National Screen of Commercially Available Biological Seed Treatment for Soybean

2023 Annual Summary – Grain Yield

Preliminary Results

Fabiano Colet and Laura E. Lindsey

Participants in 2023

State	Number of sites	University	Soybean Specialist
Alabama	3	Auburn University	Eros Francisco
Arkansas	1	University of Arkansas	Jeremy Ross
Florida	1	University of Florida	Emma Matcham
Illinois	2	University of Illinois Urbana-Champaign	Giovani P. Fontes
Indiana	2	Purdue University	Shaun Casteel
Iowa	-	Iowa State University	Mark Licht
Kentucky	2	University of Kentucky	Chad D. Lee
Louisiana	2	Louisiana State University	David Moseley
Maryland	2	University of Maryland	Nicole Fiorellino
Michigan	3	Michigan State University	Maninder Singh
Minnesota	2	University of Minnesota	Seth Naeve
Mississippi	2	Mississippi State University	Trent Irby
Mississippi	1	Mississippi State University	Michael Mulvaney
Missouri	1	University of Missouri	Andre Borja Reis
Nebraska	1	University of Nebraska - Lincoln	Nicolas C. La Menza
North Carolina	4	North Carolina State University	Rachel Vann
North Dakota	2	North Dakota State University	Hans Kandel
Ohio	4	The Ohio State University	Laura E. Lindsey
Pennsylvania	1	Penn State University	Daniela Carrijo
South Carolina	2	Clemson University	Michael Plumblee
South Dakota	4	South Dakota State University	Jonathan Kleinjan
Virginia	1	Virginia Tech	David Holshouser
Wisconsin	10	University of Wisconsin - Madison	Shawn P. Conley
Total	**~53**	**20 universities across 21 states**	

Introduction

Biological seed treatment is a growing market in the US, and soybean growers are interested in understanding the benefits of applying biological products to the seed. Often, farmers are bombarded with marketing claims about biological seed treatments. And in many cases, there is little or no third-party evidence regarding the ability of these biological seed treatments to improve soybean yield and profitability. Therefore, one of the objectives of this study is to evaluate situations where biological seed treatments improve soybean grain yield.

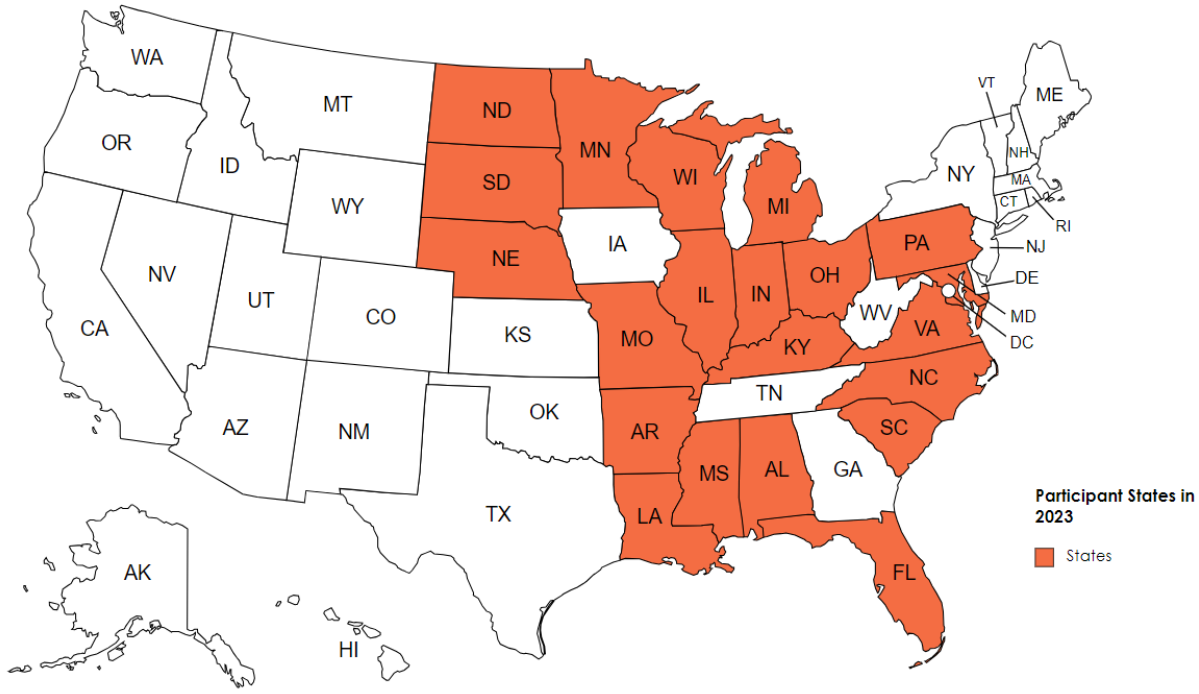


Figure 1. Map of state participating in this project in 2023 (in red).

Methodology

In 2023, we established small plot trials in 53 locations across 21 states (Figure 1). In each location, we evaluated the influence of nine biological soybean seed treatments and one untreated control on grain yield. The experiment design was a randomized complete block design with six replications. Products were applied to the seeds before planting, and the application protocol used was according to each product's recommendations (labels).

Each state collaborator obtained the soybean varieties recommended for their regions. All seed came treated with fungicide + insecticide to represent practices adopted by farmers. Soybean yield was adjusted to 13% moisture concentration prior to data analysis.

Table 1. List of treatments (products) and active ingredients in each biological product.

Treatment (product)	Active ingredients
1	*Azospirillum brasilense, Bacillus licheniformis, Bacillus amyloliquefaciens, Bacillus subtillis, Pseudomonas fluorescens, Rhizobium*
2	*Kosakonia cowanii strain SYM00028*
3	*Bradyrhizobium spp.*
4	*Bacillus subtillis + Bradyrhizobium japonicum*
5	*Bacillus amyloliquefaciens* Strain PTA-4838
6	*Methylobacterium hispanicum*
7	*Bradyrhizobium elkanii, Delftia acidovorans + Bacillus velezensis*
8	*Bacillus velezensis*
9	*Glomus intraradices, Glomus mosseae, Glomus aggregatum, Glomus etunicatum*
10	Untreated Control – seeds have fungicide and insecticide only

Statistical Procedures

Yield values that fell outside of three standard deviations of each site's average yield were removed from the analysis. The analysis of variance (ANOVA) was performed using the procedure Proc Glimmix in SAS for the response variable of grain yield for each site. When the global F-test ($\alpha = .05$) was significant, means were separated using pairwise comparisons. The treatment product was used as a fixed effect, while replication error was treated as a random effect.

Results

A summary of the average grain yield (in bu/acre) by product at each site is shown in Table 2. In this summary, results from 25 locations across 7 states are presented and will be updated once more data are received. Only three sites- Suffolk (VA), Clinton (WI), and Fond Du Lac (WI)- had significant results, and a means separation was performed at these locations (Table 2). Figure 2 shows the average grain yield (bu/acre) at each site for each treatment (product) plotted against the average grain yield (bu/acre) of the untreated control (treatment 10) at the same site.

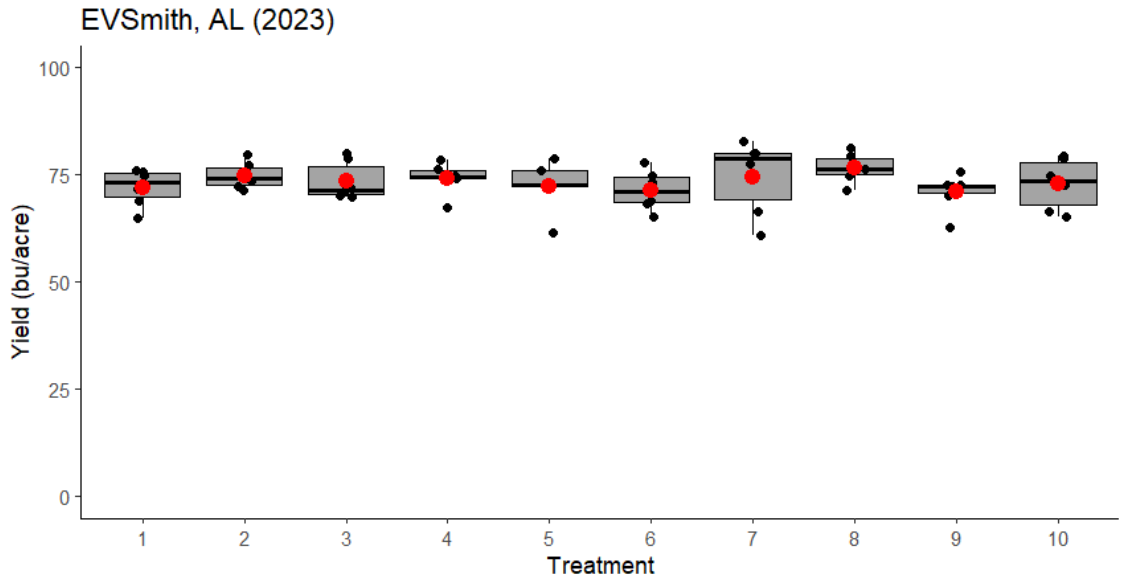
Table 2. Treatment grain yield means in bu/acre for each site in 2023. The means separation was performed for sites with statistically significant differences in yield between treatments (p=0.05).

