

A photograph of a field of young green cover crop plants, likely rye or a similar grass, growing in rows. The plants are vibrant green and appear to be in the early stages of growth. The soil between the rows is dark and rich. The background is slightly blurred, showing more of the field.

Cover crops for reducing winter nitrate leaching

**Richard Smith, Emeritus Farm Advisor
for Eric Brennan, USDA Horticulture Researcher**

Source of the pool of Soil Nitrate

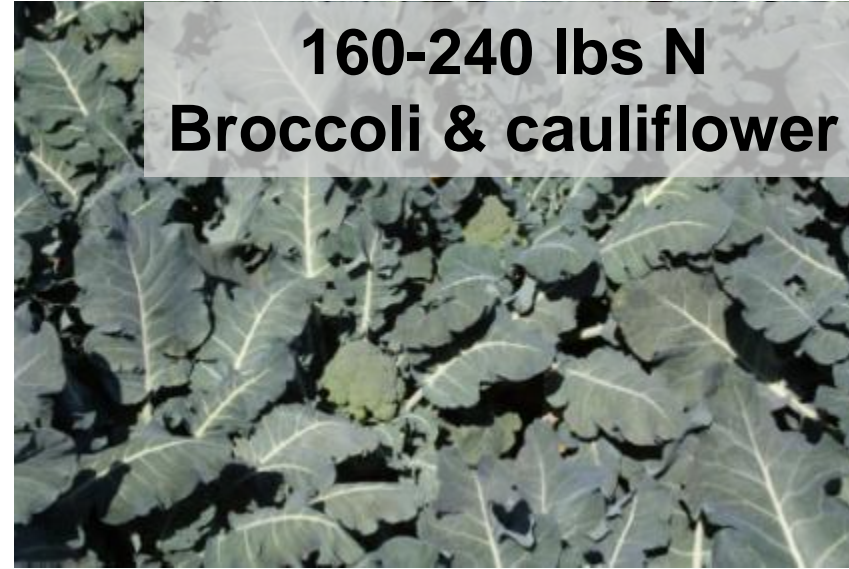
- **Sources of N:**
 - **inorganic fertilizer N**
 - **biological N fixation**
 - **atmospheric deposition**
 - **manures/composts/organic fertilizers**
 - **mineralization of soil organic matter**
 - **mineralization of crop residues**
 - **N in irrigation water**
- **All these sources can contribute to the pool of residual soil nitrate in the soil during the cropping season**

Crop Rotations and Residual Soil N

**60-80 lbs N
Lettuce**



**160-240 lbs N
Broccoli & cauliflower**



**60-80 lbs N
Celery**



**20-40 lbs N
Spinach & spring mix**

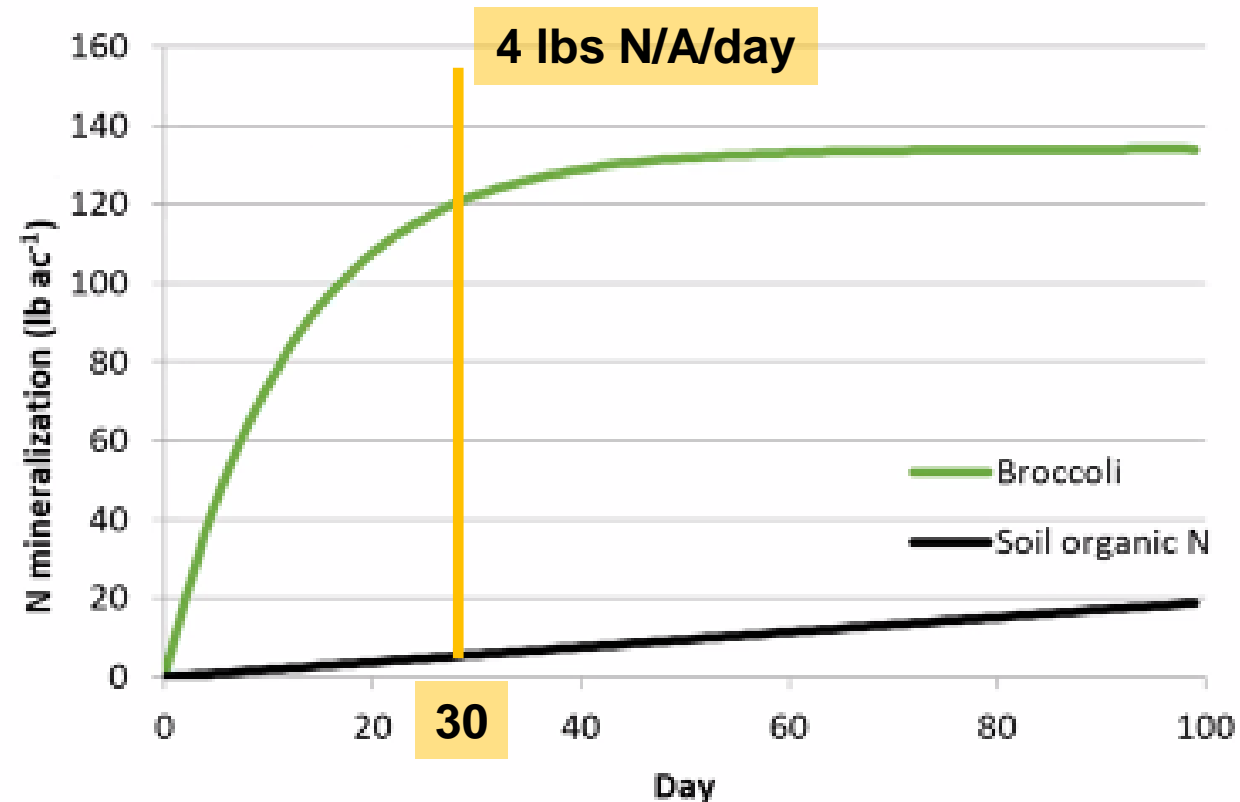


Mineralization of Broccoli Residue

Daniel Geisseler

Broccoli
210 lbs N/A
C:N=10

**Residue with
a higher %N
mineralized a
higher
percent of N**



- If this N can be maintained in the rootzone, it can contribute a significant amount of N for crop growth
- The fate of this N can be measured as residual soil nitrate

