

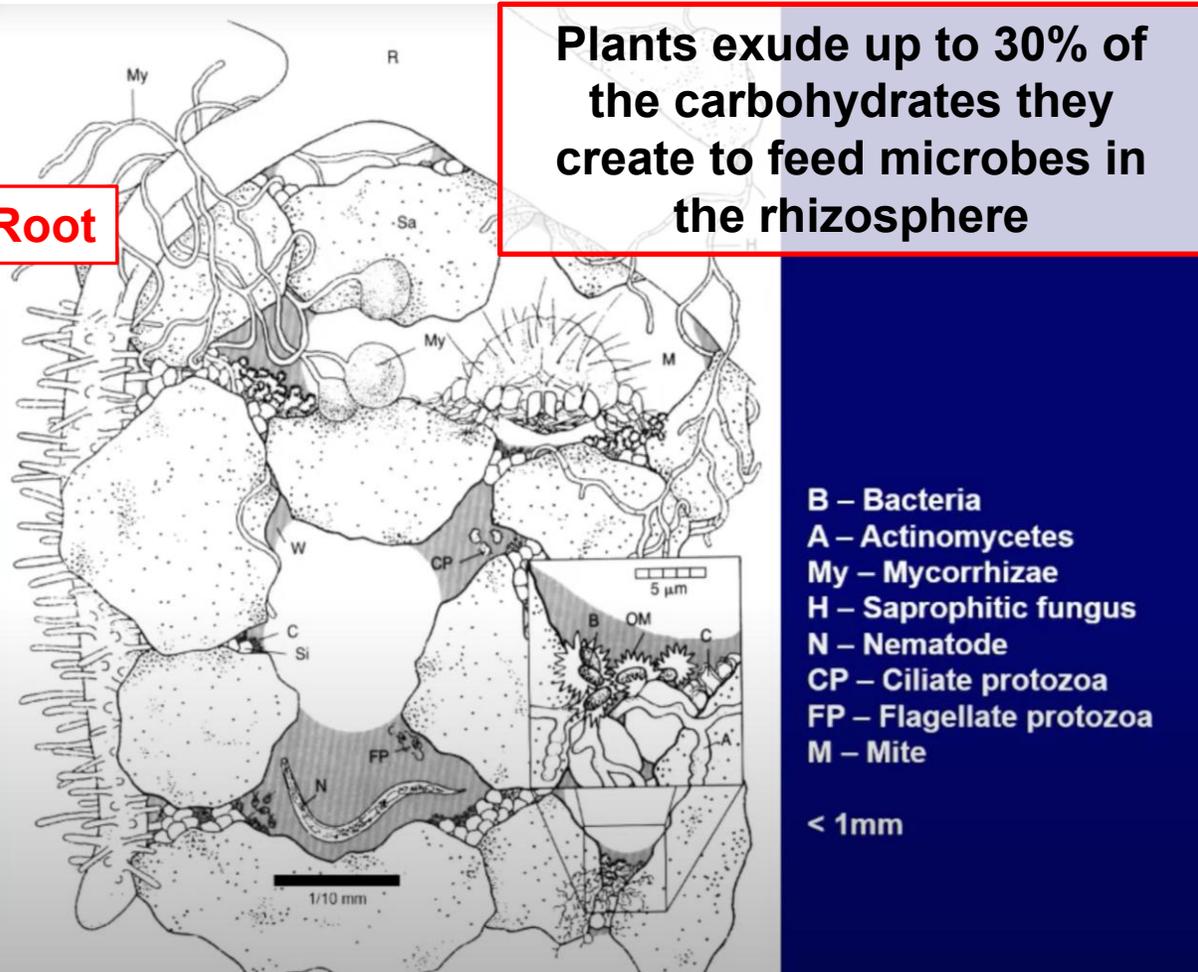
Increasing Cover Crop Opportunities in Vegetable Crops on the Central Coast

- **Richard Smith, Emeritus Farm Advisor**
- **Michael Cahn, Farm Advisor**
- **Eric Brennan, USDA ARS, Horticulturalist**

Critical Role of Cover Crops in Our Intensive Vegetable Production Area

Root

Plants exude up to 30% of the carbohydrates they create to feed microbes in the rhizosphere



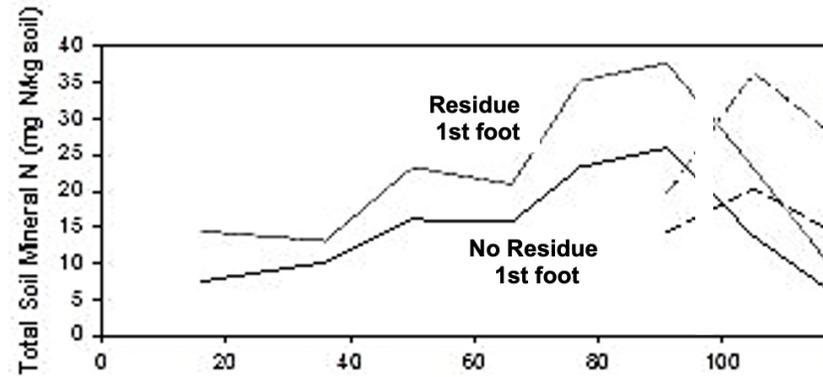
Our soils have inherent qualities from their development over millennia as grassland soils – how can we maintain these qualities?

