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

Mohammed El-Sayed El-Mahrouk¹, Yaser Hassan Dewir¹,²,⁴, and Salah El-Hendawy²,³

ADDITIONAL INDEX WORDS. compost, nursery, Ocimum basilicum, Vitis vinifera, waste recycling, waste management

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. The 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., 1997; 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; Lazzë 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., 1997).

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

We extend our appreciation to the Deanship of Scientific Research at King Saud University for funding this work through research group NO (RGP-1438-012).

¹Horticulture Department, Faculty of Agriculture, Kafrelsheikh University, Kafir El Sheikh 33516, Egypt
²Plant Production Department, College of Food and Agriculture Sciences, King Saud University, P.O. Box 2460, Riyadh 11451, Saudi Arabia
³Agronomy Department, Faculty of Agriculture, Suez Canal University, Ismaila 41522, Egypt
⁴Corresponding author. E-mail: ydewir@hotmail.com or ydewir@ksu.edu.sa.

doi: 10.21273/HORTTECH03761-17

Units
To convert U.S. to SI, multiply by
U.S. unit SI unit
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 0.0553
(°F - 32) + 1.8 °C (°C × 1.8) + 32

August 2017 27(4)
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; Inbar et al., 2008; 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 (Ca²⁺), magnesium (Mg²⁺), and K⁺] and anions [carbonate (CO₃²⁻) and hydrogen carbonate (HCO₃⁻)] 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 seed 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 ± 2 °C and light intensity of 300 μmol-m⁻²-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-g-L⁻¹ solution of 19N–8.3P–15.7K water-soluble fertilizer (Rososal; 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) = [(GP₁/₁) + (GP₂/₂) + (GPₙ/ₙ)]/X, where G = germination on each subsequent day after placement, 1, 2, X = corresponding day of germination (Eschch, 1994); corrected germination rate index (CGRI) = (GRI/GPF) × 100, where FGP = final germination percentage; GT₅₀ = 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
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 ($GT_{50}$) 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 illinoiensis) 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 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)* | Relative cost ($/100 trays) |
|-------------|--------------------------------|----|--------------|-----------------------------|
| M1          | 1 coir : 1 vermiculite         | 7.59 e | 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 c | 16.00 |

Significance

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

---

*1 dS·m⁻¹ = 1 mmho/cm.

*Values 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.
EFFECT OF MIXING PURE-SGFW 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 plant growth (Perez-Murcia et al., 2006). Perez-Murcia et al., 2006) showed that microelements, 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 (Peyvat et al., 2004).

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

| Medium code | Medium composition (by volume) | Seed germination parameters  | Seedling growth parameters |
|-------------|--------------------------------|-------------------------------|----------------------------|
|             |                                | FGP | CGRI | GT<sub>50</sub> | Survival (%) | Length (cm) | Leaves (no./seedling) | Root length (cm) | Fresh wt (g) | Dry wt (g) | Greenness (SPAD) |
| M1          | 1 coir : 1 vermiculite (control) | 85.23 b<sup>+</sup> | 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 bc | 2.7 c | 5.8 b | 2.7 e | 0.308 d | 0.048 f | 25.38 cd |
| 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 b | 2.379 bc | 0.206 dc | 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 ab | 5.3 b | 6.6 ab | 8.5 ab | 1.310 bc | 0.123 bcd | 32.91 a |
| 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 b | 1.416 bc | 0.129 bc | 31.02 abc |
| M12         | 1 M4 : 1 vermiculite | 97.73 ab | 53.20 cd | 11.99 cd | 96.59 abc | 5.7 b | 6.4 ab | 8.7 ab | 1.612 a | 0.138 bce | 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 | 1.836 bc | 0.143 bde | 25.03 bcd |

*SGFW = squeezed grape fruit waste.
†FGP = final germination percentage, CGRI = corrected germination rate index, GT<sub>50</sub> = number of days lapsed to reach 50% of final germination percentage.
§1 cm = 0.3937 inch, 1 g = 0.0353 oz.
Values followed by the same letter in the same column are not significantly different at P < 0.05 level, according to Tukey's range test.
*Significant at P < 0.05 according to ANOVA.
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).

**Literature cited**

Abad, M., P. Noguera, R. Puchades, A. Maquia, and V. Noguera. 2002. Physico-chemical and chemical properties of some coconut coir dusts for use as a peat substitute for containerised ornamental plants. Bioresour. Technol. 82:241–245.