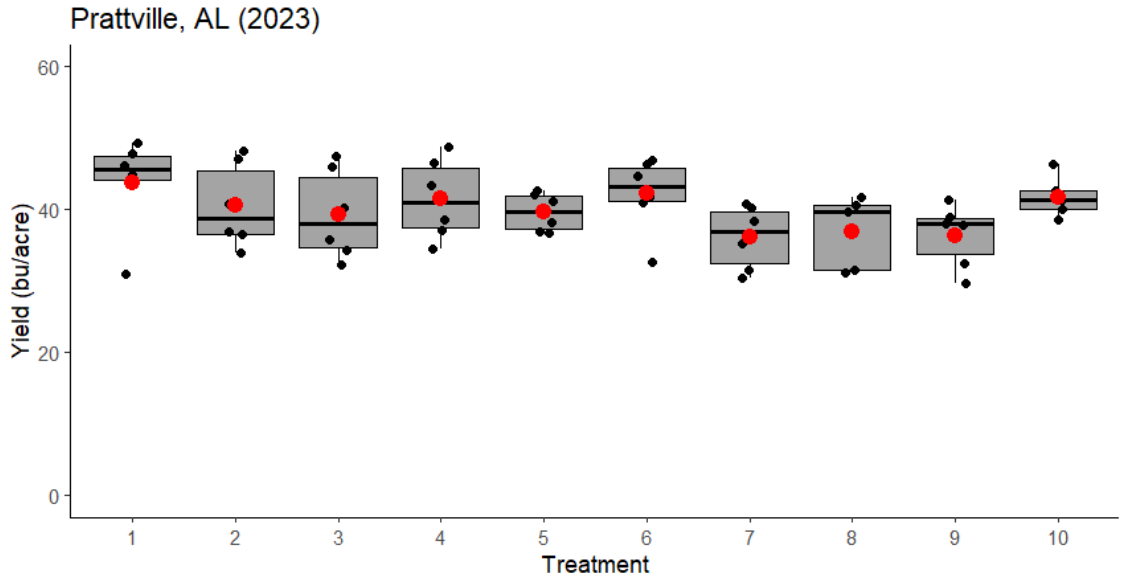
Site	Control	Trt 1	Trt 2	Trt 3	Trt 4	Trt 5	Trt 6	Trt 7	Trt 8	Trt 9
Shorter, Alabama	72.8	72.0	74.8	73.6	74.2	72.2	71.4	74.5	76.5	70.9
Prattville, Alabama	41.7	43.8	40.5	39.3	41.5	39.6	42.2	36.1	36.9	36.6
Madison, Alabama	63.7	66.8	65.3	64.8	66.1	64.5	66.2	62.8	61.8	64.9
Newport, Arkansas	54.3	55.8	54.2	54.6	55.7	55.7	54.5	54.5	53.7	55.3
Citra, Florida	41.3	37.9	33.9	29.8	39.9	36.7	32.7	41.0	37.9	34.6
Florida site 2										
Monmouth, Illinois	74.6	78.5	77.7	77.4	73.8	76.3	78.8	78.5	76.1	74.6
Urbana, Illinois	74.5	72.6	74.2	75.9	75.0	78.0	76.9	71.5	75.6	73.9
Wanatah, Indiana	76.0	76.7	76.9	77.9	77.0	79.0	76.3	75.9	75.0	75.6
West Lafayette, Indiana	70.3	68.8	73.7	71.0	72.1	71.4	71.6	72.0	68.4	71.7
Lexington (Site 1), Kentucky	79.0	73.4	72.9	77.5	74.8	78.6	78.0	76.3	78.0	77.4
Lexington (Site 2), Kentucky	64.4	64.9	66.6	67.5	65.6	63.3	67.2	65.1	58.7	65.1
Alexandria (Site 1), Louisiana	28.4	31.4	30.4	30.9	31.6	32.4	32.4	28.2	30.1	28.7
Alexandria (Site 2), Louisiana	30.4	29.3	29.5	29.6	30.3	28.8	29.2	29.6	30.3	30.8
Quantico, Maryland	55.7	56.2	54.9	54.4	53.5	54.9	55.2	52.1	56.5	57.0
Queenstown, Maryland	46.6	39.0	40.6	44.9	43.7	40.3	50.3	49.5	40.6	44.5
Lansing, Michigan	44.5	43.9	45.1	49.9	39.8	39.1	46.4	42.0	42.9	47.6
Lenawee, Michigan	66.6	64.3	62.3	68.9	60.2	60.4	68.1	63.5	63.4	60.8
Saginaw, Michigan	74.5	73.0	70.8	73.1	67.6	74.5	74.7	72.9	78.3	71.1
Le Sueur, Minnesota	59.9	66.9	67.2	65.3	67.0	62.2	61.0	62.9	60.5	62.6
Wells, Minnesota	72.2	73.1	71.1	70.9	69.0	69.4	69.9	70.3	68.8	72.4
Starkville (Site 1), Mississippi	55.4	53.3	54.9	55.4	54.7	53.3	53.8	54.3	52.2	56.5
Starkville (Site 2), Mississippi	69.7	72.0	74.4	72.2	70.9	71.4	68.0	71.1	71.6	66.6
Stoneville (DRAC), Mississippi	70.5	69.7	68.4	69.7	69.3	69.0	69.7	69.7	68.8	68.8
Columbia, Missouri	45.9	43.8	44.6	44.9	48.5	43.3	44.7	48.0	44.4	44.7
North Platte, Nebraska	41.6	41.4	41.4	47.4	48.0	38.9	40.5	48.6	41.2	37.8
Hyde, North Carolina	99.9	112.6	111.7	117.1	105.9	105.5	103.5	98.9	109.3	107.5
Sampson, North Carolina	68.4	74.1	73.7	73.6	70.8	63.5	67.5	71.2	74.3	73.7
Union, North Carolina	95.6	94.2	98.3	103.1	96.7	94.5	90.1	86.6	89.7	85.4
Yadkin, North Carolina	85.0	82.3	78.8	84.7	81.3	79.2	78.1	85.1	80.3	79.2
Fargo (Site 1), North Dakota	38.3	39.2	38.9	38.5	36.2	39.9	40.3	39.5	39.0	39.8

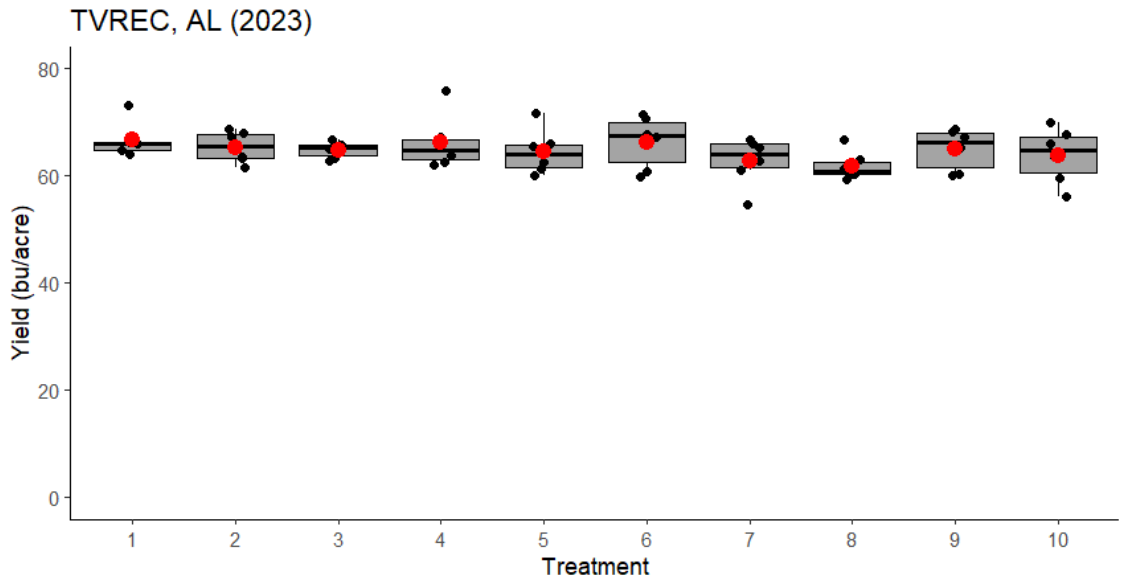
Site	Control	Trt 1	Trt 2	Trt 3	Trt 4	Trt 5	Trt 6	Trt 7	Trt 8	Trt 9
Fargo (Site 2), North Dakota	38.8	39.0	39.0	41.0	38.4	39.4	39.9	36.3	38.3	37.9
Pennsylvania Furnace, Pennsylvania	71.4	72.2	73.2	74.6	74.8	75.6	71.2	75.7	76.5	76.2
Celina, Ohio	77.0	74.6	71.0	77.6	68.9	80.0	78.9	76.5	76.8	74.9
Fremont, Ohio	81.4	81.7	78.7	82.1	83.9	81.1	81.5	84.3	81.3	83.0
Holgate, Ohio	86.7	89.5	88.9	89.8	90.8	90.5	93.7	89.9	89.1	91.7
Wilmington, Ohio	85.7	84.6	77.3	83.4	87.1	93.0	81.5	88.4	86.2	86.2
Blackville (Dryland), South Carolina	55.3	51.7	52.9	56.6	57.2	56.2	55.6	58.5	57.5	54.8
Blackville (Irrigated), South Carolina	49.7	50.1	49.0	51.8	51.1	49.1	49.9	52.2	51.0	51.5
Bath, South Dakota	70.4	67.0	69.4	65.7	69.2	69.2	70.5	70.7	71.6	70.6
Brooking, South Dakota	62.1	63.5	63.0	64.1	62.9	61.6	63.9	62.6	61.8	62.9
Miller, South Dakota	47.4	51.2	51.5	49.5	46.6	51.0	48.8	49.5	47.4	50.4
Renner, South Dakota	53.7	54.4	54.4	54.2	55.9	53.8	56.6	56.6	56.5	54.4
Suffolk, Virginia	56.1 BC	54.9 C	54.9 C	57.6 ABC	57.0 ABC	56.5 ABC	61.7 AB	56.0 BC	62.1 A	61.8 A
Arlington, Wisconsin	75.0	76.1	77.0	77.9	83.7	80.7	79.0	79.0	81.7	80.7
Clinton, Wisconsin	59.1 B	76.3 A	72.3 A	75.3 A	71.5 A	76.1 A	72.7 A	74.4 A	74.5 A	63.6 B
Cuba City, Wisconsin	94.3	88.2	87.1	94.8	89.1	89.2	90.3	87.5	91.5	89.5
Eau Galle, Wisconsin	73.7	75.0	72.6	78.7	76.7	77.3	72.0	70.0	76.5	73.4
Fond Du Lac, Wisconsin	74.8 AB	77.1 AB	73.0 AB	77.4 A	70.9 B	73.5 AB	77.3 A	64.0 C	71.7 AB	73.1 AB
Galesville, Wisconsin	70.6	73.9	71.5	73.0	68.0	69.8	73.2	68.0	72.0	70.5
Seymour, Wisconsin	68.2	65.4	67.3	68.9	70.4	61.5	68.2	66.5	64.0	67.1
Spooner, Wisconsin	66.6	67.5	68.5	67.4	67.0	67.0	66.6	67.6	67.1	65.4
Stratford, Wisconsin	59.6	59.8	59.9	60.2	60.8	58.2	60.1	60.3	59.8	60.0
Wautoma, Wisconsin	83.5	85.7	80.3	85.3	82.1	83.8	79.5	85.2	81.8	84.2

The next pages contain Box plots for each treatment in each site. Red circles represent the average for each treatment and black dots represent the value found in each plot for each treatment.

