Radishes as biofumigants and weed suppressant cover crops

Joel Gruver
Western Illinois University
What comes to mind when you hear the word RADISH?
They take radishes very seriously in Oaxaca, MX
<table>
<thead>
<tr>
<th>Thread</th>
<th>Replies</th>
<th>Views</th>
<th>Last post</th>
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<tr>
<td>Oats and Radishes</td>
<td>6</td>
<td>2025</td>
<td>sgroff 5/30/2013 06:58</td>
</tr>
</tbody>
</table>
BRASSICAS AND MUSTARDS

**Type:** Annual (usually winter or spring; summer use possible)

**Roles:** Prevent erosion, suppress weeds and soilborne pests, alleviate soil compaction and scavenge nutrients

**Mix with:** Other brassicas or mustards, small grains or crimson clover

**Species:** *Brassica napus, Brassica rapa, Brassica juncea, Brassica hirta, Raphanus sativus, Sinapis alba*

See charts, pp. 66 to 72, for ranking and management summary.

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**Nomenclature Note:** The cover crops described in this chapter all belong to the family **BRASSICACEAE.** Most but not all of the species belong to the genus *Brassica.* In common usage, the various species are sometimes lumped together as “brassicas” and sometimes distinguished as “brassicas” vs. “mustards.” In this book, we will use brassicas as an umbrella term for all species; mustards will be used to distinguish that subgroup, which has some unique characteristics.

**Adaptation Note:** This chapter addresses management of eight different cover crop species with varying degrees of winterhardiness. Some can be managed as winter or spring annuals. Others are best planted in late summer for cover crop use but will winterkill. Consult the information on management, winterhardiness and winter vs. spring use (pp. 87-88) and the examples throughout the chapter, then check with local experts for specific adaptation information for your brassica cover crop of choice.
The Cover Crops Topic Room

Visit the Cover Crops Topic Room to discover a wealth of educational materials developed out of decades of SARE-funded cover crop research. Information is organized in the following subsections:

- Selection and Management
- Economics
- Establishment
- Rotations
- Soil and Fertility Management
- Water Management
- Pest Management
- No-Till

Cover Crop Topic Room: Pest Management

Selection and Management | Economics | Establishment | Rotations | Soil and Fertility Management | Water Management | Pest Management | No-Till | Miscellaneous | Complete List

Buckwheat Cover Crop Handbook

Type: Northeast SARE Grantee-Produced Info Product

Buckwheat has been used to suppress weeds on Northeastern farms for 400 years. This handbook outlines...

Download File (458.29 kB)

Influence of Cover Crops on Insect Pests and Predators in Conservation Tillage Cotton

Type: Southern SARE Grantee-Produced Info Product

Results of a two-year research project to determine the impact of several cover crops on pest and predator...

A Sunn Hemp Cover Crop for Soil Health and Nematode Management

Type: Western SARE Grantee-Produced Info Product
Mustard Green Manures for Potato Production

Project Number: SW03-018
Year: 2003
Region: West
Type: Research and Education Project

2004 Annual Report
2005 Annual Report
2006 Annual Report
2007 Final Report

Coordinator:
Andy McGuire
Lauzier Agricultural Systems Educator
Washington State University Extension
PO Box 37, 35 C St NW, Courthouse
Ephrata, WA 98823
Phone: 509-754-2011 Ex
E-mail: amcguire@wsu.edu
Website: http://www.grant-adams.wsu.edu/agriculture/covercrops/green_manures/index.htm

SARE Funds  $ 45653
Matching Federal Funds  $
Matching Non-Federal Funds  $ 18324

This project was supported by the Sustainable Agriculture Research and Education (SARE) program, which is funded by the U.S. Department of Agriculture- National Institute of Food and Agriculture (USDA-NIFA). Any opinions, findings, conclusions or recommendations expressed within do not necessarily reflect the view of the SARE program or the U.S. Department of Agriculture. USDA is an equal opportunity provider and employer.
Radishes – A New Cover Crop for Organic Farming Systems

Last Updated: July 02, 2012

**eOrganic authors:** Dr. Joel Gruver, Western Illinois University
Dr. Ray R. Weil, University of Maryland
Charles White, Penn State University
Dr. Yvonne Lawley, University of Manitoba

Over the past decade, radishes have been redefined; once known almost exclusively as a pungent vegetable, radishes have recently gained recognition for their cover cropping potential. After reading this article, you'll be able to make an informed decision about whether cover crop radishes are worth a try on your farm.

