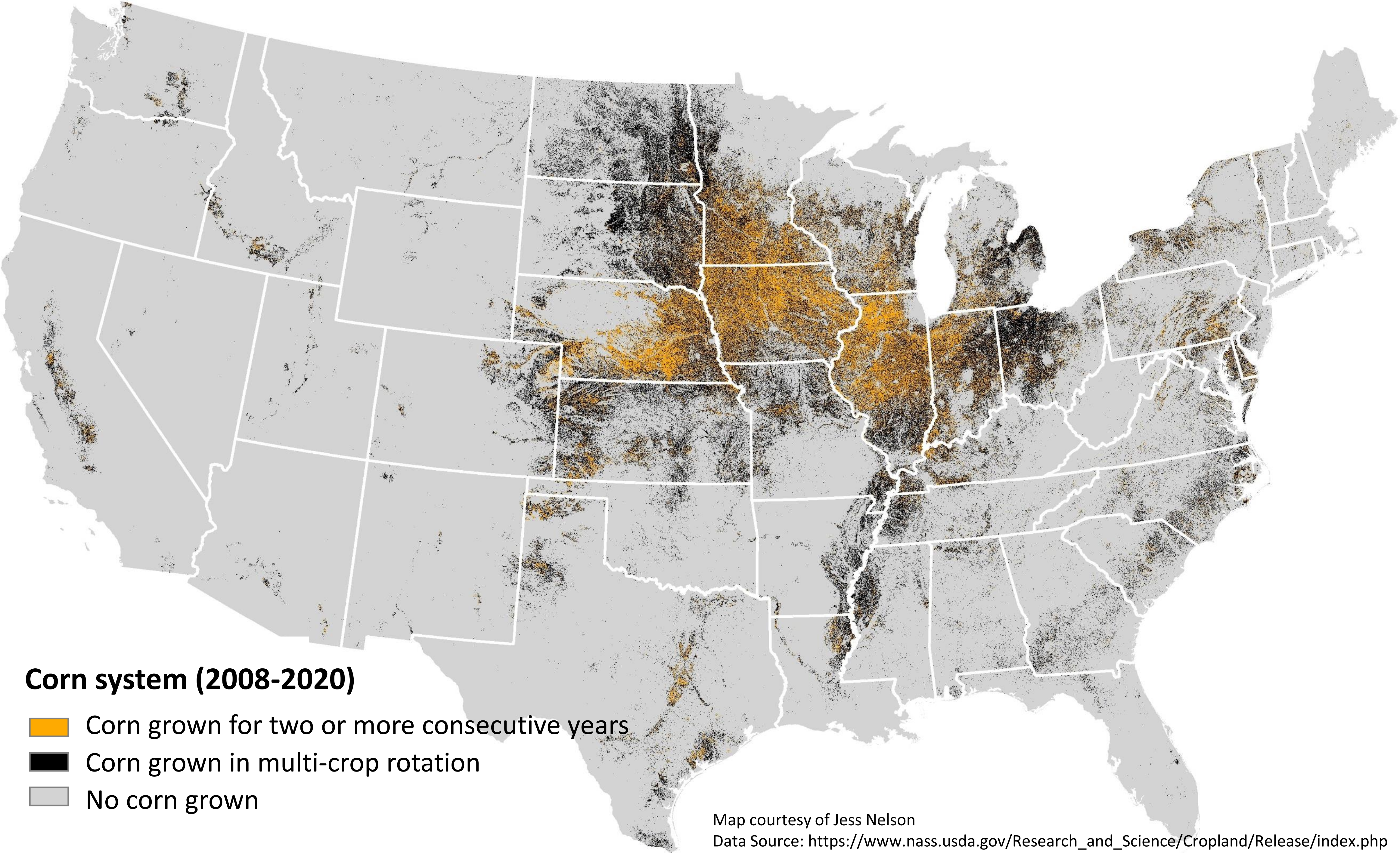
Anything but simple.

Gina Nichols | PhD Defense | Crop Physiology | August 25 2021



Map courtesy of Jess Nelson
Data Source: https://www.nass.usda.gov/Research_and_Science/Cropland/Release/index.php

Selected take-aways

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1. Longer rotations may benefit corn roots
2. Rotating corn reduces the risk of nitrate leaching
3. Cropping systems with more variation in planting dates have less weeds
4. Cover crops can effectively complement herbicides
5. (Cover crop termination – corn planting) window is where producers are exposed to the most risk

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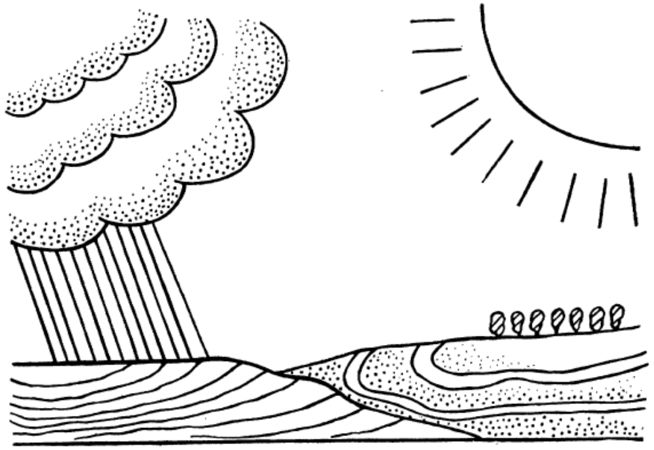
Soils & Men

Yearbook of Agriculture 1938



UNITED STATES DEPARTMENT OF AGRICULTURE

UNITED STATES GOVERNMENT PRINTING OFFICE

Organization

of the United States Department of Agriculture

Corrected to July 1, 1938

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Under Secretary	M. L. Wilson.
Assistant Secretary	Harry L. Brown.
Coordinator of Land Use Planning and Director of Information.	M. S. Eisenhower.
Director of Extension Work	C. W. Warburton.
Director of Finance	W. A. Jump.
Director of Personnel	Roy F. Hendrickson.
Director of Research	James T. Jardine.
Solicitor	Mastin G. White.
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Bureau of Agricultural Economics	A. G. Black, *Chief.*
Bureau of Agricultural Engineering	S. H. McCrory, *Chief.*
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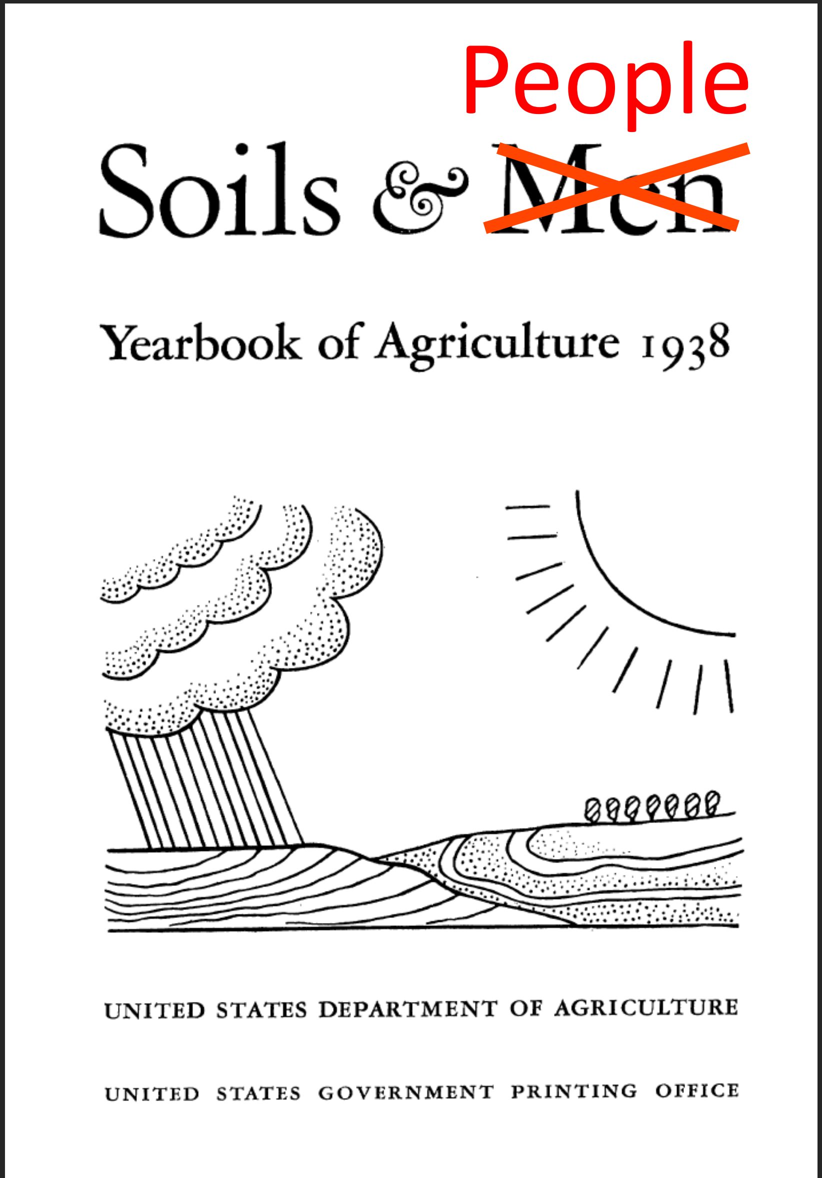

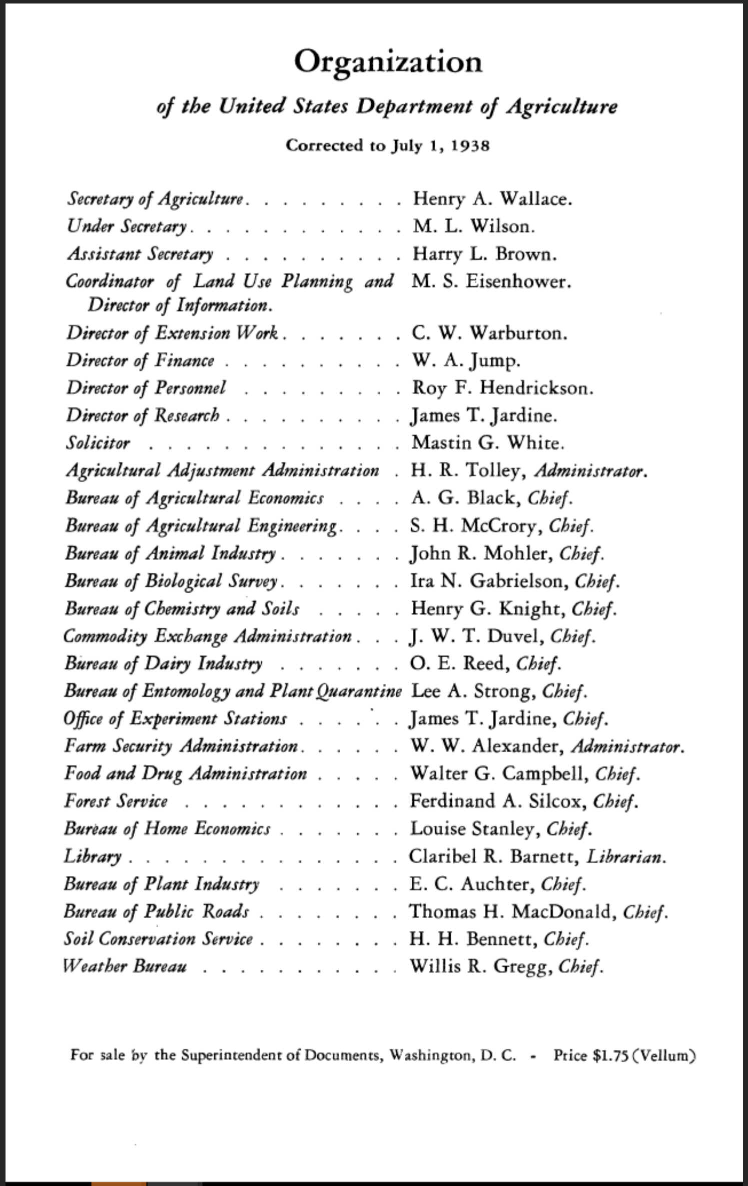

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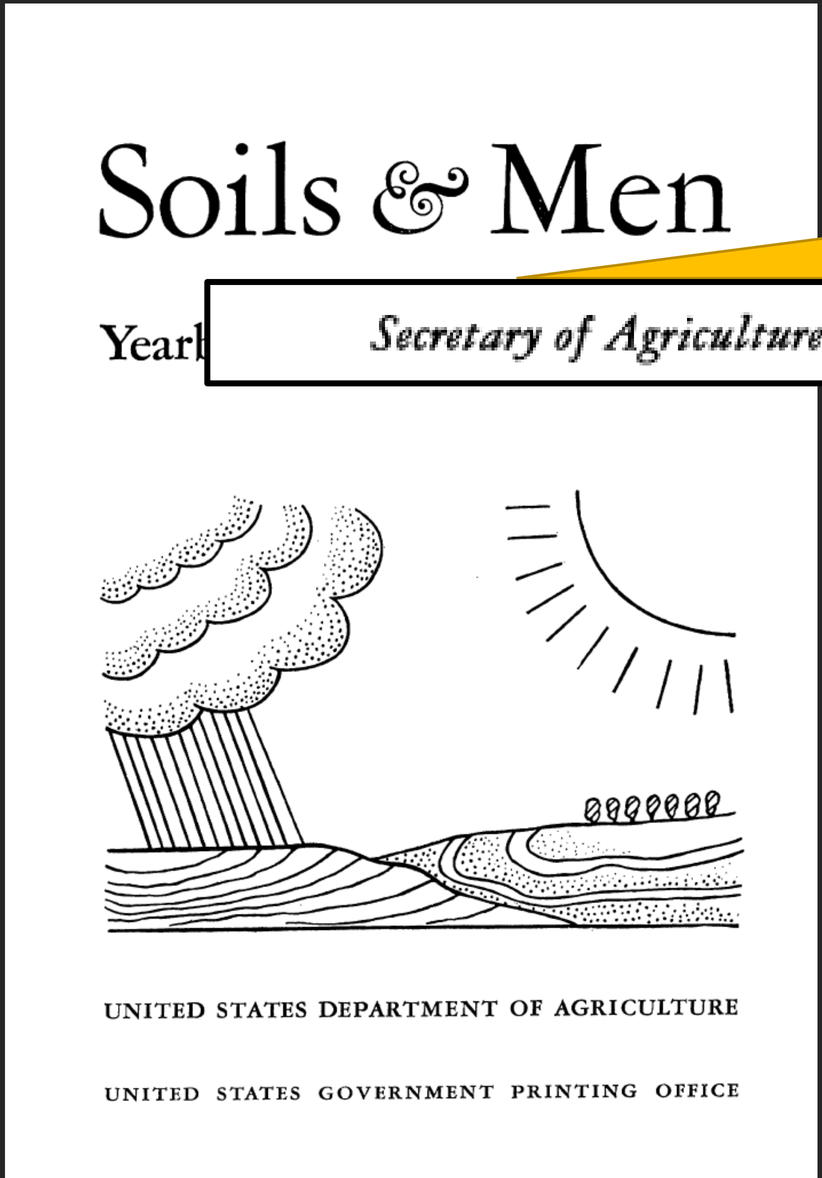

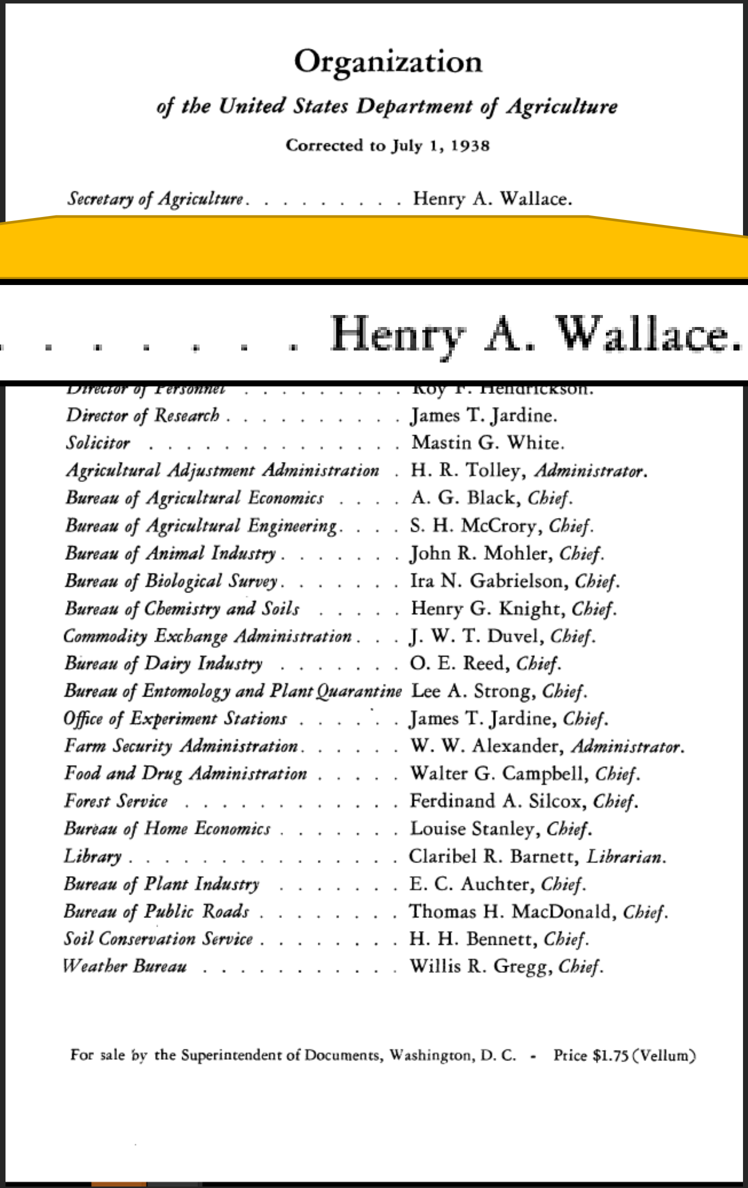

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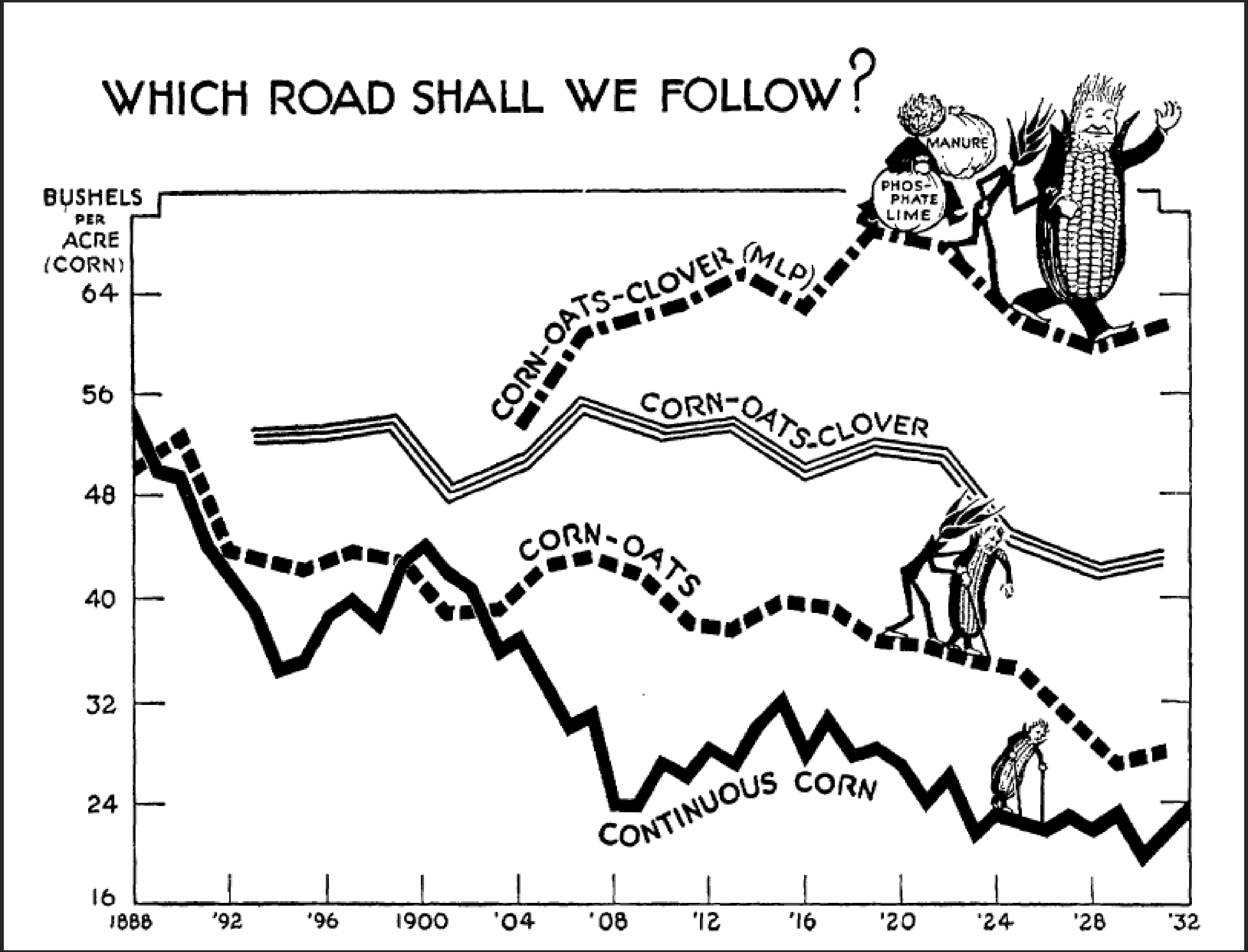
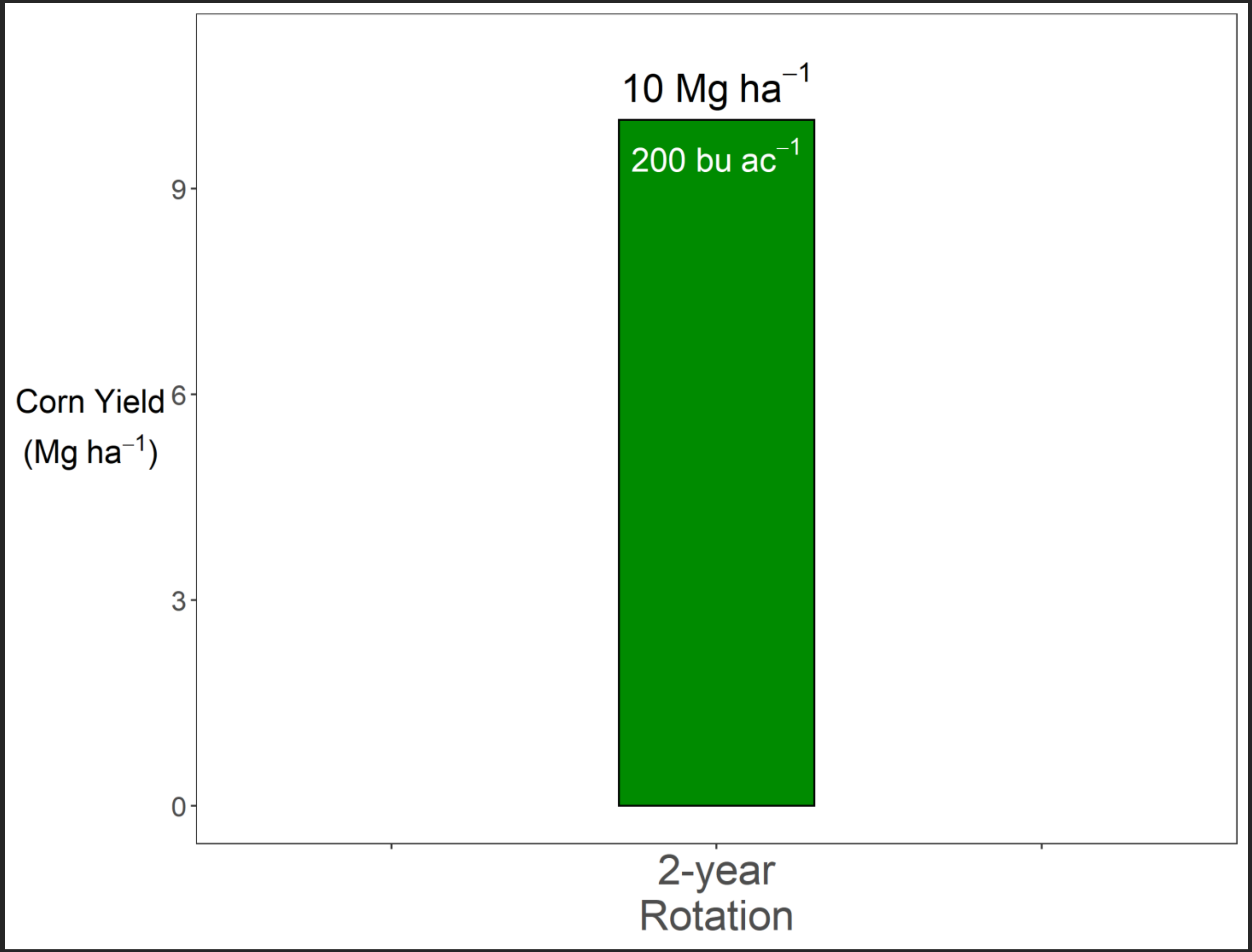
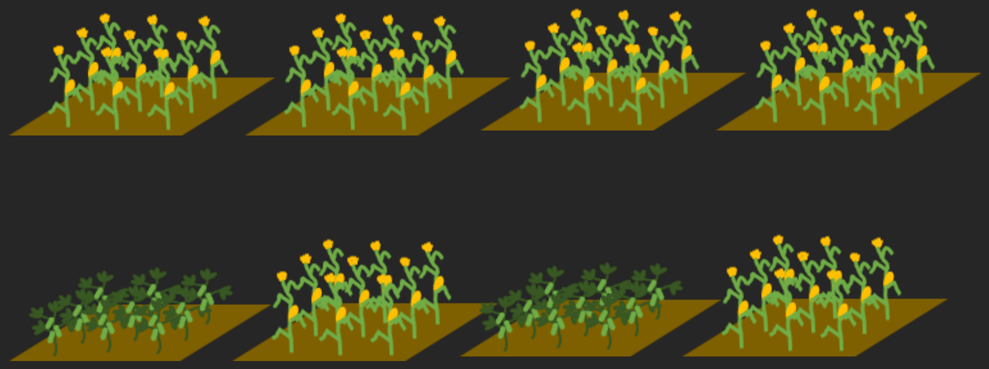


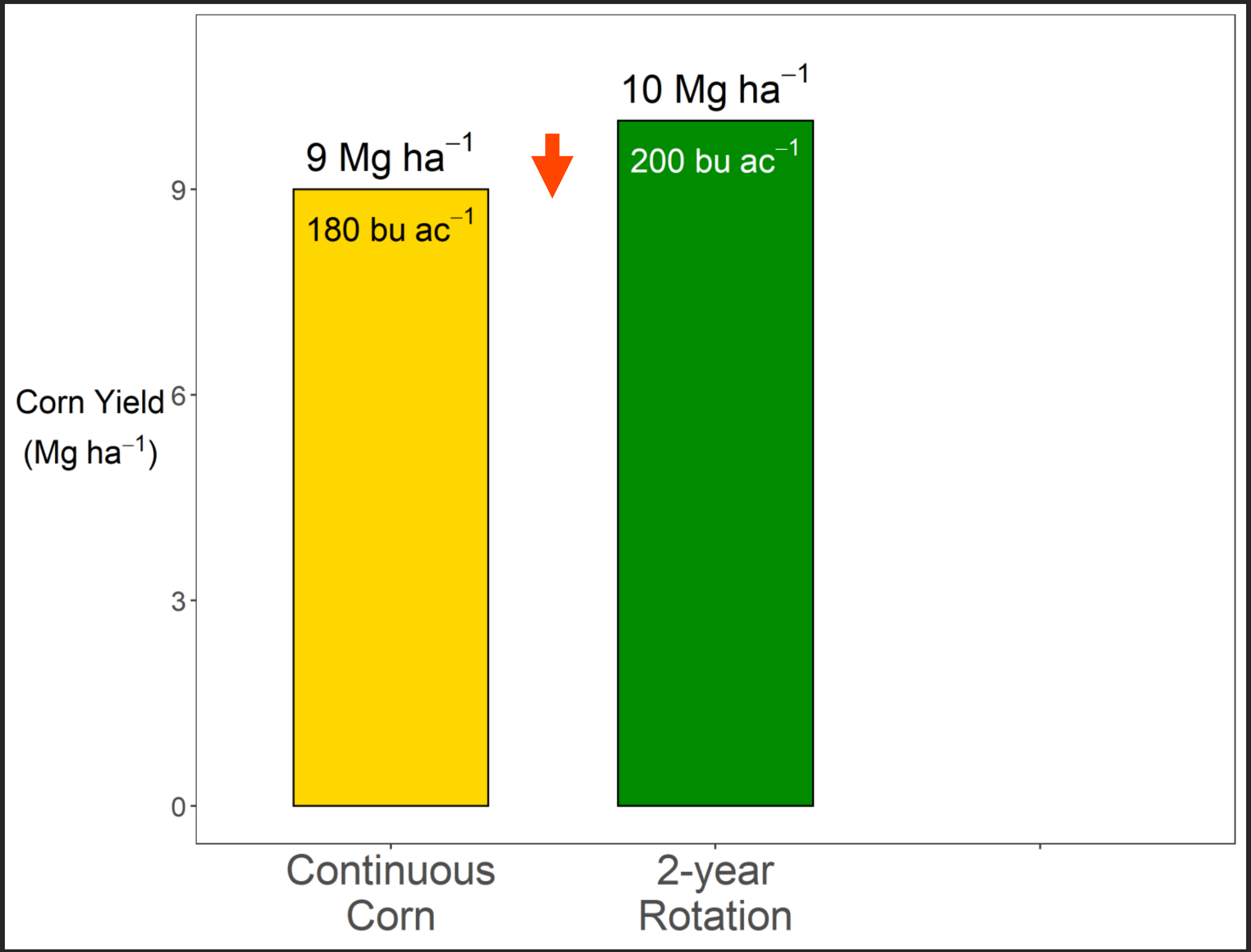
WHICH ROAD SHALL WE FOLLOW?
BUSHELS PER ACRE (CORN)
64
56
48
40
32
24
16
1888
'92
'96
1900
'04
'08
'12
'16
'20
'24
'28
'32
CORN-OATS-CLOVER (MLP)
CORN-OATS-CLOVER
CORN-OATS
CONTINUOUS CORN
MANURE
PHOS-PHATE LIME

