Utilization of Grape Fruit Waste-based Substrates for Seed Germination and Seedling Growth of Lemon Basil

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SUMMARY. Grape (*Vitis vinifera*) waste management is a major problem in juice production, but it could be transformed into a major opportunity if the waste was recycled and used as a nursery growing medium. The aim of this study was to evaluate the suitability of four composts based on squeezed grape fruit waste (SGFW), mixed with coir or vermiculite in a one-to-one ratio by volume to form 13 growing media, for seed germination and seedling growth of 'Mrs. Burns' lemon basil (*Ocimum basilicum* var. *citriodora*). The final germination percentage (FGP), corrected germination rate index (CGRI), survival percentage, and seedling growth of 'Mrs. Burns' lemon basil were the variables measured. Pure SGFW reduced seed germination and seedling growth. The medium combining pure SGFW with vermiculite in a one-to-one ratio by volume was optimal for seed germination and seedling growth; in this medium the highest FGP, CGRI, survival rate, and growth parameters were recorded. The negative effects of pure SGFW composts were eliminated by mixing all composts with coir or vermiculite. These waste recycling media are low-cost products that can be beneficially used in nurseries on a commercial scale.

Grape juice industries produce large amounts of waste, which can negatively affect the environment (Kumar and Manimegalai, 2004). Composting of 'Red Roomy' grape waste for use as a partial peat substitute has been proposed; it could also reduce environmental pollution (Bayoumi et al., 2008; El-Mahrouk and Dewir, 2016). Organic waste materials and composts have been used for growing a wide range of crops including bedding annuals, perennials, vegetables, woody shrubs and trees, and foliage plants (Aguilar-Benitez et al., 2012; Grigatti et al., 2007; Hernández-Apaolaza et al., 2005; Jahromi et al., 2012; Restrepo et al., 2013). Previous studies indicated that grape pomace can be used

as a substrate component to produce various vegetable crops and ornamental plants (Bayoumi et al., 2008; Inbar et al., 1986; Ingelmo et al., 1998; Manios, 2004). Composted grape pomace in combination with mycorrhizal fungi enhanced plant growth of 'White Lisbon' onion (*Allium cepa*) through enhancing phosphorus uptake (Linderman and Davis, 2001). Compost of grape waste and hen droppings has been used as an organic fertilizer or as a soil conditioner for corn [*Zea mays* (Ferrer et al., 2001)]. Several other potential uses and applications of grape waste in food industry have been reviewed (Arvanitoyannis et al., 2006). Grape waste contains a high concentration of fertilizer elements (El-Mahrouk and Dewir, 2016; Ferrer et al., 2001), which makes it suitable for composting. However, it

also contains a high amount of polyphenols (Arvanitoyannis et al., 2006; El-Mahrouk and Dewir, 2016; Lazzè et al., 2009), which might inhibit the microbial growth in the plant root zone (Ben Jenana et al., 2009; Mandelbaum et al., 1988) but makes it less effective as a composting material. Animal manure, especially chicken, has long been recognized as one of the most desired manures because of its high nitrogen, phosphorus, and potassium content (Agbede et al., 2008; Dikinya and Mufwanzala, 2010; Schjegel, 1992; Warman, 1986). Application of compost to the growing medium is known to have a positive effect on crop production (Woodbury, 1992). High yield of common bean (*Phaseolus vulgaris*) and tomato (*Solanum lycopersicum*) in compost-amended soils has been reported by Aguilar-Benitez et al. (2012) and Bryan and Lance (1991), respectively. It also brings economic benefits as the use of cheap residues reduces the expenditure on conventional materials (Ingelmo et al., 1998).

Peatmoss has a high cation exchange capacity (180 meq/100 g) and its pH is generally in the range of 3.0–5.0 (Landis, 1990). It provides good aeration and moderate to high water holding capacity to a mix (Bigelow et al., 2004). Therefore, because of its chemical and physical properties (Prasad and Maher, 1993; Sahin et al., 2002), peatmoss is the most desired substrate component used in greenhouse mixes. It is also a limited resource; therefore, a reduction in its availability can cause price increases. Coir is increasingly used as a substrate component because of its similarity to peatmoss (Lennartsson, 1997). It has become commercially popular worldwide as a peat substitute, especially for container-grown plants (Abad et al., 2002; Hernández-Apaolaza et al., 2005). Coir, however, is still expensive, because it is mostly produced in East Asia and is

