REPORT
Project GREEEN: MSUE Regional Proposal

"Comparing multi-species and mono-culture cover crop systems to improve soil fertility and crop performance in Michigan's Upper Peninsula"

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PERSONNEL

- Jim Isleib, MSU Extension U.P. Crop Production Educator, primary investigator
- Dr. Doo-Hong Min, MSU Extension Forage Specialist, team member
- Dr. Dale Mutch, MSU Extension Cover Crop/Field Crops IPM Specialist, team member
- Christian Kapp, MSU Research Center Technician, team member
- Rowan Bunce, Alger County Farmer, team member

PROBLEM STATEMENT:

Many Upper Peninsula farms are situated in areas with marginal soil fertility. Improving crop performance through crop rotation and utilization of cover crop systems has been identified by the Growing U.P. Agricultural Association research committee as a PROJECT GREEEN agronomy priority for the Upper Peninsula.

A series of MSUE educational programs was held across the Upper Peninsula in 2008 featuring Dr. Dale Mutch. Evaluations indicated interest in utilizing cover crops in the region, but identified obstacles including short growing season and long hay/pasture rotations without many opportunities for including cover crops into cropping systems. However, smaller direct-market produce growers, especially those without convenient access to adequate amounts of livestock manure, were more open to the idea of utilizing cover crops in their systems.

North Dakota cash crop farmers have experienced success with a multi-species cover crop "cocktail" seed mixture. This project was intended to compare the potential of this type of cover crop seed mixture with current cover crop species selections to improve crop performance on a small, diversified, 'natural' farm (organic cropping methods, but not certified as 'organic').

OBJECTIVES AND HYPOTHESES:

Objectives: 1) Compare differences in crop performance following 3 season-long cover crop treatments including a multi-species cover crop seed mixture as currently used by North Dakota no-till grain farmers, a typical legume and grass mono-culture cover crop seeding, and fallow. 2) Model economic potential of using a multi-species, season-long cover crop to enhance soil fertility.

Hypotheses: Crop performance following a full-season, multi-species cover crop will be better than crop performance following a typical mono-culture cover crop or fallow treatment. Soil

tests will indicate a trend of enhanced soil fertility, including organic matter content, following the multi-species cover crop treatment. Utilization of multi-crop cover crop will compare favorably economically to utilization of mono-crop or fallow treatment.

METHODS AND PROCEDURES:

Overview:

Four cover crop treatments were grown in a replicated, randomized complete block design in 2011 at Rock River Farms in Chatham, MI on an old pasture site. A soil test representing the entire test site was collected before planting in 2011. Grazing was simulated by mowing ½ of the plant material in early fall of 2011. The mowed material was not removed. The plots were left undisturbed to over-winter. In spring 2012, representative soil tests for each treatment were collected, the plot site roto-tilled, and Excel oats were seeded uniformly over the trial site. No synthetic or organic fertilizers were added to the plots during the trial. Oats were harvested from within each plot of the 2011 cover crop plot boundaries. Oat yield samples were processed and data was analyzed. A final set of soil tests was collected representing the four cover crop treatments in September, 2012. Personnel and equipment from the MSU U.P. Research Center were used to prepare the site, plant cover crops and oats, harvest oats and process samples.

The trial was viewed as part of an August 9, 2011 field day at the Bunce Farm, "Rock River Farm", sponsored by the Michigan Farm Market Association. 13 farmers and agency people viewed the plots.

Treatments:

Cover crop selections:

1. Marathon red clover, 12 lbs/acre
2. Special Effort hybrid sorghum sudangrass, 30 lbs/acre
3. N-builder mix, 32 lbs/acre
    - Consisting of:
        - 4 lbs LS0090 soybeans
        - 4 lbs CDC Rosetown lentils
        - 10 lbs Arvika forage peas
        - 1 lb yellow sweet clover
        - ½ lb purple-top turnips
        - 1 lb oil-seed radish
        - 4 lbs GEM-X pearl millet
        - 4 lbs 126 forage oats
        - 1/3 lb PS9441 sunflower
4. Fallow

Trial details:

- County: Alger
- Nearest town: Chatham
- Soil type: Eben very cobbly sandy loam
- Tillage: Tractor mounted rototiller prior to cover crop seeding on June 8, 2011 and oat seeding on May 14, 2012
- Previous crop: old, mixed sod prior to cover crops
- Fertilizer: No synthetic or organic fertilizers were added
- Planting dates: Cover crop plots – June 29, 2011
  Oats – May 14, 2012
- Sorghum sudangrass and Nitrogen Builder cover crop plots mowed to remove ½ vegetation on September 26, 2011. Mowed material was not removed.
- No lime, fertilizer or herbicide
- Fallow treatment tilled bi-weekly during 2012 growing season
- Soil tests collected June 14, 2011, May 14 and Sept 25, 2012
- Oat harvest: August 15, 2012
- Plot size: 6' X 32', harvested area: 4' X 32'
- Experimental design: Randomized complete block, 4 replications

Data Collection:

Plot yield, moisture and test weight of oats was tabulated, corrected to 13.5% moisture and converted to yield in bushels per acre. Statistical analysis was done using AgStats02, a simple, statistical analysis program for on-farm testing developed at Oregon State University and available on-line at http://pnwsteep.wsu.edu/onfarmtesting/index.htm. In addition, a photographic record of the project was kept.

RESULTS

Oat Yield:

Agricultural Statistics Analysis Program

Title: Cover Crop Trial, Project GREEEN-funded, Bunce Farm, Alger Co, MI 2011-12

Experimental Design

○ Completely Randomized Design (CRD) ◉ Randomized Complete Block Design (RCBD)

Level of Significance

○ 1% ○ 5% ○ 10% ◉ 20%

	Replication/Block 1	Replication/Block 2	Replication/Block 3	Replication/Block 4	Treatment Mean
Fallow	80	91	67	129	92
Red clover	85	103	83	98	92
Sorghum Sudan	109	93	95	111	102
Nitrogen Builder	104	108	103	120	109
Replication/Block Mear	95	99	87	115	99

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Source	Degree of Freedom	Sum Square	Mean Square	Observed F	P value	
Total	15	3,675	245			
Treatments	3	807	269	2	19.45%	Significant
Blocks	3	1,617	539	4	4.96%	Significant
Error	9	1,252	139			
Required F	2					
Correction Factor	155,828					
Standard Deviation	12					
Coeff. of Variation	12%					

LSD	12	
Treatment Name	Mean	
Fallow	92	A
Red clover	92	A
Sorghum Sudan	102	AB
Nitrogen Builder	109	B

Table 1. *Oat yields following cover crop treatments, Rock River Farms, Alger Co., MI 2012*

Oat test weight:
No significant difference in oat test weight was seen based on prior cover crop treatments.

Soil test results:

	Fallow							
	pH	LI	P	K	Mg	Ca	CEC	OM
June '11	6.2	67	91	134	170	942	10.1	4.5
May '12	5.9	65	113	129	146	1055	12.8	3.2
Sept '12	6.0	67	91	89	107	702	8.2	3.7

Table 2.

	Red Clover							
	pH	LI	P	K	Mg	Ca	CEC	OM
June '11	6.2	67	91	134	170	942	10.1	4.5
May '12	5.9	65	105	152	158	1207	13.7	3.5
Sept '12	5.9	66	75	97	122	811	10.1	3.4

Table 3.

	Sorghum Sudangrass							
	pH	LI	P	K	Mg	Ca	CEC	OM
June 2011	6.2	67	91	134	170	942	10.1	4.5
May 2012	5.9	66	89	145	164	1073	11.9	3.4
Sept 2012	6.1	67	91	115	137	836	9.2	3.6

Table 4.

	Nitrogen Builder							
	pH	LI	P	K	Mg	Ca	CEC	OM
June 2011	6.2	67	91	134	170	942	10.1	4.5
May 2012	6.0	66	120	174	173	1247	12.9	3.4
Sept 2012	5.9	65	120	126	152	951	12.3	3.9

Table 5.