Even today…

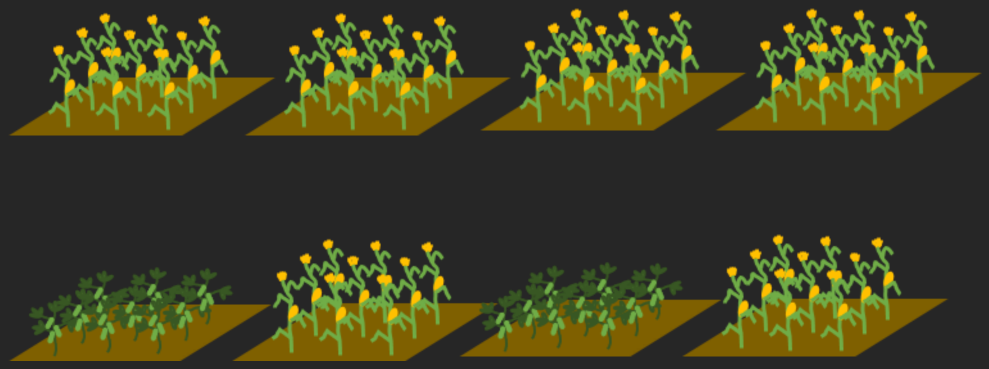


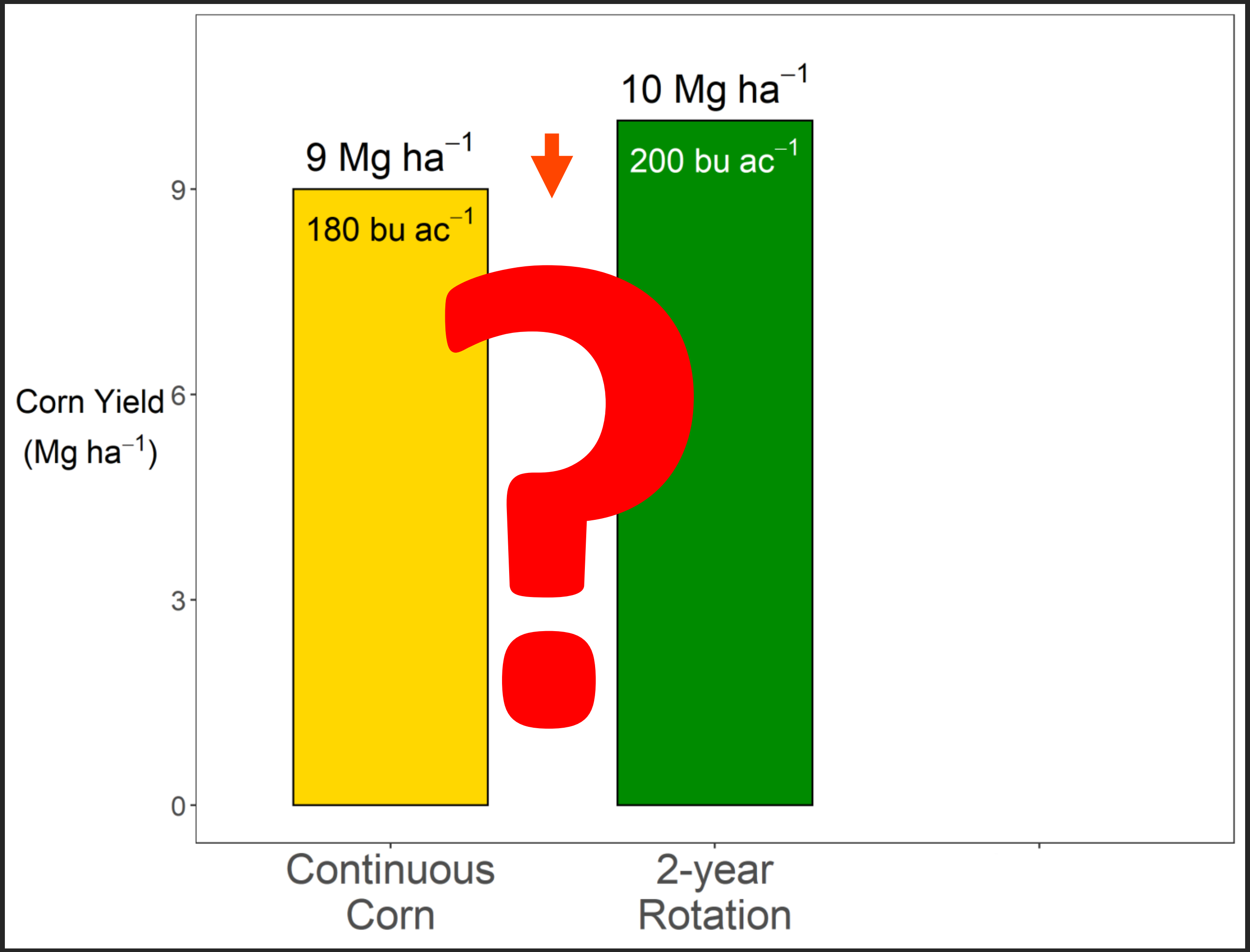
10 Mg ha⁻¹
200 bu ac⁻¹
Corn Yield (Mg ha⁻¹)
9
6
3
0
2-year Rotation





10 Mg ha^{-1}
9 Mg ha^{-1}
180 bu ac^{-1}
200 bu ac^{-1}
Corn Yield (Mg ha^{-1})
9
6
3
0
Continuous Corn
2-year Rotation





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9 Mg ha^{-1}
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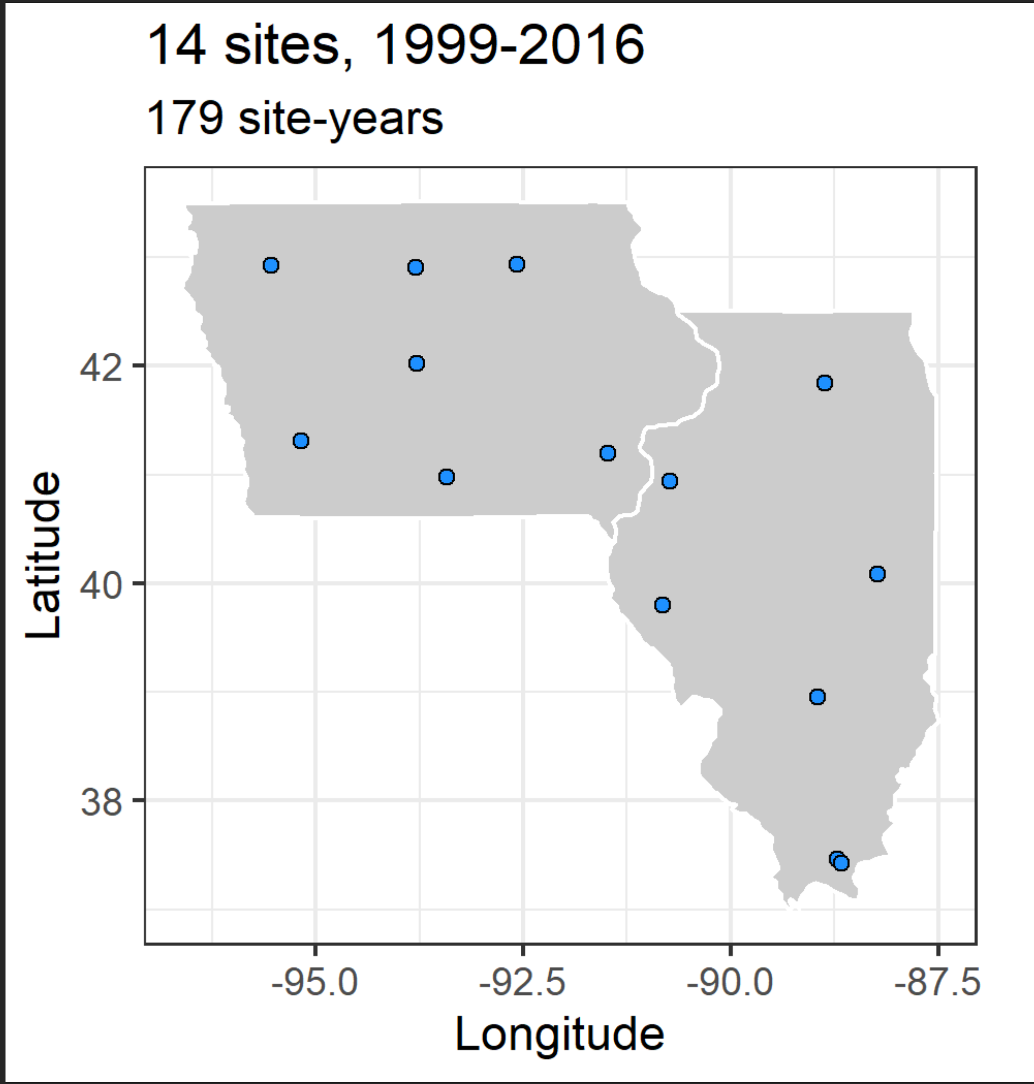
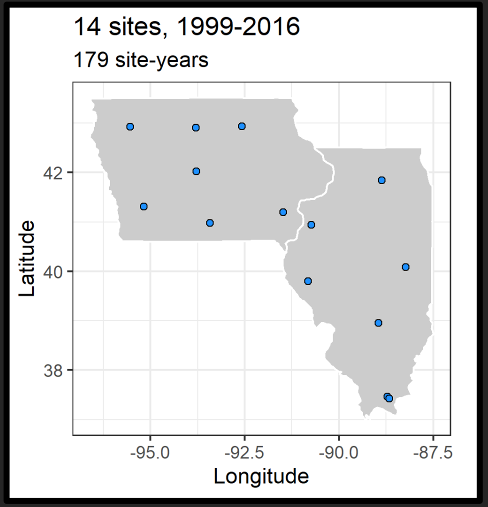
Continuous Corn
2-year Rotation

The Continuous Corn Penalty


14 sites, 1999-2016
179 site-years
Latitude
42
40
38
-95.0
-92.5
-90.0
-87.5
Longitude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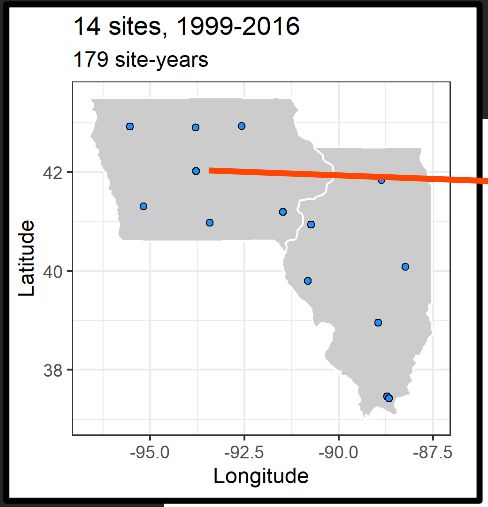
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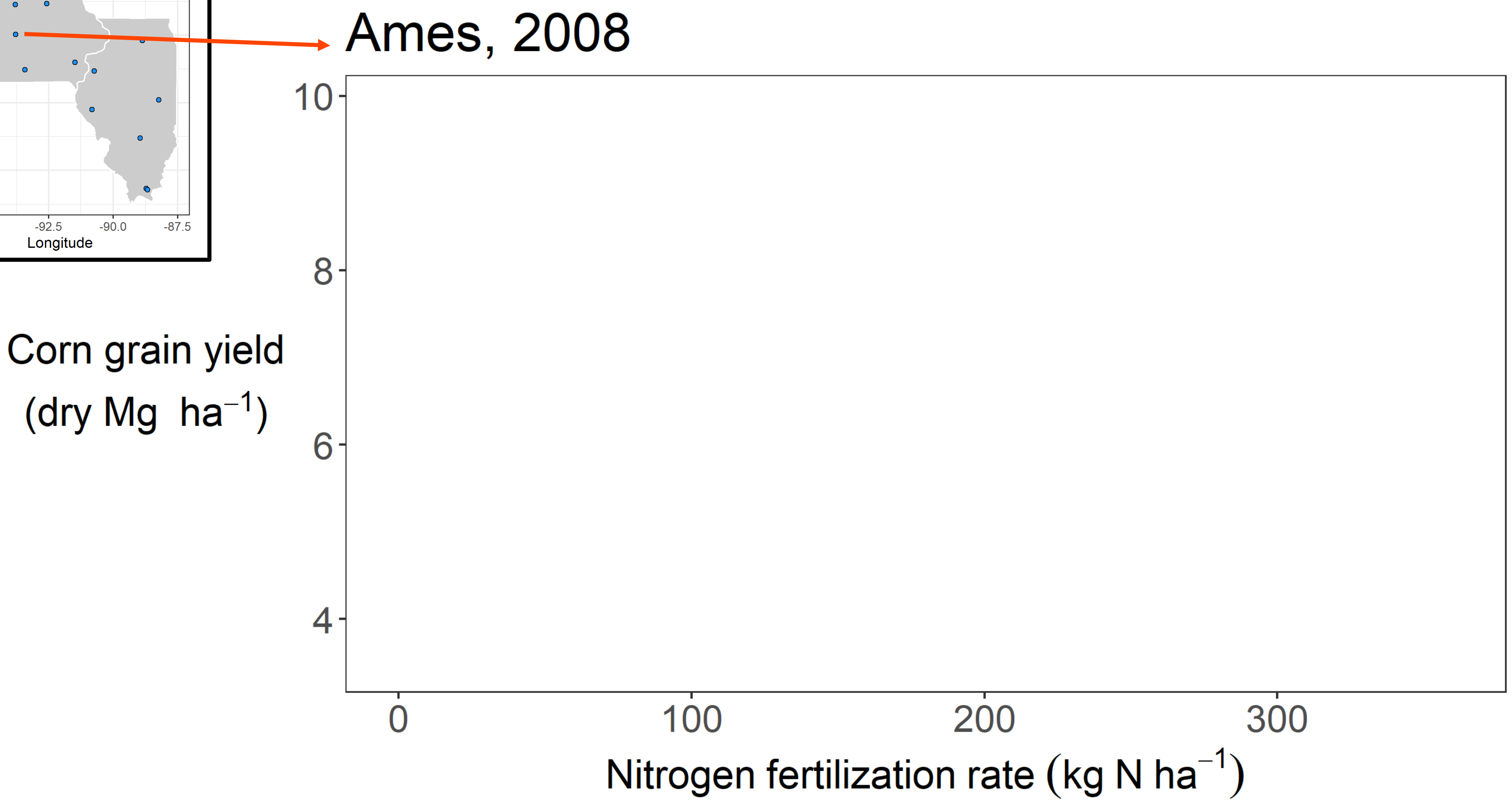
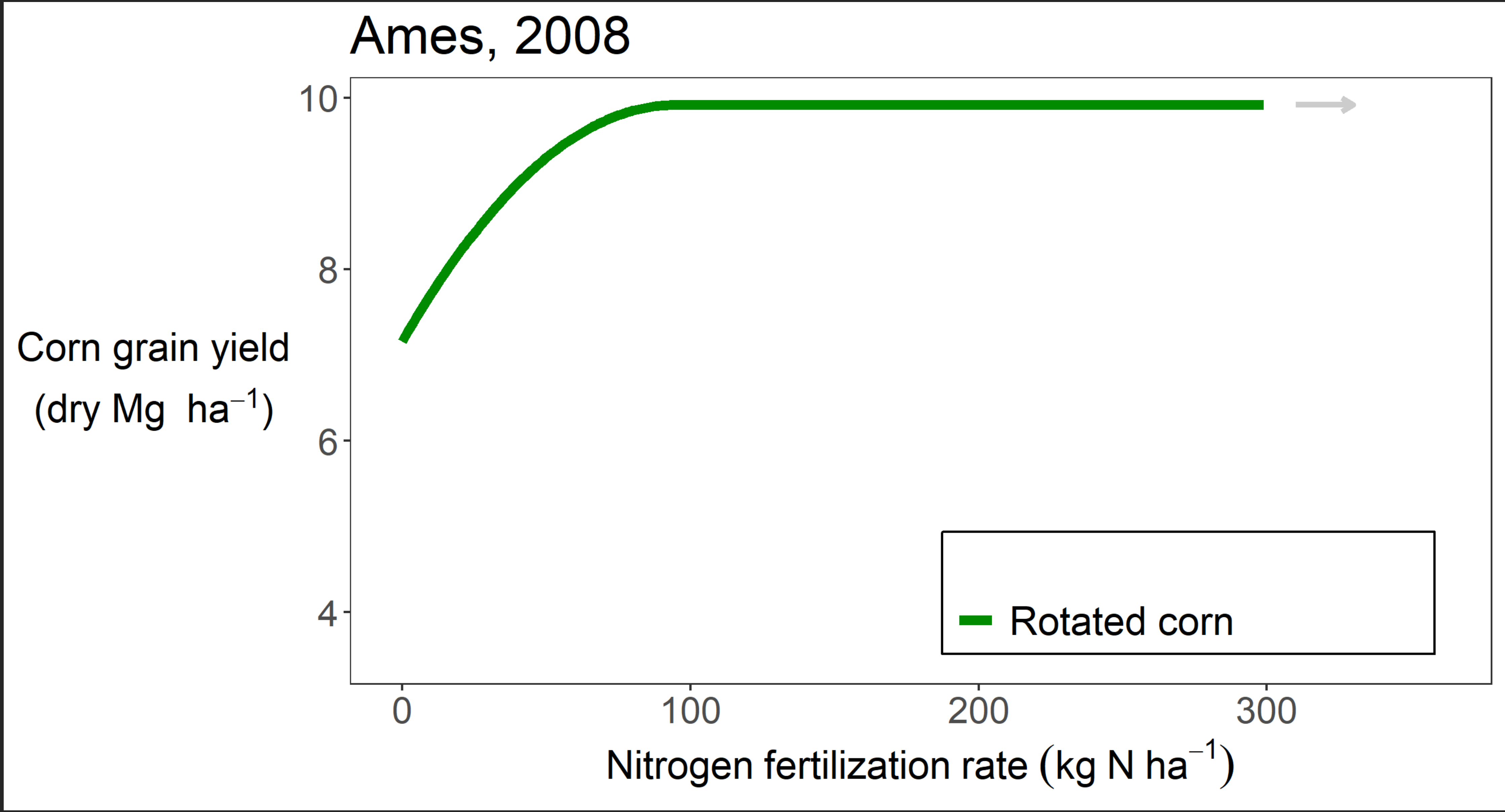
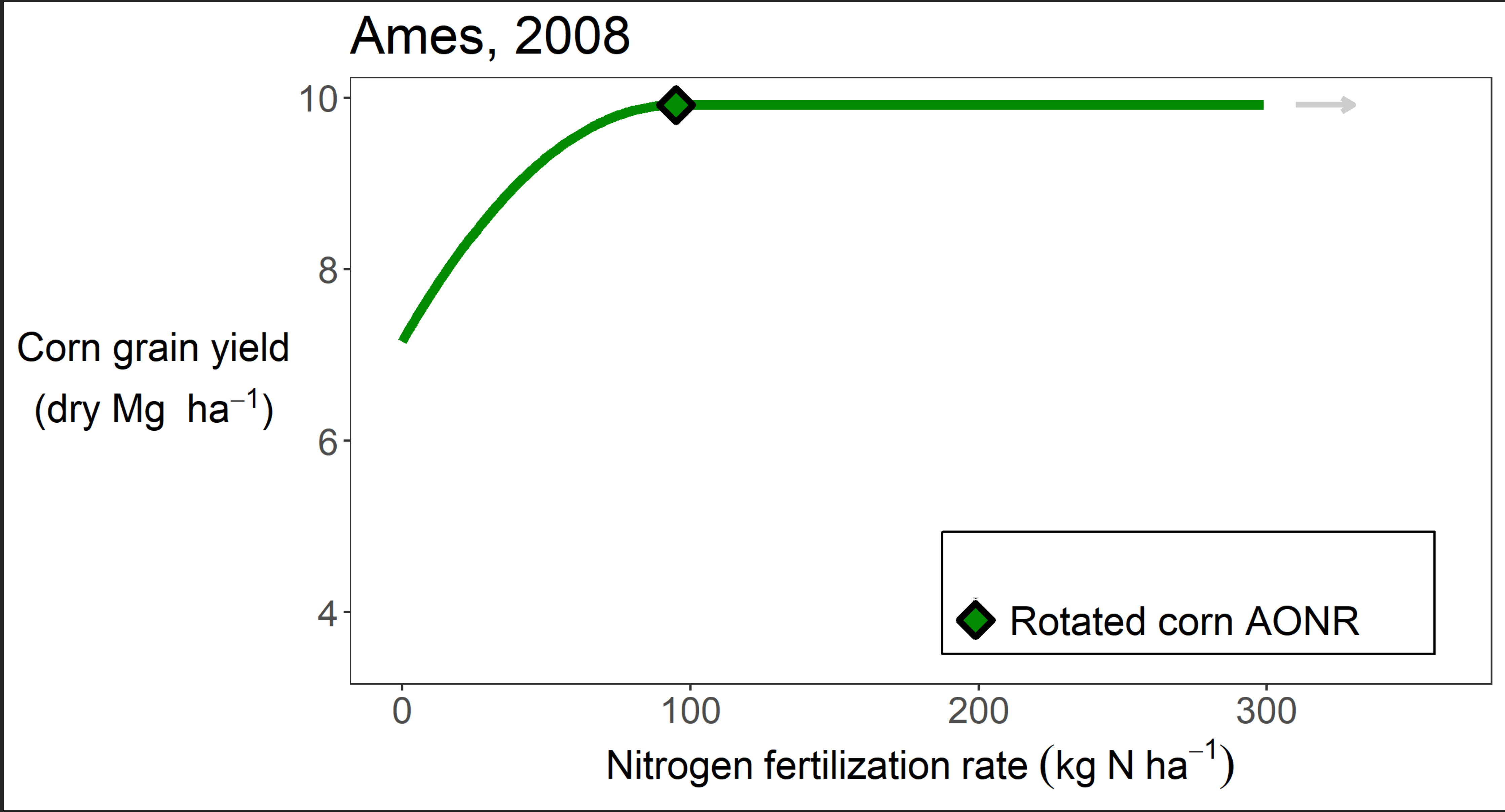
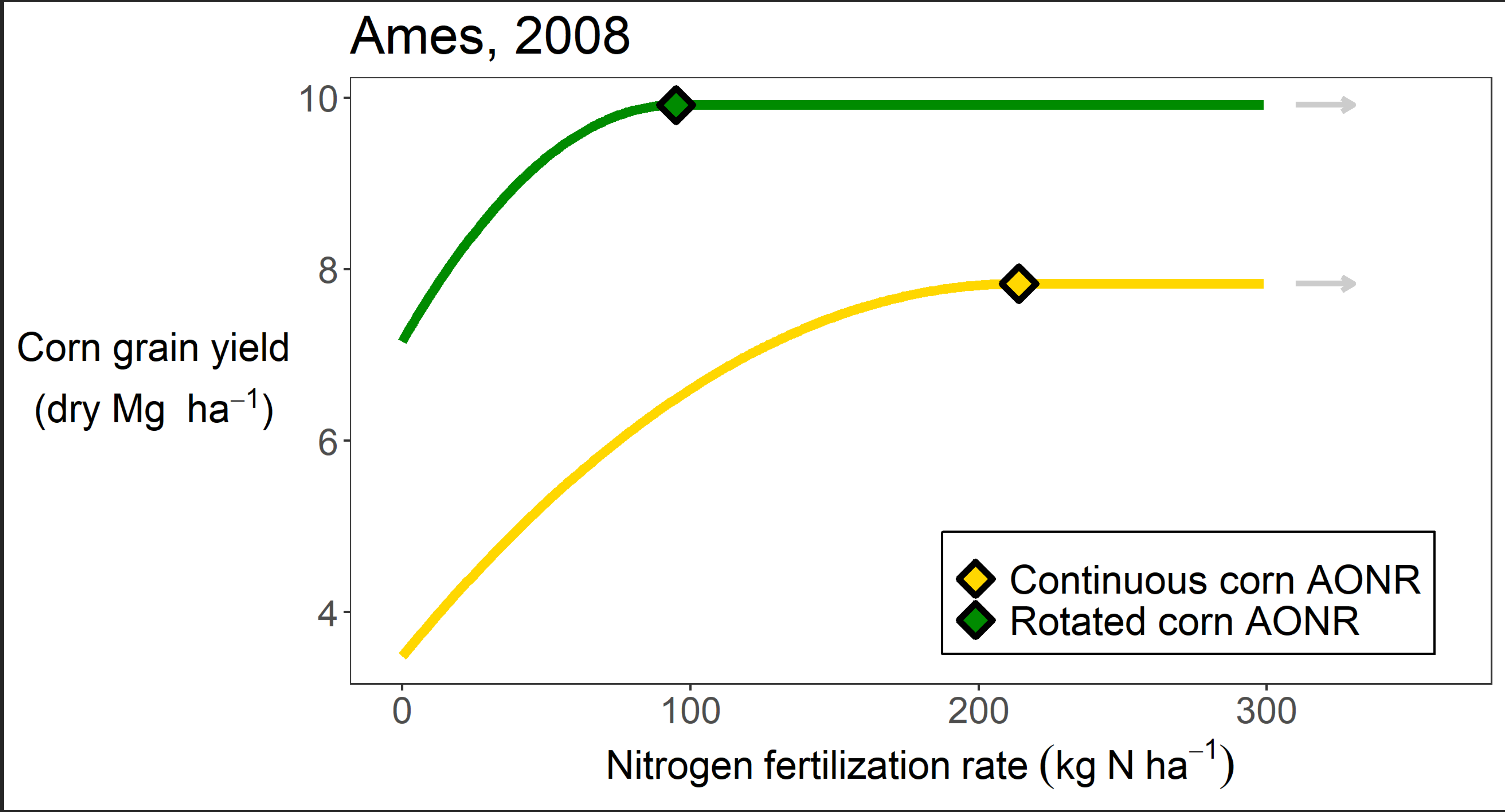

Ames, 2008
Corn grain yield
(dry Mg ha^{-1})
10
8
6
4
0
100
200
300
Nitrogen fertilization rate (kg N ha^{-1})