Agbede, T.M., S.O. Ojeniyi, and A.J. Adeyemo. 2008. Effect of poultry manure on soil physical and chemical properties, growth and grain yield of sorghum in southwest Nigeria. Amer.-Eurasian J. Sustainable Agr. 2:72–77.

Aguilar-Benitez, G., C.B. Peña-Valdivia, J.R. García-Nava, P. Ramírez-Vallejo, S.G. Benedicto-Valdés, and J.D. Molina-Galán. 2012. Rendimiento de frijol (Phaseolus vulgaris L.) en relación con la concentración de vermicompost y déficit de humedad en el sustrato. Agrociencia 46:37–50.

Arvanitoyannis, I.S., D. Ladas, and A. Mavromatis. 2006. Potential uses and applications of treated wine waste: A review. Intl. J. Food Sci. Technol. 41:475–487.

Bayoumi, Y.A., M.E. El-Mahrouk, F. El-Aidy, and Z. Pap. 2008. Using compost of grape manufacture and farm wastes as growing media in vegetable and ornamental nurseries. Intl. J. Hort. Sci. 14:45–50.

Belal, E.B. and M.E. El-Mahrouk. 2010. Solid-state fermentation of rice straw residues for its use as growing medium in ornamental nurseries. Acta Astronaut. 67:1081–1089.
Ben Jenana, R.K., R. Haouala, M.A. Triki, J.-J. Godon, K. Hihar, M. Ben Khedher, and B. Henchi. 2009. Composts, compost extracts and bacterial suppressive action on Pythium aphanidermatum in tomato. Pak. J. Bot. 41:315–327.

Bewley, J.D. and M. Black. 1994. Seeds: Physiology of development and germination. 2nd ed. Plenum Press, New York, NY.

Bigelow, C., D. Bowman, and D. Cassel. 2004. Physical properties of three sand size classes amended with inorganic materials or sphagnum peat moss for putting green rootzones. Crop Sci. 44:900–907.

Bryan, H.H. and C.J. Lance. 1991. Compost trials on vegetables and tropical crops. Biocycle 32:36–37.

Bugbee, G.J. and C.R. Frink. 1989. Composted waste as a peat substitute in peat-lite media. HortScience 24:625–627.

Bustamante, M.A., C. Paredes, R. Moral, E. Aguillo, M.D. Pérez-Murcia, and M. Abad. 2008. Composts from distillery wastes as peat substitutes for transplant production. Resour. Conserv. Recyling 52:792–799.

Castillo, J.E., F. Herrera, R.J. López-Bellido, F.J. López-Bellido, L. López-Bellido, and F.J. Fernández. 2004. Municipal solid waste (MSW) compost as a tomato transplant medium. Compost Sci. Util. 12:86–92.

Chong, C. 2005. Experiences with wastes and composts in nursery substrates. HortTechnology 15:739–747.

Colpas, F.T., E.O. Ono, J.D. Rodrigues, and R.J. Passos. 2003. Effects of some phenolic compounds on soybean seed germination and on seed-borne fungi. Braz. Arch. Biol. Technol. 46:155–161.

Diaz, M.J., E. Madejon, F. Cabrera, L. Jimenez, and M. DeBertoldi. 2004. Using a second-order polynomial model to determine the optimum vinasse/grape marc ratio for in-vessel composting. Compost Sci. Util. 12:273–279.

Dikinya, O. and N. Muñfanzala. 2010. Chicken manure-enhanced soil fertility and productivity: Effects of application rates. J. Soil Sci. Environ. Manag. 1:46–54.

Einhellig, F.A. 2004. Mode of allelochemical action of phenolic compounds, p. 217–238. In: F.A. Macias, J.C.R. Galindo, J.M.G. Molinillo, and H.G. Cutler (eds.). Allelopathy: Chemistry and mode of action of allelochemicals. CRC Press, Boca Raton, FL.

El-Mahrouk, M.S. and Y.H. Dewir. 2016. Physico-chemical properties of compost based waste-recycling of grape fruit as nursery growing medium. Amer. J. Plant Sci. 7:48–54.

Eschric, H. 1994. Interaction of salinity and temperature on the germination of sorghum. J. Agron. Crop Sci. 172:194–199.

Ferrer, J., G. Paez, Z. Marmol, E. Ramones, C. Chandler, M. Marin, and A. Ferrer. 2001. Agronomic use of biotechnologically processed grape wastes. Bioresour. Technol. 76:39–44.