Radishes have made rapid inroads as a cover crop for several reasons. First, the radish phenotype is well suited to perform many valuable cover crop functions—provide soil cover, scavenge nutrients, suppress weeds, and alleviate compaction—while creating few of the residue management challenges associated with many other cover crops. Second, recent research including many on-farm trials has documented beneficial effects of radish cover crops on soil properties and subsequent crops. Third, the seed industry has ramped up production of radish seed, brought new branded products to market, and promoted radish as a cover crop. Fourth—but perhaps most important in terms of the exponential growth in interest by farmers—radish cover crops have become a hot topic of discussion in rural coffee shops and on-line agricultural forums. Between 10/1/2011 and 12/1/2011, there were 51 threads about radishes in the Crop Talk forum of New Ag Talk, with over 500 responses and more than 240,000 views.
Radish Seedstock

Most of the radish varieties currently marketed for cover cropping are large rooted selections of daikon-type oilseed or forage radishes, but are not the product of formal breeding programs. All are morphologically similar to the large white daikon radishes traditionally used in Asian cooking. Hybrid daikon-type culinary radish seed is prohibitively expensive (more than $100/lb for bulk seed) for use in cover cropping, but open pollinated culinary daikon varieties may have some potential with bulk seed available for about $5/lb. Standard oilseed radish cultivars (e.g., Adagio, Colonel, and Defender) tend to have a stubbier, more branched taproot, greater winter hardiness, and lower seed cost than larger-rooted daikon types (Ngouajio and Mutch, 2004).
About Tillage Radish®

The original and only Tillage Radish is a cover crop radish seed carefully selected for its unique traits and superior genetics. Proven to increase cash crop yields and improve soil health, our cover crop radish seed has 10+ years of research, rigorous testing and quantifiable performance in the field.

There is nothing else like Tillage Radish. It is available exclusively from Cover Crop Solutions and its authorized dealers.
GroundHog™ Radish

Nitrogen Mining & Nutrient Scavenging
Weed Suppression
Aerates Ground and Alleviates Soil Compaction
Promotes Water Infiltration
Pilot Hole Root Penetration
Reduction of Tillage & Chemical use
Tilth Pro NitroRadish is an Oregon grown Daikon Radish used for fall/winter cover crop. It provides many helpful benefits to the grower, the soil, and the environment. It germinates and grows quickly, has a large, deep penetrating tap root; dies over the winter (in cold climates); decomposes quickly; has high nutrient content, and contains bio-active plant chemicals. It has the ability to recycle nutrients which will improve your soil quality and economic crop production.
ECO-TILL RADISH

- Superior, deep penetrating taproot
- Reduces soil compaction
- Builds organic matter
- Improves nutrient recycling
- Excellent weed suppression
- Enhances soil tilth

Eco-Till Radish is a new Daikon type forage radish variety specifically developed for fall/winter cover crop applications. These radishes offer impressive benefits to the soil and the environment including the reduction of soil compaction, improved nutrient recycling, increased organic matter, enhancement of soil tilth and suppression of weeds, to name a few.

A superior, deep penetrating taproot is one characteristic that separates Eco-Till radishes from the competition. The thin, lower portion of the taproot can grow to a depth of six feet or more while the thick upper portion of the taproot can grow to a length of 24 inches. This taproot creates vertical holes in the soil which provides drainage and aerates the soil, preventing the compaction which leads to the development of hardpan.
Sodbuster Brand Radish is a new cover crop forage radish developed in New Zealand. The Sodbuster’s large taproots are superior and can penetrate as far as 6 feet deep. The fleshy upper part can “bust” a hole from 10-20 inches long and
This is a brand page for the DRILLER DAIKON RADISH trademark by GRASSLAND OREGON, INC. in Salem, OR, 97305. Write a review about a product or service associated with this DRILLER DAIKON RADISH trademark. Or, contact the owner GRASSLAND OREGON, INC.
small seed with a big attitude