Fate of this pool of Soil Nitrate

- **During the cropping season, the goal is for the crop to take up a large percentage of this nitrogen**
- **During the winter- fallow period, cover crops offer a time-tested practice that can capture a good deal of the pool of residual soil nitrate and keep it in its biomass over the winter until it is incorporated into the soil prior to the first cash crop**

Fate of this pool of Soil Nitrate

- **In so doing, the N contained in the cover crop is awarded a credit in the reporting for Ag Order 4.0**
- **The cover crop must follow the following criteria....**

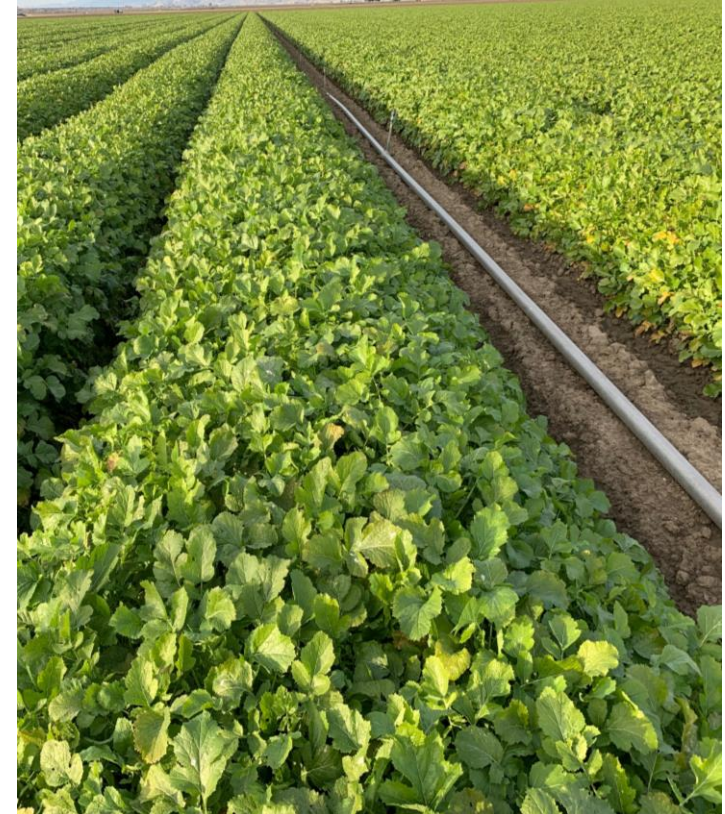
Cover crop as defined in Ag Order 4.0

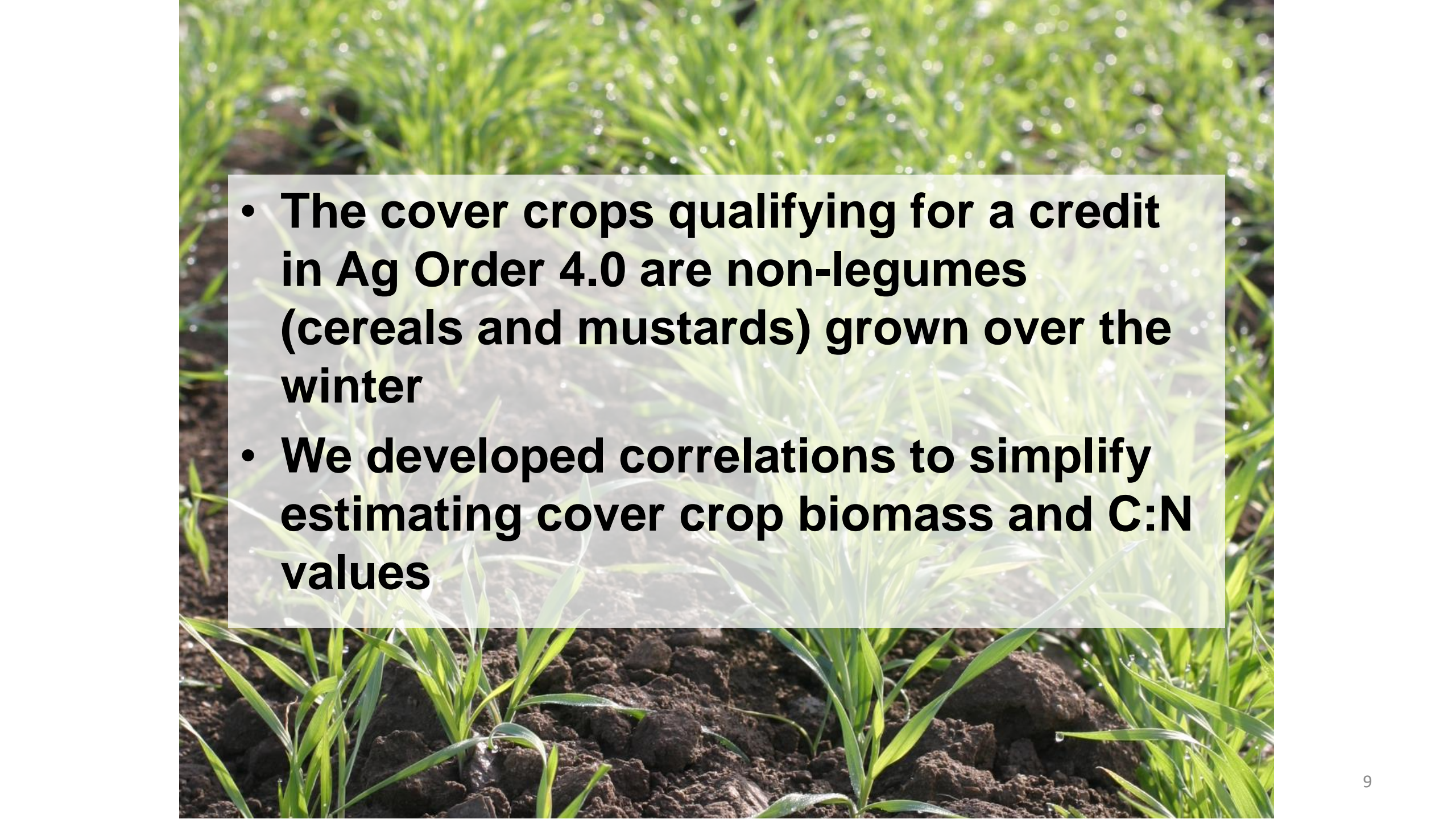
- 1. ≥ 90 days of growth during winter rainy period (October to April timeframe)**
- 2. ≥ 4500 lb per acre of oven-dry non-legume shoot biomass**
- 3. Carbon:Nitrogen ratio $\geq 20:1$ ***

