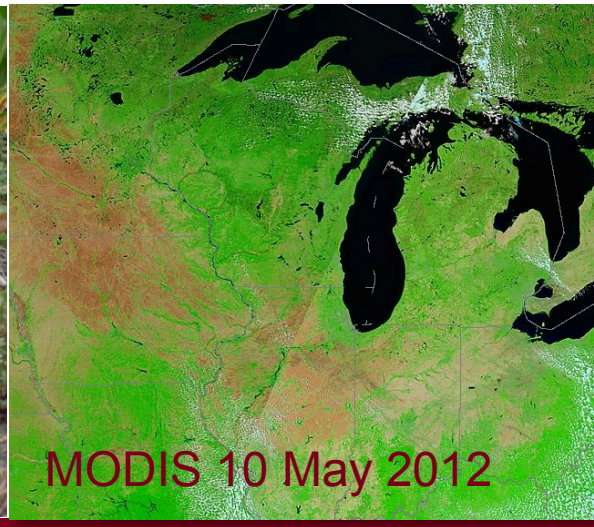
Optimization of Cover Crop Establishment Technologies in Corn-Based Cropping System

M. Scott Wells and Reagan Noland

University of Minnesota
Department of Agronomy and Plant Genetic and USDA-ARS



CLEAN WATER LAND & LEGACY AMENDMENT

MINNESOTA DEPARTMENT OF AGRICULTURE

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The University of Minnesota Extension forage team uses University research to help forage producers increase productivity, quality and profitability.

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Forage and variety selection

Varietal trials, forage identification and selection , alfalfa history

Establishment

Seeding rates and dates, stand establishment

Growth and development

Growth and stand evaluation, weather and crop damage

Utilization and management

Hay, silages, pastures and grazing, biomass, stand termination

Soil and water management

Soil properties, benefits to soil, cover crops, irrigation management

Nutrient management

Nutrient guidelines, legume N fixation and credits

Pest management

Diseases, weeds, insects

Organic production

→ Organic Risk Management website for organic and transitioning producers

Forages for "U" workshops

Forage production topics for today's producers

Minnesota Field Crop Trials – 2014

The most recent variety performance data for crops

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Forage Quarterly

A quarterly newsletter providing research-based information to Minnesota forage producers and their advisors.

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January 2015, Vol. 2 No. 1 (2.8 MB PDF)

- Double–cropping with a pea–barley forage mixture
- Alternative annual forages
- Sorghum-sudangrass and teff as summer forages for livestock systems
- Stand age affects alfalfa nitrogen credits to first–year corn
- Winter feeding tips for horse owners
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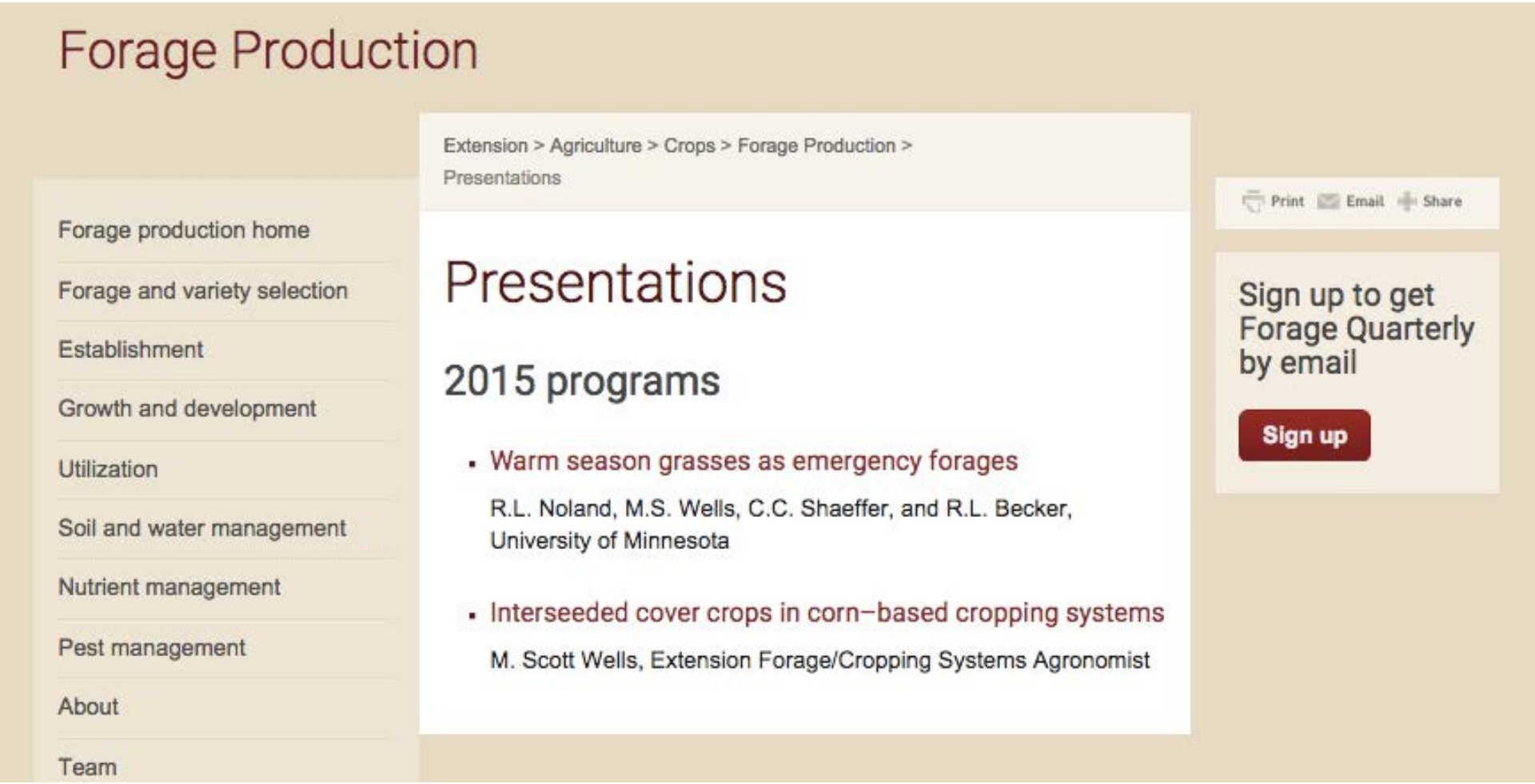
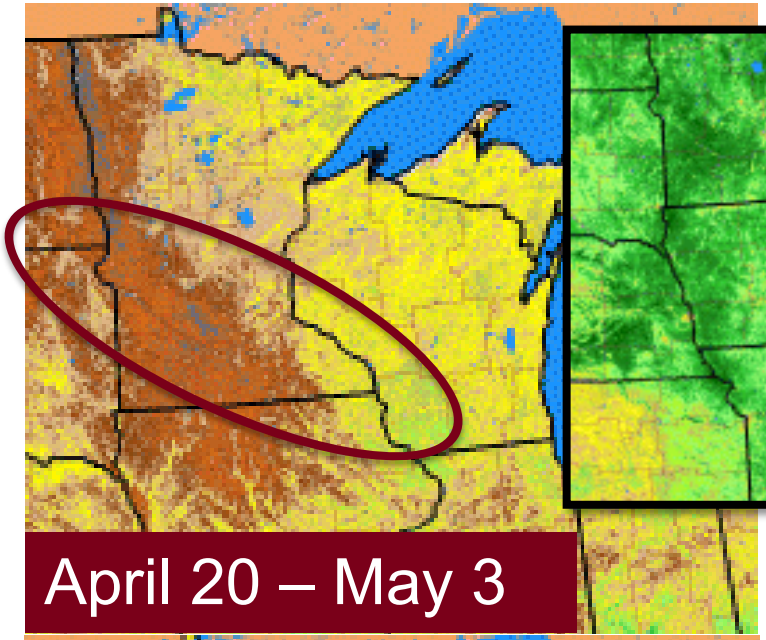
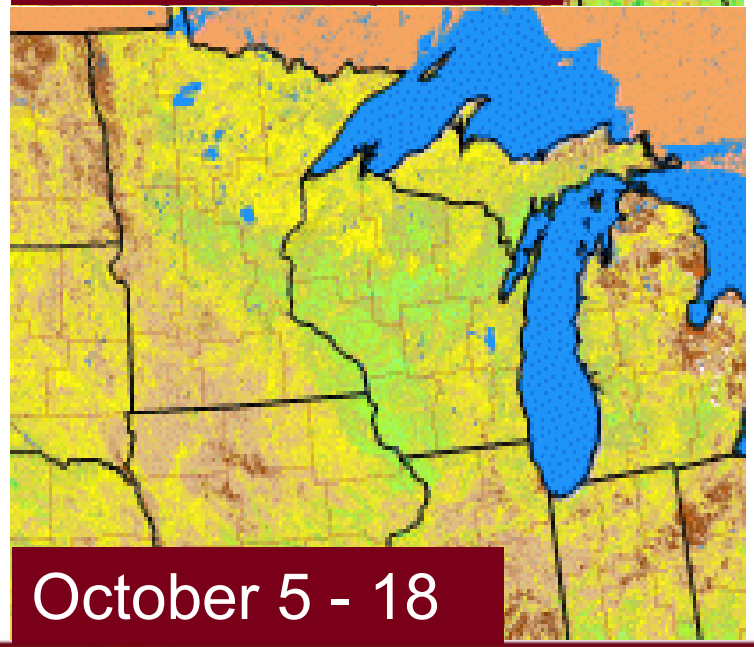


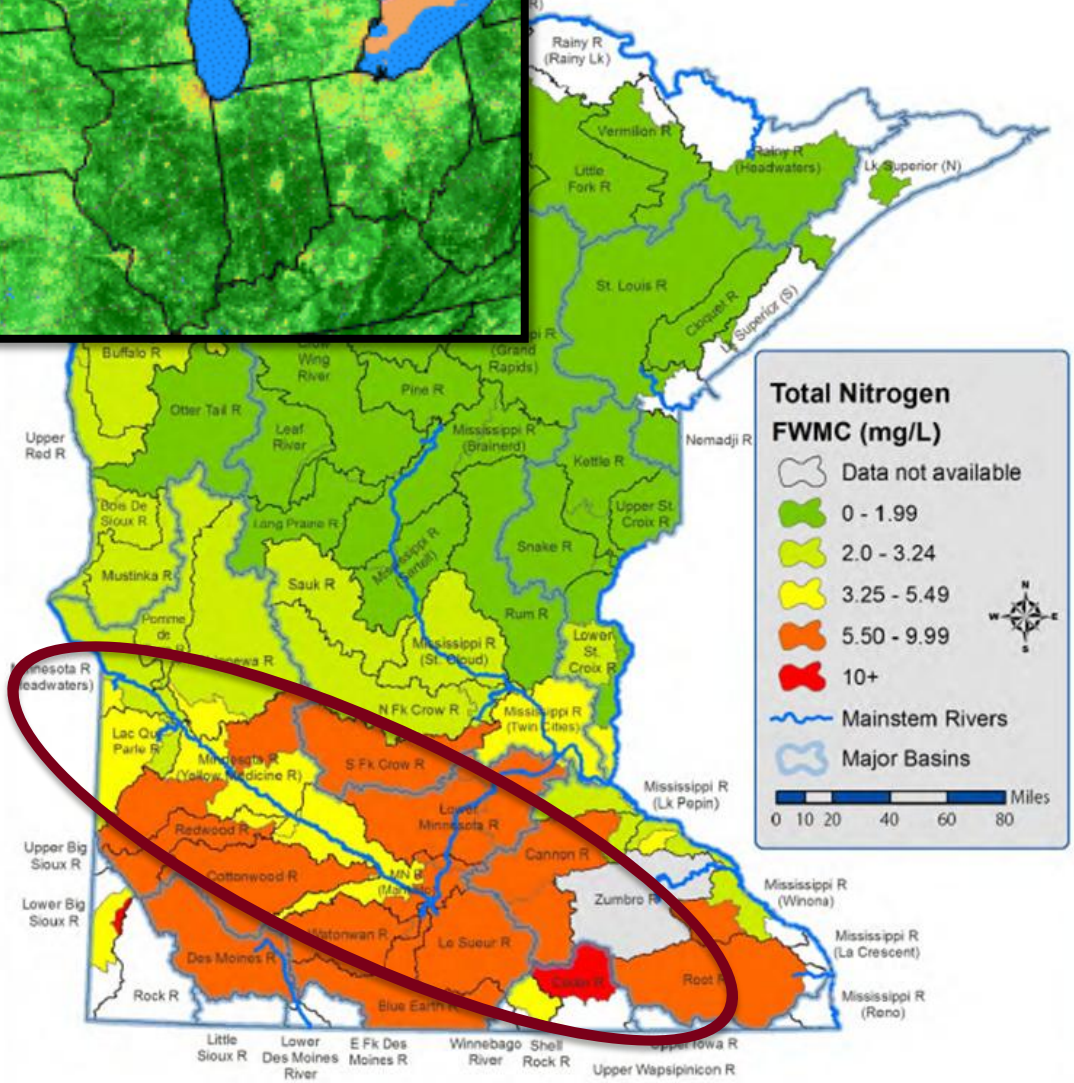


July 13 - 26

April 20 – May 3



October 5 - 18



CHALLENGES: NITRATES IN THE WATER

PRODUCERS

Iowa's Largest City Sues Over Farm Fertilizer Runoff In Rivers

Updated January 26, 2015 · 7:09 PM ET
Published January 12, 2015 · 3:26 AM ET

Fertilizer Runoff Overwhelms Streams and Rivers--Creating Vast "Dead Zones"

The nation's waterways are brimming with excess nitrogen from fertilizer--and plans to boost biofuel production threaten to aggravate an already serious situation

Drinking Water Blues: Nitrate Pollution from Coast to Coast

Like Share Tweet G+1

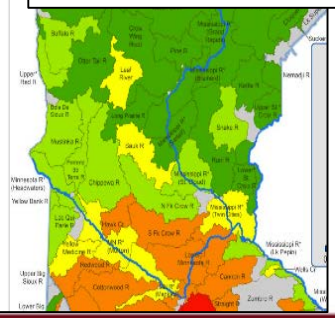
inking Water Week, when we're supposed to celebrate the generally amazing supply, yet they're singing the blues in California's Central Valley and New York's two regions may be miles away in geography and in culture, but both share one ommonality; namely, that their drinking water is heavily polluted by nitrates. s (from University of California-Davis and the Suffolk County's Department of pectively), both out in late winter 2012, outline the troubles facing each locale.

nitrogen, primarily from sources like synthetic fertilizers, animal manure and ombine with organic chemicals like ammonia to form the invisible, odorless and

Minnesota nitrate study highlights farm runoff pollution

On June 26th, The Minnesota Pollution Control Agency (MPCA) released a long-awaited study of nitrogen in Minnesotas surface waters.