Four Principles for Improving Soil Health:

- Maximize the Presence of Living Roots
- Minimize Soil Disturbance
- Maximize Soil Cover
- Maximize Biodiversity
- Provide carbon inputs

Fate of Residual Soil Nitrate – End of Season

Soil nitrate increases during the winter from mineralization of soil organic matter and crop residues



The amount of rainfall during the winter fallow impacts the amount of residual soil nitrate available for the first lettuce crop

Termination of Previous Crop

Fallow Period

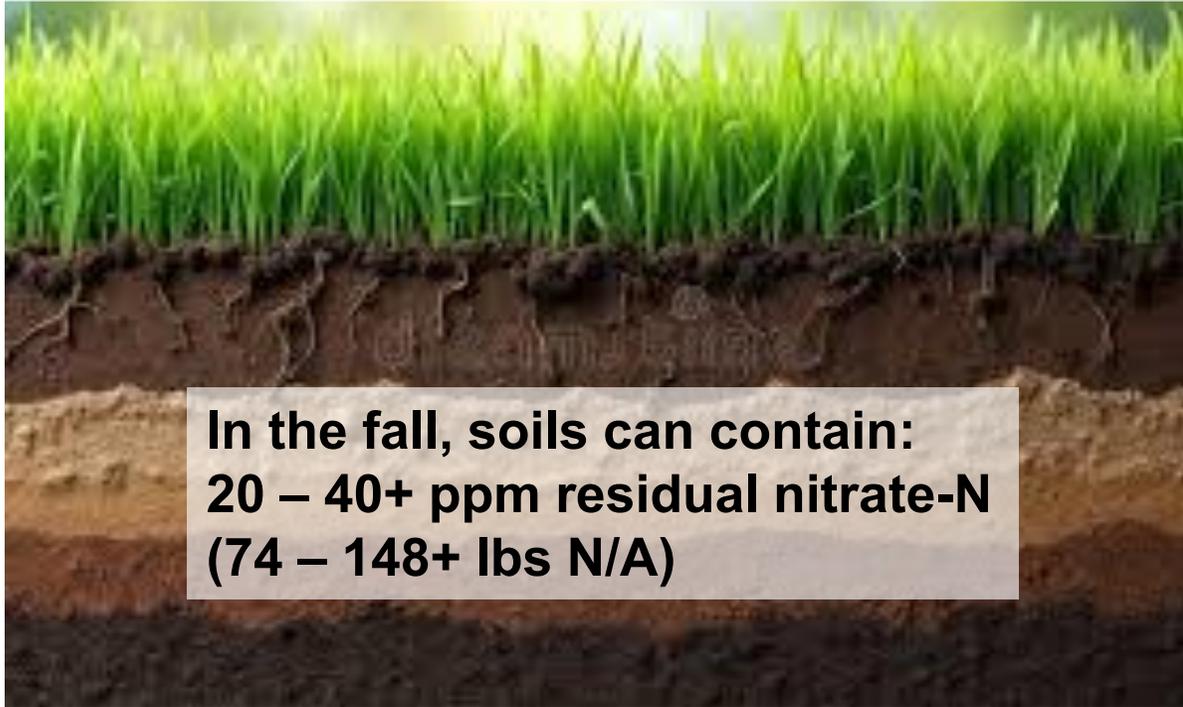
First Crop Following Season



← Rainy Season →

Role of Cover Crops in Taking up Residual Soil Nitrate and Keeping it from Leaching

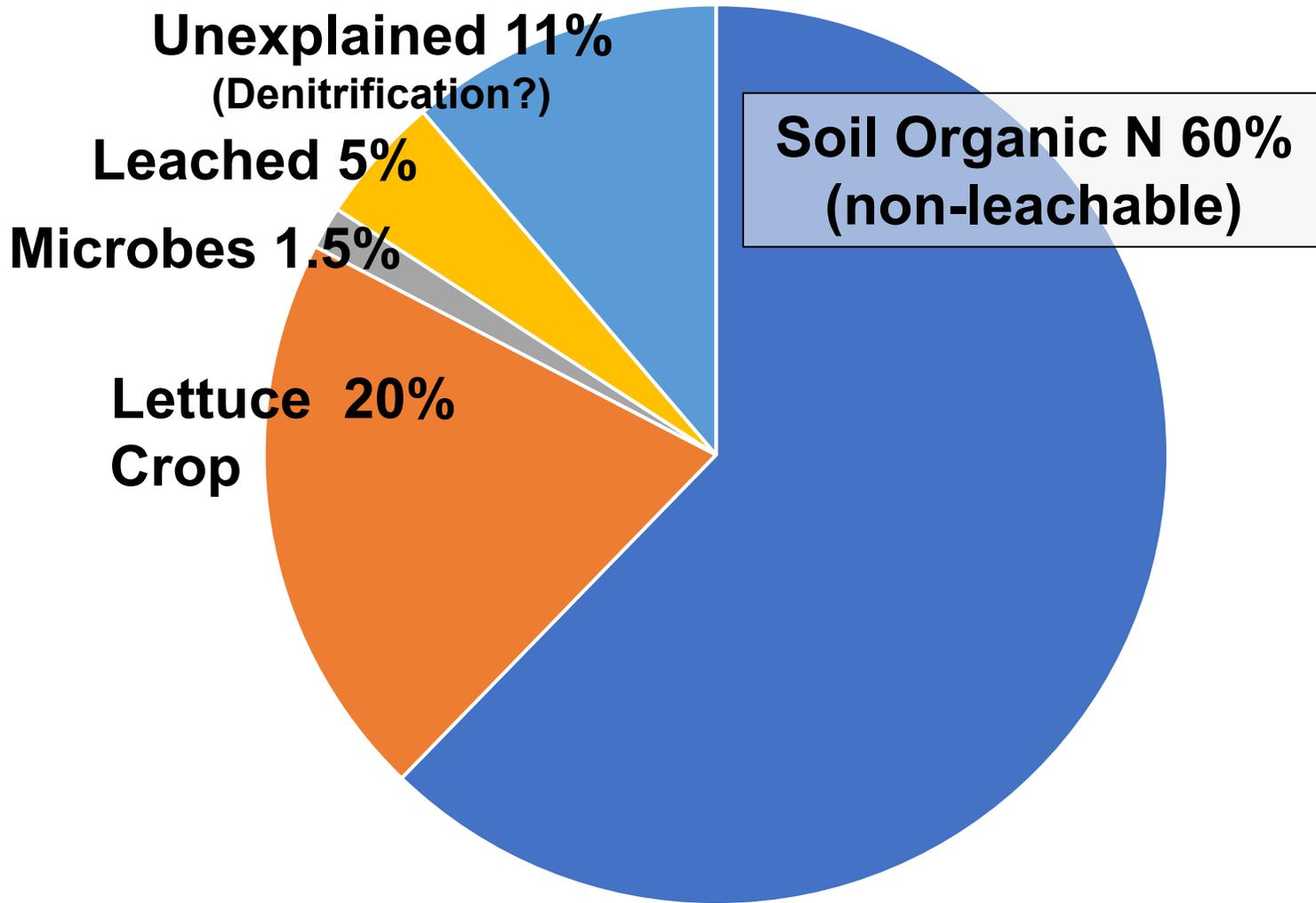
A Significant Portion of the Residual Soil N is taken up and Sequestered in cover crop biomass



