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Growing Substrates for Organic Lettuce Production in Kuwait

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Abstract: The demands for organically produced vegetable are increasing all over the world including Kuwait. Therefore, efforts are being made to develop an appropriate package of practices for organic greenhouse vegetable production under Kuwait's harsh climatic conditions. Several experiments were conducted to select suitable growing substrate for production of organic leafy vegetables like Iceberg lettuce and red oak leaf lettuce. Ready to use commercial substrates were compared with locally formulated growing based on vegetative growth parameters like height, number of leaves and chlorophyll index. The results showed that plants grown in locally formulated growing substrates were similar to those grown in ready-to-use commercial substrates. The local medium can be recommended as an alternative to expensive commercial substrates as it reduced the cost significantly; however further improvements in its composition is required to ensure greater productivity.

Key words: Organic farming · Growing substrates · Chlorophyll index

INTRODUCTION

Various kinds of substrates are being used to grow vegetable crops and ornamental plants. Since they contribute significantly to production, success and economic viability of containerized plant production, selection of a suitable growing substrate constitutes a crucial first step in any organic production operation. Producers have the option to either choose one of the several ready-to-use substrates from the market or mix their own using locally available components. The ready-to-use mixes have been developed after years of research and are straightforward in use; however, they can be expensive depending on the ingredients they contain. With proper knowledge of plant requirements and the properties of available components, it is possible to formulate superior-quality growing substrates locally at much less cost. Considering these issues, the main objective of this study was to compare locally formulated and ready-to-use commercial growing substrates for Ice berg and red oak leaf lettuce.

MATERIALS AND METHODS

Growing Substrate Treatments: The local growing substrates were prepared by mixing, vermicompost: sphagnum peat moss: perlite: coco peat in the ratio 1:1:1:1 by v/v as all these materials are approved for organic production. An organic amendment, DOrS (1.0 % N, 0.75% P, 1.0 % k, 16% Organic carbon) @ 15 kg/ m^3 was added uniformaly to all growing substrates at the time of mixing. Two commercial growing substrates, Intervale compost and Fortlite (Dirt Works, USA), were used in the study. Soil-based production with chemical fertilizers, in the same greenhouse was used as control for comparison.

Selection of Crop Varieties: Certified organic seeds of Lettuce (*Lactuca sativa* cv. Vienna) and red oak leaf (*Lactuca sativa* cv. Maserati) (ProVeg Seeds, UK) were used in these studies.

Production Practices: Seedlings were raised in 5-cm polyethylene containers filled with a locally formulated substrate containing vermicompost, sphagnum peat moss, coco peat, perlite and DOrS @ 2: 2: 0.5: 1: 0.5 by volume/ volume. Two approved organic fertilizers (Algafarm soluble K powder and Fontana) were used to provide the required nutrients during the seedling stage. Four-to six-week old uniform seedlings were transplanted in flexible polyethylene containers of 5-or 25-l capacity filled with one of experimental substrates. The substrate was watered to field capacity prior to planting and then periodic irrigations were given as per crop needs.

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Experimental Design and Data Analysis: The growing media treatments were replicated three times in a randomized complete block design. Each experimental unit (treatment) contained 264 plants. Periodic data on plant height, plant cover, number of leaves and chlorophyll index were recorded on fifteen randomly selected plants in each treatment. The average weight of head was recorded to determine the marketable yield. The data were analyzed using the analysis of variance (ANOVA) using "R" procedure and significant treatments means were separated by using Duncan Multiple Range Test [1]. Plant performance, yield and periodic growth medium analysis were also utilized to select the most suitable growing substrate for each crop.

RESULTS

Representative samples of the organic substances used in the growing substrates were analyzed for selected parameters (Table 1). The laboratory data indicated that other than the sphagnum peat moss, the other raw materials used in the growing substrate had a high pH. The coco peat also contained high levels of salts. The laboratory analysis of soluble calcium, magnesium, sodium, potassium and chloride are also presented in Table 1. The substrate treatments were compared separately for each crop.

Experiment 1. In the experiment on Lettuce (*Lactuca sativa* cv. Vienna), observations on plant height, number of open leaves and plant canopy were recorded at 10 day intervals from planting into the containers. Lettuce seedlings grown in Fortlite and control grew significantly taller (17.07 and 17.73 cm, respectively) and produced greater numbers of leaves than those grown in the local substrate and Intervale compost (Tables 2 and 3). The Fortlite and control also produced the largest canopies (Table 4).

Control plants produced the heaviest heads (average weight 254 g), but the weights were similar to those produced in the Fortlite substrate (average weight 209 g) (Table 3). The smallest heads were produced in the Intervale substrate.

Overall, Fortlite produced the best vegetative growth and superior head quality than the other organic substrates. The average weight of the heads in this treatment was comparable to that produced in the control (conventional soil-based system). However, this ready-to-use commercial substrate was more expensive than the local formulated substrate.

