

## Forage Radish: New Multi-Purpose Cover Crop for the Mid-Atlantic

Forage radish (*Raphanus sativus* var. *longipinnatus*) is a unique fall/winter cover crop that is relatively new to the mid-Atlantic region. It is a member of the Brassica family, which also includes rapeseed, canola, mustard, and cabbage. Forage radish is also known as 'Daikon' (sometimes spelled 'Dichon') radish or 'Japanese' radish and is used as a vegetable in many types of Asian cuisine. When planted by early September in the Mid-Atlantic region, forage radish



Oilseed radish (left) and forage radish (right).

exhibits a number of unique and desirable characteristics that distinguish it from other types of cover crops more commonly grown in the region.

Oilseed radish (*Raphanus sativus* var. *oleiformis*) cultivars such as 'Adagio' or 'Colonel', are similar to the forage radish, but have a stubbier, more branched taproot and tend to be somewhat more winter hardy than the forage radish ('Daikon'). The precise classification of these and other types of radishes is not well established because they can readily cross-pollinate and therefore distinctions among subspecies are often blurred. Most of the traits and management recommendations described here for forage radish should also apply to oilseed radish.

### Forage Radish Traits

- Extremely rapid germination and growth
- Large, deeply penetrating taproot
- Winter-kills
- Quick to decompose residues
- High nutrient (N, P, S, Ca, B) content
- Bioactive plant chemicals (glucosinolates)

# Multiple Benefits from One Cover Crop

Because of its unique plant characteristics, a forage radish cover crop can provide measurable benefits to the farmer, the soil, and the environment while avoiding many of the problems traditionally associated with cover crops. As a result, farmers are finding that a forage radish cover crop pays for itself with tangible benefits.

## Alleviation of Soil Compaction

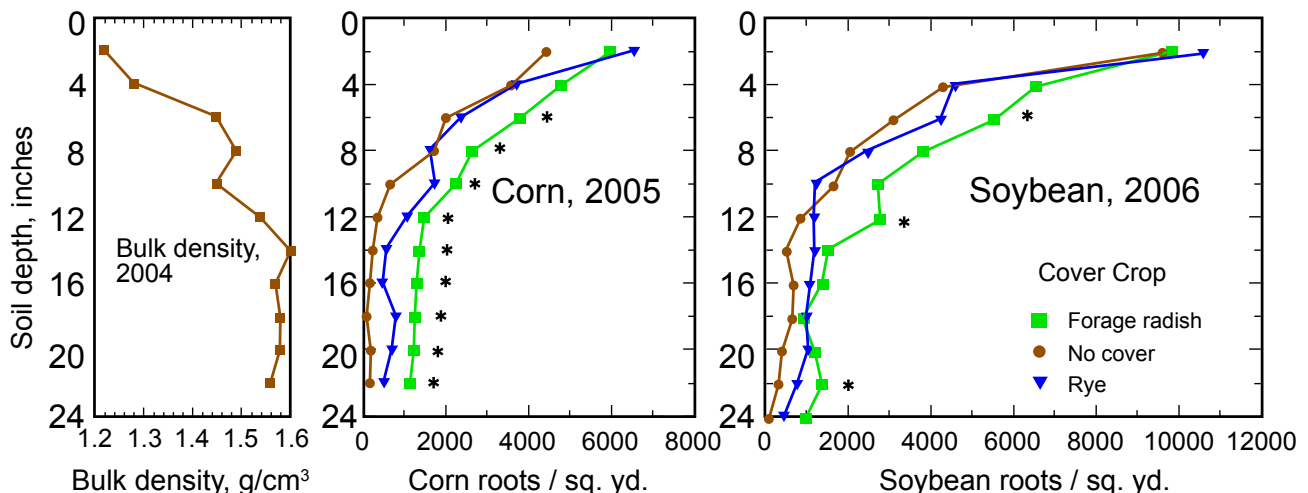
Forage radish cover crops are used by many farmers as a biological tool to reduce the effects of soil compaction, leading some farmers to refer to this cover crop as “tillage radish” or “radish ripper.” The roots of cool season cover crops can penetrate compacted soils in fall to some extent because they are growing when soils are likely to be relatively moist and easily penetrated. Forage radish roots can penetrate plow pans or other layers of compacted soil better than the other cover crops (such as cereal rye and rapeseed) tested in our research. The thin lower part of the taproot can grow to a depth of six

## Multiple Benefits

Forage radish has been shown to:

