Improving soil health with a multispecies cover cropping system: preliminary and intermediate data and analysis

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Abstract

Cover cropping is a cultural practice that can be used for soil health improvement. Organic matter accumulation and high levels of microbial activity near the soil surface can prove beneficial. Cover crops can provide increased levels of nitrogen though symbiotic fixation and can help recycle other nutrients thereby reducing producer costs. In the fall of 2012 a multi-species cover crop was established on part of a field that had been used for 15+ years to produce corn (*Zea mays*) silage under a conventional or reduced tillage. In the fall of 2014 soil health tests were conducted on the cover cropped portion of the field and on the non-cover cropped portion of the same field. In 2015 and 2016 soil health tests were repeated. Soil health tests measure characteristics such as aggregate stability, porosity, and biological activity, for instance, the number of earthworms per cubic foot of soil. Three years of data appear to show a trend toward soil health improvement, however there is year to year variation. Indicative of this improvement is the increase in earthworm numbers in the cover cropped areas compared to non-cover cropped areas. Research was supported by the MSU Department of Agricultural Sciences and MCTCS.

Introduction

The productivity of the soil is strongly influenced by the properties and characteristics of that soil. According to Carter and Stewart (1996) the productivity of the soil is reliant on properties that affect the organic matter storage and accumulation of that soil. Soil compaction, loss of structure, and loss of porosity can result in the restriction of root growth and restriction of beneficial microbe growth (Saoirse, et al. 2013). Soil quality evaluations consider biological, chemical, and physical properties and processes occurring within the soil environment. Assessment of soil quality is a process through which soil resources are evaluated based on soil function and change in soil function in response to a specific natural or introduced stress/management practice. Each test is considered to be an indication of the level of functioning (Agricultural Research Service, Natural Resources Conservation Service, 2001). The properties of soils that display poor soil quality are; soil erosion, reduced biomass production, reduced microbial populations and continued presence of standing water on the field. Increasingly, researchers are investigating the use of cover cropping practices to remediate soil properties that have deteriorated under standard production techniques. Therefore an ongoing study has been established at the Derrickson Agricultural Complex to evaluate the use of cover cropping practices for improvement of soil characteristics of Eastern Kentucky soils.

Materials and Methods

In the fall of 2012 a study was established at the Morehead State University Derrickson Agricultural Complex. An 11-acre field that had been used for silage corn production continuously for over 15 years was used for the study. The field is mapped as a Tilsit silt loam with 2-6% slope (United States Department of Agriculture Forest Service and Soil Conservation Service, 1974). The field had been managed under variable regimes including full tillage and no-tillage either with no cover crop or with winter wheat (*Triticum aestivum* L.) cut and baled before corn planting. The field displayed reduced production performance and reduced soil structure while exhibiting increased compaction. One side of the field, consisting of approximately 5.5 acres, was sown with a cover crop mix consisting of Austrian winter pea (*Pisum sativum* L. ssp. *sativum var.arvense*), crimson clover (*Trifolium incarnatum* L.), daikon radish (*Raphanus sativus* L. *var. longipinnatus*), and rye (*Secale cereal L.*). In October 2014 alsike clover (Trifolium hybridum L.) was added to the cover crop mix. It was designated as Cover Crop (CC). The other side of the field was designated as Manager's Choice (MC) and continues to be managed similarly to what it was prior to test establishment. Each management sector was divided into three sampling units with the cover cropped side designated as CC1, CC2, and CC3 and the manager's choice side designated as MC1, MC2, and MC3. Cover Crop seeding dates and rates are as listed in tables 1 and 2. Corn for silage production was established in both management units using no-tillage practices. The corn on the CC side was seeded directly into the cover crop that had been roller crimped. Standard weed control and fertilizer management practices were used on both management units. After silage harvest the cover crops were again established on the CC section. In the fall of 2014, 2015, and 2016 following the harvest of corn silage from the field, soil health assessment procedures were conducted using the protocols approved by the Natural Resources Conservation Service (NRCS). The assessments conducted were soil respiration, bulk density, electrical conductivity, soil water pH, soil nitrate, aggregate stability, slake, and earthworm counts. An additional assessment, visible surface earthworm activity, was taken in the fall of 2015.