The study was a collaborative effort led by Minnesota Pollution Control Agency, with assistance from the University of Minnesota and the U.S. Geological Survey. The report team used more than 50,000 water samples collected at 700 stream sites and used 35 years of monitoring data and findings from



PRODUCERS

What Is Farm Runoff Doing To The Water? Scientists Wade In

Updated July 9, 2013 · 12:37 PM ET

Nitrate in Drinking Water

What is nitrate?

Nitrate is a naturally occurring oxide of nitrogen and is an essential component of all living things. It is the primary source of nitrogen for plants, and it occurs naturally in soil and water. But if the levels of nitrate get too high, it can

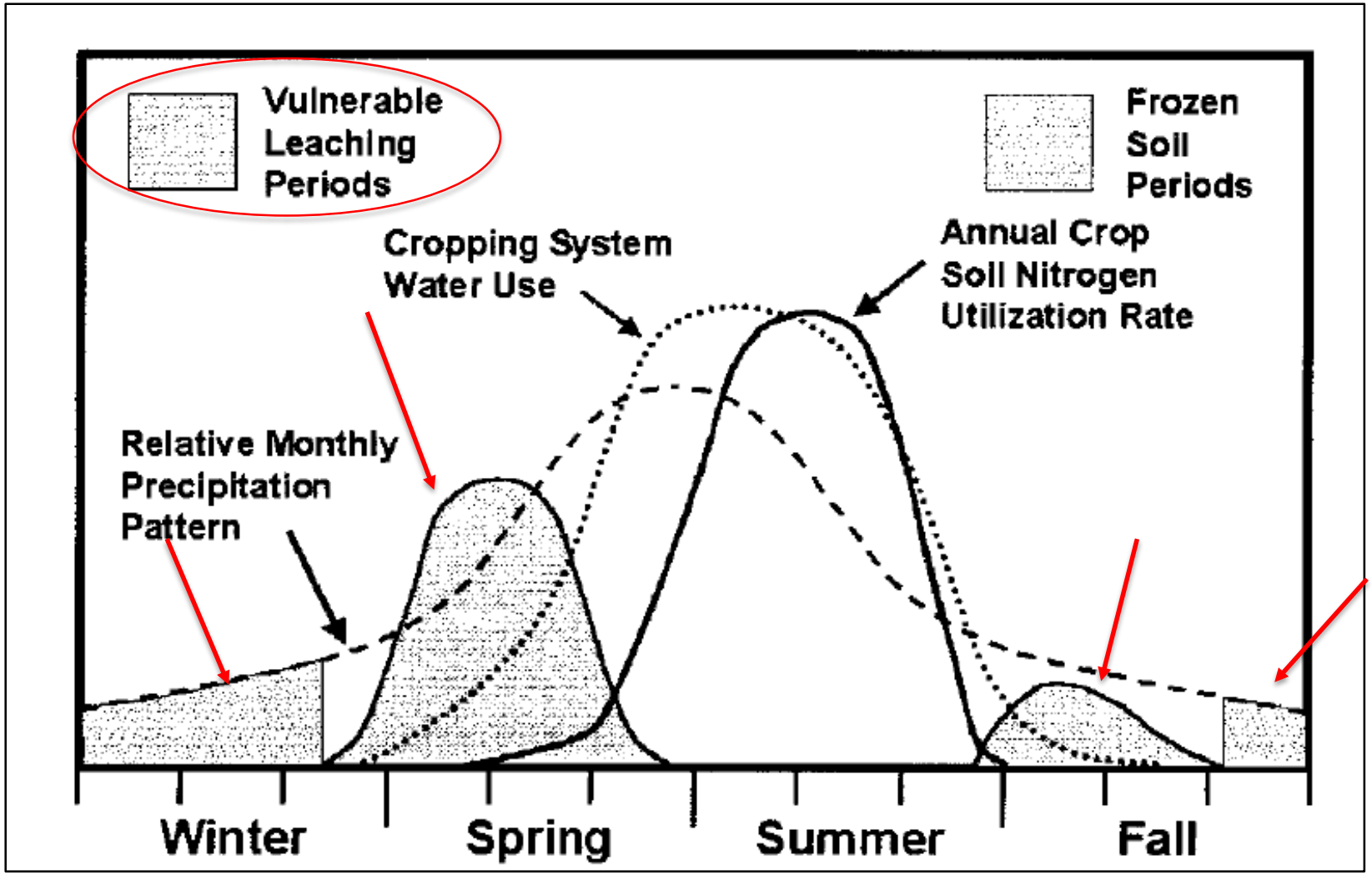
How much nitrate is dangerous?

Nitrate levels of up to three parts per million in well water may be naturally occurring or possibly indicate some low level of contamination, but are considered to be safe for consumption. EPA has set a maximum

Nitrogen Management Strategies to Reduce Nitrate Leaching in Tile-Drained Midwestern Soils

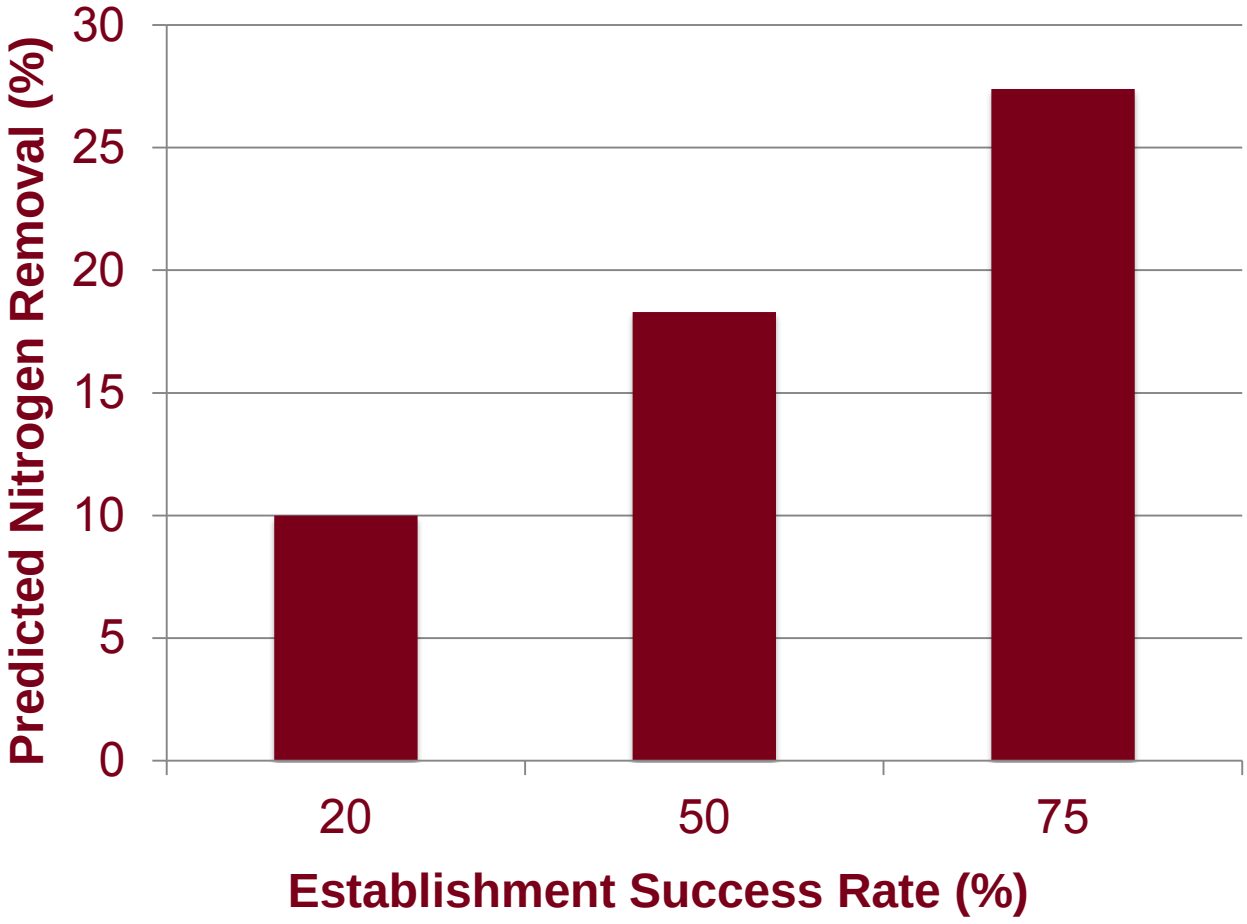
Dana L. Dinnes,* Douglas L. Karlen, Dan B. Jaynes, Thomas C. Kaspar, Jerry L. Hatfield, Thomas S. Colvin, and Cynthia A. Cambardella

Vulnerable NO_3-N leaching periods in conventional corn systems



	Range in N reductions from literature review	N removal default in MN NBMP spreadsheet for treated areas	Notes for numbers with *
Tile depth and spacing	15-59%	NA	
Controlled drainage	14-96%	40%	
Bioreactors	10-99%	*13%	*Assumes 44% removal when fully treated, but only 30% of annual flow is treated
Reduced rates of application	11-70%	Varies by watershed and climate	
N application timing and inhibitors	10-58%	Varies by watershed and climate	
Wetlands	19-90%	50%	
Alternative cropping systems	5-98%	*95%	*Perennials replacing marginal land row crops
Riparian buffers	17-99%	*95%	*Perennials replacing row crops near waters
Cover crops	11-60%	*10%	*50% N leaching reduction when successfully established and 10% runoff N reduction. 20% establishment success rate assumed for MN average.

	Range in N reductions from literature review	N removal default in MN NBMP spreadsheet for treated areas	Notes for numbers with *
Cover crops	11-60%	*10%	*50% N leaching reduction when successfully established and 10% runoff N reduction. 20% establishment success rate assumed for MN average.