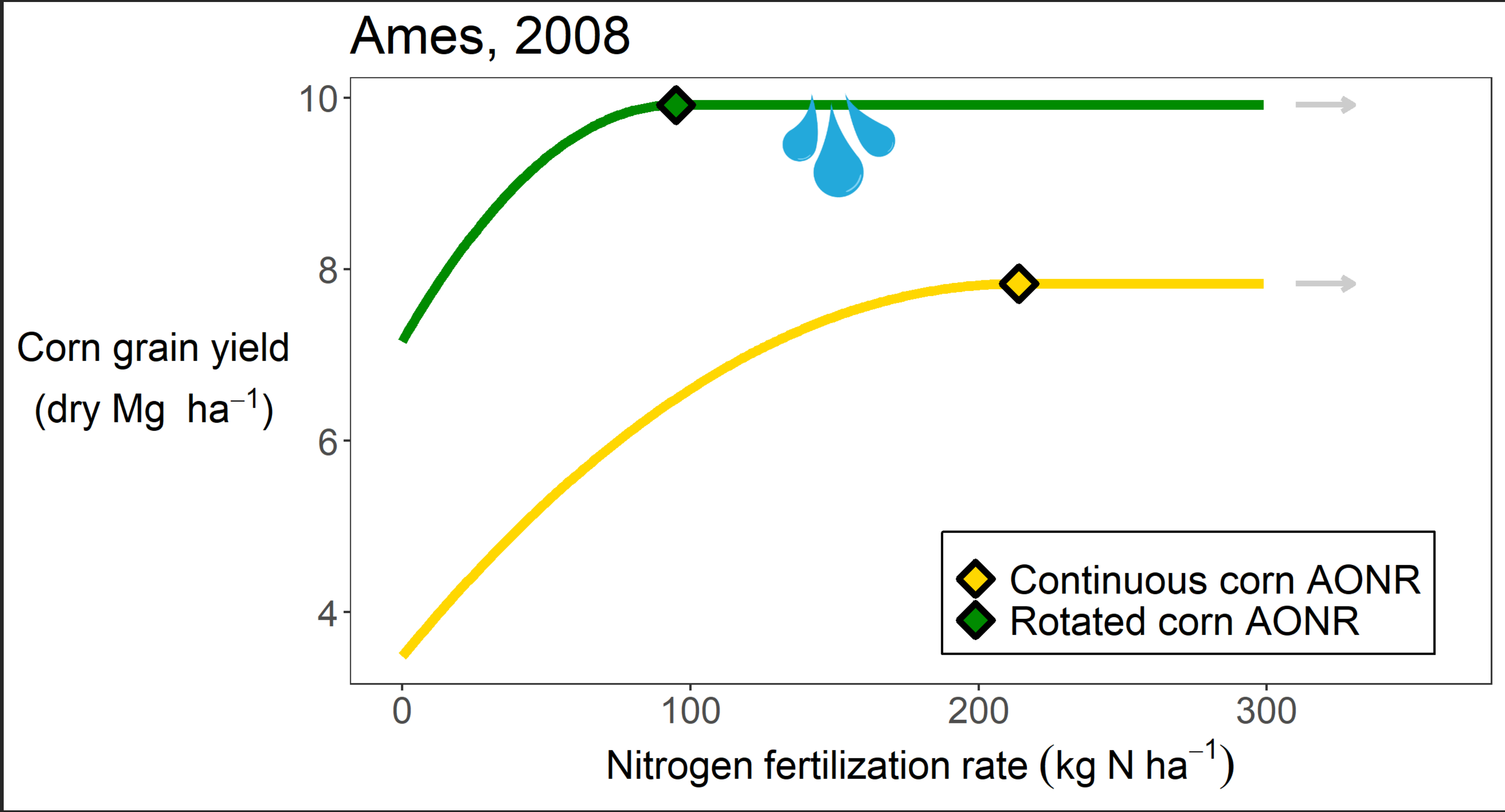


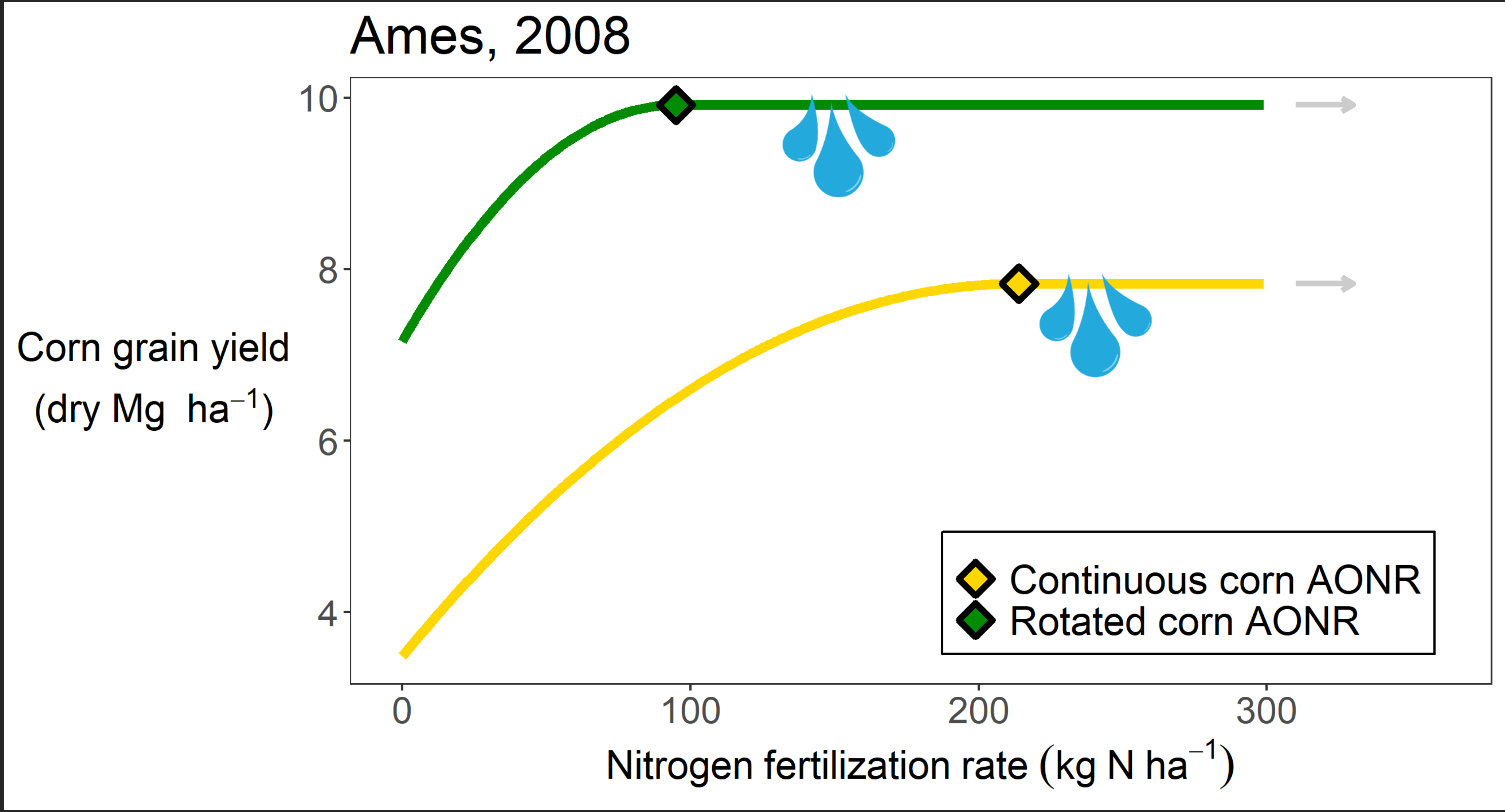
Ames, 2008
10
8
6
4
Corn grain yield (dry Mg ha^{-1})
0
100
200
300
Nitrogen fertilization rate (kg N ha^{-1})
Rotated corn



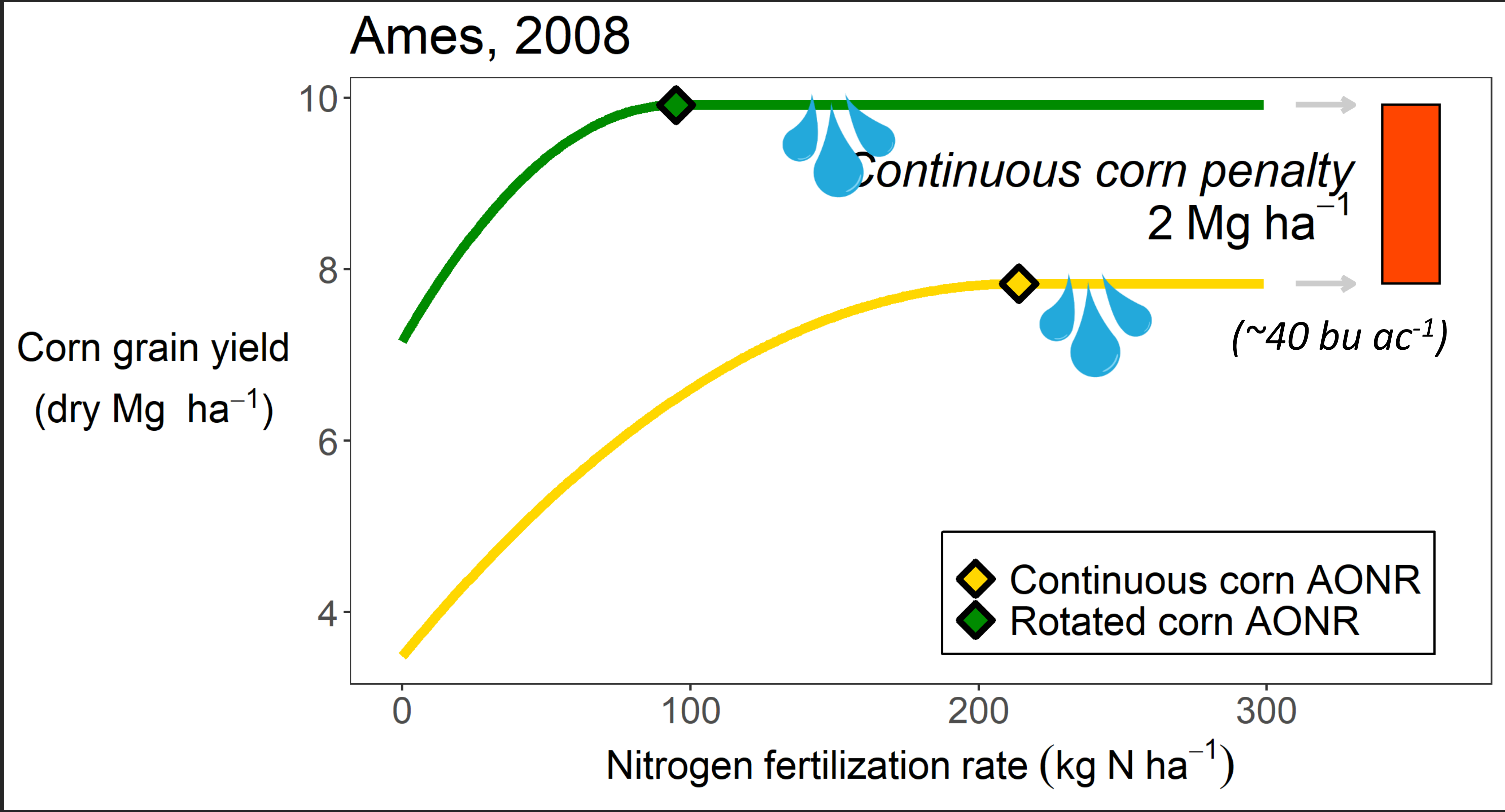
Ames, 2008
Corn grain yield (dry Mg ha^{-1})
10
8
6
4
0
100
200
300
Nitrogen fertilization rate (kg N ha^{-1})
Rotated corn AONR

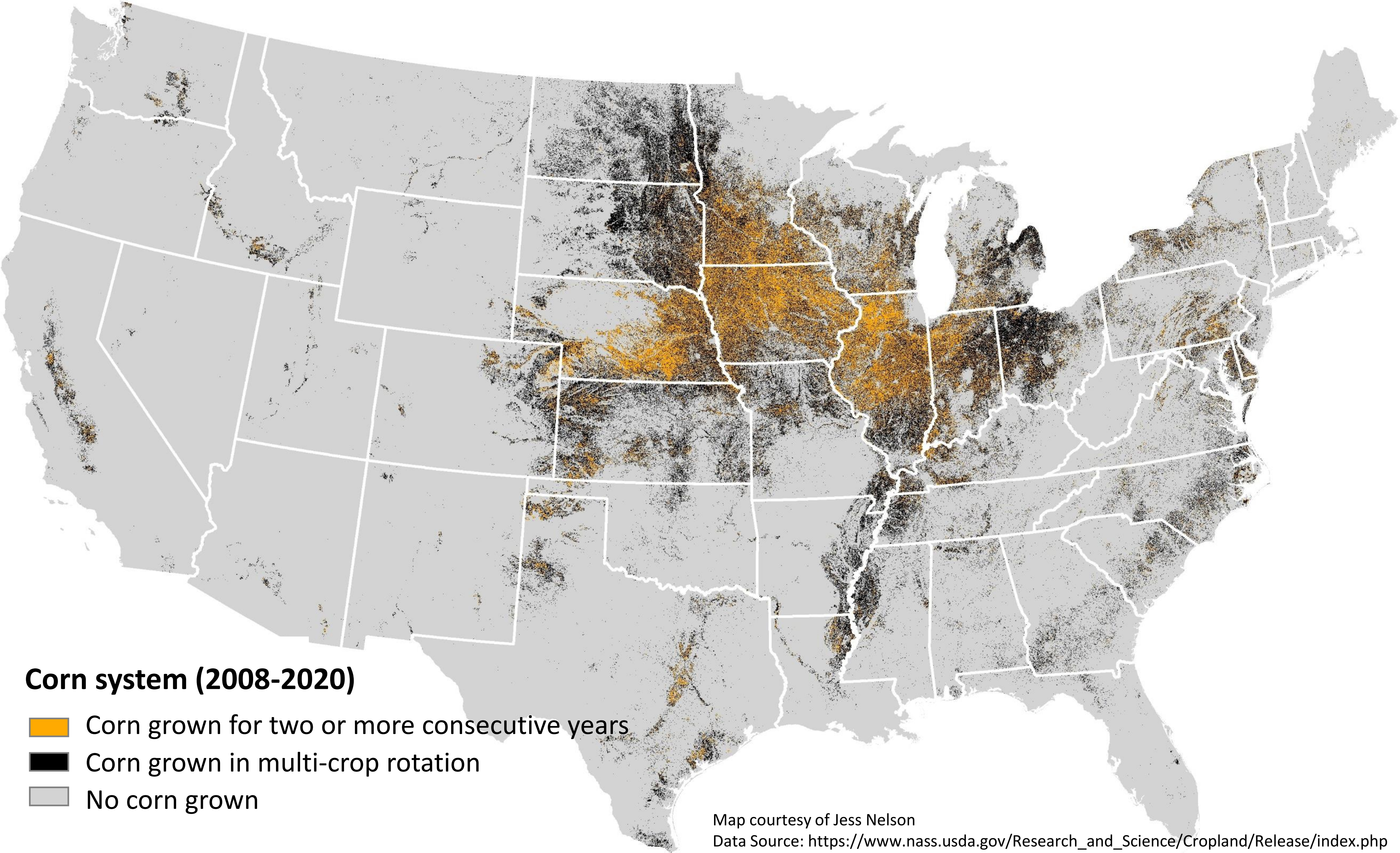

Ames, 2008
Corn grain yield (dry Mg ha−1)
10
8
6
4
0
100
200
300
Nitrogen fertilization rate (kg N ha−1)
Continuous corn AONR
Rotated corn AONR


Ames, 2008
Corn grain yield (dry Mg ha^{-1})
10
8
6
4
0
100
200
300
Nitrogen fertilization rate (kg N ha^{-1})
Continuous corn AONR
Rotated corn AONR

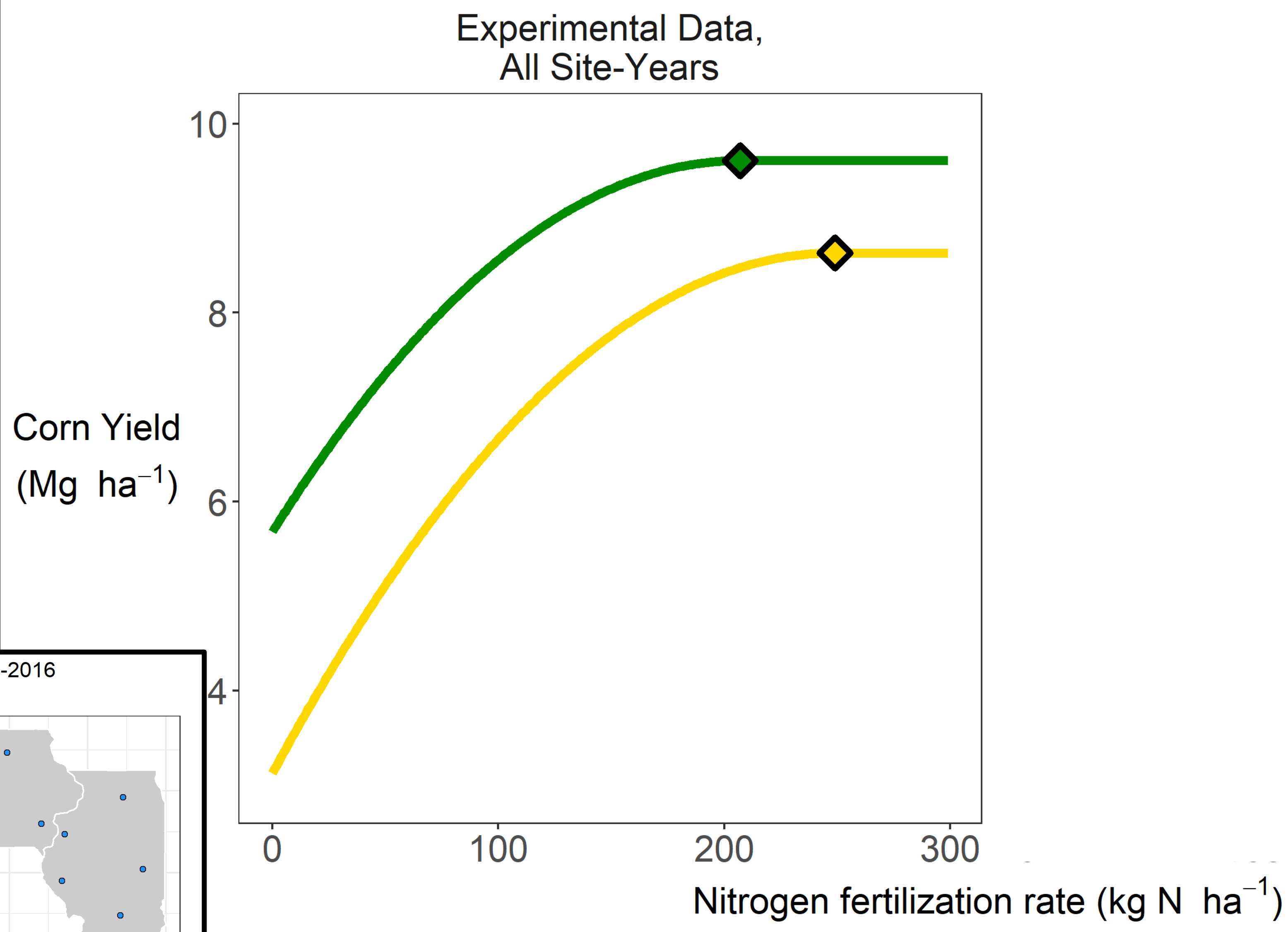


Ames, 2008
Corn grain yield (dry Mg ha^{-1})
10
8
6
4
0
100
200
300
Nitrogen fertilization rate (kg N ha^{-1})
Continuous corn AONR
Rotated corn AONR

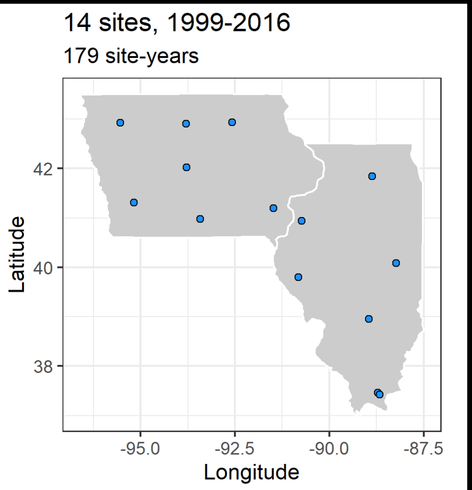

Ames, 2008
10
8
6
4
Corn grain yield
(dry Mg ha^{-1})
Continuous corn penalty
2 Mg ha^{-1}
(~40 bu ac^{-1})
Continuous corn AONR
Rotated corn AONR
0
100
200
300
Nitrogen fertilization rate (kg N ha^{-1})



Map courtesy of Jess Nelson
Data Source: https://www.nass.usda.gov/Research_and_Science/Cropland/Release/index.php



Experimental Data,
All Site-Years
Corn Yield
(Mg ha^{-1})
10
8
6
4
0
100
200
300
Nitrogen fertilization rate (kg N ha^{-1})



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Latitude
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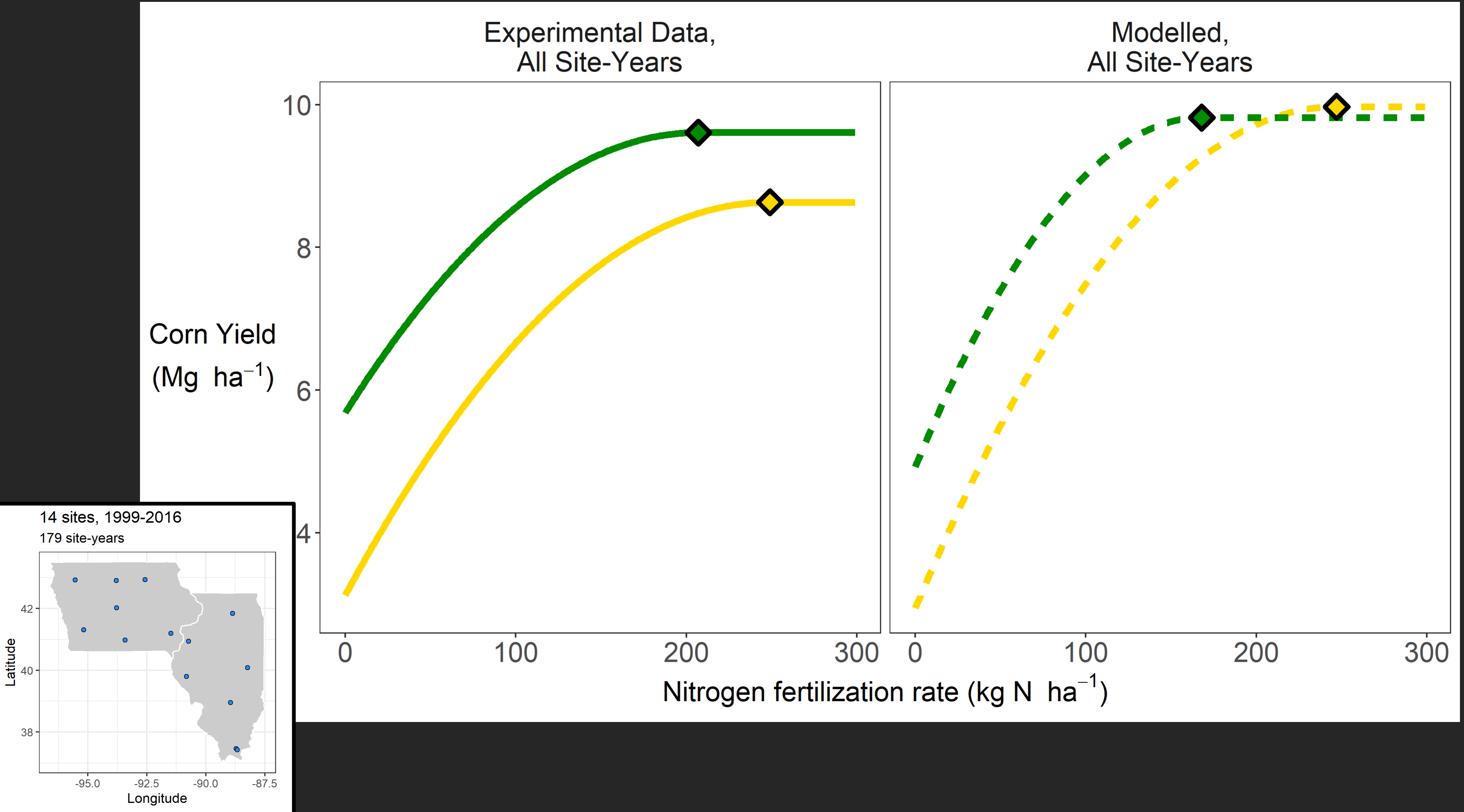
Experimental Data,
All Site-Years
Modelled,
All Site-Years
Corn Yield
(Mg ha⁻¹)
10
8
6
4
0
100
200
300
Nitrogen fertilization rate (kg N ha⁻¹)
14 sites, 1999-2016
179 site-years
Latitude
42
40
38
-95.0
-92.5
-90.0
-87.5
Longitude

The Continuous Corn Penalty

- *Requires more nitrogen, yields less, higher risk of nitrate leaching*
- *Affects a large amount of land*
- *We need a way to model it*

230 AGRONOMY JOURNAL, VOL. 81, MARCH–APRIL 1989

Crop Economics, Production & Management

Identifying Factors Controlling the Continuous Corn Yield Penalty

Environment Affects the Corn and Soybean Rotation Effect

Paul M. Porter,* Joseph G. Lauer, William E. Lueschen, J. Harlan Ford, Tom R. Hoverstad, Edward S. Oplinger, and R. Kent Crookston

ABSTRACT

Corn (*Zea mays* L.) and soybean [*Glycine max* (L.) Merr.], the backbone of Midwestern crop production, respond to rotation, but how growing conditions affect this is not well documented. Our objectives were to determine the effect of various corn and soybean cropping patterns on yields and to evaluate environmental effects on the rotation effect. The study began in 1981 at Lamberton, MN, on a Webster clay loam (fine-loamy, mixed, mesic Typic Endoaquoll), in 1982 at Waseca, MN, on a Nicollet clay loam (fine-loamy, mixed, mesic Aquic Hapludoll), and in 1983 at Arlington, WI, on a Plano silt loam (fine-silty, mixed, mesic Typic Argiudoll). Cropping sequences were (i) continuous monoculture of each crop; (ii) annual rotation of the two crops; and (iii) 1, 2, 3, 4, and 5 yr of each crop following 5 yr of the other crop. Results are based on 11 yr of data at Lamberton, 8 yr (soybean) or 9 yr (corn) at Waseca, and 9 yr at Arlington. Corn rotated annually with soybean yielded 13% more, and 1st-yr corn following multiple years of soybean yielded 15% more than continuous corn. Soybean annually rotated with corn yielded 10% more, and 1st-yr soybean following multiple years of corn yielded 18% more than continuous soybean. The crops differed in response to increasing years of consecutive planting: 2nd-yr to 5th-yr corn yields were no different from continuous corn yields; 2nd-yr soybean yielded 8% more than continuous soybean, 3rd-yr soybean yielded 3% more, and 4th- and 5th-yr soybean yielded the same as continuous soybean. Relative increase in yields of both crops in annual rotation compared with monoculture was approximately twofold greater in low-yielding than in high-yielding environments. In low-yielding environments, the yield advantage of an annual rotation of corn and soybean compared with monoculture was frequently greater than 25%. The commonly practiced annual rotation of corn and soybean maximized corn yields, but not soybean yields, relative to the other sequences studied.

A first-century B.C. Roman text states that "some crops are to be planted not so much for the immediate yield as with a view to the following year" (Varro, 1913). During the early 1980s, it was documented that corn grown on land planted to corn the previous year yielded 10 to 15% less grain than corn rotated with certain other crops (Sundquist et al., 1982), and that soybean yielded 10 to 15% more when rotated with corn rather than when grown continuously (Bhowmik and Doll, 1982). Yield increases associated with crop rotation have been referred to as the *rotation effect* (Pierce and Rice, 1988), and yield declines associated with monoculture have been referred to as *monoculture yield declines* (Sumner et al., 1990).

Several of the longest on-going studies designed to evaluate corn–soybean cropping sequences in the northern Corn Belt were initiated in the early 1980s at two locations in Minnesota and one in Wisconsin. In the Minnesota study, Crookston et al. (1991) reported that rotational cropping sequence affected both corn and soybean yields. Corn or soybean grown continuously yielded significantly less than when grown in an annual corn–soybean rotation. Likewise, corn or soybean in an annual rotation yielded significantly less than a 1st-yr crop following five consecutive years of the other crop. Follow-up research on this long-term study did not identify a cause or explanation for the corn–soybean rotation effect. It appears that root vigor of both crops was improved by rotation (Nickel et al., 1995), as was root function, as determined by nutrient and water uptake (Copeland and Crookston, 1992; Copeland et al., 1993). Neither foliar pathogens (Whiting and Crookston, 1993) nor soilborne pathogens were determined to be involved in the monoculture yield decline.

Cropping sequences in the Wisconsin study (Meese et al., 1991) were similar to those in the Minnesota study, but also included tillage, cultivar or hybrid, and N fertility components. Meese et al. (1991) reported that, for both corn and soybean, yield depressions under no-till compared with conventional tillage were less likely to occur when crops were rotated than when grown as monocultures. Soybean cultivar and corn hybrid selection affected the rotation effect. For example, a brown stem rot (BSR)–susceptible soybean cultivar was more sensitive than a resistant cultivar to annual alternation with corn and to consecutive years of soybean.

Six additional years of yield data have been collected since the analyses by Crookston et al. (1991) and Meese et al. (1991). We determined to again evaluate the yield response of both crops to rotation and focused particular attention on the effect of variations in the environment on the nature and magnitude of responses. Peterson et al. (1990) showed the effects of rainfall conditions and previous crop on crop yields. Several researchers have suggested that corn yield response to crop rotation is greater in dry or otherwise stressed environments than in more normal growing seasons (Langer and Randall, 1981; Peterson and Varvel, 1989b).

Our first objective was to determine if corn and soybean yield response to rotation sequence observed in the Minnesota and Wisconsin trials through 1995 would be consistent with the earlier reported results. Our second objective was to determine if there is a relationship between environment (stress vs. nonstress) and the response of both crops to rotation.

MATERIALS AND METHODS

The studies were established near Lamberton, MN, in 1981 on a Webster clay loam (fine-loamy, mixed, mesic Typic Endoaquoll), in 1982 at Waseca, MN, on a Nicollet clay loam (fine-loamy, mixed, mesic Aquic Hapludoll), and in 1983 at Arlington, WI, on a Plano silt loam (fine-silty, mixed, mesic

P.M. Porter, W.E. Lueschen, J.H. Ford, T.R. Hoverstad, and R.K. Crookston, Dep. of Agronomy and Plant Genetics, Univ. of Minnesota, 1991 Upper Buford Circle, St. Paul, MN 55108; J.G. Lauer and E.S. Oplinger, Dep. of Agronomy, Univ. of Wisconsin, 1575 Linden Dr., Madison, WI 53706. Minnesota Agric. Exp. Stn. Journal Series Paper no. 22,474. Received 8 July 1996. *Corresponding author (pporter@maroon.tc.umn.edu).

Published in Agron. J. 89:441–448 (1997).

