

Cover Crop Termination Methods and Challenges

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- Cover crops are of increasing interest to producers in the upper Midwest region due to many agronomic benefits.
- Cover crops have been utilized for many years in organic production.
- While cover crops are of increasing interest there may be challenges to termination.
- Over winter potential?



- Cover crops are no longer cover crops if harvested as a forage and fed to livestock. This would be classified as a forage crop and has different herbicide restrictions.
- Example: winter rye(cereal rye) is established in the fall and harvested in the spring for forage

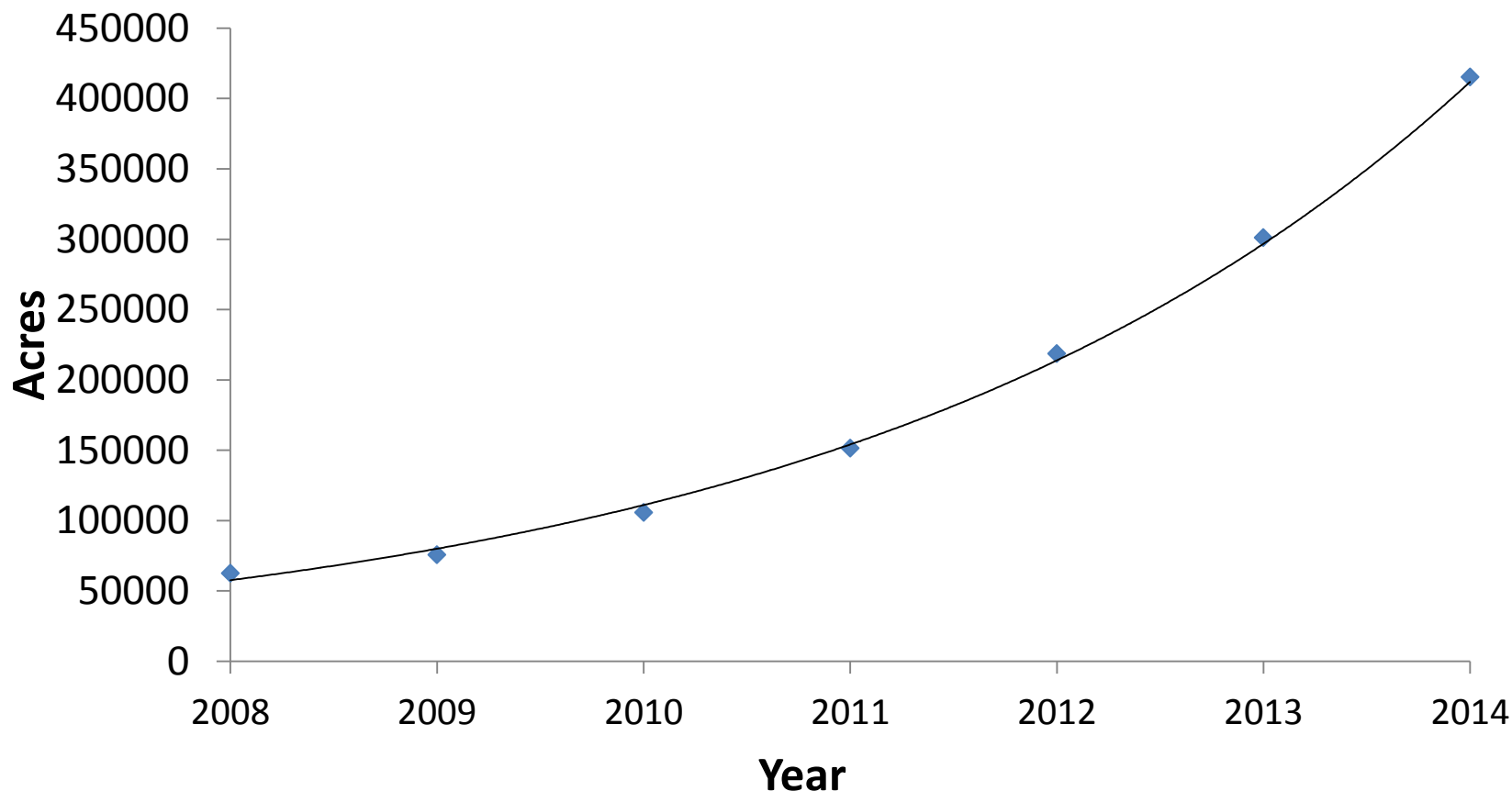


- Reducing soil erosion
- Providing and scavenging nutrients
- Weed suppression
- Improved soil health
- Reducing soil moisture losses
- Protecting water quality
- Reducing production costs
- Increased yield



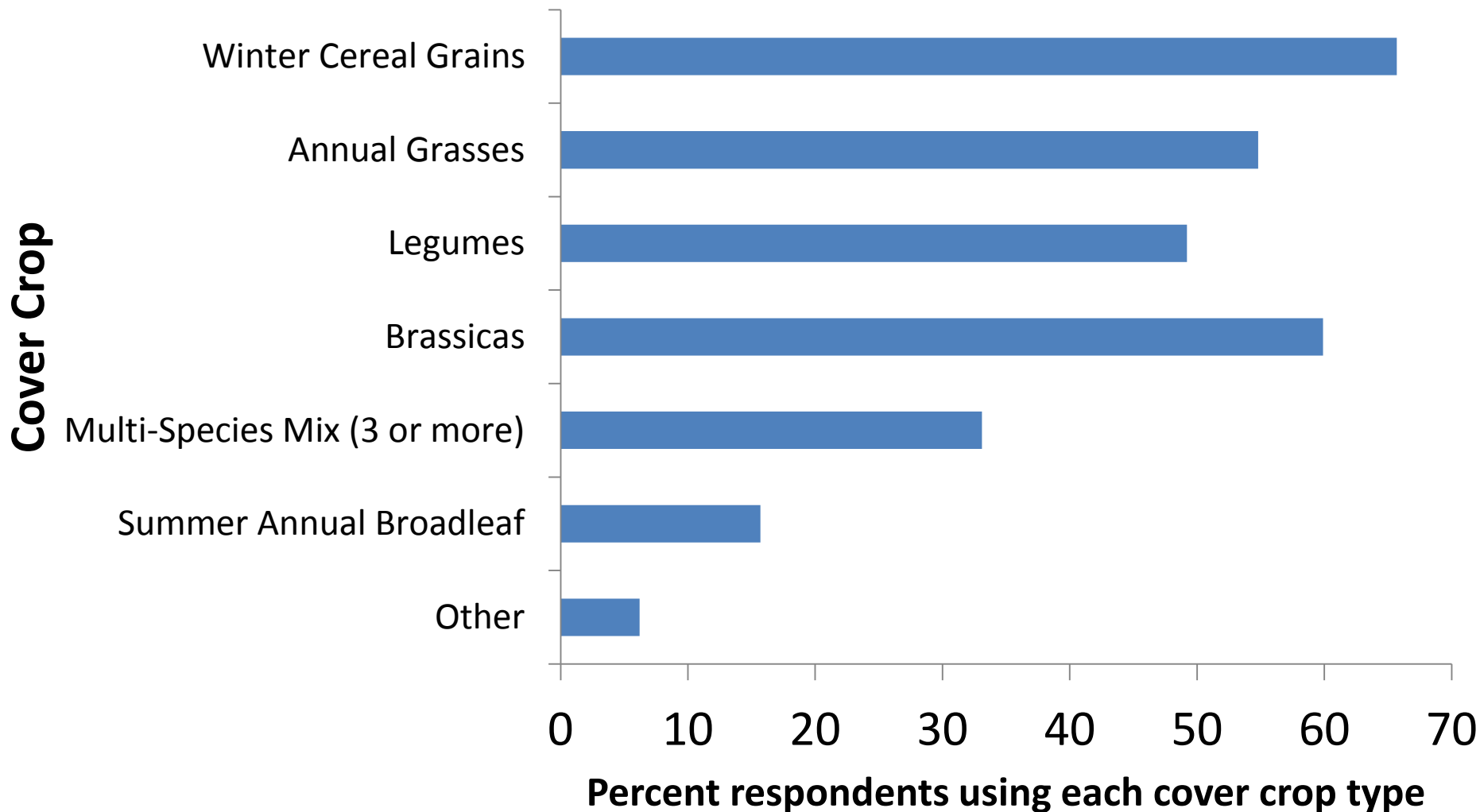
In Fall 2013 the North Central Sustainable Agriculture Research and Education (SARE) program with the Conservation Technology Information Center (CTIC) conducted a survey of cover crop use. The majority of farmers were from the Mississippi river basin. The farmers were asked to project their 2014 use .