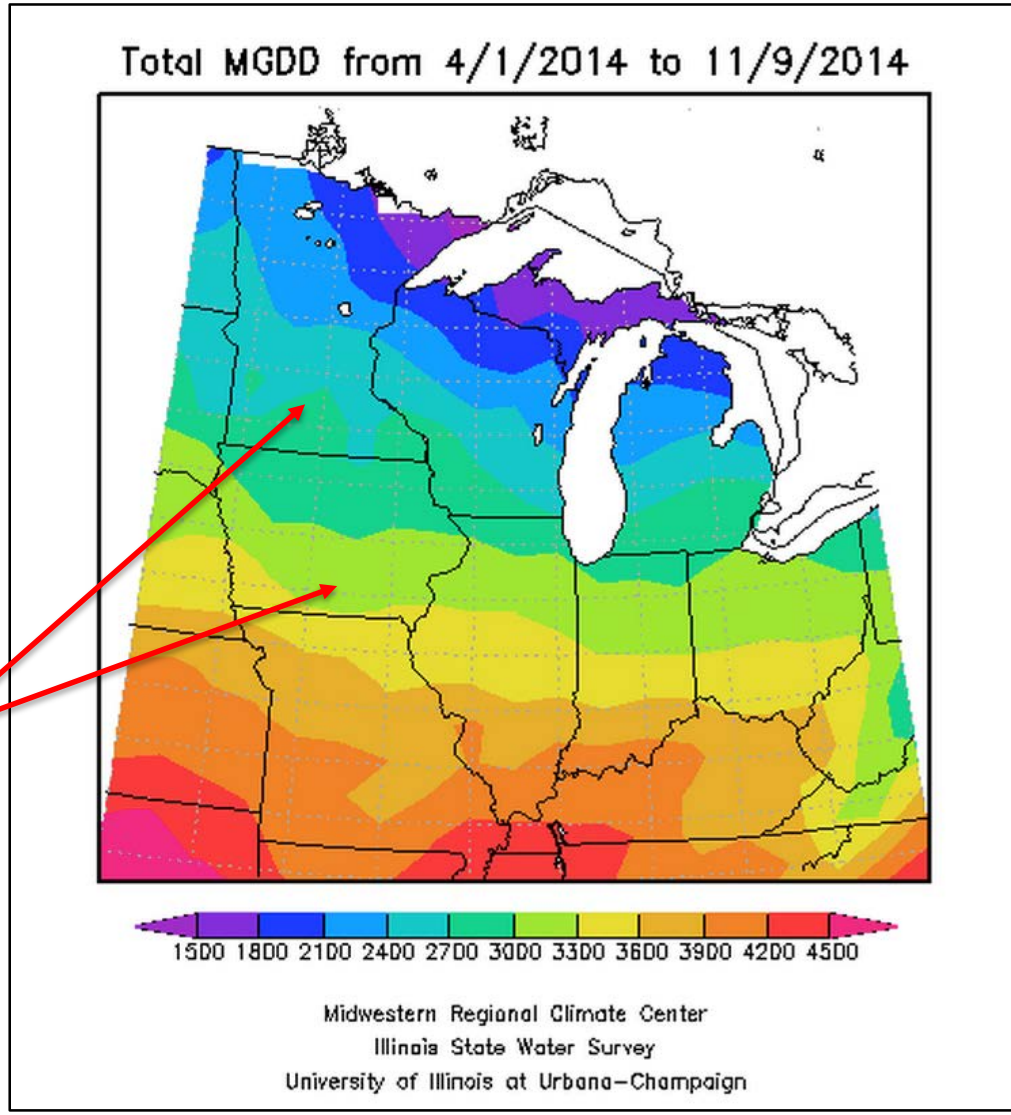
≈ 60,000 Tons-N yr^{-1} reduction

TOTAL REVENUE STREAM

New Vikings Stadium Every Decade!

CHALLENGES

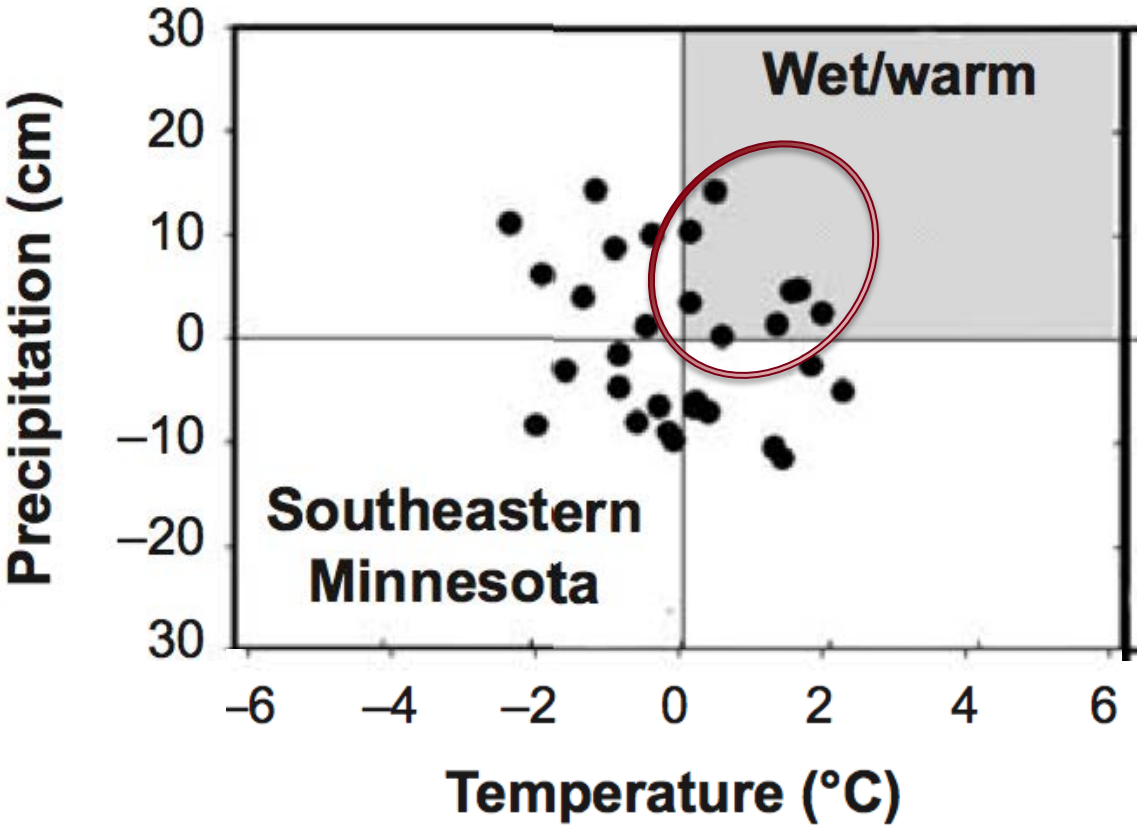
- Iowa Agricultural Extension service recommends drilling winter-hardy cereal cover crops as late as early November in southern Iowa.
- Southern Minnesota has ~600 fewer GDD units than southern Iowa.



doi:10.2489/jswc.69.3.67A

Aerially seeding cover crops in the northern US Corn Belt: Limitations, future research needs, and alternative practices

Melissa L. Wilson, Deborah L. Allan, and John M. Baker



"based on average weather patterns in southwestern MN, winter rye (*Secale cereal* L.) would successful cover crop in one out of four years."

Strock, J.S., P.M. Porter, and M.P. Russelle. 2004. Cover cropping to reduce nitrate loss through subsurface drainage in the Northern US Corn Belt. Journal of Environmental Quality 33:1010-1016.

doi:10.2489/jswc.69.3.67A

Aerially seeding cover crops in the northern US Corn Belt: Limitations, future research needs, and alternative practices

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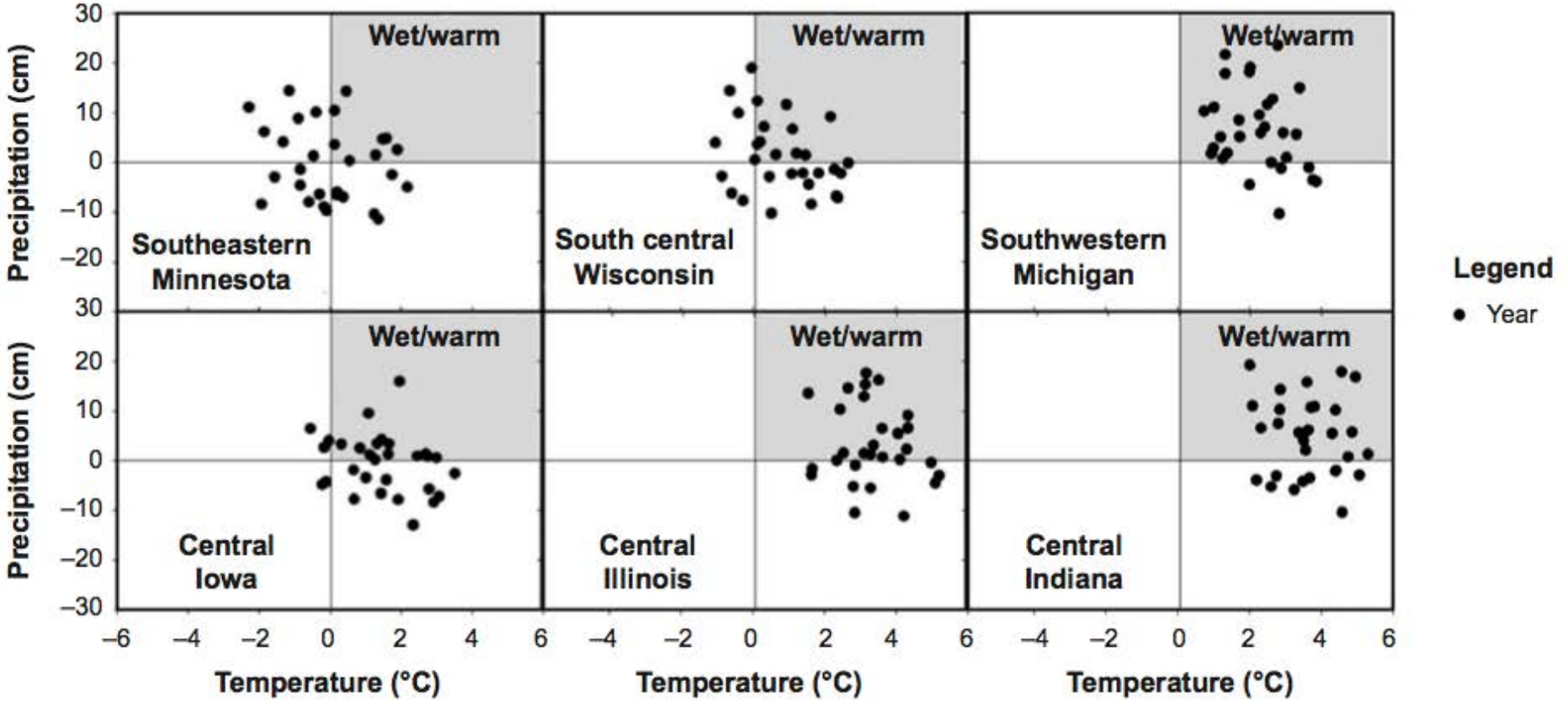
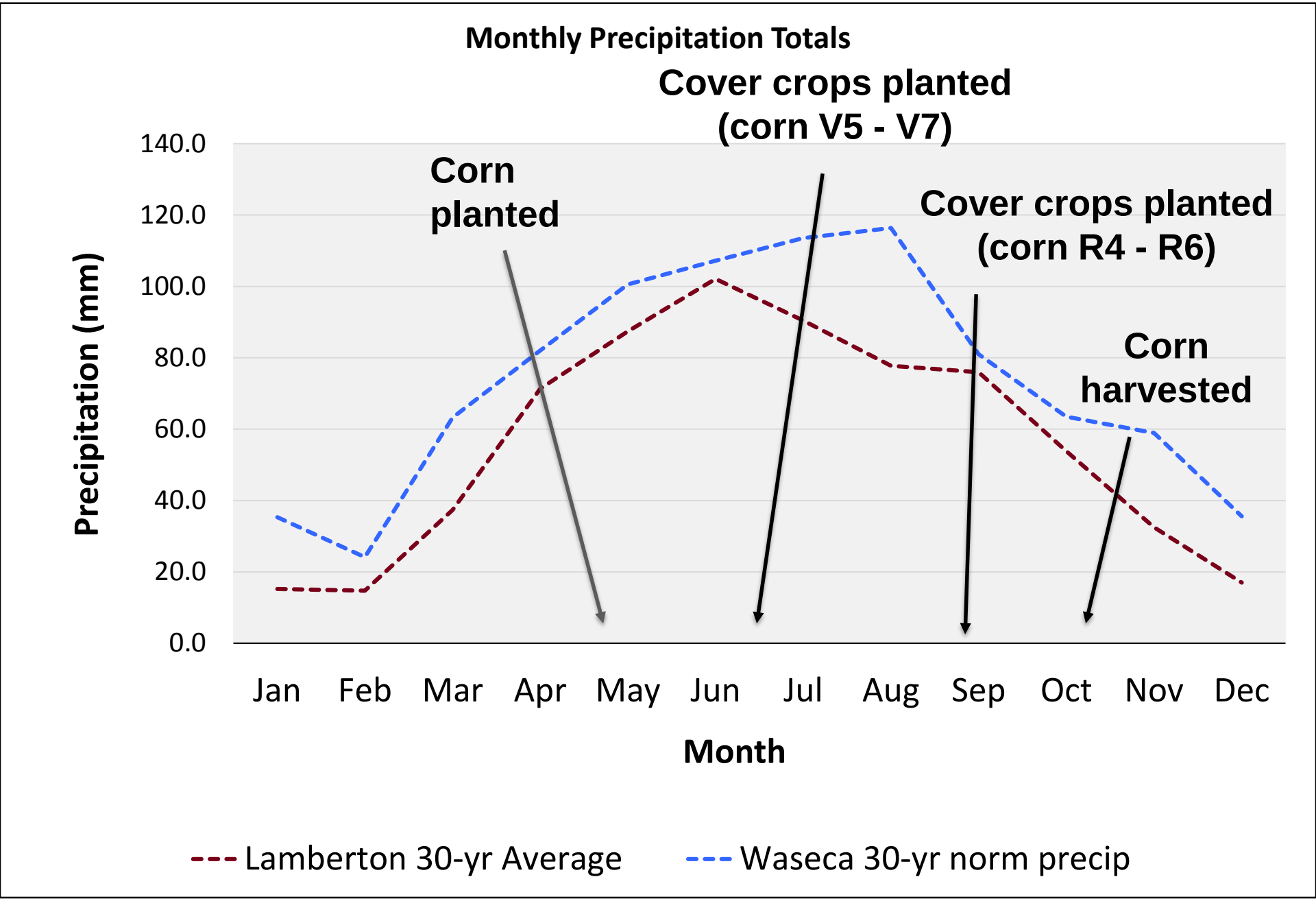
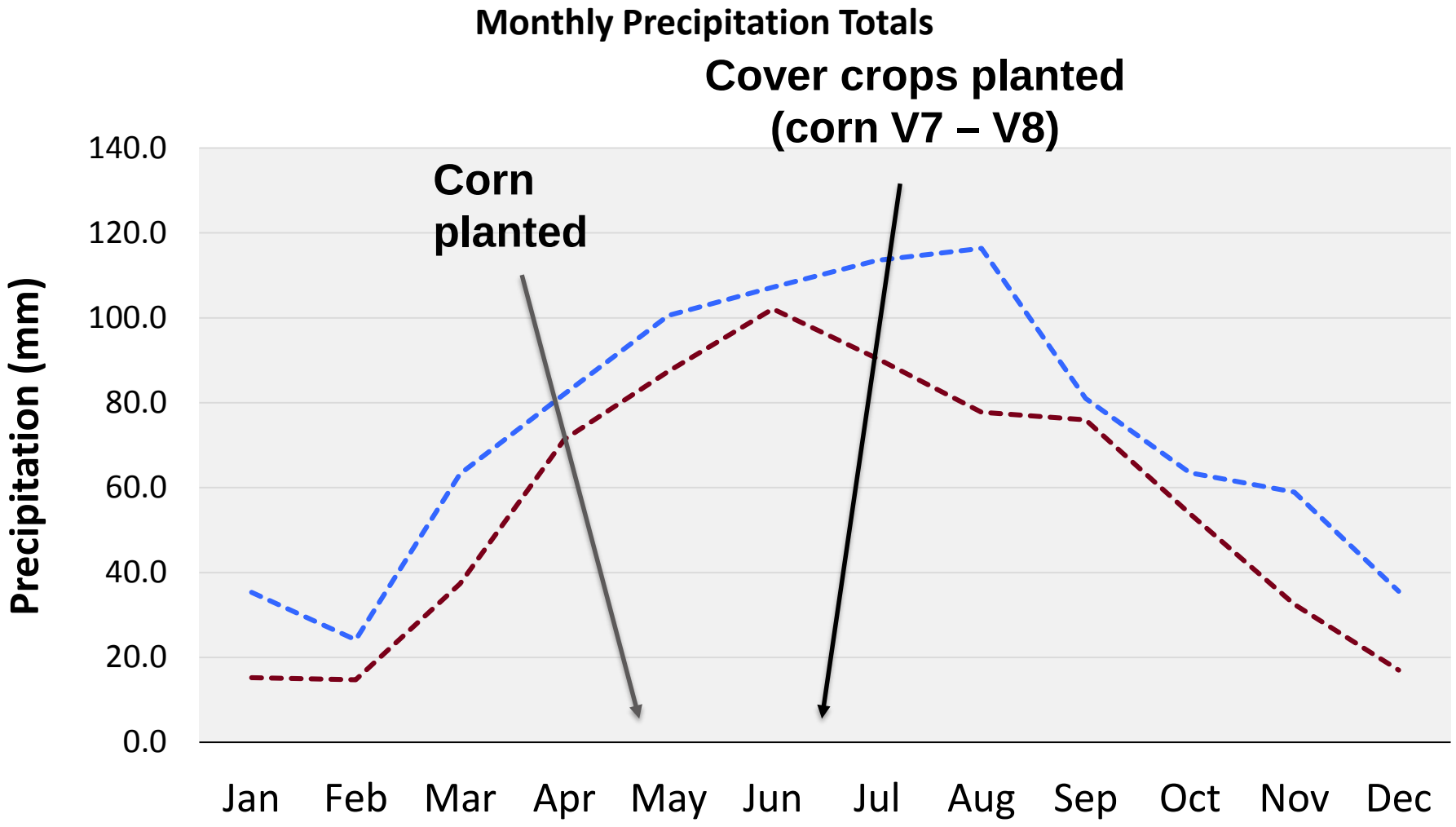
Figure 1

