HIGHBUSH BLUEBERRY RESPONSE TO COMPOST AND SULFUR

Ryan C. Costello[a], Dan M. Sullivan[a], David R. Bryla[c], Bernadine C. Strik[b], and Jim Owen[b]
Dept. Crop & Soil Science[a] and Horticulture[b], Oregon State University, Corvallis, OR;
USDA-ARS[c], Corvallis, OR. Corresponding Author: ryan.costello@oregonstate.edu

ABSTRACT

Highbush blueberry is adapted to soils with high organic matter and acidic pH, and it is often grown in Oregon with coniferous sawdust as a soil amendment or mulch. Composts could provide an alternative to sawdust, but acidification is needed to overcome high pH. Our objectives were to (i) predict the quantity of acidity needed to reduce compost pH to 4.8 (ideal for blueberry), (ii) determine compost characteristics suited for blueberry, and (iii) evaluate plant growth response and soil pH response to elemental S addition. Nine composts, including five plant-based and four manure-based materials, were titrated in the laboratory with 0 to 7 mL of 0.15M H_2SO_4 to estimate buffering capacity and determine the Acid Requirement Forecast (ARF; acidity required to reduce compost pH to 4.8). Compost buffering capacity averaged 0.7 mol H^+ kg^{-1} compost-C^{-1} per pH unit, and ARF ranged from 0 to 3.6 mol H^+ kg^{-1} compost-C^{-1}. Plant response to compost was evaluated in a 119-d summer growth trial. Plants were grown in 3.5-L pots filled with a 2:1 (v/v) soil:compost mix using each of the nine different composts or in a 2:1 soil:sawdust mix or in soil only. Plants were placed outdoors under micro-spray irrigation and fertilized periodically with liquid fish fertilizer. Soil pH at Day 76 in the growth trial was more strongly correlated with compost ARF (Day 0) than starting compost pH (Day 0). Final root dry matter was negatively correlated with soil pH. Plant-based composts produced 18% greater shoot and 22% greater root growth than manure-based composts. Root and shoot dry matter of plant-based composts was not significantly different than the sawdust control, while root and shoot dry matter of manure-based composts was lower than for sawdust. Across all soil mixes, elemental S increased shoot and root dry weight by 11% and 12% respectively, although soil pH reduction with elemental S averaged only 0.3 pH units. We conclude that laboratory testing of compost ARF can be used as a screening tool to select composts appropriate for blueberry production. Further research is needed to assess optimum elemental S rate, particle size, and incubation conditions needed to acidify compost.

INTRODUCTION

Blueberry plants are adapted to soils with high organic matter and acidic pH. In Oregon, highbush blueberry (*Vaccinium corymbosum* L.) is grown with a mulch of acidic coniferous sawdust, which has been shown to increase plant growth. Sawdust is increasingly expensive and immobilization of inorganic nitrogen can be a problem. Compost may be a viable alternative to sawdust but composts most suitable for blueberry have never been tested.

Composts are often alkaline or neutral in pH and high in soluble salts. Acidification of composts using elemental sulfur could be a remedy for high pH, but acidification of composts with elemental S also increases salinity (Garcia de la Fuente et al, 2008). Wong et al (1998) reported that the ability of a compost to increase soil pH could be predicted by the "Proton Consumption Capacity", or H^+ consumed by the compost in a laboratory titration to a target pH. Garcia de la Fuente et al. (2008) found that a laboratory titration of high pH composts with $FeSO_4$ was correlated with compost response to elemental S addition in a 70-d incubation.

OBJECTIVES

Our objectives were to (i) predict the quantity of acidity needed to reduce compost pH to 4.8 (in the ideal range for blueberry), (ii) determine compost characteristics suited for highbush blueberry, and (iii) evaluate plant growth response and soil pH response to elemental S addition.