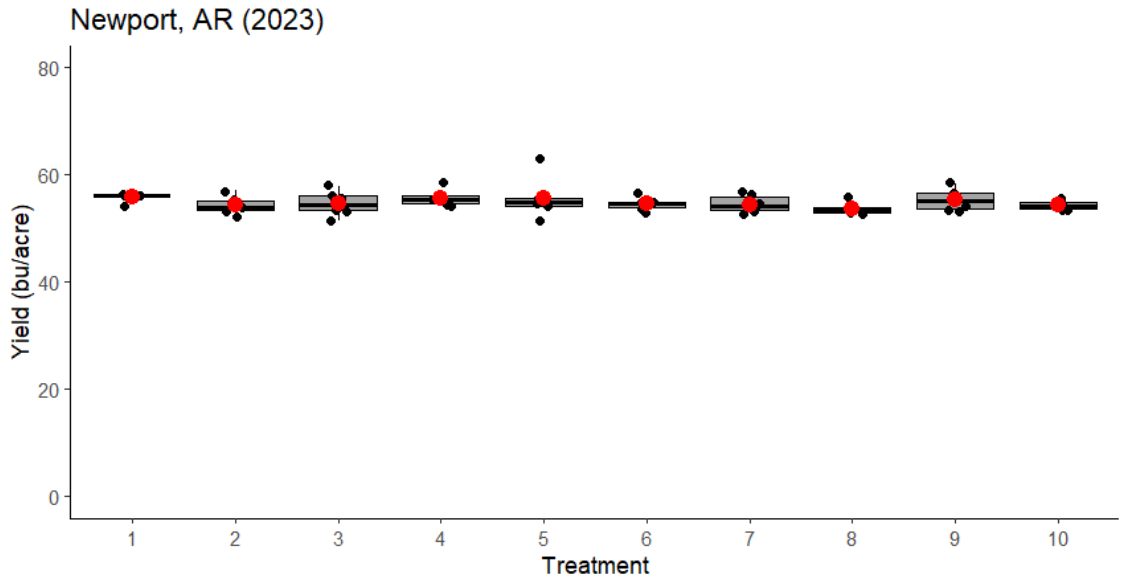
Alabama






TVREC, AL (2023)
Yield (bu/acre)
0
20
40
60
80
1
2
3
4
5
6
7
8
9
10
Treatment

Arkansas


Newport, AR (2023)
Yield (bu/acre)
0
20
40
60
80
1
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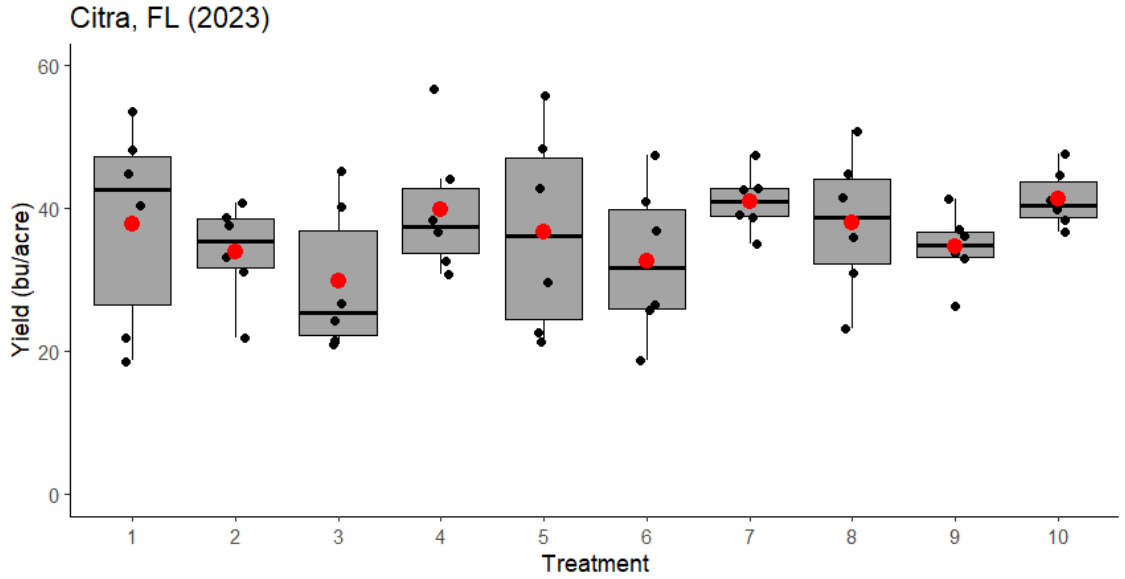
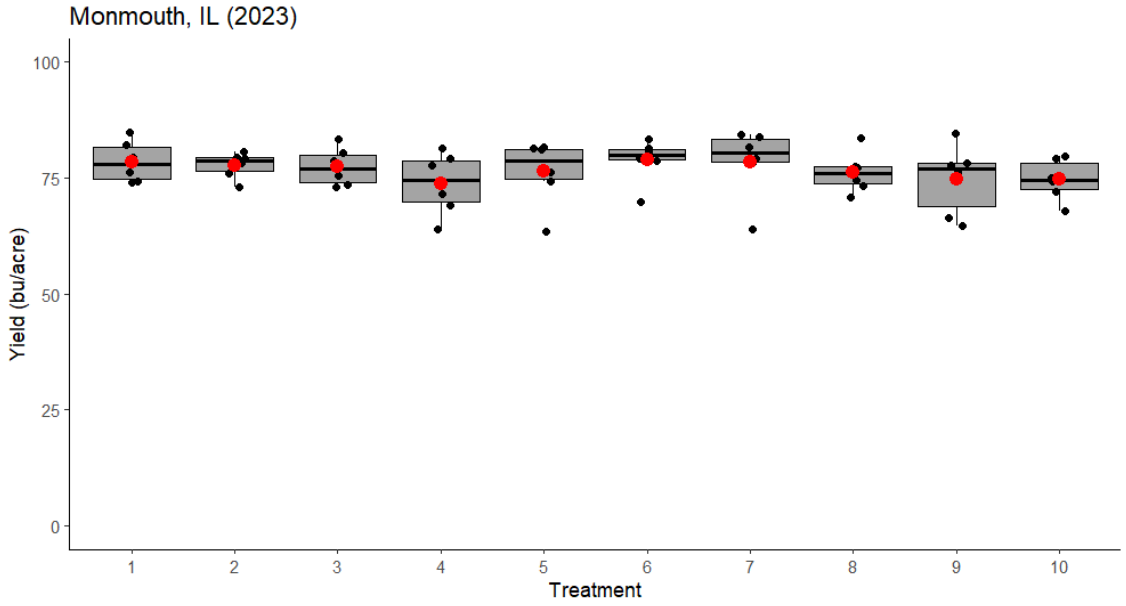
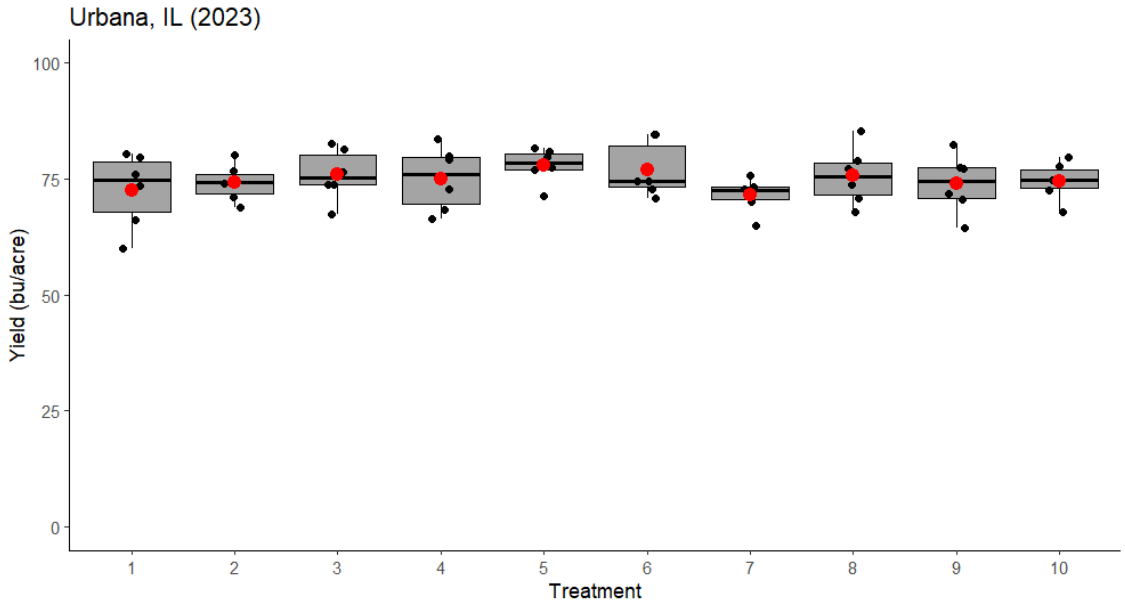
10
Treatment