Cover Crop Acres

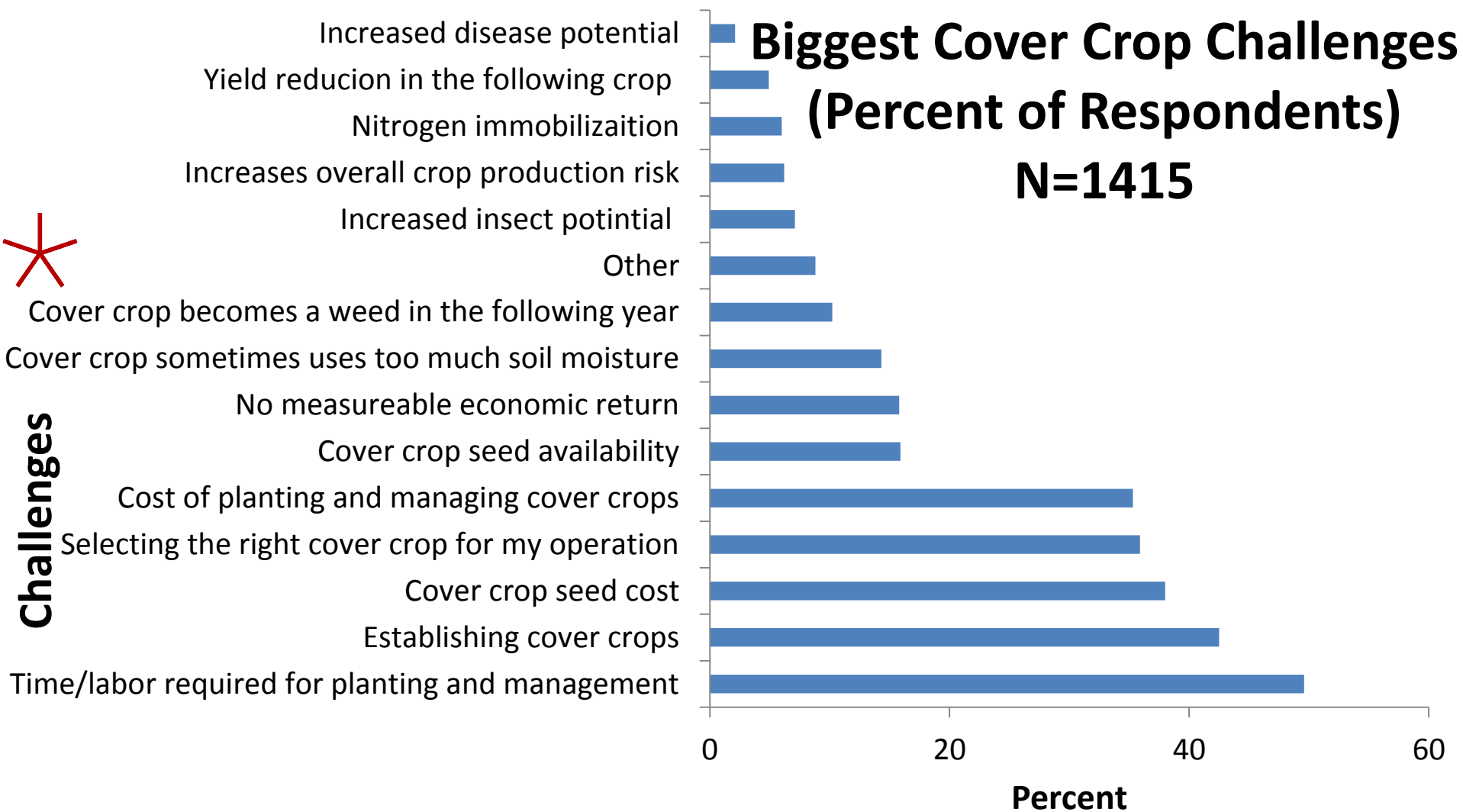


The SARE/CITC survey asked farmers what cover crops they were currently utilizing

Cover Crop Use in the Midwest

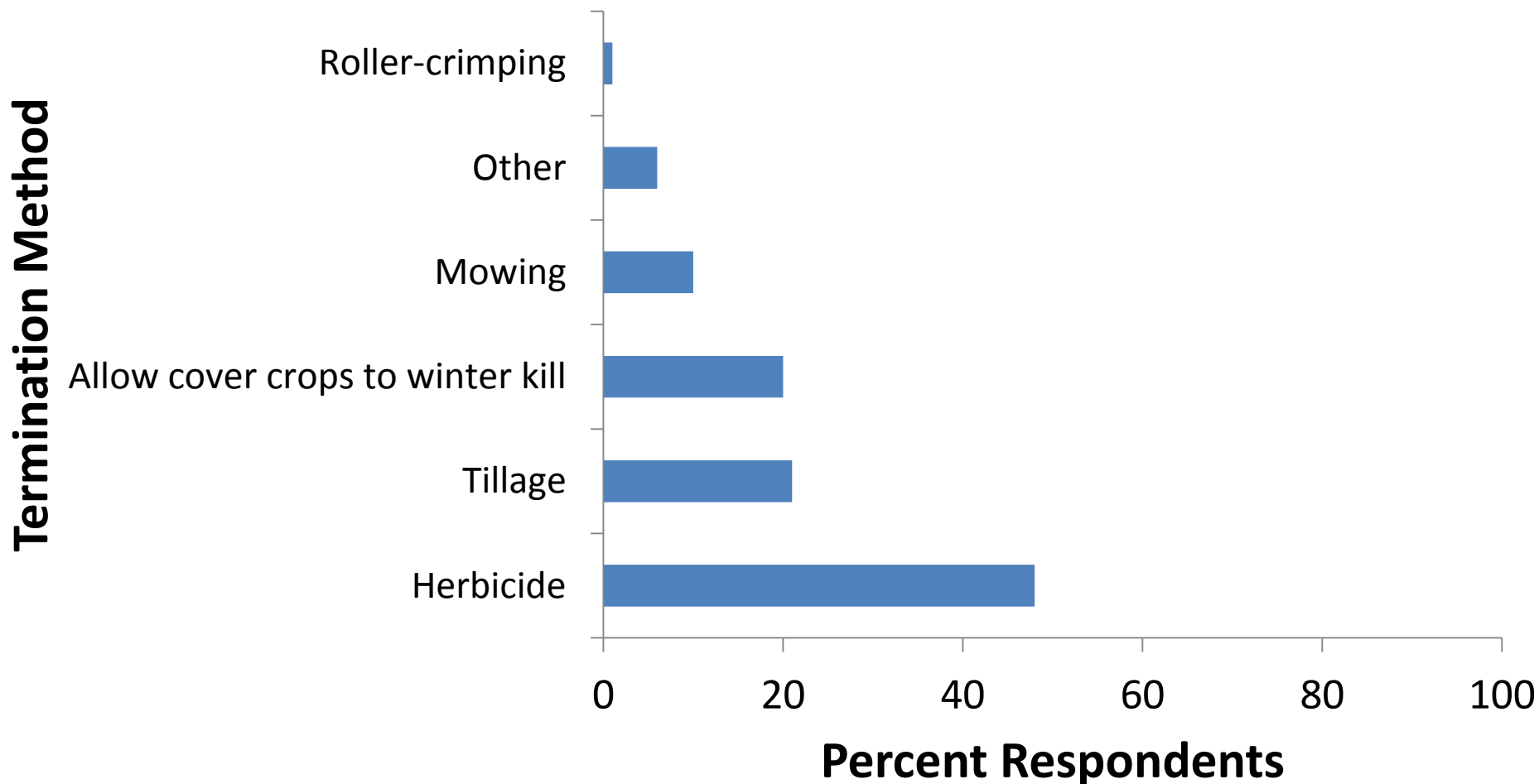


The SARE/CITC survey asked farmers what their biggest challenges with cover crops have been. **>15% of respondents indicated cover crop becomes a weed!**



The SARE/CITC survey asked farmers their primary cover crop termination method.
>48% of respondents utilize herbicides!

Cover Crop Termination Methods





Not if planned for and managed correctly!

- Certain cover crops can over winter from seeds. Examples: rye, buckwheat, and hairy vetch
- Seed Production: many cover crops can quickly flower and produce seed in the spring



Overwinter-Yes



Overwinter-No



Annual Ryegrass
Variety dependent
2013 3 out of 4 varieties
Survived



Difficult to Terminate: annual ryegrass, hairy vetch, clovers, and rye



		Winterkill	Crimping	Mowing	Tillage	Herbicide
Brassica	Canola/Radish	Maybe	No	No	Yes	Glyphosate
Legume	Red Clover	No	No	No	?	Glyphoate + Dicamba or 2,4-D
	Crimson Clover	Yes	No	No	Yes*	Glyphoate + Dicamba or 2,4-D
	Berseem Clover	Yes	No	No	Yes*	Glyphoate + Dicamba or 2,4-D
	Winter pea	Maybe	No	Yes	Yes*	Glyphoate + Dicamba or 2,4-D
	Sweet Clover	Maybe	No	No	?	Glyphoate + Dicamba or 2,4-D
	Hairy Vetch	No	Yes	No	Yes*	Glyphoate + Dicamba or 2,4-D
Non-Legume	Annual ryegrass	Maybe	No	No	Yes*	Glyphosate-See later results
	Winter barley	No	Yes	Yes	Yes*	Glyphosate 4.5 lb ae per gal, 22 fl oz per acre
	Winter wheat	No	Yes	Yes	Yes*	Glyphosate 4.5 lb ae per gal, 22 fl oz per acre
	Winter rye	No	Yes	Yes	Yes*	Glyphosate 4.5 lb ae per gal, 22 fl oz per acre

Tillage Note- May require multiple passes and tillage should fully incorporate cover crop to prevent regrowth. Chart Adopted from WCWS 204 Cover Crop Termination by Elizabeth Bosak and Vince Davis

- Termination should occur during a period of active growth
- Day/ night temperatures should be 55/40°F and should be above these temperatures for 3 days pre and post application
- Application should occur four hours prior to sunset



- Trial #1 Glyphosate termination of winter rye and annual ryegrass heights exceeding current recommendations
- Trial #2 Winter rye and annual ryegrass termination utilizing mowing, mowing + collection, and mowing + collection + glyphosate
- Neither trial examined herbicide combinations that may antagonize control



Comparison of glyphosate application rates for winter rye and annual ryegrass with heights exceeding current recommendations

Hypothesis: Termination will be most effective when the ryegrass and winter rye are actively growing early in the spring



- Control annual ryegrass prior to 6 inches of growth.
Control winter rye prior to boot stage or ≤ 18 inches of growth



Crop Heights 5-23-14

Annual Ryegrass 6-18"

Winter Rye-34-40"



- Terminate cover crops at or within 5 days after planting, but before crop emerge (NRCS Cover Crop Termination Guidelines December 2013)



- Annual ryegrass- Ideally terminate when plant is less than 6 inches in height, prior to jointing, and use translocated herbicides.
- Good terminated achieved using glyphosate, fomesafen+glyphosate (Flexstar GT©), paraquat + atrazine
- Winter Rye- 22 fl oz glyphosate up to 18 inches in height(Successful Cover Crop Termination with Herbicides Purdue Ext. Fall 2013)



- Winter Rye- 18 fl oz glyphosate up to 16 inches in height (Integrated Crop Management News Spring 2014)



- Annual ryegrass and winter rye plots were established in the fall of 2013 following silage harvest. Varieties utilized include three varieties of annual ryegrasss ‘Bruiser,’ ‘Gulf,’ and ‘King’ and ‘Guardian’ winter rye.
- RCB with 4 Replications and each trial included a nontreated control