MATERIALS AND METHODS

Composts. Nine composts were evaluated in this study (Table 1). Composts were primarily created from a single feedstock and were sourced locally, with both municipal and on-farm processing. Five plant-based composts (two yard debris, leaf, mint hay, and bark) and four manure-based composts (two separated dairy solids and two horse manures) were used.

Table 1. Compost treatments.

Origination	Compost Feedstock	Plant (P) or manure (M) based	Compost Abbreviation
Corvallis	Yard Debris	P	CO-Yard
Eugene	Yard Debris	P	EU-Yard
Aurora	Dairy Solids	M	AU-Dairy
Sherwood	Dairy Solids	M	SH-Dairy
North Plains	Horse Manure	M	NP-Horse
Salem	Horse Manure	M	SA-Horse
Portland	Leaf	P	PO-Leaf
Tacoma	Composted Bark	P	TA-Bark
Aurora	Fir Sawdust	N/A	AU-Sawdust
Newburg	Mint Hay	P	NE-Mint

Acid Requirement Forecast. Five grams of compost was titrated in the laboratory with 0-7 mL of 0.15M H_2SO_4 in a total volume of 50 mL to determine compost buffering capacity and Acid Requirement Forecast (ARF). The response of selected composts to acid addition is shown in Figure 1.

Plant Growth Trial. Plant growth response to compost was evaluated by transplanting two-year old highbush blueberry plants (cv. *Duke*) into 13.5-L containers filled with a 2:1 (v/v) soil:compost mix. Control treatments were 2:1 soil:sawdust and soil only. Soil used in the trial was a Willamette silt loam. "Split-pea" size elemental S pellets were added at potting at 11 g S per pot (approx 0.9 g S kg^{-1} dry compost). This S application rate was based on average compost pH buffering capacity determined in earlier trials. The S addition rate used was targeted to reduce compost pH by 2 units (e.g. from 7 to 5), assuming typical compost buffering capacity, and 75% oxidation of elemental S. The full rate of S needed to neutralize compost alkalinity (ARF) was not added in this trial because of concerns about excess salinity from elemental S oxidation.

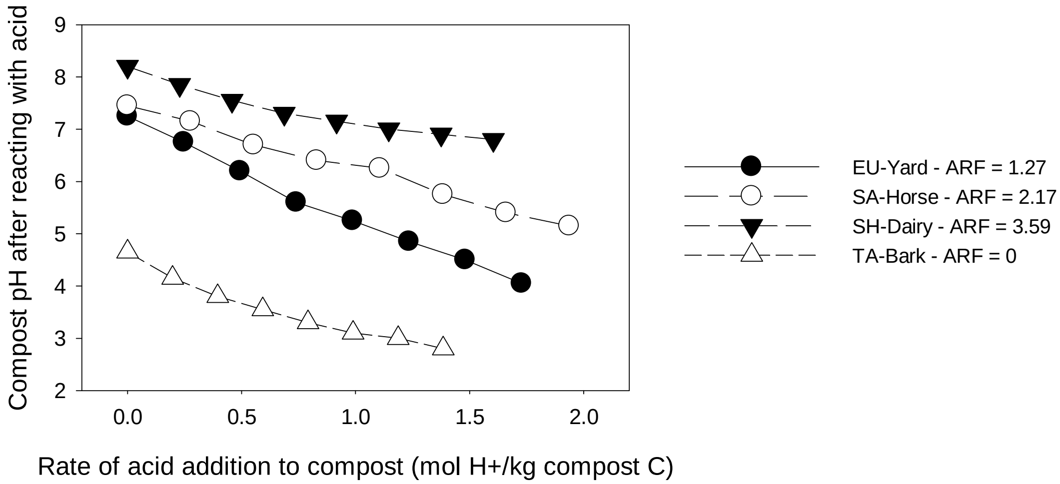

Figure 1. Response of selected composts to acid titration. Slope of response line estimates compost pH buffering capacity. Compost pH was determined in 5 g compost + 50 mL acid solution after 72 h equilibration. ARF = Acid Requirement Forecast based on titration data (above) and linear regression line extended to pH 4.8.