*** This needs to be removed as a criteria, this cover crop has done its job; the C:N ratio is irrelevant**

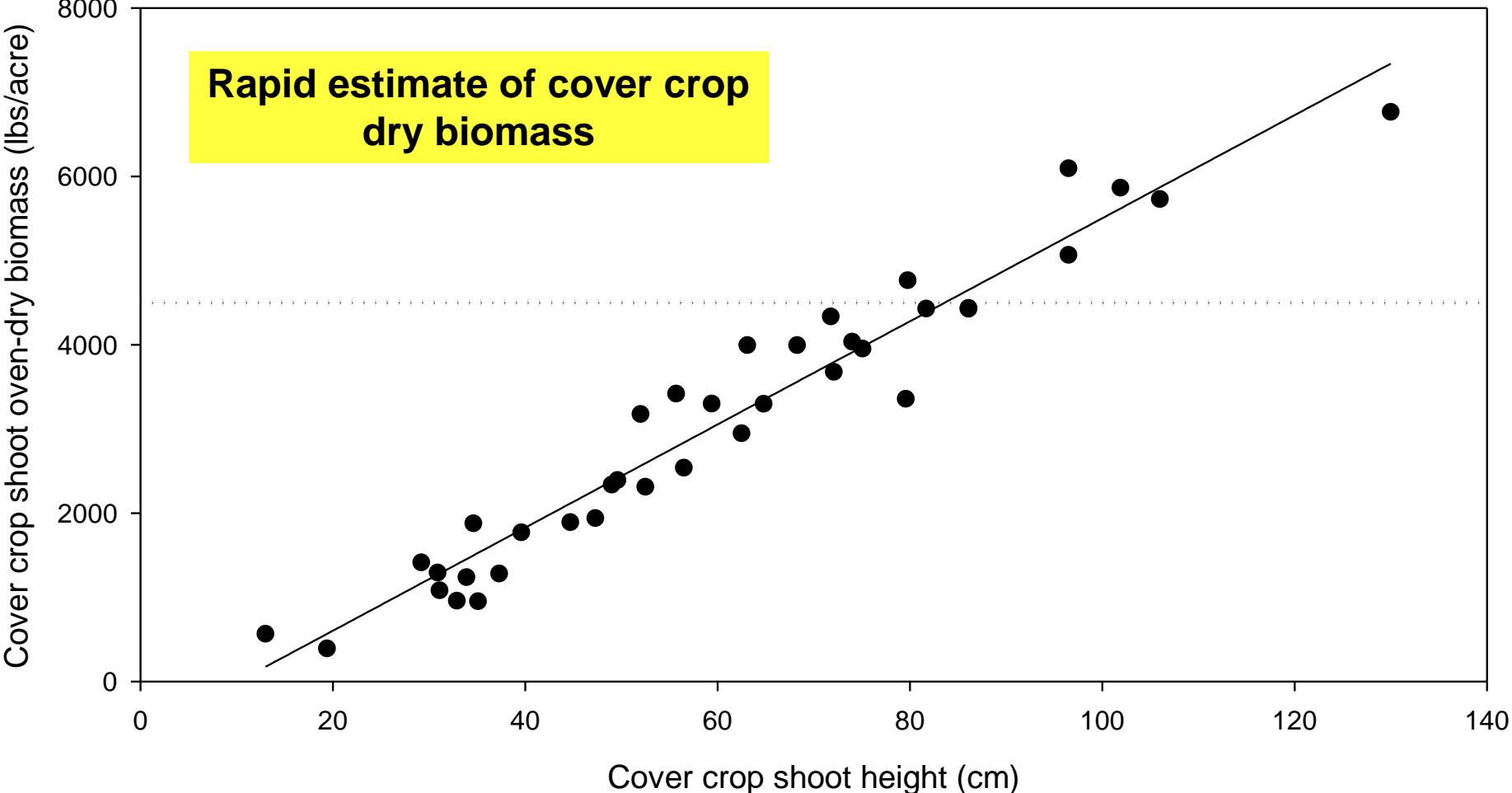
Cover Crops

- The reality is that about 5% of the vegetable production land is cover cropped each year:
 - That is equivalent to a given parcel receiving a cover crop once every 20 years
- The reasons for this is due to the high land rents, scheduling issues, etc.
- However, this reality is showing signs of changing as the Ag Order 4.0 is incentivizing the use of cover crops and the emphasis on improving soil health is gaining more interest