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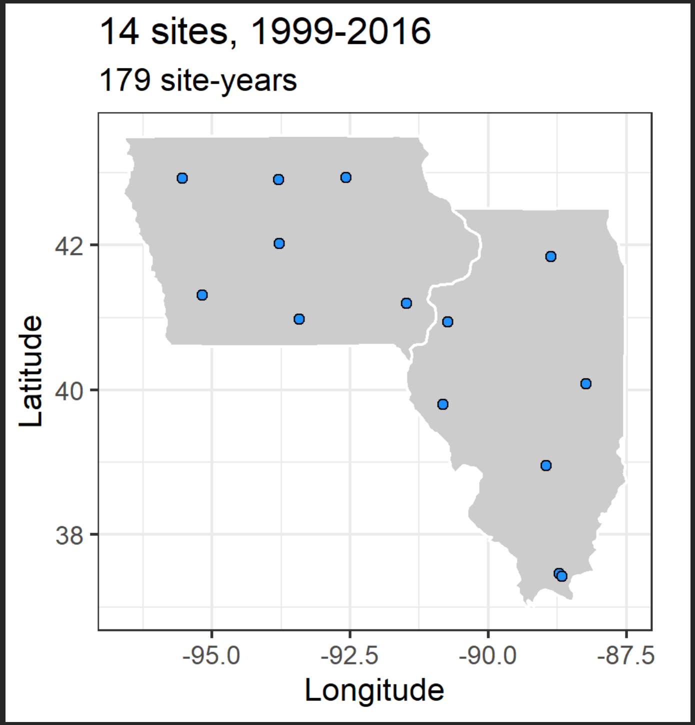

230 AGRONOMY JOURNAL, VOL. 81, MARCH–APRIL 1989

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A FIRST-CENTURY B.C. ROMAN TEXT states that "some crops are to be planted not so much for the immediate yield as with a view to the following year" (Varro, 1913). During the early 1980s, it was documented that corn grown on land planted to corn the previous year yielded 10 to 15% less grain than corn rotated with certain other crops (Sundquist et al., 1982), and that soybean yielded 10 to 15% more when rotated with corn rather than when grown continuously (Bhowmik and Doll, 1982). Yield increases associated with crop rotation have been referred to as the *rotation effect* (Pierce and Rice, 1988), and yield declines associated with monoculture have been referred to as *monoculture yield declines* (Sumner et al., 1990).

Several of the longest on-going studies designed to evaluate corn–soybean cropping sequences in the northern Corn Belt were initiated in the early 1980s at two locations in Minnesota and one in Wisconsin. In the Minnesota study, Crookston et al. (1991) reported that rotational cropping sequence affected both corn and soybean yields. Corn or soybean grown continuously yielded significantly less than when grown in an annual corn–soybean rotation. Likewise, corn or soybean in an annual rotation yielded significantly less than a 1st-yr crop following five consecutive years of the other crop. Follow-up research on this long-term study did not identify a cause or explanation for the corn–soybean rotation effect. It appears that root vigor of both crops was improved by rotation (Nickel et al., 1995), as was root function, as determined by nutrient and water uptake (Copeland and Crookston, 1992; Copeland et al., 1993). Neither foliar pathogens (Whiting and Crookston, 1993) nor soilborne pathogens were determined to be involved in the monoculture yield decline.

Cropping sequences in the Wisconsin study (Meese et al., 1991) were similar to those in the Minnesota study, but also included tillage, cultivar or hybrid, and N fertility components. Meese et al. (1991) reported that, for both corn and soybean, yield depressions under no-till compared with conventional tillage were less likely to occur when crops were rotated than when grown as monocultures. Soybean cultivar and corn hybrid selection affected the rotation effect. For example, a brown stem rot (BSR)–susceptible soybean cultivar was more sensitive than a resistant cultivar to annual alternation with corn and to consecutive years of soybean.

Six additional years of yield data have been collected since the analyses by Crookston et al. (1991) and Meese et al. (1991). We determined to again evaluate the yield response of both crops to rotation and focused particular attention on the effect of variations in the environment on the nature and magnitude of responses. Peterson et al. (1990) showed the effects of rainfall conditions and previous crop on crop yields. Several researchers have suggested that corn yield response to crop rotation is greater in dry or otherwise stressed environments than in more normal growing seasons (Langer and Randall, 1981; Peterson and Varvel, 1989b).

Our first objective was to determine if corn and soybean yield response to rotation sequence observed in the Minnesota and Wisconsin trials through 1995 would be consistent with the earlier reported results. Our second objective was to determine if there is a relationship between environment (stress vs. nonstress) and the response of both crops to rotation.

MATERIALS AND METHODS

The studies were established near Lamberton, MN, in 1981 on a Webster clay loam (fine-loamy, mixed, mesic Typic Endoaquoll), in 1982 at Waseca, MN, on a Nicollet clay loam (fine-loamy, mixed, mesic Aquic Hapludoll), and in 1983 at Arlington, WI, on a Plano silt loam (fine-silty, mixed, mesic

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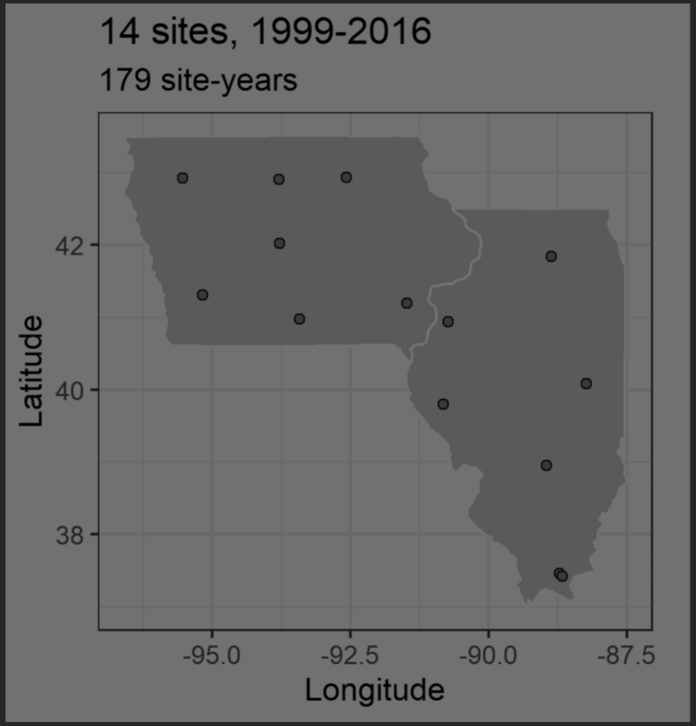
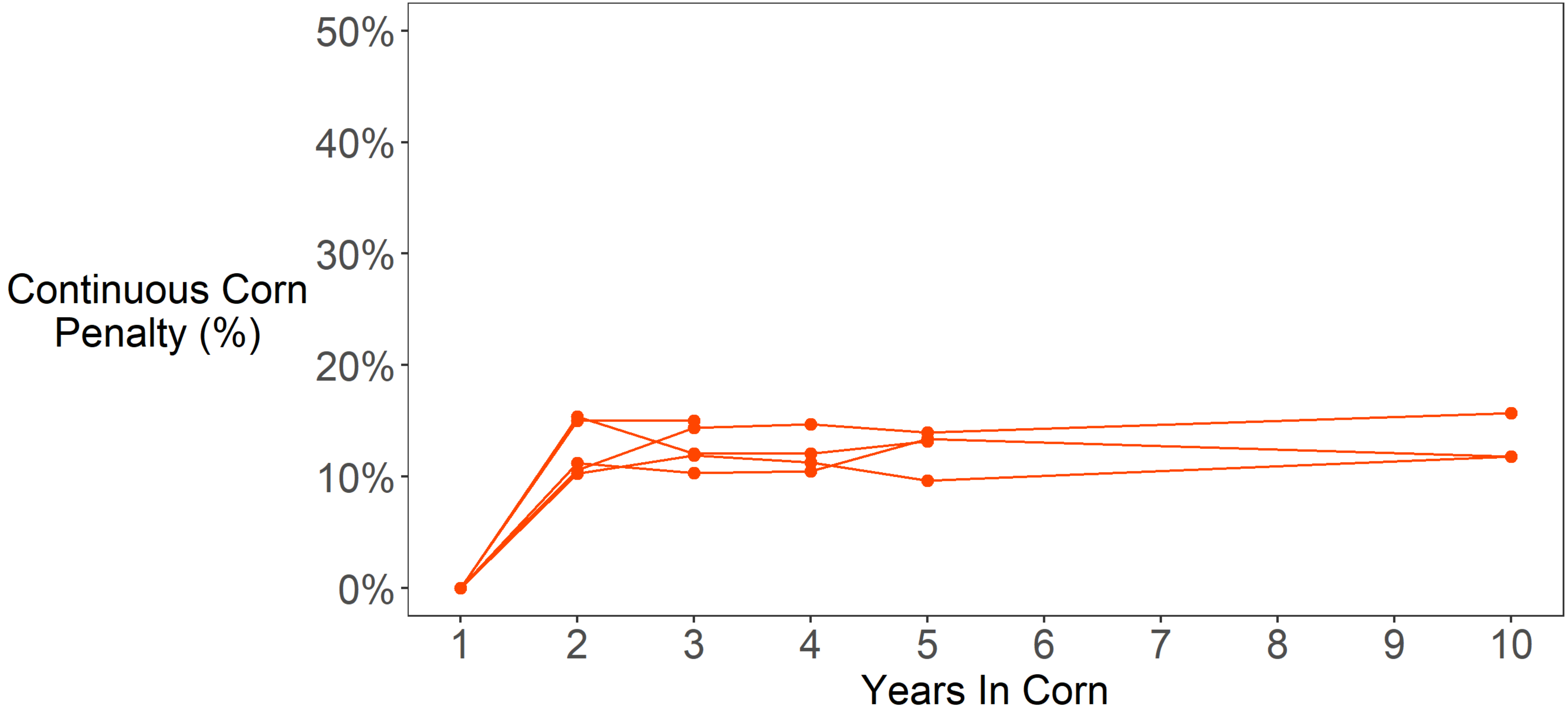
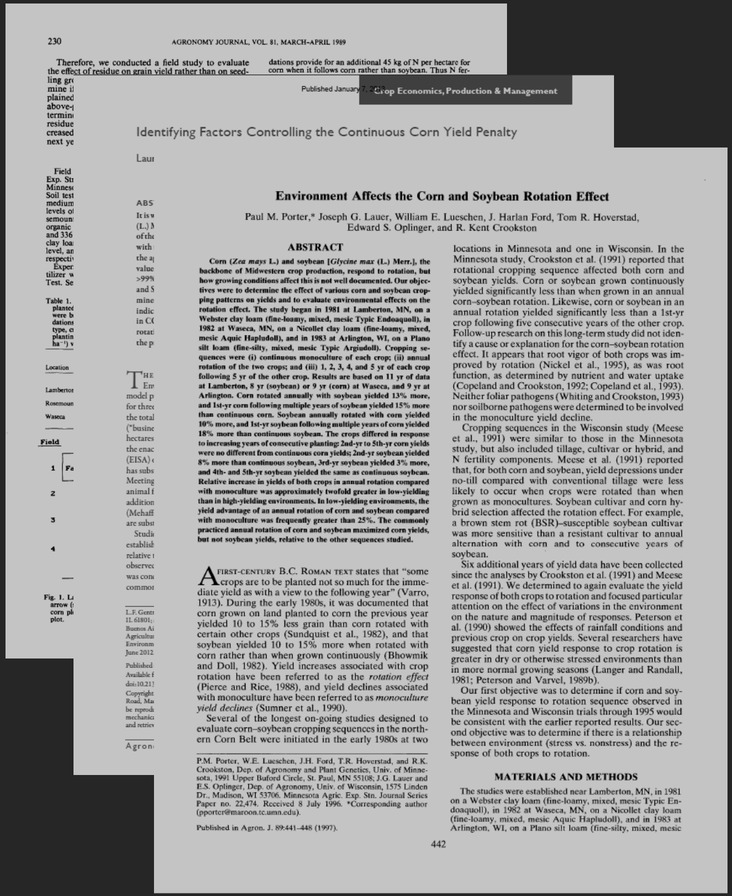


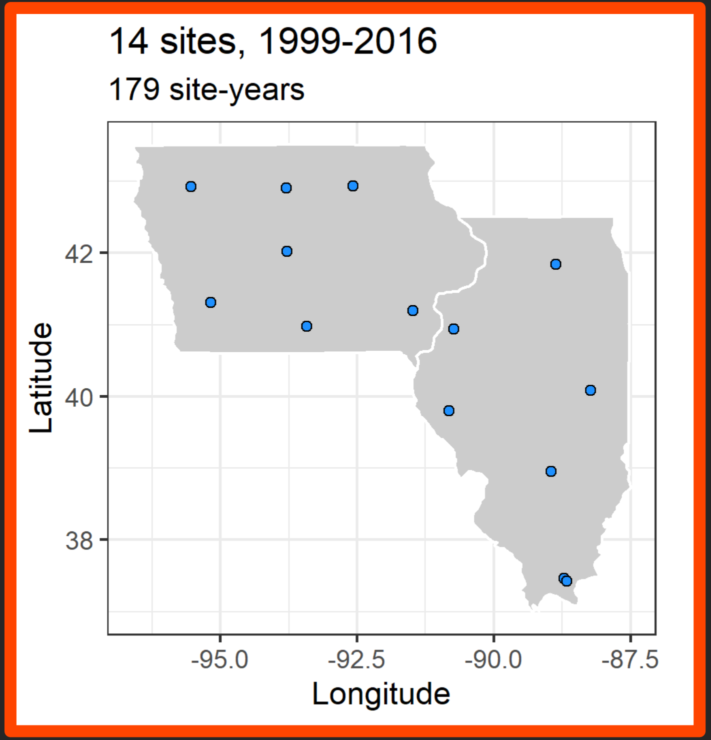
Experimental data from literature

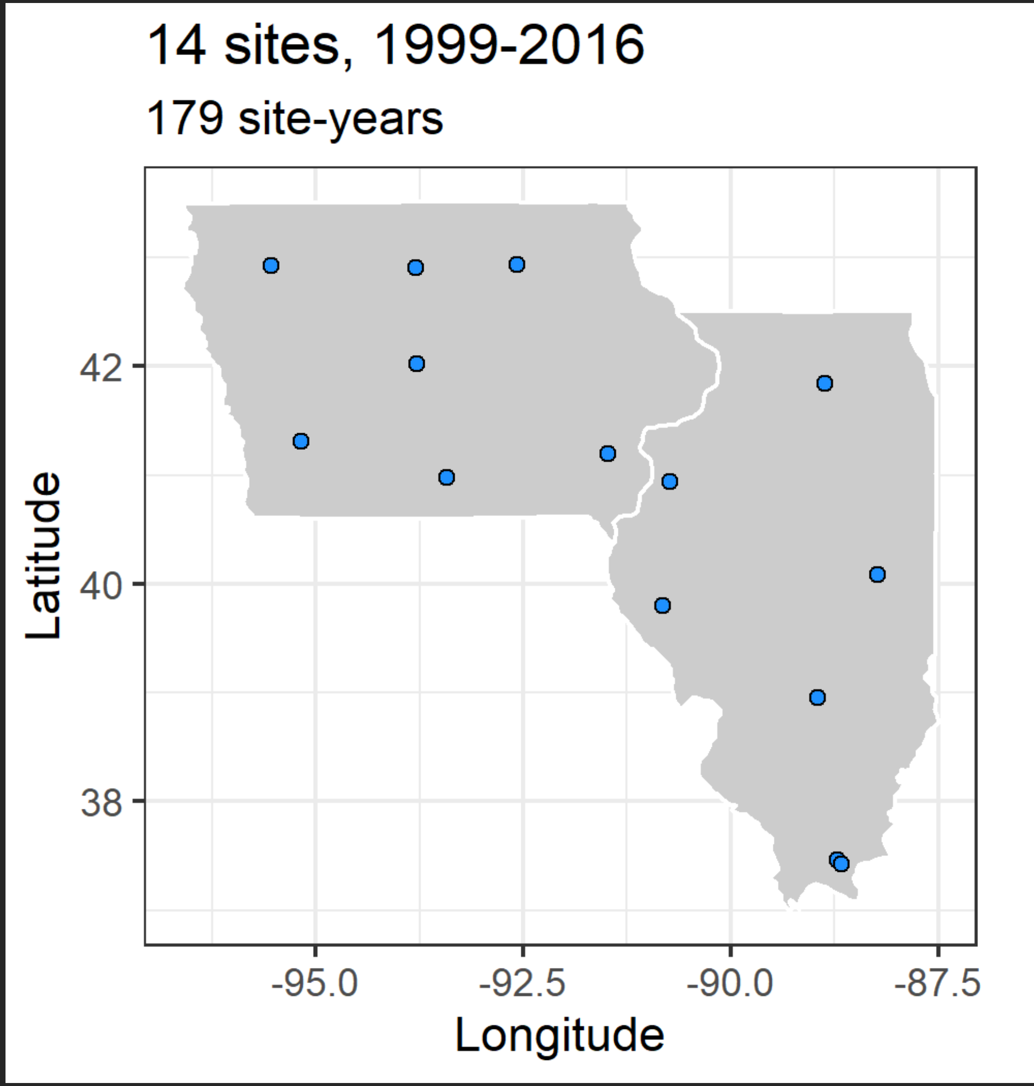


Crookston et al. 1991;
Meese et al. 1991;
Porter et al. 1997


AGRONOMY JOURNAL, VOL. 81, MARCH–APRIL 1989
Crop Economics, Production & Management
Identifying Factors Controlling the Continuous Corn Yield Penalty
Environment Affects the Corn and Soybean Rotation Effect
Paul M. Porter,* Joseph G. Lauer, William E. Lueschen, J. Harlan Ford, Tom R. Hoverstad, Edward S. Oplinger, and R. Kent Crookston
ABSTRACT
MATERIALS AND METHODS


APSIM
AGRICULTURAL PRODUCTION SYSTEMS SIMULATOR


14 sites, 1999-2016
179 site-years
Latitude
42
40
38
-95.0
-92.5
-90.0
-87.5
Longitude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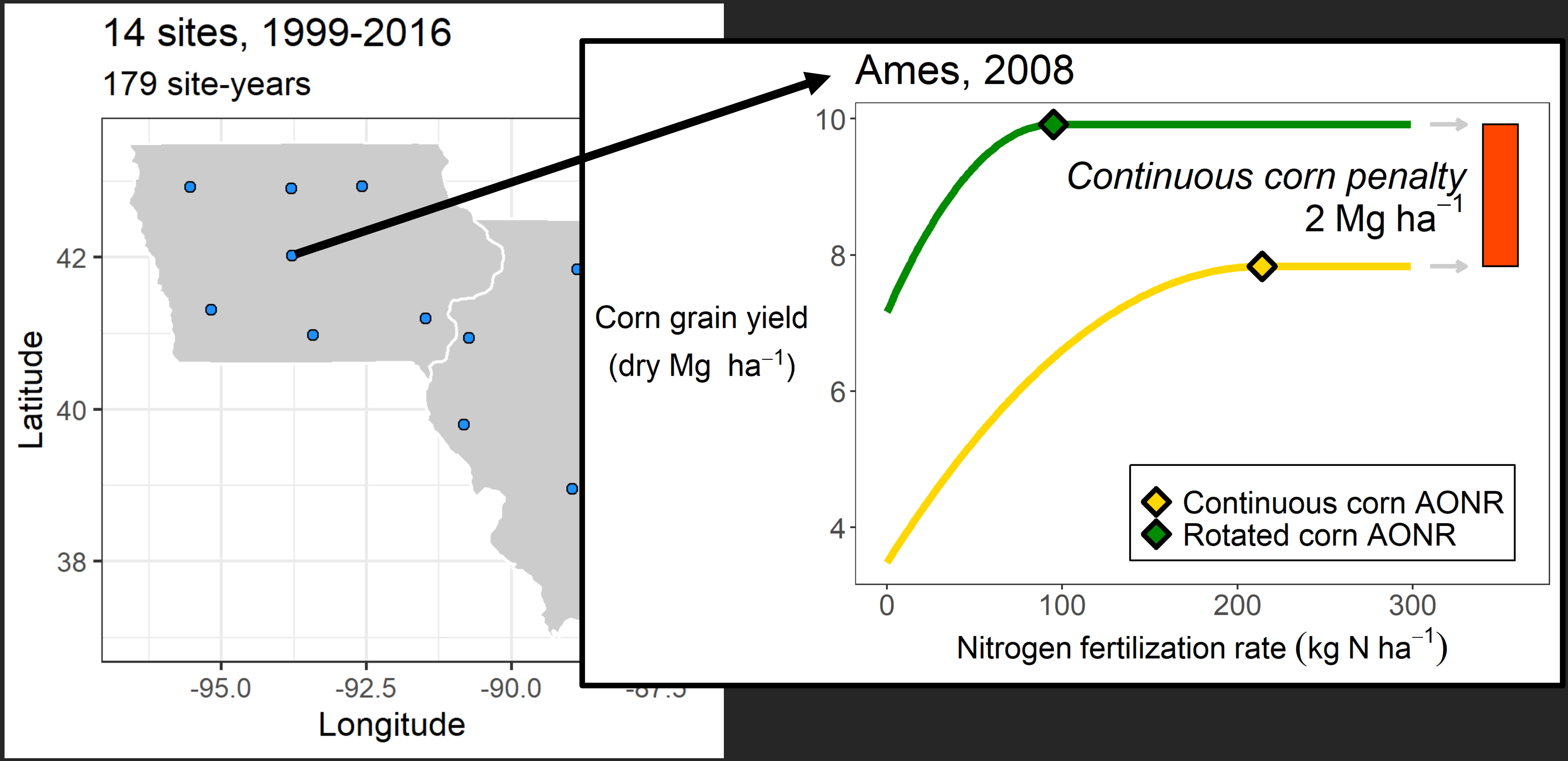
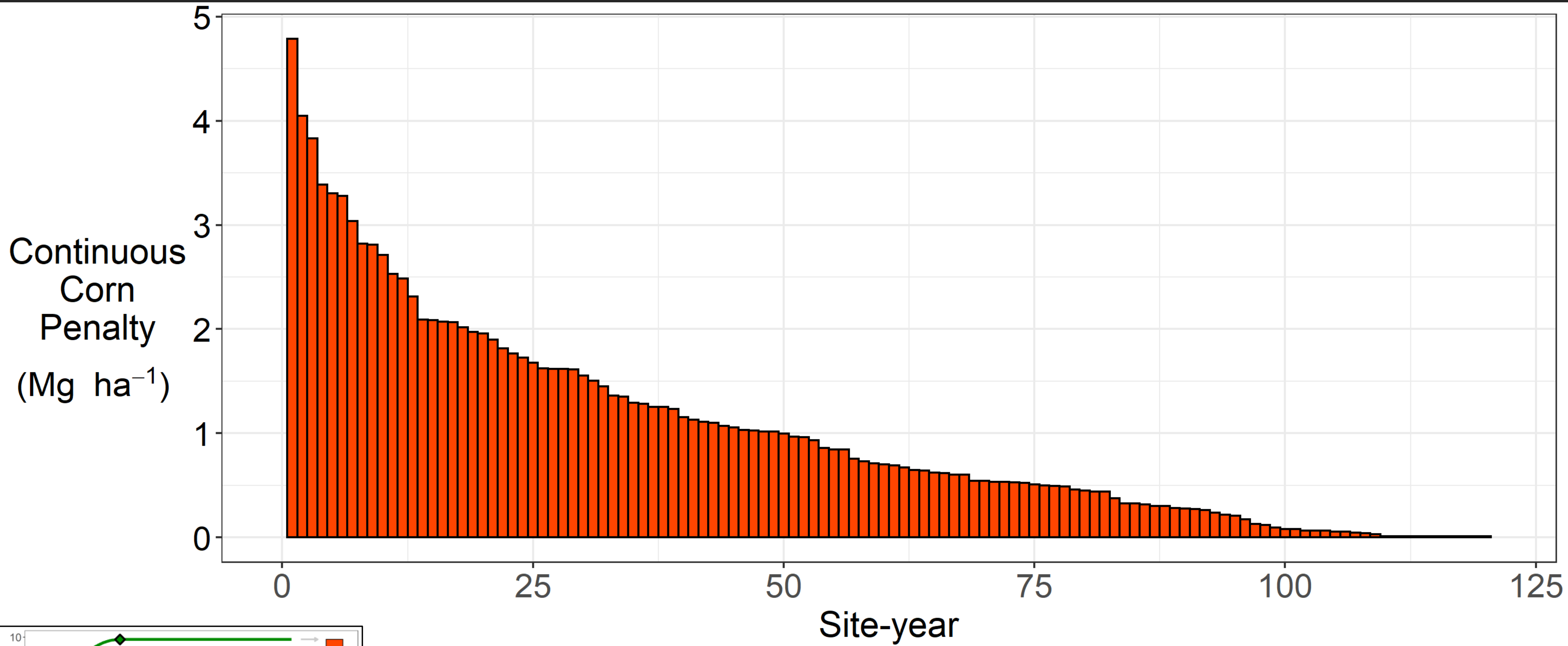
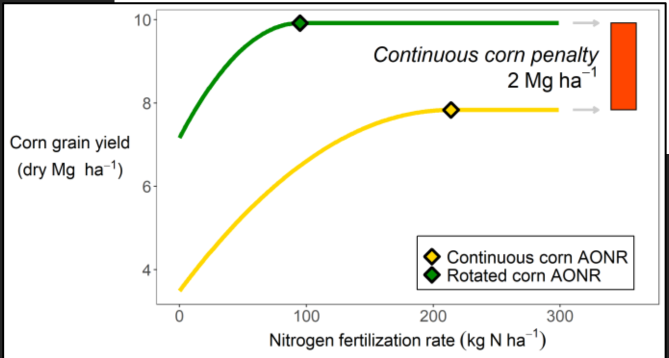
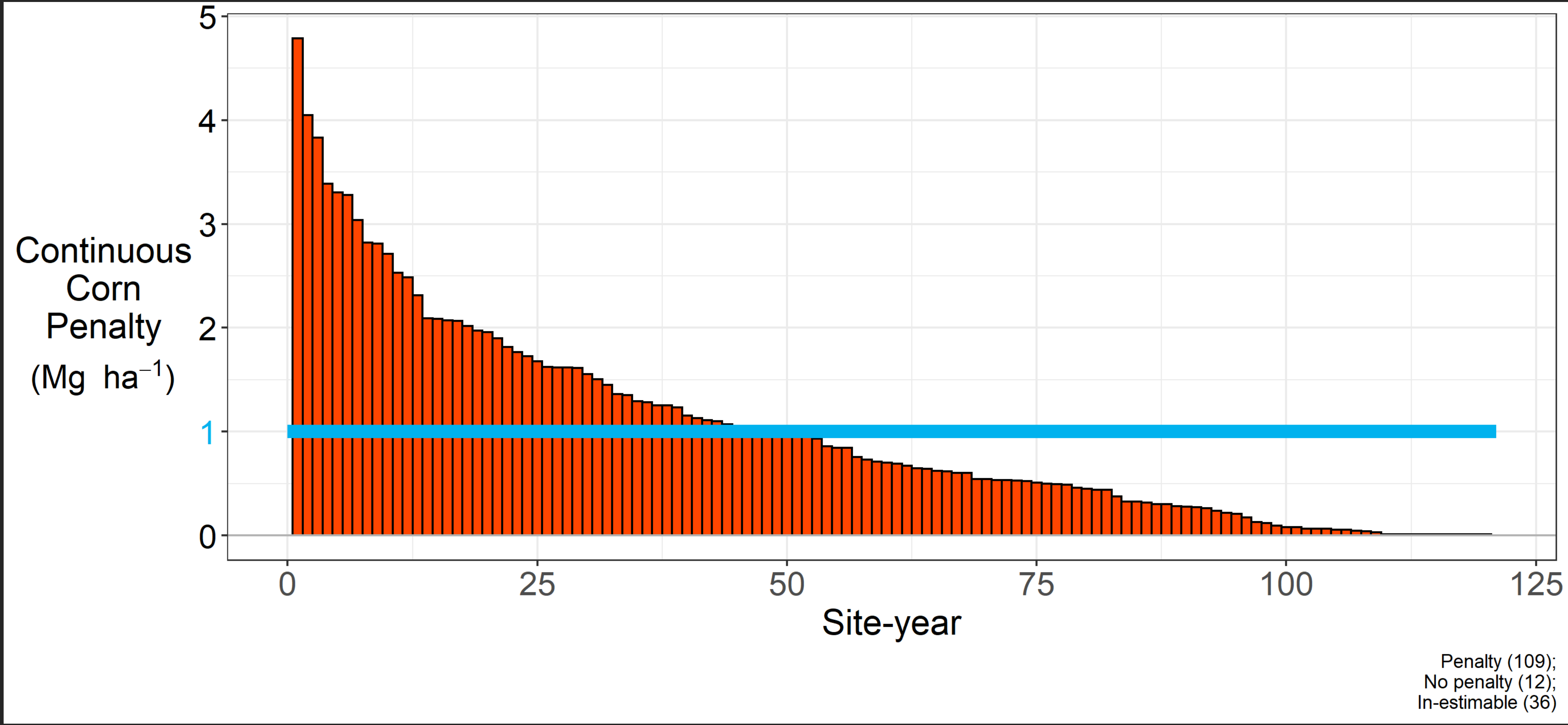