	Winter rye	Annual ryegrasses
Depth (in)	1	1
Seeding Rate(lb ac ⁻¹)	120	32



Example Treatment

43 FT



7.5 Ft.

Example Plot



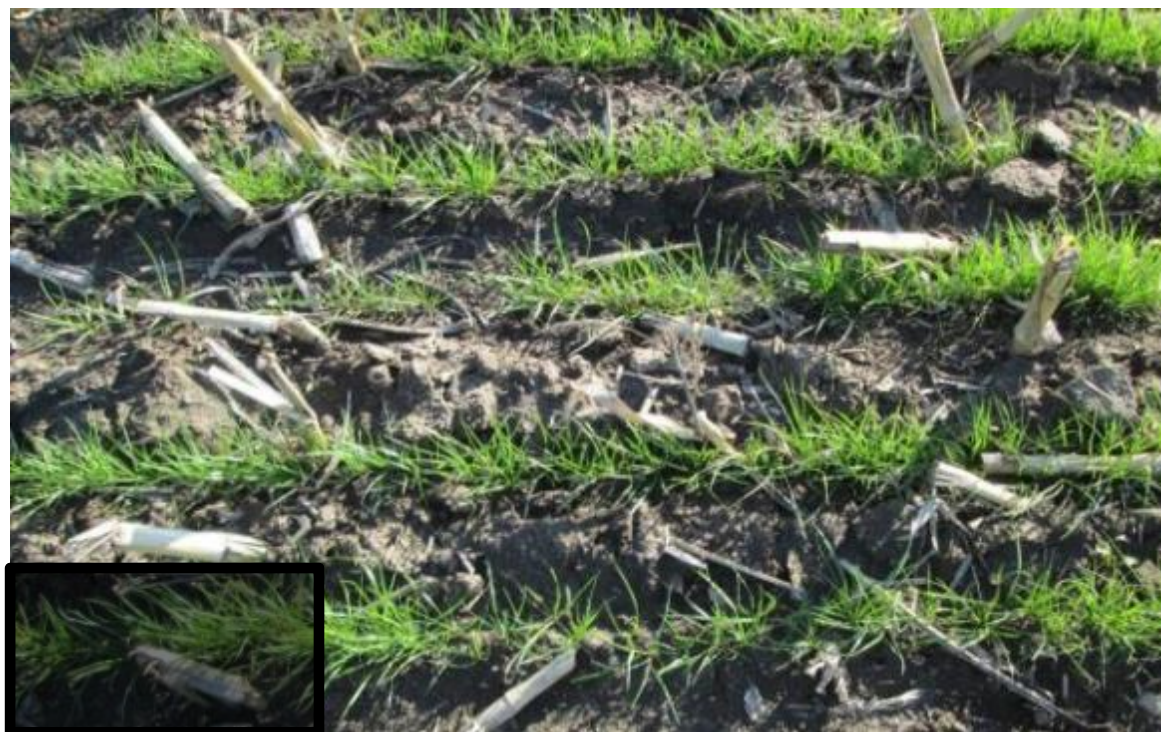
- Glyphosate applied on May 23rd, May 29th, and June 4th
- Glyphosate rates include 0,16,32,64, and 128 ounces per acre.
- Roundup PowerMAX© 4.5 lb ae/gal applied with 17 lbs/100 gallon AMS

- Application were sprayed at 15 GPA using XR11002 flat fan nozzles pressurized at 18 psi
- Boom height 20 inches above canopy
- Ideal Weather Conditions!



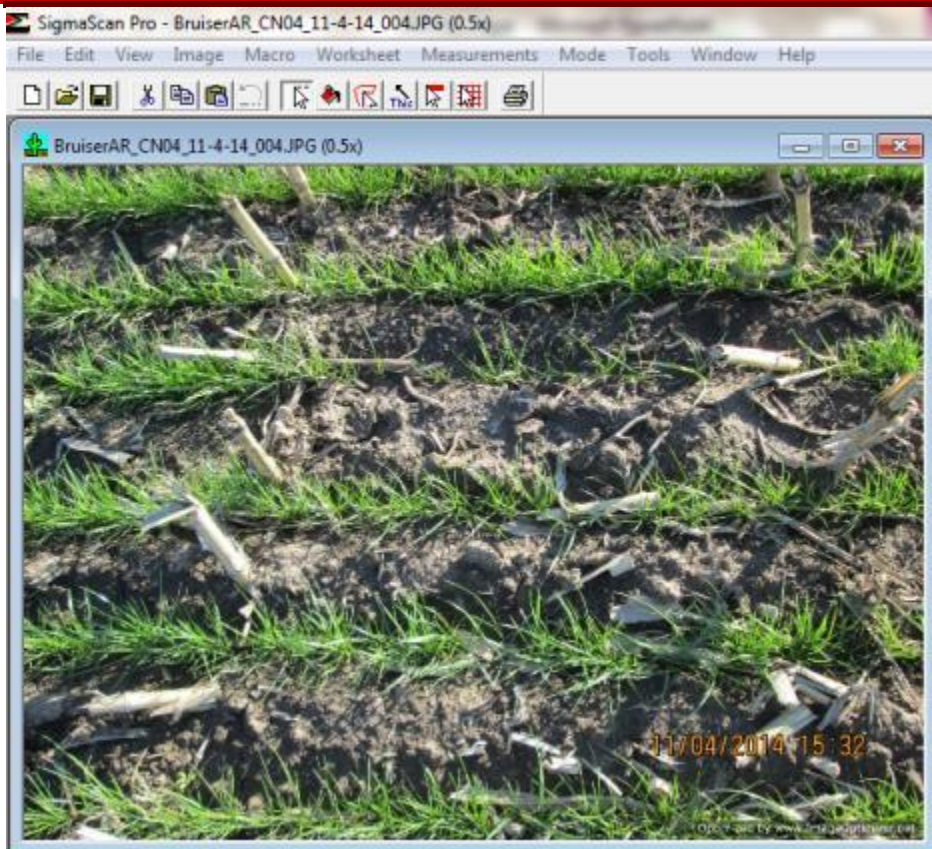
Backpack plot sprayer (Tommy Butts)

- Two weeks after application, the cover crops were evaluated for herbicide injury. The data were collected with digital imagery analysis for percent cover and for total dried biomass collected from a 0.25m² quadrat per subplot.
- Digital images were taken at 91 cm above each cover crop in every plot. The camera (Canon PowerShot A1400) was mounted at a 70 degree angle on a 2.5 cm by 114 cm board, set to auto mode with zoom set to 0. This board created a stand for the camera to capture consistent photos of all subplots.

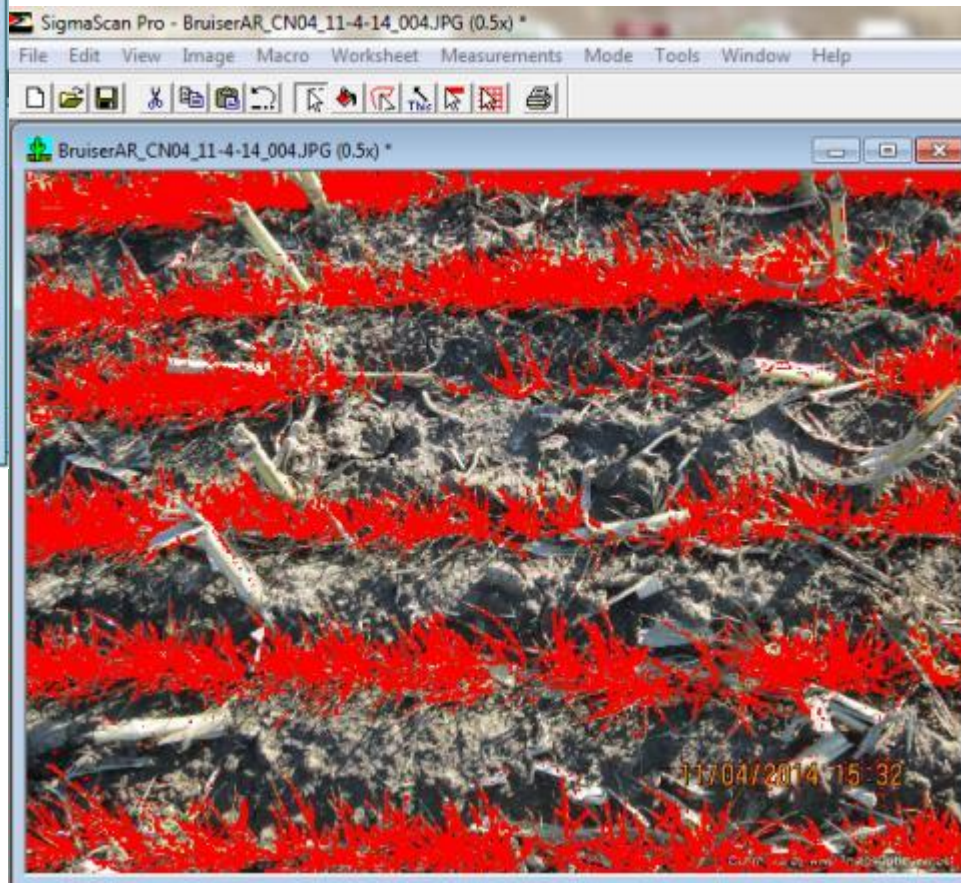


SigmaScan Pro 5[®] and Turf Analysis 1-2 Macro

Percent cover is estimated using the software to turn the green pixels red and then they are counted