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- **The cover crops qualifying for a credit in Ag Order 4.0 are non-legumes (cereals and mustards) grown over the winter**
 - **We developed correlations to simplify estimating cover crop biomass and C:N values**

Relationship between Merced Rye Height and Biomass

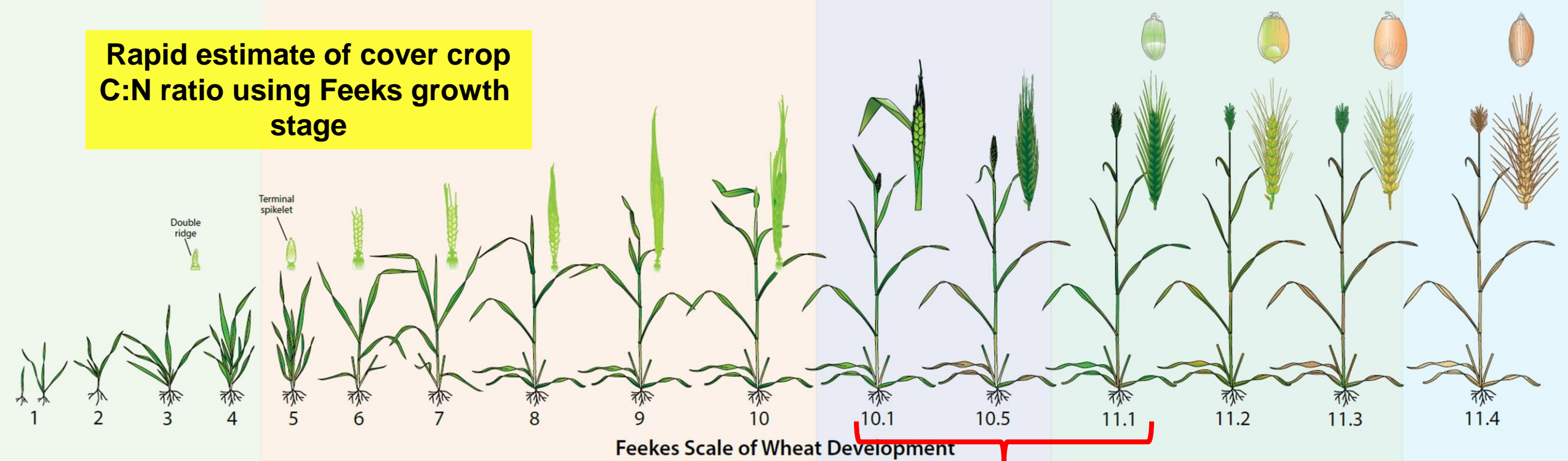


This correlation was developed for Merced Rye and Pacheco Triticale



Brennan and Smith, unpublished data 2022

Rapid estimate of cover crop C:N ratio using Feekes growth stage



Source: Lollato R. 2018. Wheat Growth and Development, Kansas State University Agricultural Experiment Station and Cooperative Extension Service. MF3300



