Opportunities for Spent Coffee Grounds in Agronomic Systems

Prepared by:
Benjamin Wherley, PhD- Associate Professor
Department of Soil & Crop Sciences
Center for Coffee Research and Education
Texas A&M University

Background and Rationale

Given the current and anticipated growth of the cold-brew and instant coffee production industry nationally and worldwide, there is growing importance and opportunity to better understand the agronomic merits/demerits of spent coffee grounds (SCG) use in agronomic systems (Figure 1). This is especially true in light of the growing environmental and ecological concerns relating to peat production. Considering that peat continues to be the predominant amendment utilized for constructed golf course and athletic field sand root zones in many parts of the world, SCG could offer a more sustainable alternative in many regions. For row crop agriculture systems, SCG could add value through addition of organic matter when amended into soil, or, by serving as a mulch when applied over the soil surface.

There has been a lack of published information relating to SCG effects on agricultural systems including crop production or lawns/landscapes. Over the past three years, field and greenhouse studies funded by United States Golf Association and GeoJava were conducted by Flores, Wherley, and McInnes (Dept. of Soil & Crop Science) at Texas A&M University to explore the physical, chemical, and agronomic properties of SCG in turfgrass systems. Evaluations of both direct application of fresh and composted spent coffee grounds, as well as SCG-derived organic and bridge fertilizers have been evaluated against other commercially available organic, synthetic, and bridge-type fertilizers in the field. Greenhouse studies have also been conducted to evaluate SCG in comparison to sphagnum peat moss for water and nutrient retention in sand-based root zones. Field and greenhouse studies were conducted to evaluate pre-emergence herbicide potential of SCG across a range of weed species (Figure 2). Currently, Birnbaum, Reed, and Wherley (Horticulture and SCSC) are conducting mineralization experiments as well as SARE-funded vegetable production/yield experiments using various SCG/soil mix ratios.

Observations to Date

- Chemical analyses suggest many agronomically favorable properties of spent coffee grounds, including a ~2.3% N content, ~23:1 C:N ratio, slightly acidic pH of 5.6, and presence of many essential macro and micronutrients including S, Mg, Zn, Fe, and Cu (Flores et al., 2020). Coffee beans also have a highly porous nature, which may also contribute to improved water/nutrient retention (Figure 3).

- In field studies on bermudagrass lawn plots, no differences in turf quality, color, density, soil moisture, or pH could be detected between SCG-treated (both fresh and composted) and untreated plots after 2.5 years of repeated applications totaling nearly 9 lbs. N/ 1000 sq. ft (392 lbs. N/ Acre) despite accumulation of a layer of coffee grounds being visible at the soil surface. This seems to indicate that any N within SCG is tightly bound and slow to break down/release.

- In field studies, an experimental SCG-based fertilizer performed as well or slightly superior to other commercially available quick and slow-release organic fertilizers (Flores et al., 2020). This may suggest that when applied combined with N fertilizer, SCG may improve the availability/release of N to plants.

- Greenhouse studies in sand-based root zones showed SCG possess shrink/swell properties that result in mild to moderate soil heaving following water application, which may aid in root zone aeration and/or increased porosity.

- In greenhouse studies, a brief period of mild chlorosis was observed during both experiments in which 5-10% of the turf canopy in SCG treatments expressed leaf yellowing. This disappeared after 4-6 weeks, with all treatments retaining good color through the duration of the study.

- In greenhouse studies, SCG-amended pots showed similar or improved water retention compared to sphagnum peat moss and unamended sand treatments. During a multiple week dry-down period, this resulted in a greater number of days until wilt was observed within SCG treatments compared to peat moss and straight sand.

- In greenhouse studies, SCG-amended pots showed greater nutrient retention/ nutrient use efficiency following a single 1 lb. N/1000 sq. ft. application of ammonium sulfate. This was supported by a much greater and longer duration of clipping production over the study period (up to 14 weeks after this application).

- During the recovery phase following the greenhouse dry-down and re-watering, SCG treatments showed much stronger bermudagrass vigor, recovery, density, color, and final N content than sphagnum peat and unamended sand treatments (Figure 4)

- At the conclusion of the greenhouse study, bermudagrass roots were found to have grown into and through coffee grounds, making it difficult to separate out and isolate roots (Figure 5).

- Studies with vegetable crops (Birnbaum, Reed, and Wherley) suggest that reduced growth and yields are observed with SCG amended into soil above 50%. Leachate draining out of pot bottoms appears to contain high amounts of dissolved organic compounds, possibly tannins.

Questions

- Why is such limited benefit seen when applied over time to the soil surface, but positive benefits seen when amended into sand?