Florida

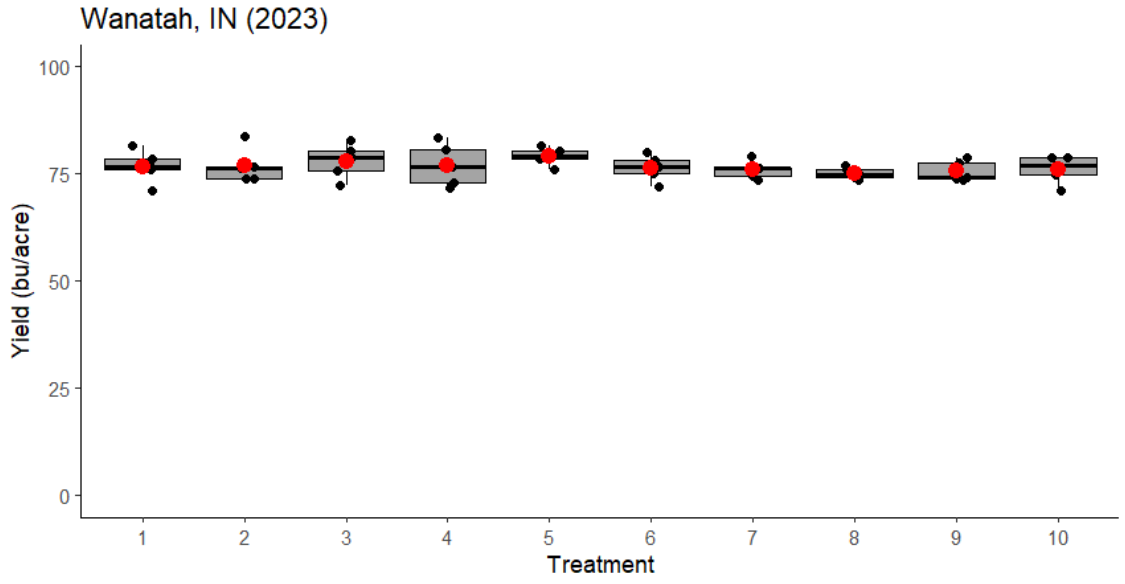


Illinois




Urbana, IL (2023)
Yield (bu/acre)
100
75
50
25
0
1
2
3
4
5
6
7
8
9
10
Treatment

Indiana


Wanatah, IN (2023)
Yield (bu/acre)
100
75
50
25
0
1
2
3
4
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8
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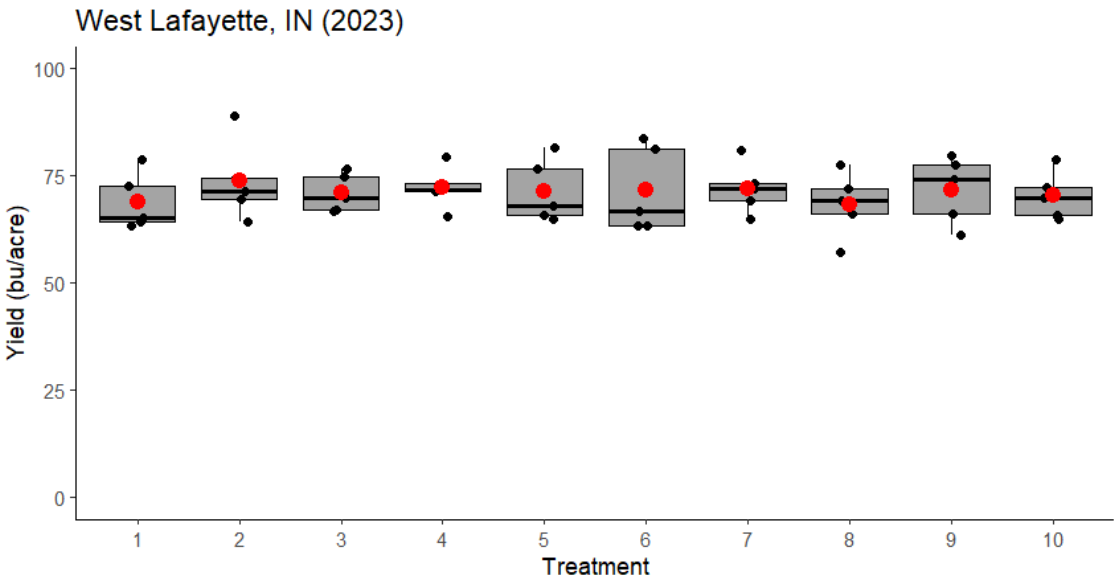
10
Treatment


West Lafayette, IN (2023)
Yield (bu/acre)
100
75
50
25
0
1
2
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4
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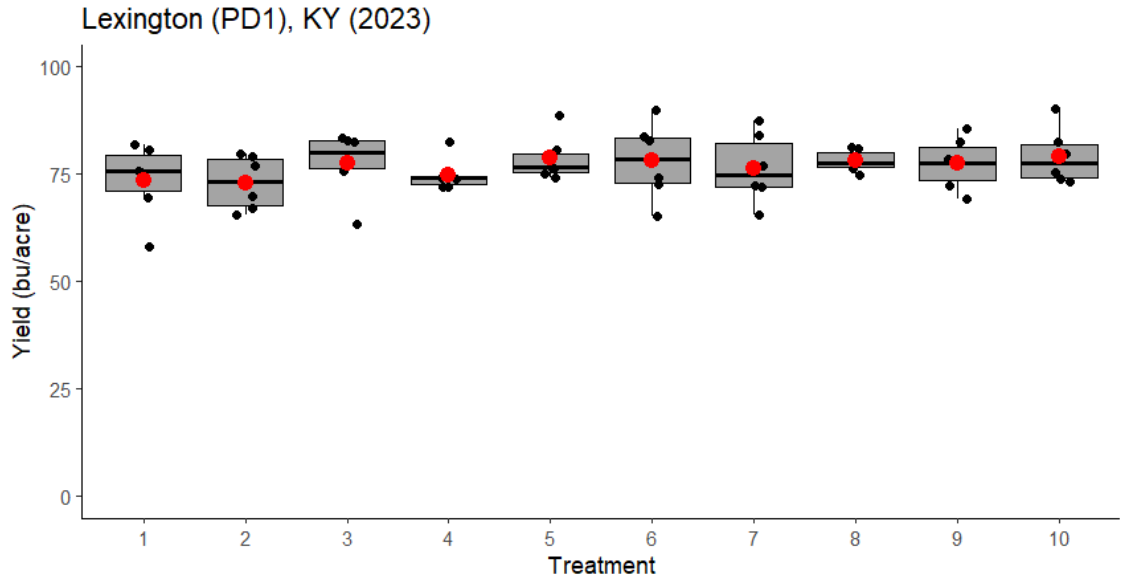
10
Treatment

Kentucky


Lexington (PD1), KY (2023)
Yield (bu/acre)
100
75
50
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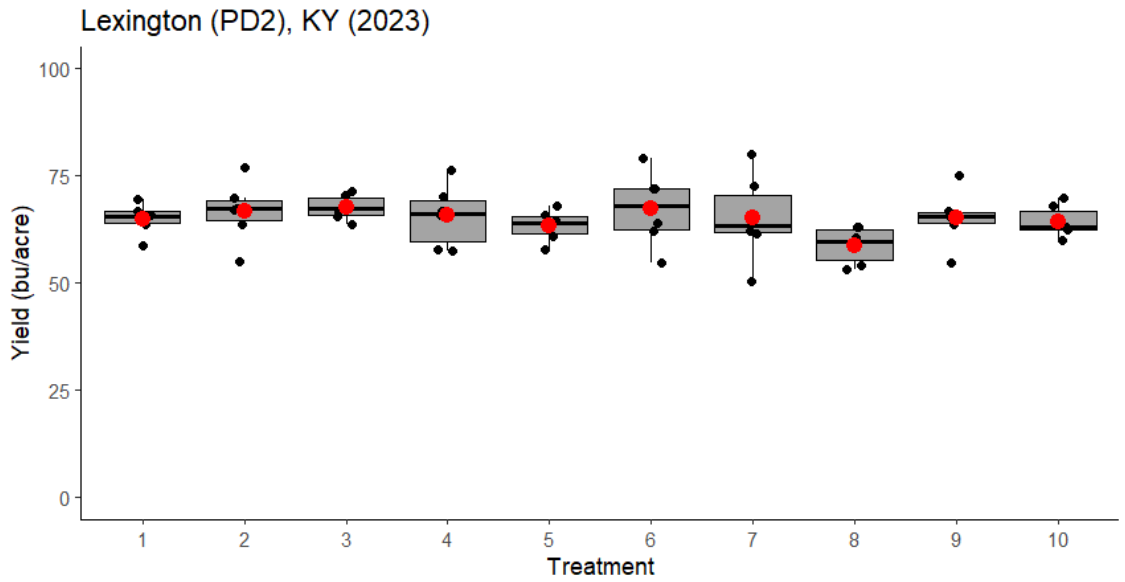
Treatment


Lexington (PD2), KY (2023)
Yield (bu/acre)
100
75
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25
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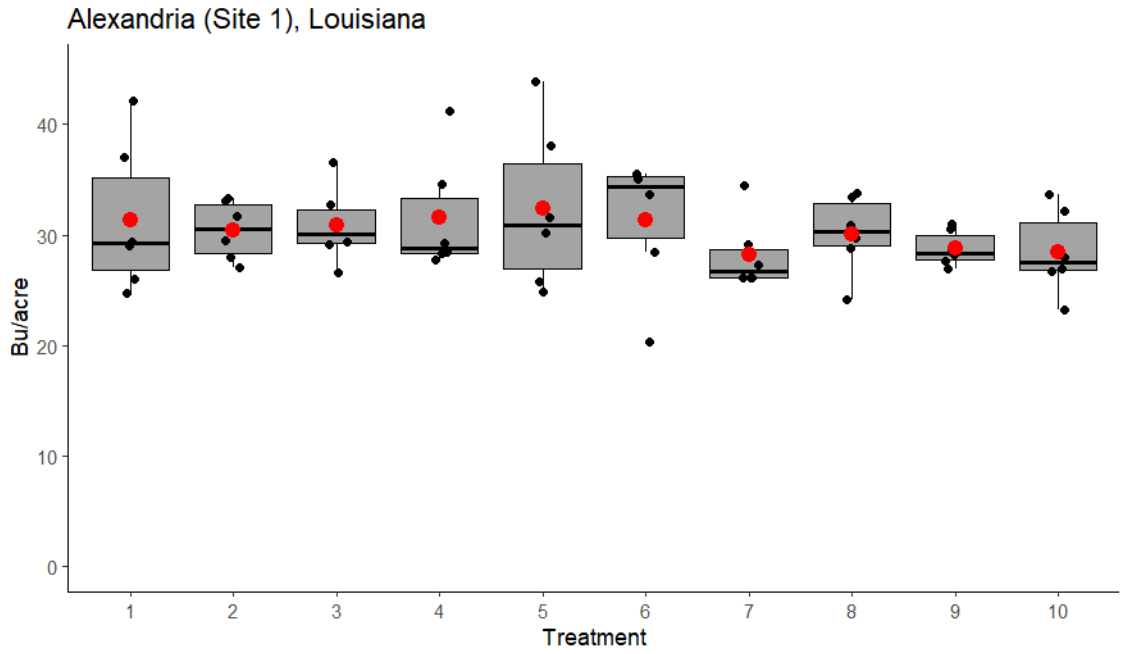
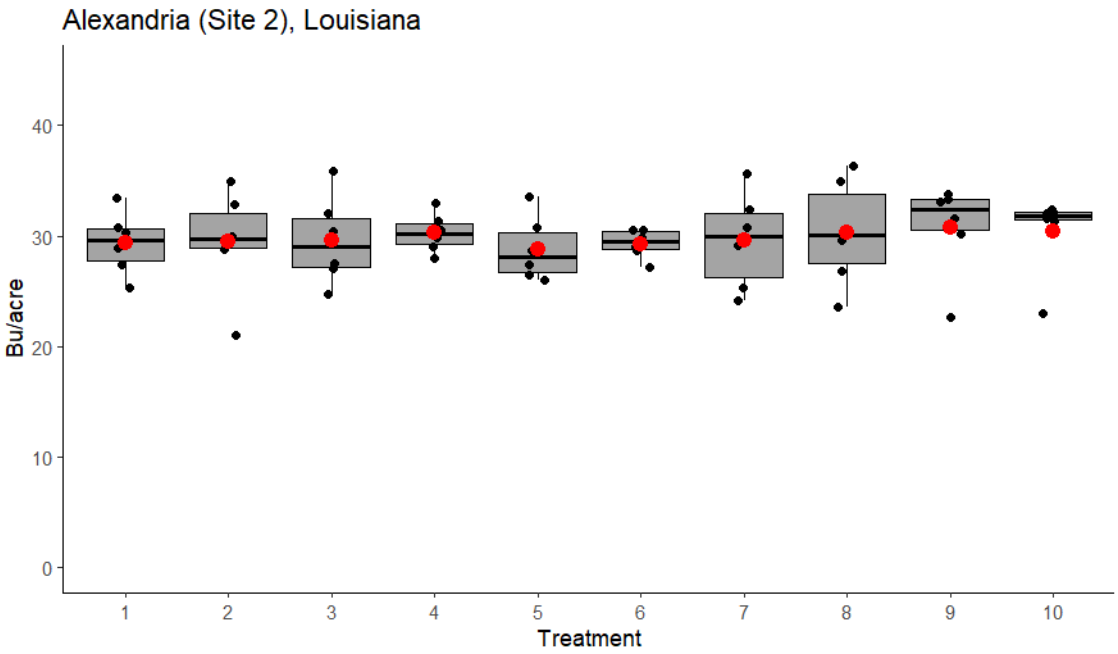
10
Treatment