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Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
10	%	g·L ⁻¹	0.1
0.3048	ft	m	3.2808
3.7854	gal	L	0.2642
2.54	inch(es)	cm	0.3937
1	mmho/cm	dS·m ⁻¹	1
28.3495	oz	g	0.0353
(°F – 32) ÷ 1.8	°F	°C	(°C × 1.8) + 32

exported to all other destinations. Consequently, studies on peatmoss and coir alternatives are of great interest in agriculture as they have the potential to provide more sustainable alternatives to these resources (Chong, 2005; Herrera et al., 2008). Increasing demand and rising costs for peat have led to a search for high quality and low-cost composts derived from organic wastes such as grape wastes (Bayoumi et al., 2008; El-Mahrouk and Dewir, 2016; Inbar et al., 1986). In our previous study, we reported on the composting of squeezed grape fruit waste and its physicochemical properties (El-Mahrouk and Dewir, 2016). As a continuation of that research, the objective of the present study was to evaluate pure SGFW and different SGFW-based substrates as alternatives to coir and vermiculite for seed germination and seedling growth of 'Mrs. Burns' lemon basil.

Materials and methods

COMPOSTING PROCESS AND MEDIA. SGFW of 'Red Roomy' was purchased from Al Ahram Beverages Co. (Behira, Egypt) and divided into four groups. Each group was mixed with other materials to improve and accelerate the composting process. The following materials were composted as previously described by Bayoumi et al. (2008) and El-Mahrouk and Dewir (2016) and used in this study: a) SGFW + chicken manure including hardwood sawdust (CMSD) (3 SGFW : 2 CMSD v/v); b) SGFW + bean (*Vicia faba*) hay (BH) (4 SGFW : 1 BH v/v); c) SGFW + chicken manure including wheat (*Triticum aestivum*) hay (CMWH) (4 SGFW : 1 CMWH v/v); and d) pure SGFW. The wastes were arranged in heaps at 2 m wide × 1.5 m high × 20 m long, which were regularly turned and crushed using compost machine (Backhus 17.60 windrow turner for compost; Blue Group, Appleton, UK) and watered for 3 months to ensure appropriate composting conditions. Heaps were watered with sprinkler system when needed (at field capacity point) and turned weekly to ensure adequate aeration and high decomposition. Maturity of composts considered complete when the temperature inside the heap decreased to the

surrounding temperature. Analysis of the physicochemical properties of these composts revealed that nitrogen (N), phosphorus (P), and potassium (K) concentrations in SGFW composts were higher than the coir or vermiculite. The soluble cations [calcium (Ca^{2+}), magnesium (Mg^{2+}), and K^+] and anions [carbonate (CO_3^{2-}) and hydrogen carbonate (HCO_3^-)] in (3 SGFW : 2 CMSD v/v) compost were the highest among substrates (El-Mahrouk and Dewir, 2016). The concentrations of trace elements and heavy metals in SGFW composts were far lower than the range of phytotoxicity. On the other hand, total phenols in SGFW composts were higher than coir (El-Mahrouk and Dewir, 2016).

The four composts were soaked in water for 48 h for leaching and mixed with coir (Jiffy, Mirigama, Sri Lanka) or fine vermiculite [Egyptian Company for Mineral Resources (ECMR), Cairo, Egypt] (1 compost : 1 coir or 1 compost : 1 vermiculite v/v) to form 13 growth media (Table 1). A medium composed of coir and vermiculite (1 coir : 1 vermiculite v/v) was used as the control because of its wide utilization in nurseries. The pH, electrical conductivity (EC), and relative cost to fill 100 planting trays of the 13 growth media are presented in Table 1. Aqueous compost extracts were prepared by shaking the compost in distilled water at a ratio of 1:10 (w/v) for 2 h at room temperature. The suspension was centrifuged and the supernatant was filtered through filter paper. The pH and EC were determined in compost extract according to Page et al. (1982).

GREENHOUSE EXPERIMENT. 'Mrs. Burns' lemon basil seeds were purchased from Sutton Seeds (Paignton, United Kingdom) and sown in foam trays (3.0 cm × 3.0 cm, 209 cells per tray) containing 13 media. One seed was sown manually in each well and covered with the same substrate in the tray. After sowing, the trays were kept in a greenhouse at a temperature of $25 \pm 2^\circ\text{C}$ and light intensity of $300 \mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$. They were watered manually every 4 d using 10-L watering cans; the same water amount was applied to each tray. Seedlings were fertilized twice with $1.5\text{-g}\cdot\text{L}^{-1}$ solution of 19N–8.3P–15.7K water-soluble fertilizer (Rosasol; Rosier, Moustier, Belgium) after emergence.