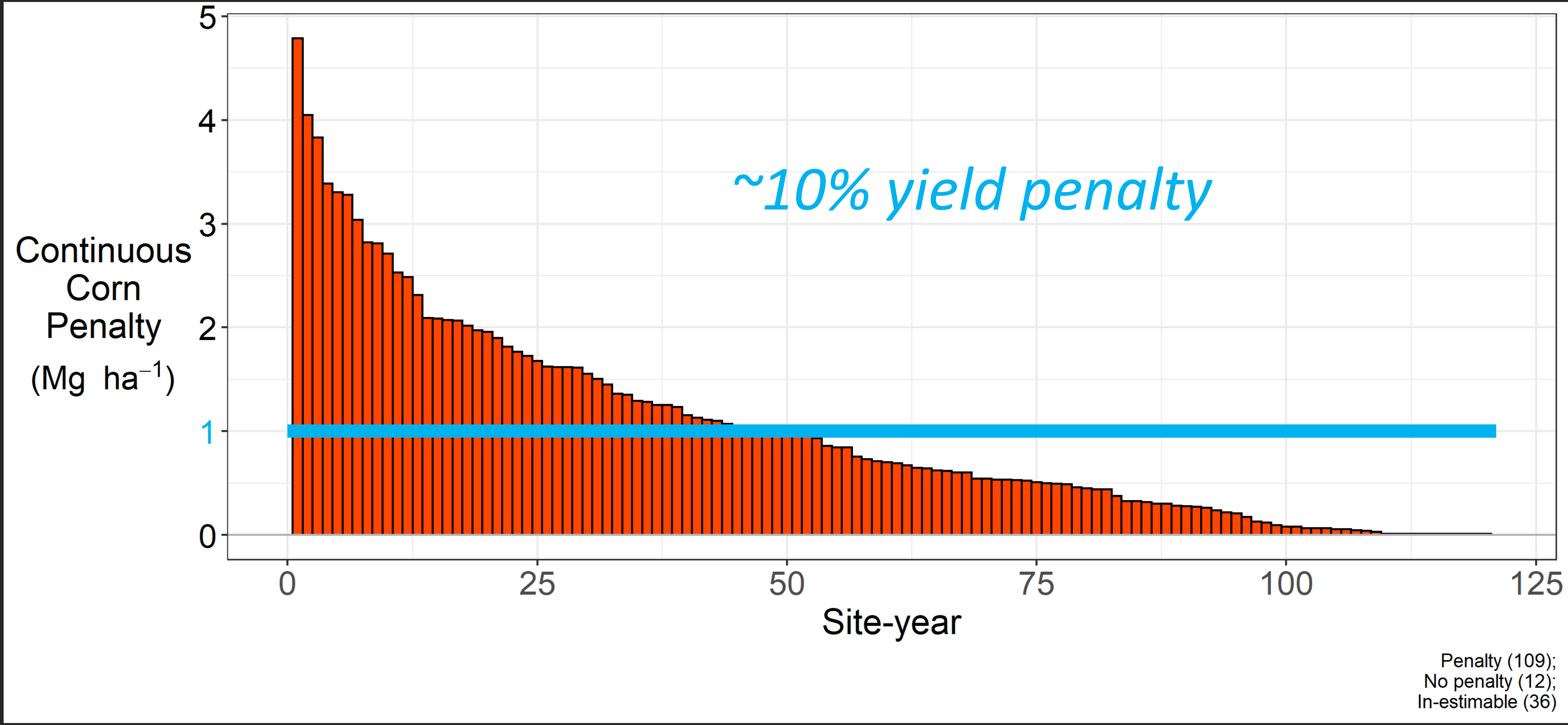
14 sites, 1999-2016
179 site-years
Latitude
42
40
38
-95.0
-92.5
-90.0
Longitude
Ames, 2008
Corn grain yield
(dry Mg ha^{-1})
10
8
6
4
0
100
200
300
Nitrogen fertilization rate (kg N ha^{-1})
Continuous corn penalty
2 Mg ha^{-1}
Continuous corn AONR
Rotated corn AONR





Penalty (109);
No penalty (12);
In-estimable (36)

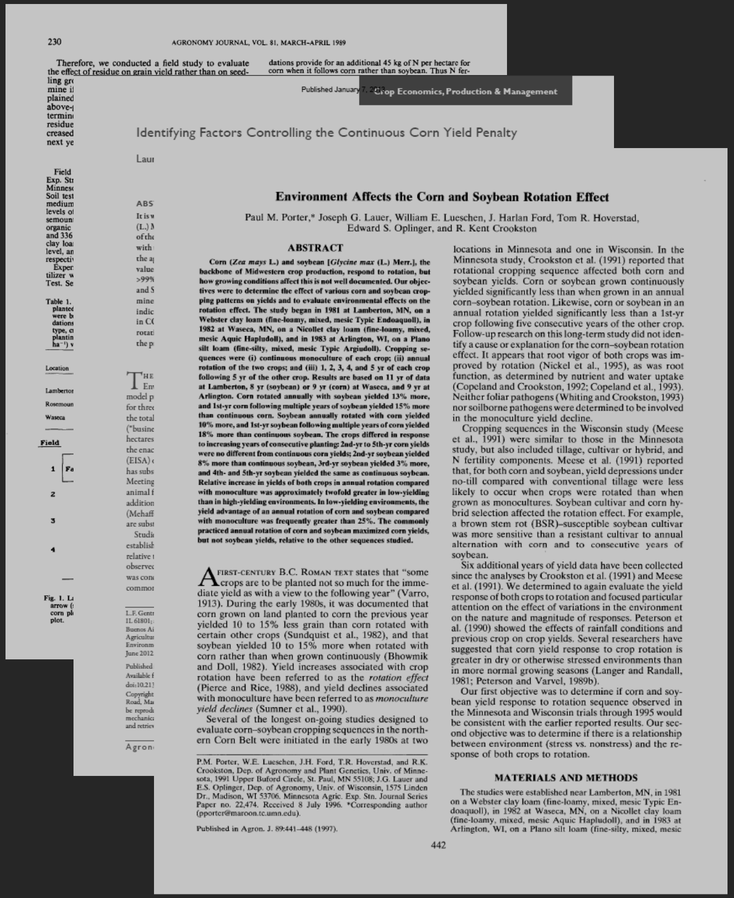

Continuous Corn Penalty (Mg ha^{-1})
Site-year
0
1
2
3
4
5
0
25
50
75
100
125
Penalty (109);
No penalty (12);
In-estimable (36)


~10% yield penalty
Continuous Corn Penalty (Mg ha^{-1})
0
1
2
3
4
5
0
25
50
75
100
125
Site-year
Penalty (109);
No penalty (12);
In-estimable (36)

The Continuous Corn Penalty

- *Effect does not compound over time*
- *Exists in literature*
- *Exists in our field sites*

Hypothesis
Insufficient soil water recharge following corn
Altered nitrogen cycling
More variable stand
Seedling death
Delayed emergence
Foliar disease
Compromised root growth
Compromised root function
Decreased early plant growth



230 AGRONOMY JOURNAL, VOL. 81, MARCH–APRIL 1989

Crop Economics, Production & Management

Identifying Factors Controlling the Continuous Corn Yield Penalty

Environment Affects the Corn and Soybean Rotation Effect

Paul M. Porter,* Joseph G. Lauer, William E. Lueschen, J. Harlan Ford, Tom R. Hoverstad, Edward S. Oplinger, and R. Kent Crookston

ABSTRACT

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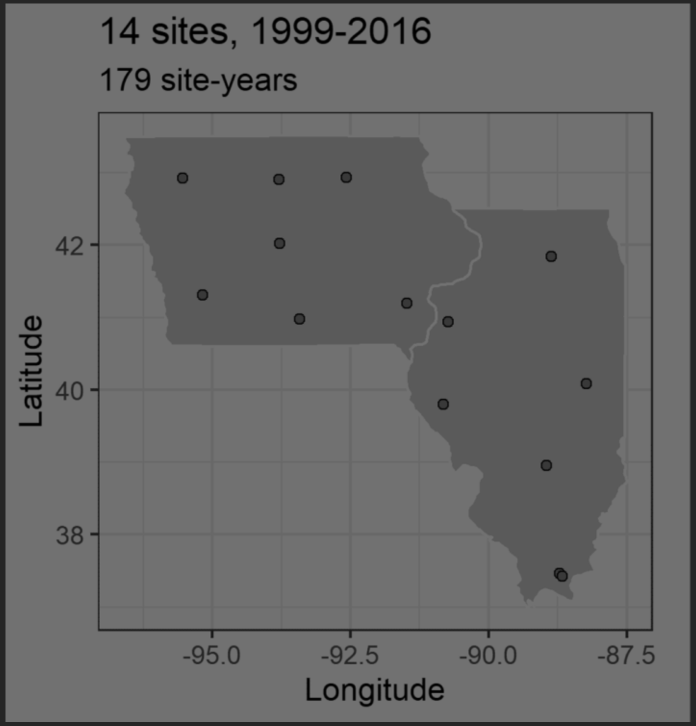

- Open-source
- Team of support
- Used world-wide
- Validated in Midwest

Hypothesis	Model Approach
Insufficient soil water recharge following corn	
Altered nitrogen cycling	
More variable stand	
Seedling death	
Delayed emergence	
Foliar disease	
Compromised root growth	
Compromised root function	
Decreased early plant growth	

Hypothesis	Model Approach
Insufficient soil water recharge following corn	Look at soil moisture
Altered nitrogen cycling	
More variable stand	
Seedling death	
Delayed emergence	
Foliar disease	
Compromised root growth	
Compromised root function	
Decreased early plant growth	

Hypothesis	Model Approach
~~Insufficient soil water recharge following corn~~	Look at soil moisture
Altered nitrogen cycling	
More variable stand	
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Foliar disease	
Compromised root growth	
Compromised root function	
Decreased early plant growth	

Hypothesis	Model Approach
~~Insufficient soil water recharge following corn~~	Look at soil moisture
Altered nitrogen cycling	*In progress*
More variable stand	*In progress*
Seedling death	
Delayed emergence	
Foliar disease	
Compromised root growth	
Compromised root function	
Decreased early plant growth	

Hypothesis	Model Approach
~~Insufficient soil water recharge following corn~~	Look at soil moisture
Altered nitrogen cycling	*In progress*
More variable stand	*In progress*
Seedling death	**Decrease planting density**
Delayed emergence	
Foliar disease	
Compromised root growth	
Compromised root function	
Decreased early plant growth	

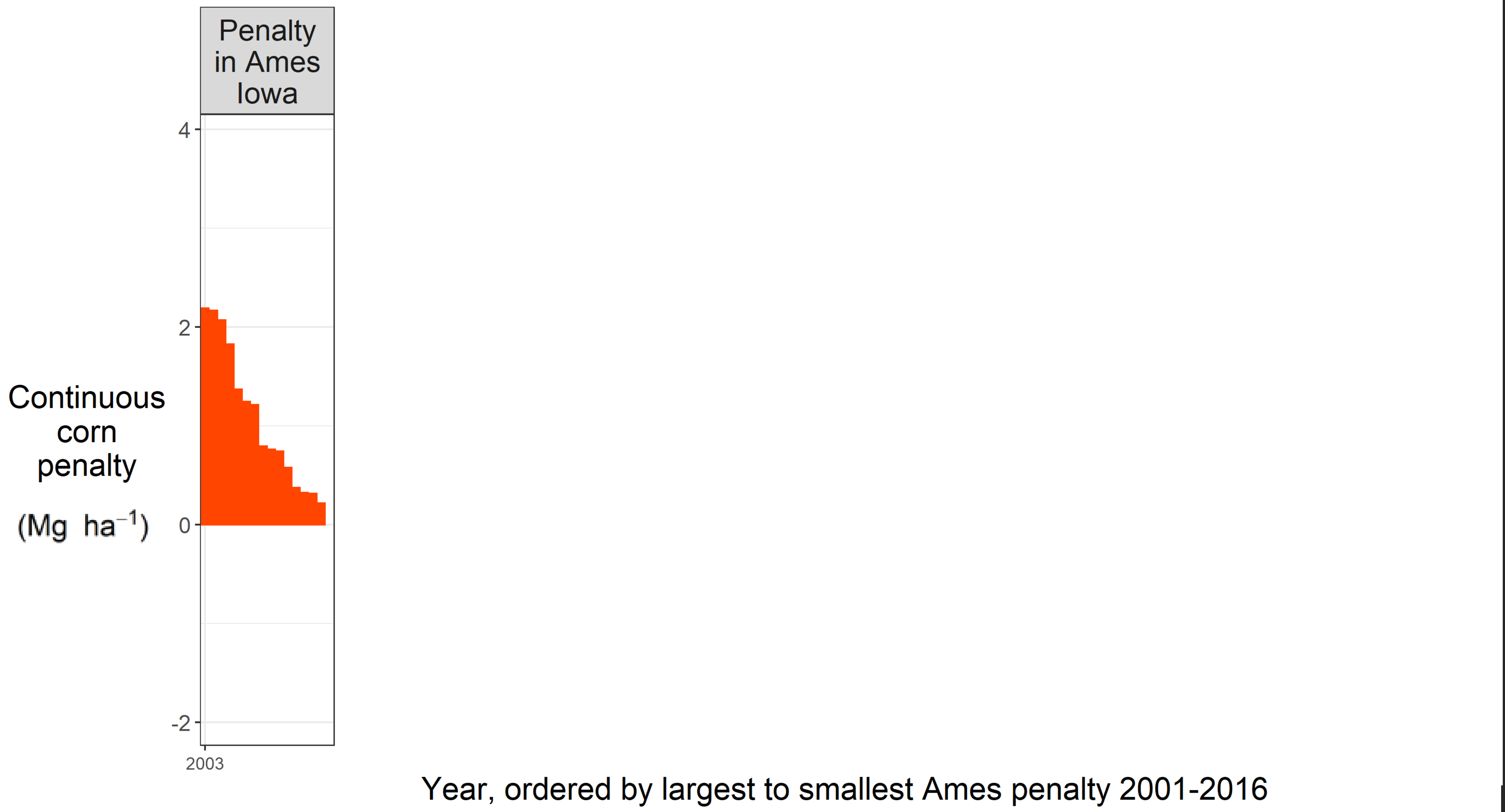
Hypothesis	Model Approach
~~Insufficient soil water recharge following corn~~	Look at soil moisture
Altered nitrogen cycling	*In progress*
More variable stand	*In progress*
Seedling death	Decrease planting density
Delayed emergence	**Increase planting depth**
Foliar disease	
Compromised root growth	
Compromised root function	
Decreased early plant growth	

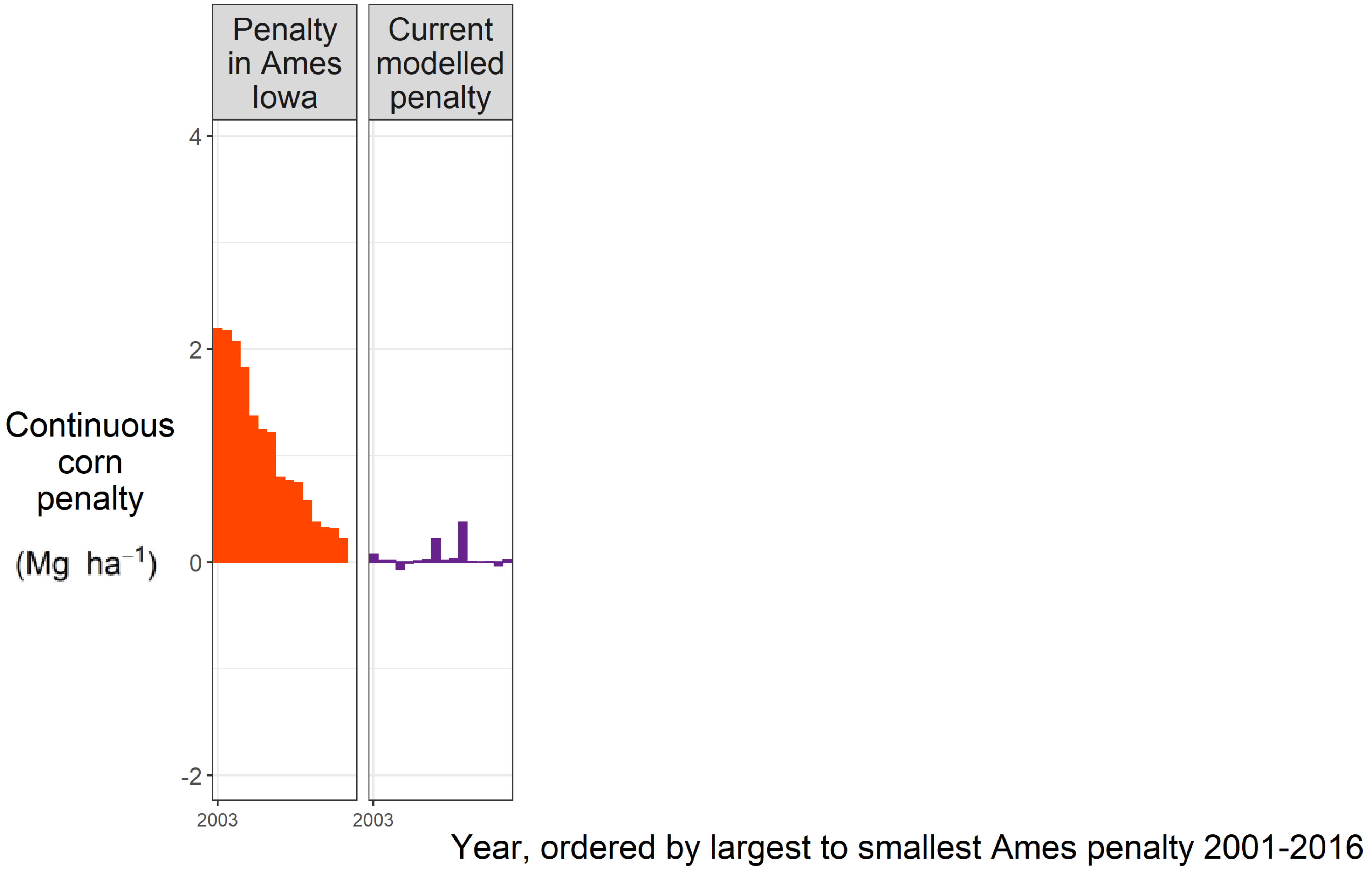
Hypothesis	Model Approach
~~Insufficient soil water recharge following corn~~	Look at soil moisture
Altered nitrogen cycling	*In progress*
More variable stand	*In progress*
Seedling death	Decrease planting density
Delayed emergence	Increase planting depth
Foliar disease	**Decrease RUE**
Compromised root growth	
Compromised root function	
Decreased early plant growth	

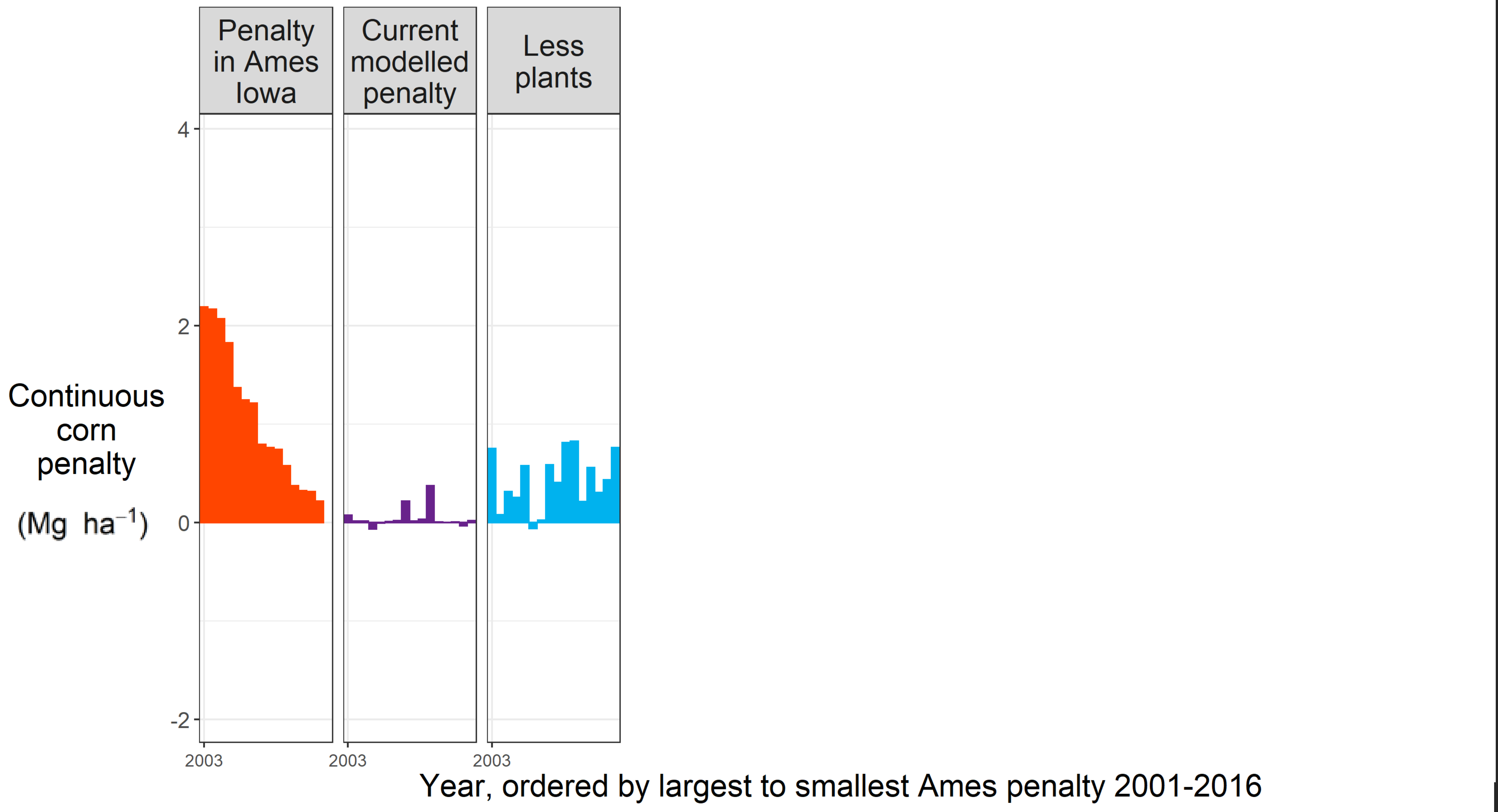
Hypothesis	Model Approach
~~Insufficient soil water recharge following corn~~	Look at soil moisture
Altered nitrogen cycling	*In progress*
More variable stand	*In progress*
Seedling death	Decrease planting density
Delayed emergence	Increase planting depth
Foliar disease	Decrease RUE
Compromised root growth	**Decrease root exploration factor**
Compromised root function	
Decreased early plant growth	

Hypothesis	Model Approach
~~Insufficient soil water recharge following corn~~	Look at soil moisture
Altered nitrogen cycling	*In progress*
More variable stand	*In progress*
Seedling death	Decrease planting density
Delayed emergence	Increase planting depth
Foliar disease	Decrease RUE
Compromised root growth	Decrease root exploration factor
Compromised root function	**Decrease root absorption factor**
Decreased early plant growth	

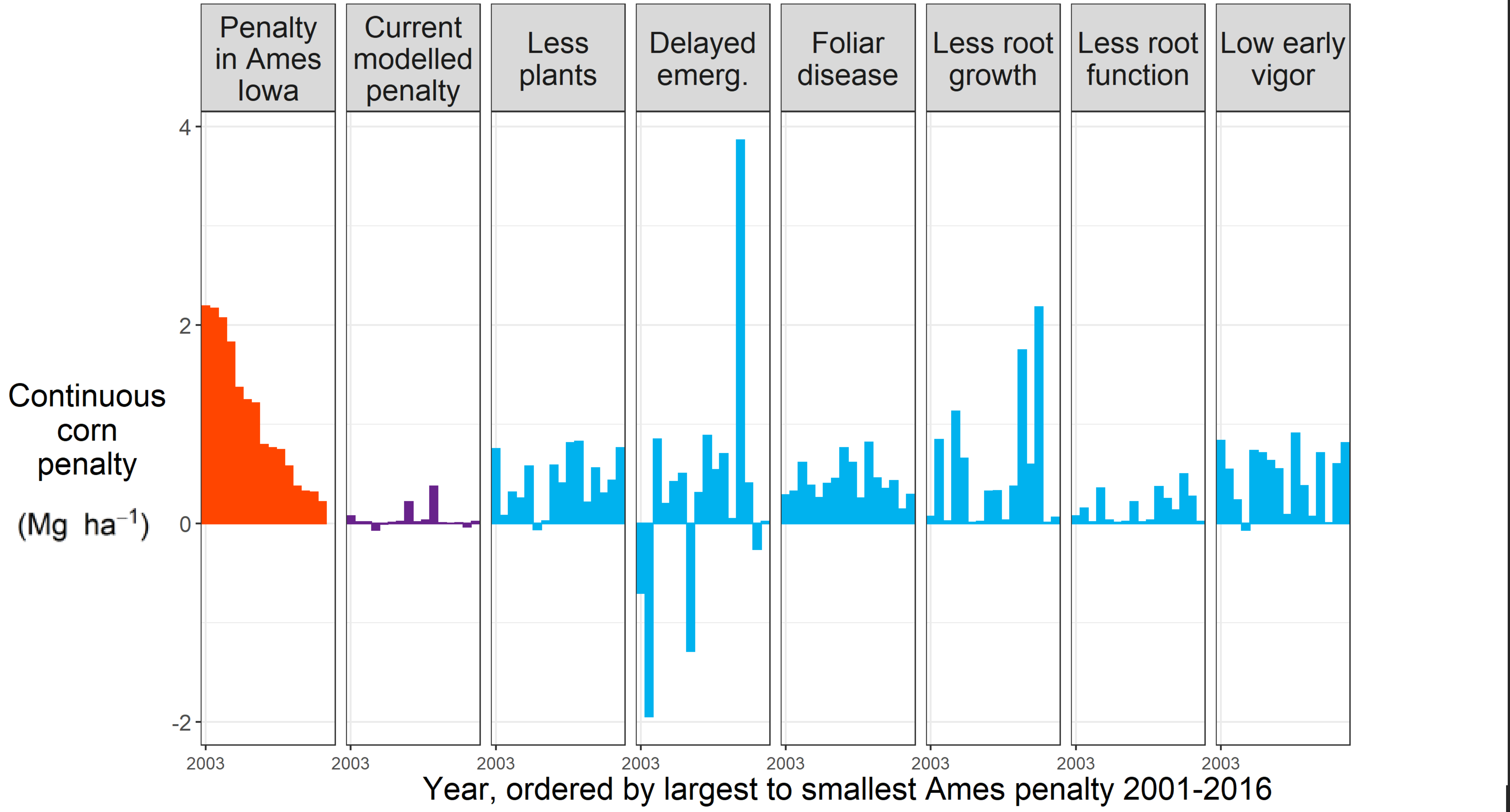
Hypothesis	Model Approach
~~Insufficient soil water recharge following corn~~	Look at soil moisture
Altered nitrogen cycling	*In progress*
More variable stand	*In progress*
Seedling death	Decrease planting density
Delayed emergence	Increase planting depth
Foliar disease	Decrease RUE
Compromised root growth	Decrease root exploration factor
Compromised root function	Decrease root absorption factor
Decreased early plant growth	**Decrease maximum kernel number**

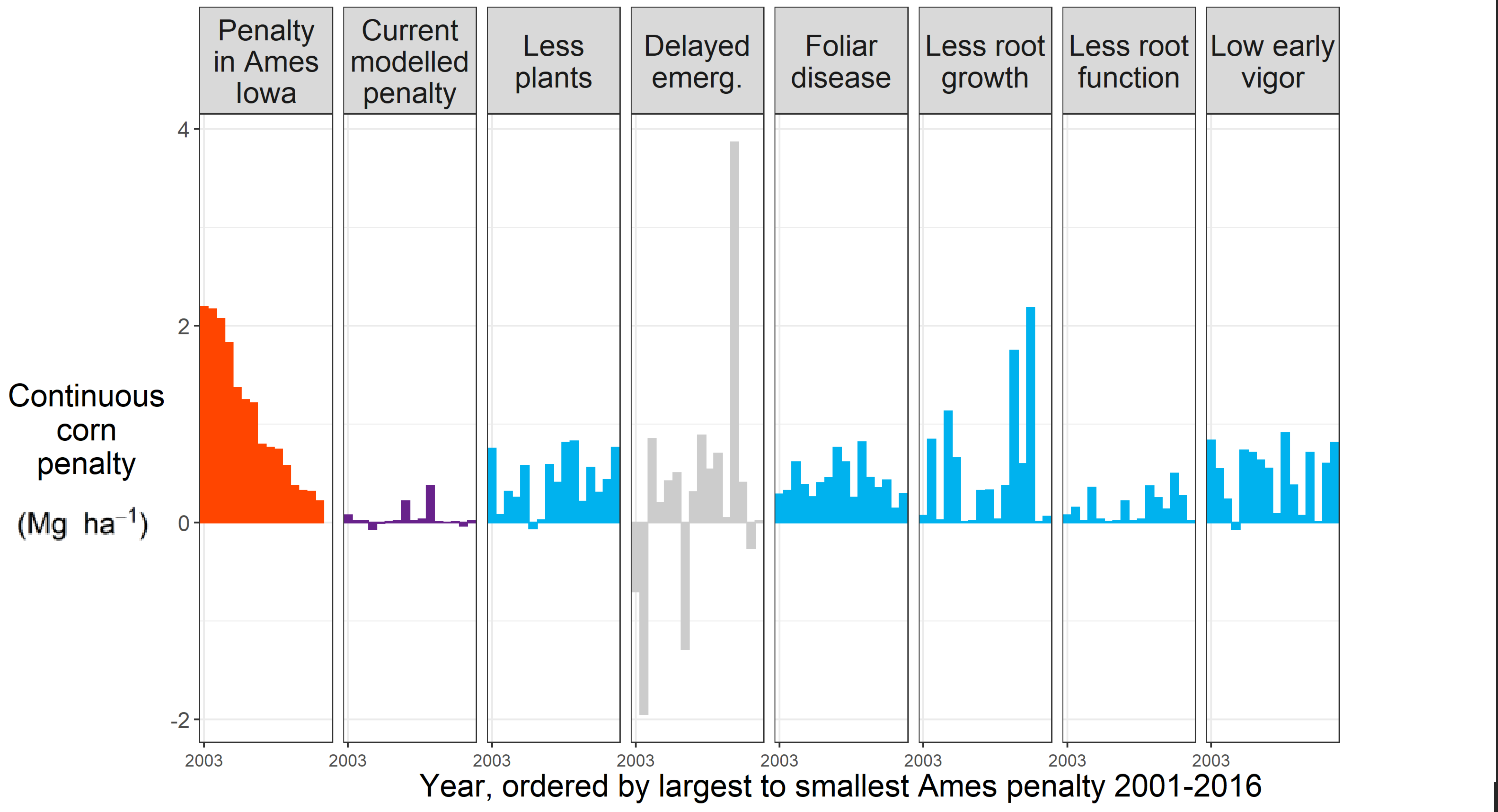

Penalty in Ames Iowa
Continuous corn penalty
(Mg ha^{-1})
4
2
0
-2
2003
Year, ordered by largest to smallest Ames penalty 2001-2016