In the fall, soils can contain:
20 – 40+ ppm residual nitrate-N
(74 – 148+ lbs N/A)

- The cover crop scavenges residual soil nitrate from the soil, holds it in its biomass while it is growing
- Upon incorporation into the soil, it decomposes and the fate of the N that it contains depends on the C:N ratio
- Not all of the N in cover crop residue mineralizes to nitrate
- There is a recalcitrant fraction, that resists decomposition and the N is in a non-leachable form

Fate of Cover Crop Nitrogen in Subsequent Lettuce Crop



- Louise Jackson documented the fate of nitrogen in cover crop biomass (C:N = 19) with N^{15} tracers in a subsequent lettuce crop
- A portion was taken up by the lettuce crop but the majority of the N was found in soil organic matter

Cover Crops Defined in Ag Order 4.0



Over-Wintered Cover Crop

- Cover crops in Ag Order 4.0 were defined as a non legume planted in the fall and grown for 90 days; need to achieve a C:N ratio of 20 or more; have a dry biomass of >4500 lbs/A
- This defines an overwintered cover crop
- However, the essential aspect of the cover crop is how much N did it prevent from leaching during the rainy season
- The Applied minus Removed (A-R) metric in the Ag Order attempts to calculate the amount of N loading to groundwater
- Winter cover crops transfer N from one season to the next where it can be used by the subsequent crop

Regulations Regarding the Use of Cover Crops are Under Review



- Several aspects of Ag Order 4.0 were remanded by the State Water Resources Control Board (SWRCB)
- An Expert Panel was organized by the SWRCB to review Ag Order 4.0
- This process is currently underway
- It is uncertain, but it is possible that Targets/Limits in 4.0 will be unremanded
- Cover crops on the R side of the A-R metric will be important in helping growers to meet targets/limits

Reminder of what was proposed in Ag Order 4.0

Enforcement	A-R lbs N/A	Date
Target	500	2023
Target	400	2025
Limit	300	2027
Limit	200	2031
Limit	150	2036
Limit	100	2041
Limit	50	2051

An Expanded Role for Cover Crops



- The definition of a cover crop needs to be expanded to include other strategies that are currently used by growers and that are being evaluated
- The fate of nitrogen in cover crop biomass needs to be expanded and implemented in the regulations:
 - The essential aspect of a cover crop is how much nitrate did it reduce from leaching either in its biomass or incorporated into recalcitrant biomass
 - All of the non leachable N should be given a credit in the A-R calculation

Video for Determining Biomass of Cereal Cover Crops

By Eric Brennan



There is a companion video on Eric's site for calculating N content of the cover crop

Other Cover Crops Strategies not Included in Ag Order 4.0



- **Fall-grown cover crops**
- **Low residue winter cover crops**
- **Mixed non legume/legume cover crops**

Fall-Grown Cover Crops – Aug/Sept to Oct/Nov

For some growers fall-grown cover crops makes sense if there is the window to plant them. They are terminated prior to the onset of wet weather

Cereal cover crops grow rapidly in warm fall conditions and take up large quantities of nitrogen in 60 days of growth

Studies have shown that a portion of the nitrogen in the cover crop biomass is recalcitrant and is not mineralized and is not leachable

Fall-grown cover crops are worked in before the onset of winter weather and do not pose issues with too much residue for planting the next crop

