



United States Department of Agriculture

Agricultural Research Service

U.S. Dairy Forage Research Center



# The Cover Crop Breeding Network

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*December 2<sup>nd</sup>, 2020*



17 million acres  
of cover crops...  
and rising

# Common Cover Crop Species

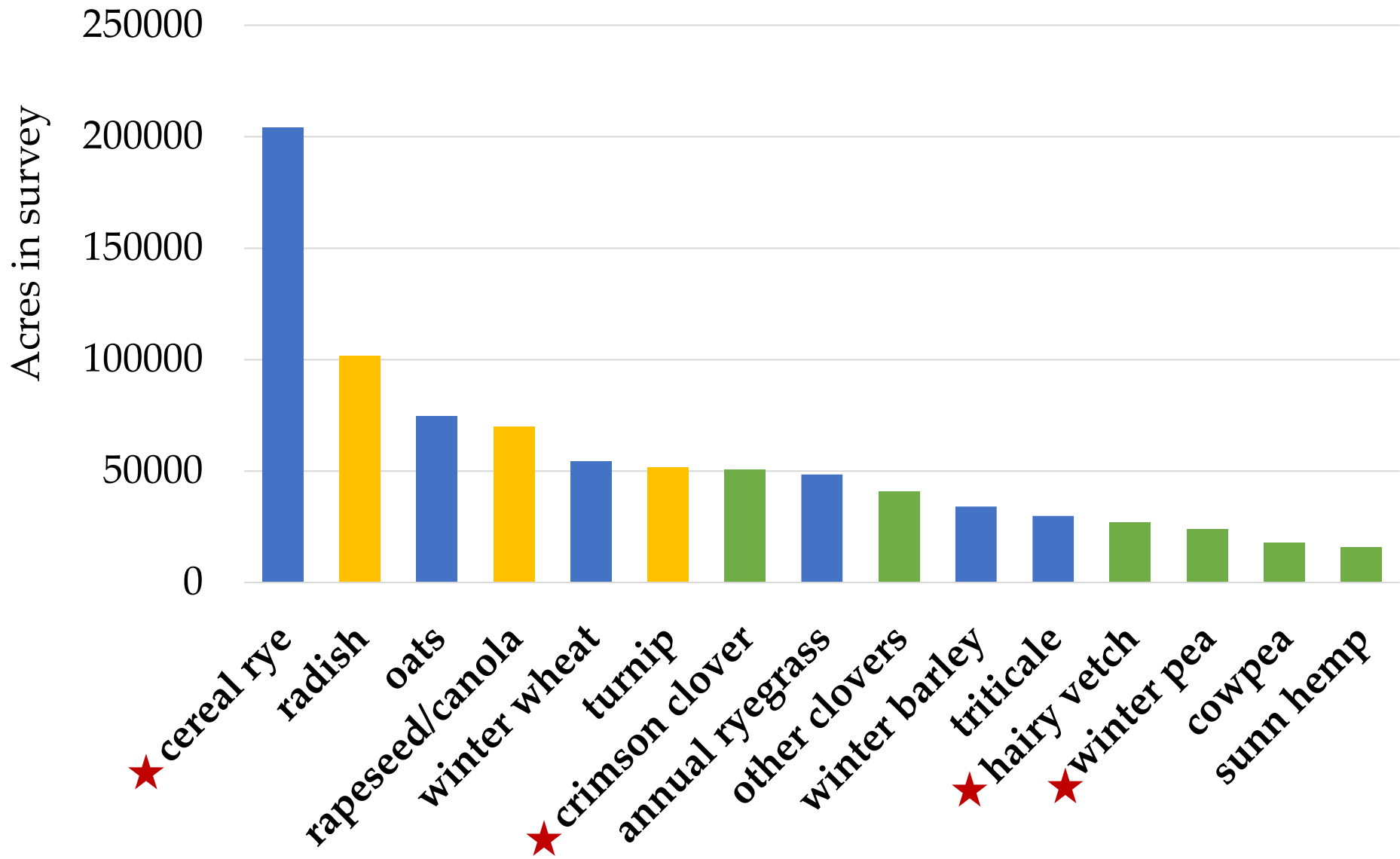
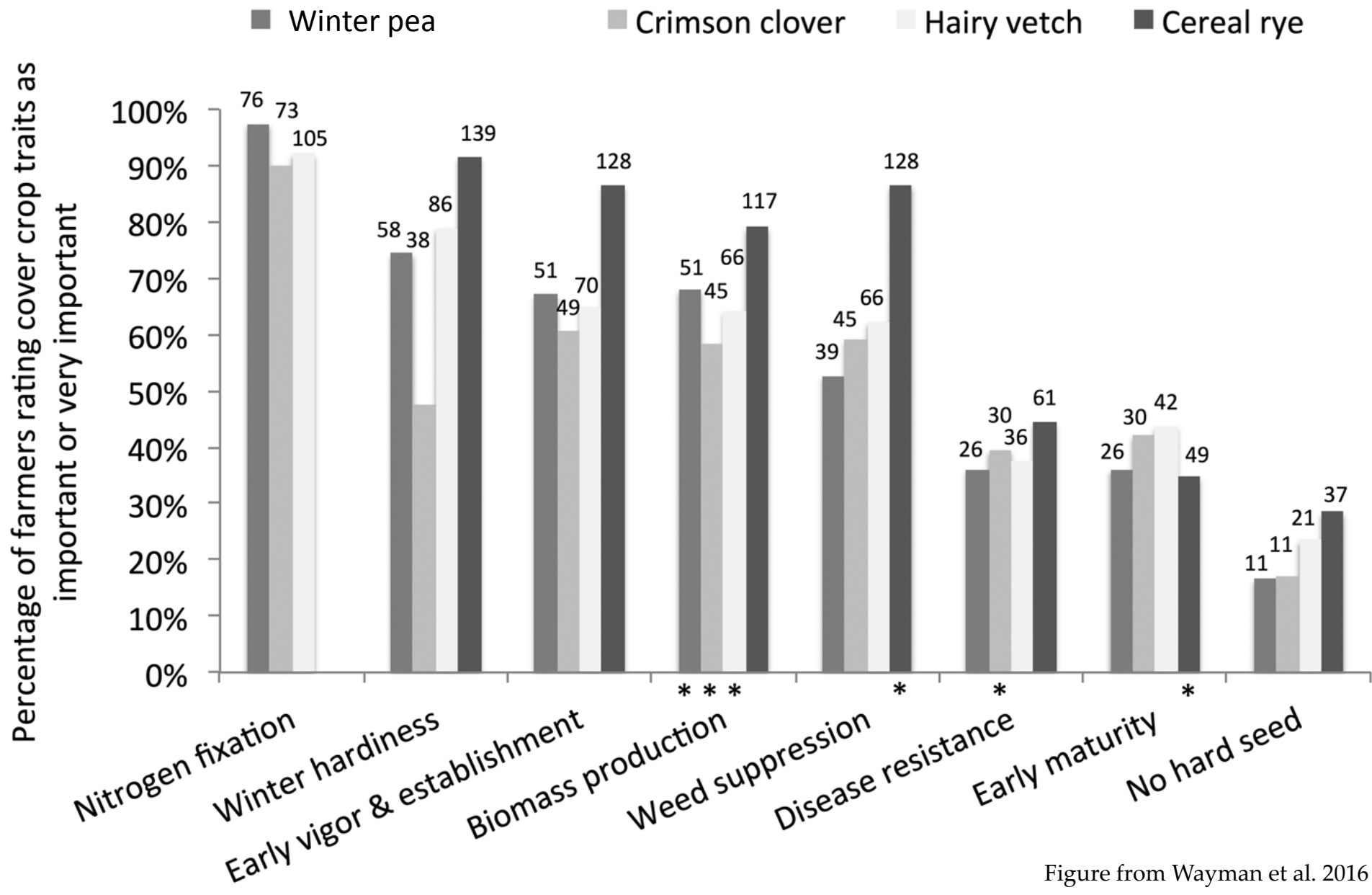
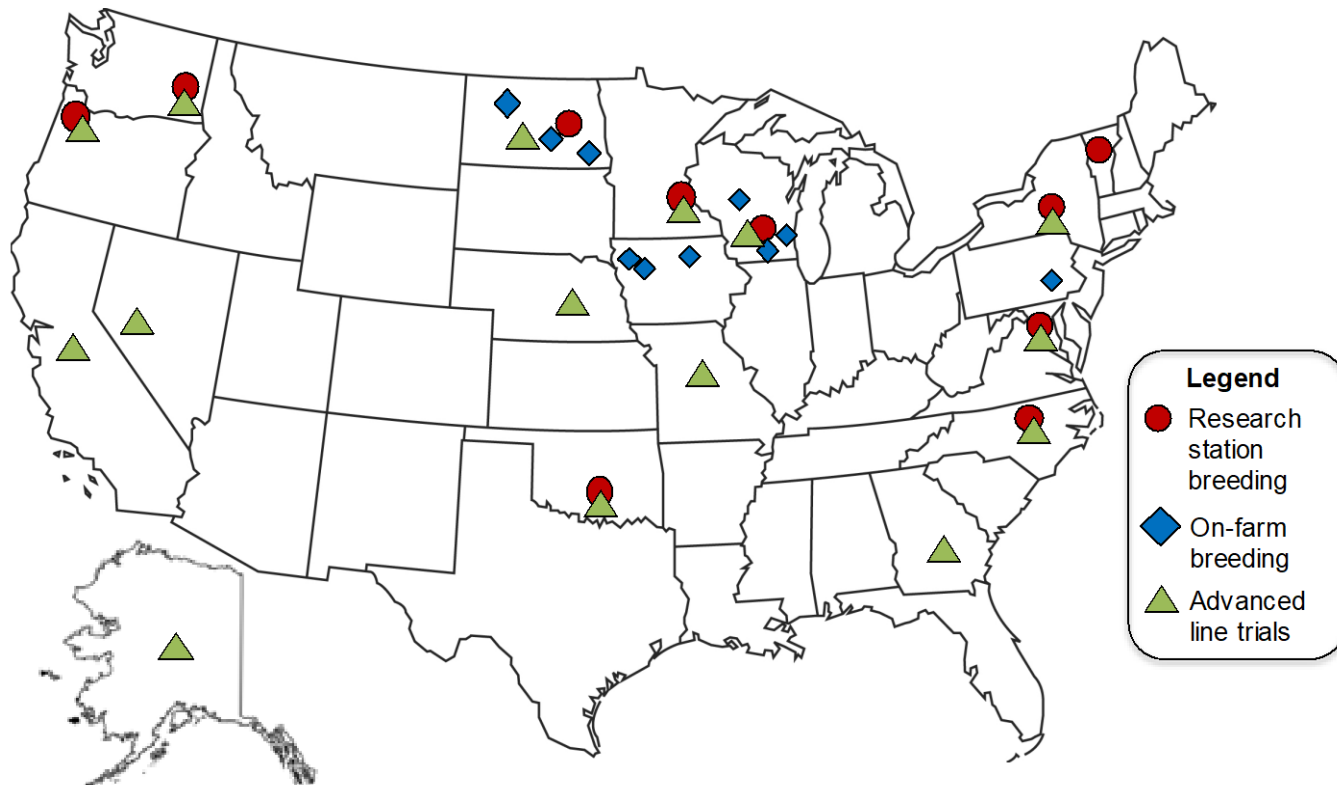
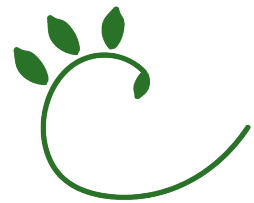