Tables 2-5. *Soil test results from test site in June 2011 (prior to cover crops), May 2012 (following cover crops) and September 2012 (following oats)*

DISCUSSION

Oat yield following the cover crop treatments in this trial gives a single indication of the impact of a single year cover crop treatment. Other factors, including weed suppression, were not included in this trial. Soil test results following cover crops and after the next year's oat crop are not meant to be conclusive and were not subjected to statistical analysis. Rather, information on short-term changes in soil conditions was observed informally. This 2-year trial was not expected to result in dramatic changes in crop yield or soil conditions. Cover crops are understood to be a long-term investment in soil health and crop performance, with benefits becoming more apparent over several seasons.

Statistical analysis of oat yield data did not result in significant yield differences at 1%, 5% or 10% level of significance. Yield differences were significant at 20% level of significance. In simple terms, this means that there is a 20% chance that these results are wrong (or a 4 in 5 chance that they are right). This result lessens confidence in the conclusiveness of the trial but allows for limited conclusions to be made. There were no significant differences in oat test weight based on the cover crop treatments. The soil test data is not meant to be conclusive, simply to demonstrate the short-term changes in soil fertility that can occur under this type of practice.

Oat yields following the fallow, red clover and sorghum sudan grass cover crop treatments were not different statistically. Oat yield following the "Nitrogen Builder" cover crop treatment was significantly higher than the fallow and red clover cover crop treatments, at 20% level of significance. Oat yield following the sorghum sudan grass cover crop treatment was not significantly different from oat yield following the fallow, red clover or Nitrogen Builder cover crop treatments.

The initial soil test on this trial site reveals a healthy, relatively fertile and well-drained soil high in organic matter. Soil test results show a drop in soil organic matter following the cover crop season. This is likely due to thorough tillage prior to seeding cover crops and resulting oxidation and decomposition of raw organic matter. Soil organic matter showed an increase on all treatments except red clover following the oat crop. The increase in Cation Exchange Capacity (CEC) from June 2011 to May 2012 on all 4 treatments may be due to the increased volume of humus resulting from the breakdown of a large volume of organic matter from the previous crop of old, dense sod. CEC seemed to decline following the oat crop. Changes in pH and nutrient levels may be the result of initial tillage of old sod, incorporation of cover crop residues, and nutrient removal from the oat crop. The inclusion of a cover crop can be expected to help maintain soil organic matter following the initial plowdown of an old, dense sod and in following cropping years. Sampling error, difference in sampling dates, and other variables must be considered when interpreting soil test results. It must be noted that these soil test data are not conclusive and are for demonstration purposes only.

<u>Economic comparison:</u>

The cost of establishing a cover crop of 'Nitrogen Builder' seed mixture is estimated as follows:

Seed: 32 lbs/acre X $75/100 lbs =	$24/acre
Tillage (moldboard plow + tandem disk 2X) =	$39/acre
Seed drill =	$10/acre
TOTAL =	$73/acre (+$15/acre if glyphosate is used)

Assume livestock are used to graze the Nitrogen Builder cover crop once:

1 ton/acre dry matter grazed @ $90/ton dry matter = $90

Net gain for cover crop year: $90 forage value - $73 establishment cost = $17/acre

Expected return for conventionally produced oats (80 bu/acre @ $3.85/bu + 1.5 tons straw/acre X $90/ton) = $108.09/acre *(see attached enterprise budget)*

The Nitrogen Builder cover crop does not compare favorably with oats in a simple, one-year economic comparison based on conventional systems using synthetic fertilizer and herbicides and including livestock grazing. However, the potential for reduced fertilizer needs in the following year, along with probable improvements in soil health and tilth due to crop diversification and incorporation of organic matter, have potential to improve the comparison. If incorporated into a regular rotation, as done currently on North Dakota no-till farms, long term advantages are possible.

The Nitrogen Builder cover crop has potential to compare favorably with other cover crop/green manure choices.