Louisiana


Alexandria (Site 1), Louisiana
Bu/acre
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
Treatment


Alexandria (Site 2), Louisiana
Bu/acre
40
30
20
10
0
1
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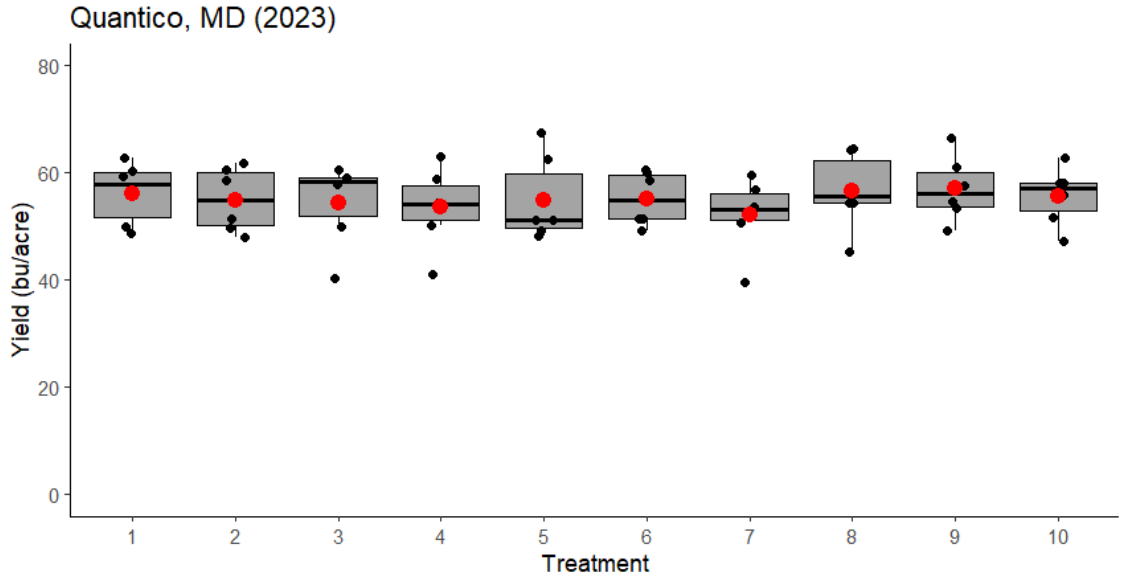
Treatment

Maryland


Quantico, MD (2023)
Yield (bu/acre)
0
20
40
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80
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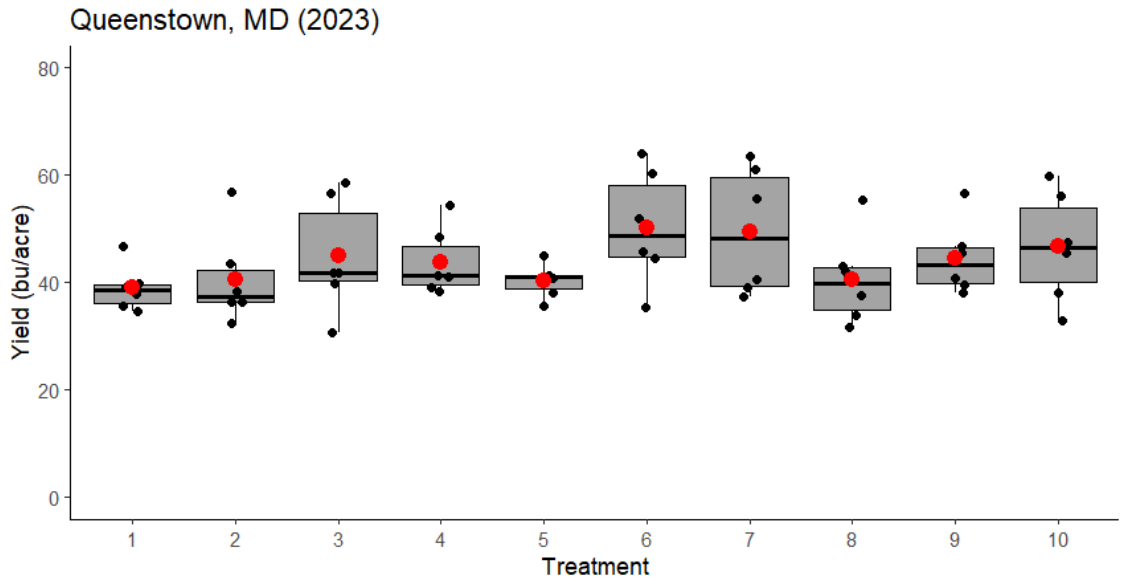
10
Treatment


Queenstown, MD (2023)
Yield (bu/acre)
0
20
40
60
80
1
2
3
4
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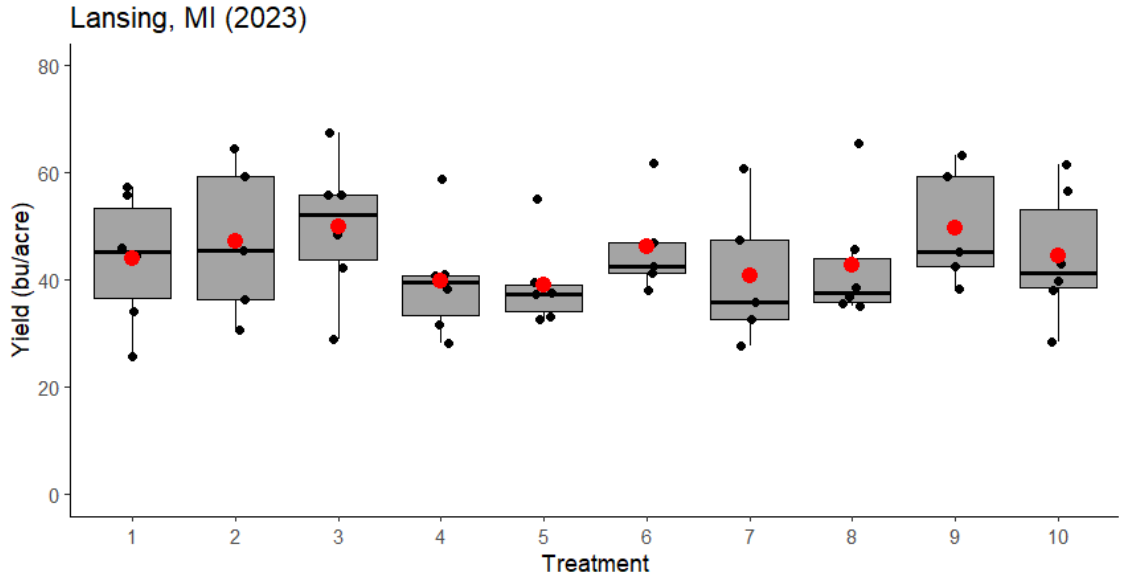
10
Treatment

Michigan


Lansing, MI (2023)
Yield (bu/acre)
80
60
40
20
0
1
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4
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8
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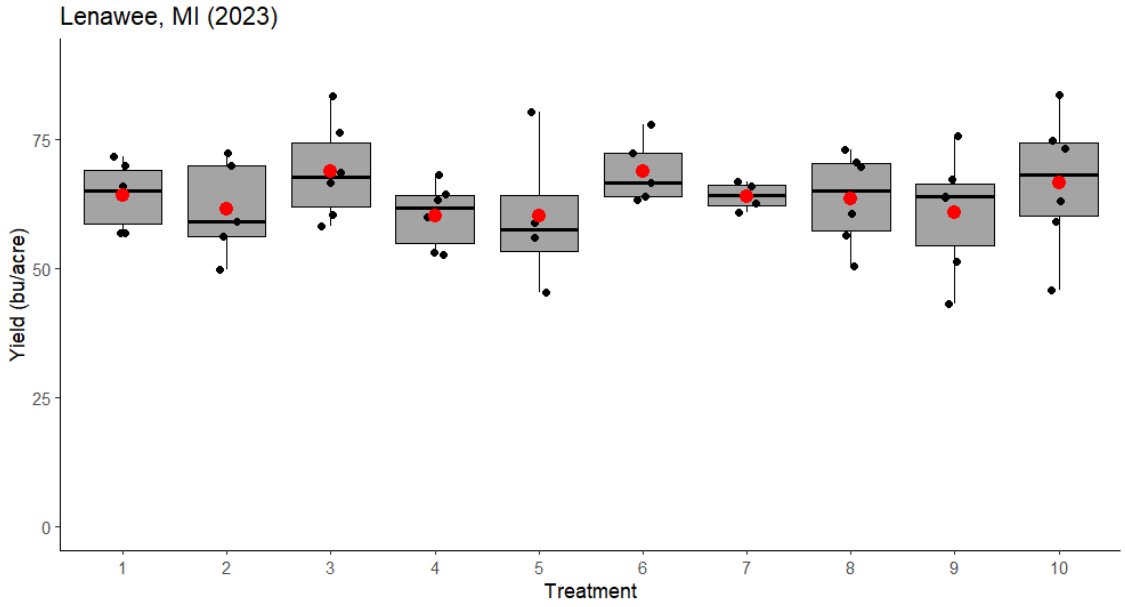
10
Treatment