Yearly departure from the southeastern Minnesota 30-year average temperature (1981 to 2010) versus departure from the southeastern Minnesota 30-year average precipitation during September to November. Shaded areas highlight the years with favorable weather conditions (wetter and warmer than the Minnesota average) for establishment of aerially seeded cover crops.





UMN SROC &SWROC Weather Data

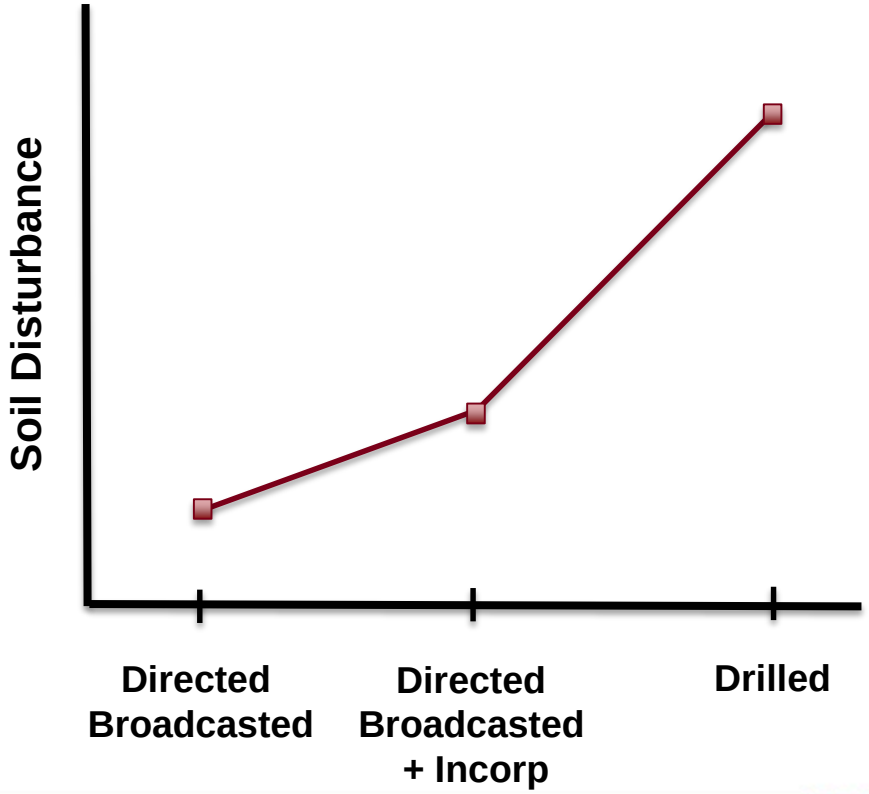


Objective: Identify suitable cover crops and effective planting methods for interseeding into full season corn systems.

UMN SROC &SWROC Weather Data

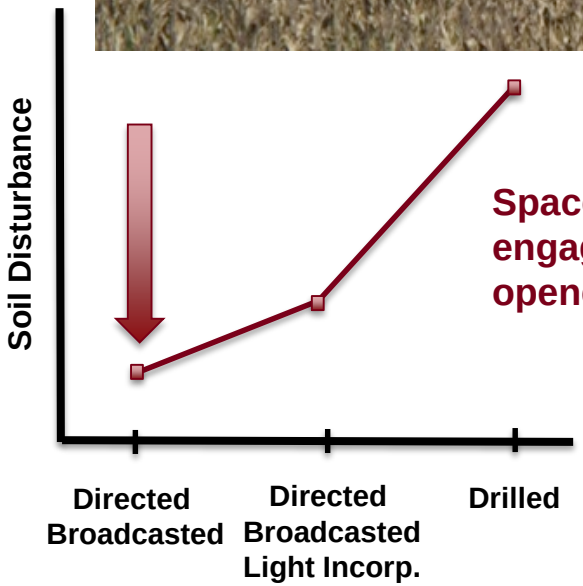
COVER CROP ESTABLISHMENT

- Cover crop planting treatments:
  - Directed Broadcasted
  - Directed Broadcasted + Light incorporation
  - Drilled



COVER CROP ESTABLISHMENT

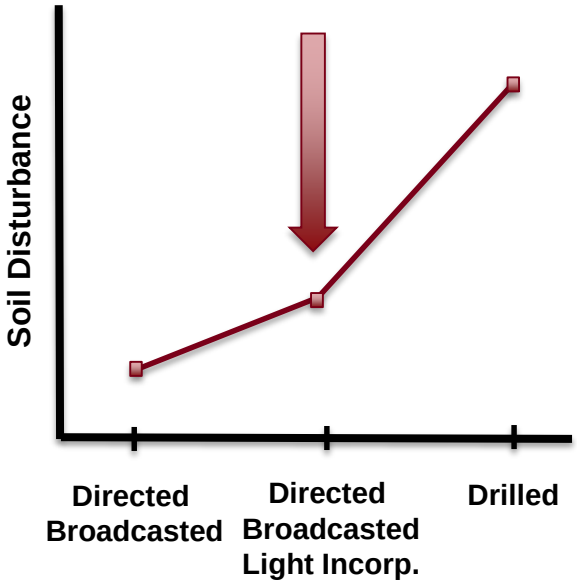
- Directed Broadcasted



Spacers used to operate drill without engaging wavy coulters, double disc openers, and closing wheels

COVER CROP ESTABLISHMENT

- Directed Broadcast + Incorporation
  - Drill units lifted
  - Incorporation units installed



COVER CROP ESTABLISHMENT

Cover Crop	Species	Variety	Seeding Rate (kg ha^{-1})
Cereal Rye	***Secale cereale***	**Rymin**	**168**
Pennycress	***Thlaspi arvense***	**PC 105, 106, 109, 111**	**9.9**
Red Clover	***Trifolium pratense***	unspecified	**13.4**
Hairy Vetch	***Vicia villosa***	unspecified	**35.1**
Fall Green Manure Mix		**Albert Lea NitroMax CC1**	**140**
Oats	*Avena sativa*	unspecified	
Field pea	*Pisum sativum ssp. Arvense*		
Tillage radish	*Raphanus sativus L.*		

