Spent Tea Grinds as a Substrate Component in Nursery Crop Production[1]

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Abstract

In the United States commercial, ready-to-drink tea production has increased dramatically during the past 20 years, leading to an increased amount of waste. Spent tea grinds (STG) is the finely ground waste product of the tea brewing process that possesses some physical properties similar to peat moss (PM), making it a potential replacement for common substrate components such as pine bark (PB) and PM. 'Tuscarora' crapemyrtle (*Lagerstroemia indica* L. 'Tuscarora'), 'Chang's Ruby' loropetalum (*Loropetalum chinense* Oliv. 'Chang's Ruby'), 'Fire Power' nandina (*Nandina domestica* Thunb. 'Fire Power'), and 'Macrantha Pink' azalea (*Rhododendron indicum* L. and Sweet 'Macrantha Pink') were grown in containers filled with five substrates composed of PB, STG, or a combination thereof. Substrate pH remained within an acceptable range throughout the study. Substrate electrical conductivity (EC) values were within an acceptable range at the beginning of the study, but fell below an acceptable range in substrates containing 50% or greater (by vol) STG by the end of the study. For all four species, plant growth in substrates containing up to 50% by volume STG was similar to those grown in 100% PB. Estimated leaf chlorophyll content (SPAD) of crapemyrtle, loropetalum, and azalea was the same for all treatments at the end of the experimental period.

Index words: food waste, potting soil, media, *Camellia sinensis*, substrate blends.

Significance to the Nursery Industry

Pine bark (PB) and peat moss (PM) are major substrate components used for production of container-grown plants in the southeastern United States. High costs of PM along with a questionable future supply of PB have spawned recent research investigating possible alternative substrate components. The commercial tea production industry in the United States, which has grown tremendously over the past twenty years (15), has increased output of not only its product but also its waste material. This waste material, called spent tea grinds (STG), is most often dumped into landfills at the tea brewing company's expense, a practice that is neither environmentally nor economically sustainable. STG was investigated for its suitability as a container substrate component when used alone, and in conjunction with PB, in the production of four popular woody ornamental species. Plant growth in substrates containing up to 50% (by vol) STG was similar to those grown in 100% PB for all four species. At the end of the study, estimated leaf chlorophyll content was similar in all species grown in substrates containing up to 75% STG by volume. Plant growth in substrates containing up to 50% (by vol) STG was similar to those grown in 100% PB for all four species. At the end of the study, estimated leaf chlorophyll content was similar in all species grown in substrates containing up to 75% STG by volume.

Introduction

In the southeastern United States, pine bark (PB) is the major substrate component used in the nursery industry for production of container-grown plants. Future availability of PB for horticulture production is predictably low (13). Peat moss (PM) is another widely used substrate component and is typically the most expensive (2). These factors have encouraged a search for alternative substrate components. Spiers and Fietje (16) reported that composted green materials were beneficial to plant growth when replacing a fraction of a typical PB substrate. Many studies have shown that marketable plants can be grown in several types of substrates containing different components (4, 6, 8, 11, 14). Furthermore, Hernandez-Apaolaza et al. (10) reported that waste materials, including coconut coir and sewage sludge, can be reused in substrate blends to produce marketable plants.

Most tea consumed worldwide is brewed with leaves from *Camellia sinensis* (9). Over the past twenty years, market development for refrigerated, ready-to-use tea has grown exponentially in the United States (15). Tea brewers are faced with disposal problems of their waste materials. These materials are most often dumped into landfills at the tea brewer's expense.

As in many other rapidly developing industries, domestic tea brewers' attention has focused on production with little regard for recapture of their byproducts. However, costly and inconvenient disposal of this byproduct has prompted tea brewers to search for a suitable avenue for its recapture or reuse. Finding an alternative use for this byproduct may alleviate unnecessary costs for the tea brewers while also leading to a more environmentally sustainable waste reduction practice.

Spent tea grinds (STG) is a term used to describe the waste product of the tea-brewing process. STG contains finely ground tea leaves that have a high water holding capacity and peat-like structure, offering its potential to replace a portion of the PB fractions of container-production substrates.