Figure modified from CTIC-SARE-ASTA 2020

# Traits of Interest to Farmers



# The Cover Crop Breeding Network

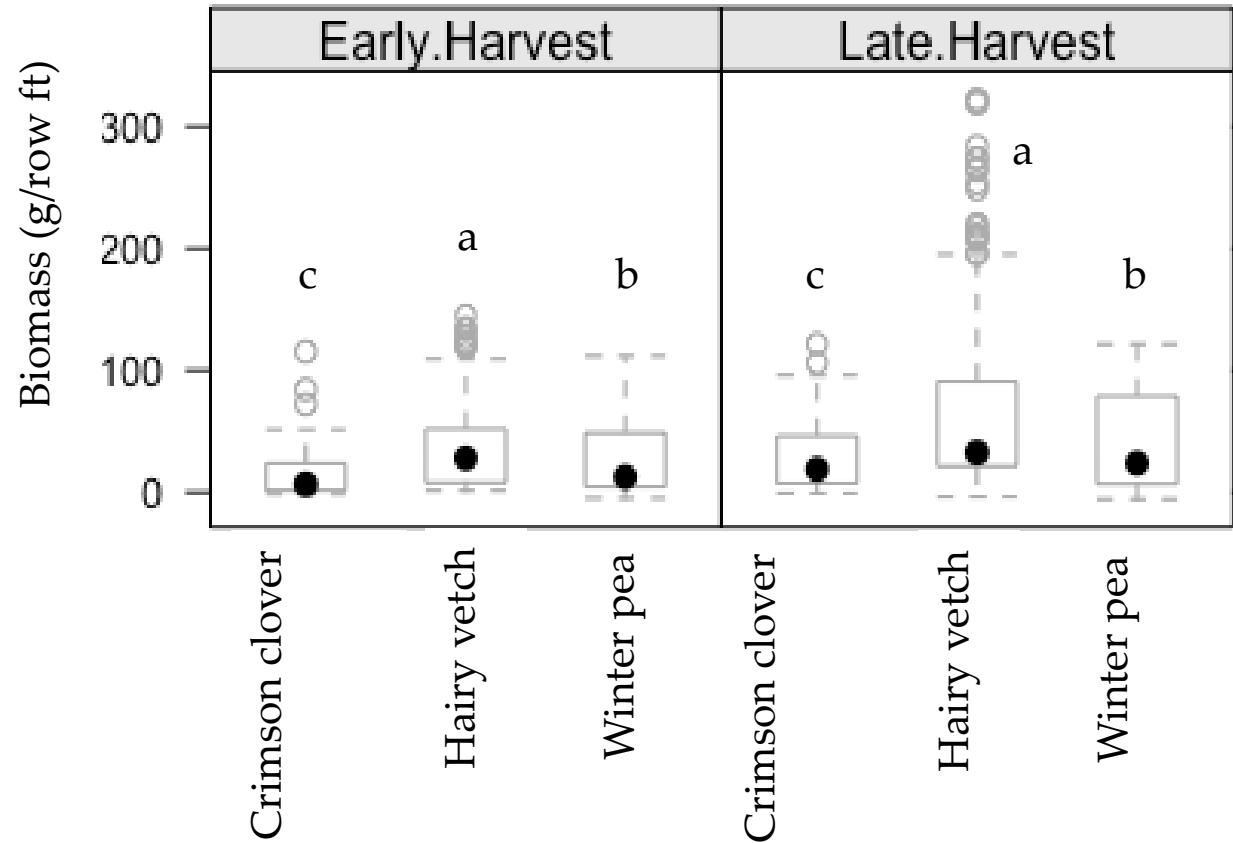


# Hairy Vetch



# Why Vetch?

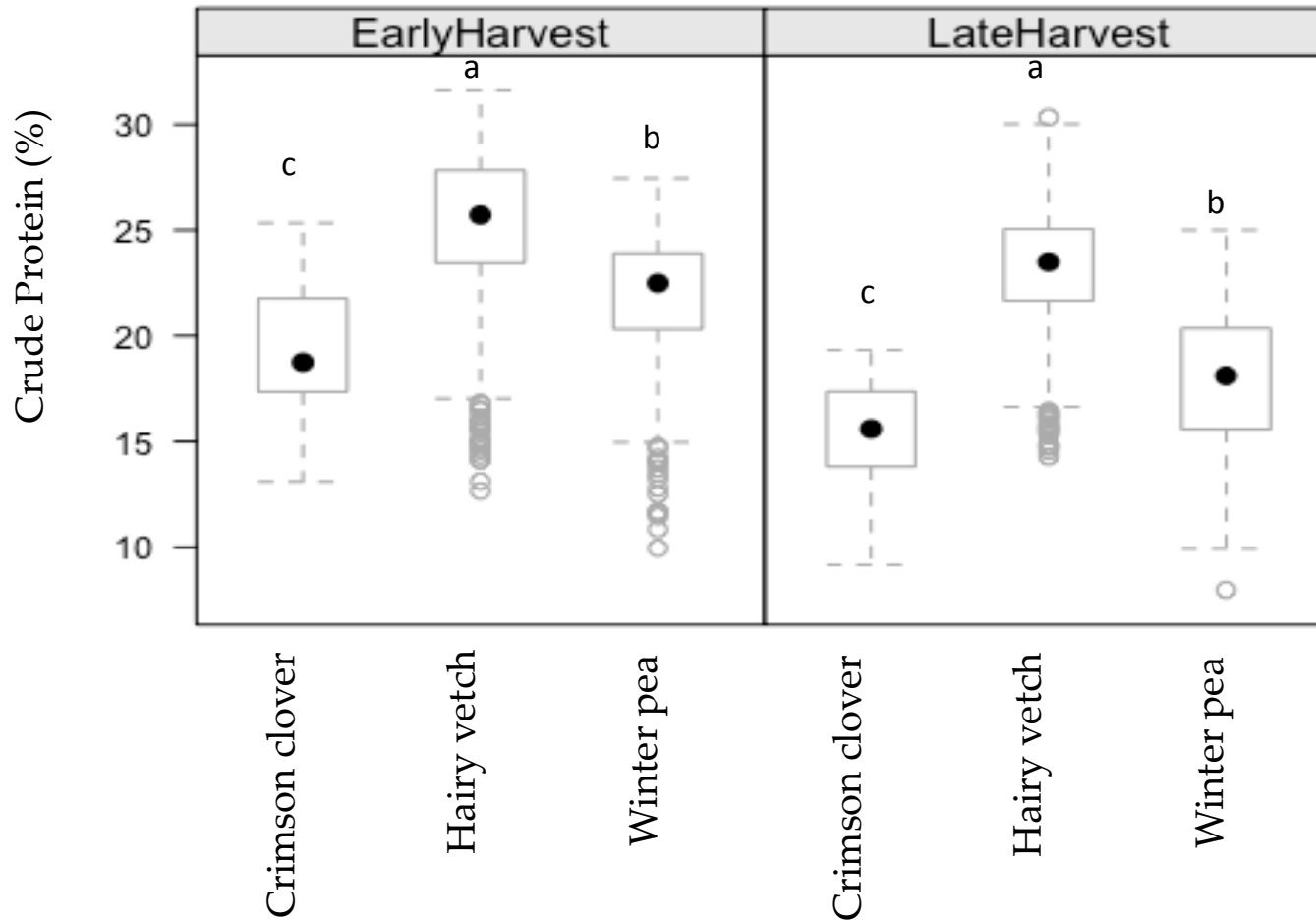
Highest biomass of winter legume cover crops



A single vetch plant can be huge  
photo by Jenyne Loarca

# Why Vetch?

Highest protein of winter legume cover crops