The growth trial was conducted in a split-plot design with 5 replications, with compost type as main plot and sulfur as subplot, on an outdoor gravel pad with microspray emitter irrigation. Plants were fertigated with Eco-Nutrient 2-4-0.2 fish emulsion once a week starting on Day 30 at a dilution of 1.7 %, or 0.35g N/pot. On Day 49 the fertigation rate was increased to 3.1%, or 0.67g N/pot. Weekly fertigation continued until Day 78. During the trial, a total of 3.7g N/pot was applied. On Day 119, plants were destructively harvested and partitioned into leaves, new stem, old stem, and roots for determination of dry weight.

Two compost treatments (SA-Horse and CO-Yard) and the soil-only control were severely water-stressed. The two compost treatments had low soil water holding capacity after compost addition (0.27-0.28 volumetric water content), compared to 0.32+ volumetric water content for the other treatments. The soil-only control treatment had surface crusting and the soil pulled away from the sides of the pot, which caused preferential water flow. Plants in these three treatments had leaf burn and plant dieback. We excluded these treatments for analysis of pH effects on plant growth, because plant response was confounded by water stress.

RESULTS AND DISCUSSION

Acid Requirement Forecast. Compost laboratory analyses are shown in Table 2. Compost buffering capacity averaged 0.74 mol H^+ kg^{-1} C^{-1} per pH unit. Acid Requirement Forecast ranged from 0 to 3.6 mol H^+ kg^{-1} compost-C^{-1}. The starting compost pH was not a good indicator of compost resistance to pH change. We expressed buffering capacity per unit of compost-C to allow comparison among composts that differ in organic matter content.

Plant Growth Trial: effects of compost and S. The main effects of compost and sulfur were both significant on shoot and root dry weight, as presented in Table 3. Statistical analysis showed significant interaction between compost and sulfur on shoot dry weight, but not on root dry weight. Linear statistical contrasts showed that plants performed better with plant-based composts than with manure-based composts. Plants grown in plant-based composts were not significantly different from the sawdust control. Plant-based composts produced 22% greater shoot dry weight and 18% greater root dry weight than manure-based composts.

Table 2. Starting compost analyses (Day 0).

Compost Abbreviation	Total N[a]	N03-N[a]	C:N[a]	pH[b]	Ec[b]	Buffering Capacity[c]	Acid Requirement Forecast [d]
	%	%				mol H+ kg^{-1} C^{-1} per pH unit	mol H+ kg^{-1} C^{-1}
CO-Yard	1.5	0.09	15	7.5	1.2	0.87	2.11
EU-Yard	1.2	0.001	23	7.6	0.5	0.54	1.27
AU-Dairy	2.1	0.14	15	9.1	2.9	0.54	1.90
SH-Dairy	1.8	0.01	18	8.7	2.2	1.11	3.59
NP-Horse	0.6	0.01	36	9.0	1.2	0.36	1.21
SA-Horse	1.7	0.07	17	7.5	3.0	0.81	2.17
PO-Leaf	1.2	0.08	21	8.8	0.3	0.98	3.00
TA-Bark	1.1	0.13	26	4.6	0.8	0.75	NA
AU-Sawdust	0.1	0.0001	638	4.0	0.0	NA	NA
NE-Mint	4.2	0.21	8	8.7	4.9	0.68	2.26

[a] Total C and N via LECO combustion analysis; nitrate-N via automated colorimetric analysis.

[b] pH and EC (mS/cm) measured in 10:1 (v/v) water:compost .

[c] Buffering Capacity estimated via titration with H2SO4 in a 10:1 water:compost slurry.

[d] Acid Requirement Forecast (ARF) estimated by multipying buffering capacity x desired pH change (to pH 4.8).