Gao, M., F. Liang, A. Yu, B. Li, and L. Yang. 2010. Evaluation of stability and maturity during forced-aeration composting of chicken manure and sawdust at different C/N ratios. Chemosphere 78:614–619.

García-Gómez, A., M.P. Bernal, and M. Roig. 2002. Growth of ornamental plants in two composts prepared from agro-industrial wastes. Bioresour. Technol. 83:81–87.

Grigatti, M., M.E. Giorgioni, and C. Ciavatta. 2007. Compost-based growing media: Influence on growth and nutrient use of bedding plants. Bioresour. Technol. 98:3526–3534.

Hernández-Apaulaza, L., A.M. Gasco, J.M. Gasco, and F. Guerrero. 2005. Reuse of waste materials as growing media for ornamental plants. Bioresour. Technol. 96:125–131.

Herrera, F., J.E. Castillo, A.F. Chica, and L. Lopez Bellido. 2008. Use of municipal solid waste compost (MSWC) as a growing medium in the nursery production of tomato plants. Bioresour. Technol. 99:287–296.

Hsu, F.H., C.J. Nelson, and A.G. Matches. 1985. Temperature effects on germination of perennial warm-season forage grasses. Crop Sci. 25:212–220.

Inbar, Y., Y. Chen, and Y. Hadar. 1986. The use of composted separated cattle manure and grape marc as peat substitute in horticulture. Acta Hort. 178:147–154.

Ingelmo, F., R. Canet, M.A. Ibanez, F. Pomares, and J. Garcia. 1998. Use of MSW compost, dried sewage sludge and other wastes as partial substitutes for peat and soil. Bioresour. Technol. 63:123–129.

Jahromi, M.G., A. Aboutalebi, and M.H. Farahi. 2012. Influence of different levels of garden compost (garden wastes and cow manure) on growth and stand establishment of tomato and cucumber in greenhouse condition. Afr. J. Biotechnol. 11:9036–9039.

Ko, H., K. Kim, H. Kim, C.H. Kim, and M. Umeda. 2008. Evaluation of maturity parameters and heavy metal contents in composts made from animal manure. Waste Mgt. 28:813–820.

Kumar, R.S. and G. Manimegalai. 2004. Fruit and vegetable processing industries and environment, p. 97–117. In: A. Kumar (ed.). Industrial pollution and management. APH Publ., New Delhi, India.

Landis, T.D. 1990. Growing media, p. 41–85. In: T.D. Landis, R.W. Tinus, S.E. McDonald, and J.P. Barnett (eds.). The container tree nursery manual. Vol. II. Container and growing media. U.S. Dept. Agr., For. Serv., Washington, DC.

Lazzé, M.C., R. Pizzala, F.J. Gutiérrez Pecharrromán, P.G. Gatoñ, J.M. Antolín Rodríguez, N. Fabris, and L. Bianchi. 2009. Grape waste extract obtained by supercritical fluid extraction contains bioactive antioxidant molecules and induces antiproliferative effects in human colon adenocarcinoma cells. J. Med. Food 12:561–568.

Lennartsson, M. 1997. The peat conservation issue and the need for alternatives. Proc. IPS Intl. Peat Conf. Peat in Horticulture. Schmiedeki, Amsterdam, The Netherlands. p. 112–121.

Linderman, R.G. and E.A. Davis. 2001. Vesicular-arbuscular mycorrhiza and plant growth response to soil amendment with composted grape pomace or its water extract. HortTechnology 11:446–450.

Mandelbaum, R., Y. Hadar, and Y. Chen. 1988. Composting of agricultural wastes for their use as container media: Effect of heat treatments on suppression of Pythium aphanidermatum and microbial activities in substrates containing compost. Biol. Wastes 26:261–274.

Manios, T. 2004. The composting potential of different organic solid wastes: Experience from the island of Crete. Environ. Int. 29:1079–1089.

Miaomiao, H., L. Wenlong, L. Xinqiang, W. Donglei, and T. Guangming. 2009. Effect of composting process on phytotoxicity and speciation of copper, zinc and lead in sewage sludge and swine manure. Waste Mgt. 29:590–597.

Moreland, D.E. and W.P. Novitzky. 1987. Effects of phenolic acids, coumarins, and flavonoids on isolated chloroplasts and mitochondria, p. 247–261. In: G.R. Waller (ed.). Allelochemicals: Role in agriculture and forestry. Amer. Chem. Soc., Washington, DC.