Materials and Methods

On May 18, 2007, crapemyrtle, loropetalum, dwarf nandina, and azalea were potted from 3.2 liter containers (1 gal) filled with 6:1 PB:sand (by vol) into 10.6 liter (3 gal) containers filled with five substrates (100% PB, 75:25 PB:STG, 50:50 PB:STG, 25:75 PB:STG, or 100% STG by vol). All treatments were pre-plant incorporated with 9.9 kg·m^{-3} (16.7 lb·yd^{-3}) of 18N-2.6P-9.9K (18-6-12 Polyon® NPK; 8–9

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month release; Agrium Advanced Technologies, Sylacauga, AL), 0.9 kg·m^{-3} (1.5 lbs·yd^{-3}) Micromax® (The Scotts Company, Marysville, OH), and 3.0 kg·m^{-3} (5 lbs·yd^{-3}) dolomitic limestone. All plants were placed outside and were irrigated with 1 cm (0.4 in) water daily. Substrate physical properties, including total porosity, air space, container capacity, and bulk density were determined using the NCSU Porometer (7). Particle size distribution (PSD) of substrates was determined by passing a 100-g air-dried sample through a series of sieves with the following opening sizes: 12.5, 9.5, 6.35, 3.35, 2.36, 2.0, 1.4, 1.0, 0.5, 0.25, and 0.11 mm. Particles that passed the 0.11 mm sieve were collected in a pan. Sieves were shaken for 3 minutes with a Ro-Tap (Ro-Tap RX-29, W.S. Tyler, Mentor, OH) sieve shaker (278 oscillations·min^{-1}; 159 taps·min^{-1}). Substrate solution for pH and EC measurement was extracted using the Virginia Tech pour-thru nutrient extraction method (17) at 28, 60, 91, 126, and 168 days after potting (DAP). Growth indices [(height + widest width + perpendicular width) / 3] were measured at 1 DAP and 168 DAP. Chlorophyll content was estimated using the SPAD-502 Chlorophyll Meter (Konica Minolta Sensing Inc., Osaka, Japan) at 28, 60, 91, 126, and 168 DAP. Plants were arranged by species in a randomized complete block containing five single plant replications. Data were subjected to analysis of variance (ANOVA) in SAS and means were separated using Tukey's Studentized Range Test (α = 0.05).

Results and Discussion

Physical properties. According to Yeager et al. (18), a substrate used for nursery production should possess the following properties after irrigation and drainage (% volume basis): a total porosity of 50 to 85%, air space of 10 to 30%, water holding capacity of 45 to 65%, and a bulk density of 0.19 to 0.70 g·cm^{-3}. Total porosity for all substrates fell into the recommended range of 50–80% (Table 1). Container capacity was below the recommended range (45 to 65%) for the 100% PB substrate (36.5%) and above the recommended range for the 100% STG substrate (68.7%). Inversely, air space was above the recommended range (10 to 30%) for the 100% PB substrate (36.9%) and low for the 100% STG substrate (9.6%). Substrate bulk densities were slightly below the recommended range (0.19 to 0.70 g·cm^{-3}) for substrates containing 50% or more STG. However, since these substrates possessed high container capacities, blow over from wind was not encountered.

The 100% PB substrate contained a higher percentage of coarse (> 3.35 mm) particles than substrates composed of 50% or more (by vol) STG (Table 1). Since coarse particles increase air space of a substrate, 100% PB had higher air space (36.9%) and lower container capacity (36.5%) percentages than any substrate containing STG. As the percentage of STG contained in the substrate increased, air space percentages decreased and container capacities increased. Medium textured particle percentages were not different for substrates containing up to 75% (by vol) STG. 100% STG contained the lowest percentages of coarse (> 3.35 mm) and medium textured (< 3.35 – > 1.00 mm) particles while having the highest percentage of fine (< 1.00 mm) textured particles corresponding to its high container capacity (68.8%) and low air space (9.6%) percentage.

Table 1. Particle size analysis and physical properties of various substrates.