The addition of elemental S increased shoot dry weight by 2.9 g/pot, an increase of 11%, and root dry weight by 1.6 g/pot, an increase of 12%. Elemental S addition decreased soil pH at Day 76 by an average of 0.3 units. The least buffered compost treatment (sawdust) had the greatest pH decrease of 0.6 units, and the most buffered compost (SH-Dairy) had the least pH decrease of 0.1 units.

Overall, elemental S addition was not very effective in reducing soil pH, especially for manure-based composts with high ARF. With little effect of S on soil pH, we were surprised to see that S did improve root growth. We hypothesize that S oxidation near elemental S prills created micro-scale zones of lower pH within the soil matrix that provided a lower pH environment for root growth. We do not think that S addition corrected a plant S deficiency, because plants received regular addition of fish fertilizer that should supply adequate S. Plant tissue analysis is being conducted (not completed at time of manuscript preparation) to assess the effect of elemental S addition on uptake of other nutrients.

Root dry matter was negatively correlated with soil pH, shown in Figure 2. Laboratory determination of Acid Requirement Forecast was more strongly correlated with soil pH at Day 76 than was starting compost pH, illustrated by the two graphs in Figure 3.

Table 3. Plant shoot and root growth at end of growth trial (Day 119) and soil pH (Day 76).

Compost	Shoot			Root			Soil pH (Day 76)[a]		
	No S	S	Avg	No S	S	Avg	No S	S	Avg
		g/pot			g/pot				
CO-Yard	23	19	21	10	11	10	6.1	5.9	5.9
EU-Yard	29	24	27	16	15	15	5.9	5.4	5.7
AU-Dairy	31	35	33	11	14	13	5.9	5.6	5.7
SH-Dairy	33	21	27	11	10	11	7.0	7.0	7.0
NP-Horse	17	28	23	10	20	15	5.4	5.2	5.3
SA-Horse	19	21	20	10	12	11	5.4	5.3	5.3
PO-Leaf	32	39	36	15	18	17	6.0	5.9	5.9
TA-Bark	37	40	38	20	21	21	5.2	4.7	5.0
AU-Sawdust	24	42	33	18	17	17	5.3	4.7	5.0
NE-Mint	27	33	30	11	13	12	6.0	5.8	5.9
None (Soil Only)	21	21	21	11	10	11	5.2	4.8	5.0
Average	27	29	28	13	15	14	5.7	5.5	5.6
LSD (.05)			6.3			4.2			0.1
Compost (Main Plot)			***			***			***
Sulfur (Subplot)			*			*			***
Interaction			**			NS			***
Contrasts:									
Manure-based vs plant-based composts			**			*			***
Plant-based vs sawdust control			NS			NS			***
Manure-based vs sawdust control			**			**			***

*, **, *** Significant at the 0.05, 0.01, and .001 probability levels, respectively.

[a] Soil pH measured via 1:2 soil:water (v/v) method.

CONCLUSIONS

Laboratory titration of composts and determination of Acid Requirement Forecast (ARF) was a more effective predictor of final soil pH than was the starting compost pH. Laboratory determination of ARF can be an effective screening tool to determine which composts are appropriate for highbush blueberry production.

Plant-based composts had lower pH and lower EC than manure-based composts, making them more suitable for highbush blueberry.

The addition of elemental S increased shoot and root growth, although it did not reduce the pH of compost + soil treatments to that of the sawdust + soil control. A higher S addition rate, finer S particles, or more time between S addition to compost and planting may be necessary to facilitate greater compost acidification.