The fertilizer solution was applied using a sprinkler system. Emergence (defined as a seedling with cotyledons visible above the medium surface) started 1 week after sowing.

VARIABLES MEASURED. Germinated seeds were counted every 2 d, for 30 d. A seed was considered germinated when the two cotyledons appeared on the medium surface. The following germination parameters were recorded: germination percentage (GP) = (number of germinated seeds/number of tested seeds) × 100; germination rate index (GRI) = $[(G_1/1) + (G_2/2) + (G_x/X)]$, where G = germination on each subsequent day after placement, 1, 2; X = corresponding day of germination (Esechie, 1994); corrected germination rate index (CGRI) = $(\text{GRI}/\text{FGP}) \times 100$, where FGP = final germination percentage; GT_{50} = number of days elapsed to reach 50% of FGP (Hsu et al., 1985) and survival (%) = (number of germinated seeds – number of seedlings that died after germination) × 100.

Seedling growth parameters were estimated 45 d after sowing. The following parameters were recorded for each seedling: height (measured from the medium surface to the shoot apex), number of leaves (excluding cotyledons), root length (seedlings were washed and the longest root was measured), fresh and dry weight, and degree of greenness. Dry weight was recorded after drying at 60°C for 48 h. The degree of greenness was measured on fully expanded and apical leaves using a portable leaf chlorophyll meter (SPAD-501; Minolta Corp., Osaka, Japan), following the methodology described by Tenga et al. (1989).

STATISTICAL ANALYSIS. The experiment was set up as a completely randomized design. The media were arranged in five random replicates; each replicate contained one tray (209 cells), but occupied only 156 wells per tray because the data obtained from edge cells were not used. The experiment was conducted at Elkenana Co. (Tanta, Egypt) and repeated twice, on 15 Mar. and 1 Apr. 2014. The mean values of the both experiments are presented in this report (data on seed germination were collected from 120 seeds for each treatment whereas data on seedlings growth were collected from 24

Table 1. Media composition, pH, electrical conductivity (EC) and relative cost of different squeezed grape fruit waste (SGFW)-based media used for seed germination and seedling growth of ‘Mrs. Burns’ lemon basil.

Medium code	Medium composition (by volume)	pH	EC (dS·m ⁻¹) ^z	Relative cost (\$/100 trays)
M1	1 coir : 1 vermiculite	7.59 c ^y	0.378 f	30.00
M2	3 pure SGFW : 2 chicken manure sawdust	8.25 b	1.820 a	12.00
M3	4 pure SGFW : 1 bean hay	8.04 b	1.670 a	10.00
M4	4 pure SGFW : 1 chicken manure wheat hay	7.86 c	0.788 d	11.00
M5	Pure SGFW	7.65 c	0.832 d	09.00
M6	1 M2 : 1 coir	7.36 d	1.191 c	19.00
M7	1 M3 : 1 coir	7.53 cd	1.430 b	17.71
M8	1 M4 : 1 coir	7.28 d	0.576 e	18.14
M9	1 pure SGFW : 1 coir	7.33 d	0.599 e	14.57
M10	1 M2 : 1 vermiculite	8.96 a	0.996 d	17.57
M11	1 M3 : 1 vermiculite	8.86 a	1.665 ab	16.29
M12	1 M4 : 1 vermiculite	8.37 ab	0.703 de	16.71
M13	1 pure SGFW : 1 vermiculite	8.08 b	0.603 e	16.00
Significance		*	*	—

^z1 dS·m⁻¹ = 1 mmho/cm.

^yValues followed by the same letter in the same column are not significantly different at $P \leq 0.05$ level, according to Tukey’s range test.

*Significant at $P \leq 0.05$ according to ANOVA.

randomly chosen seedlings). The mean values of seed germination and seedling growth, and the one-way analysis of variance (ANOVA) were calculated using SPSS software (version 20; IBM Corp., Armonk, NY). The mean separations were carried out using Tukey’s range test; the significance threshold was set at $P \leq 0.05$.