# Why Vetch?

Winter hardiness and drought tolerance

Incidence of total death among 43 U.S. site-years:

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**Hairy Vetch**

2%

**Winter Pea**

10%

**Crimson Clover**

14%

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Fall 2016



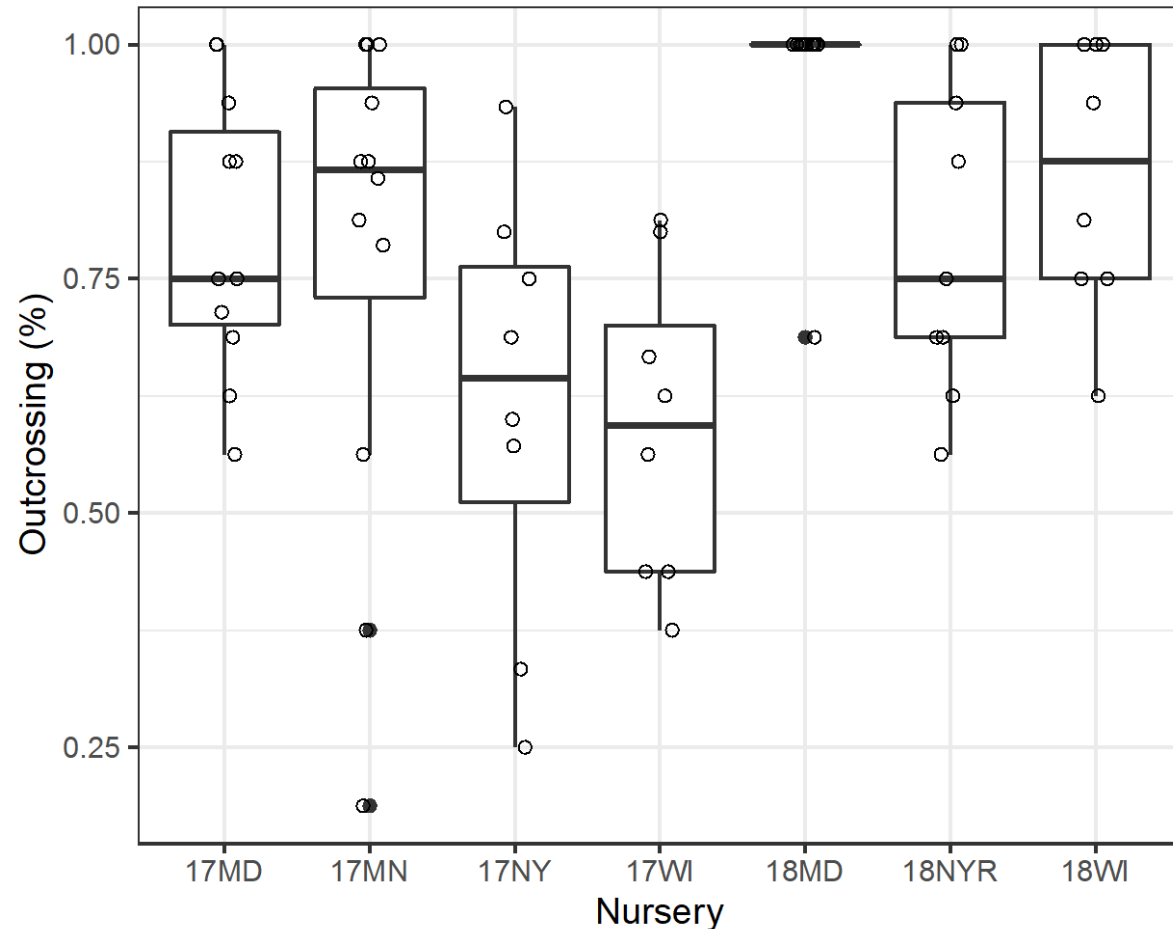
Spring 2017 (9% survival)