Pre Software Analysis





May



Mid-May

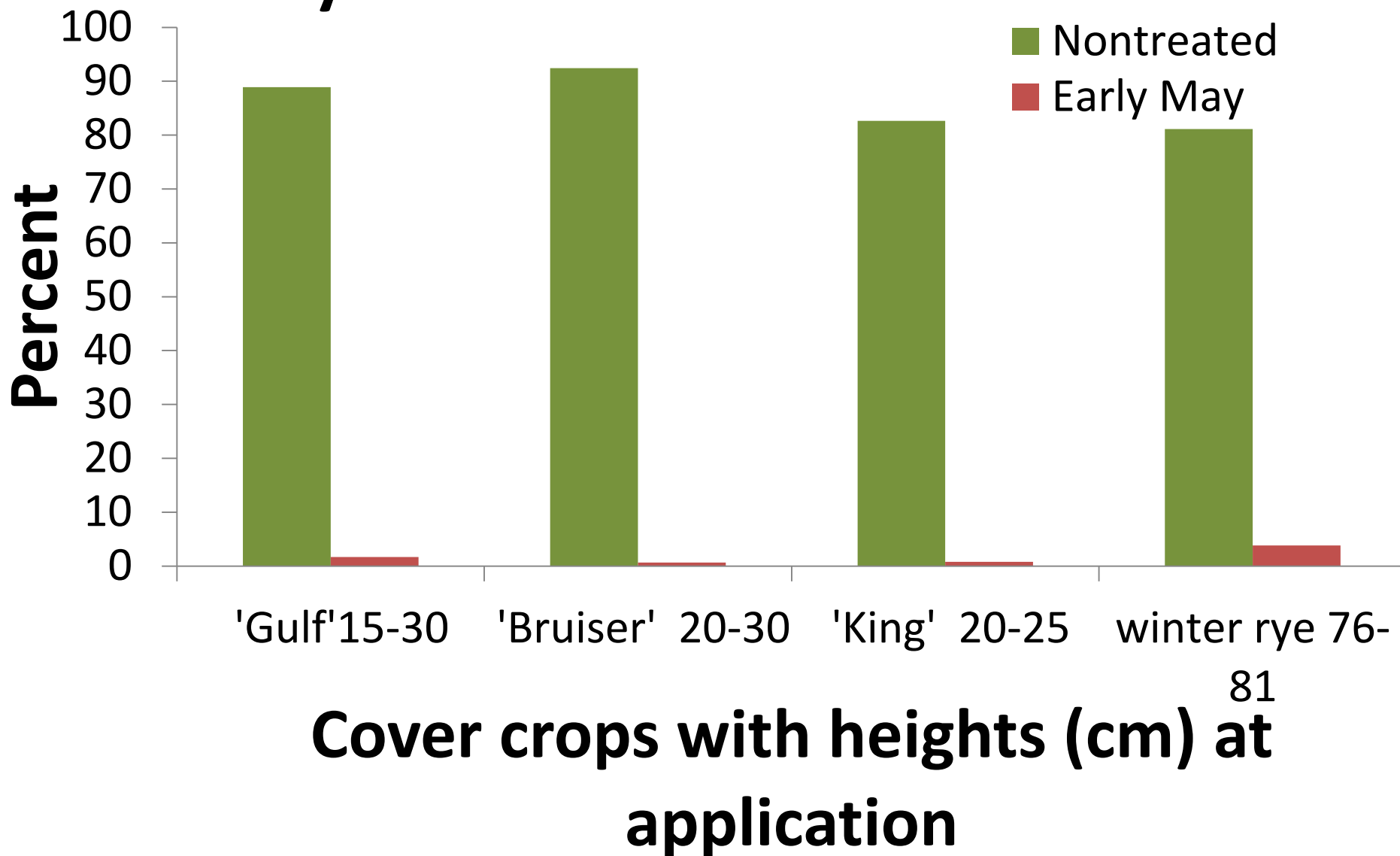


Early-June

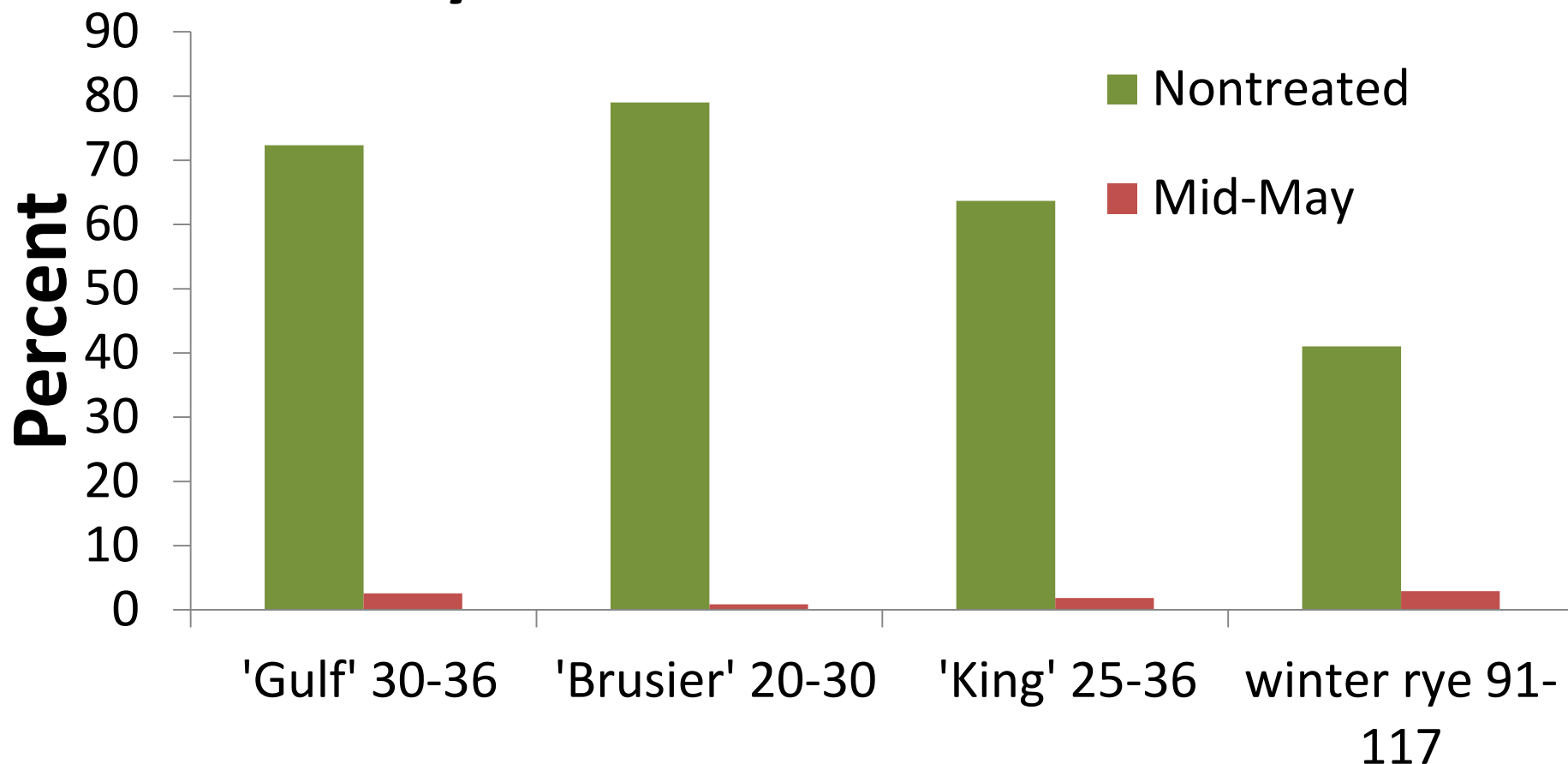


- Percent green cover of annual ryegrass (AR) and winter rye (WR) decreased ($P < 0.0001$) for all cover crops at all rates at 14 days after application. **May**
- AR and WR dry biomass weight was significantly decreased ($P < 0.001$) at the 16 fl. Oz. rate for early **Mid-May** and **Early-June**.