- Why does brief period of chlorosis occur early on in amended sand? Could this be due to immobilization of N in the soil due to SCG, or is this due to release of specific compounds from SCG that leach out over time?

- What is the basis for SCG benefits when amended into sand root zones. Physical (aeration)? Chemical (N release or retention), biological (hosting specific beneficial microorganisms)

- How long does SCG remain in sand-based root zones. Decomposition rates vs. other organic materials.

- What are the best methods for composting of SCG?

- Is composting beneficial compared to direct incorporation of fresh SCG?

Agronomic Possibilities

- Microbiome research
- Fungal disease suppression
- Use as infill for sports fields for improving player safety (natural and synthetic turf)
- Animal feedstock or supplement

Potential Industry Partners

- Starbucks
- Nestle
- Smuckers
- Swyer Tea
- Sustainability Resources Group
- GeoJava
- Meyer Materials

Potential Funding Agencies

- USDA-AFRI
- USDA-SARE
- USGA Greens Section
- FFAR

Potential Texas A&M Faculty Involvement

- Ben Wherley, PhD- Turfgrass Ecology, Soil & Crop Science Dept.
- Kevin McInnes, PhD- Soil Physics, Soil & Crop Science Dept.
- David Reed, PhD- Horticulture
- Young-Ki Jo, PhD- Plant Pathologist, Department of Plant Pathology and Microbiology
- Terry Gentry, PhD- Soil Microbiology, Soil & Crop Science Dept.
- Julie Howe, PhD- Soil Fertility, Soil & Crop Science Dept.
- Chase Straw, PhD- Turfgrass Management, Soil & Crop Science Dept.
- Jason Sawyer, PhD- Animal Nutrition, Animal Science Dept.
- Biochar/ pyrolysis expert
- Microbiome expert
- Others at TAMU?
- Other institutions?

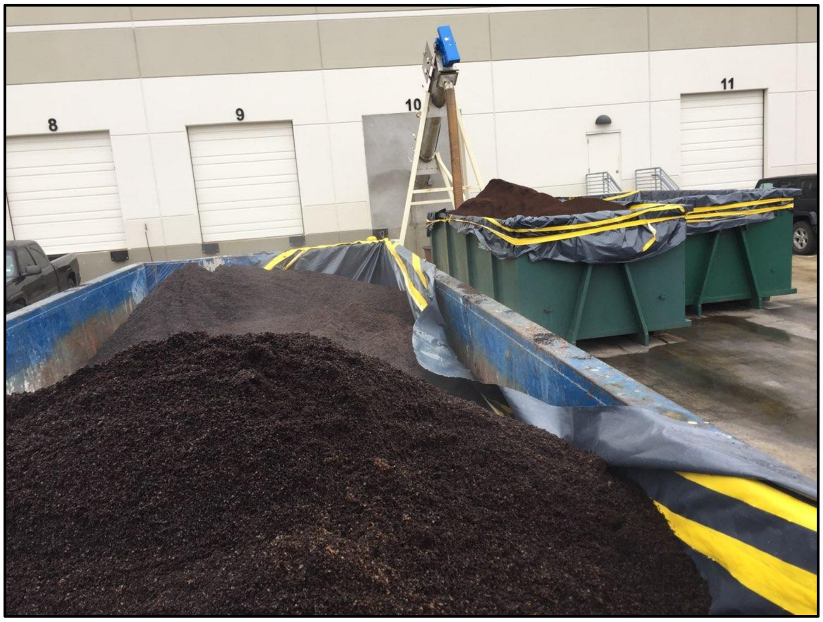

Figure 1. Spent coffee grounds (SCG) generated from cold-brew coffee production at a large facility in San Antonio, TX (Photo courtesy of Chad McNair, GeoJava Ventures)

