Suitability of Composted Bluegrass Residues as an Amendment in Container Media

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Abstract. Postharvest plant residues from Kentucky bluegrass (*Poa pratensis* L.) seed production may be useful as an organic amendment in container mixes. Postharvest residues of 'South Dakota' bluegrass were composted with and without an N amendment, such as cattle manure (M) or alfalfa seed screenings (As). After composting, all residues were ground to 4- to 6-mm segments and mixed with sphagnum peat and perlite (2:1:1 by volume). Media that contained amended bluegrass residues had higher electrical conductivity (EC) values and lower C : N ratios (<19:1) than media made with other bluegrass residues. Tomato (*Lycopersicon esculentum* Mill. 'Laura') seedlings grown in residue composted with As had at least 3.5- and 4-fold more shoot dry weight and leaf area, respectively, than plants grown in any other composted medium. In addition, seedlings grown in composted bluegrass residues amended with As had 34% and 41% more shoot dry weight and leaf area than plants grown in a 75% peatmoss–25% perlite medium. Composted residue amended with alfalfa seed screenings appears to be suitable as a peatmoss extender in container media.

Bluegrass seed is an important crop in northern Idaho and eastern Washington. Following seed harvest, open-field burning is commonly used to remove thatch and leaves that would otherwise block sunlight to seed-producing tillers. Although burning is an economical way to remove residues, the current practice of open-field burning may become politically unacceptable or banned as a result of the Clean Air Act of 1990 as well as local legislation. For example, rice straw burning is being phased out in California and will be completely banned by the year 2000 (Blank et al., 1993). Several straw removal processes, such as mechanical raking or "crew cutting," are being examined as alternatives to field burning, but few management strategies have been developed for disposal or use of bluegrass residues.

One management option for bluegrass residues is composting. The advantages of composting are a 50% reduction in mass and volume of residues (Chen et al., 1992); en-

hanced plant growth following incorporation of compost into soils or container mixes, provided the C : N ratio has been reduced to prevent N immobilization (Chen and Inbar, 1993); increased cation exchange capacity (Inbar et al., 1991); and destruction of weed seeds associated with the grasses (Shiralipour and McConnell, 1991). Various types of composted materials have been incorporated into greenhouse potting media as a substitute or extender for peatmoss and have enhanced plant growth (Chen et al., 1988; McConnell et al., 1991). Composted organic materials improve soil fertility by increasing soil aeration, water-holding capacity, and water infiltration, and lowering soil bulk density and surface crusting (Dick and McCoy, 1993). Mature or stabilized compost is effective in suppressing various soilborne plant diseases (Hoitink and Fahy, 1986; Schuler et al., 1989). Use of composted bluegrass residues in container mixes may represent a viable management strategy due to the decreased availability and high cost of peatmoss.

Likewise, few disposal options are available for the 2300 t of alfalfa seed screenings produced annually in Idaho alone (Todd Flick, Pioneer Hi-Bred Intl., personal communication). Historically, alfalfa seed screenings have been burned or taken to the landfills for disposal, but these management options are no longer available. Alfalfa seed screenings generated in eastern Oregon, Washington, and parts of Nevada are now transported to a composting facility in southern Idaho that has doubled the cost for screenings disposal.

The objective of this research was to determine the suitability of composted bluegrass

residues as amendments in container growth media. Physical and chemical properties of the compost-amended media were determined, and the ability of the media to support tomato plant growth was evaluated.

Materials and Methods

General procedures. Postharvest residues of *Poa pratensis* ('South Dakota') consisting of leaves, stems, thrashed panicles, seeds and empty seed heads, and chaff were composted with or without an N amendment. Some of the bluegrass residues were processed in an industrial tub grinder [BG_(tg)] before composting to investigate the effect of particle size on the final compost product, whereas some residues were composted without grinding (BG). A portion of the residues was also amended before composting. Compost amendments included fresh cattle manure (M) or alfalfa seed screenings (As) that consisted mainly of weed seeds and some alfalfa chaff. The manure was collected at a Univ. of Idaho farm, and the screenings were obtained from a commercial seed processor. Some of the bluegrass residue was not composted (raw) but was mixed with peat and perlite and then evaluated in a container medium.