Muzaffar, S., B. Ali, and N.A. Wani. 2012. Effect of catechol, gallic acid and pyrogallic acid on the germination, seedling growth and the level of endogenous phenolics in cucumber (Cucumis sativus...
Ostos, J.C., R. López-Garrido, J.M. Murillo, and R. López. 2008. Substitution of peat for municipal solid waste- and sewage sludge-based composts in nursery growing media: Effects on growth and nutrition of the native shrub *Pistacia lentiscus* L. Bioresour. Technol. 99:793–800.

Page, A.L., R.H. Miller, and P.R. Keeney. 1982. Methods of soil analysis. Amer. Soc. Agron., Madison, WI.

Pérez-Murcia, M.D., R. Moral, J. Moreno-Caselles, A. Pérez-Espinosa, and C. Paredes. 2006. Use of composted sewage sludge in growth media of broccoli. Bioresour. Technol. 97:123–130.

Peyvast, G.H., M. Noorizadeh, J. Hamidoghli, and P. Ramezani-Kharazi. 2008. Effect of four different substrates on growth, yield and some fruit quality parameters of cucumber in bag culture. Acta Hort. 742:175–182.

Prasad, M. and M.J. Maher. 1993. Physical and chemical properties of fractionated peat. Acta Hort. 342:257–264.

Raviv, M., Y. Chen, and Y. Inbar. 1986. Peat and peat substitutes as growth media for container-grown plants. p. 257–287. In: Y. Chen and Y. Avniimelech (eds.). The role of organic matter in modern agriculture. Martinus Nijhoff, Dordrecht, The Netherlands.

Raviv, M., Y. Oka, J. Katan, Y. Hadar, A. Yogeit, S. Medina, A. Krasnovsky, and H. Ziadna. 2004. High-nitrogen compost as a medium for organic container-grown crop. Bioresour. Technol. 96:419–427.

Restrepo, A.P., E. Medina, A. Pérez-Espinosa, E. Agulló, M.A. Bustamante, C. Mininni, M.P. Bernal, and R. Moral. 2013. Substitution of peat in horticultural seedlings: Suitability of digestate-derived compost from cattle manure and maize silage co-digestion. Commun. Soil Sci. Plant Anal. 44:668–677.

Sahin, U., O. Anapali, and S. Ercisli. 2002. Physico-chemical and physical properties of some substrates used in horticulture. Die Gartenbauwissenschaft 67:55–60.

Sánchez-Monedero, M.A., M.P. Bernal, A. Anton, P. Noguera, A. Abad, A. Roig, and J. Cegarra. 1997. Utilización del compost como sustratos para Semilleros de Plantas Horticolas en Cepellón. Proc. I Congreso Ibérico III Nacional de Fertirrigación, Murcia, Spain. p. 78–85.

Schijegel, A.J. 1992. Effect of composted manure on soil chemical properties and nitrogen use by grain sorghum. J. Prod. Agr. 5:153–157.

Spiers, T.M. and G. Fietje. 2000. Green waste compost as a component in soilless growing media. Compost Sci. Util. 8:19–23.

Stafne, E.T. and B.L. Carroll. 2008. Pot production of pecan seedlings with ‘Cynthiana’ grape pomace. J. Food Agr. Environ. 6:89–91.

Tenga, A.Z., A.M. Beverly, and D.P. Ormrod. 1989. Leaf greenness meter to assess ozone injury to tomato leaves. HortScience 24:514 (abstr.).

Walter, I., F. Martinez, and V. Cala. 2006. Heavy metal speciation and phytotoxic effects of three representative sewage sludges for agricultural uses. Environ. Pollut. 139:507–514.

Warman, P.R. 1986. The effect of fertilizer, chicken manure and dairy manure on Timothy yield, tissue composition and soil fertility. Agr. Wastes 18:289–298.

Westerman, P.W. and J.R. Bicudo. 2005. Management considerations for organic waste use in agriculture. Bioresour. Technol. 96:215–221.

Woodbury, I.L. 1992. Applying composts to crops. Biocycle 32:70–72.

Yukiko, I., K. Yasuoand, and T. Minoru. 2001. Effects of phenolic compounds on seed germination of shirakamba birch, *Betula platyphylla* var. *japonica*. Eurasian J. For. Res. 2:17–25.

Zucconi, F., A. Pera, M. Forte, and M. de Bertolli. 1981. Evaluating toxicity of immature compost. Biocycle 22:54–57.