BIG DOG RADISH

BIG DOG

MINO EARLY

daikon radish

VARIETY DESCRIPTION

MINO EARLY RADISH, like other daikon radishes, has been and is primarily used in the vegetable markets. MINO EARLY is a specific variety, not a brand, with specific characteristics. In the vegetable markets, uniformity is very important. For the cover crop market, MINO EARLY offers that same predictable growth and uniform performance. MINO EARLY offers:

Silverton, OR (April 4, 2006) -- GRAZA forage radish is the latest offering in brassica breeding from PGGSEEDS of New Zealand, and distributed by Ioka Farms in the United States. GRAZA is a fast growing, drought tolerant, and multiple grazing leaf brassica, and its growing points allow for rapid, repeated regrowth after grazing. GRAZA has persisted for up to a year without flowering in Oregon and Louisiana, and has survived the rigors of hot, wet summers.

GRAZA offers a palatable solution to summer grazing when milk production and weight gains are difficult with cool season pastures. High intake is required for high production, and GRAZA has digestible dry matter and metabolisable energy levels higher than corn or sorghums. This means animals will consume more feed of higher quality.
TERRANOVA

This is an extremely late flowering variety with fast early vigour and good re-growth after cutting. Terranova is resistant against the white and the yellow beet cyst nematode (*Heterodera schachtii* and *betae*) – reduction of the population with 80 to 90% is possible – and the variety is also resistant against (false) Columbia root-knot nematode (*Meloidogyne chitwoodii* and *fallax*) with a reduction comparable with black fallow.

TERRANOVA is a non-host for:

- *Globodera rostochiensis* and *pallida* (Potato cyst nematode)
- *Heterodera avenae* (Cereal cyst nematode)
- *Heterodera goettingiana* (Pea cyst nematode)
- *Meloidogyne naasi* (Cereal root-knot nematode)
- *Ditylenchus dipsaci* (Bulb nematode)
- *Ditylenchus destructor* (Potato tuber nematode)
- *Prathylelenchus scripnerie* (Scribner’s lesion nematode)
- Tobacco rattle virus (TRV)

TERRANOVA is a bad host for:

- *Paratrichodorus teres* (Stubby root nematode)
Fodderradish / *Raphanus sativus*

Fodderradish is a kind of radish without or with very small tubers. The crop has a rapid early vigour. Depending on the variety, flowering is early or late. A late flowering variety will normally not flower if it is sown as a second crop. All the Joordens varieties are relatively short which simplifies it to plough them under. Because of its fast early vigour fodderradish is - also in case of late sowing - a very good green manure crop. Fodderradish can be drilled till mid September. Through inbred of resistances against nematodes like *Heterodera schachtii* and *Heterodera betae* our varieties are suitable to use as biological control of several soil diseases and plagues so that the use of chemicals can be limited.

**Varieties available:**
- ADIOS
- ANACONDA
- DOUBLET
- FINAL
- RADAR
- RADICAL
- TERRANOVA
There has been some evaluation of radish varieties and other brassicas.

**FIELD PLOT DESIGN & MANAGEMENT**

<table>
<thead>
<tr>
<th>Randomized complete block with 4 replicates</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 or 20 accessions of <em>Raphanus sativus</em> and <em>Brassica spp.</em></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Planted 17 August 2010</th>
<th>Planted 13 August 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oilseed and tillage radish @ 10 lbs/acre</td>
<td></td>
</tr>
<tr>
<td>Mustard @ 8 lbs/acre</td>
<td></td>
</tr>
<tr>
<td>Rapeseed @ 5 lbs/acre</td>
<td></td>
</tr>
<tr>
<td>Forage turnip @ 2 lbs/acre</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hand weeding 7 days after planting</th>
<th>Herbicide to manage volunteer oats</th>
</tr>
</thead>
<tbody>
<tr>
<td>No irrigation</td>
<td>Irrigation</td>
</tr>
</tbody>
</table>
Biomass by Species