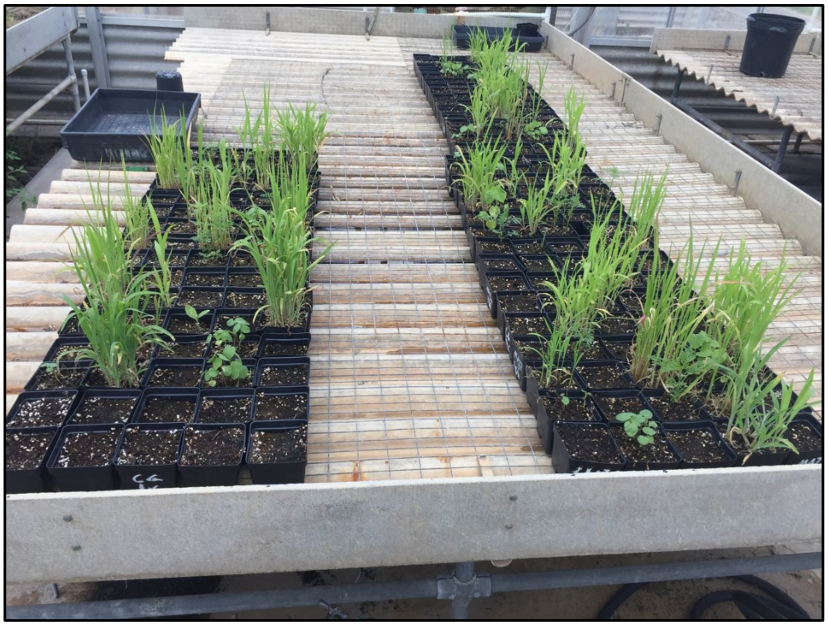

Figure 2. Greenhouse SCG pre-emergence weed control studies being conducted at Texas A&M University. (Photo Courtesy of Garrett Flores).

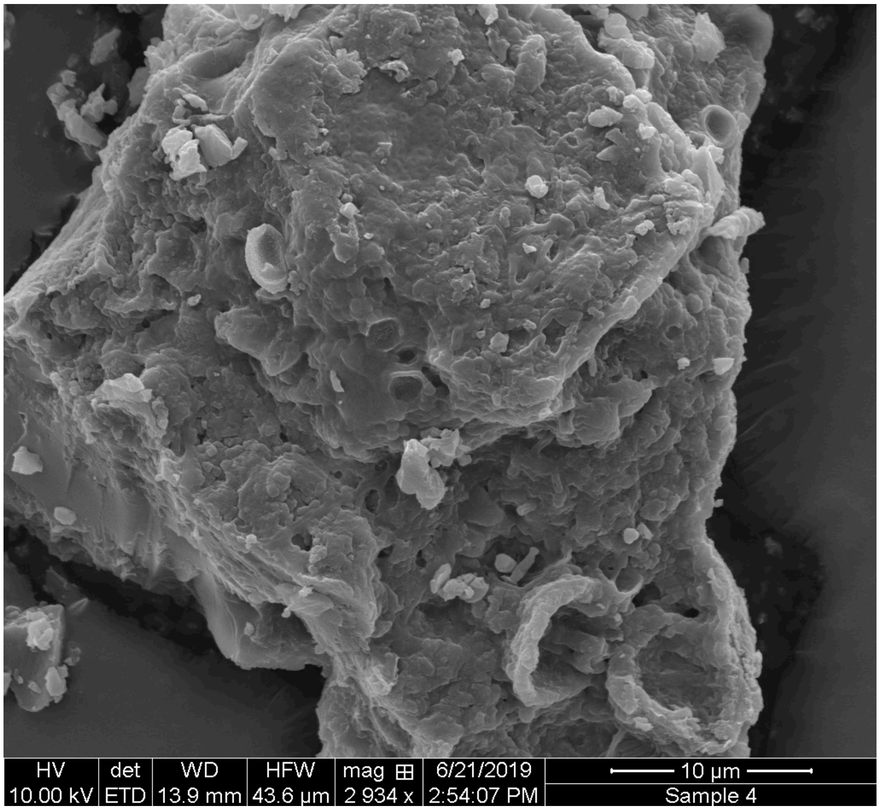

Figure 1. Image of 'Tifway' bermudagrass roots after the completion of the dry down recovery phase of the spent coffee grounds root zone amendment greenhouse study at Texas A&M. Washed bermudagrass sod was established into lysimeters composed of USGA spec root zones, where the turf roots can be seen growing INTO & THROUGH the coarse spent coffee grounds.

Figure 2. Scanning electron microscope (SEM) images taken on the FEI Quanta 600 FE-SEM at the Microscope Imaging Center (MIC), Texas A&M University. The image taken with a magnification of 2934x, shows an approximately 80-micron SCG particle from a ground sample prepared with a 6nm Pt/Pd sputter coat. SEM images taken by Aditi Pandey.

Figure 4. Image of treatments at the conclusion of the sand root zone amendment study in 2019. Image was taken 4 months after N fertilization event following fertilizer use efficiency and dry-down/recovery phases. Treatments are as follows from left to right (three replicates): Coarse SCG 10%, Peat Moss 10%, Fine SCG 10%, Coarse SCG Mass, Sand-Only Control, Fine SCG Mass, Coarse SCG 20%, Peat Moss 20%, Fine SCG 20%. (Photo Courtesy of Garrett Flores).

Figure 5. Image of 'Tifway' bermudagrass roots after the completion of the dry down recovery phase of the 2018 sand root zone amendment greenhouse study at Texas A&M. Washed bermudagrass sod was established into lysimeters composed of USGA spec root zones, where the turf roots can be seen growing into the coarse SCG.