Beta-glucosidase and Soil Organic Carbon in Urban Conservation Agriculture

Don Immanuel A. Edralin[1], Gilbert C. Sigua[2], Godfrey A. Gayle[1] and Manuel R. Reyes[3]

[1]North Carolina Agricultural and Technical State University, Sockwell Hall, Greensboro, NC 27411
[2]Coastal Plains Soil, Water and Plant Research Center, ARS- USDA, Florence, SC 29501
[3]Feed the Future Lab for Collaborative Research on Sustainable Intensification, Kansas State University, Manhattan, KS 66506

Introduction

- The potentials of using urban areas to grow food has recently received quite an attention. Identifying agriculture systems that store carbon and enhance carbon cycling in these areas is important to maintain and improve urban soil quality.
- Conservation agriculture can be an alternative to conventional tillage in urban landscapes for soil quality improvement.
- Conservation agriculture consists of combining the following principles: Soils are not disturbed (by more than 15 cm in width or more than 25%, whichever is less, of the cropped area) or tilled periodically, (b) More than 30% of the soil has to be covered with organic residues at planting, and (c) Crop rotation has to be implemented involving at least three different crops [1,2,3,4,&5].
-) Similar systems to CA such as reduced tillage, no-till with crop rotations were inferred and observed to increase carbon storage in soils [1,6,7&8].
- Improved soil organic carbon (SOC) is advantageous for its role in enhancing soil aeration, and water and nutrient availability.
- "Soil enzyme activities, including BG (beta-glucosidase) are generally simple, low-cost measurements to perform, especially compared with other biochemical measures" [9].
- Beta-glucosidase (BG) is an important indicator of the ability of a soil ecosystem to degrade plant residues to simple sugars as food for the microorganisms, it gives an overall picture of the soils metabolic functioning ability and was found to be sensitive to different management regimes [9].

Objective

- To determine differences in beta glucosidase activity and soil organic carbon levels between conservation agriculture, no-till and conventional tillage.

Methodology

- A turf lawn at NCA&T was converted into an urban raised plot of 3'by 6' experiment, using anthropogenic soil with high organic matter content, during fall of 2011 (Figure 1).
- The experiment was laid out in randomized complete block design with four replications.
- Soils were sampled at 0-10 cm depth in 2013 & 2016 and assessed for beta-glucosidase activity and soil organic carbon.
- The results for beta-glucosidase and SOC were analyzed using SAS PROC ANOVA and means were separated at alpha=0.05 using Fisher's protected Least Significance Difference (LSD).

Figure 1. Turf lawn (a) was converted into raised plot experiment for vegetables (b). North Carolina A&T State University, Greensboro, NC.

Treatments

- Treatments: conservation agriculture summer (CA summer); conservation agriculture winter (CA winter); no-till; and tillage.
- CA summer was planted with sunhemp *(Crotolaria juncea)* during the summer (Figure 2a) while CA winter plots were planted with a mixture of clovers during winter and vegetables planted in other seasons. Residues were cut and left on the soil surface (Figure2b).
- Tillage follows the conventional turning over of soil and the removal of crop residues after each vegetable production.
- No-till involves the removal of crop residues but without disturbing the soil apart from boring holes enough for planting.

Figure 2. Sunhemp *(Crotolaria juncea)* in conservation agriculture summer treatment (a) and cut sunhemp left on the soil surface as mulch (b). North Carolina A&T State University, Greensboro, NC.

Results & Discussion

- Soil organic carbon was the same for all treatments after 2 years with an average of 5.9 percent (Figure 3).

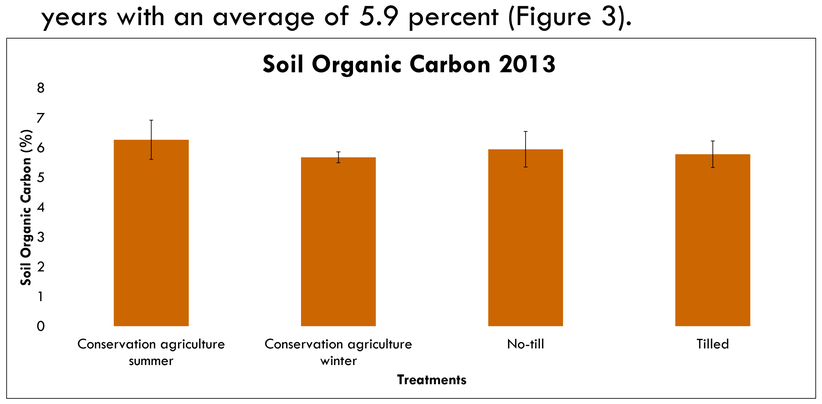

Figure 3. 2013 Percent soil organic carbon for conservation agriculture summer, conservation agriculture winter, no-till and tilled systems.

