NWHRC Open House
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Tart Cherry Orchard Soil Health Research
George Bird, Nikki Rothwell, Dean Baas and Bill Klein

Impact of Cherry Orchard Floor Management on Soil and Productivity

Six Year Means	Straw/Hay Mulch	Vegetation	Compost	Conventional
Carbon (mg/kg)	10,750 a	11,966 a	9,602 ab	8,670 b
Nitrogen (mg/kg)	740 b	1,000 a	725 b	713 b
C mineralization (mg/g)	675 b	775 a	825 a	550 c
N mineralization (mg/g)	45 a	47 a	55 a	35 b
Nematode Ratio (B+F/P)	8 a	4 b	8 a	3 b
Cherry Yield (tons/ha)	**18.5 a**	**14.7 b**	**15.0 b**	**15.9 b**

Soil + Management ⟶ Patterns of Soil Health and Cherry Productivity

Sanchez *et al*., 2003

2012--2014 NWHRS Cover Crop Trial
Four-tree plots (south end of trial)
Five Treatments

End of row filler tree	End of row filler tree	End of row filler tree	End of row filler tree
X	x	x	
5. Non-Treated Control	5. Non-Treated Control	5. Non-Treated Control	5. Non-Treated Control
X	x	x	
1. Starter 101, compost & mulch	2. Starter 101 & compost	3. Starter & mulch	4. Compost & mulch
X	x	x	x
X	x	x	x
X	x	x	x
X	x	x	x

2011 **NORTH**

Row 4	Row 3	Row 2	Row 1
1 B	7 A	13 E	19 C
2 C	8 E	14 C	20 D
3 A	9 C	15 F	21 E
4 D	10 B	16 D	22 A
5 E	11 F	17 A	23 B
6 F	12 D	18 B	24 F
WEST 25 F fall compost (didn't happen in 2010) compost	EAST 25 F fall compost	WEST 26 F no compost	EAST 26 F no compost

4 replicates in 20' by 80' plots
of 5 trees planted in 2014

Treatment plots are 40' x 80', with all treatments but F covering ~.15 acres (4 reps)
Treatment F cover ~ 0.3 acres

Table 1. Cover crop treatments at the NWMHRC

Treatment	Rotation	Flagging
A	Oats early, fumigation in the fall followed by rye	Purple
B	Essex rape followed by a rotation of Pearl millet	Orange
C	Red Clover season long, seed in alfalfa and hairy vetch early	Green
D	Oats and Pea early followed by a rotation of Ida + Pacific Gold mustards	Red
E	Oats and Pea early followed by a rotation of Oilseed Radish	Yellow
F	Oats+Pea early follwed by a rotation of IdaGold + PacificGold mustards	Blue

Cover	**Rate (lbs./A)**	**Area to cover**	**total**
Oats	108	0.75	81
Rye	140	0.15	21
Essexrape	5	0.15	0.75
Pearl millet	20	0.15	3
Red clover	108	0.15	16.2
Oilseed radish	20	0.3	6
IdaGold	15	0.3	4.5
PacificGold	20	0.3	6
Siberian Pea	120	0.6	72

Second planting need (august)

Treatment	Rotation	Flagging	Area to cover	Estimated total (lb)
A	Rye (140lb/acre)	Purple	.15 acres	22.5
B	Pearl millet (20lb/acre)	Orange	.15 acres	3
C	Seed in alfalfa and hairy vetch early (rate?)	Green	.15 acres	???
D	Mustards (20lb/acre)	Red	.15 acres	3
E	Oilseed Radish (20lb/acre)	Yellow	.15 acres	3
F	Mustards (20lb/acre)	Blue	0.3 acres	6

2014-2016 NWHRS Cover Crop Trial

Plot Design and Treatments

Cover Crop Systems

	2014	2015
1. Conventional	Sudax	Oats
	Rye	Soil Fumigation
		Rye

2. Nematode Target	Dwarf Essex Rape	Pearl Millett
	Pacific Gold Mustard	Oil Seed Radish

3. Diversity Mix	Oats and Cowpea	Oats and Cowpea
	Pacific Gold Mustard	Oil Seed Radish

Four replications of each system
Eight trees per replicate
96 tree plot

Plot Design

North

	2	1	3	1	
	2	1	3	1	
	2	1	3	1	
Rep III	2	1	3	1	Rep IV
3 rows	2	1	3	1	1 row
	2	1	3	1	
	2	1	3	1	
	2	1	3	1	
	3	2	1	2	
	3	2	1	2	
	3	2	1	2	
Rep II	3	2	1	2	
3 rows	3	2	1	2	
	3	2	1	2	
	3	2	1	2	
	3	2	1	2	
	1	3	2	3	