May Percent Green Cover 14 DAT

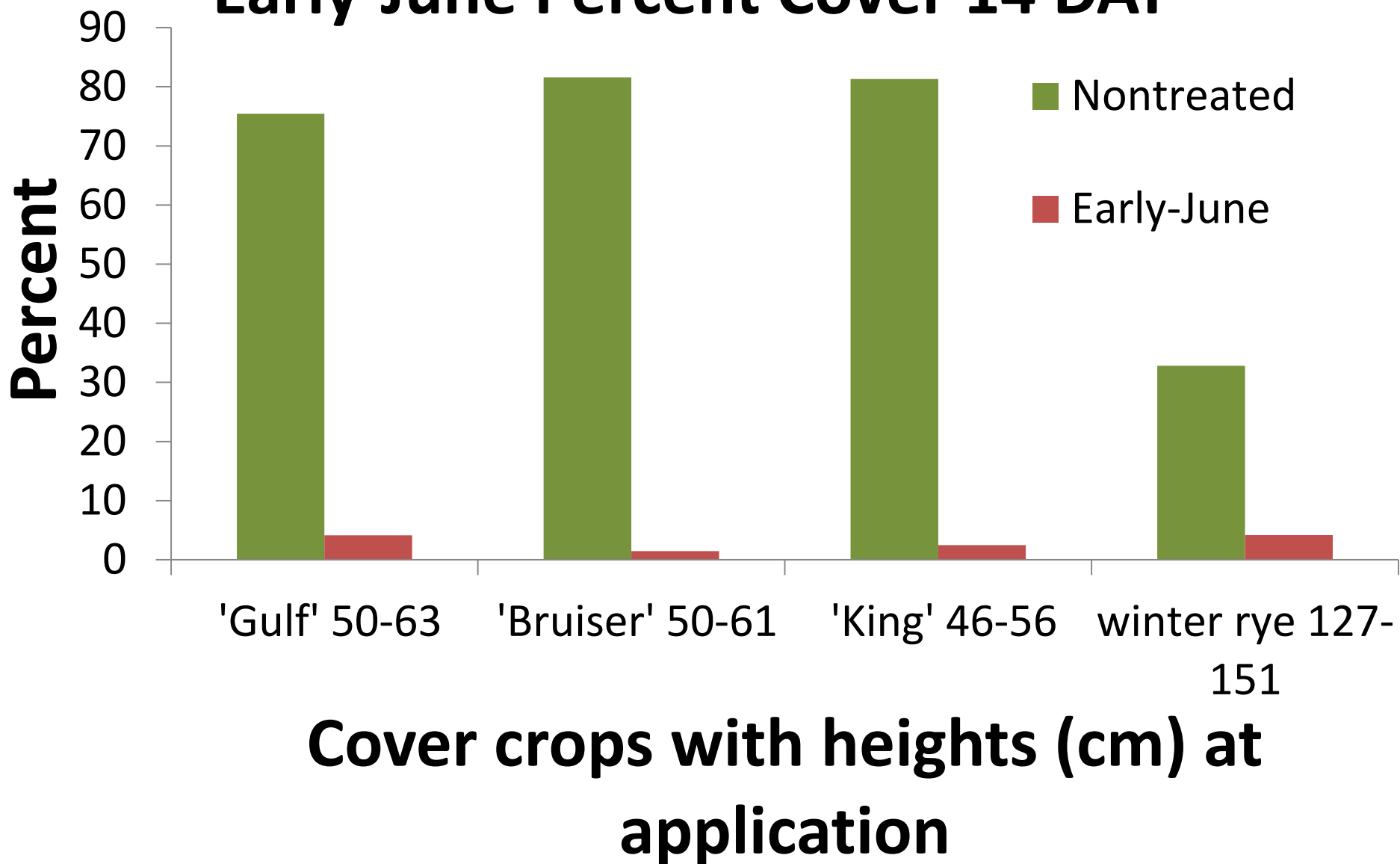


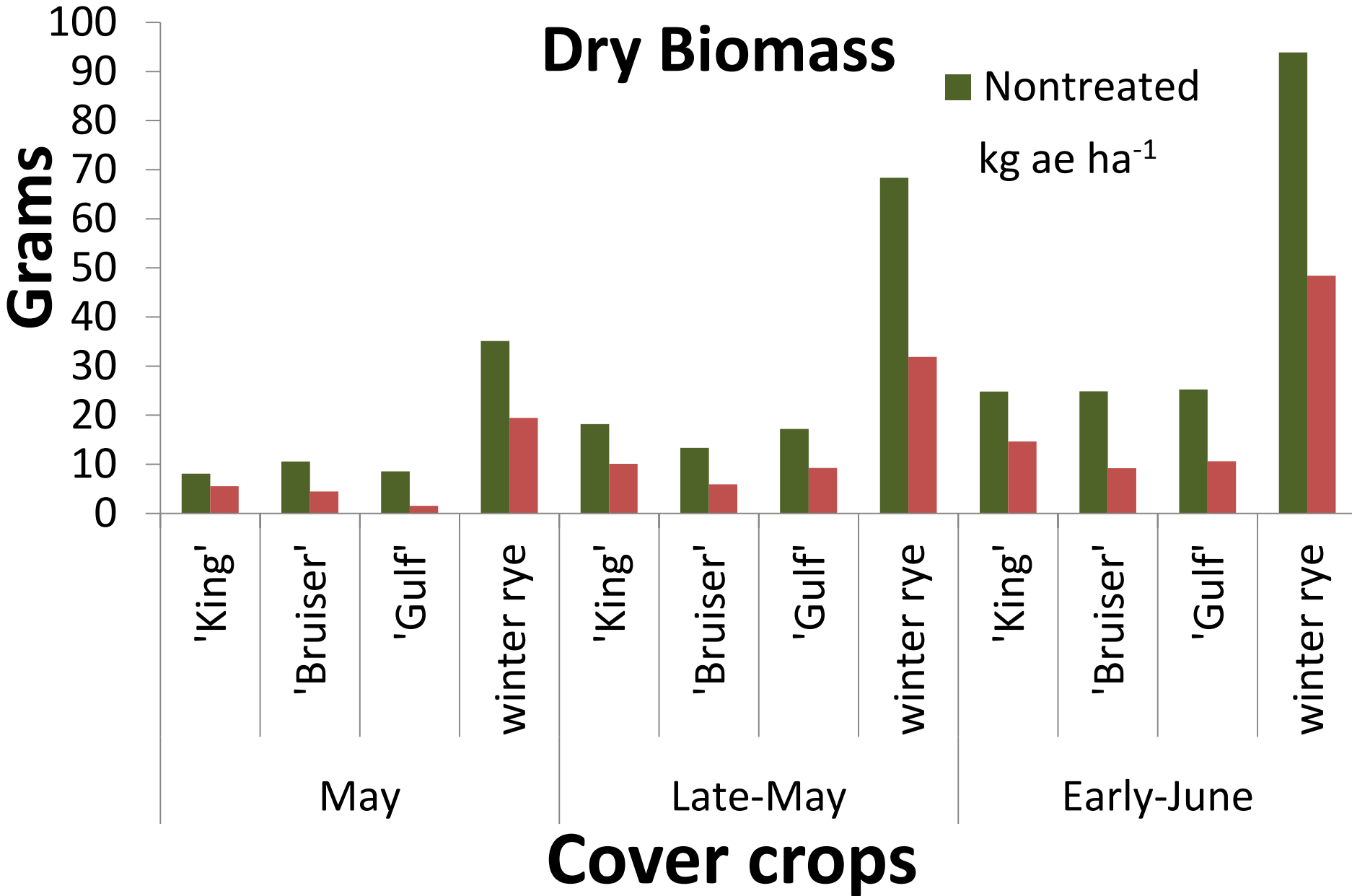
Late-May Percent Green Cover 14 DAT



Cover crops with heights (cm) at application

Early-June Percent Cover 14 DAT





- Our preliminary results indicate that winter rye and annual ryegrass can be effectively terminated using a glyphosate rate of 16 fl. oz. if targeted under good weather conditions. Repeat trial in 2015
- All three annual ryegrasses had similar growth and good winter survival in 2014.





- More termination research is needed to establish best management practices based on rates, crop heights and to better define where glyphosate performance may be reduced due to weather conditions.

- Objective- Determine if termination of winter rye and annual ryegrass are significantly affected using methods of termination that include mowing, mowing plus collection of biomass, herbicide application, mowing plus herbicide application, and mowing plus collection and herbicide application.



- RCB Design with 4 Replications
- Establishment and data collection procedures same and trial #1



- Two Timings-Mid May(5/23/14) and full anthesis of winter rye (6/5/14)
- Glyphosate (4.5 lb ae 32 fl. oz/acre)
- Glyphosate + Mowing + Collection
- Mowing + Collection



