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Project Title: Maximize continuous no-till sustainability with cover crop blends and zeolite

Project Leader(s):
Rafiq Islam
Soil, Water and Bioenergy Specialist
Ohio State University South Centers
1864 Shyville Road, Piketon, OH 45661
Phone: 740-289-2071 Fax: 740-289-4591
islam.27@osu.edu
http://southcenters.osu.edu/soil-and-bioenergy

Randall Reeder
Professor Emeritus and Extension Engineer
Dept. of Food, Agricultural and Biological Engineering
The Ohio State University
Tel 614-292-6648
reeder.1@osu.edu

Producer(s) and Location of Farm(s):
David Brandt
Brandt's Family Farm
6100 Basil Western Road
Carroll, OH 43112
Phone: 740-438-4620
brandtsfarm@yahoo.com

GOAL AND SPECIFIC OBJECTIVES

The goal of our on-farm research study was to evaluate the potential of an innovative combination of continuous NT, multi-functional cover crop blends and Zeolite for enhanced agroecosystem services including economic crop yields, weed control, C sequestration, compaction alleviation, soil health and farm productivity. Specific objectives were to:

- Identify appropriate mixing of cover crops for efficient creation and recycling of nutrients to support NT grain crops
- Determine the effectiveness of cover crops to control weeds in NT crop rotation
- Measure the effects of Zeolite on N and P availability to plants, and
- Evaluate the temporal effects of continuous NT, cover crops and Zeolite on selected biological, chemical, and physical indicators of soil quality

MATERIALS AND METHODS

The on-going field research study was conducted at Brandt's Family Farm, 6100 Basil Western Road, Carroll (Fairfield County), Ohio using randomized complete block design (3 cover crop blends x 3 Zeolite levels) with 3 replications in a split-plot experiment under NT.

Cover crop blends and Zeolite were considered as main plot (900-ft x 100-ft) and sub-plot (300-ft x 100-ft), respectively. The NT cover crop blends as a main plot were: **(1) Cover crop blend-1:** *Cowpea, winter pea, soybeans, Sun hemp, oilseed radish, carrot, oats, rye, pearl millet and Sudan-sorghum;* **(2) Cover crop blend-2:** *Cowpea, soybeans, hairy vetch, red clover, Phacelia, oil seed radish, pearl millet, Sudan-sorghum, sunflower, turnip and rye;* **(3) Cover crop blend-3:** *Cowpea, soybeans, Sun hemp, sweet clover, sunflower, oil seed radish, pearl millet, rye, Ethiopian cabbage, kale and turnip, and* **(4)** ***Control*** (compared with standard NT without any cover crops). Zeolite as a sub-plot was surface applied in fall at 0, 500 and 1000 lbs/ac, respectively within each NT cover crop blend.

After harvesting wheat, the cover crop blends were drilled by the 3rd week of July, 2014. In 1st week of October (during maximum vegetative growth), the shoot biomass of cover crop blends were randomly sampled from 3 subplots (3-ft x 3-ft) within each replicated plot. The samples were oven-dried at 65^{0}C, ground and analyzed for total C and N contents.

Prior to lay-out of the experiment, GPS guided composite soil samples were collected at 0 to 6 and 6 to 12-inch depths from each replicated plot for baseline information. Soil samples were analyzed for (1) Biological properties: total microbial biomass C, N and P, biological activity, and metabolic efficiency; (2) Chemical properties: pH, total organic C and N, and active C; and (3) Physical properties: bulk density, total porosity, and aggregate stability.

RESULTS

Biomass production and total carbon and nitrogen contribution of cover crop blends

Results showed a significant variation in growth and biomass production and total carbon and nitrogen contribution of different cover crop blends (**Table 1 and Photo 1-3**). Photo 1-3 showed the growth and biomass production of cover crop blend-1 (Ccrop-1), Ccrop-2 and Ccrop-3, respectively. Among the cover crop blends, the Ccrop-1 had the highest biomass production (both fresh and dry weight basis) followed by Ccrop-3 and Ccrop-2, respectively (**Table 1**).

While Ccrop-2 had the highest total biomass N concentration, it did not vary significantly with other cover crop blends. All the cover crop blends had C: N below 20. When the total biomass N concentration was multiplied with the total amount of dry biomass, the amount of possible biomass N contribution among the cover crop blends did not vary significantly.

All of cover crop blends showed a possible contribution of biomass N (due to biological N fixation and soil N recycling) over 100 kg/ha for the next crop. However, possible contribution of biomass C was significantly different among the cover crop blends. The Ccrop-1 had the highest possible C contribution followed by Ccrop-3 than the Ccrop-2.

Preliminary results based on total dry biomass production with substantial amount of possible N contribution by the tested cover crop blends suggested that these cover crop blends were able to produce enough biomass to cover the ground and contribute significant amount of N to support agronomic crops especially corn.

Table 1: Cover crop blends biomass production, biomass carbon and nitrogen concentration and nitrogen and carbon contribution in soil.

