SOIL AMENDMENTS FOR ROADSIDE VEGETATION IN VIRGINIA

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INTRODUCTION

The establishment and maintenance of roadside wildflowers and vegetative cover crops are dependent on both the inherent productivity of roadside soils and management practices. Roadside soils are almost always highly disturbed relics of the road construction process and vary significantly from soils that have formed in place. In particular, roadside soils are generally compacted, high in soil strength, acidic, and low in organic matter and plant-available nutrients.

The combined influence of adverse soil properties and soil variability in roadside soils has led to irregularities in wildflower growth and bloom display and, in certain instances, to complete stand failures in field trials (Bill Watson and Roger Dove, personal communication). Management practices such as tillage, liming, and fertilization have mitigated these problems to only a limited extent. Land reclamation studies have proven that a lack of organic matter and organically bound nutrients are the primary properties that differentiate disturbed soils such as roadside soils from their natural counterparts (Daniels and Haering, 1994; Haering et al., 2000).

Numerous studies have demonstrated that composts produced from a wide variety of organic materials such as biosolids (sewage sludge), animal manure, and yard wastes can improve soil physical, chemical, and biological properties (Shiralipour, et al., 1992; Brosius, et al., 1998). The use of organic amendments can reduce or eliminate the need for periodic conventional fertilization and is typically less costly. Finally, and perhaps most importantly, organic amendments can ameliorate local irregularities in surface soil properties. In Virginia, many potentially useful organic amendments are available in each of the Virginia Department's of Transportation (VDOT) Districts, and regulatory guidance and financial incentives promote the utilization of these amendments. The objectives of this study are to determine the effects of application of various composts on the growth and quality of roadside vegetation and soil properties that influence vegetation sustainability.

MATERIALS AND METHODS

In August 1998, two nearly level sites were selected in Culpeper and Staunton, Virginia. The Culpeper soil has a clay loam texture and is located near an exit ramp off Hwy 29 in Culpeper County in the Northern Piedmont soil physiographic region. The Staunton soil also has a clay loam texture and is located in the median of I-81 in Augusta County of the Appalachian Ridge and Valleys soil physiographic region.

Initial soil chemical properties (Table 1) were determined using established procedures for southern U.S. soils (Donohue, 1992). Soil pH, Ca and Mg were adequate for establishment of vegetation because the soils had previously been limed by VDOT staff. Soils at both sites contained lower concentrations of P than optimum for pant growth. Soil K concentration was adequate at Culpeper but lower than necessary for optimum plant growth at Staunton.

Table 1. Analysis of the soils used in the study.

Location	PH	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Soluble Salts (ppm)
Culpeper	5.8	8	101	816	120	141
Staunton	6.1	10	25	840	117	90

The study is a two-factor experiment consisting of three plant species and six soil treatments. Plant species were lanceleaf coreopsis (*Coreopsis lanceolata*), corn poppy (*Papaver rhoeas*) and tall fescue (*Festuca arundinaceae*). The soil treatments were composts from four sources, an NPK fertilizer applied according to soil test results, and an unamended control. The composts were produced from: 1) biosolids + wood chips, 2) yard waste + poultry litter, 3) paper mill sludge, and 4) cotton gin trash. The source of each amendment is listed in Table 2. Each treatment was replicated 4x. The experimental designs were a randomized complete block at Culpeper and a completely randomized block at Staunton. Individual plots were 100 ft^2.

Table 2. Sources of amendments applied in Culpeper and Staunton in August 1998.

Treatment or Amendment	Source
Biosolids compost (BC)	Harrisonburg-Rockingham Regional Sewage Authority, Mount Crawford
Yard waste compost (YWC)	Panorama Farms, Earleysville
Paper mill sludge compost (PMSC)	Greif Bros., Amherst
Cotton gin trash compost (CGTC)	Commonwealth Gin, Windsor

The existing vegetation was sprayed with glyphosate (2 gal/acre) two weeks prior to seeding. The sites were then roto-tilled six to eight inches deep. The amendments were incorporated into the top three to four inches of soil on 8/26/98 at Culpeper and 8/28/98 at Staunton. The composition of each amendment is presented in Table 3.

Table 3. Analyses of soil amendments used in the study.

