Utilization of Manure to Energy Co-Products as a Fertilizer Source.

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Poster Information

Eastern Shore AREC Soil Fertility Program

ABSTRACT

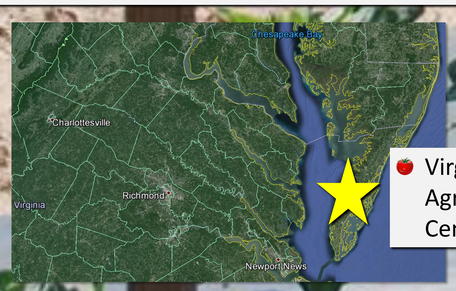
We evaluated the poultry litter pyrolysis co-product biochar as a potential phosphorus (P) fertilizer source and overall soil amendment for the Mid-Atlantic's fresh market tomato industry. Mid-Atlantic soils utilized for vegetable production are typically sandy loam soils with low organic matter, low water holding capacity, and a low cation exchange capacity. After pyrolysis, any concerns regarding bacterial contamination in growing fresh vegetables is eliminated and biochar retains high concentrations of P, nitrogen (N), and potassium (K). We tested biochar in a 2 P source (biochar and inorganic P fertilizer) × 3 P rate (biochar at 8,961, 17,922, and 26,884 kg ha^{-1}) factorial arrangement in a randomized complete block design using alpha = 0.10. Yield and aboveground biomass production were used for treatment comparison. In 2011, marketable tomato yield increased as biochar rate increased. However, salt injury reduced yields and plant biomass in 2012. Farmers need to consider quality of biochar when selecting soil amendment products. More research needs to be completed to fully understand the potentials and problems with using co-products in the marketplace and Mid-Atlantic crop productions systems.

INTRODUCTION

Virginia farmers produce 2,500 ha of tomatoes annually with an annual farm gate value of $100 million (5-year average; USDA-National Agricultural Statistics Service, 2013). In Virginia, most fresh market vegetables are grown in the Eastern Shore counties of Accomack and Northampton on the tip of the Delmarva Peninsula. Virginia Tech soil tests from tomato production fields in Eastern Shore counties dictate that 86% require additions of P fertilizer; which is met with the use of inorganic P fertilizer sources. Overall fertilizer prices have risen significantly in recent years, with cost for P inorganic fertilizers rising over 300% since 2003 (USDA-Economic Research Service, 2013). With prices continuing to rise, the P content of poultry litter may provide a lower cost alternative and a way to recycle P for local producers. However, at this time, vegetable production does not utilize fresh poultry litter as a fertilizer source because of food safety concerns. After pyrolysis, any concerns regarding bacterial contamination are eliminated and the biochar co-product can be expected to retain high concentrations of plant available P, as well as other nutrients needed for tomato production, such as N and K. Also, biochar is an excellent carbon source that may increase soil cation exchange capacity, water holding capacity, and improve general soil tilth.

OBJECTIVES

- To determine if biochar co-products that are derived from fresh poultry litter can provide adequate P fertility for fresh market tomato production systems in the Mid-Atlantic.
  - Tomato plant biomass production.
  - Tomato yield and marketable quality.



Virginia Tech Eastern Shore Agricultural Research and Extension Center

MATERIALS AND METHODS

- Study was initiated in 2011 at the Virginia Tech Eastern Shore Agricultural Research and Extension Center in Painter, Virginia, USA.
- Bojac sandy loam (Coarse-loamy, mixed, semiactive, thermic Typic Hapludult).
- Tomato variety: BHN 602.
- Potassium and boron fertility was broadcast applied and incorporated prior to establishing raised tomato beds, based on soil tests.
- Tomatoes grown using plasticulture:
  - Polyethylene mulch system.
  - Raised beds (20 cm high × 90 cm wide).
  - Drip irrigation that was increased as plants grew in size.
  - 1.83 m row spacing.
  - Plants spaced 46 cm apart.
- No fumigation under the plastic to avoid interference with microbial activity.
- Nitrogen application:
  - 97 kg N ha^{-1} incorporated into the bed area under plastic mulch using urea.
  - 103 kg N ha^{-1} applied via fertigation using 32% urea-ammonium nitrate solution.
  - No biochar N was assumed to be available during the first growing season based on Nelson et. al., 2011.
- Phosphorus source × biochar rate (2 × 3) factorial arrangement of treatments plus four controls.
- Phosphorus sources:
  - Biochar derived from fresh poultry litter.
  - Inorganic triple super phosphate (TSP; 0-46-0) (Data not shown).
- Biochar rates:
  - 8,961 kg ha^{-1}
  - 17,922 kg ha^{-1}
  - 26,884 kg ha^{-1}
- Controls:
  - No fertilizer or biochar.
  - No P + N fertigation.
  - No N + P fertilization based on soil test.
  - Nitrogen + P fertilization standard farmer practice based on Virginia Cooperative Extension guidelines.
- Tomatoes were hand harvested at mature green and graded according to marketability and size.
- All other production practices were followed as outlined by *Commercial Vegetable Production Recommendations – Virginia*.
- The study included four replications and was arranged as a randomized complete block design.
- Means were separated using Fisher's Protected Least Significant (LSD) tests at alpha = 0.10.