Bluegrass residues were composted in 1.7-m³ laboratory reactors, except for the BG + M mixture, which was composted in a 1.8-m³ outdoor bin made of wire mesh (10-cm squares). About 50 kg of straw (air dry weight) was placed in each reactor after moisture content was adjusted to 60% to 70%. Nitrogen-containing amendments (M or As) were spread in layers between 15-cm layers of residue to yield an initial C : N ratio that ranged from 22–35:1. For the BG + M mixture, 80 kg of bluegrass residue was mixed with 91 kg of manure. After 1 week, 23 kg of residue and 54 kg of manure were added to the compost pile to return the volume to its initial level. About 6.8 kg of As was added initially to the bluegrass residue, and 1.7 kg of screenings was added three more times during the composting process to promote decomposition of the bluegrass residues. Laboratory reactors were aerated with compressed air for 1.5 min every hour. Passive air flow through the pile was used for aeration of the outdoor bin. Piles were turned periodically when temperature decreases indicated the rate of composting was slowing. The duration of the composting period was based on physical appearance and integrity of the composted residues. The compost period was from 50 days for BG + As to 137 for BG (Table 1).

Following the composting process, chemical properties of all composted substrates and potting media were analyzed by the Holm Research Laboratory at the Univ. of Idaho following standard procedures for soils and included pH (McLean, 1982); cation exchange capacity (CEC) measured at pH 7 with barium acetate (Harudu and Inoko, 1980); electrical conductivity (EC) (Rhoades, 1982); C, H, and N contents (McGeehan and Naylor, 1988); mineralizable ammonium (Keeney, 1982); available P (Olsen and Summers, 1982) and K

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Table 1. Chemical properties of raw and composted bluegrass residues compared to peatmoss.²

Property	Bluegrass					Peat-moss
	Raw	Whole	Ground	+M ³	+As	
pH	7.0	6.7	6.7	7.6	6.5	3.8
CEC cmol (+)/kg	25	30	41	43	69	123
EC (dS·m ⁻¹)	2.5	1.3	1.3	3.1	4.6	0.32
C (%)	44	45	44	31	42	43
N (%)	0.7	1.3	1.4	1.7	2.7	1.2
C : N	63:1	35:1	31:1	18:1	16:1	36:1
NH ₄ -N (μg·g ⁻¹)	28	21	144	21	535	267
NO ₃ -N (μg·g ⁻¹)	12.5	6.6	2.5	49.5	2250	23.5
NH ₄ : NO ₃	2:1	3:1	58:1	1:2	1:4	11:1
Mineralizable N (μg·g ⁻¹)	878	992	1142	1705	3147	484
P (μg·g ⁻¹)	449	284	139	938	1457	11
K (meq/100 g)	28.1	17.2	19.1	22.9	54.1	0.5
Mg (meq/100 g)	4.2	9.4	11.8	12.2	17.1	14.1
Ca (meq/100 g)	4.6	10.1	12.8	15.1	15.7	14.4
Compost period (days)	0	137	101	88	50	---

²Data based on a single analysis of each material.³M = cattle manure; As = alfalfa seed screenings.

(Knudsen et al., 1982); nitrate and ammonium (Keeney and Nelson, 1982); and extractable cations (Berg and Gardner, 1978), as obtained by extraction with ammonium acetate at pH 7.

All bluegrass residues were ground to 4- to 6-mm segments before being mixed with peatmoss and perlite. Potting media were prepared by adding the residues (raw or composted) to peatmoss and perlite (2:1:1 by volume). A medium consisting of 3 peatmoss : 1 perlite (v/v) was used as the control. Initial bulk density, aeration, water-holding capacity, and total porosity were measured on four samples of each medium (Holstead, 1983). Initial chemical properties, including pH, EC, C : N ratio, and CEC, of four samples of each medium were also determined as described above.