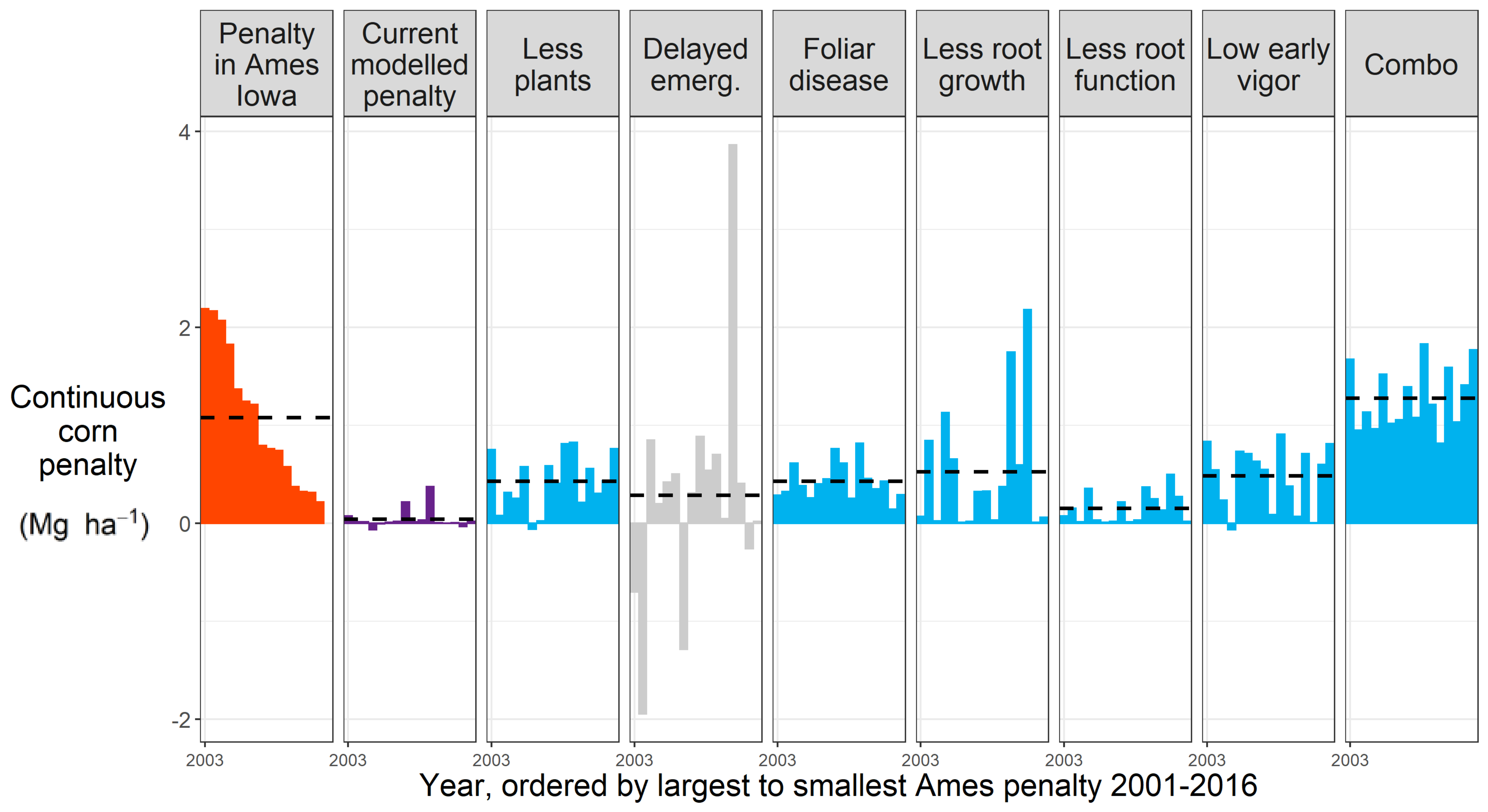

Penalty in Ames Iowa
Current modelled penalty
Continuous corn penalty
(Mg ha⁻¹)
4
2
0
-2
2003
2003
Year, ordered by largest to smallest Ames penalty 2001-2016



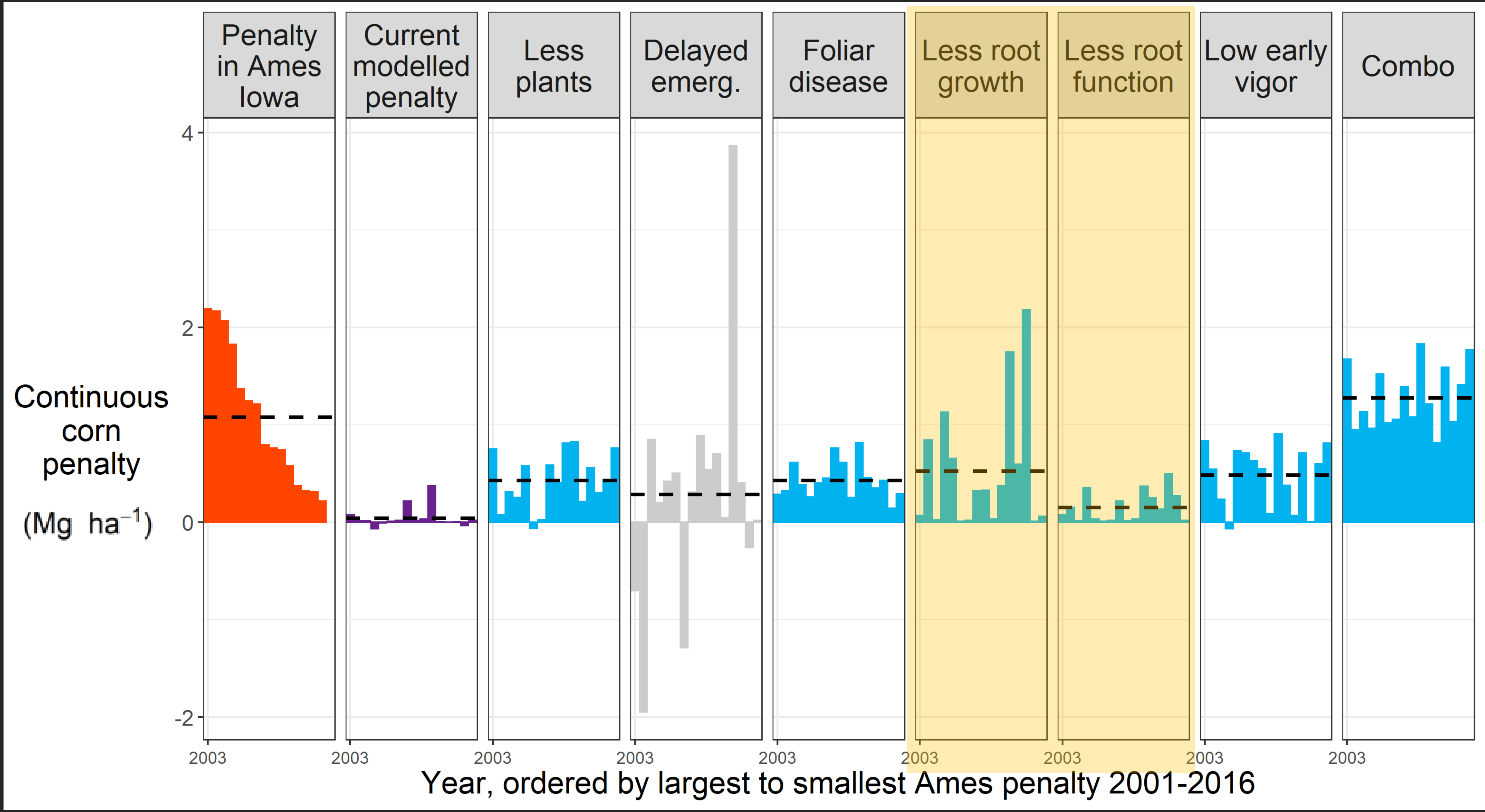
Penalty in Ames Iowa
Current modelled penalty
Less plants
Continuous corn penalty
(Mg ha^{-1})
4
2
0
-2
2003
2003
2003
Year, ordered by largest to smallest Ames penalty 2001-2016


Penalty in Ames Iowa
Current modelled penalty
Less plants
Delayed emerg.
Foliar disease
Less root growth
Less root function
Low early vigor
Continuous corn penalty
(Mg ha⁻¹)
4
2
0
-2
2003
Year, ordered by largest to smallest Ames penalty 2001-2016


Penalty in Ames Iowa
Current modelled penalty
Less plants
Delayed emerg.
Foliar disease
Less root growth
Less root function
Low early vigor
Continuous corn penalty
(Mg ha^{-1})
4
2
0
-2
2003
Year, ordered by largest to smallest Ames penalty 2001-2016



Penalty in Ames Iowa
Current modelled penalty
Less plants
Delayed emerg.
Foliar disease
Less root growth
Less root function
Low early vigor
Combo
Continuous corn penalty
(Mg ha^{-1})
4
2
0
-2
2003
Year, ordered by largest to smallest Ames penalty 2001-2016



Penalty in Ames Iowa
Current modelled penalty
Less plants
Delayed emerg.
Foliar disease
Less root growth
Less root function
Low early vigor
Combo
Continuous corn penalty
(Mg ha-1)
4
2
0
-2
2003
Year, ordered by largest to smallest Ames penalty 2001-2016

The Continuous Corn Penalty

- *Maximum rooting depth, specific root length*
- *Growth analysis*
- *Yield components*
- *Surface residue at planting*

A Side Note

How can agriculture be done such that

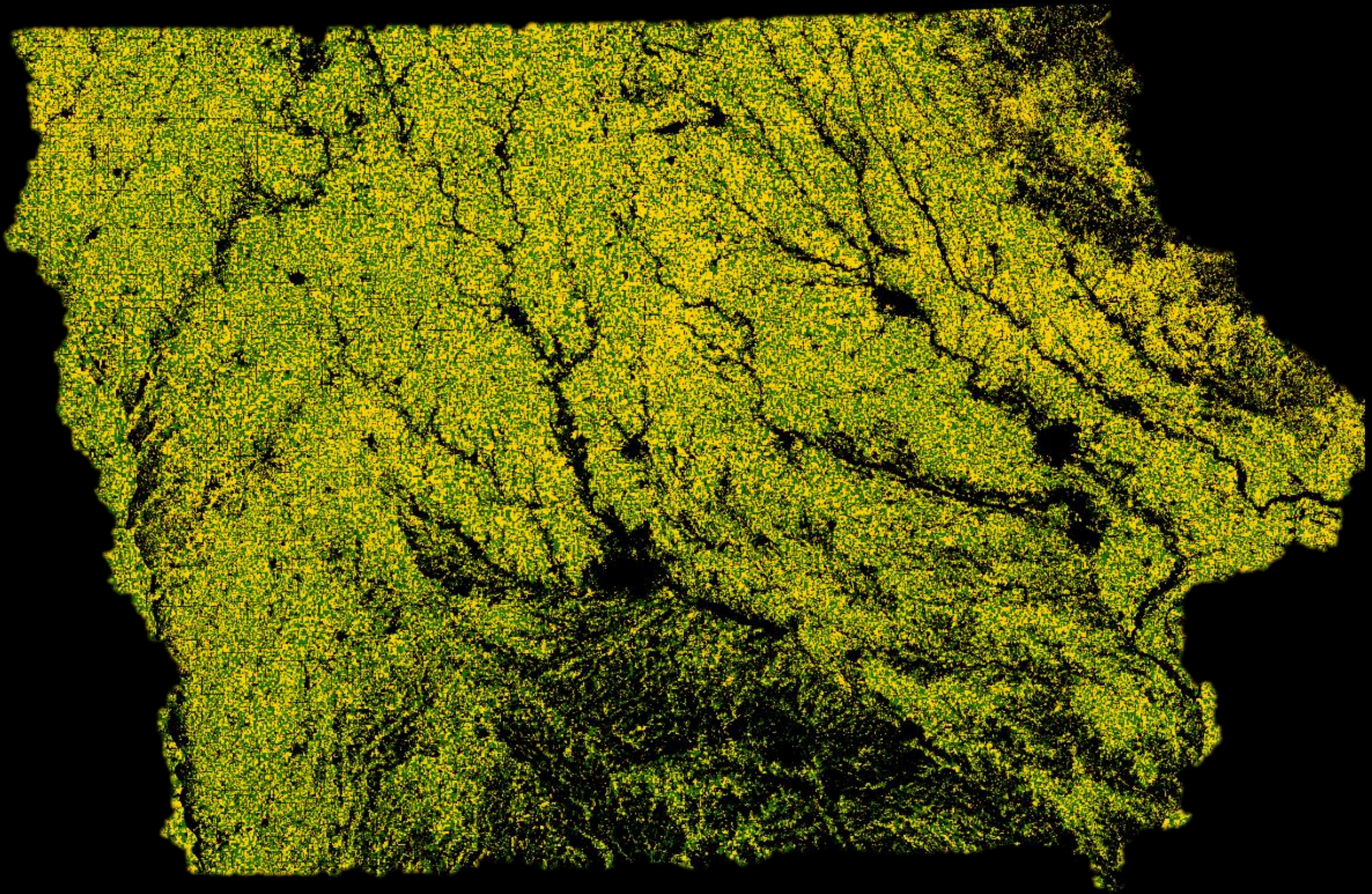
the farmer,

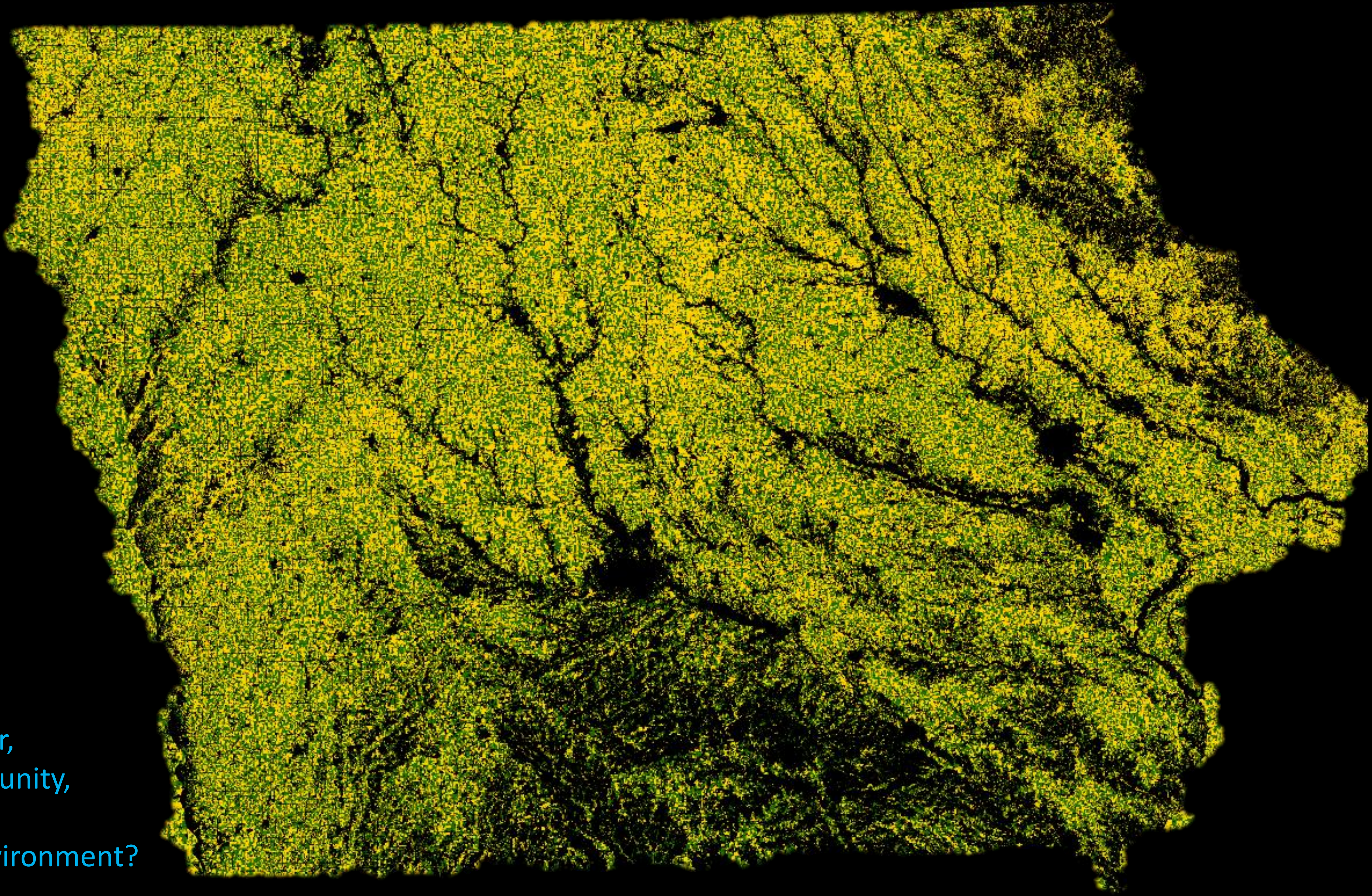
their community,

society,

and the environment…

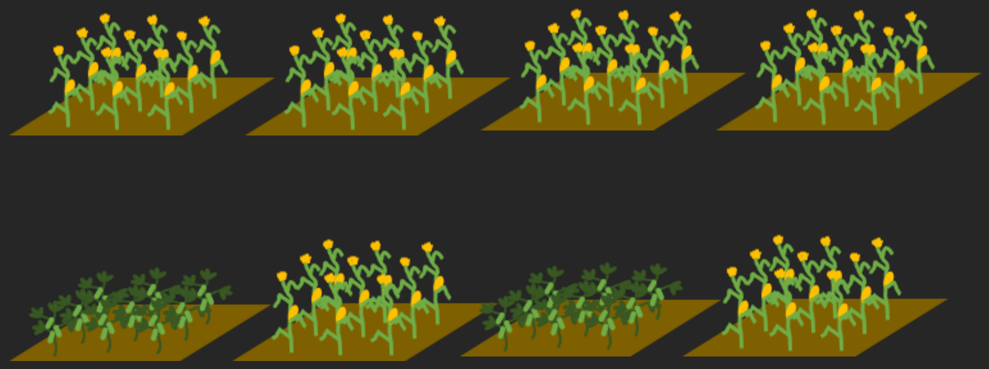
…all benefit?

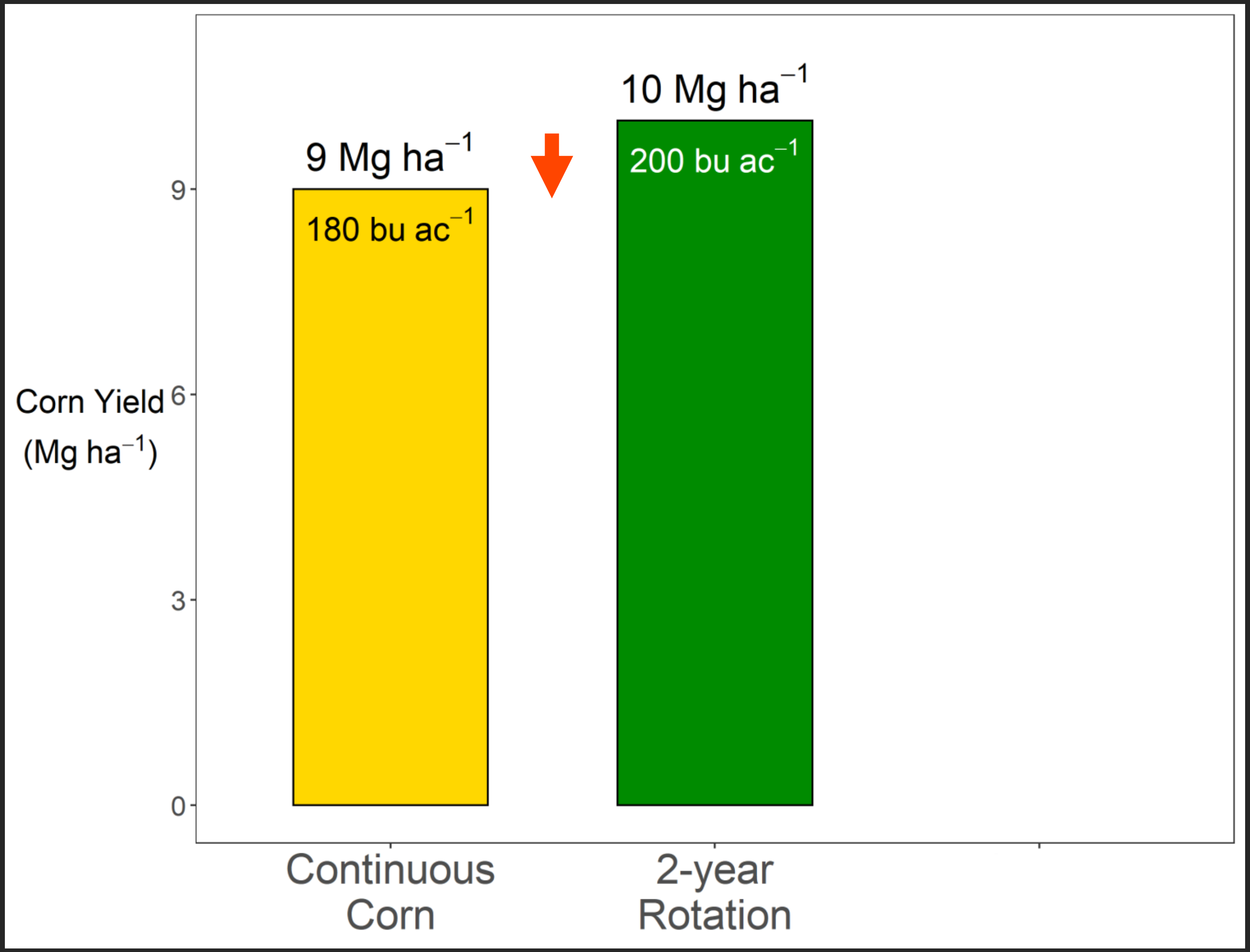




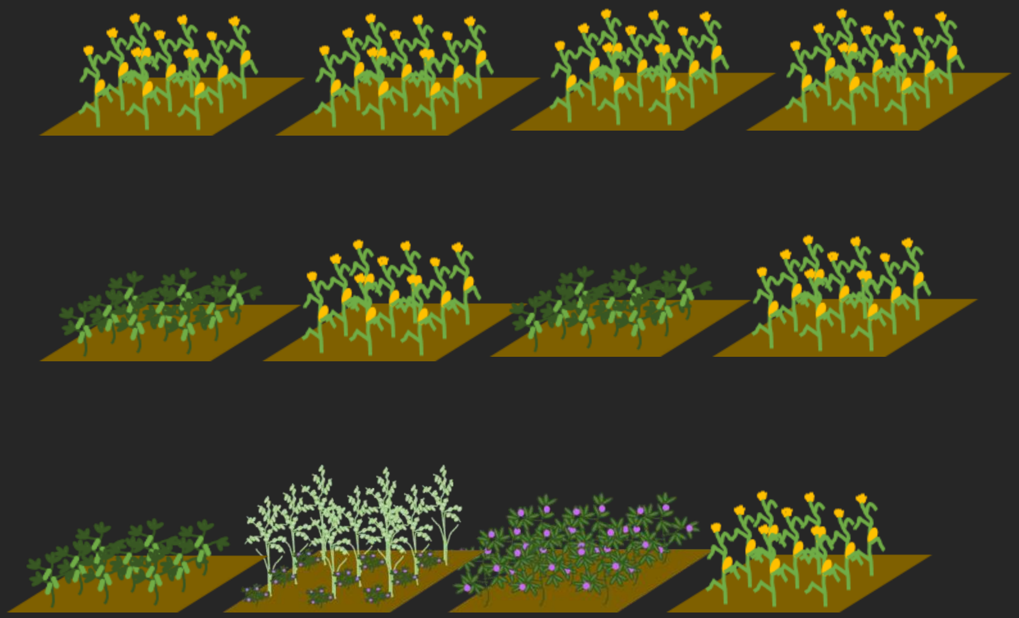
…the farmer,
their community,
society,
and the environment?

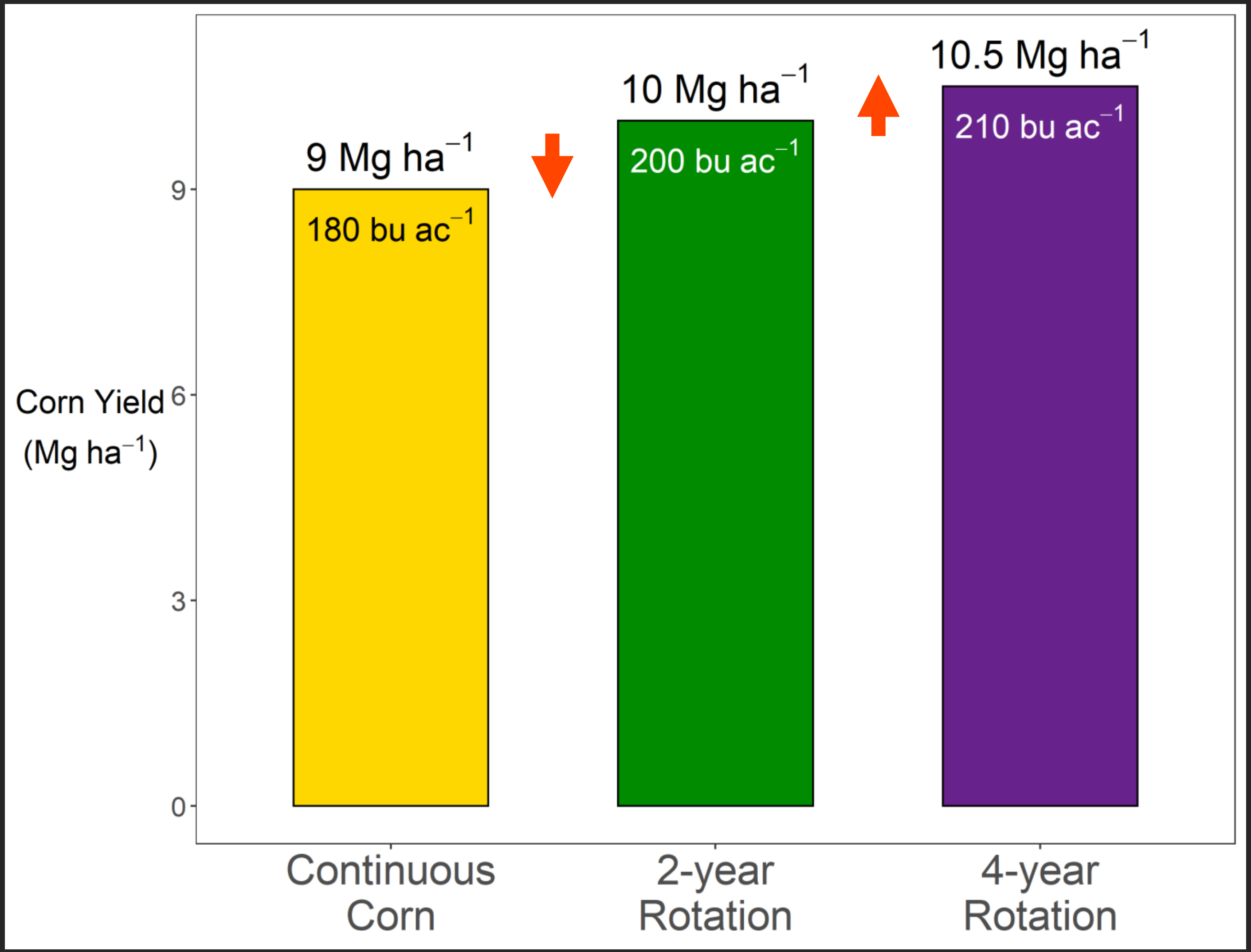
What if we grew more crops?