	Cost of cover crop seed per acre (A)	Oat yield above fallow treatment	Value of oat yield @ $3.85/bu above fallow treatment (B)	B - A
Fallow	$0	0 bu/acre	$0.00/acre	$0.00
Red Clover	$33.12	0 bu/acre	$0.00/acre	-$33.12
Sorghum Sudangrass	$15.00	10 bu/acre	$38.50/acre	$23.50
Nitrogen Builder	$24.00	17 bu/acre	$65.45/acre	$41.45

Table 6. *Comparison of cover crop seed costs vs value of resulting oat yield*

The Nitrogen Builder cover crop treatment resulted in the most favorable economic comparison based on yield of oat crop the following year.

CONCLUSIONS

Oat yield was better following Nitrogen Builder cover crop treatment than following fallow or red clover cover crop treatments in 2012 on this trial site. There was not a statistically significant difference between oat yield following sorghum sudangrass and Nitrogen Builder cover crop treatments. Soil tests following the cover crop showed a modest increase in P, K, Mg, Ca and CEC under the Nitrogen Builder cover crop treatment. Soil organic matter, pH and lime index content were reduced. The Nitrogen Builder multi-species cover crop treatment compared favorably to the fallow and mono-culture cover crop treatments included in the trial.

Attachment – Budget for oats without forage seeding, conventional production

Ag Decision Maker -- Iowa State University Extension					
U.P. Oats - without hay seeding					
Crop					
U.P. Oats without hay seeding			**Acres**	25	
Field Name			**Expected Grain Yield**	80	bu. / acre
Example			**Straw Production Level**	1.5	tons / acre
		Cost per Acre			**Total Cost**
Preharvest Machinery		Fixed	Variable	**Total**	**All Acres**
Spray herbicide		$5.46		$5.46	$137
Tandem disk w/harrow (2 times)		18.54		$18.54	$464
Spread fertilizer		6.21		$6.21	$155
Seed (drill)		10.00		$10.00	$250
Other		-	-	$0.00	$0
Total per acre		$40.21	$0.00	**$40.21**	**$1,005**
Total all acres		$1,005	$0	**$1,005**	----
Seed, fertilizer, etc.					
Seed			24.88	$24.88	$622
price per bushel	*$9.95*				
bushels per acre	*2.5*				
Total Seed Cost			**$24.88**	**$24.88**	**$622**
		Cost per Acre			**Total Cost**
		Fixed	**Variable**	**Total**	**All Acres**
Nitrogen (urea)			40.80	$40.80	$1,020
price per pound	*$0.68*				
pounds per acre	*60*				
Phosphorus			$23.85	$23.85	$596
price per pound	*$0.53*				
pounds per acre	*45*				
Potash			$63.80	$63.80	$1,595
price per pound	*$0.58*				
pounds per acre	*110*				
Total Fertilizer Costs			**$128.45**	**$128.45**	**$3,211**

Herbicide			$13.15	$13.15	$329
Lime (estimated annual cost)			$15.00	$15.00	$375
Harvesting Costs					
Combine		$29.09		$29.09	$727
Haul Grain		1.60	2.40	$4.00	$100
fixed cost per bushel	*0.02*				
variable cost per bushel	*0.03*				
Bale straw (small bales)		77.44		$77.44	$1,936
Haul Straw		1.10	1.60	$2.70	$68
fixed cost per ton	*1.10*				
variable cost per ton	*1.60*				
Total Grain/Straw Harvest		**$109.23**	**$4.00**	**$113.23**	**$2,831**
Costs and Returns					
		Cost per Acre			**Total Cost**
Total Costs		**Fixed**	**Variable**	**Total**	**All Acres**
Per acre		$149.44	$185.48	$334.92	$8,373
Returns				**Total**	**All Acres**
Expected Price per bu.	*$3.85*			$308.00	$7,700
Grain Yield	*80 bu. / acre*				
Expected Straw Price per ton	*$90.00*			$135.00	$3,375
Straw Yield	*1.5 T/ acre*				
		Cost per Acre			**Total Cost**
		Fixed	**Variable**	**Total**	**All Acres**
Total returns				**$443.00**	**$11,075**
			Net Return per Acre Over		
			Variable	**Total**	**Net Return**
			Costs	**Costs**	**All Acres**
Net Returns			**$257.53**	**$108.09**	**$2,702**
Version 1.0					
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