# Vetch Improvement

## The Organism



- $2n=14$   
(Chooi 1971)
- 2.04 Gbp  
(Macas et al. 2015)
- Genome assembly  
(Bickart et al. *in press*)
- 76% outcrossing  
calculated from 66 mothers  
and 14-16 progeny per mother  
among 7 environments



# Vetch Improvement

## Breeding design



- 7 locations per year since 2017
- 104 half-sibling lines with 24 space-planted progeny per nursery
- Selection of best ~100
- Crossing by bumblebee pollinators
- Further selection for maturity, disease resistance, and seed yield
- Best ~40 mothers within a site-year (2% selection intensity) form a line

# Vetch Improvement

## Variety testing and release



- 14 nationwide U.S. locations
- ~20 breeding lines
- RCBD with 4 replicates
- One 15 ft row of legume surrounded by rows of triticale to simulate cover crop mixtures

Photo Taken by Evan Taylor at the NCDA Caswell Research Farm in Kinston

# Vetch Improvement

## Seed yield



Photos from Mark Azevedo & Ryan Hayes, USDA-ARS Forage Seed & Cereal Research Unit

# Vetch Improvement

## Heritability of traits

Calculated using an animal model with  
2400 to 46000 genotypes among 36 site-years

<b>Trait</b>	<b>Heritability</b>
Fall vigor	0.25
Spring vigor	0.27
Flowering time	0.28
Determinacy	0.32
Hard seed	0.40
Pod dehiscence	0.38

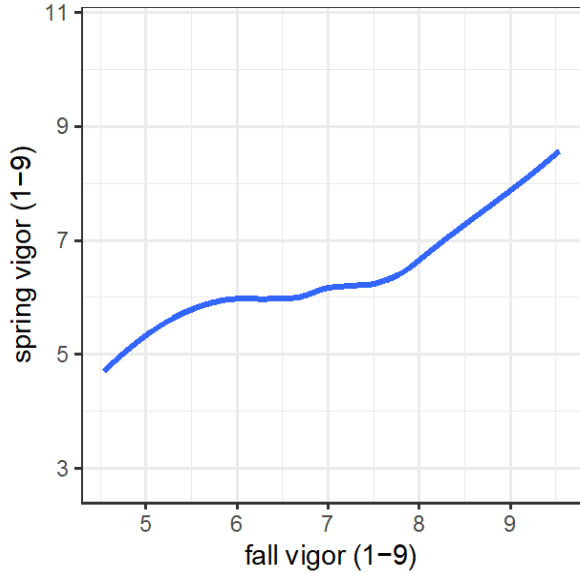
# Vetch Improvement

Correlations: No major tradeoffs evident

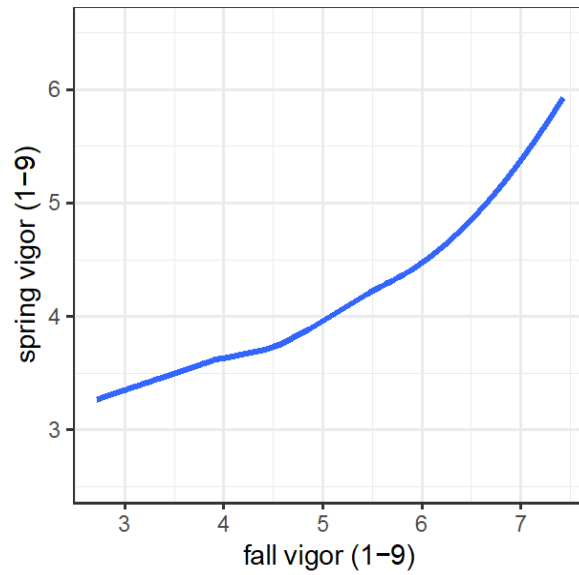
	Fall vigor	Spring vigor	Maturity	Determinacy	Hard seed	Pod dehiscence
Fall vigor	1	0.61***	0.04**	0.07	-0.04*	-0.02
Spring vigor		1	-0.06***	-0.08*	-0.19***	-0.07***
Maturity			1	0.14***	0.16***	-0.33***
Determinacy				1	-0.17***	0.08*
Hard seed					1	-0.03
Pod dehiscence						1