COVER CROP ESTABLISHMENT

COVER CROP – 9/16/2014

Hairy Vetch

NWH Fall Mix

Red Clover

Winter Rye

COVER CROP PLANTING DATE – 6/25/2014

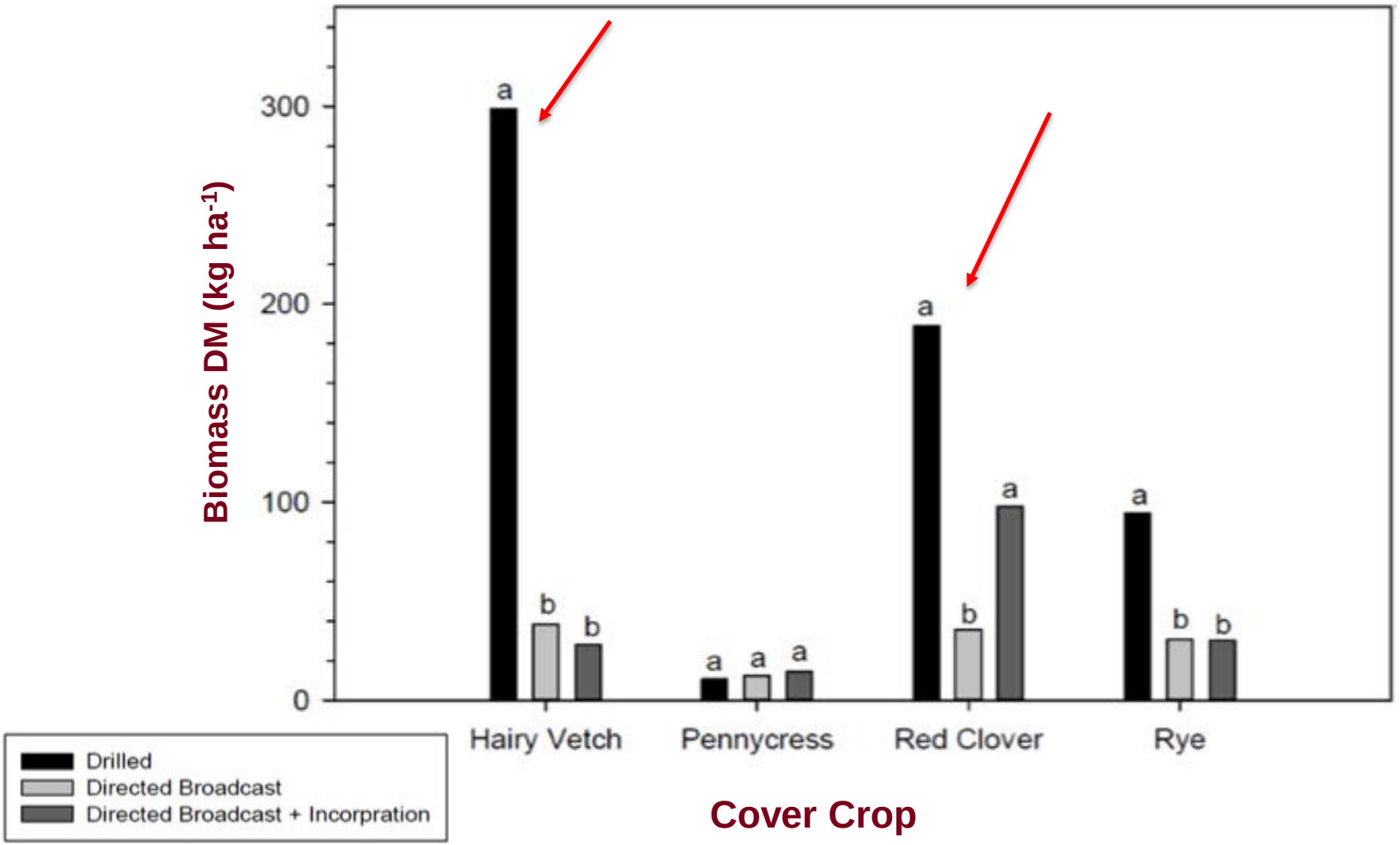
COVER CROPS - 9/16/2014

Broadcast

Broadcast + Incorp

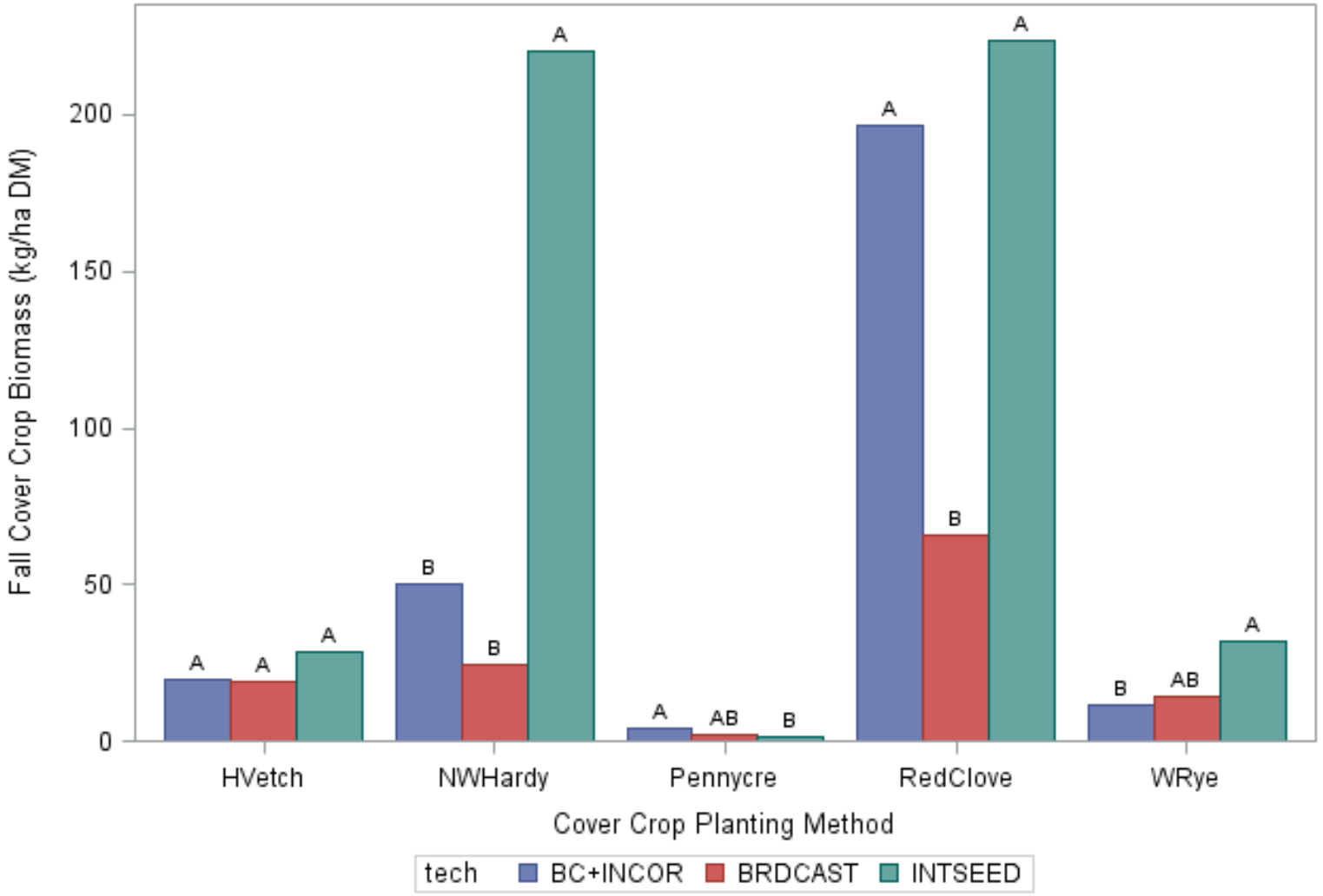
COVER CROPS - 10/16/2015

COVER CROP BIOMASS (FALL 2014)



COVER CROP BIOMASS (FALL 2015)