Full Anthesis

- Recommended stage
for crimping
- 2014 -June 6th





Two weeks
after mowing-
no glyphosate



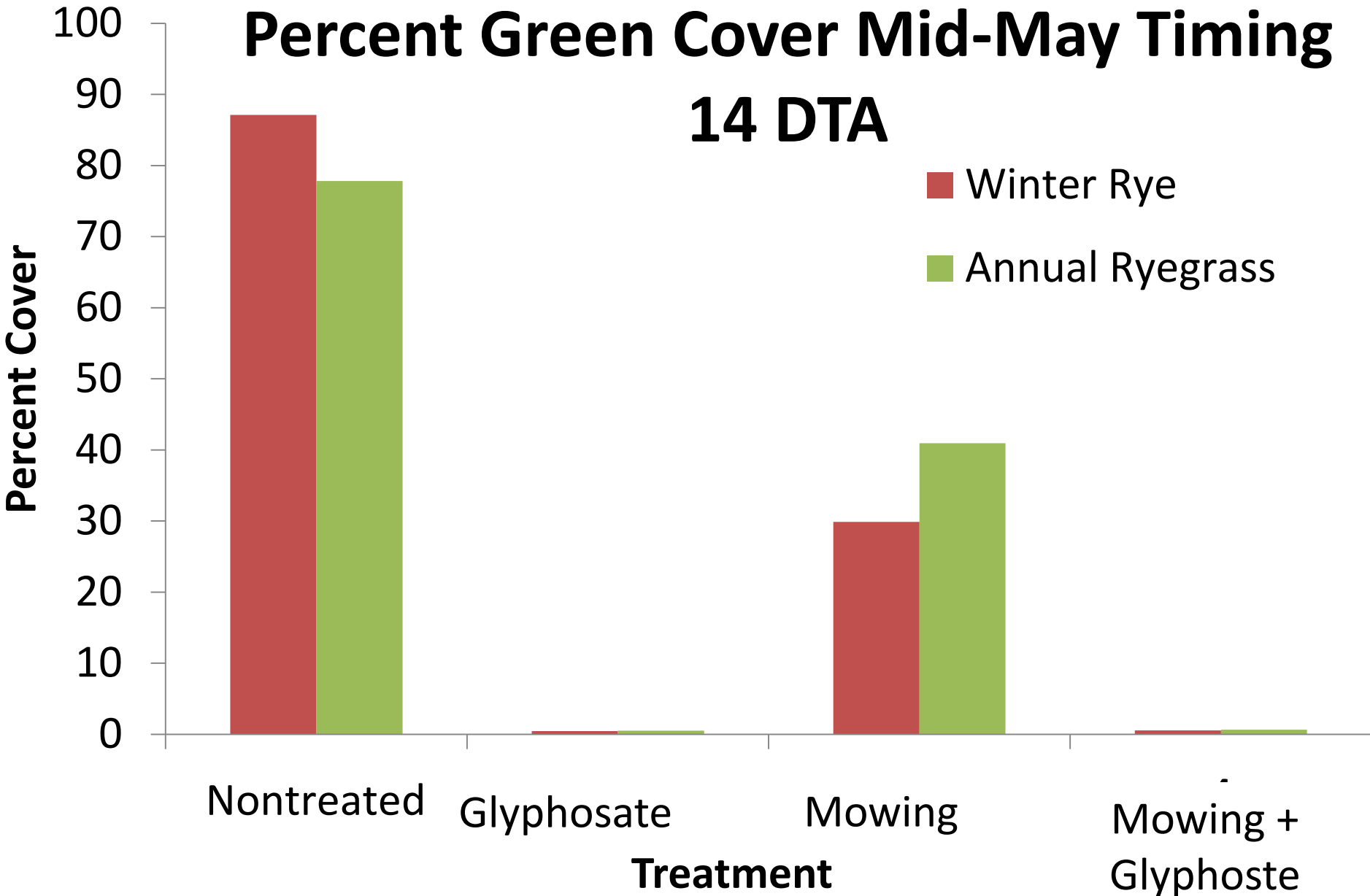


Two Weeks after mowing-
no glyphosate



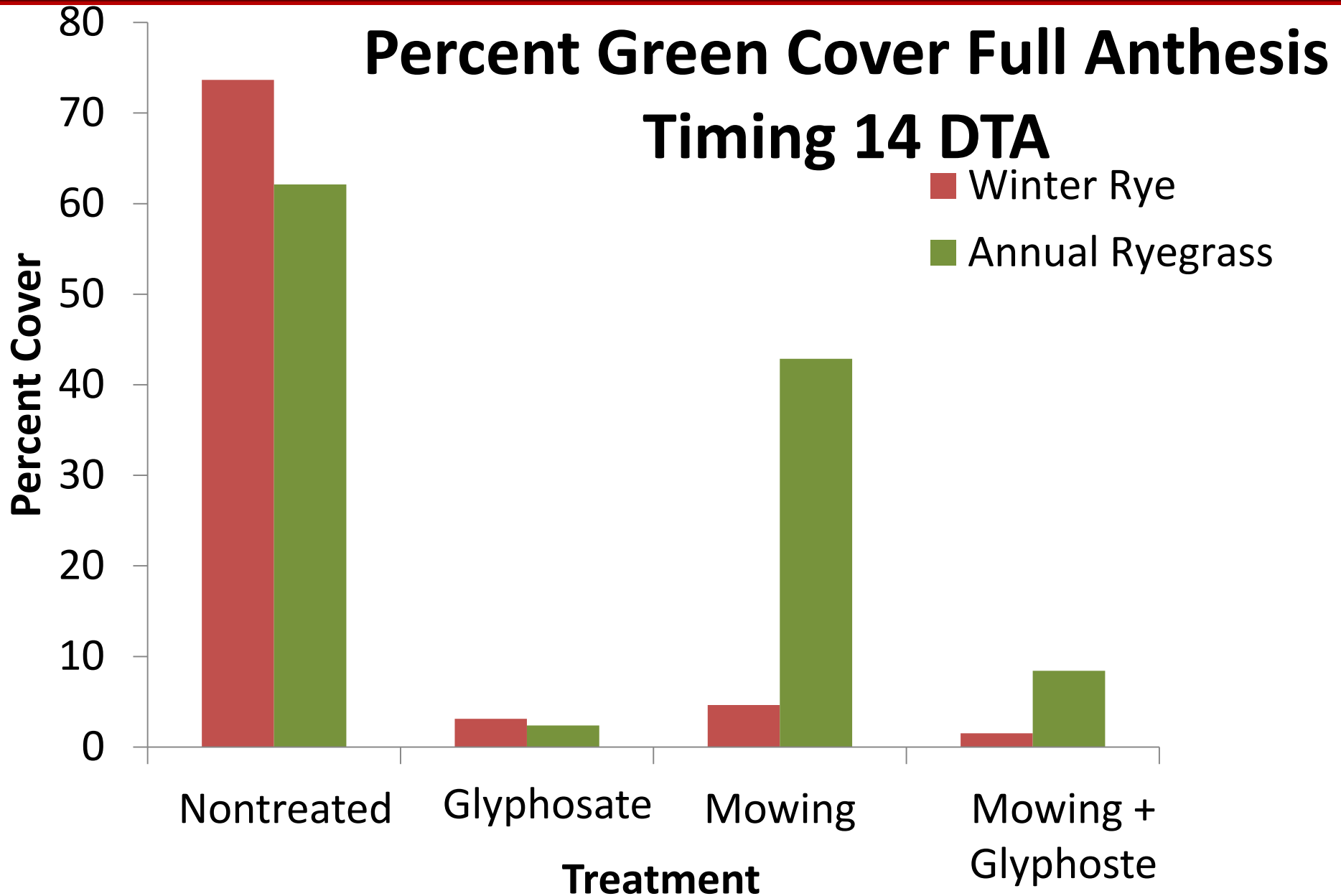
Percent Green Cover Mid-May Timing 14 DTA

■ Winter Rye
■ Annual Ryegrass



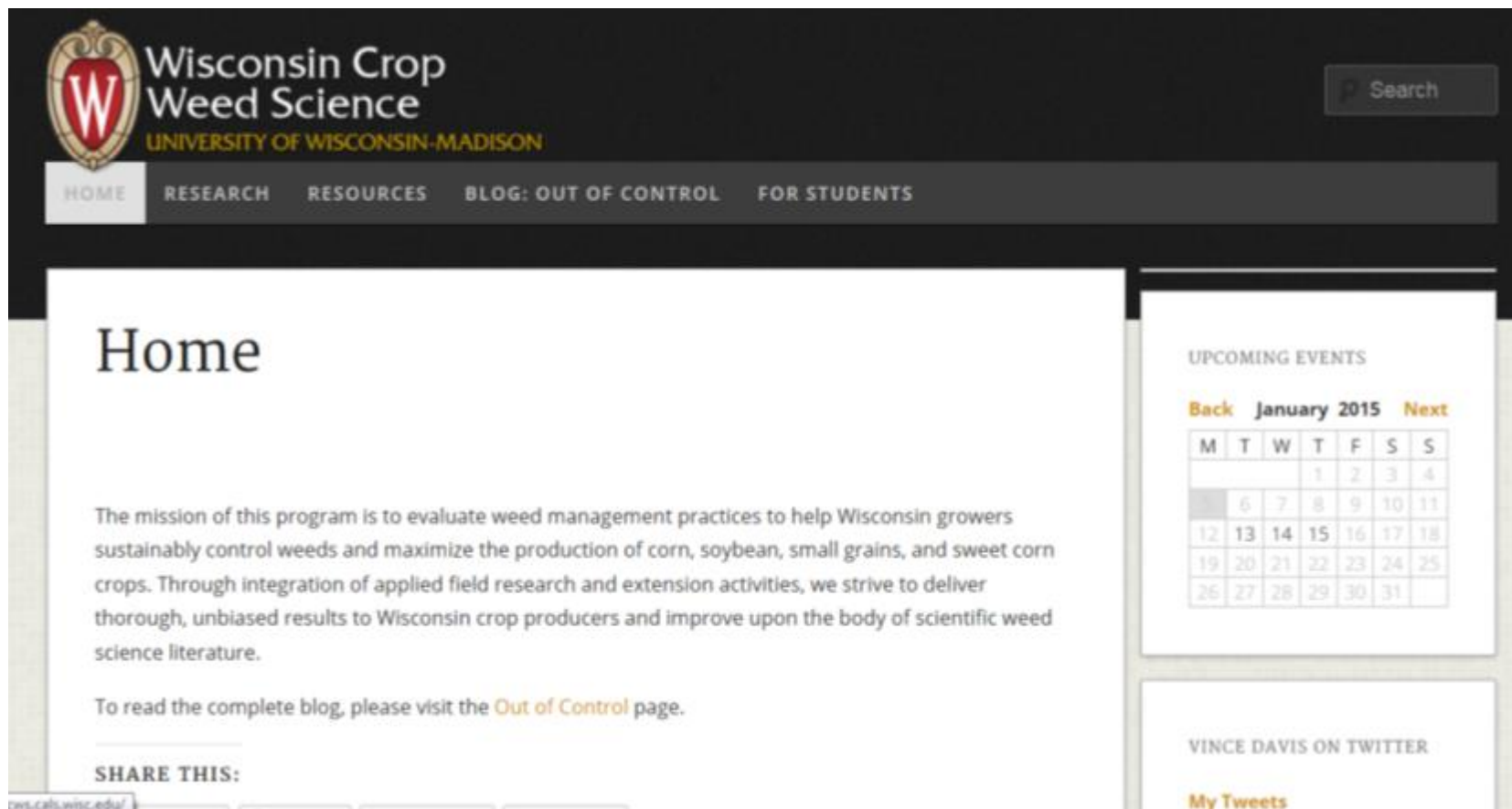
One week after glyphosate application-32 fl. oz/ac 4.5 ae/gal





- Percent green cover of annual ryegrass and winter rye was decreased ($P < 0.0001$) for all treatments
- Mowing + Collection was only effective at slowing down the growth of both annual ryegrass and winter rye.
- Both species grew back quickly, especially annual ryegrass after mowing
- Glyphosate was effective both alone and with mowing + collection





The screenshot shows the homepage of the Wisconsin Crop Weed Science website. At the top left is the WCWS logo, and at the top right is a search bar. Below the logo is the text "Wisconsin Crop Weed Science" and "UNIVERSITY OF WISCONSIN-MADISON". A navigation menu includes "HOME", "RESEARCH", "RESOURCES", "BLOG: OUT OF CONTROL", and "FOR STUDENTS". The main content area features a "Home" heading, a mission statement, and a link to the "Out of Control" blog. On the right side, there is a calendar for January 2015 and a section for "VINCE DAVIS ON TWITTER" with a "My Tweets" link.

Home

The mission of this program is to evaluate weed management practices to help Wisconsin growers sustainably control weeds and maximize the production of corn, soybean, small grains, and sweet corn crops. Through integration of applied field research and extension activities, we strive to deliver thorough, unbiased results to Wisconsin crop producers and improve upon the body of scientific weed science literature.

To read the complete blog, please visit the [Out of Control](#) page.

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VINCE DAVIS ON TWITTER

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Wisconsin Crop Weed
Science Website:
<http://wcws.cals.wisc.edu/>



Cover Crop Termination

Elizabeth Bosak and Vince Davis
Department of Agronomy, University of Wisconsin-Madison



University of Wisconsin-Extension

Available as free download on WCWS webpage
Authors: Liz Bosak and Vince Davis

This quick sheet is intended to give a brief overview of **cover crop termination methods and suggestions for termination using herbicides**. These recommendations are specifically for cover crops - NOT forage crops that will be fed to animals.

The chart to the right includes all of the cover crops listed by the Midwest Cover Crops Council broken into three categories: Brassica, Legume, and Non-legume. The seeding dates listed are based on the Midwest Cover Crops Council suggested last seeding date for good cover crop establishment prior to the first hard frost. Last seeding dates vary according to county in Wisconsin and the chart contains dates for Columbia county.