Heads fully emerged.
Feekes 10.5

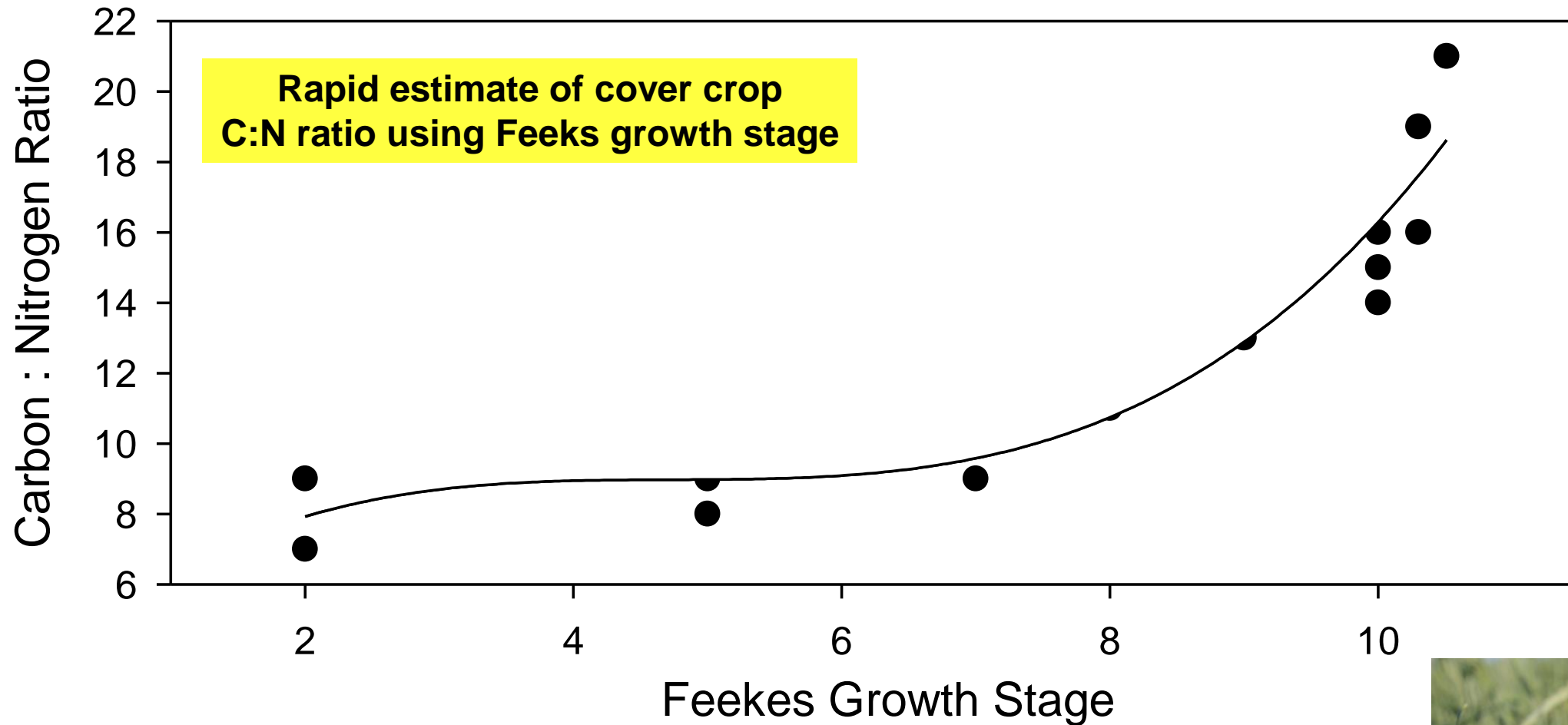
Anthers at center of head
Feekes 10.5.1

Anthers at top of head
Feekes 10.5.2

Anthers at bottom of head
Feekes 10.5.3

- **Feekes 10.5.4 – kernels watery ripe**
- **Feekes 11.1 – kernels milky ripe (use caution)**
- **Watching the weather and availability of equipment, letting the cover crop mature as much as possible maximizes the R credit and input of carbon into the soil**
- **Will use of reverse mulchers facilitate incorporation of high residue cover crops?**

Relationship between Feekes Growth Stage and Carbon:Nitrogen Ratio





E3

	A	B	C	D
1	Table 1. Feekes growth stages, C:N ratios and % N used to calculate the Cover Crop Nitrogen Scavenging Calculator for Merced Rye			
2	Feekes Growth Stage #	Growth stage description	Predicted C:N	Predicted % N
3	6	1st node of stem visible at base of shoot	10:1	4.2
4	7	2nd node of stem visible	11:1	3.6
5	8	Last leaf (flag leaf) just visible, but still rolled up	14:1	3.1
6	9	Ligule of flag leaf just visible	20:1	2.2
7	10	Boot. Head is inside flag leaf giving it a swollen appearance	27:1	1.6
8	10.1	Heading begins, 1st awns of head are just visible	29:1	1.4
9	10.2	1/4 of heading process complete	29:1	1.4
10	10.3	1/2 of heading process complete	31:1	1.4
11	10.4	3/4 of heading process complete	32:1	1.3
12	10.5	Head completely out of flag leaf sheath	33:1	1.3
13	10.5.1	Flowering begins; starts in the center of the head	33:1	1.3
14	10.5.2	Flowering complete to top of head	33:1	1.3
15	10.5.3	Flowering complete at base of head	33:1	1.3
16	10.5.4	Kernel watery ripe; Flowering complete;	33:1	1.3
17	11.1	Milk stage, Kernel milky ripe; Milk stage	41:1	1.1
18	11.2	Soft dough; Kernel mealy ripe; soft but dry consistency	42:1	1.1
19				
20				
21				