- Shoot and total biomass were greater in MN than in MI.
- Radish had greater root biomass and root:shoot ratio than the other species.
- Average total biomass ranged from 1.7 to 3.1 tons per acre.
Biomass of Radish Varieties

- Radish varieties did not differ significantly in shoot or total biomass.
- Driller radish had a higher root biomass and root:shoot ratio than the other varieties in MN but not in MI.
Nitrogen Accumulation by Species

- Brassicas accumulated 95-145 lbs/acre N.
- Most of the N was in the shoots.
- In MI, turnips accumulated significantly more N than mustards.
Planted August 16  
10/25, UMN trial  
Planted August 30  

Planted September 13  
Planted September 29  

Photos by Miriam Gieske, Univ. of Minn.
# Forage Brassica trial in Eastern Oregon

**Brassica Trial Entries**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Seeding Rate (lb/acre; PLS&lt;sup&gt;a&lt;/sup&gt;)</th>
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</thead>
<tbody>
<tr>
<td>Pulsar Rape</td>
<td>4</td>
</tr>
<tr>
<td>Purple Top White Globe Turnip</td>
<td>4</td>
</tr>
<tr>
<td>Dwarf Siberian Kale</td>
<td>4</td>
</tr>
<tr>
<td>Winfred (Turnip x Kale)</td>
<td>4</td>
</tr>
<tr>
<td>New York Turnip</td>
<td>4</td>
</tr>
<tr>
<td>Graza Radish</td>
<td>7</td>
</tr>
<tr>
<td>Hunter (Turnip x rape)</td>
<td>4</td>
</tr>
<tr>
<td>Winter Triticale</td>
<td>100</td>
</tr>
<tr>
<td>Terranova Radish</td>
<td>7</td>
</tr>
<tr>
<td>Colonel Radish</td>
<td>7</td>
</tr>
</tbody>
</table>
2009 PD1: Variety Effect

Variety:
- Wini
- Colon
- Prape
- Hunt
- Terra
- PTurn
- Grad
- DSKale
- NYTurn
- Wtrit

Dry Matter Yield (Tons/Acre):
- Wini: 3.5
- Colon: 3.0
- Prape: 2.5
- Hunt: 2.0
- Terra: 1.5
- PTurn: 1.2
- Grad: 1.0
- DSKale: 0.8
- NYTurn: 0.6
- Wtrit: 0.5

p = 0.0003

Where are the weeds?
Forage radish provided complete suppression of winter annual weeds in fall and early spring but the suppression did not persist into the subsequent cropping season. When forage radish cover crops were used in place of preplant burndown herbicide treatments to control weeds in early planted corn, some weeds were present at the time of corn emergence but corn yields were not reduced as long as emerged weeds were controlled with a postemergence herbicide.
Cited research

In the Netherlands, fodder radish (Raphanus sativus L. cultivar *Brutus*) suppressed the growth of weeds while it grew in the fall (Kruidhof et al., 2008).

In Ontario, Canada, oilseed radish (Raphanus sativus L. var. oleiformis) suppressed the fall growth of volunteer winter wheat (Swanton et al., 1996).

Oilseed radish suppressed weeds in vegetable crop rotations in western New York (Stivers-Young, 1998) and in the Great Lakes Region of Michigan (Wang et al., 2008).
Brassica cover crops: do they kill the weeds though? by Paul Kristiansen

Recent work on brassica cover crops in Finland, Italy, the USA and Australia has found very little evidence of a reliable effect on weed numbers, even using high glucosinolate varieties. Although weeds may be effectively controlled during the time when the cover crop is growing, the weed levels in the following cash crops are the same as those for cash crops grown after various fallows or other cover crop varieties. The absence of an effect on weeds is may be attributed to:

• insufficient plant material grown in a season to achieve effective weed control

• incorrect timing of operations related the cover crop including termination and incorporation

• the lack of persistence of glucosinolates in the soil after incorporation of the cover crop, especially where cover crop residues are turned in to the soil

• disturbance of soil due to tillage practices in annual cropping
A number of indications show that allelopathy was probably not the main factor in inhibiting weeds during the cover crop phase.

Such indications include a strong link between shading and weed levels with weeds continuing to emerge very close to the cover crop without inhibition.