	1	3	2	3
Rep I	1	3	2	3
3 rows	1	3	2	3
	1	3	2	3
	1	3	2	3
	1	3	2	3
	1	3	2	3
	Row 1	R0w 2	Row 3	Row 4

Successful Cover Cropping: With Special Reference to Radish

Micro-Essay No. 86 (draft 1.2)

George W. Bird (soilhealthbiology@gmail.com),
Michigan State University,

Definition: A cover crop is a plant grown to maintain or enhance soil health (the ability to resist degradation and respond to management in a predictable manner). Cover crops may be grown between cash crop rotations or monoculture plantings, inter-seeded with cash crops, as cash crops, as forage or for grazing.

Cover Cropping Objectives: There are at least 14 different reasons (objectives) for use of cover crops. These include: 1) Soil builders, 2) Soil hardness reducers, 3) Soil water conservers, 4) Erosion fighters, 5) Nutrient sources (nitrogen and about 20 other elements when biologically mineralized), 6) Hay crops, 7) Silage crops, 8) Seed crops, 9) Livestock grazers and Pest Managers such as 10) Weed fighters, 11) Friend feeders, 12) Pest starvers, 13) Pest trappers and 14) Pest gassers (bio-fumigation).

Laws for Successful Cover Cropping: There are Three Laws for Successful Cover Cropping. These include: 1) Clearly identify the specific objective(s) for use of a cover crop or mixture (blend) of cover crops, 2) Select the proper cover crop cultivar (variety) for achieving the objective and 3) Manage the cover crop in a manner specifically designed to attain the objective.

Cover Crop Types: There are four basic kinds of cover crops. These include: 1) Grasses, 2) Legumes, 3) Brassicas and 4) Other Broad Leaf Plants.

Micro-Essay Objective: The primary objective of this micro-essay is to document and hopefully clarify what is currently known about radishes for use as cover crops in Mid-West agriculture.

Radish Taxonomy and Development: Radishes are classified in the plant species *Raphanus sativus*, as described by Carl Linnaeus in 1758 in Systems Naturae. Throughout the years there have been many synonyms, subspecies and taxonomic varieties proposed. Some of these may be valid and others may have caused confusion. The radish may have originated in China, with one or more populations moving east and others moving west. As a result of natural and human-managed selected, there are currently a vast array of different types of radish, each with different names (e.g. Daikon), specific biological characteristics and potential uses. Since this micro-essay is about cover-cropping, a system of <u>Functional Types</u> will be used to describe the attributes of radishes. It also may be helpful to discuss the word *variety*. This word can be used to: 1) indicate diversity, 2) indicate a formal taxonomic subspecies category or 3) identify a plant cultivar that is usually marketed under the name of a specific variety, some of which may have Registered Trade Marks such as GroundHog™, Driller™ or Tillage Radish®.

Functional Types: There are at least five functional types of radish. These include:

1. Agronomic Cover Crop Radish Varieties,
2. Beet Cyst Nematode Management Radish Varieties,
3. Seed Oil Radish Varieties,
4. Common Backyard Garden Radish Varieties and
5. Eastern Culinary Radish Varieties.

Agronomic Cover Crop Radish Characteristics:

Beneficial

1. Excellent Nitrogen Scavenger,
2. Excellent Subsurface Hardness Reducer,
3. Good Topsoil Hardness Reducer,
4. Assists in Reducing Wind and Water-Based Soil Erosion,
5. Provides Some Organic Residue,
6. Good Weed Fighter,
7. Good Grazing-Forage Values and
8. Demonstrated Crop Yield Increases-Profitability

Potentially Detrimental

1. Increase risk to Beet Cyst Nematode (*Heterodera schachtii*) damage,
2. Increase risk to Northern Root-Knot Nematode (*Meloidogyne hapla*) damage,
3. Increase risk to Root-Lesion Nematode (*Pratylenchus penetrans*) damage,
4. Increase risk to Southern Root-Knot Nematode (*Meloidogyne incognita*) damage, and
5. Highly attractive to Flea Beetles (*Alticini* spp.).
6. Contrary to what is said in the *Midwest Cover Crop Council Field Guide* (p. 112), the jury is still out in regards to Soybean Cyst Nematode (*Heterodera glycines*).