- After 5 years, CA summer and CA winter soil organic carbon were significantly higher than both tillage and no-till(Figure 4).
- The two CA systems did not differ significantly from each other having an average of 6.4 percent.
- No-till and tillage systems also did not differ from each other having an average of 5.5 percent. Tillage action did not cause differences in soil organic carbon content.

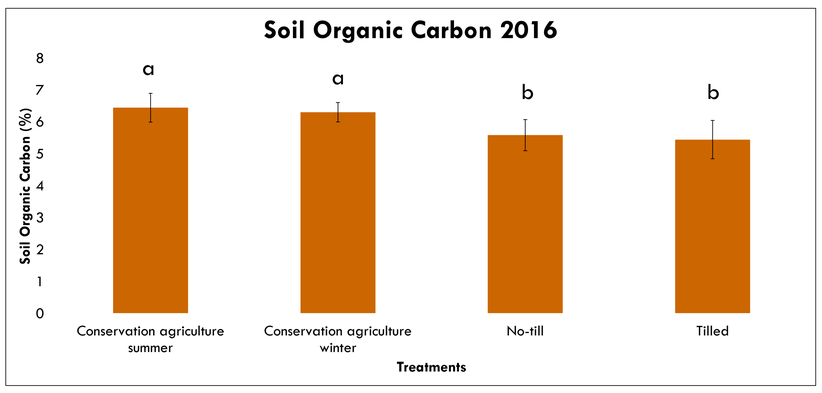

Figure 4. 2016 Percent soil organic carbon for conservation agriculture summer, conservation agriculture winter, no-till and tilled systems.

- The observations revealed that changes in soil organic carbon were not detected two years after treatment establishment but were observed five years later. This soil quality parameter takes time to change and does require high organic matter input.
- The addition of crop and cover crop residues in CA built up the organic carbon content of the soil overtime.
- Regardless of CA system, CA was able to improve the soil organic carbon content compared to no-till and tilled systems.
- Tillage and no-till, having their residues removed, did not differ in organic carbon content.
- Tillage does not appear to affect SOC build up.

- In 2013, CA summer has significantly higher BG activity than tillage by 57 µg g^{-1} hr^{-1} (Figure 5).
- CA winter, no-till and tillage BG were not different to each other in that year having an average of 172 µg g^{-1} hr^{-1}.
- In the same year, BG of CA summer, CA winter and no-till were the same 153 µg g^{-1} hr^{-1}.

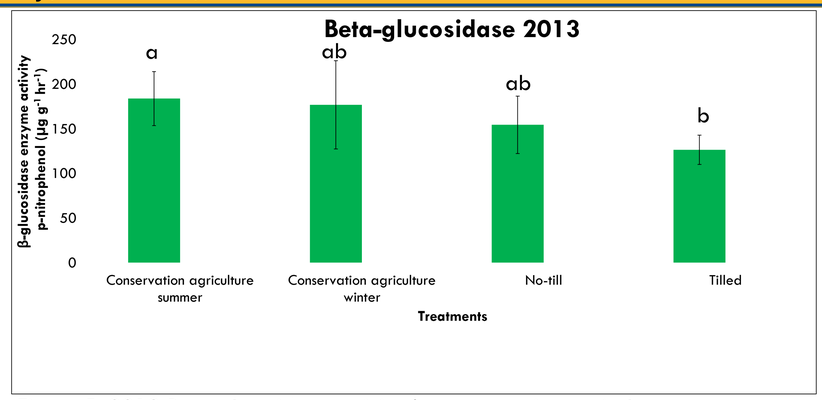

Figure 5. 2013 Beta-glucosidase activity for conservation agriculture summer, conservation agriculture winter, no-till and tilled systems.

- In 2016, CA summer has significantly higher BG activity than tillage by 221 µg g^{-1} hr^{-1} (Figure 6).
- CA summer has also significantly higher BG activity than no-till by 169 µg g^{-1} hr^{-1}.
- CA summer and CA winter were not significantly different from each other having an average BG activity of 309 µg g^{-1} hr^{-1}.
- In the same year, CA winter and no-till were the same having an average of 224 µg g^{-1} hr^{-1} BG activity.
- Tilled and no-till were also not significantly different from each other having an average of 141 µg g^{-1} hr^{-1} BG activity.