Results and discussion

EFFECT OF PURE-SGFW COMPOST ON SEED GERMINATION, SURVIVAL, AND GROWTH OF ‘MRS. BURNS’ LEMON BASIL SEEDLINGS. Using pure-SGFW compost as the sole substrate drastically reduced FGP and increased the number of days to reach FGP (GT₅₀) as compared with the control treatment (Table 2). It also resulted in the lowest survival rate (15.91%) as well as among the lowest growth parameters: shoot length, root length, number of leaves, fresh and dry weights, and degree of greenness (Table 2; Fig. 1). The root system was poorly developed and the roots did not penetrate to the bottom of the culture well suggesting poor aeration (Fig. 1). It is also noted that composts that were not leached prevented seed germination of lemon basil. Composts may have physical and chemical properties similar to peat, which make them suitable as peat substitutes (Bustamante et al., 2008). However, the use of compost as a substrate can also have certain limitations because of high salt

content, unsuitable physical properties, and variable quality and composition, including potential heavy-metal toxicity (Herrera et al., 2008). Inclusion of grape pomace at high percentage volumes (80%) as a substrate component suppressed root development, increased leaf necrosis, and had detrimental effects on pecan (*Carya illinoensis*) seedling growth (Stafne and Carroll, 2008). The inhibition of seed germination and reduction of germination speed have been attributed to phytotoxic compounds that are released in the course of organic matter decomposition, such as ammonium, acetic acid, phenol, or low-molecular weight fatty acids (Zucconi et al., 1981). In the present study, the low germination rate and low survival of ‘Mrs. Burns’ lemon basil seeds observed on pure-SGFW medium could be due to phytotoxicity resulting from the composting process. The prevention of seed germination in SGFW that was not leached could be an indication of its phytotoxicity. Similar results have been obtained in a study on tomato (Restrepo et al., 2013).

In practice, compost phytotoxicity is usually evaluated using the plant germination index, which is a rapid and sensitive technique for the identification of substances that strongly inhibit plant germination and development (Gao et al., 2010; Ko et al., 2008; Miaomiao et al., 2009; Walter et al., 2006). One study suggested that the observed lower weight of marigold (*Calendula officinalis*)

plants grown on peat, compared with those grown on two compost-based substrates, might be due to a lower availability of macronutrients (García-Gómez et al., 2002). Our findings that pure compost is unsuitable as a growing medium are consistent with previous report by Spiers and Fietje (2000) as they concluded it is characterized by inadequate air space, high salt content, and high pH. Grape waste is rich in phenolic compounds, which have been shown to inhibit seed germination and seedling growth (Diaz et al., 2004). This effect has been reported in many species, such as ‘Japonica’ shirakamba birch [*Betula platyphylla* (Yukiko et al., 2001)], soybean [*Glycine max* (Colpas et al., 2003)], and cucumber [*Cucumis sativus* (Muzaffar et al., 2012)]. In our previous study, we reported that pure SGFW is rich in phenolic compounds when compared with coir and vermiculite (El-Mahrouk and Dewir, 2016). Phenolics have the ability to alter mitochondrial and chloroplast membranes, hindering the energy transfer necessary for ion transport, as observed in spinach [*Spinacia oleracea* (Moreland and Novitzky, 1987)]. The inhibitory effects of phenolic compounds on seed germination are closely related to the regulation of endogenous auxin, seedcoat permeability, and oxygen supply to embryos (Bewley and Black, 1994). They are generally considered allelochemicals that affect many physiological processes such as nutrient uptake, respiration, germination, plant

Table 2. Effect of different media on seed germination and seedlings growth of 'Mrs. Burns' lemon basil.