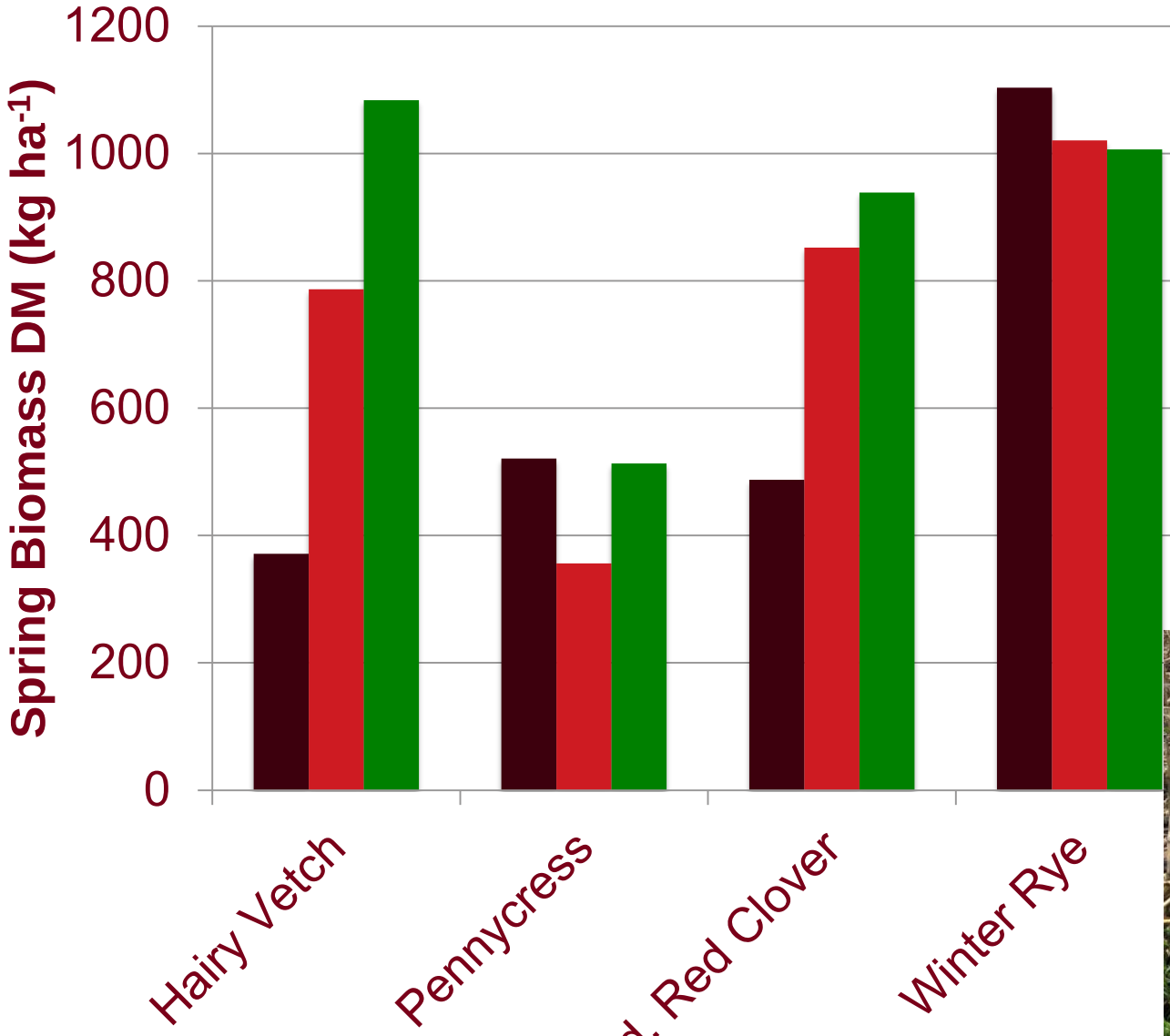
- **Waseca**



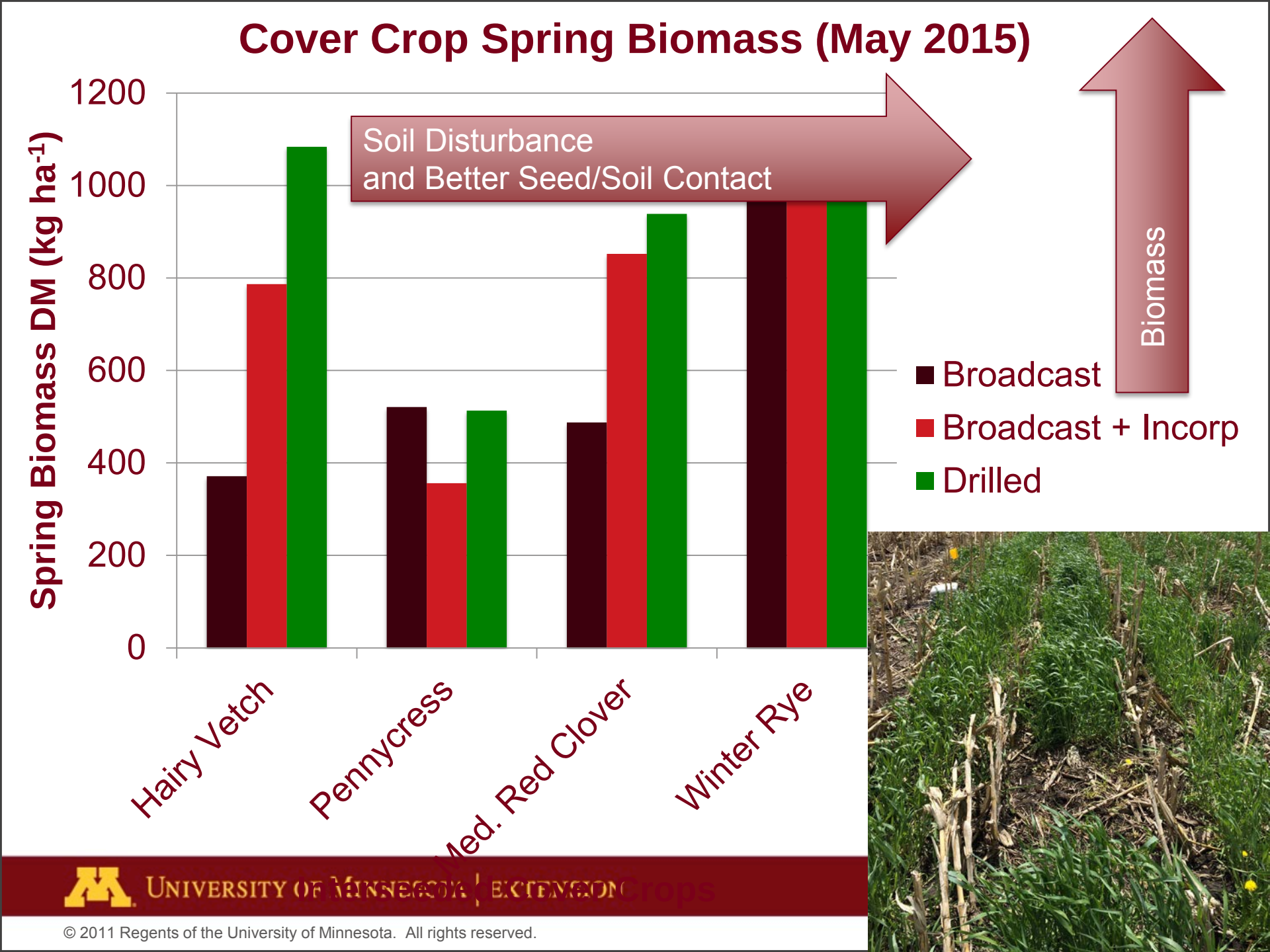
COVER CROP ESTABLISHMENT

COVER CROP – 5/16/2015 PRIOR TO TERMINATION AND NO-TILL SOYBEAN PLANTING

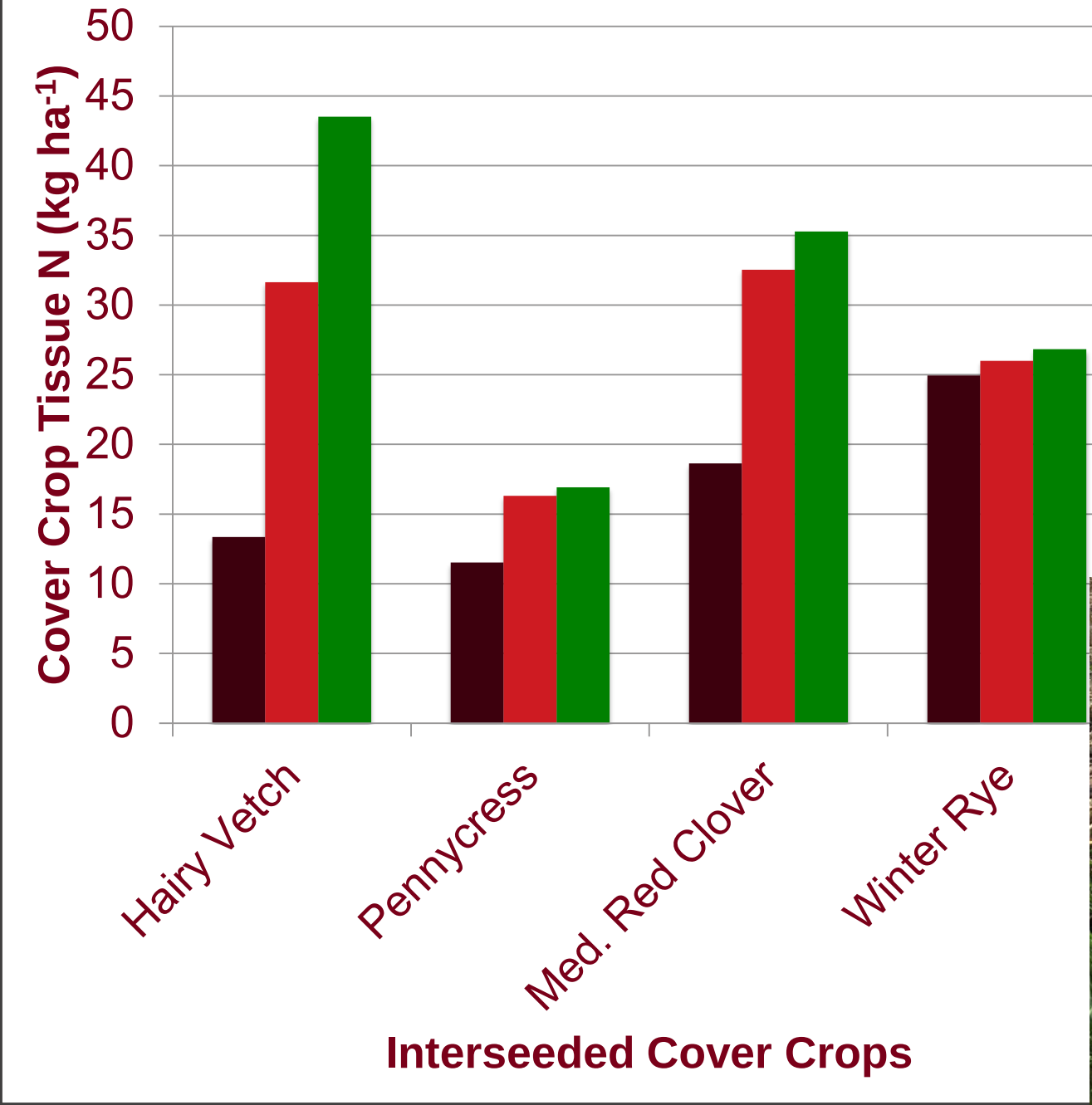
Cover Crop Spring Biomass (May 2015)

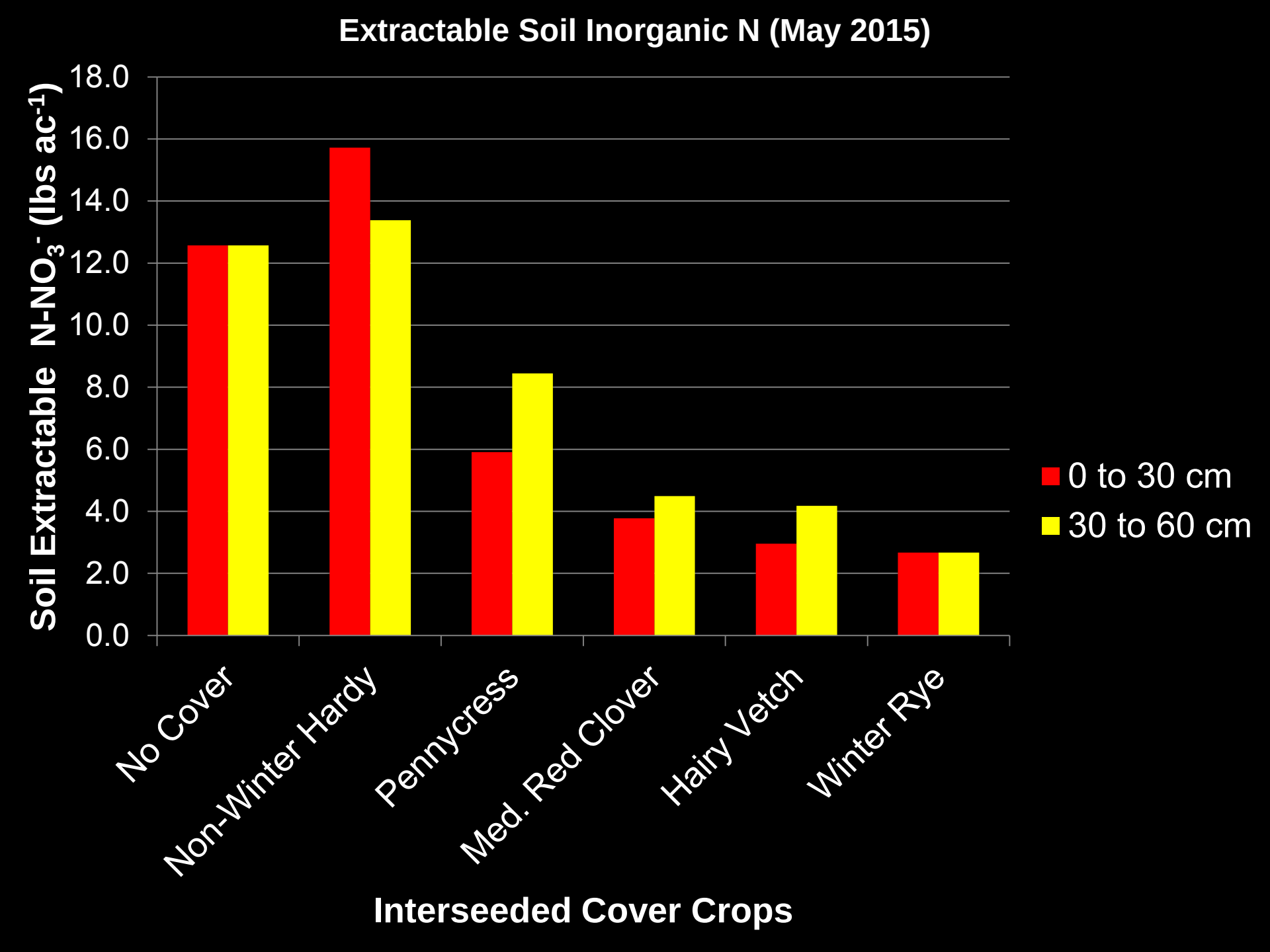


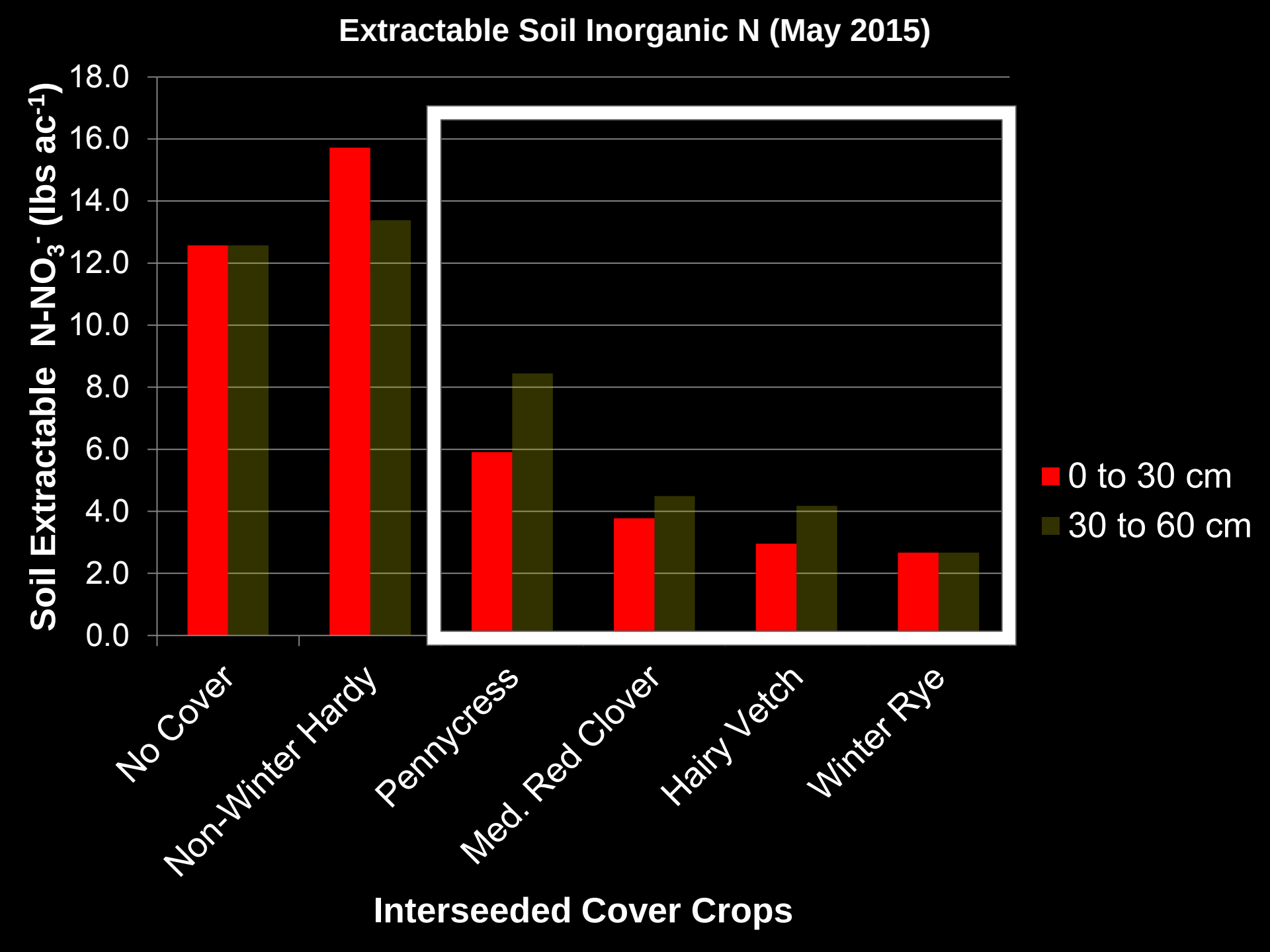
Cover Crop Spring Biomass (May 2015)



Cover Crop Spring Tissue N (May 2015)