U.S standard sieve no.	Sieve opening (mm)		Substrate[z]				
			100% PB	75:25 PB:STG	50:50 PB:STG	25:75 PB:STG	100% STG
1/2	12.50		0.00a[yx]	0.00a	0.00a	0.34a	0.00a
3/8	9.50		0.00a	0.00a	0.00a	0.39a	0.00a
1/4	6.35		9.37a	5.09b	4.98bc	1.98cd	0.00d
6	3.35		23.90a	19.60ab	15.20bc	10.20c	0.00d
8	2.36		12.10a	11.10a	8.21b	6.97b	0.00c
10	2.00		4.59a	4.31ab	3.44ab	3.06b	0.00c
14	1.40		11.20a	10.50ab	8.13c	9.64b	0.00d
18	1.00		8.97c	9.30c	9.86bc	13.20b	21.90a
35	0.50		13.30c	17.90c	27.80b	34.10b	44.90a
60	0.25		7.68c	13.00bc	18.20b	17.30b	28.00a
140	0.11		4.40ab	6.01a	3.57ab	2.59b	4.39ab
270	0.05		1.99a	1.62ab	0.37ab	0.18b	0.50ab
pan	0.00		2.35a	1.46b	0.19c	0.16c	0.16c
Texture[w]							
Coarse			33.30a	24.80ab	20.30bc	12.90c	0.00d
Medium			36.90a	35.20a	29.60ab	32.90ab	21.90c
Fine			29.80d	39.90cd	50.00bc	54.20b	78.10a
Physical Property[v]		RR[u]					
Air space		10–30	36.90a	27.60b	18.80c	12.80d	9.60e
Container capacity		45–65	36.50e	47.70d	58.30c	64.70b	68.80a
Total porosity		50–85	73.50c	75.40bc	77.10ab	77.40ab	78.30a
Bulk density (g·cm^{-3})		0.19–0.70	0.19a	0.19a	0.18a	0.18a	0.18a

[z]Substrates were PB = pine bark; STG = spent tea grinds.

[y]Percent weight (g) of samples collected on each screen.

[x]Values in row followed by different letters are significant according to Tukey's Studentized Range Test (α = 0.05).

[w]Coarse = > 3.35 mm; medium = (< 3.35 mm – > 1.00 mm); fine = < 1.00 mm. Reported values in grams.

[v]All physical properties determined using the North Carolina State University porometer.

[u]RR = recommended range (percentage) reported by Yeager et al., 2007. Best Management Practices for Producing Container-Grown Plants.

Table 2. Substrate pH and EC measurements in *Loropetalum chinense* 'Chang's Ruby'.

Substrate[z]	pH		EC (mS·cm^{-1})[y]	
	28 DAP[x]	168 DAP	28 DAP	168 DAP
100% PB	5.93a[w]	5.32c	0.42b	0.53a
75:25 PB:STG	5.39a	5.64bc	0.45b	0.47a
50:50 PB:STG	5.53a	5.79abc	0.81ab	0.37b
25:75 PB:STG	5.17a	6.38a	1.22a	0.27c
100% STG	5.33a	6.25ab	1.00a	0.17d

[z]Substrates were PB = pine bark; STG = spent tea grinds.

[y]mS·cm^{-1} = milliSiemens per centimeter.

[x]DAP = days after potting.

[w]Values in column followed by different letters are significant according to Tukey's Studentized Range Test (α = 0.05).

pH and EC. Substrate pH was the same for all treatments at 28 DAP (Table 2). Substrate pH measurements remained within an acceptable range of 5.0 to 6.0 (18) for substrates containing 50% or less (by vol) STG throughout the study, but rose slightly above this level by 168 DAP for substrates containing 75% or more (by vol) STG. Substrates containing 75% or more STG had higher substrate EC values at 28 DAP than substrates containing 25% or less (by vol) STG, while substrates containing 50% or more (by vol) STG had substrate EC values above a recommended range of 0.2 to 0.5 milliSiemens·cm^{-1} (18). At 168 DAP substrate EC values were highest for 100% PB and 75:25 PB:STG, but were within an acceptable range for all substrates containing 75% or less (by vol) STG. Exceedingly high or low substrate pH and high electrical conductivity (EC) levels are often encountered when using waste materials as substrate components. Substrate pH levels as high as 7.3 and EC levels above 2.0 mS·cm^{-1} were reported for a substrate containing 40% (by vol) green waste compost (16). High substrate pH levels (7.7 to 8.9) were also reported for substrates containing green waste composts, composted wood chips, municipal waste compost, and rubber tire chips (12). Substrate pH values between 6.8 and 7.1 and substrate EC values between 4.1 and 7.6 mS·cm^{-1} were reported when the substrate consisted of 15% or more (by vol) paper mill sludge (3). Exceedingly high substrate pH and EC values were not encountered in this study.

Crapemyrtle. At 28 DAP estimated leaf chlorophyll content (SPAD) was lowest for crapemyrtles grown in 100% STG, while no differences existed in crapemyrtles grown

Table 3. Effects of various substrates on *Lagerstroemia indica* 'Tuscarora', *Loropetalum chinense* 'Chang's Ruby', *Nandina domestica* 'Fire Power', and *Rhododendron indicum* 'Macrantha Pink'.