Medium code	Medium composition (by volume) ^z	Seed germination parameters ^y				Seedling growth parameters ^x					
		FGP	CGRI	GT ₅₀	Survival (%)	Seedling length (cm)	Leaves (no./seedling)	Root length (cm)	Seedling fresh wt (g)	Seedling dry wt (g)	Greenness (SPAD)
M1	1 coir : 1 vermiculite (control)	85.23 b ^w	50.64 d	12.72 bc	77.27 d	5.6 b	6.6 ab	8.4 b	1.210 bc	0.116 cde	32.53 ab
M2	3 pure SGFW : 2 chicken manure sawdust	90.91 ab	38.60 f	15.79 a	90.91 abc	4.0 c	6.2 ab	6.9 d	0.465 d	0.054 f	29.42 cd
M3	4 pure SGFW : bean hay	93.18 ab	59.28 bc	10.67 fg	88.64 bc	3.8 c	5.8 b	7.4 cd	0.501 d	0.059 f	29.10 cd
M4	4 pure SGFW : 1 chicken manure wheat hay	54.55 c	57.65 c	11.12 def	42.05 e	2.7 c	5.8 b	2.7 e	0.308 d	0.048 f	25.38 e
M5	Pure SGFW	57.95 c	45.76 e	13.77 b	15.91 f	2.3 c	5.0 c	2.9 e	0.119 d	0.020 g	20.62 f
M6	1 M2 : 1 coir	86.36 b	52.04 d	12.25 cd	84.09 cd	7.0 a	7.0 a	7.9 bc	2.379 bc	0.206 de	31.07 abc
M7	1 M3 : 1 coir	96.59 ab	65.54 a	9.42 g	86.36 bcd	5.6 b	6.2 ab	8.10 bc	1.269 bc	0.104 de	28.27 cd
M8	1 M4 : 1 coir	97.73 ab	62.73 ab	9.88 fg	96.59 ab	5.6 b	6.2 ab	8.7 ab	1.023 c	0.099 e	29.32 cd
M9	1 pure SGFW : 1 coir	96.59 ab	61.75 abc	10.07 fg	96.59 ab	7.1 a	7.0 a	8.7 ab	1.388 bc	0.121 bcde	29.24 cd
M10	1 M2: 1 vermiculite	95.45 ab	53.15 d	11.86 cde	94.32 abc	5.3 b	6.0 b	9.4 a	1.415 bc	0.129 bc	31.02 abc
M11	1 M3 : 1 vermiculite	93.18 ab	49.11 de	12.90 bc	90.91 abc	5.6 b	6.6 ab	8.5 ab	1.310 bc	0.123 bcd	32.91 a
M12	1 M4 : 1 vermiculite	97.73 ab	53.20 d	11.99 cd	96.59 abc	5.7 b	6.4 ab	8.7 ab	1.632 a	0.135 bc	27.66 de
M13	1 pure SGFW : 1 vermiculite	100.00 a	60.29 bc	10.41 fg	100.00 a	5.6 b	6.6 ab	8.7 ab	1.363 bc	0.143 b	29.77 bcd
	Significance	*	*	*	*	*	*	*	*	*	*

^xSGFW = squeezed grape fruit waste.^yFGP = final germination percentage, CGRI = corrected germination rate index, GT₅₀ = number of days lapsed to reach 50% of final germination percentage.^z1 cm = 0.3937 inch, 1 g = 0.0353 oz.^wValues followed by the same letter in the same column are not significantly different at $P \leq 0.05$ level, according to Tukey's range test.*Significant at $P \leq 0.05$ according to ANOVA.

growth, and development (Einhellig, 2004).

EFFECT OF MIXING PURE-SGFW COMPOST WITH CMSD, BH, AND CMWH SUBSTRATES ON GERMINATION, SURVIVAL, AND GROWTH OF 'MRS. BURNS' LEMON BASIL SEEDLINGS. Mixing SGFW with CMSD (3 SGFW : 2 CMSD v/v) or BH (4 SGFW : 1 BH v/v) increased FGP and survival rate but seedling growth was not improved (Table 2) as compared with pure SGFW. Using SGFW with CMWH (4:1 v/v) did not improve seed germination or seedling growth as compared with pure SGFW. However, the longest time to reach 50% of the final seed germination (15.79 d) was recorded in seedlings grown in the SGFW + CMSD medium which could be attributed to its high EC (Tables 1 and 2). Herrera et al. (2008) recorded the fastest emergence rates in substrates that had lower pH and EC than saline media. It is known that mixing organic materials with soil has a positive effect on plant growth as a soil amendment and a nutrient source (Westerman and Bicudo, 2005). It has been found that compost can comprise up to 66.7% of the growth medium with no negative effects on broccoli (*Brassica oleracea* var. *italica*), tomato, and onion growth (Sánchez-Monedero et al., 1997). In another study, compost-based media had a significant positive effect on plant height compared with controls (Ostos et al., 2008). Furthermore, Bugbee and Frink (1989) reported that maximum marigold growth occurred in mixtures containing 30% compost. On the other hand, Castillo et al. (2004) showed that the growth and development of nursery-produced tomato seedlings on a mixture of peat and municipal solid waste compost were similar to those on a standard peat mixture. Composts are reported to be very rich in macroelements and microelements such as N, P, K, Fe, Zn, and Mn, which have a positive effect on plant growth (El-Mahrouk and Dewir, 2016). Pérez-Murcia et al. (2006) showed that micronutrients like Fe and Zn were the main nutrients extracted by the plants grown on the peat-compost mixtures. Different substrates contain different sets of materials that can affect plant growth and development directly or indirectly (Peyvast et al.,