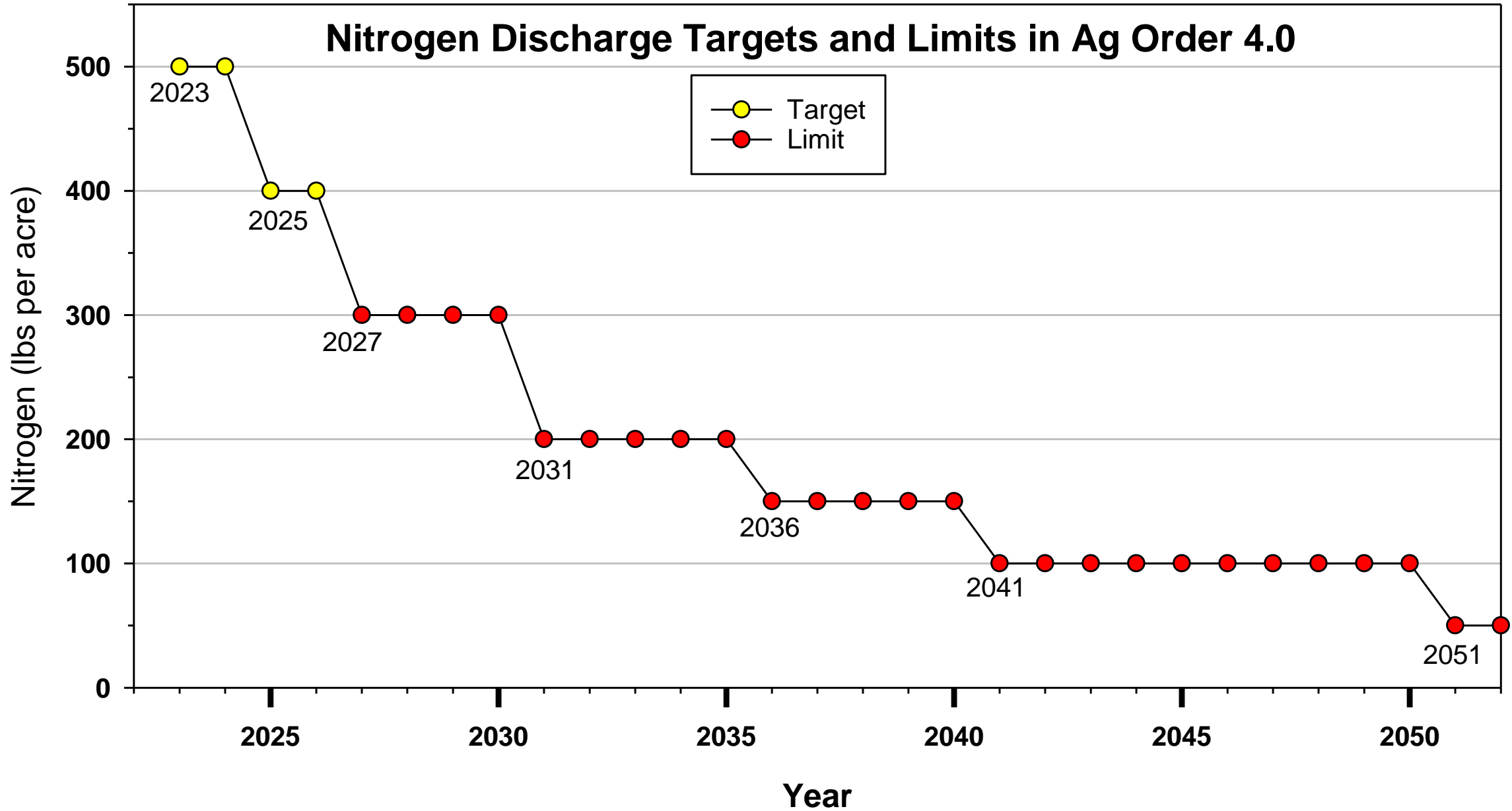
Percent N is calculated assuming that the carbon content is 42%. On Eric Brennan's website there is a chart that calculates the percent nitrogen from the C:N ratio estimate based on the Feeks growth stage. This can be multiplied by the biomass to get the total nitrogen contained in the cover crop biomass

Cover crop Nitrogen Credit

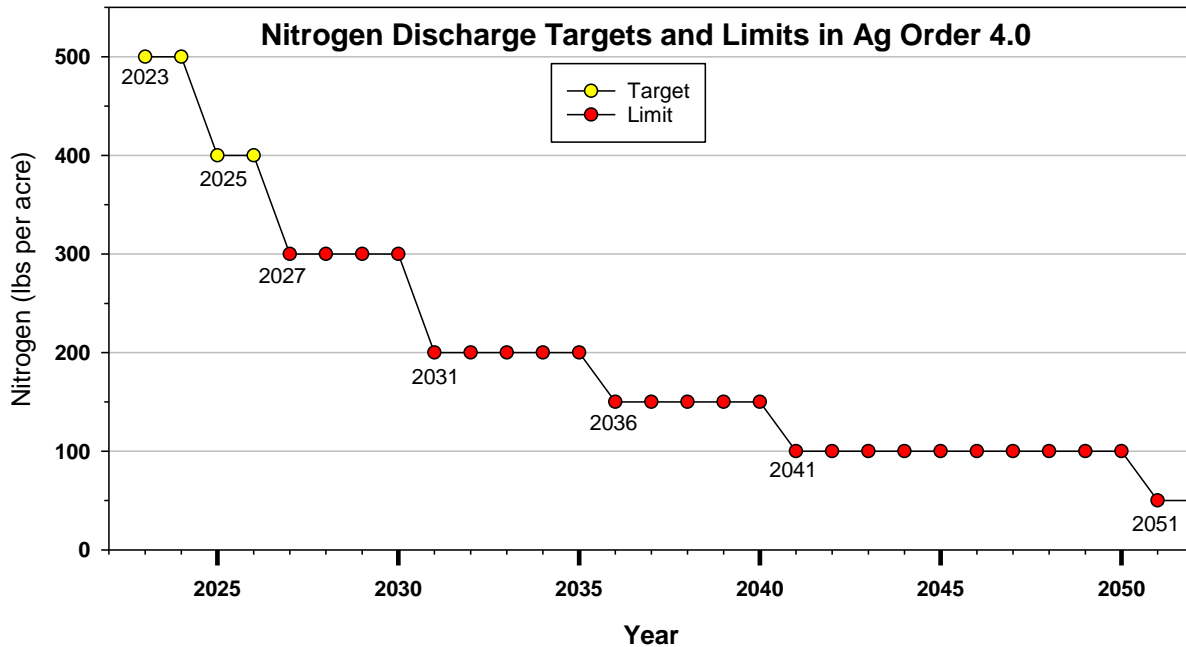
Assuming C:N=20, 2% N, and 97% credit

Oven dry biomass	Nitrogen uptake	Nitrogen credit
-----lb per acre-----		
4,500	90	87
6,000	120	116
8,000	160	155
10,000	200	194