In addition, weed growth was not correlated with the amount of brassica plant material incorporated into soil or to measured glucosinolate levels.
Tillage Radish to Control Weeds in Horticulture Crops

Abstract

Scattergood Farm near West Branch tested tillage radish for weed control in one of their vegetable fields. They also collected data on seed germination for the cash crop after tillage radishes to observe if the tillage radish had an adverse effect on seed germination. Mean weed counts (34.25 in control and 31.75 in tillage radish plots) combined with statistical analysis indicated no difference in weed control between the tillage radish and control.

Statistical analyses of cash crop germination also illustrated no difference in cash crop seed germination between tillage radish and control plots. Mark Quee, farm manager at Scattergood, said that observations were in line with the data. He thinks tillage radish may have potential to contribute to soil tilth and organic matter, and plans to find out with further research.
Radishes are highly competitive and a good stand of radishes can eliminate nearly all weed growth both during and for some time after active radish growth.

To obtain near-complete weed suppression, radishes should be planted early (6 or more weeks before frost), at a relatively high population (more than 5 plants per square foot) into a clean seed bed.

Weed suppression from fall planted radishes typically lasts into April, but does not extend much into the summer cropping season.
What is biofumigation?
Bio fumigation results from the production of toxic compounds after the shredding and incorporation of certain types of fresh plant biomass into soil.

Glucosinolates, which are present in the vacuoles of radishes and other brassicas, are exposed to the enzyme myrosinase, which is present in cell cytoplasm, when plant biomass is shredded and incorporated.

The enzyme cuts the sugar part of the glucosinolate producing methyl isothiocianate.
A green manure planted before the susceptible crop. Purpose bred to naturally reduce nematode populations by up to 300%. Nematodes are especially a problem in potatoes and carrots—Terranova reduces damaging nematode populations in potato, sugar beet and carrot crops increases organic matter, “domestos” for soils.

Terranova has been bred especially for this use to reduce nematodes and is a high glucosinolate variety, required to produce high levels of isothiocynate (ICT) for effective suppression of soil borne pests and diseases.

- Topical and popular with potato farmers-
- Biofumigant
- Green Manure

The main goals of any fodder radish cover crop in arable farming are to:
- To catch nutrients that may be lost after the growing season and reduce nitrogen leaching
- To reduce soil erosion and weed growth
- To suppress Nematode populations
- It is more effective than mustard and other fumigant crops

Terra Nova, Anti Nematode Radish is an excellent cover crop for use before a sugar beet, potato or carrot crop due to its OUTSTANDING ability to reduce the population of nematodes in the soil. It has been purpose bred to reduce the amount of potato cyst nematode. Not only is it a non-host plant to the Nematode thereby giving them nothing to feed on but it also, on ploughing back into the soil, releases a
The natural bio-fumigant that is contained within TERRANOVA becomes active immediately upon “chopping” and once the crop is ploughed under the nematode population starts to reduce.

In choosing, TERRANOVA is a valuable and beneficial cover crop to be used after a harvest of sugar beet or potatoes and is likely to become very popular in the upcoming years.

Radish Varieties

# of nematode egg masses per potato planted
Reducing effect of biofumigation

By making a blend of these crops (oilseed radish, Ethiopian mustard, white mustard and fodder rape) a wide range of pests and diseases can be reached. The combination of the different glucosinolates can stimulate the lethal activity towards the pathogen.

Main glucosinolates in our blends of BioFum are Sinigrin, Sinalbin, Glucoraphasatin, Glucoraphenin and Glucoerosylin.

The following fungi are eliminated in tests in glasshouse due to the use of BioFum.

- Gaeumannomyces take all diseases cereals
- Rhizoctonia
- Fusarium
- Bipolaris (Helminthosporium)
- Pythium

In field trials it has been proven that Brassicaceae suppresses, Verticillium, silver scab and sclerotinia. Also free living nematodes, like root-knot and stubby root nematodes, will be eliminated after a continue use of BioFum.
Management for successful biofumigation

Seeding
The time of sowing depends on the space in the farmer’s rotation. Best time of sowing is April - September.