Cover crop Blend	FBM	DBM	DBM/ FBM	TN	TC	CN ratio	TN (kg/ha)	TC (Mg/ha)
	___ (Mg/ha) ___			___ (%) ___				
Ccrop-1	38.8a¥	5.5a	14.3a	2.30a	42.6a	19.9a	126.3a	2.37a
Ccrop-2	20.8b	3.3c	15.9a	3.01a	42.8a	14.4a	100.1a	1.40c
Ccrop-3	25.3b	4.3b	17.3a	2.35a	41.9a	18.7a	101.1a	1.80b

TN=Total nitrogen, TC=Total carbon, FBM=Fresh biomass, and DBM=Dry biomass.
¥Means separated by lower case letter in each column were not significantly different at $p<0.05$ level among the cover crop blends.

Photo-1: Cover crop blend-1: Cowpea, winter pea, soybeans, Sun hemp, oilseed radish, carrot, oats, rye, pearl millet and Sudan-sorghum

Photo-2: Cowpea, soybeans, hairy vetch, red clover, Phacelia, oil seed radish, pearl millet, Sudan-sorghum, sunflower, turnip and rye.

Photo-3: Cowpea, soybeans, Sun hemp, sweet clover, sunflower, oil seed radish, pearl millet, rye, Ethiopian cabbage, kale and turnip.

Baseline soil information

Analysis of composite soil samples collected at 0-6 and 6-12 inches depth has shown a significant variation in biological properties between 2 depths (**Table 2**). Surface soil had higher concentration of total microbial biomass carbon (MBC), nitrogen (MBN) and phosphorus (MBP), metabolic quotient (qR), basal respiration (BR) and mineralizable C (C_{Min}) than the sub-surface soil (6-12 inches depth).

Soil chemical properties varied significantly between 2 depths (**Table 3**). While pH did not vary significantly between depths, the EC was higher at surface soil than at sub-surface depth. Total and active organic C concentrations were significantly higher at surface soil compared with sub-surface soil. Likewise, total N was higher at surface soil. While soil aggregate stability (AS) and total porosity (TP) were higher, the bulk density (ρb) was significantly lower at surface soil than that of sub-surface soil.

When the concentration of MBC, MBN, MBP, TC, AC and TN was multiplied with the concurrently measured ρb, the stocks of MBC, MBN, MBP, TC, AC and TN varied significantly between depths (**Table 4**). Surface soil had higher MBC (2.5 times), MBN (1.7 times), MBP (27%), TC (59%), AC (25%), and TN (67%) stocks than the sub-surface soil.

Table 2: Baseline information on soil microbial biomass carbon, nitrogen and phosphorus contents and associated biological properties at different depths.

Depth (inch)	MBC (mg/kg)	qR (%)	MBN (mg/kg)	qN (%)	MBP (mg/kg)	BR (mg/kg/d)	qCO_2 (mg/mg/d)	C_{Min} (%)
6	233.7a	1.5a	36.1a	2.42a	18.5a	20.4a	0.090a	2.0a
12	84.4b	1.0b	19.0b	2.15a	13.2b	6.2b	0.073a	1.1b

MBC=Total microbial biomass carbon, qR=Total microbial biomass carbon over total organic carbon, MBN=Total microbial biomass nitrogen, qN=Total microbial biomass nitrogen over total nitrogen, MBP=Total microbial biomass phosphorus, BR=Basal respiration, qCO_2=Specific maintenance respiration, C_{Min}=Mineralizable carbon.

¥Means separated by lower case letter in each column were not significantly different at $p<0.05$ level among the cover crop blends.

Table 3: Baseline information on soil chemical and physical properties at different depths.

Depth (inch)	pH_{water} (1:1)	pH_{KCL} (1:1)	EC (dS/cm)	TC (%)	AC (mg/kg)	TN (%)	CN ratio	AS (%)	ρb (g/cm^3)	Tp (%)
6	6.0a	5.2a	95.3a	1.52a	638.1a	0.149a	10.2a	79.4a	1.56b	41.3a
12	6.0a	5.1a	66.3b	0.87b	475.6b	0.088b	9.8a	69.4b	1.72a	35.0b

EC=Electrical conductivity, TC=Total organic carbon, AC=Active carbon, TN=Total nitrogen, AS=Aggregate stability, ρb=Bulk density, and Tp=Total porosity.

¥Means separated by lower case letter in each column were not significantly different at $p<0.05$ level among the cover crop blends.

Table 4: Baseline information on stocks of soil microbial biomass carbon, nitrogen and phosphorus, total and active carbon and total nitrogen at different depths.

Depth (inch)	MBC	MBN (kg/ha)	MBP	TC	AC (Mg/ha)	TN
6	546.8a	84.5a	43.3a	35.6a	1.5a	3.5a
12	217.7b	49.0b	34.1b	22.4b	1.2b	2.1b

MBC=Total microbial biomass carbon, MBN=Total microbial biomass nitrogen, MBP=Total microbial biomass phosphorus, TC=Total organic carbon, AC=Active carbon, and TN=Total nitrogen.

¥Means separated by lower case letter in each column were not significantly different at $p<0.05$ level among the cover crop blends.