If there is a "X" for a specific cover crop, then it should likely winterkill and no spring termination is required. If there is an "*", then depending on either the variety or severity of the winter it may not winterkill. This chart does not consider changes in winter hardiness due to mixing cover crop species such as hairy vetch with oats.

For some of these cover crop species, like hairy vetch, hard seed will continue to germinate throughout the season and the following growing seasons. Remember to check your seed container for the percentage of hard seed. The initial cover crop may winterkill, but more seedlings emerging in subsequent crops may become weeds.

On the reverse side of this sheet, there is a chart of termination methods and herbicides for termination of legumes and winter cereals that will survive a Wisconsin winter. Please remember to factor in the site-of-action(s) of your cover crop bumdown application into your herbicide resistance management plan.

Termination methods include mowing, rolling/crimping, tillage, and chemical desiccation with herbicides. Final choice of a termination method may depend on your goal for that cover crop. For instance, if you planted buckwheat to attract

		LAST SEEDING DATE	WINTERKILL
BRASSICA COVER CROPS	Canola/Rapeseed	AUG 15	*
	Oilseed radish	AUG 15	X
	Turnip	AUG 15	X
LEGUME COVER CROPS	Field pea	JUN 10	X
	Cowpea	JUL 15	X
	Berseem clover	AUG 1	X
	Crimson clover	AUG 1	X
	Red clover	AUG 15	
	Sweet clover	AUG 15	
	Winter pea	SEPT 1	*
	Hairy vetch	SEPT 1	
NON-LEGUME COVER CROPS	Japanese millet	JUL 15	X
	Pearl millet	JUL 15	X
	Sorghum-sudangrass	JUL 15	X
	Sudangrass	JUL 15	X
	Buckwheat	AUG 1	X
	Spring barley	AUG 15	X
	Spring wheat	AUG 15	X
	Oats	SEPT 1	X
	Annual ryegrass	SEPT 1	*
	Winter barley	OCT 10	
	Winter triticale	OCT 10	
	Winter wheat	OCT 10	
	Winter/Cereal rye	OCT 20	

pollinators, but do not want a buckwheat weed problem, then you should mow the buckwheat before seeds start to develop.

Please visit the Wisconsin Crop Weed Science website for more information:
wcws.cals.wisc.edu



		WINTERKILL	ROLLING CRIMPING	MOWING	TILLAGE	HERBICIDE	COVER CROP GROWTH STAGE	HERBICIDES FOR TERMINATION
ROW CROPS	Canola/Rapeseed	*	NO	NO	YES	YES		Glyphosate, may require multiple applications (see reference 3)
	LEGUME COVER CROPS	Red clover	NO	NO	NO	?	YES	AT BLOOM
Sweet clover		NO	NO	NO	?	YES		Dicamba or 2,4-D (see reference 3)
Winter pea		*	NO	YES			YES	Glyphosate + 2,4-D or either product alone
Halcy vetch		NO	YES AT FULL BLOOM	NO			YES	PRE OR MID BLOOM Glyphosate + Dicamba or 2,4-D
NON-LEGUME COVER CROPS	Annual ryegrass	*	NO	NO	YES 2+		YES 2 APPS <4 IN HEIGHT	SEE BELOW
	Winter barley		YES AT MILK OR DOUBT STAGE	YES			YES	PRIOR TO BOOT STAGE <18 IN HEIGHT Glyphosate 4.5 lb ae per gal, 22 fl oz per acre
	Winter triticale							
	Winter wheat Winter/Cereal rye							

* May not winterkill depending on variety and/or severity of the winter
? Difficult to terminate using tillage alone

Annual ryegrass termination recommendation: Plan for two applications of glyphosate at the FULL labeled rate and a tank mix of other herbicides to provide additional sites of action and residual weed control. Be sure that any herbicides added to glyphosate do not antagonize ryegrass control. Only apply herbicide during active growth with day/night temperatures above 55/40 F for at least 3 consecutive days. Application should occur at least four hours prior to sunset. Please be aware that annual ryegrass, *Lolium perenne ssp. multiflorum*, has shown resistance to 5 herbicide sites-of-action according to the International Survey of Herbicide Resistant Weeds (Heap, 2014). Also, populations resistant to one or multiple sites-of-action have been identified in 14 other states. Glyphosate-resistant populations have been found in Arkansas, California, Mississippi, North Carolina, Oregon, and Tennessee.

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

References:

1. Heap, I. The International Survey of Herbicide Resistant Weeds. Online. Internet. Friday, March 28, 2014. Available www.weedscience.org
2. Legleiter, T; Johnson, B; Jordan, T; Gibson, K. Successful Cover Crop Termination with Herbicides. Purdue Extension WS-50-W.
3. Managing Cover Crops Profitably. 2007. Sustainable Agriculture Research and Education (SARE) program, Handbook Series 9.

Additional resources:

Pesticide labels and material safety data sheets (MSDS) can be viewed at <http://www.cdms.net/LabelsMsd/LMDefault.aspx>

Midwest Cover Crops Council <http://www.mccc.msui.edu/>

TakeAction Herbicide Classification chart <http://wcws.cals.wisc.edu/documents>

Take Action on Weeds website, sponsored by the United Soybean Board, <http://takeactiononweeds.com>

This publication is available from the Wisconsin Crop Weed Science program. For more copies, please contact us at:

email: wiscropweedsct@gmail.com

phone: (608) 515-3224

website: <http://wcws.cals.wisc.edu/>





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Midwest Cover Crops Council Cover Crop Decision Tools

The Midwest Cover Crop Council (MCCC) Cover Crop Decision Tools are web-based systems to assist farmers in selecting cover crops to include in field crop and vegetable rotations.

[Instructions for Using the Cover Crop Decision Tool-Field Crops](#)

[Go to the Cover Crop Decision Tool-Field Crops](#)

(If your browser is Internet Explorer (IE), please close the Favorites Pane for proper display)