End of Previous Season

Fall-Grown Cover Crop

Fallow Period

First Crop of Next Season



Rainy Season



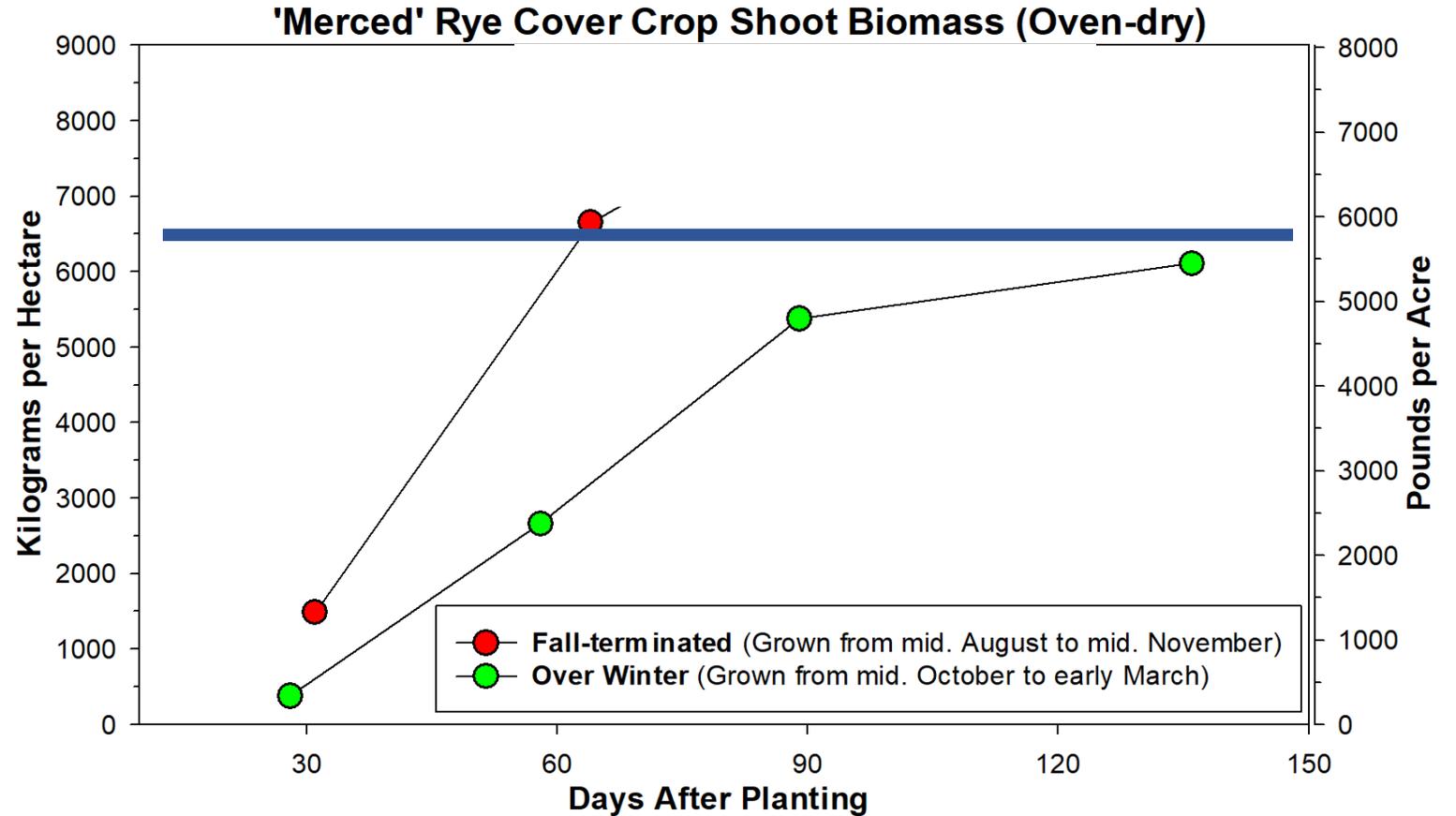
Mineralization of Nitrogen from Fall-Grown Cover Crops

- The fall is an optimal time for the cover crops to grow, they produce as much biomass in 60 days as an over winter cover crop does in 120 days
- Because they are developing so quickly there is a risk of setting seed, so watching for flowering and seed development is critical (e.g. 55-60 days)
- They are typically incorporated into the soil, but researchers are looking at growing the plants on beds, killing the biomass and letting it stand through the winter and incorporate it the following spring to receive a greater credit on the R side of the A-R calculation



Mineralization of Nitrogen from Fall-Grown Cover Crops

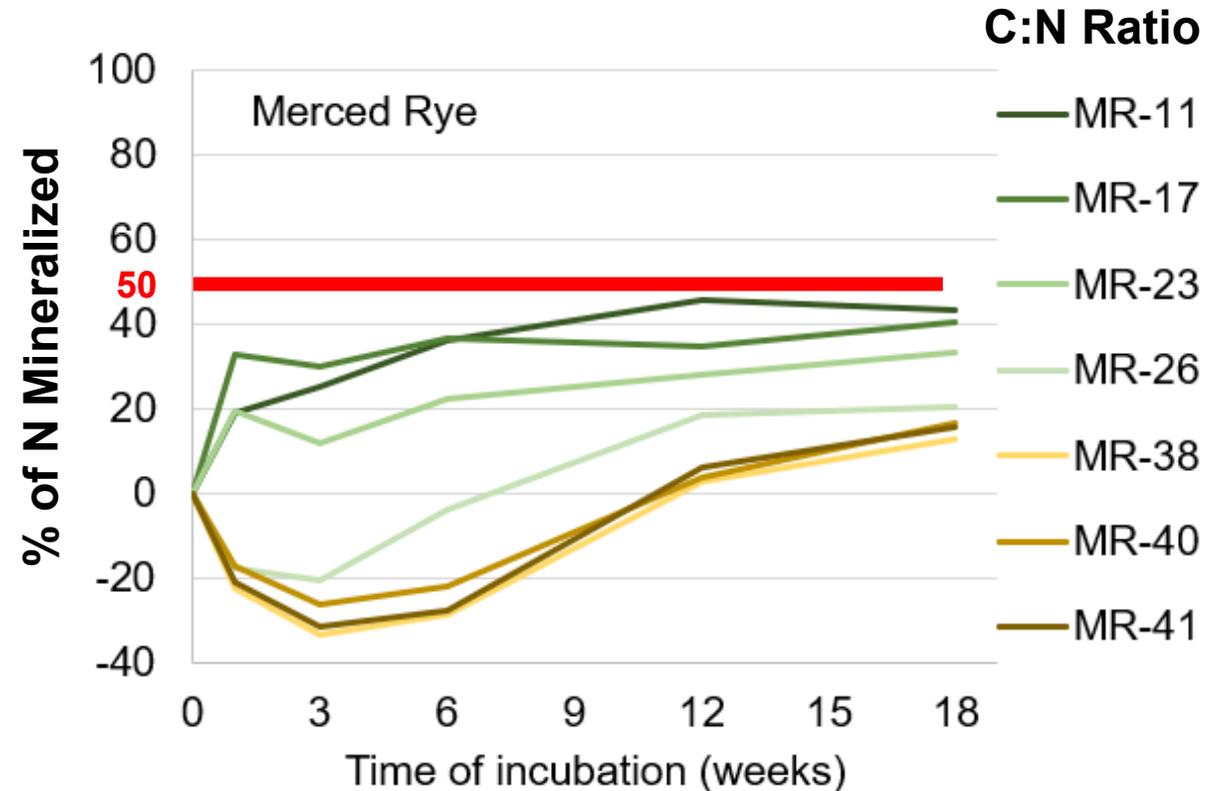
- The fall is an optimal time for cover crops to grow, they produce as much biomass in 60 days as an over winter cover crop does in 120 days
- They can take up as much as 150 lbs N/A