Substrate[z]	SPAD[y]					GI[x] (cm)
	28 DAP[w]	60 DAP	91 DAP	126 DAP	168 DAP	168 DAP
'Tuscarora' crapemyrtle						
100% PB	73.7a[v]	76.0[NS]	79.9[NS]	58.6[NS]	—[u]	56.9ab
75:25 PB:STG	77.7a	70.3	79.9	62.9	—	54.1ab
50:50 PB:STG	73.5a	65.7	80.8	68.6	—	62.0a
25:75 PB:STG	71.4a	65.3	75.6	66.8	—	49.9ab
100% STG	62.4b	71.0	70.7	61.6	—	40.8b
'Chang's Ruby' loropetalum						
100% PB	44.7[NS]	56.4a	55.5ab	51.8[NS]	47.4[NS]	73.4ab
75:25 PB:STG	43.5	57.2a	60.0a	50.9	47.5	73.9ab
50:50 PB:STG	42.3	58.8a	53.1ab	53.2	51.8	79.3a
25:75 PB:STG	45.3	50.3a	54.4ab	48.3	47.8	56.2b
100% STG	38.7	36.6b	50.1b	43.8	45.9	56.6b
'Fire Power' nandina						
100% PB	32.3[NS]	44.2a	40.7a	40.5a	39.9a	25.6a
75:25 PB:STG	25.9	38.0ab	42.9a	40.3a	37.8ab	29.7a
50:50 PB:STG	22.9	36.3ab	44.2a	40.8a	41.3a	24.9a
25:75 PB:STG	28.7	39.4ab	39.4ab	34.9ab	35.3ab	21.1ab
100% STG	24.2	30.6b	29.3b	29.9b	29.9b	8.9b
'Micrantha Pink' azalea						
100% PB	42.3[NS]	45.9[NS]	48.8[NS]	54.7[NS]	51.8[NS]	12.1ab
75:25 PB:STG	40.2	47.3	53.1	53.8	53.3	11.9ab
50:50 PB:STG	39.2	45.4	50.4	51.9	49.2	12.8a
25:75 PB:STG	36.8	43.7	50.3	52.7	53.6	11.6ab
100% STG	35.0	35.8	46.9	48.2	51.3	7.9b

[z]Substrates are: PB = pine bark; STG = spent tea grinds.

[y]Leaf chlorophyll content was estimated using a SPAD-502 Chlorophyll Meter (Konica Minolta Sensing, Inc., Osaka, Japan).

[x]Growth Index = [(height + widest width + perpendicular width) / 3].

[w]DAP = days after potting.

[v]Values in column followed by different letters are significant according to Tukey's Studentized Range Test (α = 0.05); [NS] = column not significant.

[u]Leaf chlorophyll content not estimated due to leaf fall color.

in substrates containing 75% or less (by vol) STG (Table 3). From 60 DAP to 168 DAP no differences in mean SPAD existed.

Growth index (GI) of crapemyrtle was higher for plants grown in 50:50 PB:STG than for those grown in 100% STG. Mean GI was similar for crapemyrtles grown in substrates containing 75% or less STG at 168 DAP.

Loropetalum. With the exception of 100% STG at both 60 and 91 DAP, there were no differences in SPAD values.

At 168 DAP loropetalum grown in 50:50 PB:STG had a higher mean GI than those grown in substrates containing 75% or more (by vol) STG. Loropetalum grown in substrates containing 50% or less STG were similar in size.

Nandina. SPAD values were the same at 28 DAP (Table 3). However, at 60 DAP, nandina grown in 100% STG had a lower mean SPAD than those grown in 100% PB. At 91 DAP and 126 DAP, SPAD values for treatments containing 50% or less STG were higher than those grown in 100% STG. At 168 DAP, SPAD values for 100% PB and 50:50 PB:STG were higher than those for 100% STG.

Nandina with the highest mean GI were grown in substrates containing 75% or less STG (Table 3). Nandina grown in the treatment containing 100% STG had a lower mean GI than those grown in substrates containing 50% or less STG.

Azalea. All SPAD values were the same for all recorded dates (Table 3). Azaleas grown in 100% STG were smaller than plants grown in 50:50 PB:STG, but were similar in size to those grown in other treatments (Table 3).