Fig. 1. Vegetative growth of 'Mrs. Burns' lemon basil seedlings 45 d after sowing in 13 different growing media (by volume): M1 = 1 coir : 1 vermiculite, M2 = 3 pure squeezed grape fruit waste (SGFW) : 2 chicken manure sawdust, M3 = 4 pure SGFW : 1 bean hay, M4 = 4 pure SGFW : 1 chicken manure wheat hay, M5 = pure SGFW, M6 = 1 M2 : 1 coir, M7 = 1 M3 : 1 coir, M8 = 1 M4 : 1 coir, M9 = 1 pure SGFW : 1 coir, M10 = 1 M2 : 1 vermiculite, M11 = 1 M3 : 1 vermiculite, M12 = 1 M4 : 1 vermiculite, M13 = 1 pure SGFW : 1 vermiculite.

2008). Based on these previous studies, we conclude that the 'Mrs. Burns' lemon basil growth was influenced by composition of the compost (SGFW, CMSD, CMWH, and BH). However, the proportion of noncompost substrate in the final substrate is also known to be very important for minimizing potential hazards, especially salinity (Pérez-Murcia et al., 2006; Raviv et al., 1986).

EFFECT OF MIXING PURE-SGFW COMPOST OR SGFW-BASED SUBSTRATES WITH COIR OR VERMICULITE ON SEED GERMINATION, SURVIVAL, AND GROWTH OF 'MRS. BURNS' LEMON BASIL SEEDLINGS. Mixing pure SGFW with coir or vermiculite substrates in a one-to-one ratio by volume significantly improved seed germination, survival rate, and seedling growth as compared with pure SGFW or the commonly used substrate [control; 1 coir : 1 vermiculite v/v (Table 2)]. In addition, mixing SGFW-based substrate (4 SGFW : 1 CMWH v/v) in a one-to-one ratio by volume with coir or vermiculite also improved seed germination and seedling growth. On the other hand, mixing

other SGFW-based substrates (with CMSD and BH) with coir or vermiculite did not improve seed germination and seedling growth as compared with these SGFW-based substrates. In general, well-developed root systems with vigorous and whitish roots were observed in vermiculite containing substrates indicating good aeration and drainage (Fig. 1). The highest FGP (100%), CGRI (60.29), and survival rate (100%) were recorded using pure-SGFW compost mixed with vermiculite [1 SGFW : 1 vermiculite v/v (Table 2)]. Vermiculite proved to be better than coir when mixed with pure SGFW (1 vermiculite : 1 SGFW v/v) for seed germination, seedling survival, and seedling growth. Coir is commonly mixed with vermiculite and used as a growing substrate in nurseries but it is an expensive component of growing substrates. Using SGFW with vermiculite as an alternative component to coir not only improved the plant growth but also could reduce the substrate cost by nearly 50% (Table 1). These results indicate that achieving the correct proportions of compost and noncompost substrate in the growth medium is essential to improve plant growth. They also confirm previous findings on the potential of compost addition to reduce hazards such as salinity (Bustamante et al., 2008). Raviv et al. (1986) reported that the use of compost-peat mixtures could minimize the potential negative consequences of using single materials, such as high salinity, heterogeneity, or high content of pollutants. Moreover, the addition of organic materials is recommended as these tend to have porosity and aeration properties comparable with peat (Chong, 2005). Substrates containing compost and peat had the highest seedling emergence in tomato (Herrera et al., 2008), cockscomb [*Celosia plumosa* (Bayoumi et al., 2008)], hollyhock (*Althea rosea*), and marigold (Belal and El-Mahrouk, 2010) when pH and EC values were in a suitable range. Similarly, our compost analysis showed that pH, EC, and salinity values were within the range suitable for seed germination (Table 1). Composts with a high pH value can frequently occur after bioconversion, which severely restricts their use as

growing media in nursery crop production (Raviv et al., 2004).

Conclusion

Pure-SGFW compost was found unsuitable as a substrate for seed germination and seedling growth of 'Mrs. Burns' lemon basil. However, with proper leaching before using SGFW compost and by mixing it with coir or vermiculite, it can be used as a substitute for the standard commercial substrate (1 coir : 1 vermiculite v/v). Mixing SGFW compost with coir or vermiculite (1 SGFW : 1 coir or 1 SGFW : 1 vermiculite v/v) improved its quality and prevented the negative effects. The SGFW compost is a low-cost waste product of grape juice production; we recommend its use as a nursery growing medium when mixed with vermiculite (1 SGFW : 1 vermiculite v/v).

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