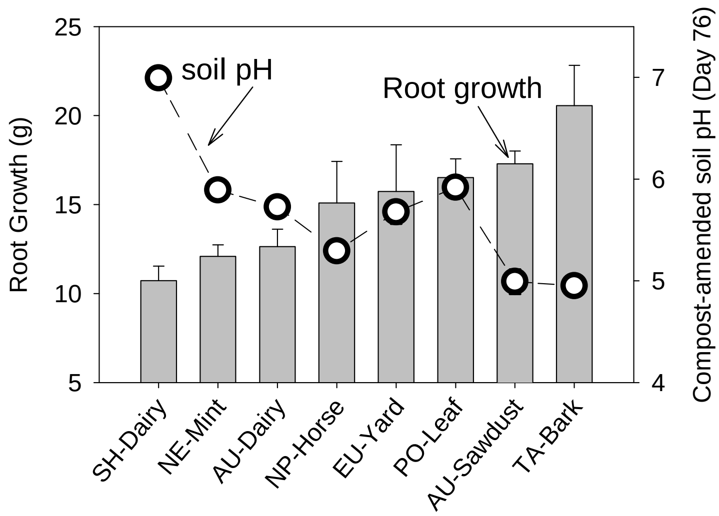

Figure 2. Compost effects on plant root growth (Day 119) and soil pH (Day 76). Soil pH in 1:2 soil:water.. Data from water-stressed treatments (CO-Yard, SA-Horse, soil only) excluded.

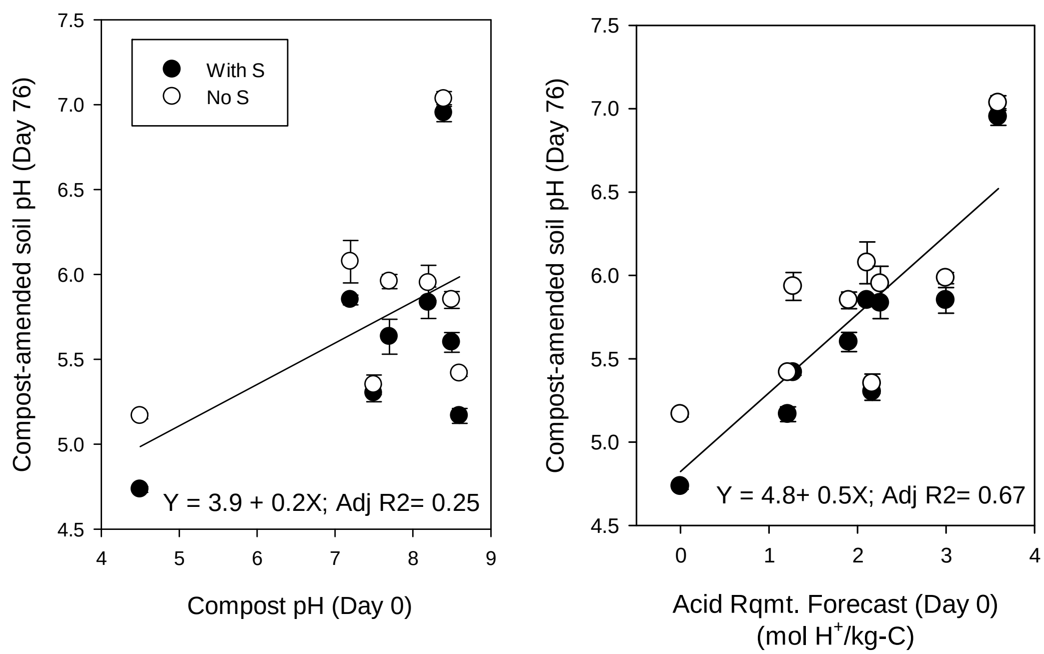

Figure 3. Effect of initial compost pH (left) or compost Acid Requirement Forecast (right) on compost-amended soil pH (1:2 soil:water) on Day 76 in growth trial.

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Program Chair:
Robert Flynn, Program Chair
New Mexico State University
67 E Four Dinkus Road
Artesia-NM 88210
(575) 748-1228
rflynn@nmsu.edu

Coordinator:
Phyllis Pates
International Plant Nutrition Institute
2301 Research Park Way, Suite 126
Brookings, SD 57006
(605) 692-6280
ppates@ipni.net