Plant growth results from this study are consistent with previous container production studies focused on PB substitutes. Jackson et al. (11) reported similar or greater growth of nandina (*Nandina domestica* 'Fire Power') azalea (*Rhododendron indicum* 'Midnight Flare' and *R. indicum* 'Renee Mitchell'), and boxwood (*Buxus microphylla* 'Winter Gem') grown in substrates containing up to 64% (by vol) cotton gin compost compared to those grown in 6:1 PB:sand (by vol). Similarly, Beeson (1) reported superior growth of azalea (*Rhododendron indicum* 'Duc du Rohan') and variegated pittosporum (*Pittosporum tobira* 'Variegata') in substrates containing 4:5:1 (by vol) composted yard waste:PB:sand. Craig and Cole (5) reported similar growth of spirea (*Spiraea japonica* 'Froebelii') grown in substrates containing up to 50% by volume recycled paper when combined with PB. As the percentage of recycled paper increased to 75% or greater (by vol), plant growth was decreased. Another study, conducted by Chong and Cline (3), reported that up to 30% (by vol) raw paper mill sludge, when combined with PB, produced plants of similar size to those grown in 100% PB.

In this study, plant growth in substrates containing up to 50% (by vol) STG was similar to those grown in 100% PB for all four species. At the end of the study, estimated leaf chlorophyll content was similar in all species grown in substrates containing up to 75% STG by volume. These results indicate that STG could be used to replace up to 50% (by vol) of a PB substrate for container production of crapemyrtle, loropetalum, nandina, and azalea.

Literature Cited

1. Beeson, R.C., Jr. 1996. Composted yard waste as a component of container substrates. J. Environ. Hort. 14:115–121.

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

3. Chong, C. and R.A. Cline. 1993. Response of four ornamental shrubs to container substrate amended with two sources of raw paper mill sludge. HortScience 28:807–809.

4. Cole, D.M., J.L. Sibley, E.K. Blythe, D.J. Eakes, and K.M. Tilt. 2005. Effect of cotton gin compost on substrate properties and growth of azalea under differing irrigation regimes in a greenhouse setting. HortTechnology 15:145–148.

5. Craig, P.B. and J.C. Cole. 2000. Recycled paper as a growth substrate for container spirea production. HortScience 35:1253–1257.

6. Fain, G.B., C.H. Gilliam, J.L. Sibley, C.R. Boyer, and A.L. Witcher. 2008. WholeTree substrate and fertilizer rate in production of greenhouse-grown petunia and marigold. HortScience 43:700–705.

7. Fonteno, W.C., C.T. Hardin, and J.P. Brewster. 1995. Procedures for determining physical properties of horticultural substrates using the NCSU Porometer. Horticultural Substrates Laboratory. North Carolina State University.

8. Garcia-Gomez A., M.P. Bernal, and A. Roig. 2002. Growth of ornamental plants in two composts prepared from agroindustrial wastes. Bio Tech. 83:81–87.

9. Harler, C.R. 1966. Tea Growing. Oxford University Press.

10. Hernandez-Apaolaza, L., A.M. Gasco, J.M. Gasco, and F. Guerroro. 2005. Reuse of waste materials as growing media for ornamental plants. Bioresource Tech. 96:125–131.

11. Jackson, B.E., A.N. Wright, D.M. Cole, and J.L. Sibley. 2005. Cotton gin compost as a substrate component in container production of nursery crops. J. Environ. Hort. 23:118–122.

12. Jarvis, B.R., J.B. Calkins, and B.T. Swanson. 1996. Compost and rubber tire chips as peat substitutes in nursery container media: effects on chemical and physical media properties. J. Environ. Hort. 14:122–129.

13. Lu, W., J.L. Sibley, C.H. Gilliam, J.S. Bannon, and Y. Zhang. 2006. Estimation of U.S. bark generation and implications for horticultural industries. J. Environ. Hort. 24:29–34.

14. Sibley, J.L., C.H. Gilliam, W.G. Foshee, III, A.N. Wright, and G.B. Fain. 2005. Development of nursery crop substrates from recycled materials and composted poultry litter. Proc. Southern Nurseryman's Assoc. Res. Conf. 50:127–130.

15. Simarny, J.P., 2007. The state of the U.S. tea industry. Tea Association of the U.S.A., Inc. Accessed April 12, 2010. http://www.teausa.com/general/002ga.cfm

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

17. Wright, R.D. 1986. The pour-thru nutrient extraction procedure. HortScience 21:227–229.

18. Yeager, T.H., T. Bilderback, D. Fare, C. Gilliam, J. Lea-Cox, A. Niemiera, J. Ruter, K. Tilt, S. Warren, T. Whitwell, and R. Wright. 2007. Best Management Practices: Guide for Producing Nursery Crops 2nd ed. The Southern Nursery Association. Atlanta, GA.