Table 1. Cover crop seeding and termination dates

Years	Seeded	Terminated
2012/2013	Oct 5	May 21
2013/2014	Sept 19	May 19
2014/2015	Sept 23	May 11
2015/2016	Sept 18	May 25

Visible surface earthworm activity (holes and castings) assessments were conducted by pacing out 60 yards and counting activity touching the right toe of the pacer's boot. Each plot was paced twice and the numbers were summed. Surface conditions did not allow visible activity to be assessed in 2016. Also soil samples were collected and sent to the University of Kentucky Soil Testing Laboratory for a standard soil test plus organic matter analysis and to the Agricultural Research Service research laboratory in Temple Texas for the Haney Soil Health Tests performed by ARS researcher Dr. Rick Haney. Soil samples, one from each alternative practice half of the field, were sent to Earthfort Labs in Corvallis Oregon to perform a Food Web analysis of soil organisms. (This data is not reported here.)

Table 2. Seeding rates of cover crops

Cover Crop Species	Seeding rate (lb/A)
Rye	35
Crimson clover	3
Austrian winter pea	35-50
Daikon radish	4

Figure 1. Cover Crop portion of silage field showing Crimson Clover, Austrian Winter Pea and Rye.

Results

Initial observations of the physical characteristics of the plot soils revealed that the surface soil of the three cover cropped sections had a soil structure classified as blocky. The surface layer of the sections of the Manager's Choice plot had soil structure classified as platy. The soil physical characteristics are displayed in Table 4. Statistical analysis showed no significant difference in bulk density over the years and also showed no significant difference in bulk density between CC and MC plots. Statistical analysis of the earthworm count showed a significant difference in the total number over the years. The mean numbers of earthworms were 6.3 in 2014, 10.0 in 2015and 17.1 in 2016. Analysis of earthworm count data over all years appears to show large difference in worm presence attributable to the cover crop, however these numbers are not significantly different ($p = 0.08$). Mean earthworm numbers averaged over years were 17 on the cover cropped area and 5.3 on the manager's choice area.

Statistical analysis of visible earthworm surface activity for 2015 (Table 3) showed significant differences between the different management systems. The CC section had a mean of 82.7 while the MC mean was 23.3. for 2015 surface earthworm activity and actual earthworm count are highly correlated ($r = 0.92$). We were unable to collect similar data in 2016. Due to space limitations we have only presented earthworm data, CO_2 evolution, and soil physical characteristics.

Conclusion

After the fourth cover cropping cycle the evidence suggests a trend toward improved soil health. Increases in biological activity in the cover cropped sections as evidenced by differences in earthworm numbers and carbon dioxide evolution that are approaching statistical significance tend to indicate better soil health. . Further trends toward improvement are shown by the differences in aggregate stability that is approaching significance and differences in slake class that are significant.

Figure 2. Cover Crop stand November 2015

Table 3. Earthworm Data 2015

	Surface earthworm Activity	Actual Earthworm count
CC1	57	15
CC2	83	12
CC3	108	20
CC MEANS	**82.7**	**15.7**
MC1	15	4
MC2	33	5
MC3	22	4
MC MEANS	**23.3**	**4.3**

Figure 3. Cover crop mechanically terminated with crimper roller.

Figure 4. Cover crop plot earthworm count.

Table 4. Soil Health Test Data Means

Test	2014 CC Means	2015 CC Means	2016 CC Means	3-year CC Means	2014 MC Means	2015 MC Means	2016 MC Means	3-year MC Means
Earthworm Count	12.3	15.7	23.0	17.0	0.33	4.3	11.33	5.32
Aggregate Stability (%)	63.1	48.3	56.8	56.1	54.1	37.1	46.1	45.8
CO_2 Evolution (lb/A/day)	28.4	51.6	17.6	32.5	13.3	37.3	21.8	24.1
Slake Index	5.4	5.2	6.0	5.52	5.0	3.6	5.7	4.8

Figure 5. Rolled cover crop prior to corn planting.

Figure 6. Corn emergence in cover crop residue.

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