Compost	Solids (%)	Org C (%)	C:N	TKN* (%)	Org N (%)	NH_4-N (%)	P (%)	K (%)	EC** (dS/m)	pH
BC	70	37.8	9.6	3.95	3.14	0.81	2.9	0.25	10.74	6.8
YWC	32	30.3	16.0	1.89	1.88	0.02	0.6	0.65	1.48	7.6
PMSC	58	37.8	22.8	1.66	1.66	0.01	0.6	0.44	1.78	7.4

CGTC	58	23.0	10.5	2.20	2.19	0.01	0.2	0.97	1.50	7.9

*TKN = Total Kjeldahl Nitrogen
** EC = Electrical Conductivity (dS/m = mmhos/cm)

Amendments were applied at rates designed to supply 45 lbs/acre of first year plant available N (PAN), which is the estimated annual N requirement of wildflowers. Tall fescue N needs are higher than wildflowers, but the same rates were applied to all plants to provide consistent compost rates. The equation used to estimate PAN from the various organic amendments was:

PAN = (X * Org-N) + (NH_4-N),
where:
PAN = lbs of plant available nitrogen per dry ton of amendment,
Org-N = lbs of organic nitrogen per dry ton of amendment, determined as TKN - NH_4-N,
NH_4-N = lbs of (ammonia + ammonium) nitrogen per dry ton of amendment, and
X = estimated availability coefficient for organic N (x=0.10 for compost).

Nutrient application rates were estimated based on the actual composition of the composts (Table 4). Phosphorus and K rates were variable because the N:P and N:K ratios in the composts were different. Wildflower P and K needs are not known, but establishment of tall fescue required 140 lbs P_2O_5/acre at both sites and 160 and 75 lbs K_2O/acre at Staunton and Culpeper, respectively.

Table 4. Applied plant available nutrients for the first year.

Treatment	Amendment Rate	Estimated Plant Available Nutrients (lbs/acre)		
		Total N	P_2O_5	K_2O
BC	3 tons/acre (fresh wt)	47	280	12
YWC	33 tons/acre (fresh wt)	44	292	164
PMSC	22 tons/acre (fresh wt)	45	352	134
CGTC	13 tons/acre (fresh wt)	34	69	175
15-30-15	300 lbs/acre	45	90	45
Control	Not amended			

The three species selected have different characteristics. Corn poppy is a biennial that is seeded each year in the fall, coreopsis is a perennial that often takes two years to become fully established, and tall fescue is a perennial grass that is most widely planted along Virginia roadsides. Corn poppy and fescue have higher N demands than coreopsis. Corn poppy and coreopsis were expected to be more sensitive to phytotoxicity produced by immature compost than fescue. Seeding rates were 20 lbs/acre of coreopsis, 18 lbs/acre of corn poppy, and 100 lbs/acre of tall fescue. The plots were rolled after seeding to increase seed-soil contact.

Weeds were controlled with periodic use of 2,4-D (1.4 gal/acre), imazapic (4 oz/acre), and pendimethalin (1 gal/acre). In June 1999, vegetation at both sites was mowed to eight inches to control weeds. At this time, the corn poppy had senesced, the tall fescue seed heads had fully expanded, and the coreopsis was not yet tall enough to be damaged by mowing. The corn poppy was replanted in early September 1999 after the plots were sprayed with glyphosate and imazapic and roto-tilled to three inches. The plots were again rolled after seeding.

The performance of the vegetation is being evaluated until at least spring, 2001 (2-1/2 years). A visual rating system that is frequently employed by turfgrass researchers is used each spring to measure living plant ground coverage density. Soil was sampled in each plot to a depth of 3-4 inches 18 months after soil amendments were applied (March 2000) for determination of pH; Bray 1 P; cation exchange capacity; exchangeable Ca, Mg, K, and acidity; and base saturation.