Eric Brennan

Mineralization of Nitrogen from Fall-Grown Cover Crops

- There is a portion of the nitrogen in the Cover Crop biomass that does not mineralize when incorporated into the soil even after 18 weeks
- This is the recalcitrant fraction of the nitrogen in the biomass
- This portion should be granted a credit in the A-R calculation
- The fate of N in recalcitrant biomass needs further study



Geisseler et al, 2025

Video with Further Info on Fall-Grown Cover Crops

By Eric Brennan



Low Residue Winter Cover Crops

At the end of the production cycle the ground is worked as normal and winter beds are listed. Low residue winter cover crops are planted on beds

A variety of low residue strategies can be employed

The goal of the low residue cover crop strategy is to facilitate being able to rapidly prepare beds for planting the subsequent cash crop

End of Production Season

Low Residue Cover Crop

First Crop of Season B



Rainy Season

Low Residue Winter Cover Crops



- **Different strategies to manage cover crop biomass:**
 - Planting winter adapted cereals or mustards as short-term cover crops (e.g. 60 days) to manage their residue production
 - Planting summer adapted species (e.g. Sudangrass) in Sept/Oct. They grow vigorously for a time then slow down due to cold winter weather which reduces the biomass production

Why Use Low Residue Winter Adapted Cover Crop Species



- This practice provides an opportunity to use a cover crop where you might not otherwise consider their use
 - They grow vigorously in a short time frame
 - Rapid ability to get the beds ready for the subsequent cash crop
 - Provides a quick infusion of biomass to the soil
 - Depending on the biomass produced, they can receive a modest credit R side of the A-R calculation

Managing Biomass of Winter Adapted Cover Crop Species



- **Planting on beds facilitates rapidly preparing the ground for planting small seeded vegetable crops**
- **Need to limit the cover crop biomass (e.g. 0.5 to 1.0 dry ton/A)**
 - **If mechanical management is not possible, may need to kill with herbicides (e.g. Roundup, Rely or grass specific herbicides to safeguard adjacent crops)**
 - **Drone applications of herbicides are useful when wet soils prevent mechanical incorporation**

Managing Biomass of Winter Adapted Cover Crop Species

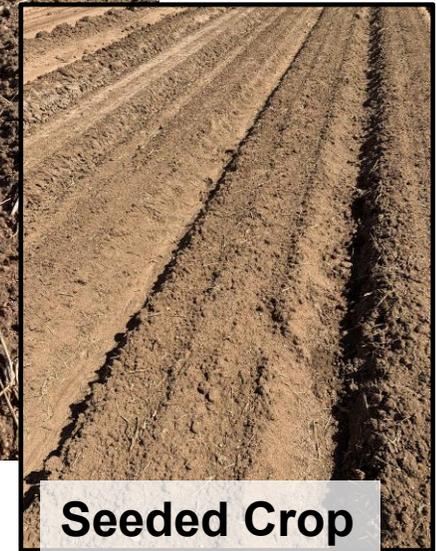
- Depending on how vigorously the cover crop is growing, the quantity of biomass will need to be limited to allow the biomass to be easily incorporated into the bed and allow for quick preparation of the beds for planting the subsequent cash crop



**There is a need to take adjacent crops into consideration
When planning for the use of these cover crop strategies**

Managing Biomass of Winter Adapted Cover Crop Species

- Depending on the amount of biomass that the cover crop produced:
 - Can be mowed
 - A lilliston may be capable of incorporating the residue
 - A reverse mulcher or chisels may be used for more aggressive incorporation
 - The key is to preserve the beds, make them ready for planting
- The amount of credit is less than overwintered cover crops