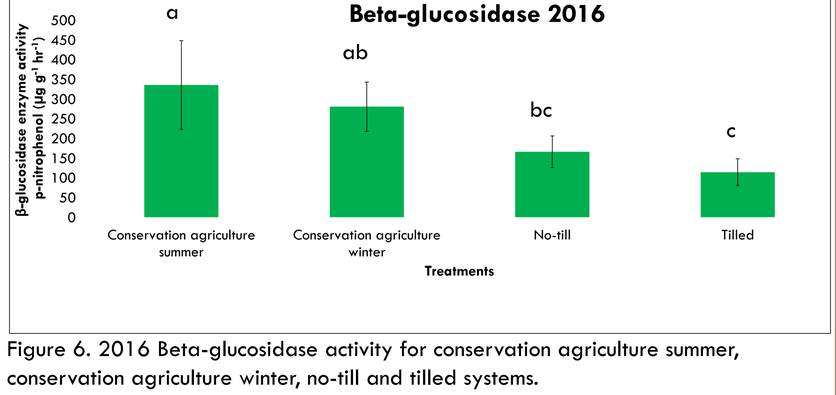

Figure 6. 2016 Beta-glucosidase activity for conservation agriculture summer, conservation agriculture winter, no-till and tilled systems.

- Changes in the soils metabolic activity as indicated by its BG activity was observed after just two years from treatment establishment even before changes in soil organic carbon occurred. CA Summer system, having a high yielding residue, consistently gave higher metabolic activity than tillage.
- Use of cover crop may have caused higher metabolic activity. Faster observed differences may be achieved by using high residue yielding cover-crop such as sunhemp.
- Tillage does not appear to affect the soils metabolic activity as seen by no-till and tilled systems having the same BG activity in both years, although both have numerically low metabolic activity than CA systems.
- No-till's metabolic activity appears to be intermediate between CA and tilled but does not appear to be optimal, with the criteria of having greater BG activity as better.

Conclusion

- Cover crops in CA, especially high residue yielding ones, play an important role in enhancing soil organic carbon levels and soil metabolic activity.
- SOC and metabolic activity were not influenced by soil tillage action but by the presence and choice of cover-crop.

References

1. Edralin, D.I.A, Sigua, G.C., Reyes, M.R. 2016. Dynamics of soil carbon, nitrogen and soil respiration in farmer's field with conservation agriculture Siem Reap, Cambodia. International Journal of Plant and Soil Science. 11(1):1-13.
2. Derpsch, R. 2008. No-tillage and conservation agriculture: A progress report. In: T. Goddard et al., editors, No-till farming systems. World Association of Soil and Water Conservation, Bangkok, Thailand. Vol. 3, p. 7–39.
3. FAO. 2001. Conservation agriculture, Case studies in Latin America and Africa. FAO Soils Bulletin 78. FAO, Rome, Italy. http://www.fao.org/docrep/003/y1730e/y1730e00.HTM (accessed 1 Nov. 2011)
4. Hobbs, P. R., K. Sayre, and R. Gupta. 2008. The role of conservation agriculture in sustainable agriculture. Philos. Trans. R. Soc. B. 363:543–555.
5. Kassam, A., T. Friedrich, F. Shaxson, and J. Pretty. 2009. The spread of conservation agriculture: Justification, sustainability and uptake. Int. J. Agric. Sustainability 7(4):292–300.
6. Edwards J.H., C.W. Wood, D.L. Thurlow, and M.E. Ruf. 1999. Tillage and crop rotation effects on fertility status of a Hapludalf soil. Soil Sci. Soc. Am. J. 56:1577-1582.
7. Govaerts, B., N. Verhulst, A. Castellanos-Navarrete, K.D. Sayre, J. Dixon, and L. Dendooven. 2009. Conservation agriculture and soil carbon sequestration: Between myth and farmer reality. Crit. Rev. Plant Sci. 28(3):97–122.
8. West, T.O., and W.M. Post. 2002. Soil organic carbon sequestration rates by tillage and crop rotation: A global data analysis. Soil Sci. Soc. Am. J. 66:1930–1946.
9. Stott, D.E., S.S. Andrews, M.A. Liebig, B.J. Wienhold and D.L. Karlen. 2009. Evaluation of β-glucosidase activity as a soil quality indicator for the soil management assessment framework. Soil Sci. Soc. Am. J. 74:107-119.

Poster # 1339
SSSA Session: Sustainable Soils in Urban Environments- Water, Carbon, Mapping, Assessment and Reclamation
2017 ASA, CSSA, and SSSA Annual Meeting
Tampa Convention Center, East Exhibit Hall,
Tampa Florida, October 23, 2017

This project was made possible through support provided by the United States Department of Agriculture Evan-Allen Research Program and Coastal Plains Soil, Water and Plant Research Center, Agriculture Research Service with some funds from the United States Agency for International Development (USAID) through the generous support of the American people for the Feed the Future Sustainable Agriculture and Natural Resources Management Innovation Lab. The views reflected herein does not necessarily reflect that of USDA, USAID or the US Government.