Extractable Soil Inorganic N (May 2015)
Soil Extractable N-NO3- (lbs ac-1)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
No Cover
Non-Winter Hardy
Pennycress
Med. Red Clover
Hairy Vetch
Winter Rye
0 to 30 cm
30 to 60 cm
Interseeded Cover Crops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Med. Red Clover
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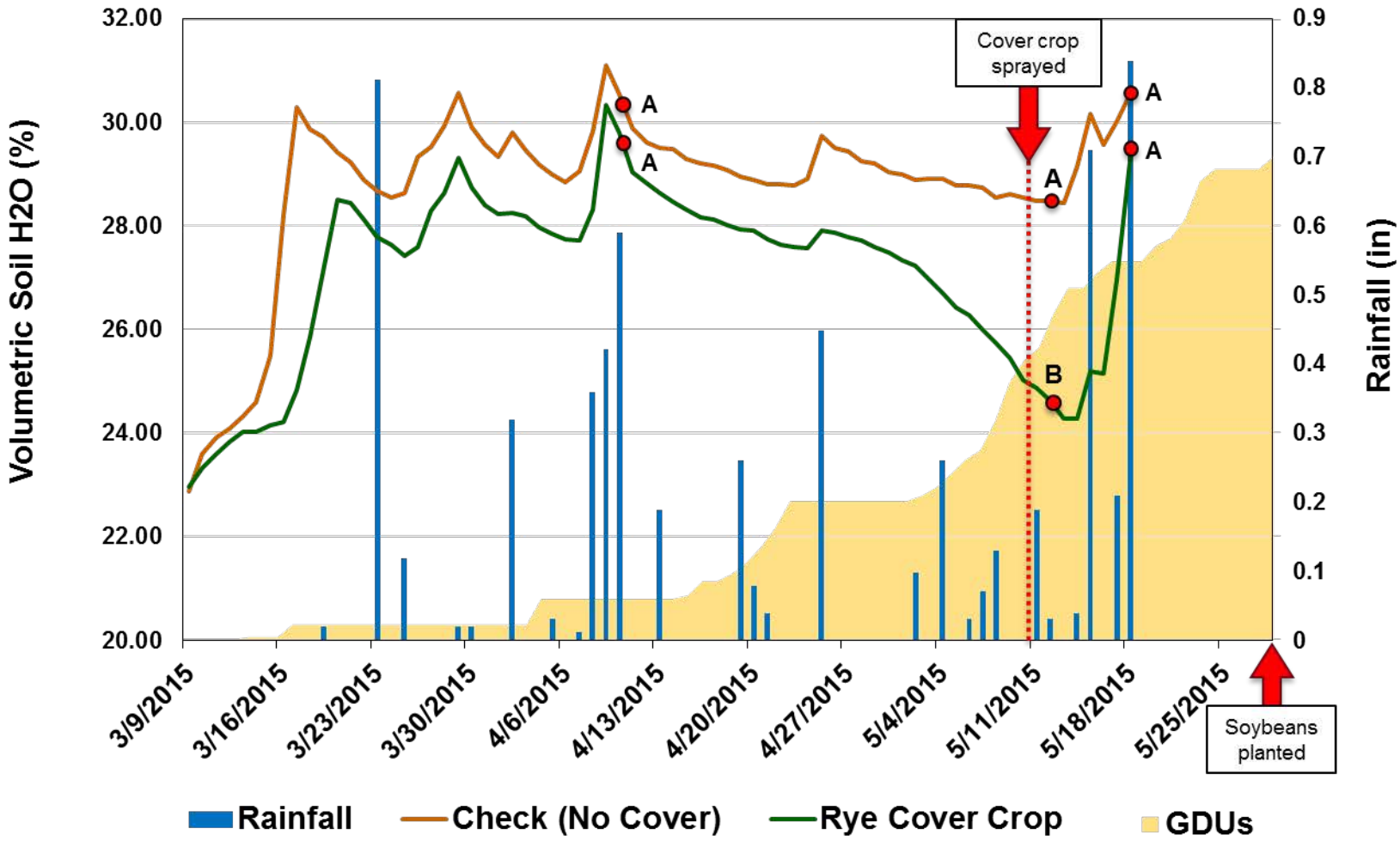
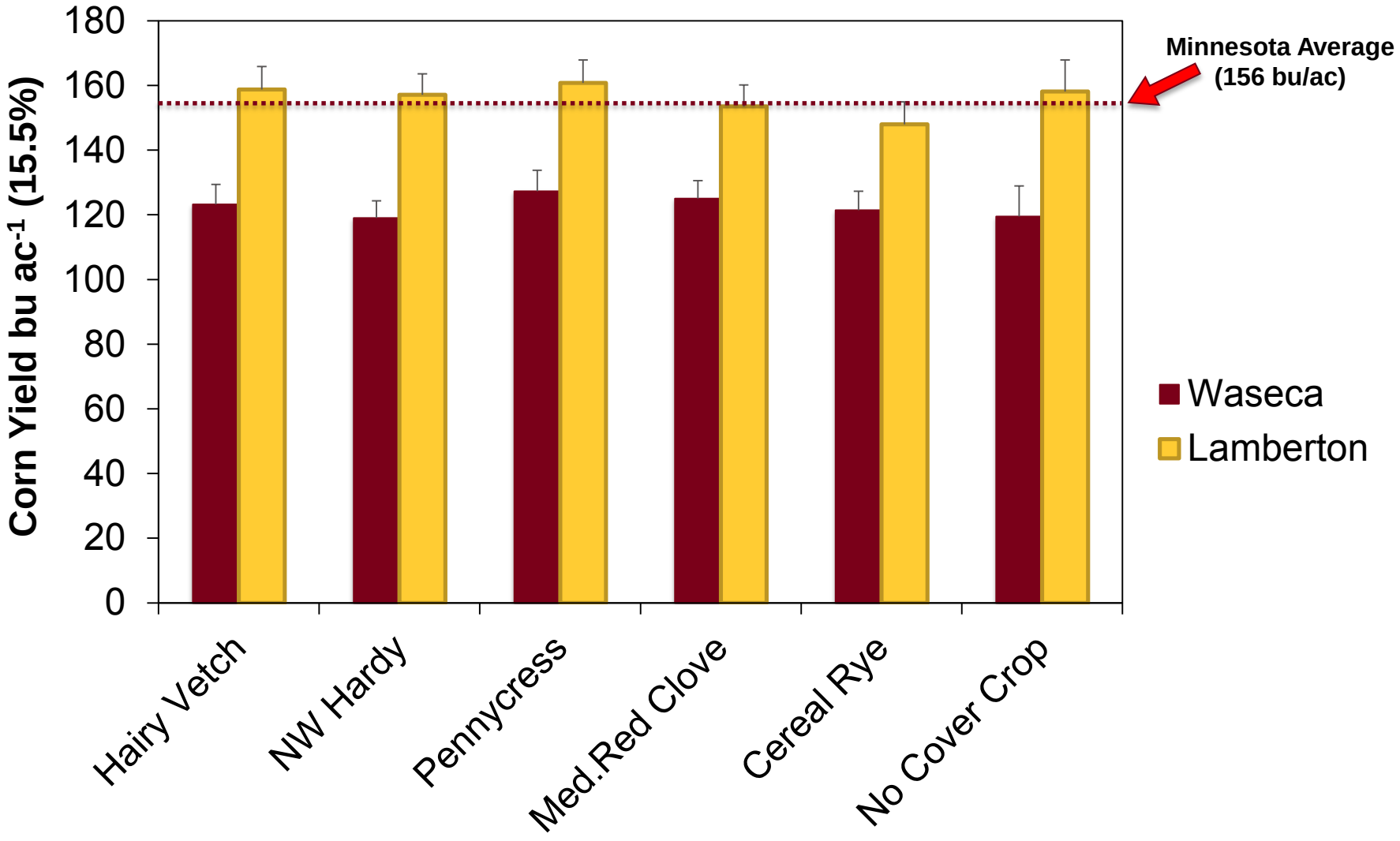
Winter Rye
0 to 30 cm
30 to 60 cm
Interseeded Cover Crops

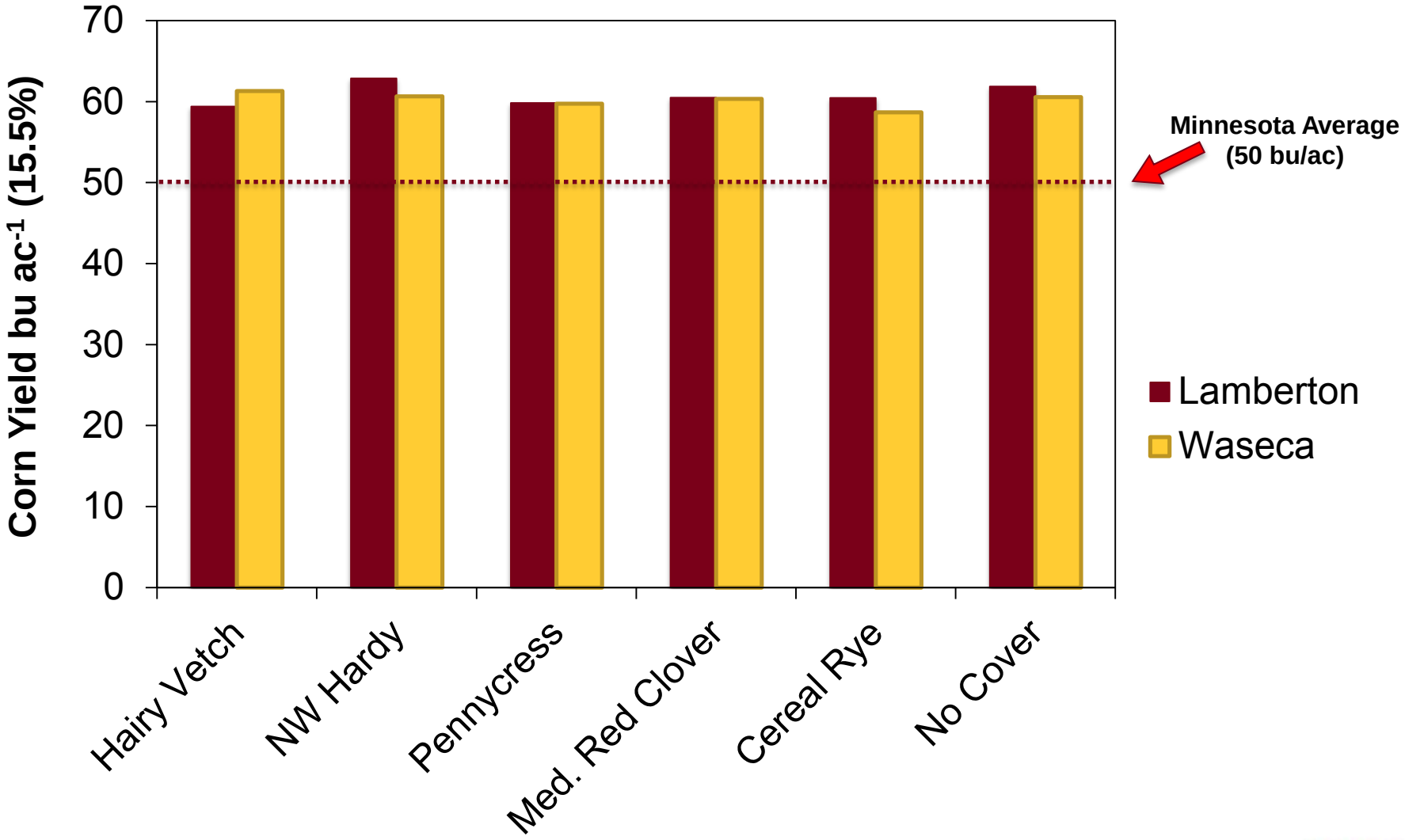
Cover Crop Effects on Spring Soil Moisture (Waseca 2015)



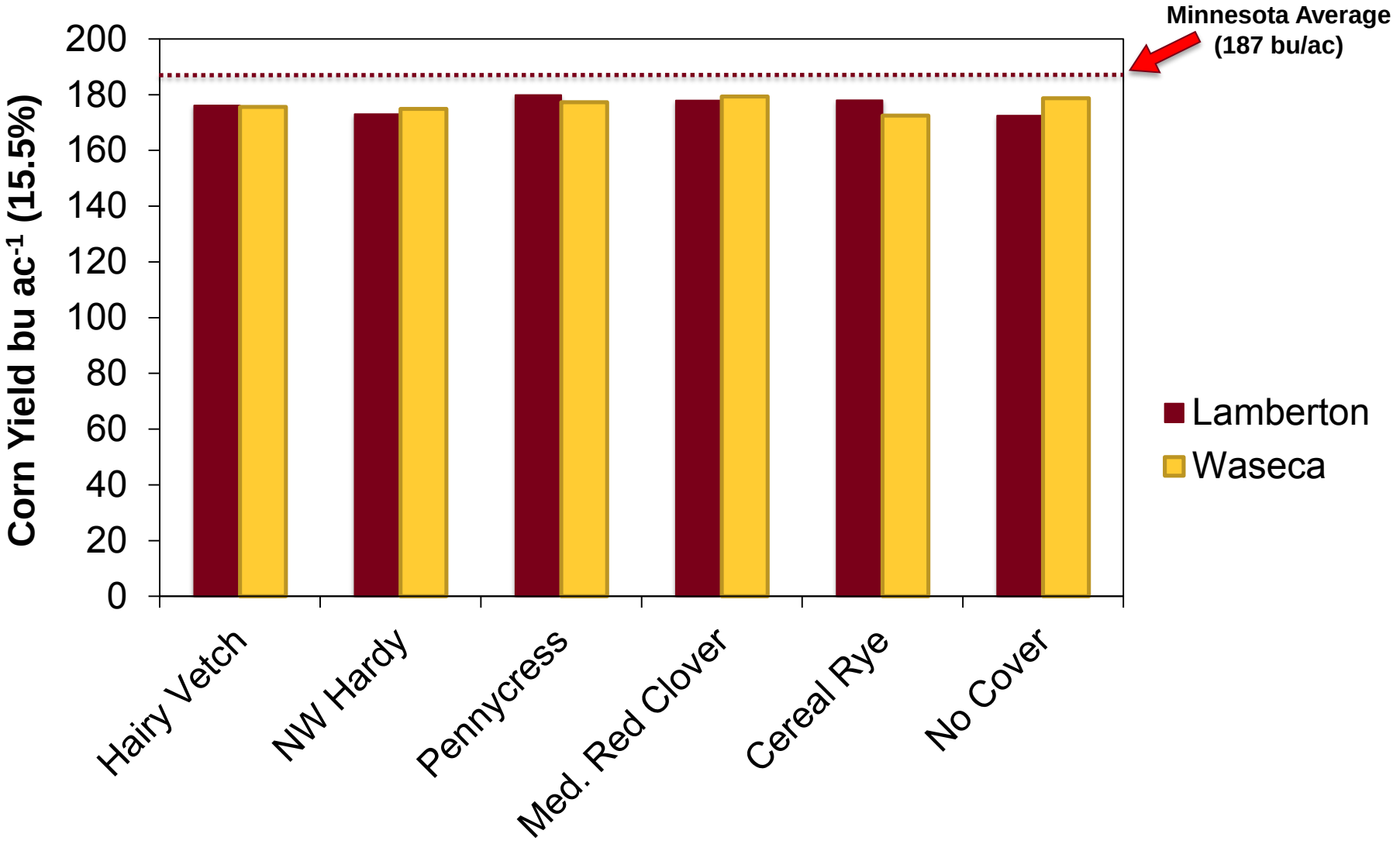
CORN GRAIN YIELD 2014



SOYBEAN GRAIN YIELD 2015



CORN GRAIN YIELD 2015



ECONOMICS (2 YEAR CYCLE)