# Early Vigor

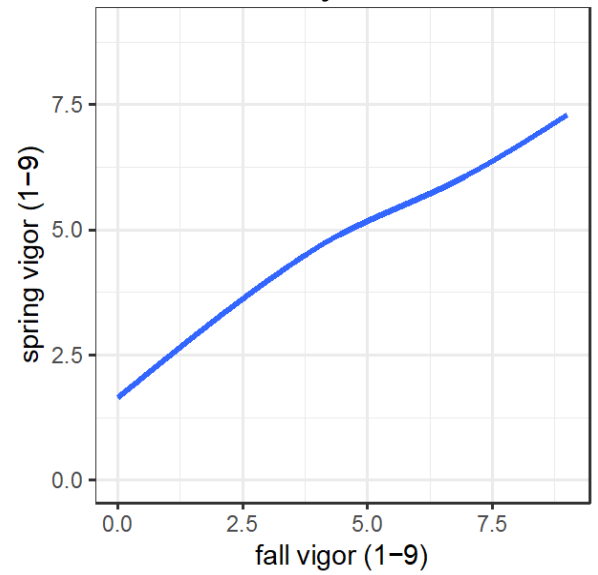
**North Carolina 1**



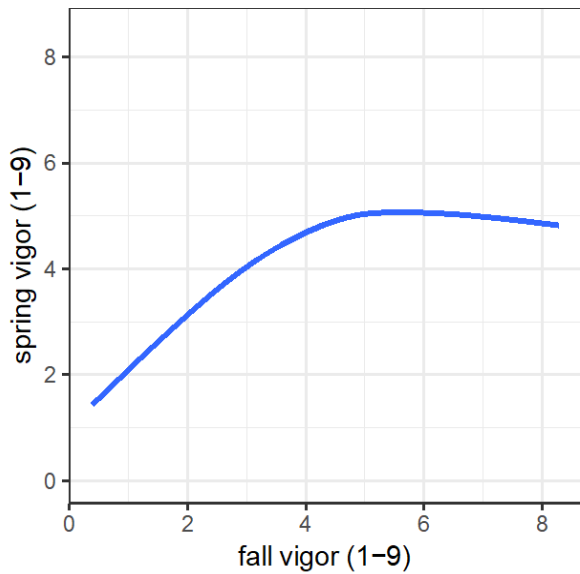
**North Carolina 2**



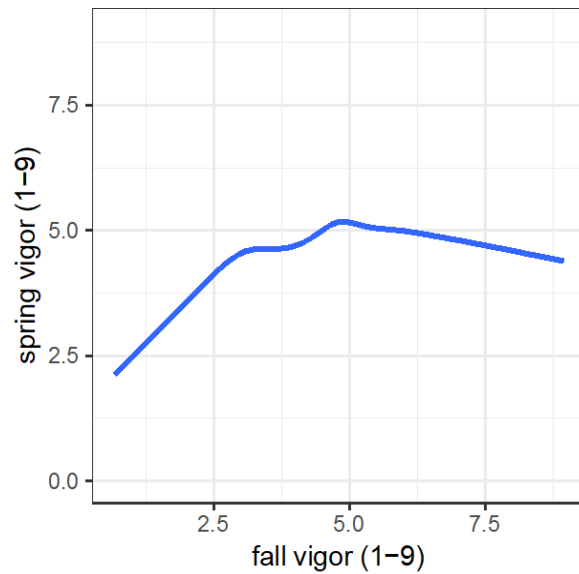
**Maryland**



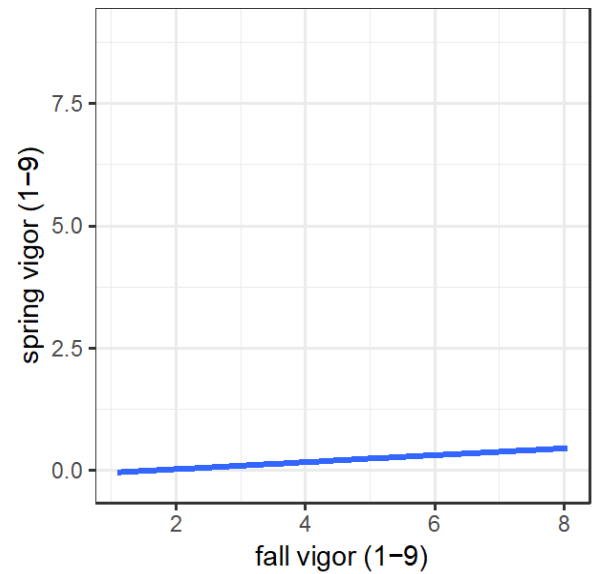
**New York**



**Wisconsin**



**Minnesota**





# Vetch Improvement

## Hard seed

>5000 genotypes evaluated for hard seed

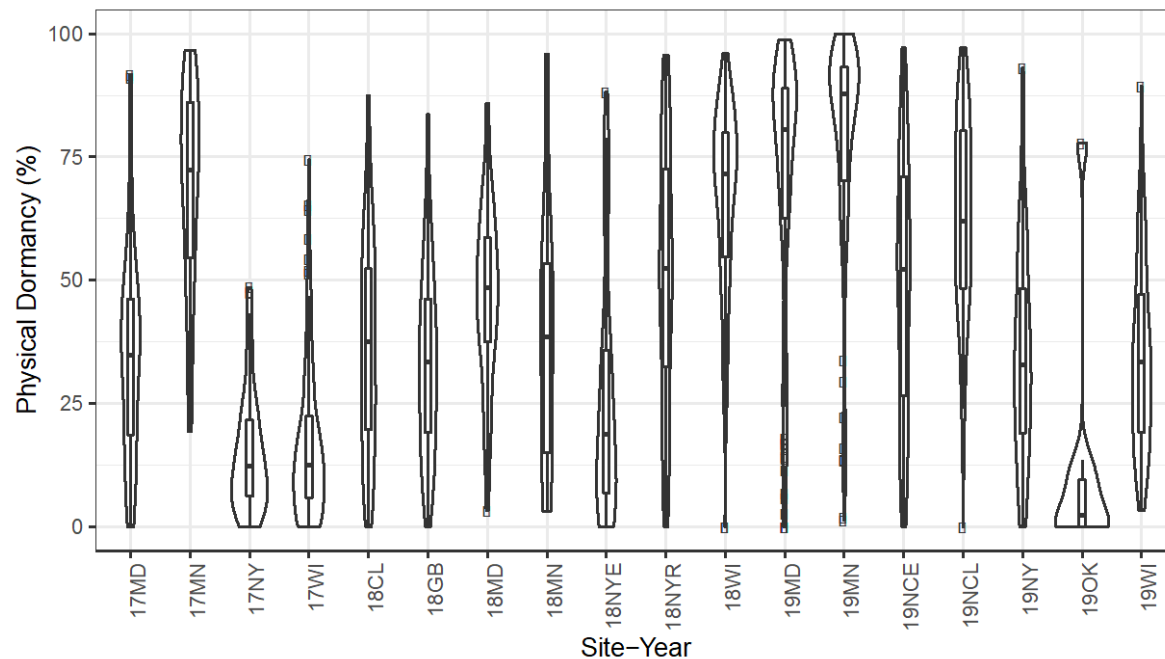


Figure from Kissing Kucek et al. 2020 *Agronomy*  
Photo from Rob Mattson

- 80 divergent half-sibling lines for extreme hard and soft seed
- 10 RCBD space-planted progeny at each of 2 locations
- Phenotyping of all plants for hard seed and shatter
- Genome by sequencing of 1120 individuals