Recommendation

Each agronomic cover crop radish variety needs to be evaluated under local conditions by one or more highly respected growers, having a significant interest in soil health.

Beet Cyst Nematode Management Radish Varieties

Plant breeders have developed several oil seed radish varieties that are trap crops for the Beet Cyst Nematode (*Heterodera schachtii*).

Which Ones?

Defender, Adagio and Colonel are BCN trap crop varieties.

How Do They Work?

The germinating young oil seed radish plant attracts the second-stage juveniles to its roots. The juvenile penetrates the root-system and moves to its potential feeding site in vascular parenchyma tissue. The nematode chemically signals to the plant to produced nurse cells as a source of food for egg production. In these BCN trap crop varieties, the plant fails (refuses) to form the nurse cells and the females are unable to produce eggs for the next generation of nematodes.

Selected References

Bailey, L. H. *Manual of Cultivated Plants*. Macmillan Co. N.Y. 1116 pp.
Fernald, M. L. *Grays Manual of Botany*. American Book Co. N.Y. 1632 pp.
Midwest Cover Crops: Field Guide. www.mccc.msu.edu. 136 pp.
Managing Cover Crops Profitably (3rd ed.). USDA/SARE. 244 pp.
Plants USDA.gov

NEWS

Commission releases white paper on soil health

May 16, 2012—The Michigan Potato Industry Commission today released a new "white paper" on soil health, which is a critical factor in maximizing productivity not only in the potato industry but in all commodities.

The document explains the issue and the Commission's action plan for addressing the issue including long-range steps that need to be implemented. The white paper will be distributed to other commodity groups and agricultural organizations for their feedback as part of a general effort to continue enhancing the role of Michigan agriculture as a vital positive force within the state's economy.

The full text of the white paper is published below...

Michigan Potato Industry Commission
White Paper on Michigan Soil Health
The Issue

Healthy soil is the critical component undergirding crop productivity. Attention is increasingly turning to soil health as many Michigan producers question if they are achieving their highest possible yields and crop quality. Some potato growers are experiencing stagnant or even declining yields in particular fields. Corn farmers are concerned that superior new varieties may not be performing everywhere to their potential. Growers of other field crops are likewise sensing that productivity should be better. Fruit growers are nagged by the suspicion that planting new trees in old orchards without making soil amendments may reduce yields and tree life.

Soil impairment is a limiting factor in productivity. Inputs including technological innovations may boost yields relative to past performance, but if the soil is not in optimal condition, stress on the plants exacts a toll. Growers are aware of this relationship and are increasingly seeking soil analyses to determine precise data for representative fields. However, the biodynamics within the organic portion of the soil are still not adequately understood, and soil management suffers as a result. Many growers now perceive a need for a stronger grower-university partnership to expand soil research and demonstration projects applicable to the broad spectrum of Michigan commodities. Improvement in soil-management practices should spur productivity and elevate the numbers on the "dashboard" that tracks the growth and development of Michigan agriculture.

Michigan Soils

Soil management is more difficult in Michigan than most other places because action of Ice Age glaciers resulted in a highly complex mixture of soils. As many farmers well know, several soil types can exist within a relatively small field. Slow glacial melting deposited the ice sheet's mixed rock contents directly downward to serve as parent material for subsequent soil formation. Faster melting led to rushes of water that distributed coarser materials across the landscape forming sandy and gravelly plains. Areas of ponded water led to the extensive swamplands that hindered early Michigan settlement before drainage made them tillable.

It was in Michigan that early soil "science" foundered. The rule of thumb as settlers pushed westward was "the thicker the forest, the more fertile the land." They knew that soils under the wider tree spacings in an oak forest were inferior to those cleared from a dense stand of eastern hardwoods like maples and ash and elm. Their theory began to fall apart when the openings of treeless grassy prairies in Michigan's southern tier of counties proved to be the most fertile of all. The final disastrous blow to conventional beliefs came with the felling of the heavy growth of white and red pine of the north. That land was cleared in full confidence in the pioneers' principle of "after the forest, the farm." The farmers who followed the lumberjacks were quickly doomed to failure. As we now know (but none did then), those pineland soils were too acidic to support the common field crops.