Seed rate per hectare/acre
Depends on soil type. Heavy open soils need more seeds than sandy soils:
- Heavy soil: 20 kg/ha (20 lbs/acre)
- Light soil: 15 kg/ha (15 lbs/acre)

Fertilisation
To reach a good establishment of the plants it is preferable to spread Nitrogen. Advice: 60 kg/ha (60 lbs/acre)

Soil preparation
Best is to prepare the soil as for a full season crop. Seed this crop with for example a grain drill.

Incorporation time
When the crop reaches 60 to 80% flowers it is time to incorporate. It is necessary to use a flail to chop the crop.

Incorporate the residue with a rotary cultivator or disk.

Between chopping and incorporation there should be a maximum time of 30 minutes. Watering is needed after incorporation. Approximate 10 mm (0.3937 inch.) is sufficient on soils with a normal moisture condition.

It is desirable to work the field, 2 weeks after incorporation. Wait 3 to 4 weeks to seed a new crop.
Overall, results suggest that radishes stimulated a bacterial decomposition pathway, while rapeseed and rye stimulated a proportionally greater fungal-based food web.
Fall 2003
Oilseed Radish cover crop greatly increased non-parasitic nematodes in June 2004 soybean field.

Central Md REC
June 2004

![Graph showing nematode count comparison between Mustard, No Cover, and Oil Radish treatments. Non-parasites and plant parasites are indicated.]
Summary of results

Rapeseed, forage radish and a mustard blend did not significantly reduce incidence of soybean cyst nematode. The same species, when grown with rye or clover, did reduce incidence of stubby root nematode.

In no-till corn on a sandy soil, winterkilled forage radish increased bacteria-eating nematodes, rye and rapeseed increased the proportion of fungal feeding nematodes, while nematode communities without cover crops were intermediate.

The Enrichment Index, which indicates a greater abundance of opportunistic bacteria–eating nematodes, was 23% higher in soils that had brassica cover crops than the unweeded control plots.

These samples, taken in November, June (a month after spring cover crop kill), and August (under no-till corn), suggest that the cover crops, living or dead, increased bacterial activity and may have enhanced nitrogen cycling through the food web.
Managing radish for success

Grain drill (6-8 lbs/acre):
Using small grass box, use alfalfa setting as a guide to set seeding rate. A large seed box can be used but the setting is very low and somewhat difficult to establish. Use alfalfa as comparable seed on drill charts, reducing by 10%. It's important to calibrate your drill to determine correct seeding rate.

Broadcast/Aerial Seeding (8-12 lbs/acre):
Standing corn seeding indicator is when 1" patches of sunlight on soil surface are seen or approximately 4 weeks prior to anticipated harvest time
Standing soybean seeding indicator is at leaf yellowing
Cotton seeding indicator is right before defoliation
Improve success rate by using drop tubes when seeding with a high clearance cover crop seeder.

Precision Planter (2-4 lbs/acre): 15" rows using 60-cell small sugar beet plate with 4" in-row spacing. Seed is selected for Precision Planting performance.

Nitrogen: To reach peak potential, needs 40-60 lbs of N, residual or applied.

Timing: 6+ weeks prior to the first average killing frost.
+20 lbs N/a
Are you familiar with strip-till?
Bio-strip till experiment in ND – Fall 2009
2 out of 3 bio-strip till plots were among the highest yielding plots on the farm
Bio-strip till experiment in ND – Fall 2010
Allison Organic research farm – Roseville, IL
Precision planted radishes w/ peas from 5 ft of row

Precision radishes w/o peas
Corn following cover crop experiment in 2011

<table>
<thead>
<tr>
<th>Cover crop system</th>
<th>Relative corn yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volunteer oats</td>
<td>79%</td>
</tr>
<tr>
<td>Radishes planted on 30”</td>
<td>99%</td>
</tr>
<tr>
<td>Radishes drilled on 7.5”</td>
<td>91%</td>
</tr>
</tbody>
</table>

 Corn planted on radish rows
We have also documented negative yield effects
Can you think of any ag technologies that substitute for management skill?
WIU student project last fall
This divergence of soil properties did not happen in one year.
Students in my Soil Properties class each analyzed paired soils from their farms.

Same soil type and landscape position.
Any questions?