Lenawee, MI (2023)
Yield (bu/acre)
75
50
25
0
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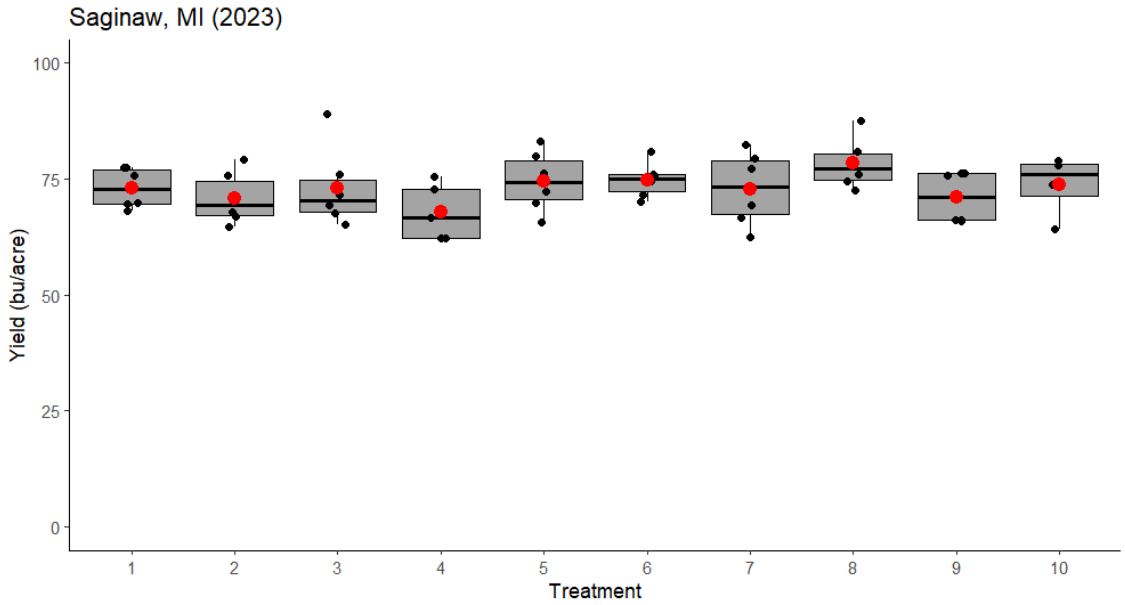
Treatment


Saginaw, MI (2023)
Yield (bu/acre)
100
75
50
25
0
1
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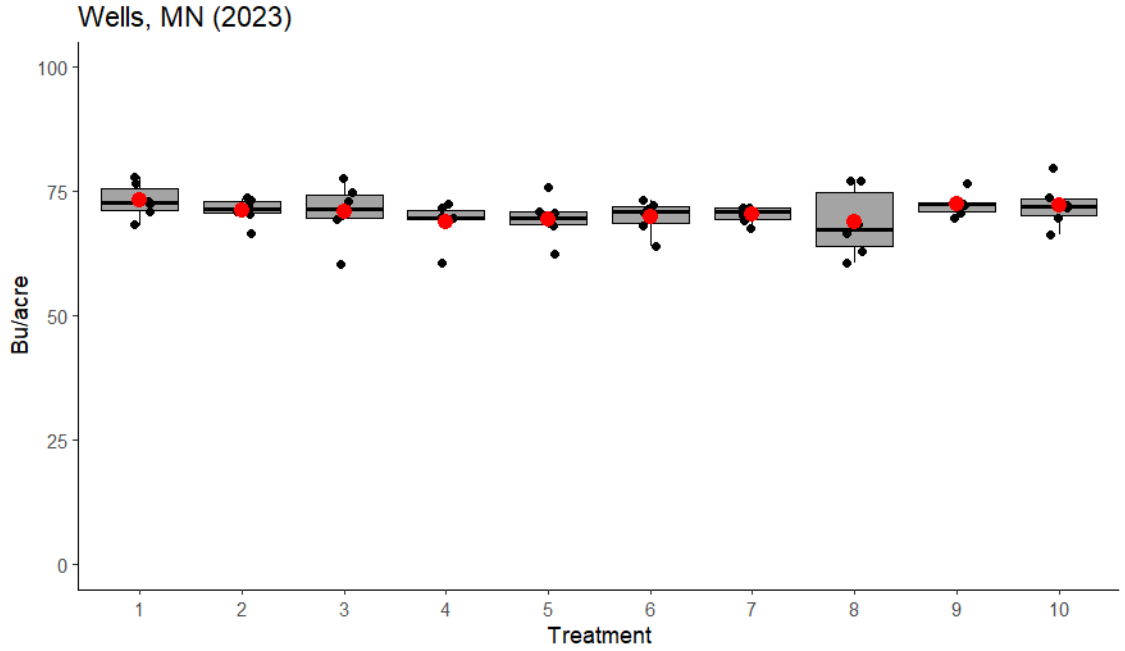
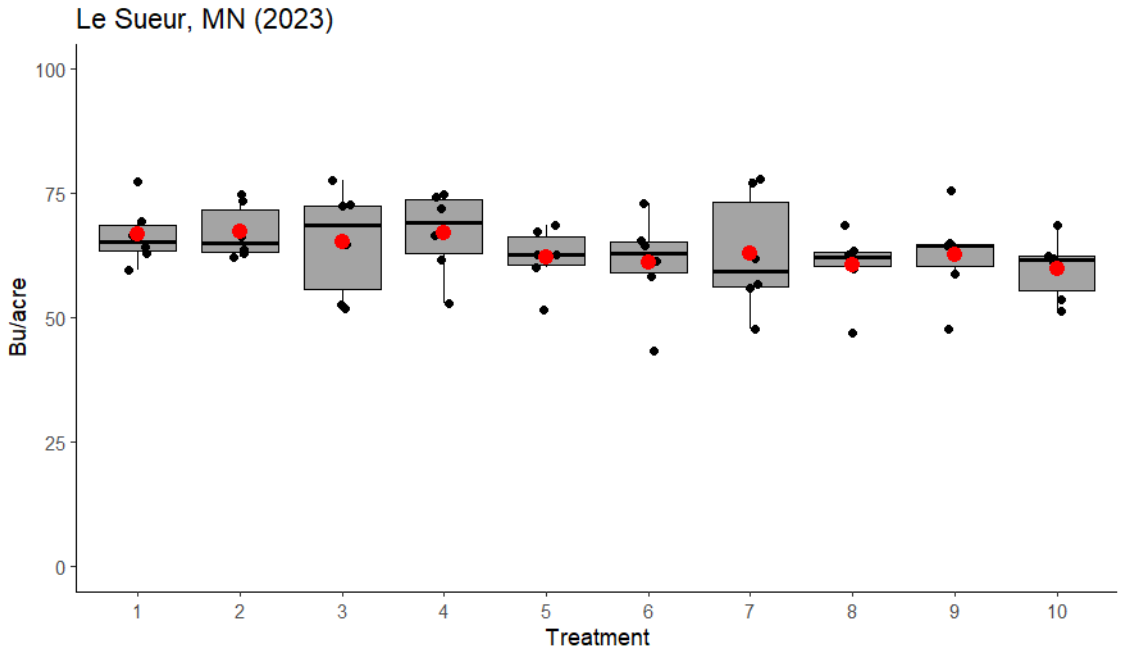
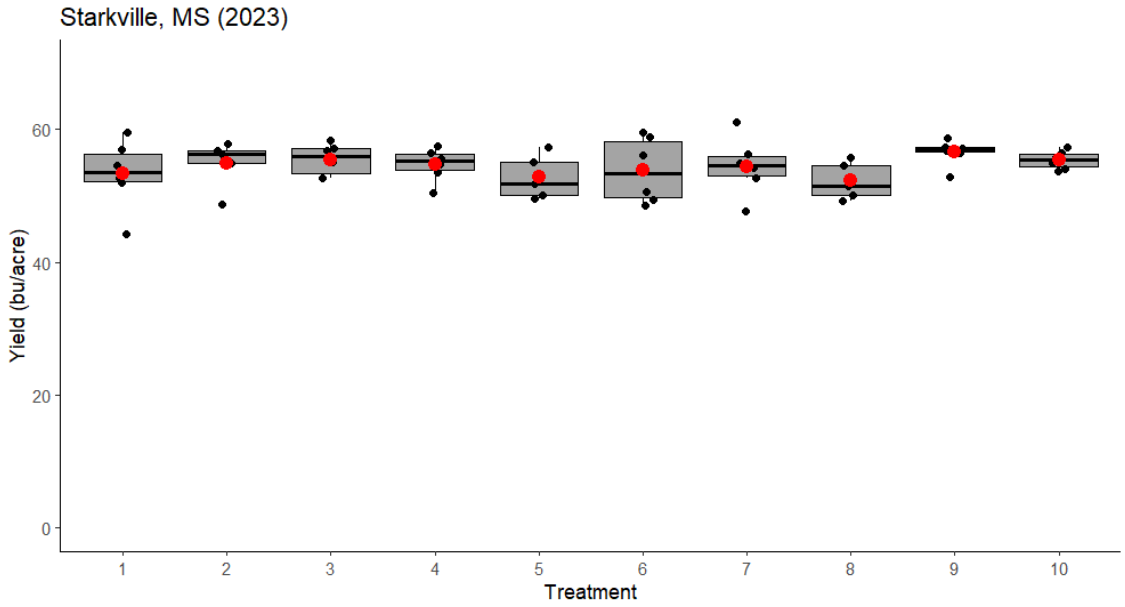
9
10
Treatment