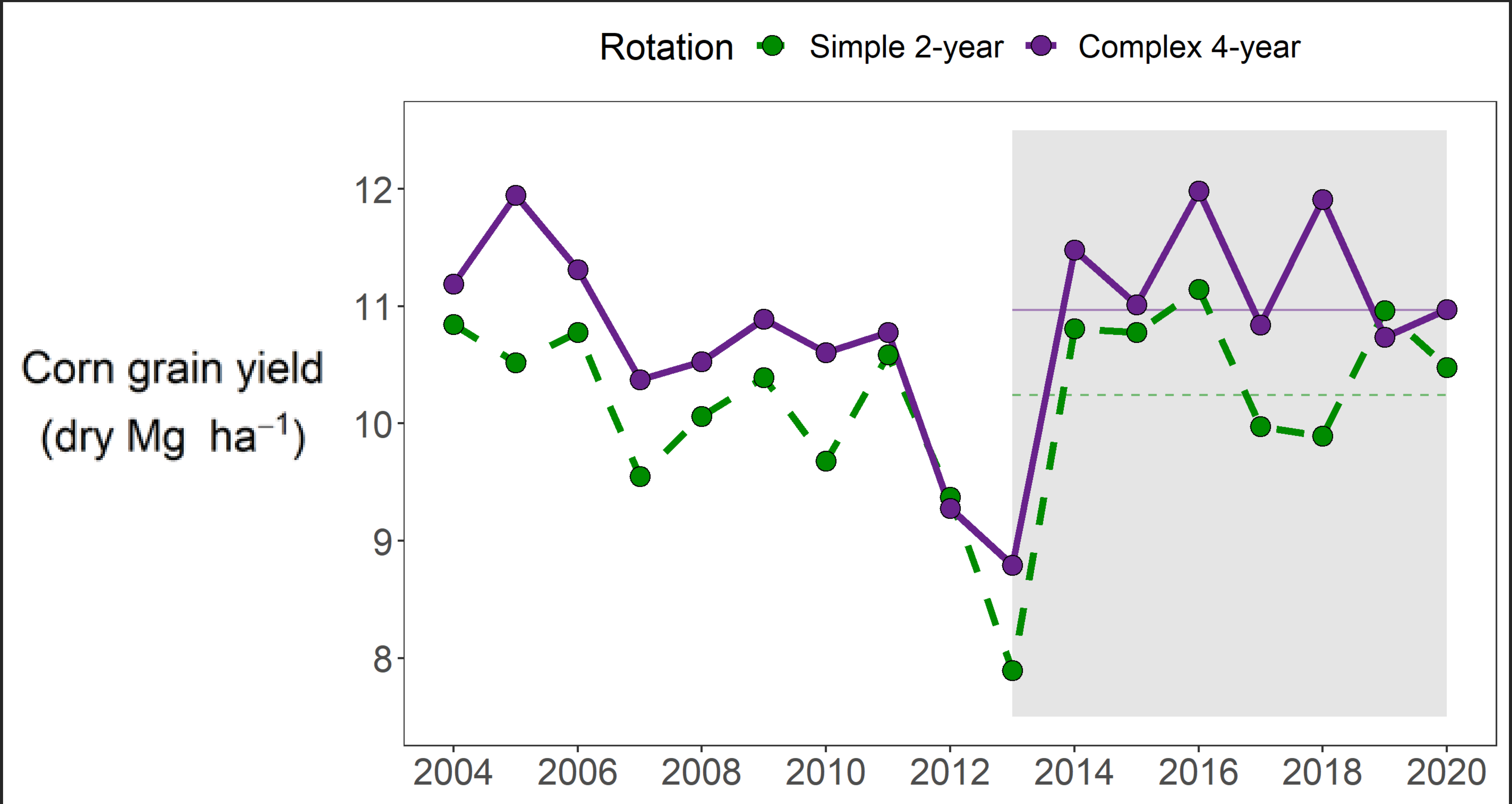
Corn Yield (Mg ha^{-1})
0
3
6
9
9 Mg ha^{-1}
180 bu ac^{-1}
10 Mg ha^{-1}
200 bu ac^{-1}
Continuous Corn
2-year Rotation





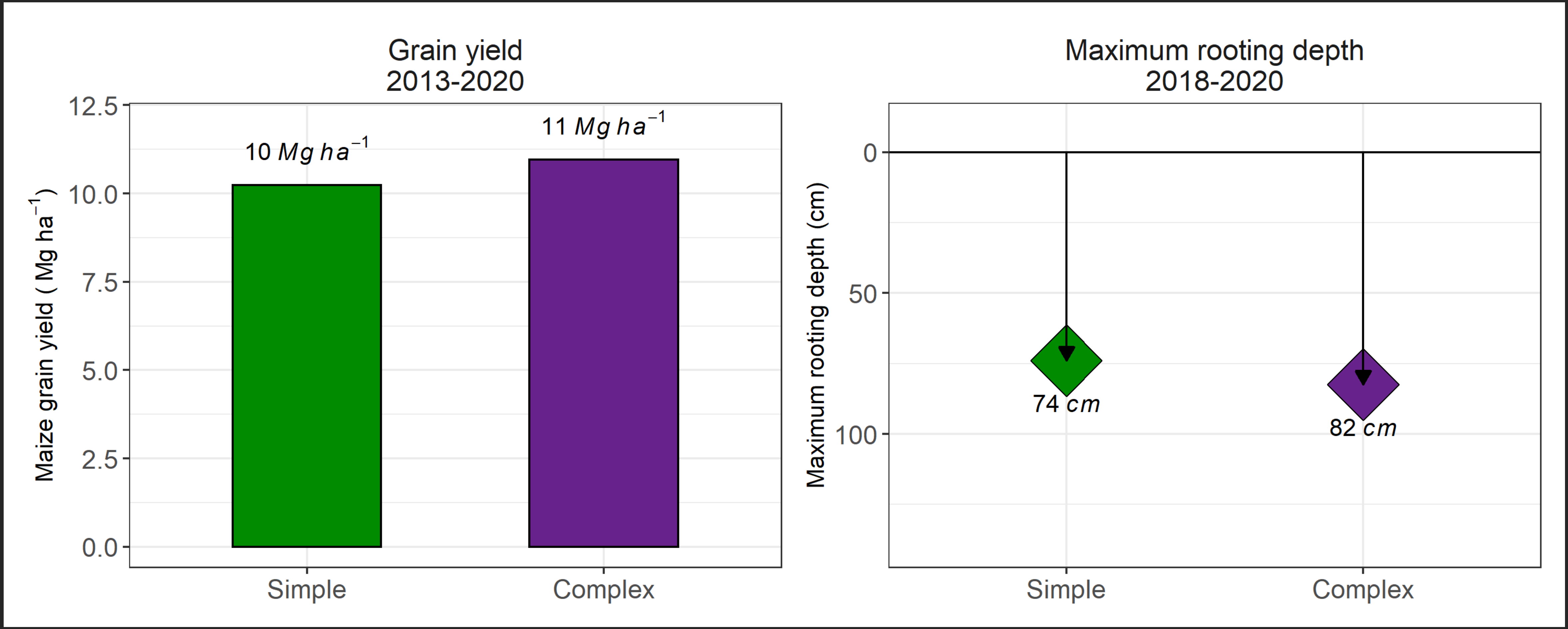
9 Mg ha^{-1}
180 bu ac^{-1}
10 Mg ha^{-1}
200 bu ac^{-1}
10.5 Mg ha^{-1}
210 bu ac^{-1}
Corn Yield (Mg ha^{-1})
0
3
6
9
Continuous Corn
2-year Rotation
4-year Rotation

The Rotation Effect


Rotation
Simple 2-year
Complex 4-year
Corn grain yield
(dry Mg ha^{-1})
12
11
10
9
8
2004
2006
2008
2010
2012
2014
2016
2018
2020

Suite of field measurements

- Grain yields
- Above ground biomass
- 500-kernel weights
- Residue
- Soil macro/micronutrient analysis 0-1 m depth
- Soil penetration resistance
- Soil moisture
- Depth to water table
- Rooting depth
- Root mass



Grain yield
2013-2020
Maize grain yield (Mg ha^{-1})
12.5
10.0
7.5
5.0
2.5
0.0
10 $Mg\,ha^{-1}$
11 $Mg\,ha^{-1}$
Simple
Complex
Maximum rooting depth
2018-2020
Maximum rooting depth (cm)
0
50
100
74 cm
82 cm
Simple
Complex

The Rotation Effect

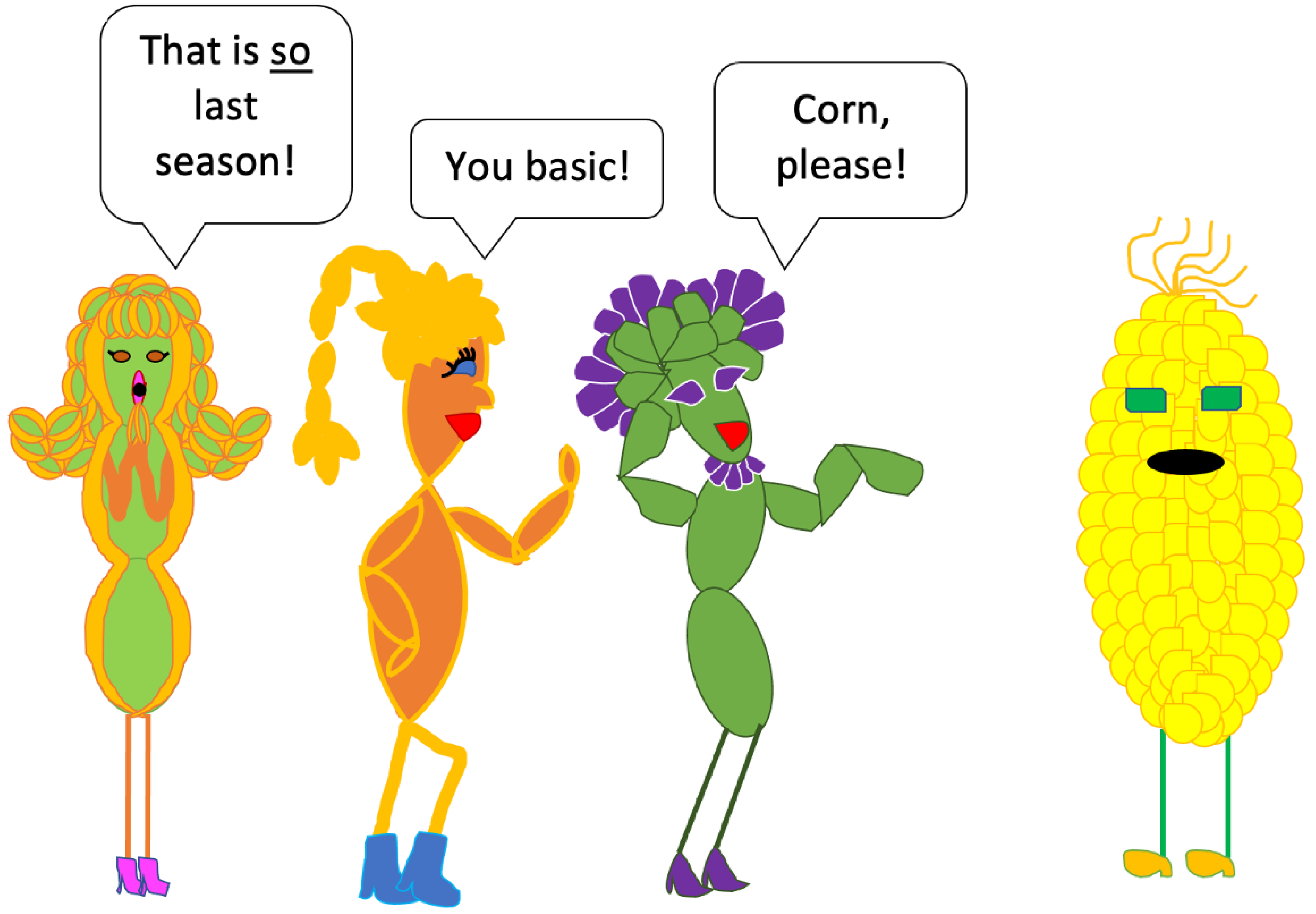
- *Deeper, cheaper roots*
- *Not clear if it’s physical, chemical, and/or biological*
- *Corn plant is more resilient?*


Anything but simple.

Anything but simple.

…the farmer,
their community,
society,
and the environment?

Created by Heather Pasley



Bonus slides...

2018-present

8. ***Nichols*** *et al. (in prep) Roots as drivers of the rotation effect in maize?*

7. ***Nichols*** *et al. (in prep) Using models to unravel causal mechanisms of the continuous maize penalty*

6. ***Nichols*** *& MacKenzie (in prep) Decision analysis to target cover crop research priorities in Central Iowa*

5. Nichols et al. (in review) Winter cover cropping effects on soil water storage vary by site: Field measurements and a proposed causal model

4. Nichols et al. (2020). Effect of long-term cover-cropping on weed seedbanks. *Frontiers in Agronomy*

3. Nichols et al. (2020) Cover crops and weed suppression in the U.S. Midwest: A meta-analysis and modeling study. *Agricultural and Environmental Letters*

2. Weisberger*, **Nichols***, Liebman (2019) Does diversifying crop rotations suppress weeds? A meta-analysis. *PloS one*

1. Nichols et al. (2019) Maize root distributions strongly associated with water tables in Iowa, USA *Plant and Soil*

5. Bird, **Nichols,** et al. (in review). Means, motive, and opportunity: A stakeholder analysis method to understand likelihood of action in food-energy-water systems. *Elementa*

4. Pasley, **Nichols,** et al. (2021). Rotating maize reduces the risk and rate of nitrate leaching. *Environmental Research Letters.*

3. Archontoulis, Castellano, Licht, **Nichols**, et al. (2020) Predicting crop yields and soil-plant nitrogen dynamics in the US Corn Belt. *Crop Science*

2. Liebman & **Nichols** (2020) Cropping system redesign for improved weed management: A modeling approach illustrated with giant ragweed (*Ambrosia trifida*). *Agronomy*

1. Martinez-Feria, **Nichols**, et al. (2019) Can multi-strategy management stabilize nitrate leaching under increasing rainfall? *Environmental Research Letters*

table of some years effects?

DataFEWSion Traineeship

Henry A. Wallace Chair for Sustainable Agriculture


New Orleans

Matt Liebman
Professor
Agronomy Dept.
Iowa State University

Sotirios Archontoulis
Associate Professor
Agronomy Dept.
Iowa State University

Mike Castellano
Associate Professor
Agronomy Dept.
Iowa State University

Jerry Hatfield
Fomer Laboratory Director
National Lab for Ag & the Env
USDA (retired!)

Neil Huth
Principal Research Scientist
CSIRO, Australia

Jarad Niemi
Associate Professor
Statistics Depart.
Iowa State University

Archontoulis Lab (past and present)

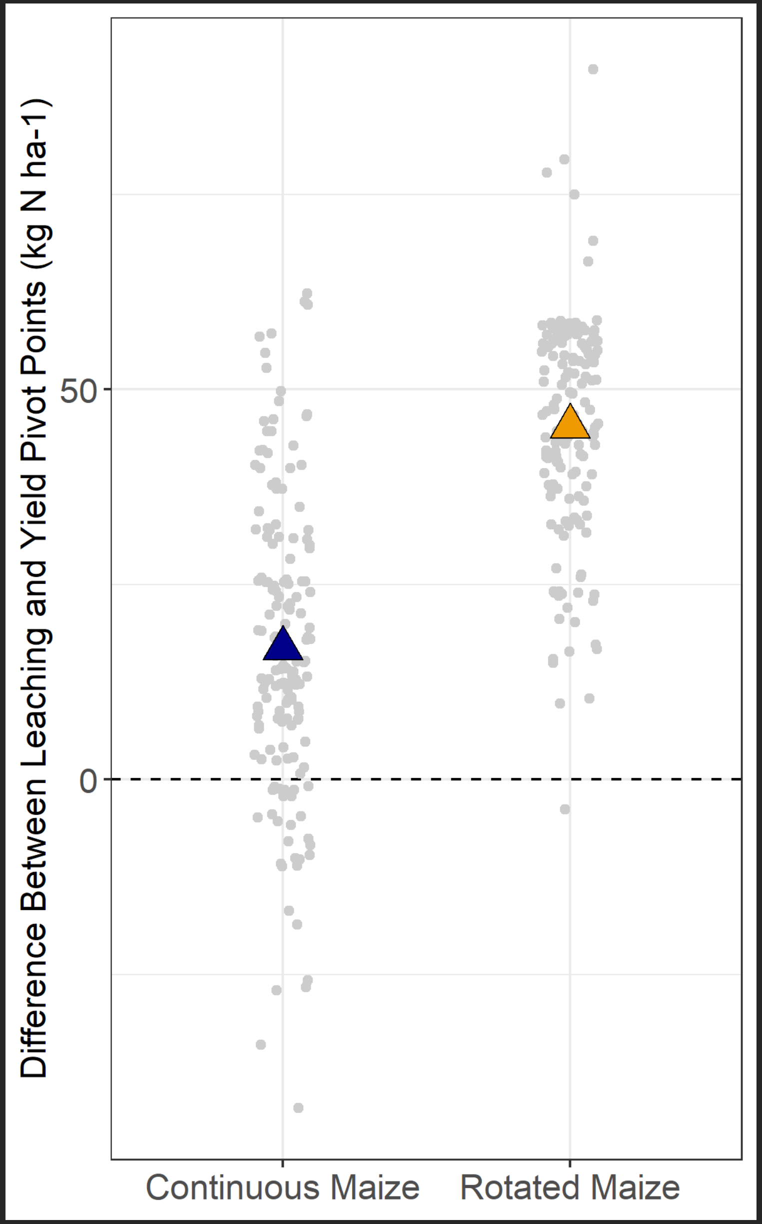
Liebman Lab (past and present)

Miguez Lab + Theo

Stefan Gailans, Lydia English, Sarah Carlson, Ranae Dietzel, Fernando Miguez, Philip Dixon, Katherine Goode, Miranda Tilton, Heike Hofman, Mitch Baum, Caio dos Santos, Jess Nelson

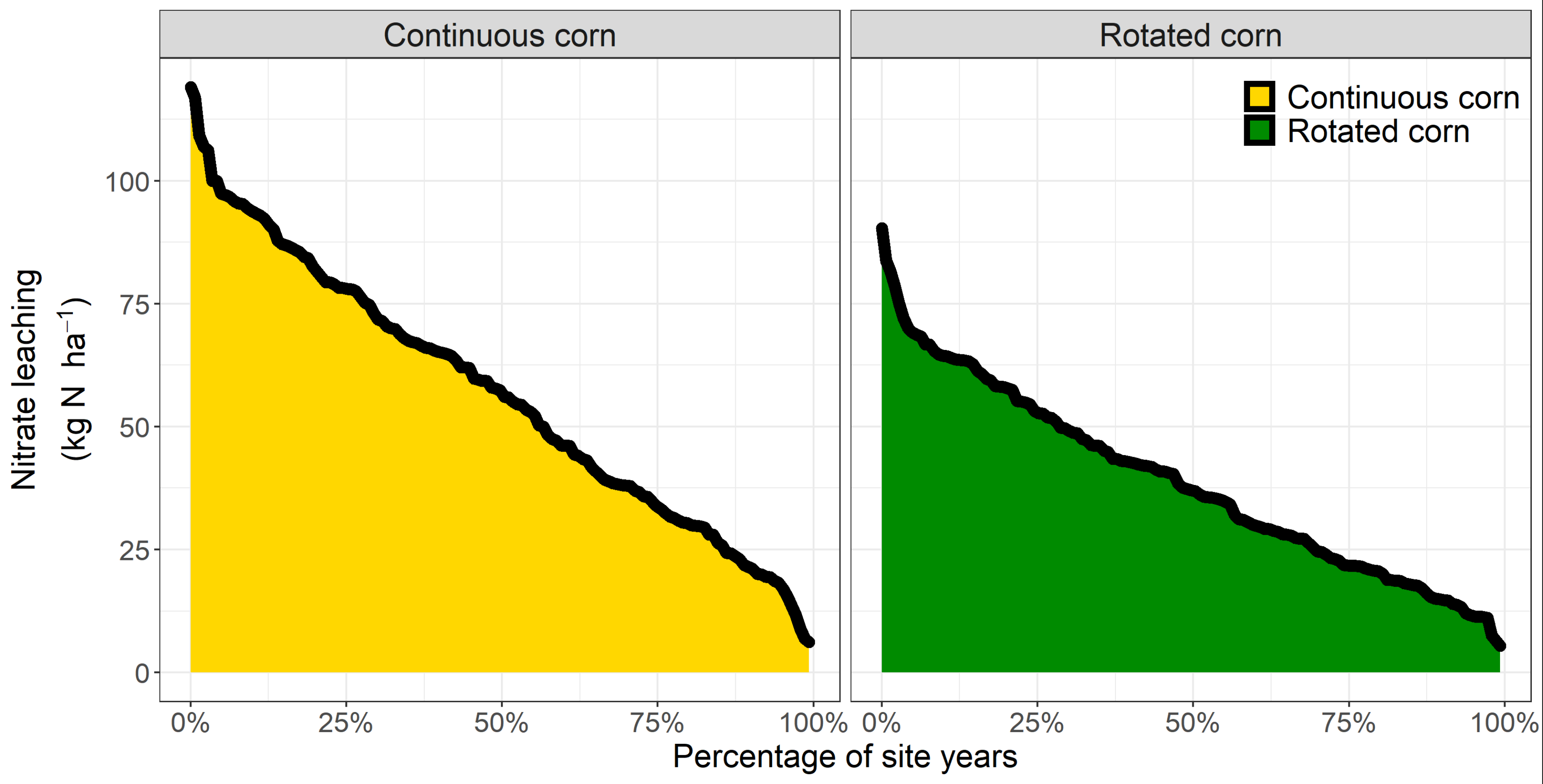
Mary D, Deb, Kevin, Mary Anne, Rita, Patrick, Michelle, Cynthia, the friendly building staff of Agronomy Hall

Extras



Difference Between Leaching and Yield Pivot Points (kg N ha-1)
50
0
Continuous Maize
Rotated Maize

8 sites, 151 site-years, modeled nitrate leaching at 150 and 200 kg N application



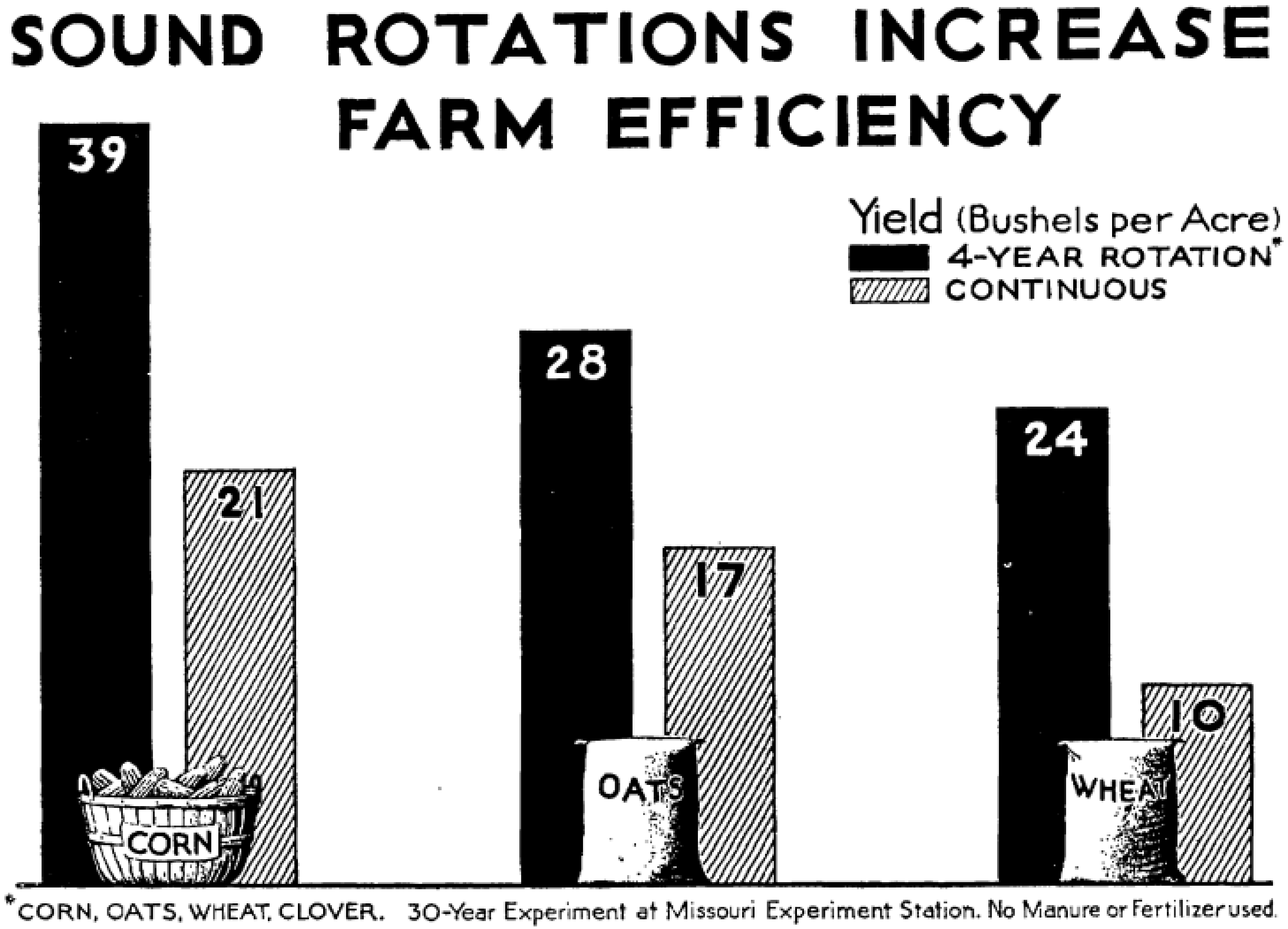
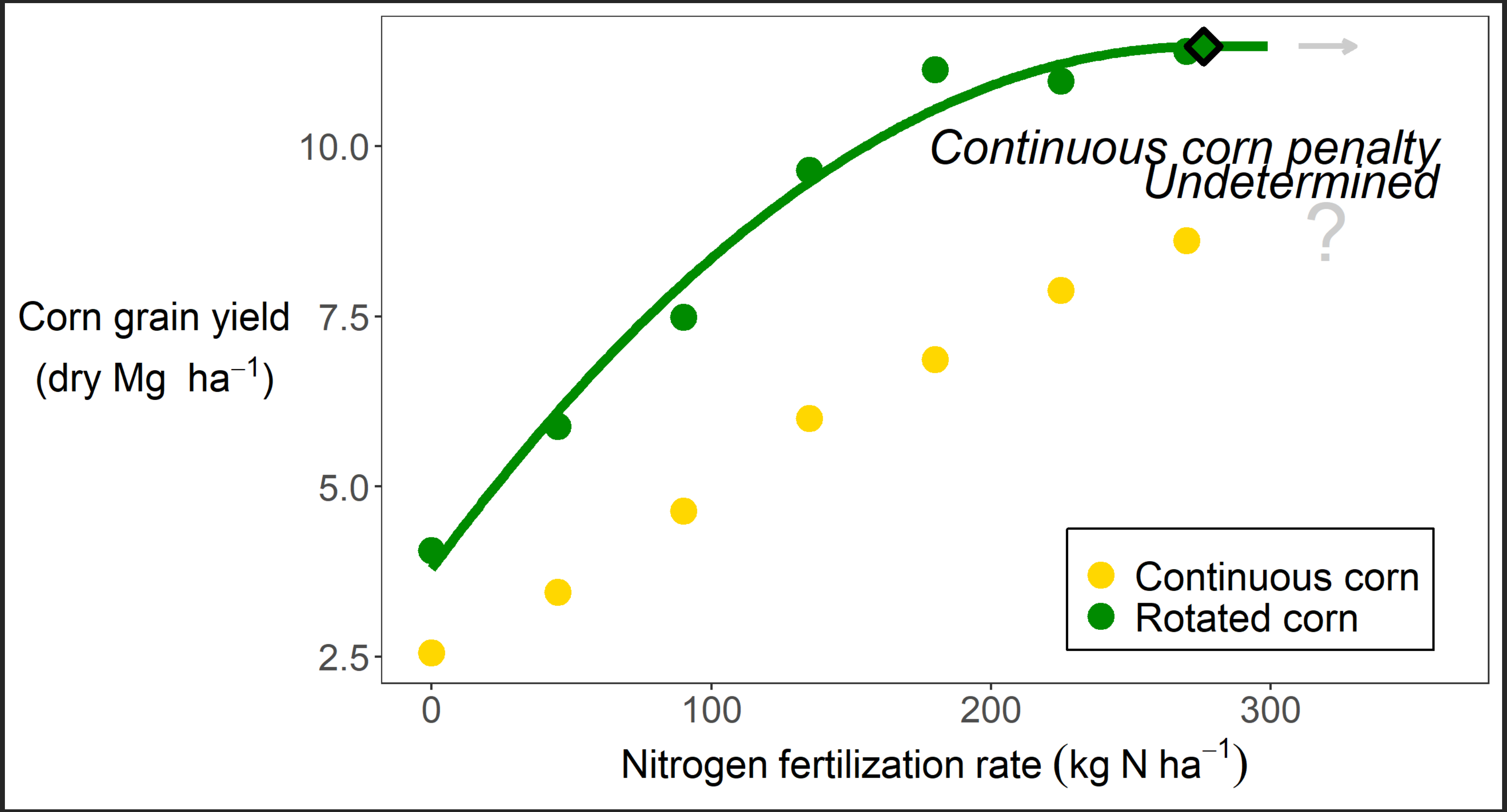
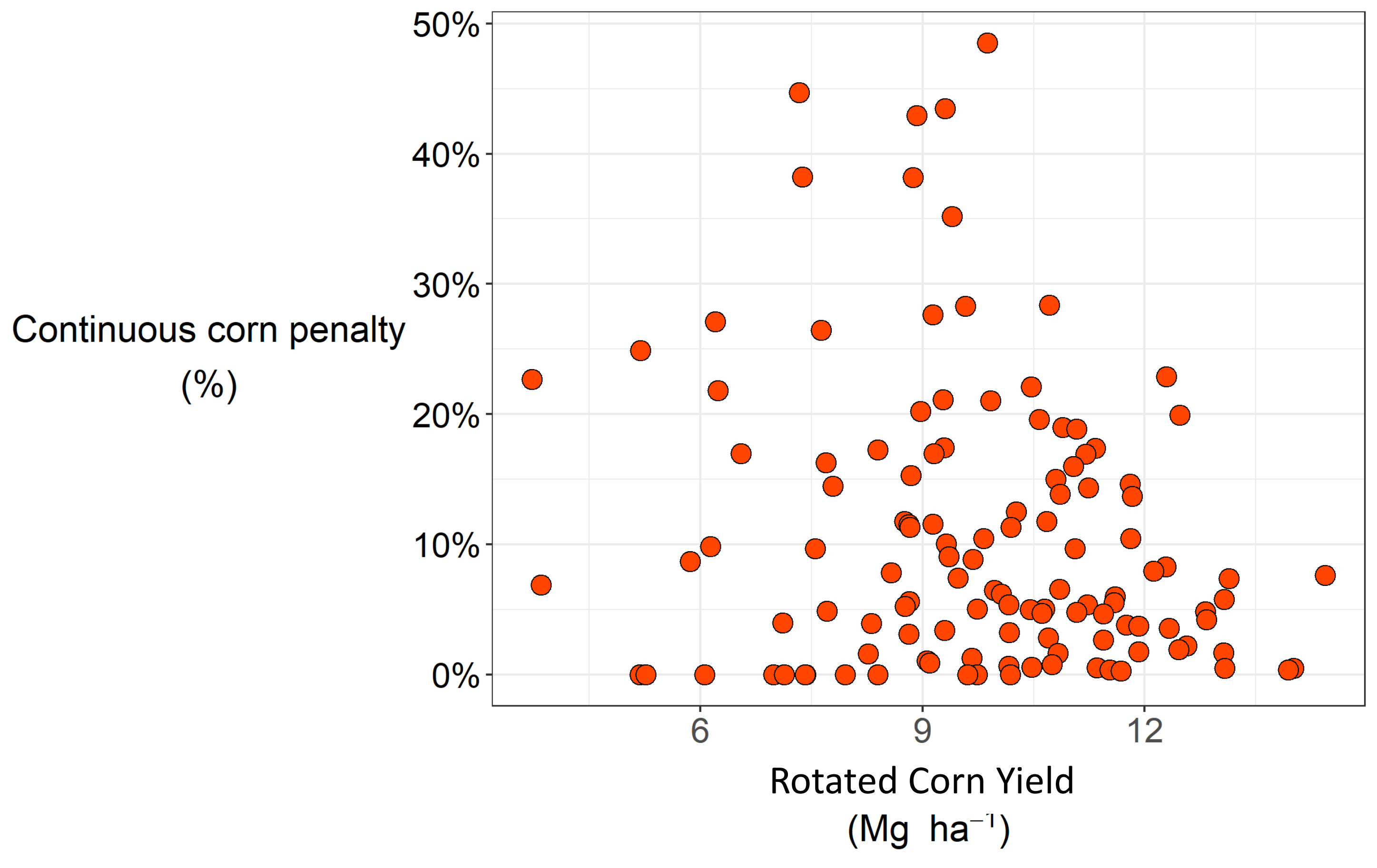