<http://www.mccc.msu.edu/selectorINTRO.html>

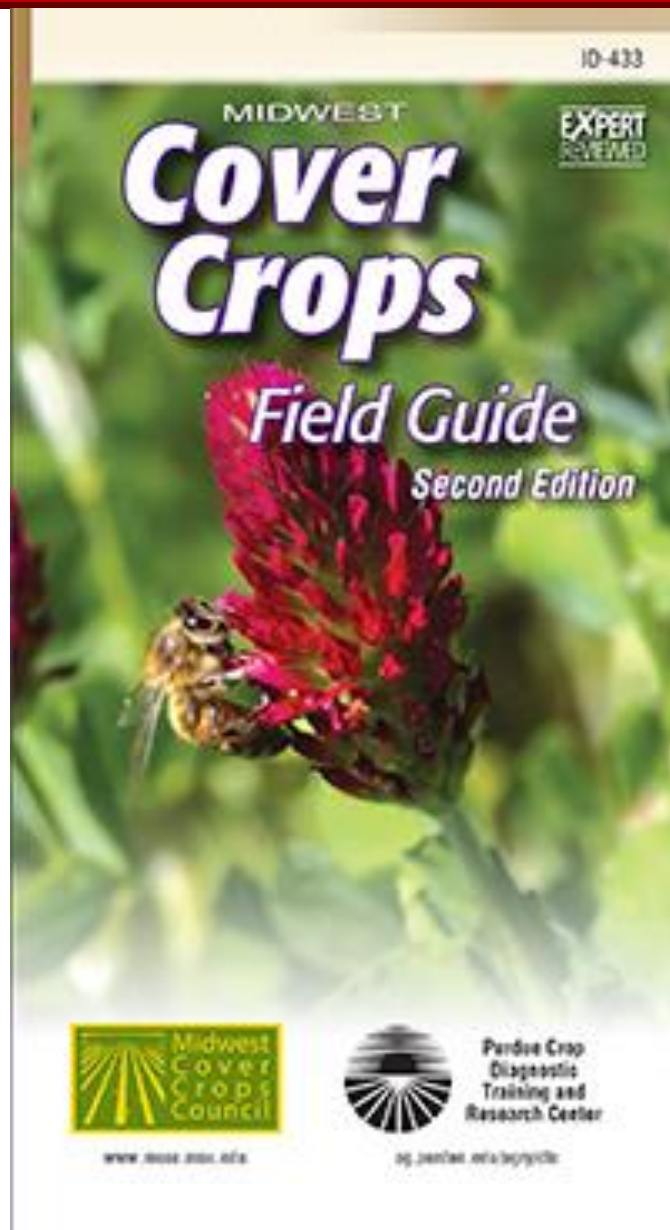
40% W Pea/60% Oats Information Sheet

Considerations for using 40% W Pea/60% Oats in Wisconsin

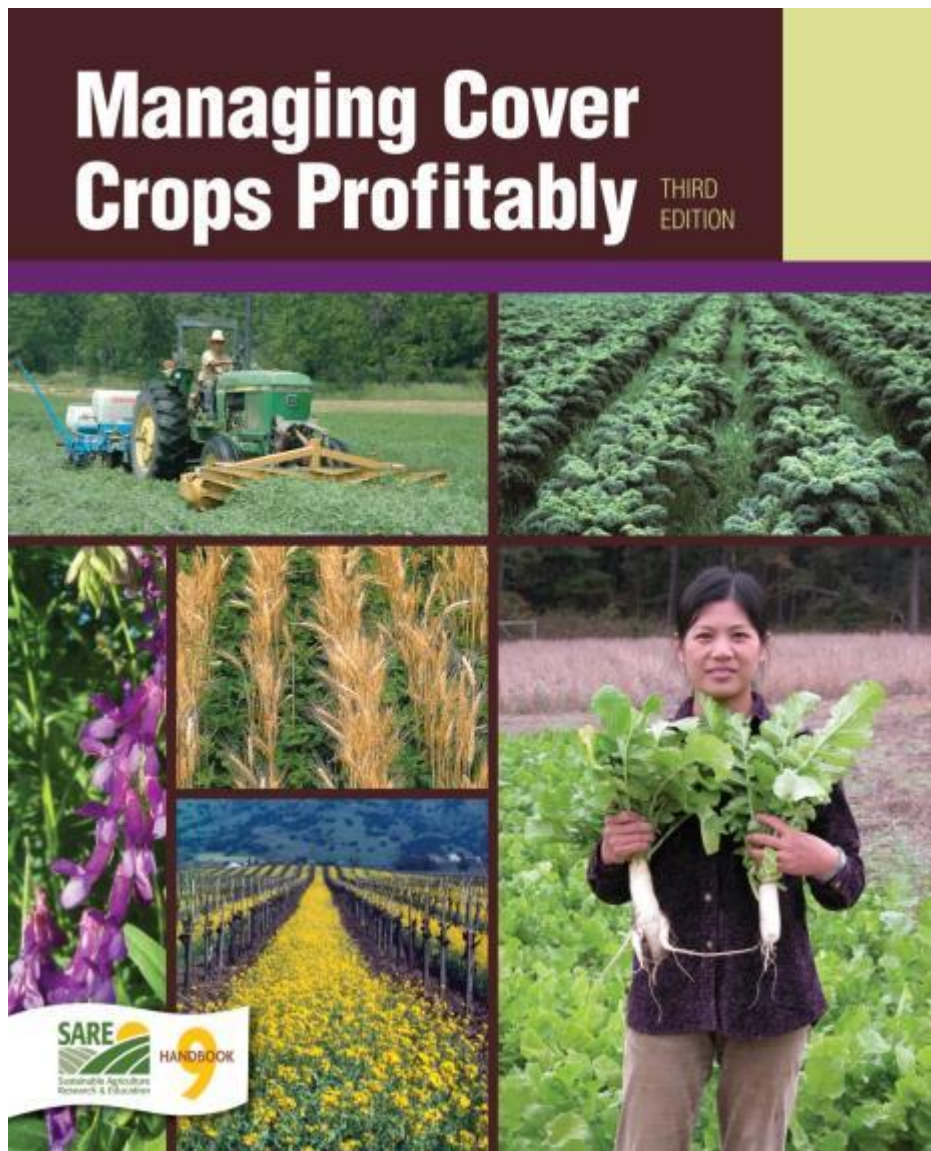
There are no special considerations

Links to information on using Cover Crops in Wisconsin can be found at: <http://mccc.msu.edu/states/Wisconsin.html>

<p>Location Information</p> <p>Location: Wisconsin - Columbia Cash Crop: Corn-Grain Plant Date: 04/30/2015 Harvest Date: 10/15/2015 Soil Drainage: Well Drained Artificial Drainage: No Flooding: No</p> <p>Cover Crop Selection Information</p> <p>Cover Crop Selected: 40% W Pea/60% Oats Cover Crop Attribute #1: Default Cover Crop Attribute #2: Default Cover Crop Attribute #3: Default Use within the state: Emerging</p> <p>Planting Information</p> <p>Drilled Seeding Depth: 1/2-1 inches Drilled Seeding Rate: 45-60 lb./A PLS Pea, Winter Drilled Seeding Rate: 40-70 lb./A PLS Oats Broadcast Seeding Rate: 50-66 lb./A PLS Pea, Winter Broadcast Seeding Rate: 44-77 lb./A PLS Oats Aerial Seeding Rate: Not Recomm lb./A PLS Pea, Winter Aerial Seeding Rate: Not Recomm lb./A PLS Oats Seed Count: 1,840 Seeds/lb Seed Count: 19,800 Seeds/lb Frost Seed: No Fly-free Date: No Inoculation Type: pea/vetch Comments: If the system is organic, be careful to use an OMRI certified inoculum</p> <p>Termination Information</p> <p>Termination Methods: Tillage, Mow, Chemical If terminating with only tillage, multiple passes often required. Mow during oats reproductive stage. May be difficult to control in an organic system due to lack of certified herbicides and difficulty terminating via tillage.</p> <p>Performance and Roles</p> <p>Legume Nitrogen Source: Good Total Nitrogen: 40-60 (lb./A) Dry Matter: 2500-4500 (lb./A/yr.) Nitrogen Scavenger: Good Soil Builder: Very Good Erosion Fighter: Good Weed Fighter: Very Good Good Grazing: Excellent Quick Growth: Good Lasting Residue: Good Forage Harvest: Very Good Grain Seed Harvest: Poor Cash Crop Interseed: Poor Comments:</p>	<p>Cultural Traits</p> <p>Scientific Name: Pisum sativum subsp. arvense Pea, Winter Scientific Name: Lolium multiflorum Oats Life Cycle: Winter Annual or Summer Annual Pea, Winter Life Cycle: Winter Annual Oats Growth Habit: Upright to Semi-upright Pea, Winter Life Cycle: Upright Oats Preferred Soil pH: 6.0-8 Min. Germination Temp.: 41F Heat Tolerance: Fair Drought Tolerance: Fair Shade Tolerance: Good Flood Tolerance: Fair Low Fertility Tolerance: Good Winter Survival: Never and Seldom or Expected Comments:</p> <p>Potential Advantages</p> <p>Soil Impact - Subsoiler: Good Soil Impact - Frees P and K: Good Soil Impact - Loosens Topsoil: Excellent Soil Ecology - Nematodes: Very Good Soil Ecology - Diseases: Fair Soil Ecology - Allelopathic: Fair Soil Ecology - Choke Weeds: Excellent Other - Attract Beneficials: Good Other - Bears Traffic: Good Other - Short Windows: Excellent Comments: Oats are a non host for root knot nematode.</p> <p>Potential Disadvantages</p> <p>Delayed Emergence: Occasionally a minor problem Increased Weed Potential: Occasionally a minor problem Increased Insects/Nematodes: Could be a minor problem Increased Crop Diseases: Occasionally a minor problem Hinders Crops: Occasionally a minor problem Establishment Challenges: Occasionally a minor problem Mature Incorporation Challenges: Occasionally a minor problem Comments Pro/Con:</p> <p>Additional Information</p> <p>Additional Information from Managing Cover Crops Profitably, 3rd Edition, Edited by Andy Clark, Sustainable Agriculture Network Pea, Winter Oats</p> <p>Other Resources</p> <p>Wisconsin: Pea and Small Grain Mixtures Wisconsin: Picking Alfalfa's Partner Out of Region: Oat + Pea for Forage in Central North Dakota</p>
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Available for purchase at Purdue Education Store \$5.00 + shipping



Available for free pdf download through SARE.
Also can purchase for \$19.00 + shipping
<http://www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition>

RYE

Secale cereale

Also called: cereal rye, winter rye, grain rye

Type: cool season annual cereal grain

Roles: scavenge excess N, prevent erosion, add organic matter, suppress weeds

Mix with: legumes, grasses or other cereal grains

See charts, pp. 66 to 72, for ranking and management summary.



The hardest of cereals, rye can be seeded later in fall than other cover crops and still provide considerable dry matter, an extensive soil-holding root system, significant reduction of nitrate leaching and exceptional weed suppression. Inexpensive and easy to establish, rye outperforms all other cover crops on infertile, sandy or acidic soil or on poorly prepared land. It is widely adapted, but grows best in cool, temperate zones.

Taller and quicker-growing than wheat, rye can serve as a windbreak and trap snow or hold rainfall over winter. It overseeds readily into many high-value and agronomic crops and resumes growth quickly in spring, allowing timely killing by rolling, mowing or herbicides. Pair rye with a winter annual legume such as hairy vetch to offset rye's tendency to tie up soil nitrogen in spring.

BENEFITS

Nutrient catch crop. Rye is the best cool-season cereal cover for absorbing unused soil N. It has no taproot, but rye's quick-growing, fibrous root system can take up and hold as much as 100 lb. N/A until spring, with 25 to 50 lb. N/A more typical (422). Early seeding is better than late seeding for scavenging N (46).

- A Maryland study credited rye with holding 60 percent of the residual N that could have leached from a silt loam soil following intentionally over-fertilized corn (372).
- A Georgia study estimated rye captured from 69 to 100 percent of the residual N after a corn crop (220).
- In an Iowa study, overseeding rye or a rye/oats mix into soybeans in August limited leaching loss from September to May to less than 5 lb. N/A (313).

Rye increases the concentration of exchangeable potassium (K) near the soil surface, by bringing it up from lower in the soil profile (123).

Rye's rapid growth (even in cool fall weather) helps trap snow in winter, further boosting winterhardiness. The root system promotes better drainage, while rye's quick maturity in spring—compared with other cover crops—can help conserve late-spring soil moisture.

Reduces erosion. Along with conservation tillage practices, rye provides soil protection on sloping fields and holds soil loss to a tolerable level (124).

- Following crop may be suppressed if cover crop is not properly terminated



- 2014 Spring termination data indicated 100% control possible at lower rates (16-22 fl oz) of glyphosate (4.5 lb ae/a) applied when the crops are under 6 inches in height.
- As crop quickly grows 100% control becomes impossible at low rates
- Consider Weather conditions



- Recommended control once crop is above 6 inches
32 fl oz/a glyphosate (4.5 lb ae/a)
- May require multiple applications
- Tank mixes may antagonize control
- Remember annual ryegrass is not always winter hardy in WI



- 2014 Spring termination data indicated 100% control only possible at lower rates (16-22 fl oz) of glyphosate (4.5 lb ae/a) when the crop is below 18 inches or prior to boot stage
- Crop grows very quickly
- Typically control is desired when crop is vegetatively growing and is more difficult to control



- Recommended control once crop is above 18 inches is to apply 32 fl oz/a glyphosate (4.5 lb ae/a)
- May require multiple applications
- Winter rye is winter hardy in WI



Acknowledgments

- Thank you to advising committee members Francisco Arriaga, Mark Renz, and Matt Ruark
- Wisconsin cover crop seed provided by Lacrosse Seed
- A special thanks to Tim Trower, the Arlington Agriculture Research Station Staff, and all graduate and undergraduate research assistants for their technical assistance

A green John Deere tractor with a yellow wheel and a red implement is parked in a field. The tractor is the central focus, with a large yellow wheel and a red implement attached to the back. The background shows a rolling green landscape under a clear blue sky. A white semi-transparent box is overlaid on the tractor, containing the text "Questions?".

Questions?