Final Project Report

"Developing organic management to restore soil quality for food production in degraded urban soils"

Josh Beniston and Rattan Lal
The Ohio State University

Project Rationale:

The formerly industrial cities of the North Central region have become a rapidly expanding frontier for urban agriculture (UA) in the US. As populations in these cities have declined, a legacy of vacant land and properties has been left behind. The city of Cleveland currently has more than 1,500 hectares (ha) of vacant land in the city, while Youngstown, Ohio contains more than 20,000 vacant city parcels. UA has emerged as an important means of utilizing vacant land and is capable of producing numerous societal benefits, including: improved nutrition, increased food security, and income generating opportunities. Urban soils, however, are highly variable and subject to high levels of anthropogenic degradation. An understanding of local soil properties is a basic starting place for sustainable agriculture, yet this information is simply not available in most urban areas. Though constraints to crop production can be common in urban soils, cities also contain enormous quantities of organic wastes, many of which have the potential to be transformed into amendments, such as compost or biochar. Data indicate that there is great potential to increase the production of amendments from these materials. These waste materials represent a tremendous potential resource for managers of urban soils.

Approach

We established an experimental garden site with the objectives of evaluating soil properties in an urban soil following the demolition of vacant houses, as well as documenting the ability of amendments produced from organic waste materials to improve soil quality (SQ) and support vegetable crop production under these conditions. The experimental site is located in a series of adjacent vacant urban lots in Youngstown OH where vacant houses were recently demolished and removed. The experiment utilized a split-plot design to test differences in soil properties and crop growth. Main plots received the following treatments: 1) control (CNT), 2)

leaf compost (15 kg m^{-2}) (CMP), 3) leaf compost (15 kg m^{-2}) + hardwood biochar (2 kg m^{-2}) (CMP+B), 4) leaf compost (15 kg m^{-2}) + intensive cover cropping (CMP+ICC). The intensive cover cropping regime consisted of growing sorghum-sudangrass (Sorghum bicolor X S. bicolor var. sudanese var "BMR") during summer 2011 followed by tillage radish (Raphanus sativus var. "Tillage") in autumn 2011. A walk behind roto-tiller was used to incorporate the amendments and a drip irrigation system provided supplemental irrigation. Sub plots compared compared in ground cultivation with cultivation in 20cm raised beds. The experiment was conducted during the 2011 and 2012 growing seasons and a number of soil physical, chemical and biological properties were measured at the initiation and conclusion of the experiment. A SQ index was developed using multivariate analyses and scoring functions from the Soil Management Assessment Framework (SMAF).

Results

At the initiation of the experiment high bulk density values of 1.79 Mg m^{-3} in ground and 1.55 Mg m^{-3} in raised beds were observed at the site following demolition activities and soil compaction was identified as the principal soil-based constraint to crop production. Soil lead (Pb) occurred at the site at a concentration of 95 mg kg-1 significantly lower than the U.S. EPA's screening level of 400 mg kg^{-1} and thus was not considered a significant risk to agriculture at the site. Total soil C and microbial biomass C analyses indicated both occurred at low levels, largely due to the removal of existing topsoil, as well as compaction, during the demolition activities at the site

During 2011, the relative yield of all crops was strongly improved by the organic matter amendments. Relative yield was 1.25, 1.21 and 0.54 for CMP+B, CMP, and CNT plots, respectively. Raised beds did not result in a significant effect on relative yields in 2011, which were 0.94 for in ground plots and 1.06 for plots with raised beds.

Organic matter treatments demonstrated a strong effect on tomato yields in 2012 which followed a decreasing trend of CMP+ICC >CMP>CMP+B >CNT. Raised beds also produced a beneficial effect. Tomato yields were in the range of "low" yields for commercial processing tomatoes according to a regional reference. Both the organic matter amendments and raised bed treatments resulted in greatly increased sweet potato yield in 2012, with OM amendments

followed a trend of CMP+ICC >CMP+B>CMP >CNT. The measured sweet potato yields are considered “excellent” for the region.