Maturity and suitability of the composts were assessed by using plant growth bioassays. 'Laura' tomato seeds were planted in a peatmoss-based medium (Sunshine No. 1; Sun Gro Horticulture, Bellevue, Wash.) and then transplanted 14 days later into the various potting mixes with as little medium as possible remaining on the roots. Seedlings were planted into 1.8-liter (15-cm) pots with four plants (pots) per treatment. Tomato plants were grown for 30 days in a completely randomized arrangement in a growth chamber under a 16-h photoperiod at 285 μmol·m⁻²·s⁻¹ with a 28C day/23C night cycle. Seedlings were fertilized twice a week with 300 ml of a nutrient solution containing (mg·liter⁻¹) Chem-Gro 3N-6.5P-21.6K (Hydro-Gardens, Colorado Springs, Colo.), 749; Ca(NO₃)₂, 300; MgSO₄, 142; and CaCl₂, 75. The types and concentrations of nutrients were specifically recommended for seedling-stage plants of 'Laura' tomato by the vendor (Hydro-Gardens).

After 30 days, plant growth indices were measured on tomato seedlings. Plant height and stem diameter were measured before leaves were removed from the shoots and the shoots detached from the roots. Leaf area was measured with a leaf area meter (model LI-3100; LI-COR, Lincoln, Neb.). Leaves and stems were dried for 72 h at 70C and then weighed.

Weed seed viability. Weed seeds were re-

moved from the mixture of composted BG + As after it had reached 37 or 46C to test the effect of compost temperature on seed viability. Seeds collected from the compost were placed in five covered petri dishes (69 seeds/dish) containing Whatman No. 2 filter paper moistened with distilled water, and incubated under indirect, diffuse sunlight at room temperature. Most of the weed seeds in the screenings were pigweed (*Amaranthus retroflexus* L.), which readily germinates. Seed germination was determined by counting the number of protruding radicles after 7 days.

Statistical analysis. Analysis of variance (Proc GLM; SAS Institute, Cary, N.C.) was completed for chemical and physical properties of container media and plant growth indices. Significant differences between treatment means were determined by Duncan's multiple range test at $P \leq 0.05$.

Results and Discussion

Composted substrates and potting media. Based on visual observations, nonamended BG and BG_(tg) residues appeared to change little during composting. Other than a slight darkening in color, the straw was relatively intact and retained its physical integrity. In contrast, the BG + M and BG + As residues were darker, more physically degraded, and straw in the residues could be easily pulled apart after composting.

Chemical properties of the residues composted without N amendments were different from those with amendments (Table 1). For example, composted BG and BG_(tg) had similar C : N ratios, whereas the BG + M and BG + As residues had much lower and similar ratios. In general, the BG + As and BG + M residues contained more mineralizable ammonium, P, and K than the other composted residues, raw BG, or peatmoss. The pH values of all composted residues were similar and ranged from 6.5 to 6.7 with the exception of BG + M residue, which measured almost one pH unit higher than the other composted residues.

Nitrogen content and EC of the composted

BG + As residues were substantially higher than those of other bluegrass residues, composted or raw (Table 1). The high N content (NO₃ and NH₄) was most likely due to the protein content of the weed seeds contained in the As rather than a residue of the herbicide (diquot) used to desiccate alfalfa plants before seed harvest (Todd Flick, personal communication). EC ranged from 1.3 dS·m⁻¹ in BG and BG_(tg) residues to 4.6 dS·m⁻¹ in composted bluegrass residues amended with As (Table 1). High EC of the BG + As residues can be attributed to the As added before and during composting. EC of As alone was 7.1 dS·m⁻¹; this high EC was probably a property of the weed seeds, which were finely ground for the EC measurement (Rhoades, 1982), rather than a herbicide residue (Todd Flick, personal communication).