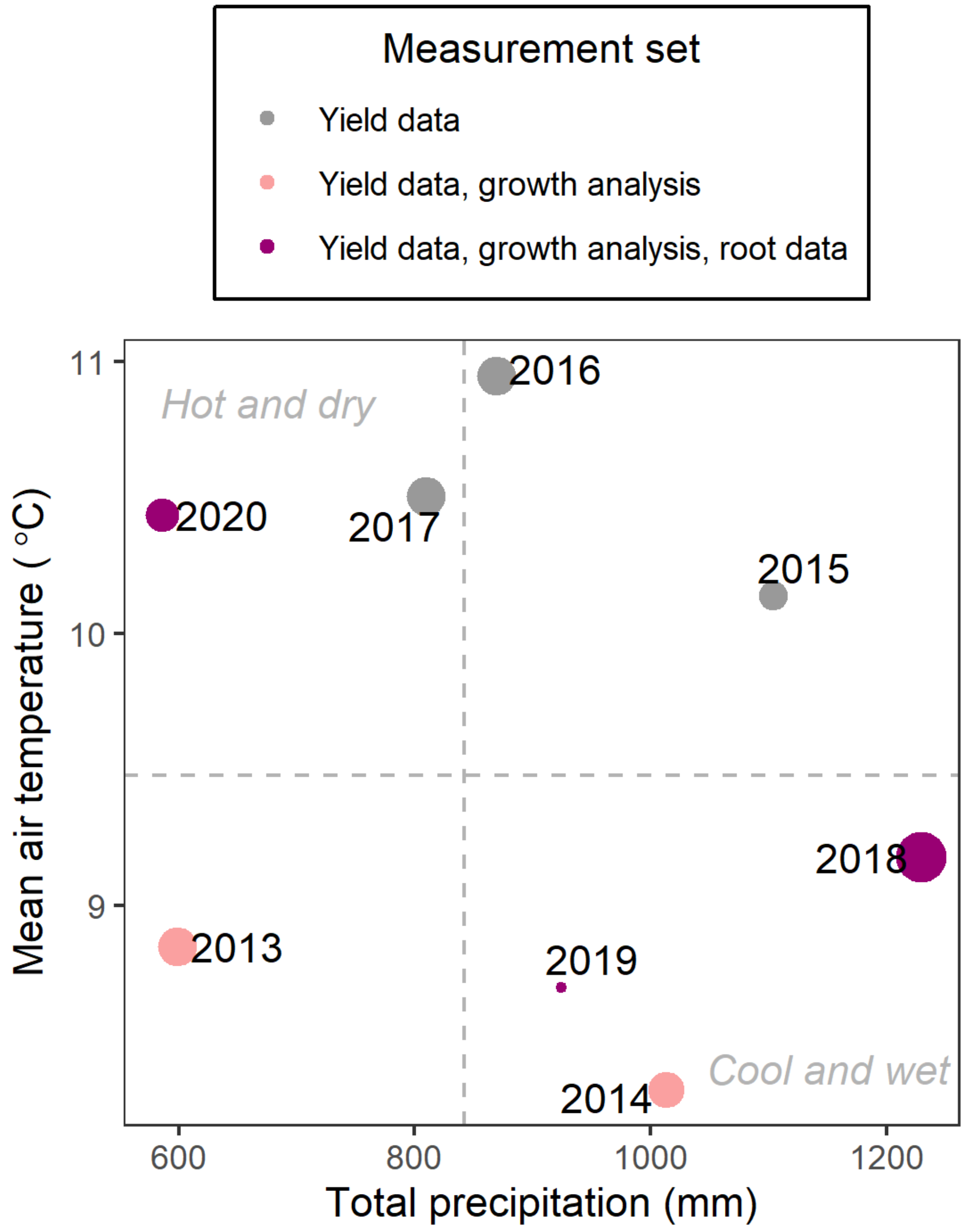
FIGURE 1.—Average yields of corn, oats, and wheat in a 4-year rotation and continuously cropped at the Missouri Agricultural Experiment Station.

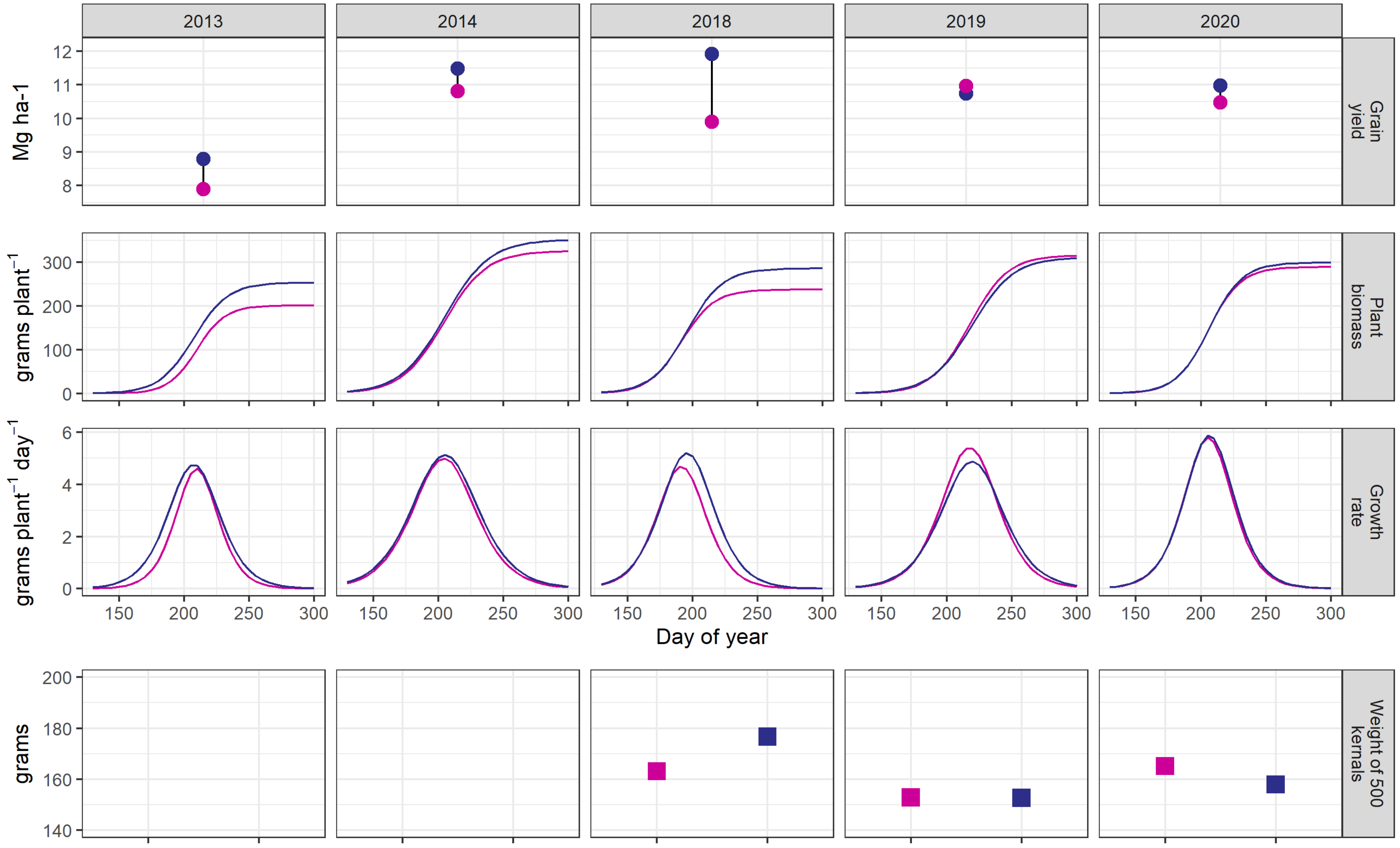
Example of undetermined penalty



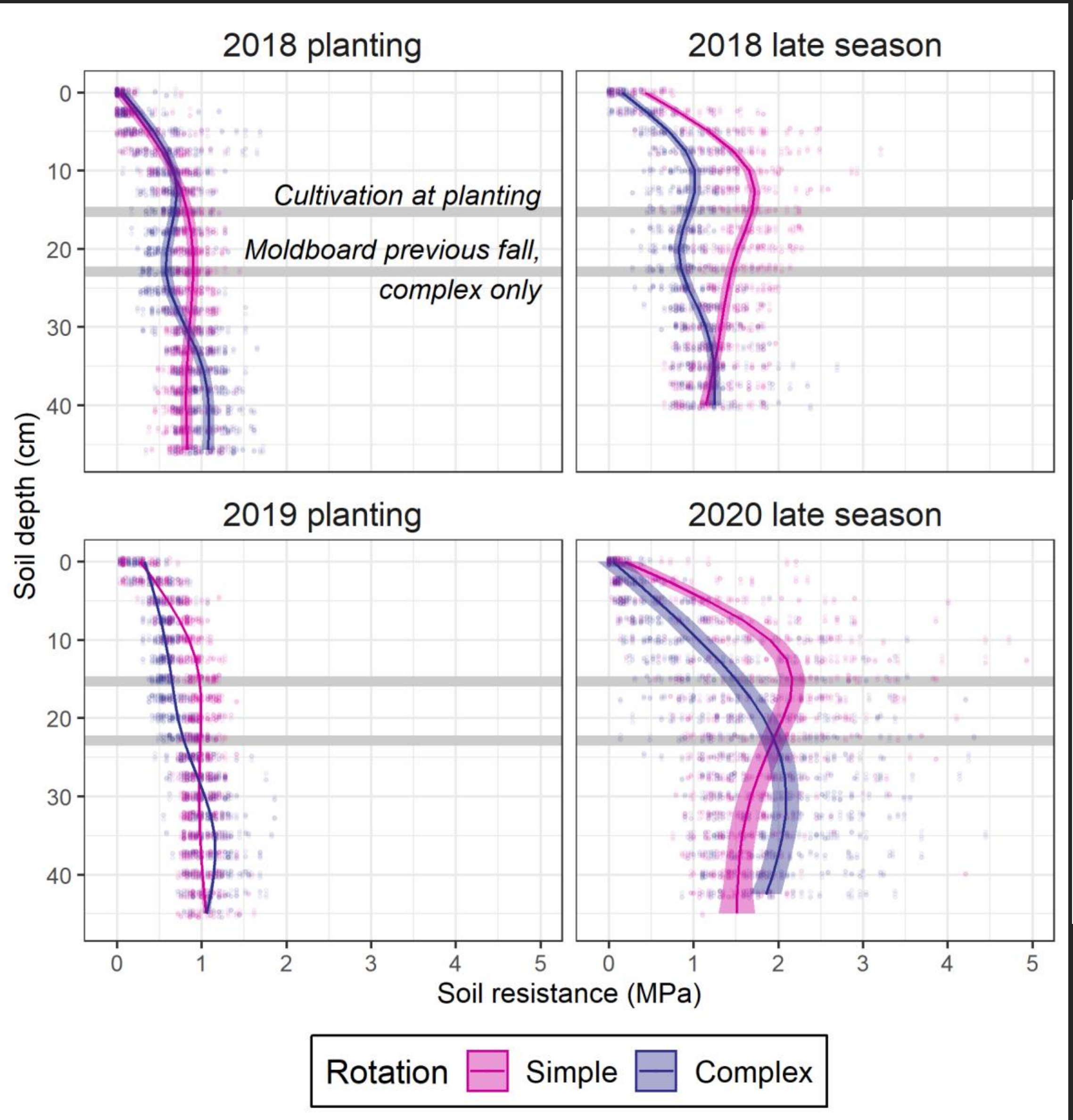
Penalty (%) not related to environmental yield potential

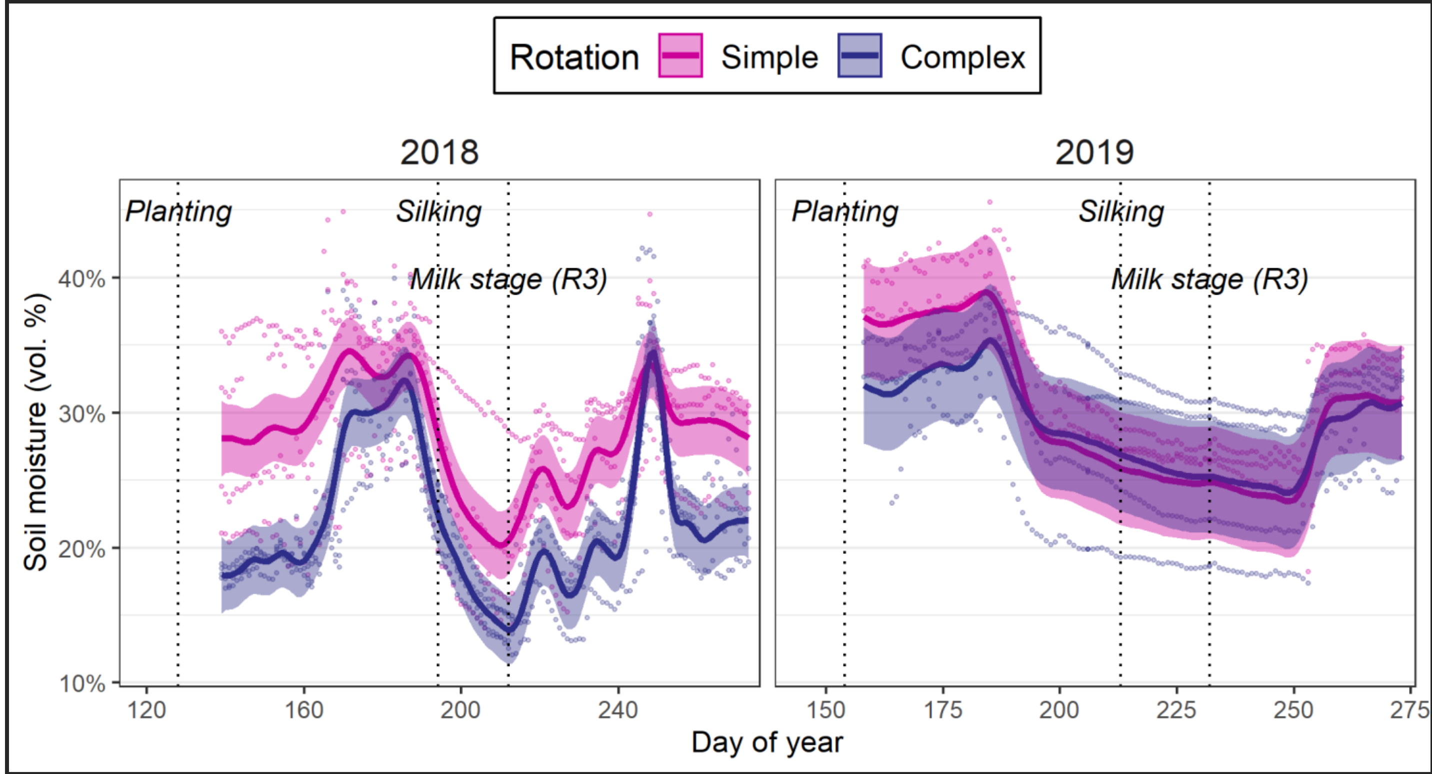


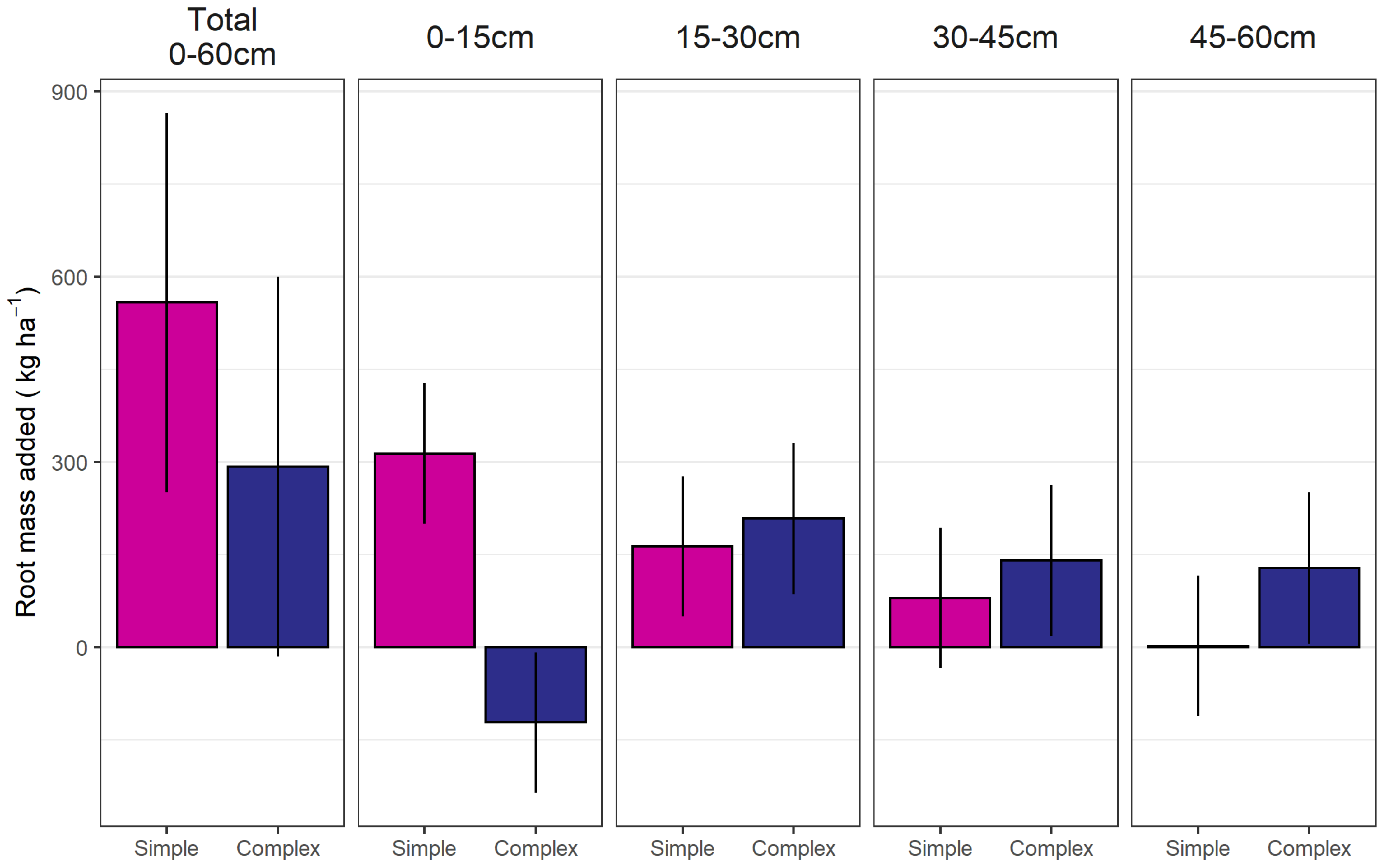

Measurement set
Yield data
Yield data, growth analysis
Yield data, growth analysis, root data
Hot and dry
Cool and wet
2016
2020
2017
2015
2018
2013
2019
2014
11
10
9
600
800
1000
1200
Mean air temperature (°C)
Total precipitation (mm)



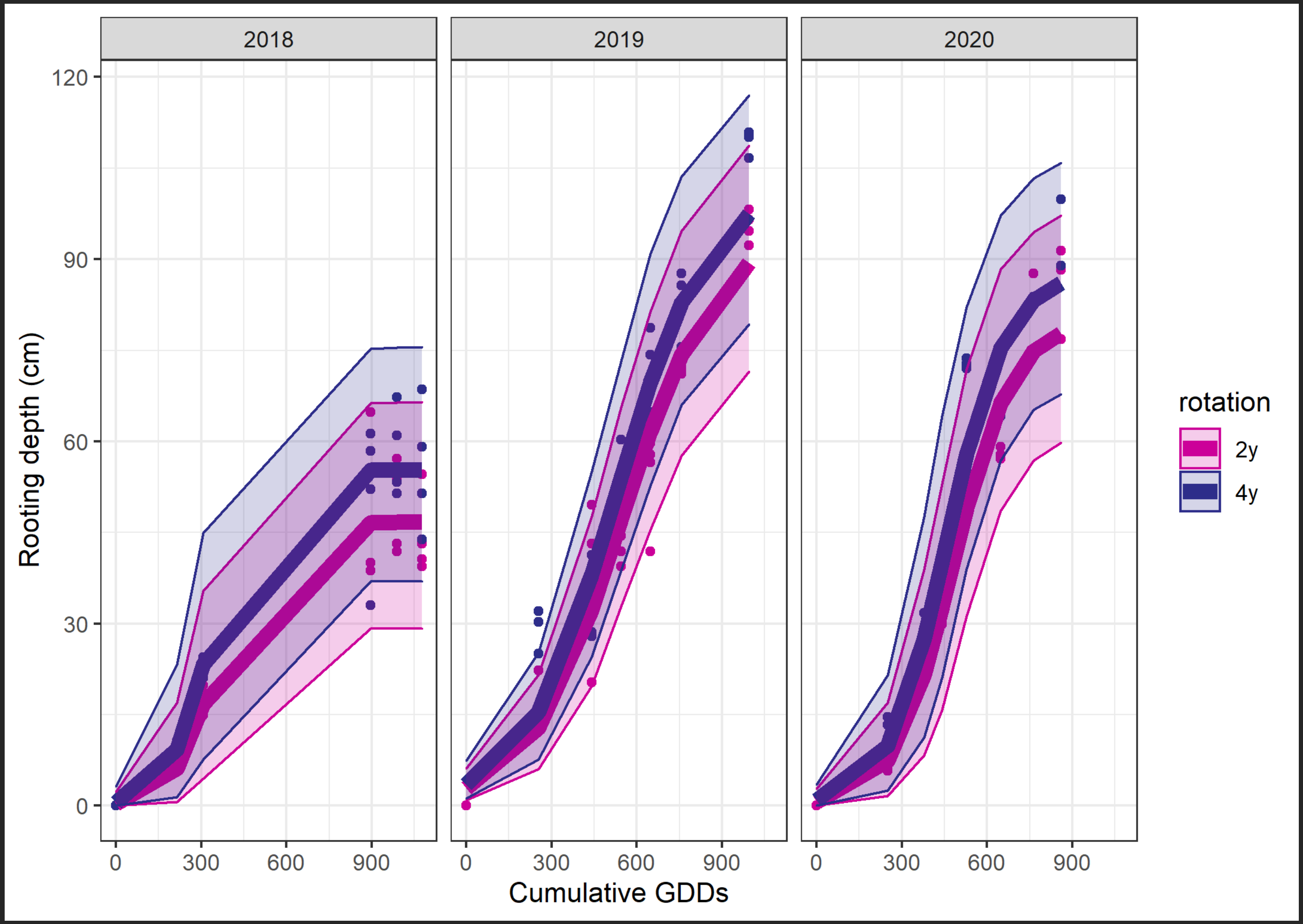
2013
2014
2018
2019
2020
Mg ha-1
Grain yield
grams plant^{-1}
Plant biomass
grams plant^{-1} day^{-1}
Growth rate
Day of year
grams
Weight of 500 kernals

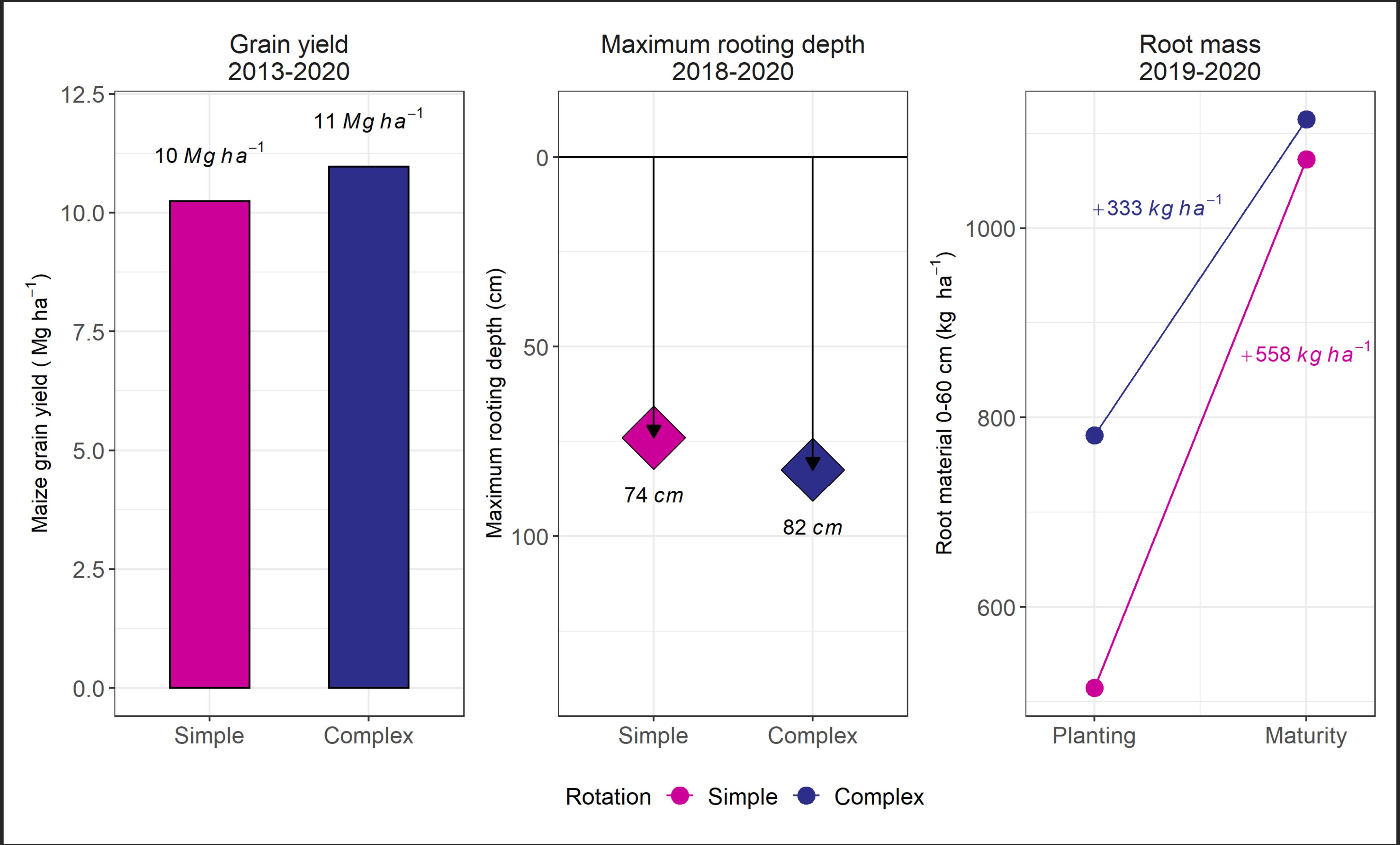

2018 planting
2018 late season
2019 planting
2020 late season
Cultivation at planting
Moldboard previous fall, complex only
Soil depth (cm)
Soil resistance (MPa)
Rotation
Simple
Complex


Rotation
Simple
Complex
2018
2019
Planting
Silking
Milk stage (R3)
Soil moisture (vol. %)
Day of year



Total
0-60cm
0-15cm
15-30cm
30-45cm
45-60cm
Root mass added (kg ha^{-1})
900
600
300
0
Simple
Complex
Simple
Complex
Simple
Complex
Simple
Complex
Simple
Complex


2018
2019
2020
Rooting depth (cm)
120
90
60
30
0
0
300
600
900
Cumulative GDDs
rotation
2y
4y



Grain yield
2013-2020
Maximum rooting depth
2018-2020
Root mass
2019-2020
Maize grain yield (Mg ha^{-1})
12.5
10.0
7.5
5.0
2.5
0.0
10 $Mg\ ha^{-1}$
11 $Mg\ ha^{-1}$
Simple
Complex
Maximum rooting depth (cm)
0
50
100
74 cm
82 cm
Root material 0-60 cm (kg ha^{-1})
1000
800
600
$+333\ kg\ ha^{-1}$
$+558\ kg\ ha^{-1}$
Planting
Maturity
Rotation
Simple
Complex