Minnesota

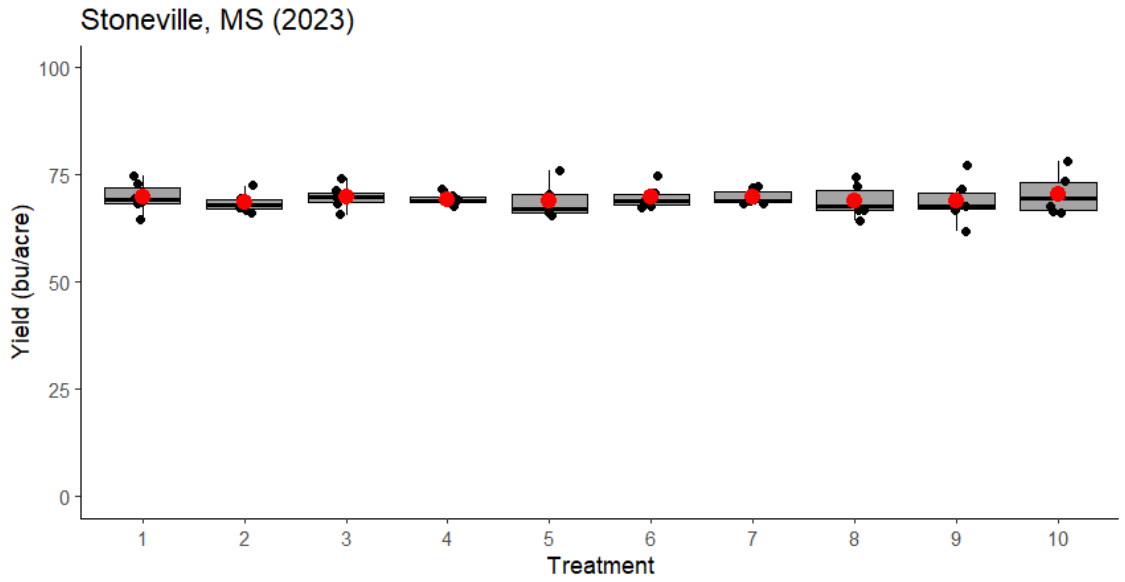

Wells, MN (2023)
Bu/acre
100
75
50
25
0
1
2
3
4
5
6
7
8
9
10
Treatment

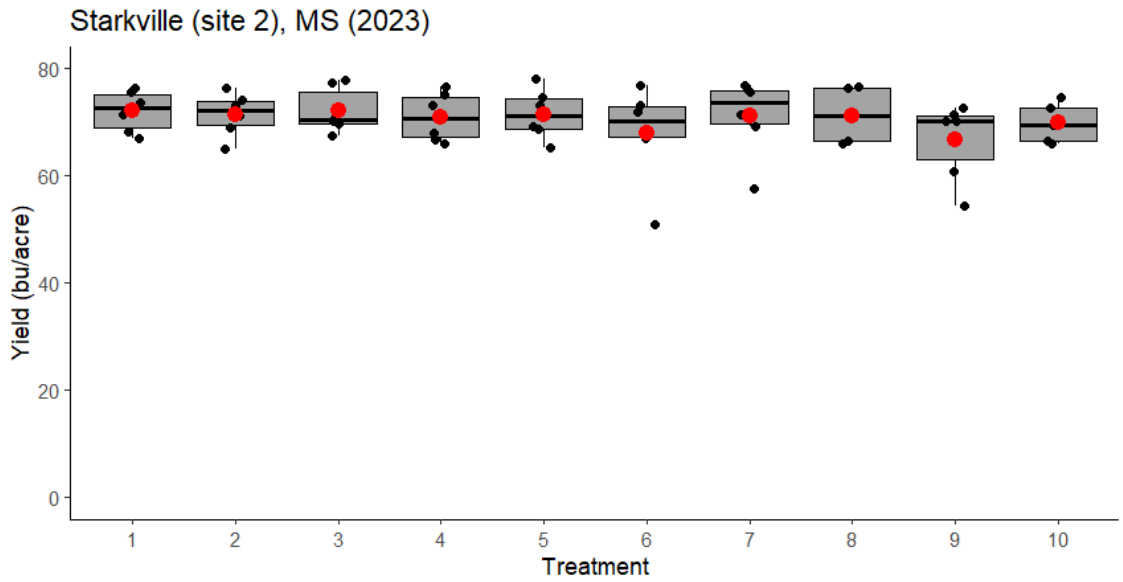

Le Sueur, MN (2023)
Bu/acre
100
75
50
25
0
1
2
3
4
5
6
7
8
9
10
Treatment

Mississippi (Dr. Mulvaney)

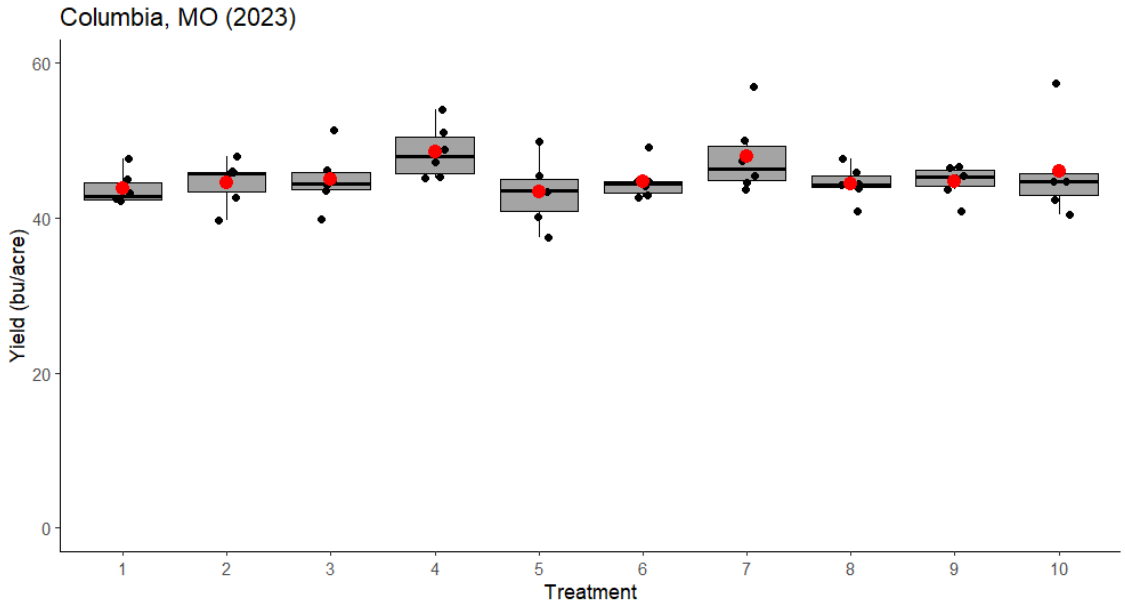


Mississippi (Dr. Irby)

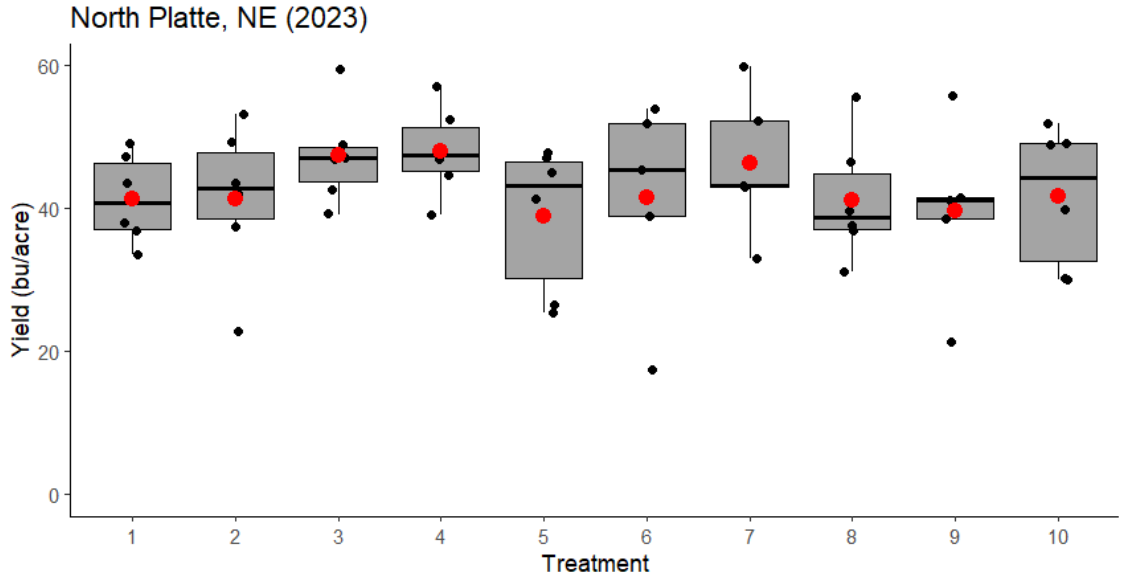



Starkville (site 2), MS (2023)
Yield (bu/acre)
0
20
40
60
80
1
2
3
4
5
6
7
8
9
10
Treatment