Reverse Mulchers may facilitate incorporation of cover crop residue

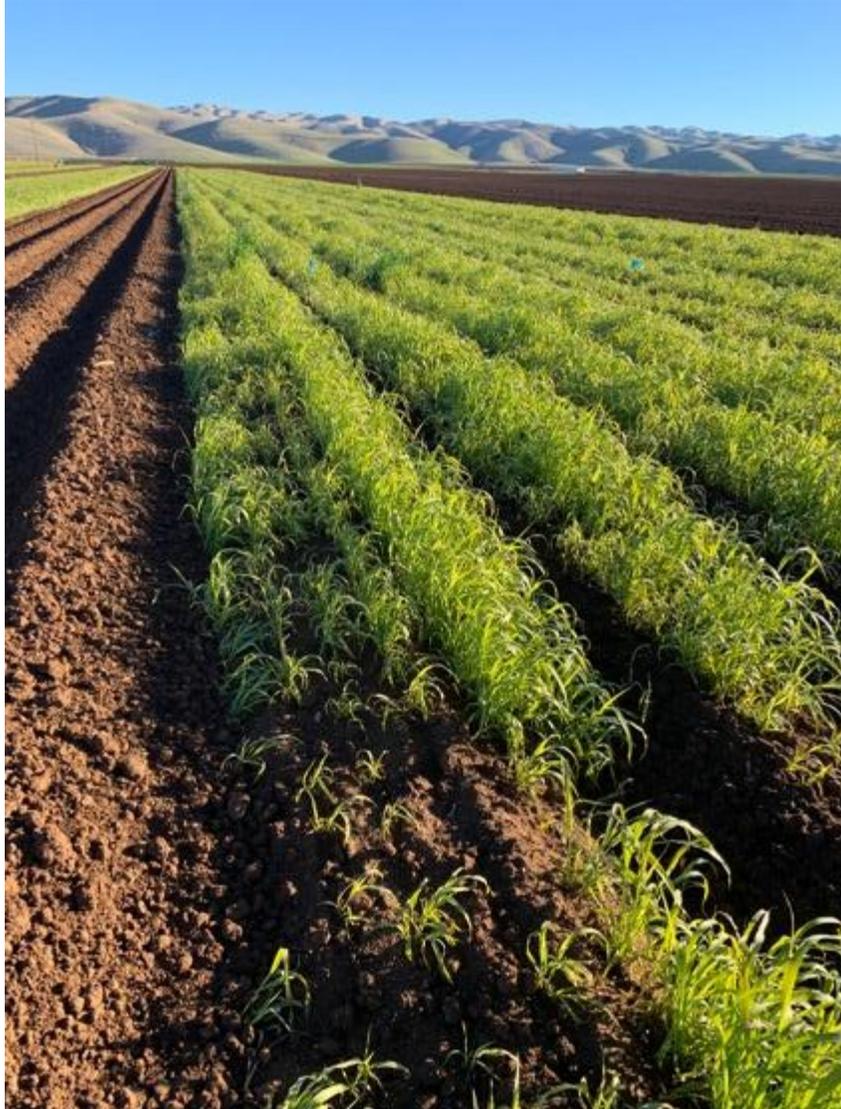
2024-2025 season

Other Winter Adapted Cover Crop Strategies



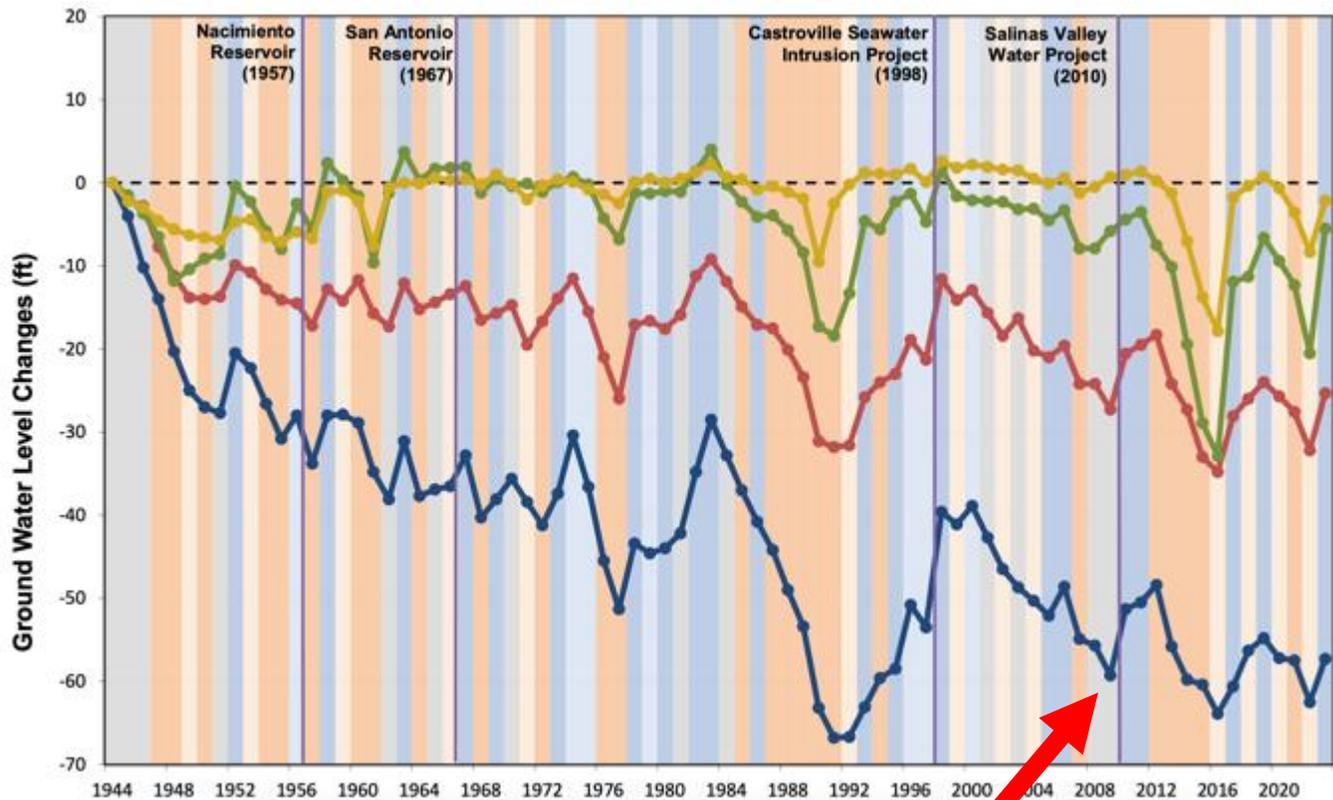
- Planting furrow bottoms and allowing them only to accumulate enough biomass to provide cover to the soil and prevent erosion and take up a modest amount of residual soil nitrate
- Their growth can then be terminated mechanically if weather allows or can be controlled chemically