- Genome wide association study

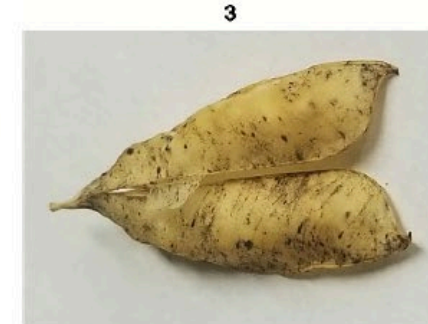
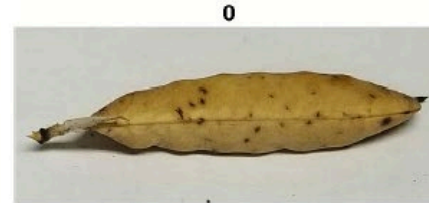
# Vetch Improvement

## Pod dehiscence

**Metric**      **Rating Scale**

**Visual Dehiscence**

0 = fully intact pod (no openings along sutures),  
 1 = one suture was partially opened (one side of pod),  
 2 = two sutures were partially opened (both sides of pod),  
 3 = pod had opened in full or partially



**Force to Dehiscence**

peak force (N) applied to create a break in the pod suture

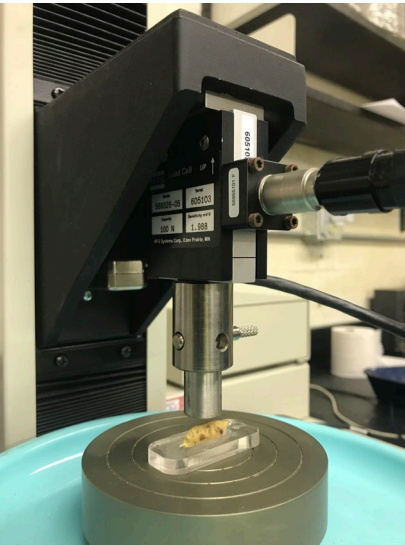
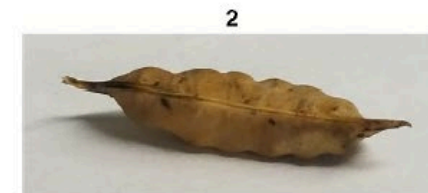
**Spiraling**

0 = no spiraling of pod,  
 1 = some spiraling of pod,  
 2 = strong spiraling of pod