Today the chemistries and physical properties of soils are well understood. The biological components remain less so, particularly because so much of the extraordinarily complex interactions are invisible to the unaided eye. "Micro" is a common prefix in soil biology, which studies microorganisms, microflora and microfauna—a full range of microbiota.

Soil Biology

Primitive agriculturists early learned that animal manures can enrich their soils and improve their crop production. Soil research today increasingly provides explanations of why. The manures act on and positively stimulate the processes of soil microbiota.

According to one estimate, hundreds of billions of microorganisms can exist in a handful of soil. The species included in this diverse community of organisms may range to thousands for bacteria, hundreds for fungi and dozens for nematodes. Animal manures can increase the populations within this biomass and enhance their activity in a process that is helpful in nutrient cycling and overall soil-quality building and maintenance. Soil enzymes, mostly produced by microbes, also contribute to improving chemical and physical characteristics of the soil. Likewise, beneficial nematodes and mites and other microarthropods play crucial roles in building soil quality and health.

Within this amazing complex of organisms are also species that cause crop diseases. However, research has indicated that the biota composition of healthy soil reduces populations and impacts of plant pathogens although not to the point of eradication. Obviously soil biology is a field ripe for much more study that can yield new strategies for optimizing crop production.

A Soil-Health Initiative

The Michigan potato industry has become concerned enough about productivity stagnation that it has begun an effort to address the issue. On January 11, 2012 an ad-hoc “soil-ecology group” comprising growers, marketers, consultants, agronomists and university specialists from various disciplines met to discuss possible causes of the problem and lay the groundwork for a practical response. The focus was on physical impairments such as soil compaction and on disruptions to beneficial soil microbes, microflora and microfauna. A follow-up meeting on March 29-30 included three out-of-state soil scientists prominent in advancing new concepts and new understandings about soils. The outcome of this meeting was a Michigan Soil Health Plan of Action geared to the potato industry but adaptable to other commodities as well.

The Soil-Health Action Plan

The Michigan potato industry has outlined a three-phase action plan:

1. In 2012, 120 soil samples from Michigan potato fields will be collected and analyzed at the Cornell University Soil Health Laboratory in New York.
2. In 2013, a more comprehensive potato soil-health research project is anticipated. A grant has been applied for under the 2008 Farm Bill Specialty Crop Block Grant program. If the competitive grant is awarded, more extensive soil sampling will be conducted in fields in various stages of productivity. Results will be correlated with an existing database of a variety of field factors. Microbial lab analyses will expand the knowledge base about relationships of soil health and chronic disease complexes. If the grant proposal is not approved, scaled-back efforts will be undertaken using Michigan Potato Industry Commission funds.
3. The Commission’s Research Committee and the Michigan State University team of potato researchers will provide leadership for development of a major multi-state and multi-commodity soil-health research and education initiative for 2014 and beyond.

Michigan potato growers are already employing practices aimed at improving soil health. Many are adding organic soil amendments. Crop rotations disrupt pest life cycles and reduce pesticide needs. Cover crops are chosen to build soil organic matter.

However, documentation of the complex of biological activities within the soil and the benefits of particular practices is still at a rudimentary state. The need is for added research-confirmed information so that longer-term soil-management strategies can be developed for adoption by growers.

Unfilled MSU position. To meet the need cited above, the action plan presupposes that a currently vacant soils-specialist position at Michigan State University must be filled. The ad-hoc “soil-ecology group” is an example of the long-standing record of strong collaboration between the Michigan potato industry and MSU researchers, but its composition exposes a critical void, the lack of anyone with a specialty in soil biology and biogeochemistry. As a stopgap measure, experts are brought in from out of state as consultants on an irregular basis. If Michigan agriculture is to advance on the soil-health issue, relying on the strengths of the land-grant tradition, MSU must add a full-time soils specialist to its staff to serve all commodities with their complex needs for soil improvement. This position is essential to achieving developmental progress on the Michigan agricultural “dashboard.”