Low Residue Summer Adapted Cover Crop Species



- This practice is of particular value on the eastside production areas
- Species like Sudangrass when planted in Sept to mid-October initially grow vigorously but their growth slows with the onset of cold weather (this was not necessarily the case in the winter of 2025-26)
- They transpire less water (after the onset of cold weather) due to their reduced vigor which facilitates greater infiltration from rainfall
- This practice should qualify for a credit from SGMA

Groundwater Levels on the Eastside



Annual Ground Water level of the Eastside

- Eastside aquifers are dependent on infiltration from the farmland as there is no significant infiltration from the river
- Eastside soils seal and, given the slopes, much of the rainfall is prone to run off
- Cover crops can help improve infiltration and reduce erosion

Low Residue Summer Adapted Cover Crops



- They are planted on beds to facilitate rapid incorporation and preparing the beds for the subsequent cash crop
- Sudangrass is small seeded and accurate seeding depth is necessary for them to germinate uniformly

Note poor growth on the bedtop seedlines, due to being planted too deep by the grain drill



Issues with Low Residue Summer Adapted Cover Crop Species



- This technique is particularly susceptible to weed pressure
- In Michael's studies it has been necessary to treat the initial flush of weeds with a broadcast application of Shark, Maestro or a combination of these two materials to control specific weeds and not damage the grass
- A second flush of weeds may also need to be treated

Issues with Low Residue Summer Adapted Cover Crop Species



First flush of weeds mostly controlled by broadcast herbicide application



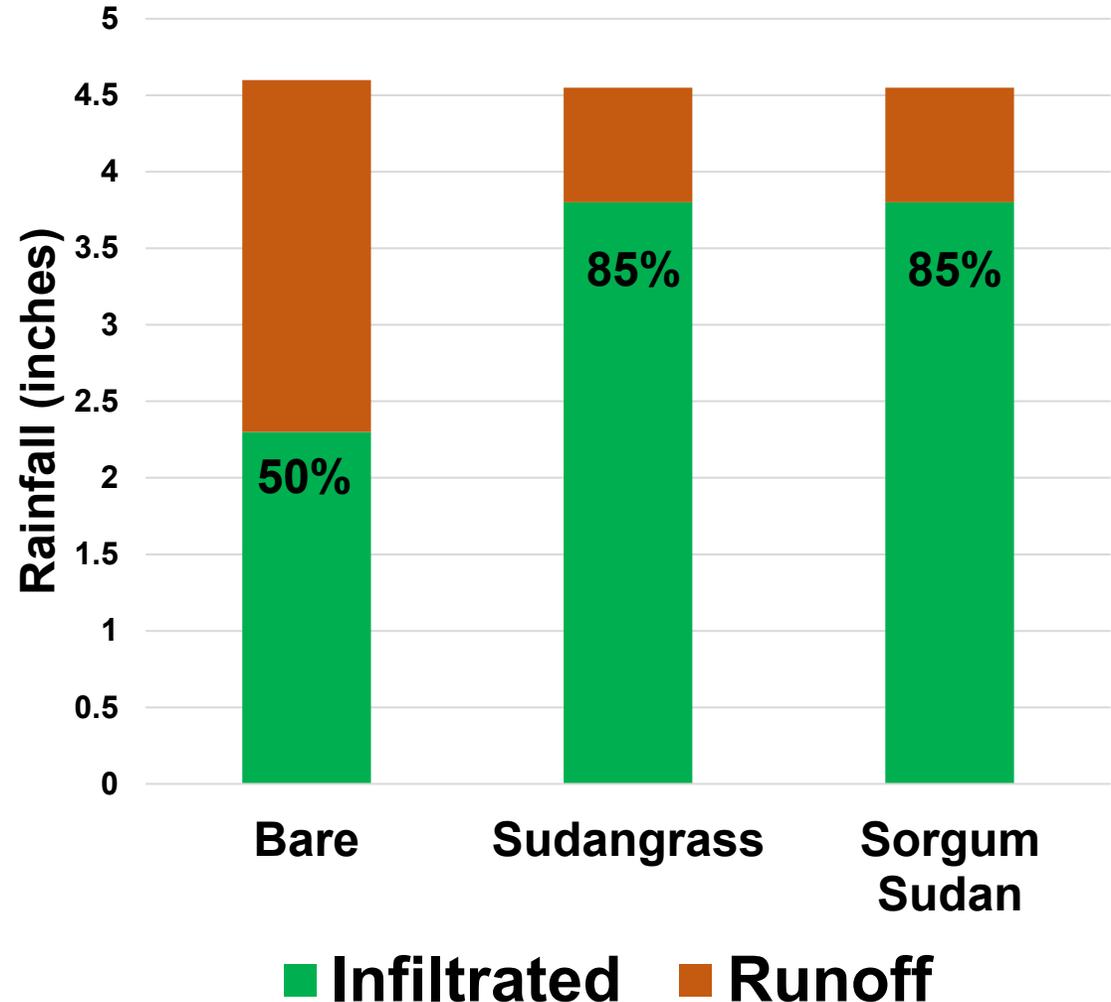
Subsequent flush of weeds: May or may not need to be controlled depending on when the cover crop will be terminated