Experiment 2: Red Oak lettuce: In the experiment on Red Oak Leaf lettuce (*Lactuca sativa* cv. Maserati, during the initial stages (until 30 DAP), plants grown in the Fortlite substrate were taller; however, at the later stages, the control plants surpassed them in height (Table 5).

Table 1: Analysis Parameters of Ingredients Used in Formulating a Growing Substrate

Sample	pH (1:10)	EC (dS/m) (1:10)	Cations (meq/kg)				Anions (meq/l)	Total N
			Ca^{+2}	Mg^{+2}	K^{+}	Na^{+}	Cl^{-1}	%
Vermicompost	7.1	1.2	28.0	59.0	20.2	21.7	35.1	1.2
Peat Moss	3.9	0.3	<0.1	<0.1	2.4	4.4	22.3	0.6-1.4
Coco Peat	6.3	4.6	5.75	1.3	286.8	130.4	386.0	0.3
Avicumus	6.2	6.0	59.5	73.8	472.3	87.0	74.0	4.0
Farmyard Manure	8.4	6.5	31.8	41.8	269.9	347.8	398.3	0.9

EC: Electrical conductivity

Table 2: Average Height of Lettuce Plants (*Lactuca sativa* cv. Vienna) Produced in Different Growing Substrates

Substrate	Initial	10 DAP[y]	20 DAP	30 DAP
	Average Height (cm)			
Local Medium 1[x]	11.20ab	12.87a	12.93a	12.87a
Fortlite	12.40v	14.93b	16.20b	17.07b
Intervale Compost	10.67a	12.33a	12.60a	12.80a
Control	12.20c	13.60a	13.73a	17.73b
Significance[z]	**	***	**	***

[x] Vermicompost, Sphagnum peat moss, perlite and cocopeat (1:1:1:1 by v/v)

[y] DAP: Days after planting.

[z] **, ***: Significant at P $\leq$ 0.01, 0.001 levels, respectively. Mean values followed by the same alphabets within a column are not significantly different at P $\leq$ 0.05.

Table 3: Number of Leaves in Lettuce (*Lactuca sativa* cv. Vienna) Plants Produced in Different Growing Substrates

Substrate	Initial	10 DAP	20 DAP [y]	30 DAP	Average Size of Head(kg)
Local Medium 1 [x]	3.93a	6.93a	7.93a	8.20ab	0.127b
Fortlite	4.33b	8.47b	10.00b	8.33b	0.209c
Intervale Compost	4.00a	6.67a	7.80a	7.53a	0.090a
Control	4.07a	6.80a	8.40a	9.40c	0.254c
Significance [z]	NS	***	***	**	***

[x] Vermicompost, Sphagnum peat moss, perlite and cocopeat (1:1:1:1 by v/v)

[y] DAP: Days after planting.

[z] **, ***: Significant at P ≤ 0.01, 0.001 levels, respectively. Mean values followed by the same alphabets within a column are not significantly different at P ≤ 0.05.

NS: Not significant.

Table 4: Average Plant Canopy of Lettuce Plants (*Lactuca sativa* cv. Vienna) Produced in Different Growing Substrates

	Initial	10 DAP [y]	20 DAP	30 DAP
Substrate	Average Plant Canopy (cm)			
Local Medium [x]	15.73d	18.80b	20.20b	21.93a
Fortlite	14.60c	23.27c	24.87c	29.13b
Intervale Compost	11.33a	16.53a	18.80a	19.93a
Control	12.20b	19.33b	22.40b	29.80b
Significance z	***	***	***	***

[x] Vermicompost, Sphagnum peat moss, perlite and cocopeat (1:1:1:1 by v/v)

[y] DAP: Days after planting.

[z] **, ***: Significant at P ≤ 0.01, 0.001 levels, respectively. Mean values followed by the same alphabets within a column are not significantly different at P ≤ 0.05.

Table 5: Average Height (cm) of Red Oak Leaf Lettuce (*Lactuca sativa* cv. Maserati) Plants Produced in Different Growing Substrates

	Initial	10 DAP [y]	20 DAP	30 DAP
Substrate	Average Height (cm)			
Local Medium [x]	4.73	5.67	8.33	10.00a
Fortlite	5.40	6.67	8.73	11.20b
Intervale Compost	5.60	6.47	7.60	8.93a
Control	5.20	6.33	8.33	12.80b
Significance z	NS	NS	NS	***

[x] Vermicompost, Sphagnum peat moss, perlite and cocopeat (1:1:1:1 by v/v)

[y] DAP: Days after planting.

[z] ***: Significant at P ≤ 0.001 level. Mean values followed by the same alphabets within a column are not significantly different at P ≤ 0.05.