Physical properties of the potting media made with N-amended bluegrass residues were often different than those of media made with the other bluegrass residues (Table 2). Container media amended with residues composted with M or As had the highest bulk densities. Raw, noncomposted bluegrass residue and residues composted without an N amendment had the lowest bulk densities, reflecting, in part, less degradation of the substrates. For potting media made with composted bluegrass residues, total porosity of BG and BG + M mixes were the only ones that differed significantly. This difference, however, was slightly <5% and probably had little effect on the rhizosphere in the pot. Total porosity of the peatmoss and perlite potting mix was significantly lower than expected due to difficulty in wetting the peatmoss when measuring physical properties of this mixture. Low water-holding capacity of this medium indicated that the peatmoss was not saturated to capacity when porosity was determined. Water-holding capacity of the media made with composted residues were similar, measuring between 57% and 60%, except for the medium amended with tubground residues. Air capacities of the potting media containing BG, BG + As, or 75% peatmoss were similar. Physical characteristics of potting media are more restrictive for containerized plants than for plants grown in the field and are a function of container size, shape, and substrate (Furuta, 1974). Holstead (1983) suggested that satisfactory water-holding capacities range from 55% to 65% and ideal air capacities, after drainage, range from 5% to 25%. Overall, water-holding and air capacities of bluegrass-amended media likely were satisfactory for plant growth.

Chemical properties of the potting media, as expected, were a function of the N source used as an amendment (Table 3). For example, pH of compost-amended media ranged from 5.0 for the mix made with plain bluegrass-perlite to 6.2 for the BG + M potting medium. The pH of each bluegrass-amended medium was about one unit lower than that of its corresponding bluegrass substrate (compare Tables 3 and 1), most likely due to the amount of peatmoss (25% by volume) used in the media. In general, soilless potting mixes having a pH between 5.0 to 6.5 are considered

suitable for plant growth (Davidson et al., 1988; Dick and McCoy, 1993). Therefore, the final pH of all composts likely was suitable to support growth of many plant species.

The final CEC of the composted bluegrass residues ranged from 30 to 69 cmol(+)/kg for BG and BG + As residues compared to 123 cmol(+)/kg for peatmoss (Table 1). The CEC of potting media amended with bluegrass residues again reflected the composition of the respective substrates. Media containing BG + M or BG + As composts had higher CEC than BG or BG_(tg), which were, in turn, only half that of the peatmoss-perlite mix (Table 3). In general, CEC directly relates to the ability of the soil to hold added mineral elements, which ultimately improves the potential for plant growth (Inbar et al., 1991). Plants can be grown in media having a wide CEC range; however, media having relatively high levels of CEC (50 to 100 meq-liter⁻¹) support a consistent cation supply (Handreck and Black, 1989). By converting CEC from a weight to a volume basis, as recommended by Furuta (1974), the CEC for the BG + As medium was 117 meq-liter⁻¹, slightly exceeding the recommended range for plant growth.

EC of potting media made with composted bluegrass residues varied from 0.4 dS·m⁻¹ in the media made with BG residues to 2.9 dS·m⁻¹ in the BG + As. Although EC of the BG + As-amended medium was at least double that of any other medium, the conductivity level was adequate for many species, including tomato and numerous woody plants (Davidson et al., 1988; Lorenz and Maynard, 1980). The amount of salts associated with this EC level, however, could cause problems for sensitive species (Lorenz and Maynard, 1980).

The C : N ratio of the composted residues incorporated into the container media ranged from 16 to 35 (Table 1). The nonamended composts [BG and BG_(tg)] had higher C : N ratios than N-amended residues. The C : N ratios of potting media containing residues that were amended with a N source and then composted were significantly lower than those containing nonamended, composted bluegrass residues or the peatmoss-perlite mixture (Table 3). Compost stability is particularly important when carbon-rich organic materials are used in container media since immature compost can potentially immobilize N and stunt growth (Zucconi et al., 1981). The C : N ratios of the BG + M or BG + As were low and were unlikely to immobilize N.