- Alleviate soil compaction—save on deep tillage
- Suppress weeds—save on herbicides/cultivation
- Enhance seedbed—save time and plant earlier in spring
- Build organic matter—improve soil quality
- Release N early and increase topsoil fertility—save on N and other fertilizers
- Reduce nitrate leaching—save the Bay
- Control erosion—save your soil
- Reduce runoff—conserve rainwater

feet or more during the fall. The thick, fleshy upper part of the taproot grows 12 to 20 inches long (including 2 to 6 inches protruding above ground) creating vertical holes and zones of weakness that tend to break up surface soil compaction and improve soil tilth. After the cover crop dies in the winter and the roots decompose, the open root channels can



Summer crop roots in soil profile as affected by previous cover crop. Bulk density of the soil (left, measured before cover crop treatments) shows the typical higher density found in subsoils. Chen and Weil (2006).

be used by roots of following crops to grow through compacted soil layers.

This process, termed “bio-drilling,” improves root access to water in the subsoil and makes following crops more resilient under drought conditions. In research plots, four times as many corn roots penetrated a compact subsoil after a forage radish cover crop as after winter fallow and twice as many as after a rye cover crop.

Data suggests that biodrilling with cover crops like forage radish can substitute for expensive and energy intensive deep ripping and other mechanical methods to alleviate the effects of soil compaction. Some farmers plant forage radish in 24- or 30-inch wide rows (with another cover crop species planted between rows—see cover crop mixtures, below) as a form of biological strip tillage. They then plant the following summer crop in these same rows to alleviate restriction of root growth into the subsoil.

## Suppression of Weeds

A good stand of early-planted forage radish produces a dense canopy that all but eliminates weed emergence in the fall and winter. This action produces a virtually weed-free seedbed in early spring. To obtain



Early April appearance of plots planted in fall to cereal rye (left) and forage radish (right).

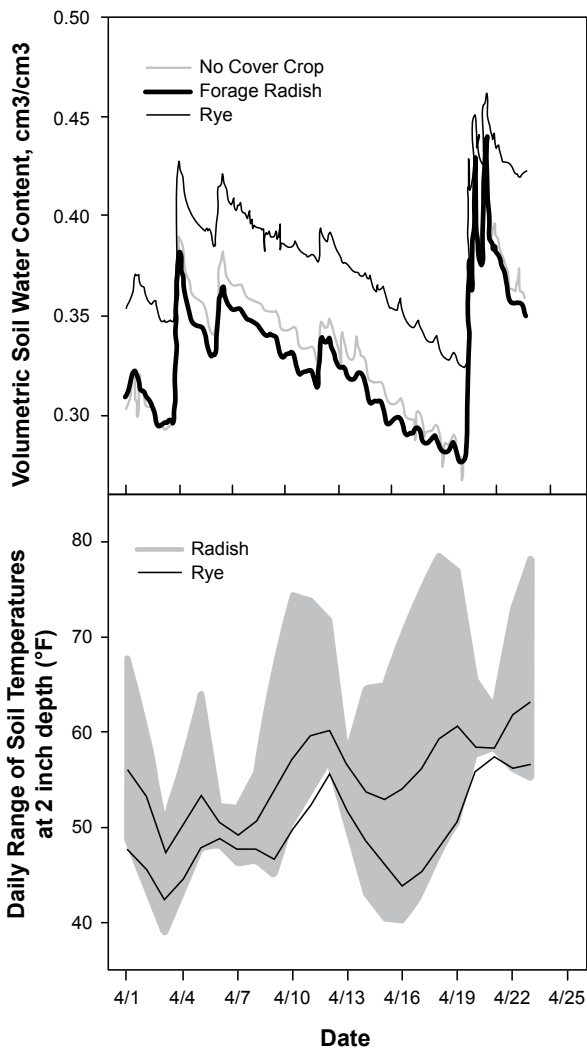
this near-complete weed suppression forage radish should be planted by September 15 (in Maryland) with a stand of 5 to 8 plants per square foot.

The near-complete weed suppression can be expected to last until early April, but does not extend into the summer cropping season. The low amount and fragility of residue and weed-free seedbed conditions in early spring following a forage radish cover crop make it possible to plant the summer crop without any seedbed preparation tillage or application of a burn-down (pre-plant) herbicide. In Maryland research where in-season (post emergence) weed control was applied, yields of corn planted after a forage radish cover crop were not affected by skipping the burn-down herbicide before planting.