NS: Not significant

Table 6: Average Plant Canopy of Red Oakleaf Lettuce Plants (*Lactuca sativa* cv. Maserati) in Different Growing Substrates

	Initial	10 DAP [y]	20 DAP	30 DAP
Substrate	Average Plant Canopy (cm)			
Local Medium [x]	10.73a	13.93a	17.87a	19.80a
Fortlite	10.87a	14.53ab	18.13a	22.40a
Intervale Compost	11.13b	13.67a	17.47a	18.67a
Control	10.73a	17.27b	25.53b	29.13c
Significance z	NS	NS	***	***

[x] Vermicompost, Sphagnum peat moss, perlite and cocopeat (1:1:1:1 by v/v)

[y] DAP: Days after planting.

[z] ***: Significant at P ≤ 0.001 level. Mean values followed by the same alphabets within a column are not significantly different at P ≤ 0.05.

NS: Not significant

Table 7: Number of Leaves Recorded in Red Oak leaf Lettuce Plants (*Lactuca sativa* cv. Maserati) in Different Growing Substrates

Substrates	Initial	10 DAP[y]	20 DAP	30 DAP
Local Medium[x]	3.40	4.53	6.13	7.00a
Fortlite	3.60	4.93	6.20	7.53a
Intervale Compost	3.60	4.67	6.00	6.47a
Control	3.60	5.00	6.67	9.53b
Significance[z]	NS	NS	NS	***

[x] Vermicompost, Sphagnum peat moss, perlite and cocopeat (1:1:1:1 by v/v)

[y] DAP: Days after planting.

[z] ***: Significant at $P \leq 0.001$ level. Mean values followed by the same alphabets within a column are not significantly different at $P \leq 0.05$.

NS: Not significant.

Table 8: Chlorophyll Index of Red Oak leaf Lettuce Plants in Different Growing Substrates

Substrates	Initial	10 DAP[y]	20 DAP	30 DAP
Local Medium[x]	6.15	5.65a	6.06	12.96
Fortlite	7.16	6.61a	6.39	11.01
Intervale Compost	6.96	6.85a	6.40	9.28
Control	6.75	6.67a	7.61	15.37
Significance[z]	NS	NS	NS	NS

[x] Vermicompost, Sphagnum peat moss, perlite and cocopeat (1:1:1:1 by v/v)

[y] DAP: Days after planting.

[z] NS: Not significant

The Intervale compost produced the shortest plants. The plants in the control treatment had higher canopies (29.13 cm) than those other substrates (Table 6).

The greatest number of leaves was produced by control plants (9.53); however, there were no significant differences in the number of leaves produced in plants grown in other substrates (Table 7). The lowest number of leaves was produced by plants in the Intervale substrate (6.47). Treatments did not differ in respect of chlorophyll index at 30 days after transplanting (Table 8).

DISCUSSION

In our earlier study, growing substrates containing vermicompost, coco peat, sphagnum peat moss and perlite (1:1:1:1 v/ v) were found to be better than other substrates or the control in tomato (Cindel F_1), cucumber (Picolino F_1), capsicum (Piment Doux F_1) and climbing bean (Makarant F_1) in KISR [2,3]. The inclusion of organic nitrogen sources (Avicumus or DOrS @ 15 kg/ m^3) in the substrate improved the quality of the substrates and enhanced yields [2].

The substrate related problems mainly result from high salt concentrations and structural and water-retention properties of components used in formulating the substrate. These factors are critical and as such determine the success of commercial production of organic vegetables in containers. While, obtaining high-quality, uniform substrate is important, it should be closely matched to the watering and fertilization techniques that are being followed in producing vegetables. This is very critical because the nutrients present in the composts are released over a longer duration compared to that from an inorganic fertilizer formulkation [4-6]. Fluctuations in the availability of nutrients, especially ammonium, potassium and phosphorus, do occur during the production period [7]. These studies also suggested that incorporation of 15 to 25% vermicompost in the growing substrate promoted better growth and yields in lettuce. The addition of an organic nitrogen source (up to 10% DOrS) to the vermicompost-based media and the addition of other ingredients, such as sphagnum peat moss, vermiculite, perlite etc. have also been suggested to provide sufficient nutrients and improve the structural quality of the substrate. Miles and Peet [8] also recommended the use of an organic substrate containing 85% of Fafard’s special organic mix (sphagnum peat moss, vermiculite, perlite gypsum, dolomitic lime and pine bark); 15% of vermicycle (commercial vermcompost); 2 g /l J. H. Bioteck “Natural Wet”, 780 g/ m^3 of each of bone meal, blood meal and potassium sulfate and 300 g/ m^3 of elemental sulfur. Rynk [9] recommended 20 to 30% of compost-content in potting mixes.

The results of these experiments suggested that vermicompost based growing substrates were superior in quality, environmentally friendly and economically viable compared to commercial composts like Intervale and were capable of promoting plant growth and producing yields close to those from the conventional soil-based production system. Though the yield was less in local medium substrate in lettuce in comparison to soil based control commercial substrates; however, more research needed to improve the productive capacity of the local substrate.

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