperature in strawberry field. Acta A graph. 6(1): 117-124.

36. Khazaei, I., R. Salehi, Ak. Kashi and S. M. Mirjalili. 2013. Improvement of lettuce growth and yield with spacing, mulching and organic fertilizer. International Journal of Agriculture and Crop Sciences.6 (16): 1137-1143.
37. Kosterna, E. 2014.The effect of covering and mulching on the soil temperature, growth and yield of tomato.Folia Hort. 26(2): 91-101.
38. Kumar, R., S. Sood, S. Sharma, R. C. Kasana, V. L. Pathania, B. Singha and R. D. Singh. 2014. Effect of plant spacing and organic mulch on growth, yield and quality of natural sweetener plant Stevia and soil fertility in western Himalayas.International Journal of Plant Production. 8(3): 1735-6814 (Print), 1735-8043.
39. Lorenzo, P., M. C. Sanchez-Guerrero, E. Medrano, T. Soriano and N. Castilla. 2005. Responses of cucumbers to mulching in an un-heated plastic greenhouse. The Journal of Horticultural Science and Biotechnology. 80: 11–17.
40. Mastouri, F., M. R. Hassandokht and M. N. PadashtDehkaei. 2005. The effect of application of agricultural waste compost on growing media and greenhouse lettuce yield. ActaHorticulturae. 697: 153-158.
41. Mayer, J. B. and N. L. Hartwig. 1986. Corn yield in crown vetch relative to dead mulches. Proc. Annu. Meet. Northeast. Weed Sci. Soc. 40: 34-35.
42. Mokhtari, S., M.R.Ismail, H.Kausar, M.H. Musa, P.E.M. Wahab, Z.Berahim, M.H. Omar and S.H.Habib.2013. Use of organic enrichment as additives in coco-nut coir dust on development of tomato in soilless culture. Compost Science and Utilization. 21: 16–21.
43. Moreira,M. A., C. A. P. dos Santos, A. A. T. Lucas, F. G. B., I. M. de Souza and P. R. A. Viégas. 2014.Lettuce production according to different sources of organic matter and soil cover. Agricultural Sciences. 5 (2): 99-105.
44. Muhammad, A. P. M., I. Khuram, S. and A. UL-Hassan. 2009. Effect of mulch on soil physical properties and NPK concentration in Maize (*Zea mays*) shoots under two tillage system. International Journal of Agriculture and Biology. 11: 120-124.
45. Okon, Y. and R. Itzigsohn. 1995. The development of *Azospirillum*asa commercial inoculants for improving crop yields. Biotechnol Adv. 13: 365-374.
46. Olle, M., M. Nagouajio and A. Simos. 2012. Vegetable quality and productivity as influenced by growing medium: A Review. Zemdirbyste Agriculture. 99(4): 399-408.
47. Paradossi, A., F. Malorgio, C. Campiotti and F. Tognoni. 2002. A comparison between two methods to control nutrient delivery to greenhouse melons grown in recirculating nutrient solution culture. ScientiaHorticulturae. 92: 82-95.
48. Relf, D. 2009. Mulching for a healthy landscape. Virginia Cooperative Extension, Publication. 426-724.
49. Robertson, R. A. 1993.Peat, horticulture and environment.Biodivers.Conserv. 2: 541-547.
50. Sarolia, D. K. and R. L.Bhardwaj.2012. Effect of mulching on crop production under rainfed condition: A Review. Int. J. Res. Chem. Environ. 2: 8-20.
51. Sikora, L. J. and N. K. Enkiri. 1999. Growth of tall fescue in compost/fertilizer blends. Soil Sci. 56: 125-137.
52. Sinkevičienė, A., D. Jodaugienė, R. Pupalienė and M. Urbonienė. 2009. The influence of organic mulches on soil properties and crop yield. Agron. Res. 7(1): 485-491.
53. Teasdale, J. R. 1993. Interaction of light, soil moisture and temperature with weed suppression by hairy vetch residue. Weed Sci. 41: 46-51.
54. Tejada, W. and J. L. Gonzalez. 2003. Effect of the application of a compost originating from crushed cotton gin residues on wheat yield under dryland condition. Eur. J. Agron. 19:357-368.
55. Trinsoutrot, B., E.NicolardotJustes and S.Recous.2000. Decomposition in the field of residues of oilseed rape grown at two levels of nitrozen fertilization. Effect on the dynamics of soil mineral nitrogen between successive crops.Nutr.Cycl. Agro Eco Syst. 56: 125-137.
56. Trupiano, D., C. Cocozza, S. Baronti, C. Amendola, F. P. Vaccari, G. Lustrato, S. Di Lonardo, F. Fantasma, R. Tognetti and G. S. Scippa. 2017. The Effects of biochar and Its Combination with compost on lettuce (*Lactuca sativa* L.) growth, soil properties, and soil microbial activity and abundance. International Journal of Agronomy.1-12.
57. Tzortzakis, N. G. and C. D. Economakis. 2008. Impacts of the substrate medium on tomato yield and fruit quality in soilless cultivation. Journal of Horticultural Science. 35: 83–89.

58. Wadas, W., E. Kosterna and A. Kurowska. 2009. Effect of perforated foil and polypropylene fibre covers on growth of early potato cultivars. Plant Soil Environ. 55(1): 33-41.
59. White, R. H., A. D. Worsham and U. Blum. 1989. Allelopathic potential of legume debris and aqueous extracts. Weed Sci. 37: 674-679.
60. Yoo-Jeong, Y., R. S. Dungan, A. M. Ibekwe, C. Valenzuela-Solano, D. M. Crohn and D. E. Crowley. 2003. Effect of organic mulches on soil bacterial communities one year after application. Biol. Fertil. Soils. 38: 273-281.