Spreading biochar. The material is a fine powder; difficult to spread in the raw form.

Transplanting tomatoes.

Tomato plants grown using white polyethylene mulch.

Chemilizer used for fertigation.

RESULTS AND DISCUSSION

Fig. 1. Marketable yield from biochar applications for tomatoes grown on sandy loam soils on the Eastern Shore of Virginia.

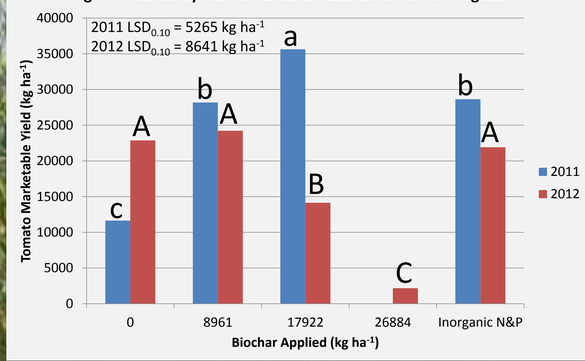


Fig. 2. Plant biomass from biochar applications for tomatoes grown on sandy loam soils on the Eastern Shore of Virginia.

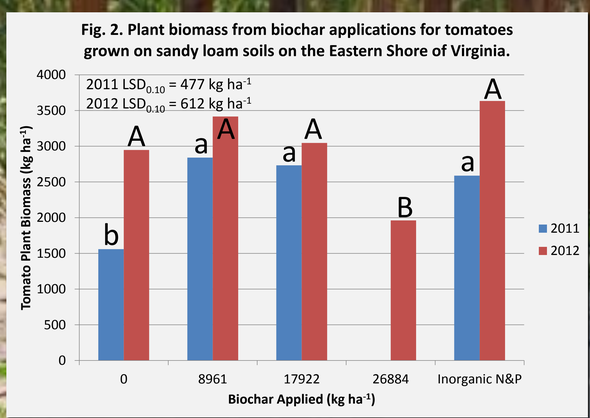


Table 1. Nutrient concentrations of biochar sources derived from poultry litter reported on a "dry basis" for 2011 and 2012.

Parameter	Unit	2011	2012
Solids	%	95.8	82.2
Nitrogen	%	2.49	3.30
Ammonical-N	%	0.018	0.198
Phosphorus	%	3.70	3.45
Potassium	%	3.55	4.48
Sulfur	%	2.04	1.86
Magnesium	%	1.56	1.71
Calcium	%	6.47	4.42
Sodium	ppm	1.21	17400
Iron	ppm	0.45	7660
Aluminum	ppm	0.51	5510
Manganese	ppm	0.09	1370
Copper	ppm	0.06	2190
Zinc	ppm	0.08	1520
Boron	ppm	0.00	145

Marketable Yield (Figure 1):

- In 2011, biochar additions increased linearly as rate increased from 0 to 17,922 kg biochar ha^{-1} (Figure 1).
- The 17,922 kg biochar ha^{-1} rate yielded 6,994 kg tomatoes ha^{-1} more than the standard inorganic N and P fertility regime in 2011.
- A higher 26,884 kg biochar ha^{-1} rate was added in 2012.
- In 2012, the 8,961 kg biochar ha^{-1} rate was similar to the no-fertilizer treatment.
- In 2012, the 17,922 and 26,884 kg biochar ha^{-1} rates had lower yields than no-fertilizer.
- Biochar in 2012 had higher salt concentrations than 2011 (Table 1) and severe salt injury occurred.

Plant Biomass (Figure 2):

- Plant biomass is the aboveground foliage and stem portions, minus fruit yield.
- In general, plant biomass produced followed a similar trend to marketable yield (Fig. 1).
- No-fertilizer treatment had lowest biomass production in 2011 and increased with biochar and inorganic fertilizer additions.
- In 2012, salt injury was demonstrated at the 26,884 kg biochar ha^{-1} rate.
- In 2012, the no-fertilizer control had similar biomass production as the low biochar and inorganic fertilizer treatments.

CONCLUSIONS

- Biochar quality needs to be a major consideration when applying this material as a soil additive to sensitive crops. Salt injury is a major concern for closed polyethylene mulched systems.
- Quality biochar can produce similar yields to the standard inorganic fertilizer practices used by farmers.
- Further extractions and data analysis will provide insight into water holding capacity improvements, increased cation exchange capacity, and other soil quality improvements.

THANK YOU!

- This project was funded by the Blue Moon Fund.