This system may be of particular interest to organic farmers because it allows no-till planting without herbicides, although cultivation or other weed control will be needed later in the season. Forage radish cover crops have also been observed to suppress or delay the emergence of horseweed or marestalk (*Conyza canadensis*) and may provide a useful new tool for controlling herbicide-resistant biotypes of this weed.



Early corn growth was more vigorous after a forage radish cover crop (right, back) than after a rye cover crop (left, front), due partly to better N availability.



Warmer and drier seedbed in April with forage radish compared to rye as cover crop. (Weil and White, unpublished)

### Enhancement of Seedbed

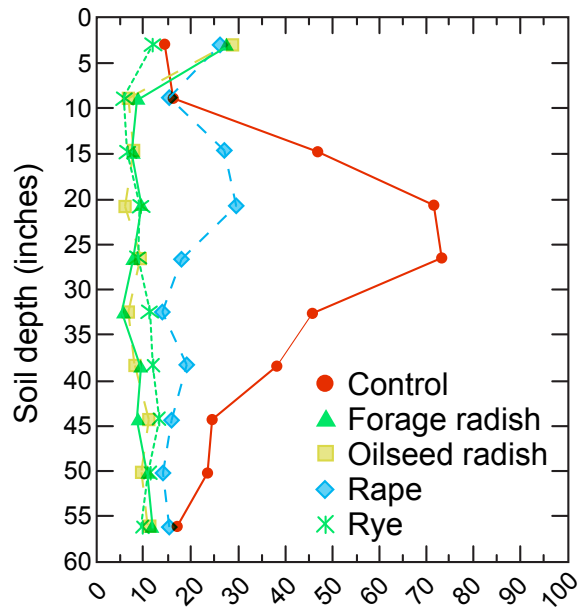
Unlike most other cover crops commonly used in the Mid-Atlantic, forage radish won't complicate or delay spring field operations. Because it winter-kills, it does not need to be killed or incorporated to prepare a spring seedbed. When conditions are favorable, the field will be ready for direct planting. Because forage radish leaves the soil surface weed free, punctured by large root holes, and covered by very thin and sparse residue, the seedbed soil warms up and dries out considerably faster in early spring than do soils covered by either winter weeds or a growing cover crop.

The warmer, drier soil and the elimination of the need for tillage can allow earlier spring planting. The earlier planting made possible by the forage radish cover crop may be important for effective utilization of the N released from the forage radish residue in early spring.

### Early Release of N and Increase in Topsoil Fertility

Unlike cereal rye and other cereal cover crops whose residues decompose slowly and immobilize N in the spring, forage radish residue decomposes rapidly and releases its N early. In fact, on sandy soils it is important to plant as early as possible following forage radish cover crops to take advantage of this flush of N before it leaches out of the rooting zone. Forage radish recycles large amounts of N taken up from the soil profile in fall and can reduce the need for N fertilizer in spring.

Because forage radish cover crops do not immobilize N, they are unlikely to slow down growth of the next crop as small



Nitrate-N in each 6 inch soil layer (lb/acre)

Forage radish and other cover crops clean up nitrate from a sandy soil profile by mid-November. Control soil had no cover crop, only winter weeds. (Data from Dean and Weil, 2009)

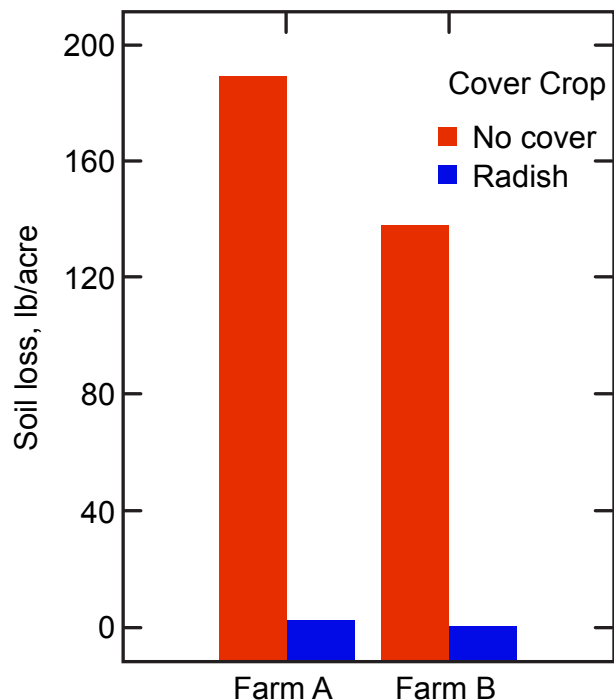
grain cover crops sometimes do. In fact, spring planted crops often show an early boost in growth and N uptake similar to that caused by a planting time N application.