RESULTS AND DISCUSSION

Compost

There was considerable variation in the nitrogen concentration of the composts, with the biosolids compost (BC) containing about double the N concentration of the others (Table 3). The BC had a low C:N ratio and a high proportion (i.e., >20%) of N in the NH_4 form, indicating that the compost was not completely stabilized at the time of application. The BC also contained (not unexpectedly) a higher concentration of P and a lower of concentration of K than the other composts. The P and K concentrations in the yard waste (YWC) and cotton gin trash (CGTC) composts were typical for composts derived from such feedstocks (Brosius et al., 1998). The paper mill sludge compost (PMSC) also contained concentrations of P and K that were consistent with published values, but the total N concentration of the PMSC used in our study was considerably higher than typical values (Campbell et al., 1995; Jackson and Line, 1997). Our PMSC was produced from a combined primary and secondary sludge that had received additions of NH_4OH during the digestion process to stimulate microbial decomposition (Evanylo and Daniels, 1999). This resulted in a higher initial C:N ratio of the sludge (40:1) than is normally associated with paper mill sludge.

Corn poppy

Eight months after seeding (May 1999), the stand density of the corn poppy at Culpeper increased in the order: control# CGTC# YWC# BC=PMSC=Fertilizer (Figure 1). There were no treatment differences at Staunton at this time. There were no differences in corn poppy density with soil amendment treatments at either site by the following spring (March 2000), when ground coverage averaged 62% at Culpeper and 71% at Staunton.

Coreopsis

None of the amendments increased coreopsis density above the control at Culpeper or Staunton seven months after seeding (April 1999; Figure 2). Coreopsis density averaged 39% at Culpeper and 55% at Staunton. Coreopsis density was decreased by the BC at Culpeper 18 months after seeding (March

2000), but no differences in density among amendments were observed at Staunton, where density averaged 65% across all treatments.

Tall fescue

Only the application of the composted yard waste at Culpeper increased the density of tall fescue above the control at either site in April 1999 (Figure 3). None of the treatments increased tall

fescue density above the control at either site by March 2000, but tall fescue density in the CGTC treatment was lower than the control at Staunton.

Soil Properties

At both locations, the greatest increases in soil extractable P concentration were effected by yard waste and biosolids composts (Table 5, 6), which each supplied nearly 300 lbs P_2O_5 per acre (Table 4). Surprisingly, the paper mill sludge compost, which supplied the greatest amount of total P (352 lbs P_2O_5 per acre), did not raise soil P concentration above that of the control, fertilizer, or CGTC treatments. The P in the PMSC was apparently not readily extractable. Composts had little effect on soil pH, which were already adequate, but soil pH tended to be higher with the PMSC and YWC than with the control and/or fertilizer treatments at both locations (Table 5, 6). This was likely due to the higher base saturation and lower exchangeable acidity with PMSC and YWC than with the control and fertilizer treatments. PMSC increased the soil Ca% above the control and fertilizer treatment at both locations. At Culpeper, the YWC-amended soil also contained higher Ca% than the control and fertilizer-amended soil. No compost treatments increased K% or Mg% above the control or fertilizer treatments at either location. Only the YWC increased soil cation exchange capacity at either site. The lower C:N ratios of the BC and the CGTC than of the PMSC and YWC may have resulted in greater N mineralization and subsequent acid-creating nitrification in the BC and CGTC soils, which may have reduced the liming effectiveness of the organic matter in the BC and CGTC.

Table 5. Effects of amendments on properties of soil sampled at Culpeper in March 2000 and averaged across species. Means for all treatments followed by the same letter are not significantly different at the 5% level according to Student, Newman and Kuels test.

Treatment	P (ppm)	pH	CEC	% K	% Mg	% Ca	% EA	% Base saturation
BC	23.6b	6.0b	9.1b	5.9	16.2ab	63.0bc	14.8a	85.2b
YWC	34.0a	6.3a	11.5a	6.7	18.0a	65.6b	9.6b	90.4a
PMSC	13.8c	6.4a	9.9b	4.9	15.8b	71.2a	8.0b	91.9a
CGTC	14.5c	6.1b	9.3b	6.9	18.2a	61.0c	13.8a	86.1b
Fertilizer	15.6c	6.0b	9.0b	6.1	16.9ab	61.4c	15.4a	84.5b
Control	11.4c	6.0b	9.1b	5.8	17.1ab	62.0c	14.5a	85.2b

Table 6. Effects of amendments on properties of soil sampled at Staunton in March 2000 and averaged across species. Means for all treatments followed by the same letter are not significantly different at the 5% level according to Student, Newman and Kuels test.