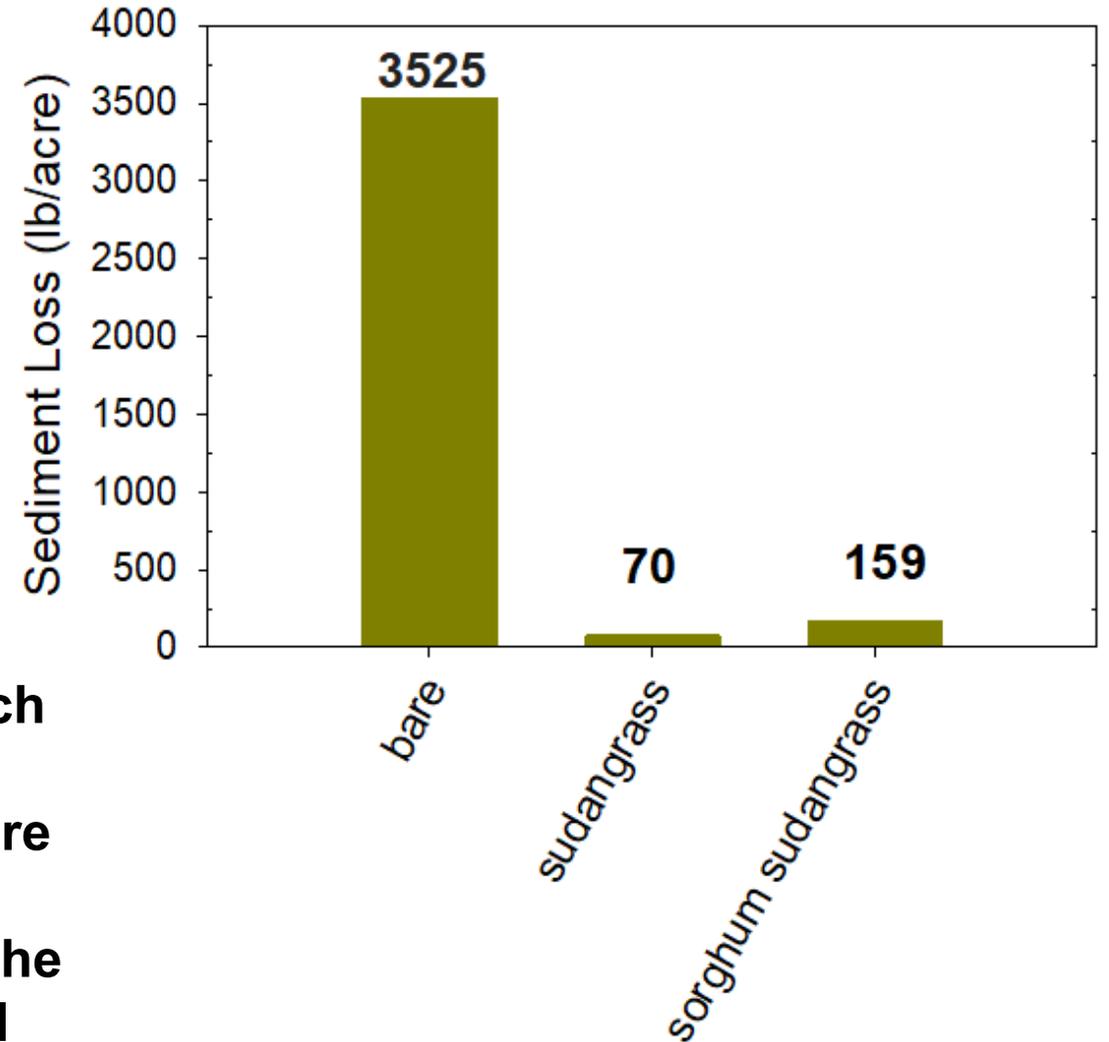
It is hoped that automated weeders that spot spray emerged weeds could be employed to help reduce weeding costs (the Verdant machine is used in grass seed production in Oregon and may be ready for this type of use)

Increased Infiltration with Low Residue Summer Adapted Cover Crops

- Half the rainfall in the Salinas Valley comes as intense atmospheric rivers and is prone to running off
- Having vegetative cover helps infiltrate a greater portion of the rainfall
- The N taken up by these cover crops should receive a modest credit on the R side of the A-R calculation (e.g. 30-50 lbs/A)



Erosion control



- The runoff in the cover crop plots also had much less sediments
- The sands stay in the field and the sediments are largely composed of clay particles
- The clays contribute to the inherent fertility of the soil, so their loss reduces the quality of the soil

Cover Crop Mixes with a Legume

- Higher soil nitrate favors the nonlegumes and lower soil nitrates favors the growth of the legumes
- Studies from many regions have shown that mixtures of legumes and nonlegumes were as effective in reducing nitrate leaching as pure non-legumes
- There is sufficient data that Regional Water Quality Control Boards can consider giving a nitrogen scavenging credit for nitrogen uptake by the non-legume component of winter cover crop mixtures of legumes and non-legumes



Video on the Value of Non legume/legume Cover Crops for Reducing Nitrate Leaching

By Eric Brennan



Details on Cover Crops and Nitrogen

- **Cover crops can only take up a finite amount of residual soil nitrate**
- **Use of Best Management Practices such as nitrate testing to adjust fertilizer applications during the growing season can help to reduce amount of residual soil N in the soil in the fall**
- **With moderate amounts of residual soil nitrate in the soil, cover crops can potentially scavenge 50 – 90% of soil nitrate in stead of 10 – 20%**

Final Details on Cover Crops and Nitrogen

- It is hoped that the State Water Board will accept the recommendation any cover crop strategy qualifies for a credit for the amount of N protected from leaching during the winter fallow
- The use of traditional over wintered cover crops has a glass ceiling of 10 – 15%
- If growers embrace the use of these other cover crop strategies just discussed, the percent of ground that is cover cropped can be further increased
- Clearly, these other strategies increase management and farming costs
- Their adoption will depend on the value that growers see in their use:
 - Options for increasing R values, improved soil health and yields – other benefits??!