## Reduction of Nitrate Leaching

Because of their exceptionally deep root system, rapid growth and heavy N feeding, forage radish cover crops can clean up most of the soluble N left in the soil profile after summer crops have ceased their uptake. This prevents excess N from leaching into groundwater during the fall/winter/spring period, during which there would be little or no plant evapotranspiration or N uptake if fields were left fallow. The forage radish takes up N from both the topsoil and from deep soil layers, storing the N in tissues near the soil surface for use by the next crop. If planted while soils are still warm, forage radish cover crops typically take up 100 to 150 lb/acre of N. Greater amounts of N may be taken up by forage radish when a drought-stricken summer crop has failed to utilize most of the fertilizer applied or on soils that mineralize large amounts of N in the fall due to previous manure applications.

## Control of Soil Erosion and Runoff

Forage radish grows rapidly if planted in late summer or early fall and a good stand can provide full canopy closure in three to four weeks. This canopy intercepts raindrops, preventing soil erosion. Even after forage radish is killed by a hard frost, a layer of decomposing residue remains on the soil surface through the winter and into the early spring providing protection from soil erosion. After surface residues have fully decomposed in spring, runoff and erosion are reduced because of the many



Erosion from three February–March storms was negligible for forage radish despite rapid decomposition of the surface residues. (Weil, 2009)

holes left behind from the large taproots. Rainwater rapidly infiltrates into these holes, eliminating runoff and trapping sediment before it leaves the field.

## Building of Soil Organic Matter

With typical dry matter production of 5,000 lb/acre shoots plus 2,000 lb/acre of root dry matter, a good forage radish cover crop adds significant quantities of easily decomposed organic material to the soil. Microbially active soil organic matter and aggregation have been observed to increase after using forage radish for several years.

## Effects on Crop Yields

In about half of our trials that included a good stand of forage radish, yields of corn (with normal N fertilizer rates) and soybean following the forage radish cover crop were significantly higher than those after fallow or cereal rye. These yield

increases may be due to improved N fertility, alleviation of soil compaction, or other effects.

## How to Grow Forage Radish as a Cover Crop

### Seeding

Establish a good stand of forage radish by seeding at 8 to 10 lb/acre using either a conventional or no-till drill (using either the box for small seed or large seed) or by broadcasting at 12 to 14 lb/acre. When using a drill, seeds are best planted ¼-inch deep when moisture conditions are good, but can be planted as deep as 1 inch during dry conditions if this is necessary to place seed in contact with soil moisture. When broadcasting, germination will be best if seeder is followed by a corrugated roller or very light disking to improve soil-seed contact.

Aerial seeding has been successful using 14 to 16 lb/acre broadcast into standing corn or soybean canopies that have begun senescence (yellowing of lower leaves). Forage radish usually germinates within just 2 to 3 days if the soil is warm and not too dry. Even unincorporated broadcast seed will achieve rapid germination if seeding is followed by a timely rain or irrigation.

Most forage radish seed is produced in Idaho or imported from Asia and Europe. Seeds similar to those used in this research are currently available from Leon Bird Seeds (3282 East State Route 18, Tiffin, OH 44883, 800-743-2473) and Steve Groff Seeds (679 Hilldale Road, Holtwood, PA 17532, 717-575-6778).

Forage radish has a very flexible and aggressive growth habit and will spread out in a rosette to fill the space it is given.

Radish plants—especially their fleshy root—will become much larger when grown at lower plant densities.