Treatment	P (ppm)	pH	CEC	% K	% Mg	% Ca	% H	% Base Saturation
BC	40.2ab	6.1ab	9.7b	1.8	14.8	70.4b	12.9ab	87.1
YWC	46.0a	6.3ab	11.5a	5.4	16.1	70.0b	11.2ab	91.6
PMSC	21.8c	6.4a	9.9b	1.8	14.4	75.1a	8.7b	91.3
CGTC	27.1bc	6.1ab	9.5b	2.7	15.2	68.9b	13.0ab	86.9
Fertilizer	27.8bc	6.1b	8.7b	2.6	14.	67.9b	14.6a	85.4
Control	21.1c	6.2ab	9.3b	1.9	15.4	70.4b	12.3ab	87.7

CONCLUSIONS

Compost is valuable for restoring productivity of disturbed soils because it improves nutrient availability, water-holding capacity, and soil structure. Plant density data obtained during the initial 1-1/2 years of this study was affected by drought, which may have masked specific effects of the various composts. Each plant species performed poorly with the CGTC relative to other compost treatments at some location and sampling time. The most noticeable difference in chemical composition between the CGTC and other composts was the lower rate of P supplied. Conversely, the YWC always resulted in plant densities that were among the best at each location and time of sampling. Composts are created by similar biological processes, but the characteristics of each will be greatly dependent on the feedstocks employed and the degree to which the finished material is allowed to mature. The concept of matching compost type to individual plant species should be considered further.

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Figure 1 - Corn Poppy Density in Culpeper and Staunton