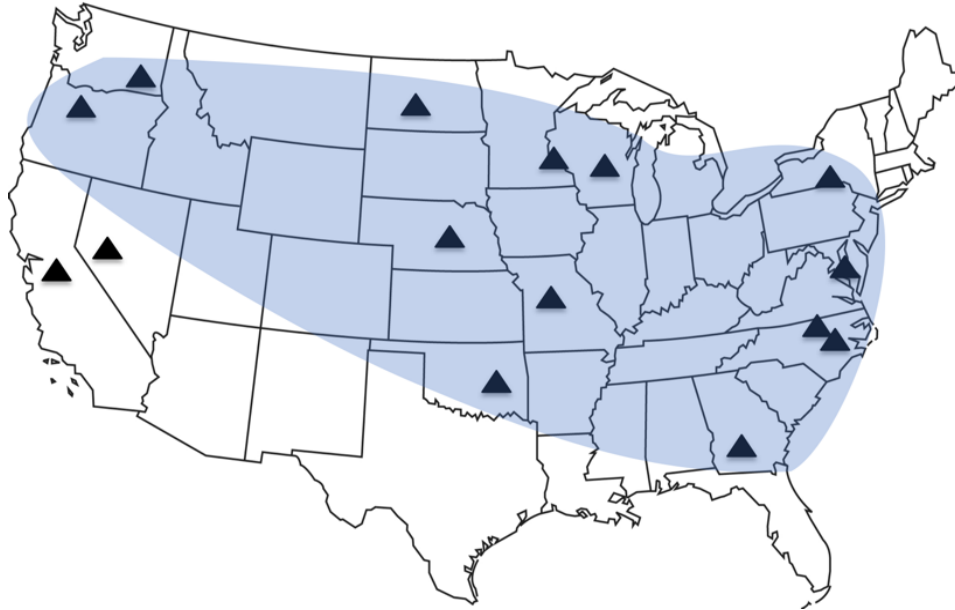


**Corrugation**

0 = smooth on the surface of the pod,  
 1 = intermediate,  
 2 = ridged on the surface of the pod - seeds evident



# Variety Release



Hairy vetch entry	Broad adaptation (environments where top ranking for biomass)	Biomass	Fall vigor	Seed yield	Release priority
	----- % of best check -----				
17NC-Early	272	102	91	119	1
18MD	128	97	86	123	2
Albert Lea Organic VNS	0	62	62	86	Check
UMN 'Minnesota Vinter'	25	78	63	71	Check
AU Early Cover	0	59	59	88	Check
AU Merit	100	100	100	100	Check
Hungvillosa	56	73	73	110	Check
Purple Bounty	24	68	68	98	Check

# Vetch Improvement

## Bruchid beetles

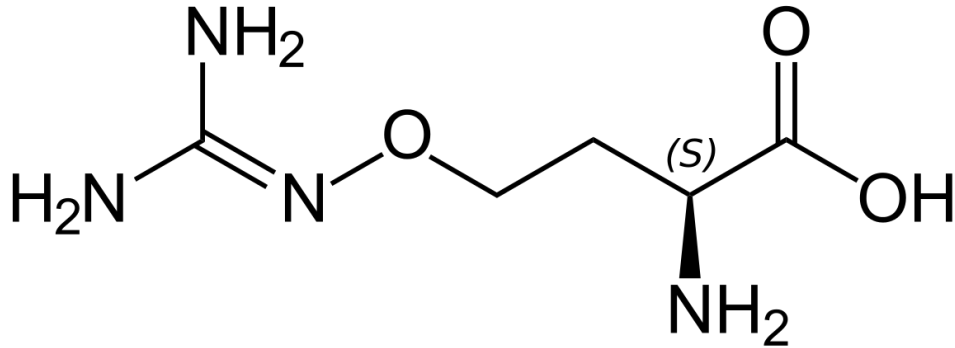


# Vetch Improvement

## Vetch associated disease

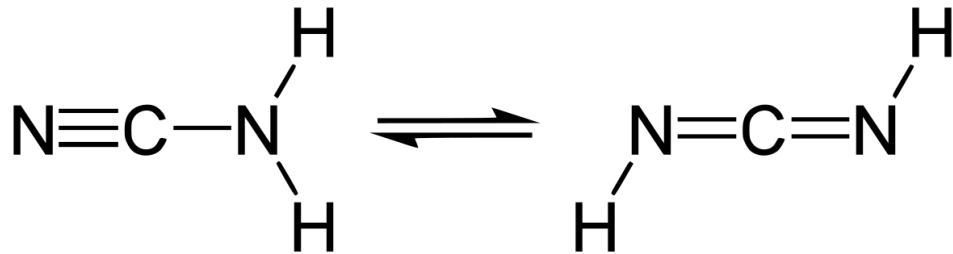


Canavanine



Enneking 1994. Image from Yikrazuul (2008)

Cyanamide



Kamo et al. 2003 *J Chem Ecol*. Image from Cacycle (2009)



Image from Aguirre et al. 2021 *Toxicon*

# Cover Crop Variety Database

**CURRENTLY SEEKING  
COLLABORATORS AND  
CONTRIBUTORS!**



Cover Crop Decision Tool

Start with where is your farm?

Missouri



Adair



Tell us your goals

#1 goal

Good Grazing



# Collaborators and Funders

## **Project Directors**

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Noble Research Institute  
North Carolina State University  
Practical Farmers of Iowa  
Texas A&M University  
University of Minnesota  
University of Missouri

University of Nebraska  
USDA-ARS Dairy Forage Research Center  
USDA-ARS Forage Seed and Cereal Research Unit  
USDA-ARS Grain Legume Genetics Physiology Research  
USDA-ARS Northern Great Plains Research Laboratory  
USDA-ARS Sustainable Agricultural Systems Lab  
USDA-ARS Western Regional Plant Introduction Station  
USDA-NRCS Plant Materials Centers

## **Funders**

USDA Organic Research and Education Initiative (OREI)  
USDA AFRI Foundational and Applied Sciences Program  
Foundation for Food and Agriculture Research (FFAR)  
USDA AFRI Education and Workforce Development (EWD)  
Noble Research Institute

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