### Planting Date

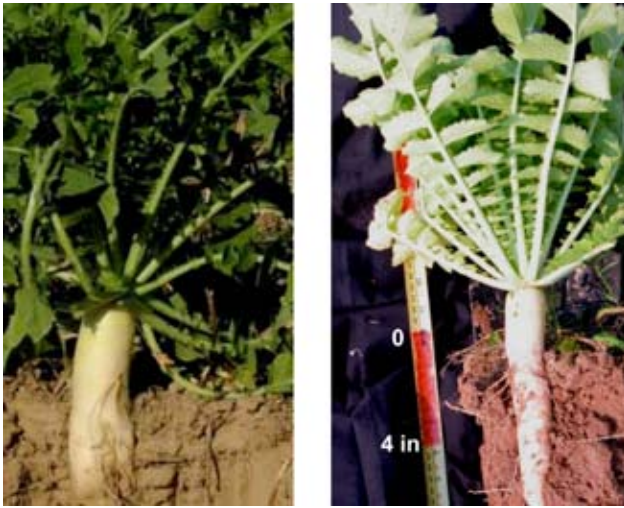
In the Mid-Atlantic forage radish grows best when planted from late July to early September but significant amounts of N can be captured by this cover crop when planted as late as October 1. Forage radish planted in late September may be less susceptible to frost and more likely to overwinter. When planted in late March as a spring cover crop, forage radish did not emerge quickly or grow as well as when planted in fall.

### Frost

Forage radish is tolerant of frost until temperatures dip below 25°F. It takes several nights of temperatures in the low 20s to kill forage radish. If mild temperatures resume and the growing point is intact, green leaves may grow back. Usually in Maryland forage radish is damaged by frost by early December but does not die completely until the longer cold spells of January. Under the freeze-thaw winter conditions of the Mid-Atlantic, forage radish tissues decompose rapidly once killed by frost and leave only a thin film of residue by March.

### Crop Rotations

Forage radish winter cover crops fit well into corn silage and vegetable crop rotations that have openings for cover crop planting by the end of August. Forage radish has successfully been aerially seeded in early September into standing corn and soybeans on commercial farms. Because forage radish seeding rates are low, the seed may be mixed with other cover crop seed of similar size to bulk it up for more even



Fully grown forage radish plants showing variation in size and root formation with differing populations.

aerial seeding. If forage radish is planted as late as a September 30 grain corn harvest, it is unlikely to provide effective biodrilling and weed suppression, but may still capture nearly as much N as earlier plantings.

### Cover Crop Mixtures

Many farmers are experimenting with cover crop mixtures that combine forage radish with other cover crops that fix N or provide N immobilizing residues in the spring. Because forage radish can out-compete most other plants in early fall, seed forage radish in rows one to two feet apart to allow enough space for a companion cover crop to grow in between. Taping-off alternating openers in the small and large seed boxes of a no-till drill is one way to create alternating rows of forage radish and a companion crop. Alternatively, reducing the forage radish seeding rate by half also allows other cover crop species to compete and stay in the cover crop mix.

Spring oats and sorghum–Sudan grass compete well with forage radish, winter kill in the Mid-Atlantic, and provide longer lasting residues to immobilize some of the N released from forage radish



Forage radish planted alone (left) and in alternating rows with Sudex (right). The Sudex was already frost killed in this late October photo.

residues in the spring. These additional residues may also help maintain soil moisture, reduce weed growth, and reduce erosion during the next growing season. When rye is mixed with forage radish, the rye overwinters and grows into the spring when it can take up the N released by the decomposing forage radish. Hairy vetch is an N fixing cover crop that overwinters and performed well when mixed with forage radish. Sun hemp fixes N but will winter kill with the forage radish in the Mid-Atlantic.

### Problems to Avoid

Forage radish does not tolerate very wet soils, so avoid planting it in low spots that collect standing water. Nitrogen deficiency will limit forage radish growth and may limit its ability to compete with weeds or grow through compacted soil. Nitrogen deficiencies have been observed when planting after silage or grain corn on sandy soils or soils that do not have a history of manure application. In such situations, an application of 15 lbs N/acre is sufficient to stimulate rapid initial growth so that the forage radish may be able to capture 100+ lbs of N from deeper in the soil profile. Nitrogen

deficient forage radish plants have been observed to be less susceptible to frost and are more likely to overwinter. If they survive the winter, forage radishes may be attacked by harlequin bugs and flea beetles. Also, be warned that during warm spells in winter, decomposing forage radish residues may produce a rotten egg-like odor.

## Summary

Forage radish is a unique cover crop that can provide multiple benefits when suitably integrated into your crop rotation. Provision of most of the benefits mentioned depends on timely planting in early fall.

There is still much to learn about this new cover crop, so experiment! Our work with forage radish has been inspired by the creativity of farmers developing solutions to problems on their own farms. We hope that this fact sheet will provide you with information that helps you innovate on your own farm.

## References

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## Forage Radish: New Multi-Purpose Cover Crop for the Mid-Atlantic

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