All organic matter amendments resulted in significant improvement to soil properties compared with the unamended control. This included 4-5 times greater soil C, 5-20 times greater microbial carbon, and 4 times greater total soil nitrogen. The cover cropping treatment produced the largest measurable improvements in soil structure and aggregation. Raised beds did not result in measurable increases in the majority of soil properties. SQI values were also much higher in the amended plots vs the control.

Conclusions

The soil was heavily compacted and had low organic matter following the demolition of the two houses. Applying large amounts (about 10 cm deep) of leaf compost allowed us to grow large amounts of vegetables in the degraded soil. Compost produced from yard wastes and purchased at a low cost (approx. $250) was highly effective at restoring soil quality for vegetable production at the site. Applying compost and also using intensive cover cropping that included growing sorghum sudangrass in the summer resulted in the biggest improvements to SQ. The cover crops loosened the compaction and produced large quantities of additional organic matter. Vegetables grew surprisingly well in the in ground plots. The raised beds produced larger amounts of vegetable crops, but did not affect soil properties to a great degree. Urban gardening can be productive. The research garden produced over 500 kg of market quality vegetables in 2012, while growing only summer crops. More intensive cropping could lead to much higher yields.

Outputs:

Publications

- **Beniston J**, Lal R (2012) Improving soil quality for urban agriculture in the North Central U.S. In Lal R, Augustin B (eds.) Carbon sequestration in urban ecosystems. Springer, Dodrecht, Holland pp 279-314.
- **Beniston J**, Lal R, Mercer K, Basta NT Assessing and managing soil quality for urban agriculture in a degraded vacant lot soil. In Preparation for "Soil Science Society of America Journal."

Conference Presentations

Oral Presentations

2012

- **Beniston J,** Lal R. Assessing and managing soil quality for urban agriculture in a degraded vacant lot soil. Soil Science Society of America Annual Meeting. Cincinnati, OH.
- **Beniston J**. Assessing and managing soil quality for urban agriculture. Hayes Graduate Research Forum. The Ohio State University. (Refereed Forum, 33% acceptance). Received third place in College of Food, Agriculture, and Environmental Studies.

2011

- Lal R, **Beniston J** . Carbon sequestration and nutrient cycling in urban soils. Soil Science Society of America Annual Meeting. San Antonio, TX.

Poster Presentations

2012

- **Beniston J,** Lal R. Assessing and managing soil quality for urban agriculture. EcoSummit 2012, Columbus, OH.

2011

- **Beniston J**, Lal R. Improving soil quality for vegetable production in a disturbed vacant urban lot soil. Soil Science Society of America Annual Meeting. San Antonio, TX.

Invited Educational Presentations (Josh Beniston)

2012

- *Urban Soils,* Vacant Land Re-Use Program. Youngstown, OH.
- *Working with Urban Soils,* Youngstown Neighborhood Development Corporation, Market gardener training program. Youngstown, OH
- *Introduction to Soil Science and Management,* The Ohio State University Extension, Cuyahoga county market gardener training program. Cleveland, OH

2011

- *Introduction to Soil Science and Management,* The Ohio State University Extension, Cuyahoga and Summit counties' master gardener program. Cleveland, OH
- *Love your soil: An introduction to soil management for urban gardeners*. The Ohio State University Extension, Cuyahoga county Urban Agriculture Program, Cleveland, OH

Research sites also hosted:

- The research garden hosted three classes on soil science and gardening, one in 2011 and two in 2012. In total more than 100 people visited the site and were given tours that explained the research project.
- Approximately 12 summer interns and Americorps VISTA volunteers from the Youngstown Neighborhood Development corporation took part in constructing and maintaining the research site.
- More than 1,500 lbs of vegetables grown at the site were donated to local organizations during the two summers of the project.

Photos

Site conditions as the experimental garden was being constructed (May 2011)

Vegetable crops and sorghum sudangrass growing, six weeks after application of treatments (July 2011).

Soil science class with project partner Youngstown Neighborhood Development Corporation (March 2012).

Josh Beniston and Rattan Lal at research garden (Autumn 2012).