Suppression of weed seed germination. Compost has been used successfully in field production, in residential landscaping, and in potting media by the horticultural industry (Hoitink and Fahy, 1986; McConnell et al., 1991; Shiralipour and McConnell, 1991), but weed seed germination must be checked before compost is used. Germination of weed seeds in the BG + As-amended residues decreased when the composting reached at least 46C. An average of 6% of the composted weed seeds subjected to 37C germinated, whereas an average of only 2.0% of the weed seeds germinated if treated at 46C. High temperatures, long exposure time at those tempera-

tures, and toxins produced during composting prevent or suppress subsequent germination of various seeds (Shiralipour and McConnell, 1991).

Plant growth. Growth indices of 'Laura' tomato seedlings, grown in a medium containing BG + As residues, usually exceeded those of plants grown in all other media, including the sphagnum peat-perlite mixture (Table 4). Plant height of seedlings grown in BG + M- or BG + As-amended media and the peat-perlite mixture was similar. These seedlings, however, were at least twice the height of those grown in media made with nonamended BG residues. Stem diameter of seedlings grown in the BG + As-amended medium was double that of plants grown in any other BG-amended medium, except for the BG + M mixture. Seedlings grown in the BG + As medium also produced at least 3-fold more stem and leaf dry weight and 4-fold more leaf area than plants grown in any other BG-amended medium. In addition, seedlings grown in the BG + As mixture produced 40% more stem dry

weight and 41% more leaf area than plants grown in the peatmoss-perlite medium. Furthermore, plants grown in the BG + As-amended medium produced 1.3- and 3.4-fold more shoot biomass (sum of the stem dry weight plus leaf dry weight in Table 4) than those grown in the peat-perlite mix and any BG-amended medium, respectively (Fig. 1).

Seedlings planted in media made with raw, noncomposted bluegrass or bluegrass residues composted without the addition of an N source grew significantly less than those grown in the BG + M or BG + As-amended media (Table 4). Similar inhibitory effects of raw materials on seedling development has been noted by others (Chanyasak et al., 1983; Zucconi et al., 1981) and has been attributed to low-molecular-weight fatty acids. Chen et al. (1992) have shown that immature compost inhibits plant growth regardless of the fertilization regime used due to phytotoxicity and competition for N and O₂. Moreover, these effects are minimized only after the compost has remained at ambient temperature (cured)

Table 2. Initial physical properties of potting media amended with various substrates [2 bluegrass residue : 1 perlite : 1 peat (by volume)].

Potting medium ^z	Bulk density (g·cm ⁻³)	Total porosity (%)	Water-holding capacity (%)	Air capacity (%)
Raw bluegrass	0.121 e ^y	66.6 cd	44.9 d	21.7 a
Bluegrass (BG)	0.159 b	68.2 bc	57.5 a	10.7 e
BG _(tg) ^x	0.128 d	71.2 ab	52.8 b	18.4 b
BG + M	0.171 a	73.1 a	58.3 a	14.8 cd
BG + As	0.172 a	70.6 ab	60.0 a	10.6 e
Peat + perlite ^w	0.139 c	59.7 e	48.9 c	10.8 e

^zM = cattle manure; As = alfalfa seed screenings.

^yMean separation within columns by Duncan's multiple range test at *P* = 0.05 (*n* = 4).

^xProcessed with an industrial tub grinder.

^wPotting mix consisted of 3 peatmoss : 1 perlite (v/v).

Table 3. Initial chemical properties of potting media amended with various substrates [2 bluegrass residue : 1 perlite : 1 peat (by volume)].