Nitrogen Discharge Targets and Limits in Ag Order 4.0



Role of Removal Credit from Cover Crops in Ag Order 4.0



450 lbs N /acre (**A**ppplied as fertilizer)

-100 lbs N /acre (**R**emoved in harvest)

350 lbs N /acre (Left in field, i.e., **D**ischarge)

450 lbs N /acre (**A**ppplied as fertilizer)

-100 lbs N /acre (**R**emoved in harvest)

-100 lbs N/acre (Cover crop N scavenging credit)

250 lbs N /acre (Left in field, i.e., **D**ischarge)

Photographed: Dec. 10, 2021

Planted Oct. 1

Planted Oct. 15

Planted Oct 30

Planted Nov. 15

Planted Nov. 30

'Merced' Rye

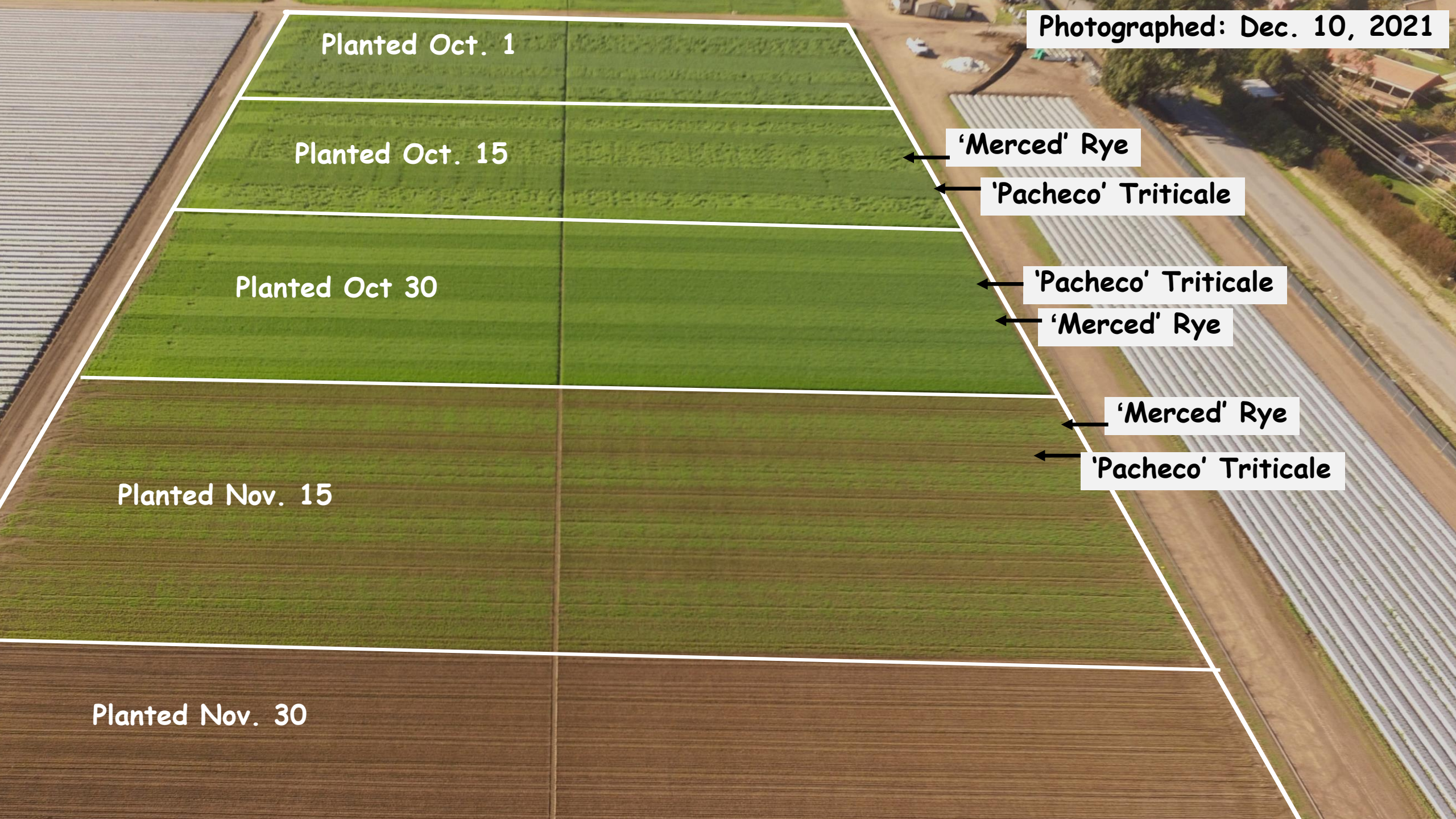
'Pacheco' Triticale

'Pacheco' Triticale

'Merced' Rye

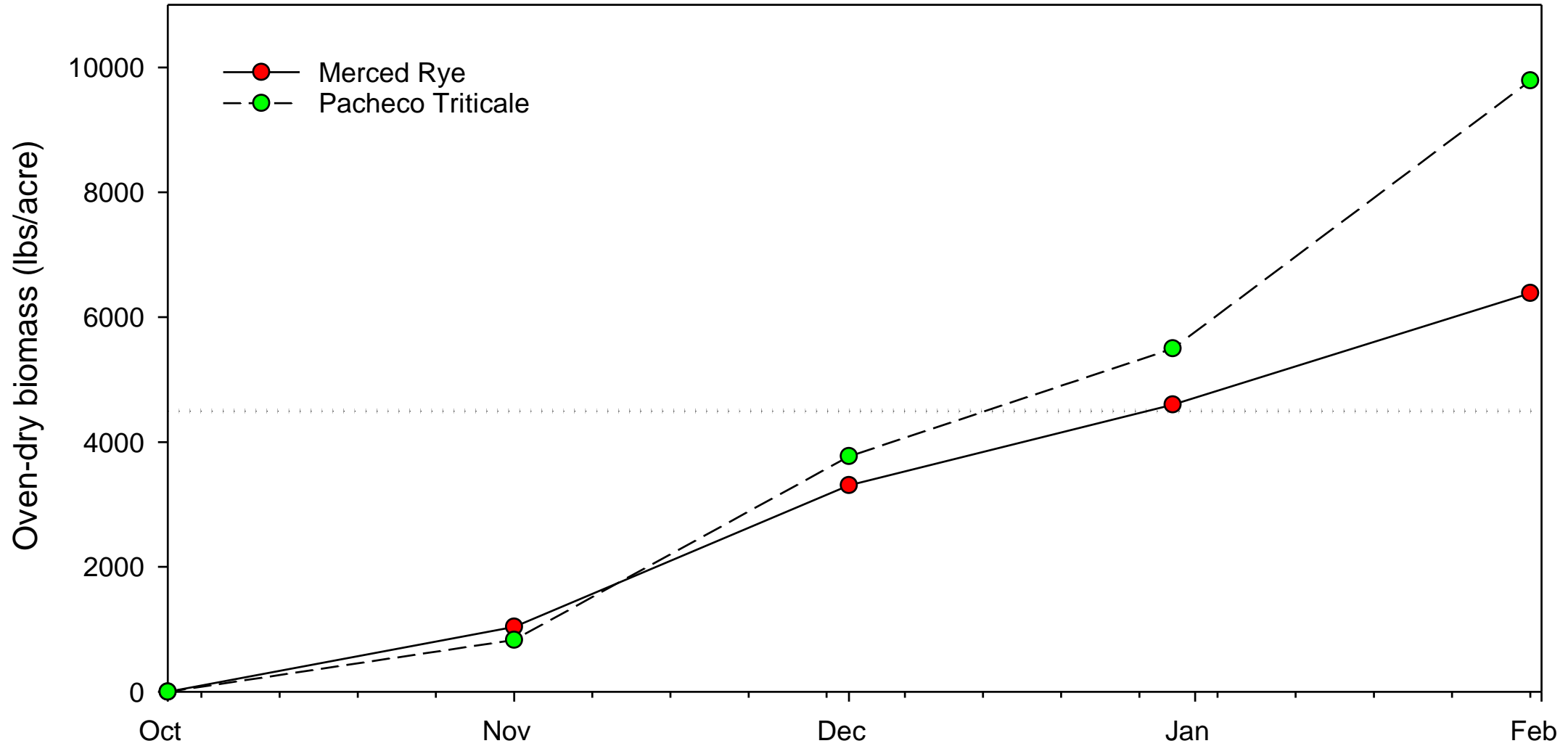
'Merced' Rye

'Pacheco' Triticale





Cover crop shoot biomass (Planted October 1, 2021)



Other Cover Crop Varieties and Production Strategies

- **Other cover crop species/varieties deserving of R removal credit:**
 - **Other cereal cover crops and mustards**
 - **It is unclear if the correlations developed for Merced rye and triticale applies to oats and barley**
 - **Mustards also do not have a rapid assessment method worked out yet.**
 - **In the meantime, they will need to be measured (e.g. 1 m²) and sent to a lab**



Fall-Grown Cover Crops (Aug-Nov)