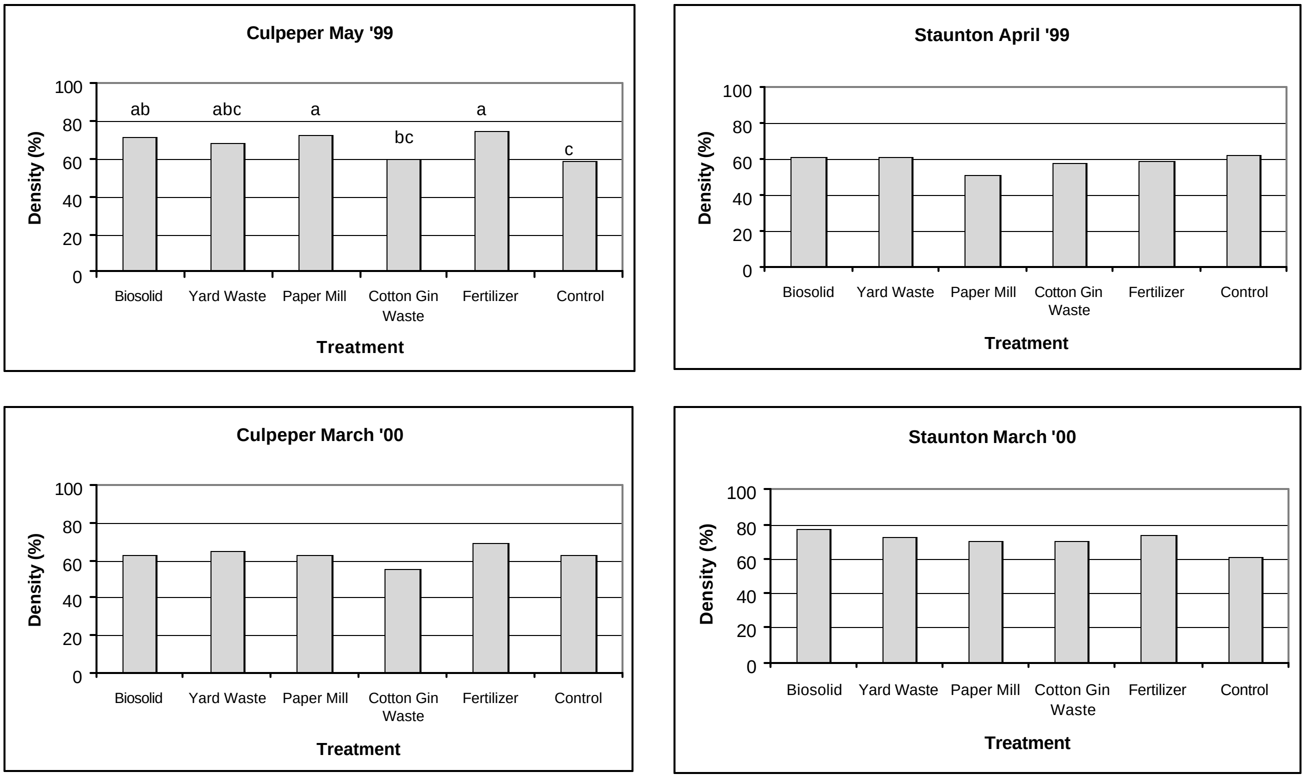

Figure 2. Coreposis Density in Culpeper and Staunton

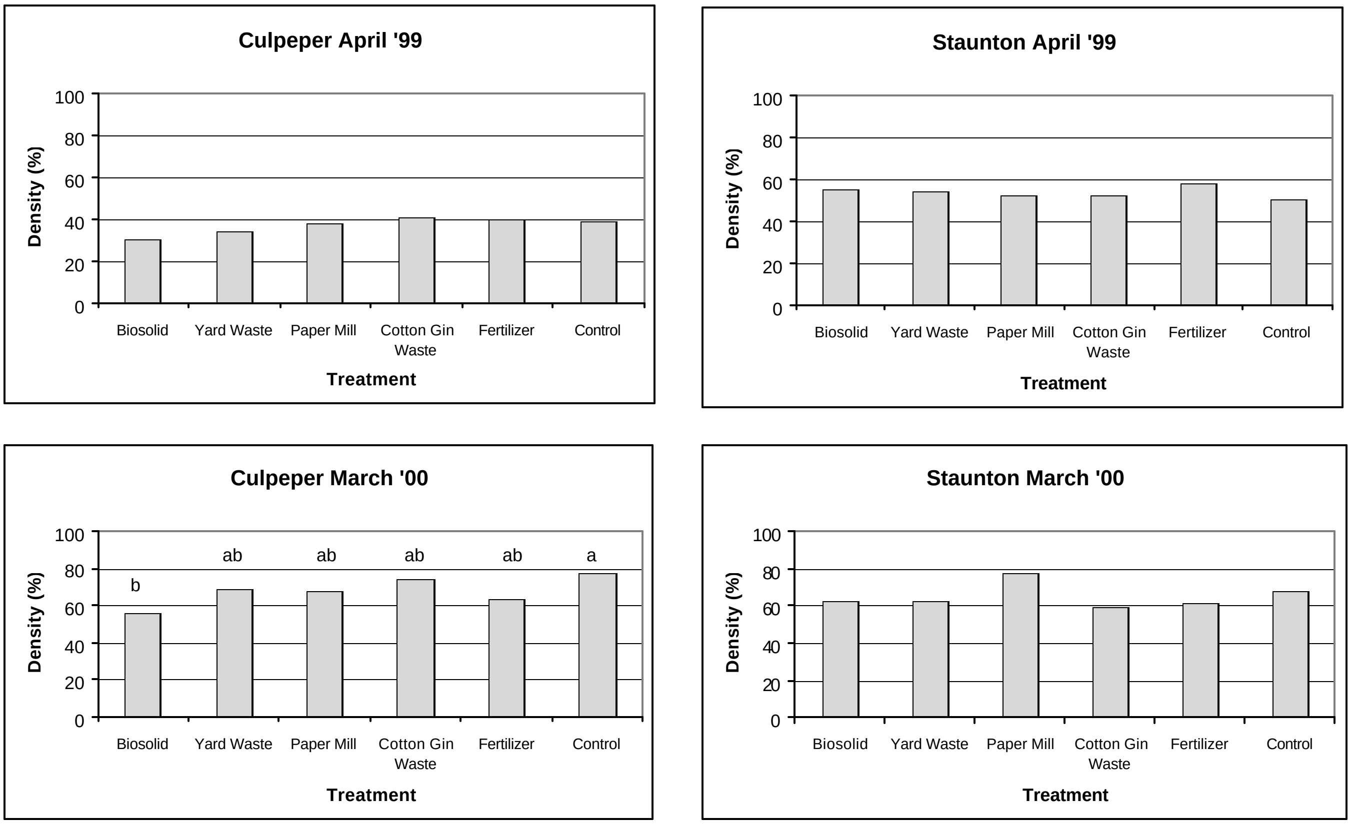

Figure 3. Tall Fescue Density in Culpeper and Staunton