Potting medium ^x	pH	EC ^z (dS·m ⁻¹)	C : N ratio	CEC ^y cmol(+)/kg
Raw bluegrass	5.0 d ^w	0.9 b	50.1 a	35.0 d
Bluegrass (BG)	5.0 d	0.5 c	34.9 b	43.0 c
BG _(tg) ^y	5.6 b	0.4 c	30.3 c	39.6 cd
BG + M	6.2 a	1.1 b	18.7 d	45.5 c
BG + As	5.5 c	2.9 a	14.5 e	68.3 b
Peat + perlite ^a	4.0 e	0.3 c	34.3 b	86.6 a

^zEC = electrical conductivity.

^yCEC = cation exchange capacity.

^xM = cattle manure; As = alfalfa seed screenings.

^wMean separation within columns by Duncan's multiple range test at *P* = 0.05 (*n* = 4).

^aProcessed with an industrial tub grinder.

^aPotting mix consisted of 3 peatmoss : 1 perlite (v/v).

Table 4. Growth indices of tomato plants grown in different potting media.

Potting medium ^z	Plant ht (cm)	Stem diam (mm)	Stem dry wt (g)	Total leaf area (cm ²)	Leaf dry wt (g)
Raw bluegrass	7.6 d ^y	3.2 f	0.05 d	22 e	0.10 d
Bluegrass (BG)	10.4 d	3.2 e	0.05 d	22 d	0.14 d
BG _(tg) ^x	15.0 c	4.0 d	0.13 d	44 d	0.28 d
BG + M	33.9 a	5.4 c	0.58 c	253 c	1.34 c
BG + As	31.6 ab	8.0 a	1.79 a	1047 a	4.80 a
Peat + perlite ^w	30.0 ab	7.5 b	1.28 b	740 b	3.67 b

^zM = cattle manure; As = alfalfa seed screenings.

^yMean separation within columns by Duncan's multiple range test at *P* = 0.05 (*n* = 4).

^xProcessed with an industrial tub grinder.

^wPotting mix consisted of 3 peatmoss : 1 perlite (v/v).

Fig. 1. Effects of potting medium on tomato shoot biomass. Potting media consisted of 2 composted bluegrass residues : 1 peatmoss : 1 perlite (by volume) except for the 75% peatmoss medium. Abbreviations are RBG=raw bluegrass residue; BG=composted bluegrass residue; BG_(tg)=composted, tubground bluegrass residue; BG + M = composted bluegrass residue and cattle manure; BG + As = composted bluegrass residue and alfalfa seed screenings; peat = medium consisting of 75% peatmoss and 25% perlite. Mean separation by Duncan's multiple range test at $P = 0.05$ ($n = 4$).

for 80 to 90 days. Composts used in these plant growth experiments remained at ambient temperature from 10 to 106 days. Two possible explanations for enhanced plant growth in the BG + As-amended medium are 1) increased levels of N, P, and K compared to other substrates (Table 1); and 2) a high initial NH_4^+ and NO_3^- level and slowly available (mineralizable) N (Table 1) during the plant growth period. Perhaps plants in the peatmoss-perlite medium would have grown as well or better than those in the BG + As-amended mix if the former medium would have initially been adjusted to pH 5.5, the level of the latter mix.

In conclusion, bluegrass residues amended with N-bearing regional waste, such as manure or alfalfa screenings, produced a compost with chemical properties suitable for plant growth. Tomato plants grown in the composted mixture of bluegrass residues and alfalfa seed screenings produced the most shoot biomass compared to those grown in other compost-amended media and in peat-perlite. Bluegrass residues composted without an N amendment significantly inhibited tomato plant growth despite the fertilization regime used and longer curing stage for the substrate. If composting temperatures are high enough to kill weed seeds, composted bluegrass residues amended with alfalfa seed screenings could be used in agronomic and horticultural crop production and land reclamation and vegetation establishment. Our data indicate that BG + As can be

used as a peatmoss extender in container media, making it suitable as an amendment in potting mixes.

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