- Based on 2015 Iowa Custom Rate averages

Conventional System	
Chisel Plow	$16.90
Liquid fert sprayed	$7.35
Field Cultivator	$14.05
Planting corn	$18.50
Side dress	$12.25
Chisel Plow	$16.90
Field Cultivator	$14.05
Spraying weeds**	$7.40
Planting soybeans	$18.50
Corn year total	$69.05
Soybean year total	$56.85
2 year total	**$125.90**

Cover Crop System	
Strip-tilled and knifed	$16.30
Planting corn	$18.50
Custom cover crop interseeding*	$16.00
Cover crop seed	$40.18
Side dress	$12.25
Spraying cover crop**	$7.40
No-till soybeans	$19.20
Corn year total	$103.23
Soybean year total	$26.60
2 year total	**$129.83**

- Seed, fertilizer, and harvest costs not included

Jerry Ackerman, Grain Farmer Personal communication 1/11/2016

STOVER IMPACTS ON OILSEED GROWTH AND DEVELOPMENT

Block 2: DIRECTED BROADCAST + INCORP

Block 2: DIRECTED BROADCAST

HERBICIDES AND COVER CROPS

Common corn and soybean herbicides, estimated half-lives, cash crop restrictions and their potential to injure fall cover crops.

CORN							
Herbicide	**Active ingredient**	**Normal Rate/acre**	**Half life (days)** [1]	**Cash crop restrictions**	**Fall cover crops**		**Other**
					OK to plant	**Concern for**	
2,4-D 4S	2,4-D	1-2 pt	7	Plant anything 30 days after application	All grasses	Wait 30 days before planting sensitive broadleaves	Amine formulations more water soluble and can leach into seed zone
Accent 75DF/ Steadfast75DF	nicosulfuron/ nicosulfuron+ rimsulfuron	0.66 oz/ 0.75 oz	21	Sensitive crops have 10-18 month restriction	Fall cereal grains, ryegrass	Small seeded legumes, mustards, sorghum	More persistent in high pH soils (> 7)
Atrazine 4L	atrazine	1-2 qt	60	Can plant corn, sorghum, and soybean the following year (some products allow others)	Sorghum species	Cereals, ryegrass, legumes, and mustards	More persistent in high pH soils (> 7). Rates < 1 lb/acre can allow more flexibility
Balance Pro 4L	isoxaflutole	2 fl. oz	50-120	Small seeded legumes and vegetables have a 10 to 18 month restriction	Fall cereals grains	Cereals, Ryegrass, legumes, and mustards	15 inches of cumulative precipitation required from application to planting rotation crops except soybean, barely, wheat, sorghum, and sunflower
Callisto (includes Lumax, Lexar, Halex GT)	mesotrione	3-6 fl. oz	5-32	10 to 18 months for legumes and vegetables	All grasses	Small seeded legumes, mustards	Sequential applications (PRE fb POST) increase the potential for injury
Clarity/ Banvel 4S (Distinct and Status)	dicamba	16 to 24 fl. oz	5-14	15 days per 8 fl. oz/acre for small grains	All crops	Only at high rates or less than 120 days after application	Anything can be planted after 120 days with 24 fl. oz/acre or less
Dual II Mag 7.62E/Cinch	metolachlor	1.67 pt	15-50	Labeled for use on many crops	Almost anything	Annual ryegrass or other small seeded grasses	Higher rates and later applications more of a potential problem

http://extension.psu.edu/plants/crops/soil-management/cover-crops/herbicide-persistence/herbicide-carryover-table

HERBICIDES AND COVER CROPS

Herbicide Rotation Restrictions in Forage and Cover Cropping Systems

UW Extension
University of Wisconsin-Extension

Designin
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forage. In th
ahead of tim

Herbici

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labels p
2. To ensu

An EPA regist
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What is

Simply put, a
A cover crop
harvested. Ty

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Months to plant forage crops after herbicide application on small grains

			NON-LEGUME FORAGE CROPS										LEGUME FORAGE CROPS					
			ANNUAL RYEGRASS	BARLEY	BUCKWHEAT	CEREAL RYE	OATS	PEARL MILLET	SORGHUM	TRITICALE	WHEAT	RADISH	ALFALFA	CLOVER	COWPEA	FIELD PEA	VETCH	MAX ROTATION (a)
POSTEMERGENCE HERBICIDES	Affinity BroadSpec	B, W	1.5	0	1.5	1.5	1.5	1.5	1.5	0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	Dicamba (Clarity)	B, O, W	(b)	(b)	4	(b)	(b)	(b)	(b)	(b)	4	4	4	4	4	4	4	4
	Buctril	ALL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Callisto	O	18	4	4	4	0	0	18	4	18	10	18	18	18	18	18	18
	Harmony Extra SG	B, O, W	1.5	0	1.5	1.5	1.5	1.5	1.5	0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	Harmony SG	B, O, W	1.5	0	1.5	1.5	0	1.5	1.5	0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	Huskie	B, W	1	1	(c)	1	1	4	4	1	(c)	4 (d)	(c)	9	9	(c)	9	9
	MCPA amine	ALL	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)
	Orion	B, O, W	0.5	0.5	12	0.5	0.5	0.5	3	0.5	12	9	12	9	9	12	12	12
	Starane Flex	B, O, W	0	0	12	0	0	0	3	0	12	9	12	9	9	12	12	12
	Starane NXT	B, O, W	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
	Starane Ultra	B, O, W	0	0	(e)	(e)	0	(e)	0	0	(e)	(e)	(e)	(e)	(e)	(e)	(e)	(e)
	Stinger (f)	ALL	0	0	18	0	0	0	10.5	0	0	10.5	0	18	18	18	18	18
	2,4-D amine	ALL	3 (g)	1	3 (g)	1	1	3 (g)	3 (g)	3 (g)	3 (g)	3 (g)	3 (g)	3 (g)	3 (g)	3 (g)	3 (g)	3 (g)

REGISTERED CEREALS
B=BARLEY, O=OATS, W=WHEAT
ALL=B,O,W, RED CLOVER AND ALFALFA

The product information compiled here is intended to be as accurate as possible at the time of printing. Refer to product label for more detailed restriction information.

Always follow the product's current label restrictions and instructions.

(a) the maximum amount of time required before planting the next crop if it is not listed on the label

(b) 15 days per 8 fl oz/acre east of Mississippi River, only count days when the ground is not frozen, maximum amount per season is 24 fl oz/acre

(c) field bioassay required

(d) requires tillage and at least 12 inches of rainfall before planting the next crop

(e) no crop rotation restrictions specified

(f) rotational interval for soils with greater than 2% organic matter and annual precipitation exceeding 15 in per year

(g) soil temperatures must exceed freezing for the entire time period

http://www.mccc.msu.edu/states/Wisconsin/2014_Factsheet_HerbicideRotationRestrictions.pdf

HERBICIDES AND COVER CROPS

IOWA STATE UNIVERSITY
University Extension and Outreach

Weed Science
Department of Agronomy

Effect of residual herbicides on cover crop establishment

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Department of Agronomy

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Table 1. Relative tolerance of several cover crop species to herbicides commonly used in corn and soybean production. Injury potential ratings are based on greenhouse trial.

Herbicide	Group No.	1X Rate	Cereal rye	Oat	Hairy vetch	Lentil	Radish
Corn products					Injury Potential[1]		
Atrazine 90DF	5	1.1 lb	2	2	2	2	2
Dual II Magnum	15	1.5 pt	2	1	1	1	1
Balance Flexx	27	5 fl oz	1	1	2	2	**3**
Callisto	27	3 fl oz	1	1	1	2	2
Laudis	27	3 fl oz	1	1	2	2	2
Corvus	2, 27	5.6 fl oz	2	2	2	2	**3**
Hornet WDG	2, 4	5 oz	1	1	**3**	**3**	**3**
Soybean products							
Classic	2	1 oz	1	1	1	1	2
Pursuit	2	4 fl oz	1	1	1	1	2
Prowl H_2O	3	3 pt	2	2	1	1	1
Reflex	14	1.25 pt	1	1	1	1	2

[1]Injury Potential: 1 = little or no risk; 2 = some risk depending upon herbicide rate and environmental factors; 3 = high potential for injury affecting cover crop establishment.

http://www.weeds.iastate.edu/mgmt/2015/CCherbicides.pdf

Questions?

http://z.umn.edu/forages

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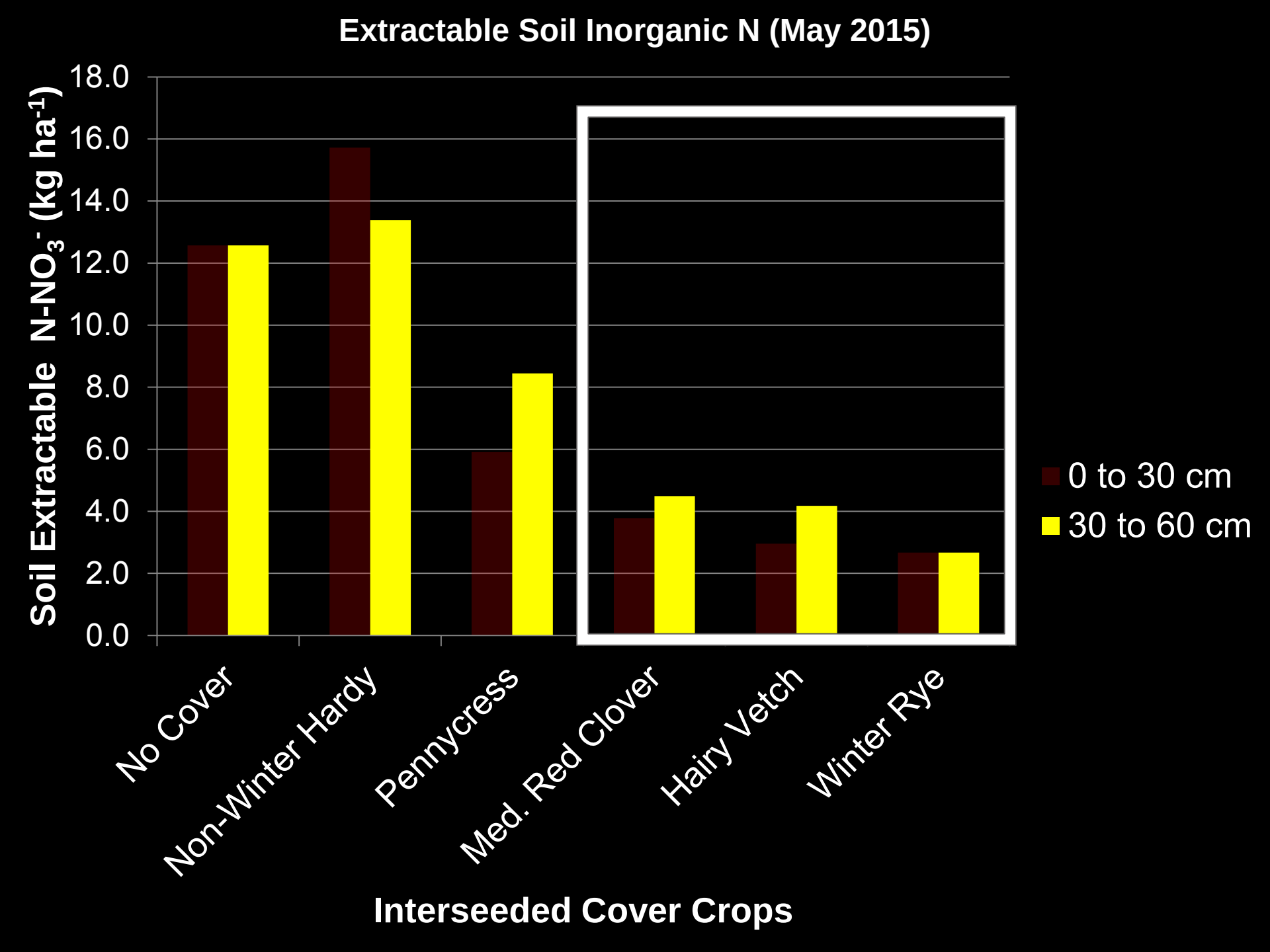
Extractable Soil Inorganic N (May 2015)
Soil Extractable N-NO3- (kg ha-1)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
No Cover
Non-Winter Hardy
Pennycress
Med. Red Clover
Hairy Vetch
Winter Rye
0 to 30 cm
30 to 60 cm
Interseeded Cover Crops