- **Currently the subject of research**
 - **Fall-grown cover crop field trials evaluating field mineralization being conducted at the USDA Research Station (Eric Brennan, Anna Gomes and Sierra Castaneda)**
 - **Lab mineralization study being conducted at UCD by Daniel Geisseler**
 - **Trying to determine the proportion of N contained in fall-grown cover crops that can receive R removal credit**



Sierra and Anna

Fall-Grown Cover Crop Evaluation

October 2022

Date	Dry Biomass	Nitrogen lbs/A	Carbon lbs/A	C:N
Oct 5	5,002	163	2,054	12.6
Oct 11	6,279	186	2,609	14.0
Oct 17	6,823	174	2,862	16.5
Oct 24*	8,237	199	3,471	17.5

* Cover crop at the 10.5.4 (watery ripe stage); it was definitely time to incorporate this cover crop before the grains ripened further

There is time between the first sight of heads in the field and the risk of seed set

Other Cover Crop Varieties

- **Other cover crop species/varieties**
 - **Cover crop mixes that contain a legume currently do not qualify for a credit**
 - **This is an area that needs specific research**
 - **It is possible that the non-legume part of mixes may qualify for a credit**
 - **Other non-legumes will qualify for a credit, but a rapid assessment technique needs to be worked out**



Buckwheat



Phacelia



Multi species

Thank you for your Attention