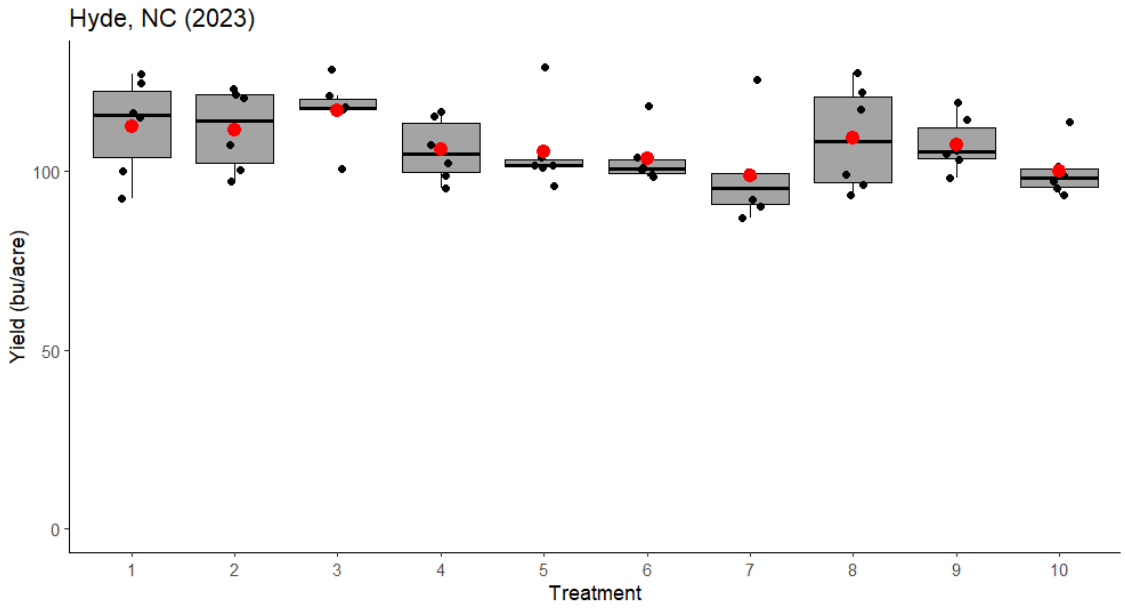
Missouri

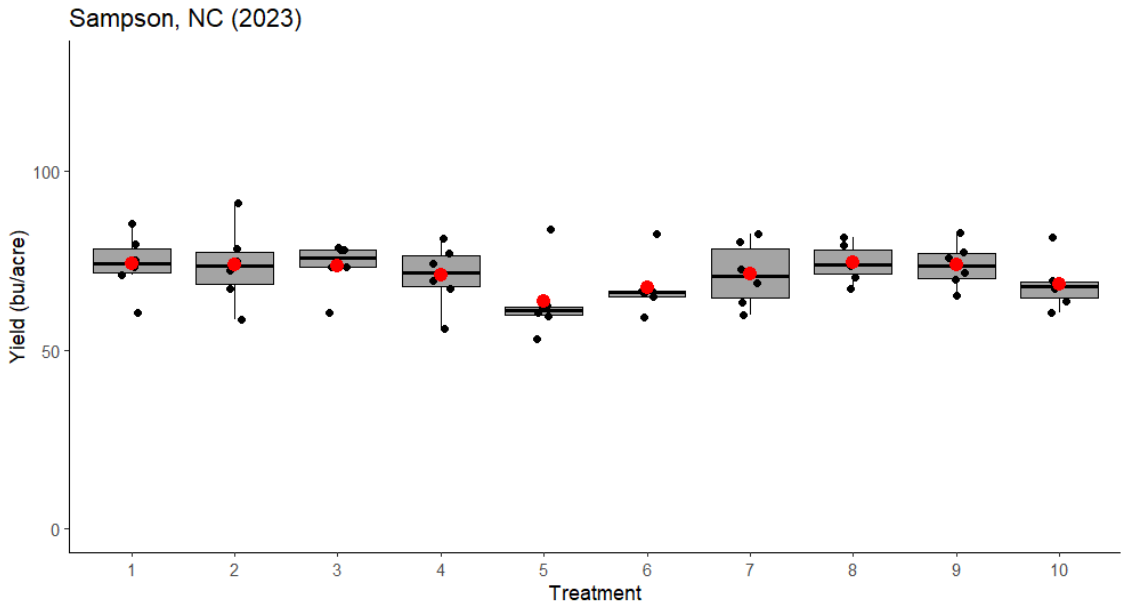


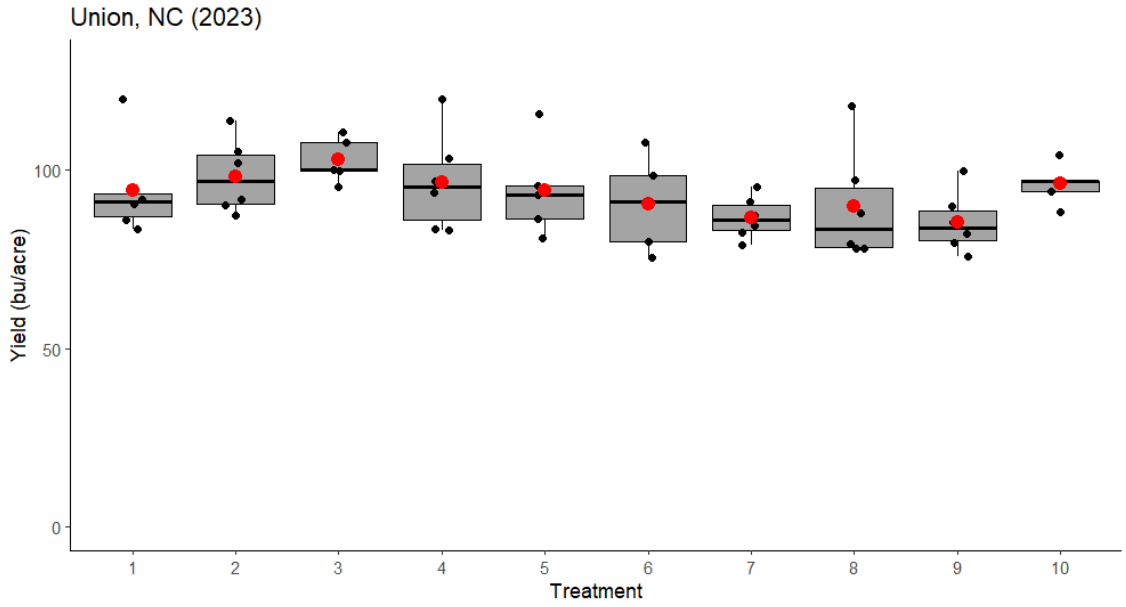
Nebraska

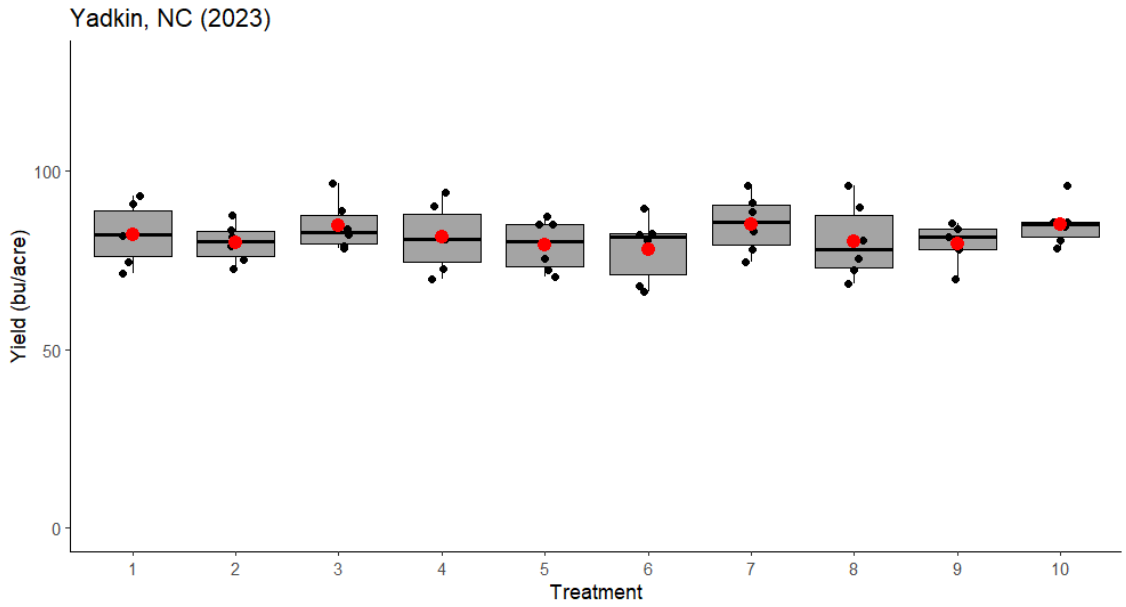


North Carolina

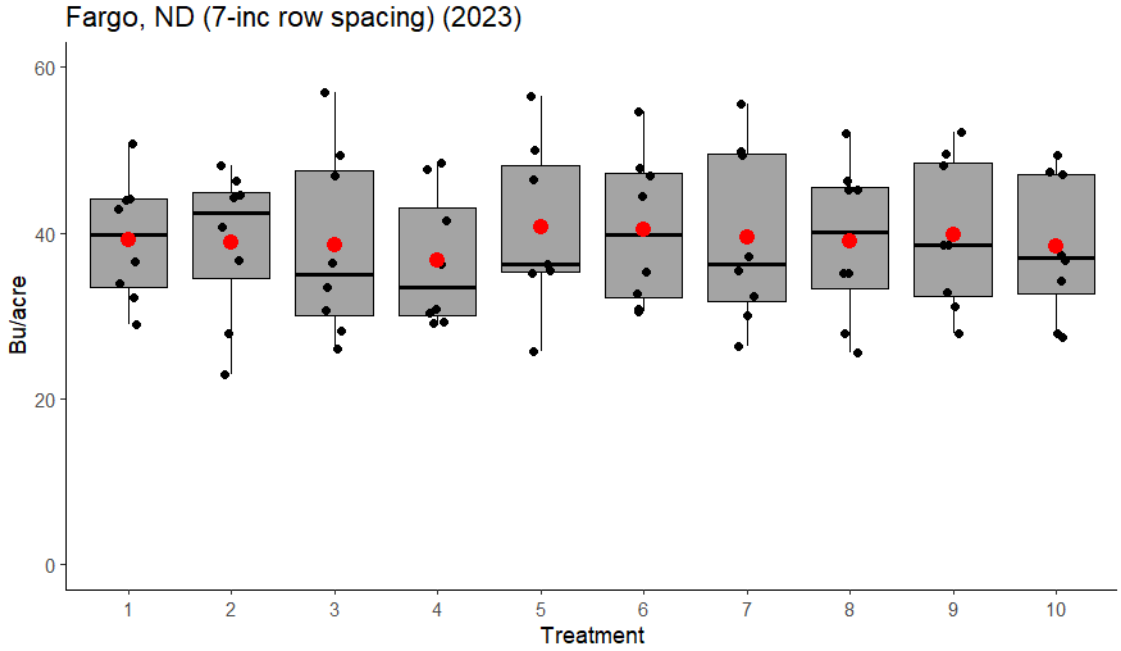


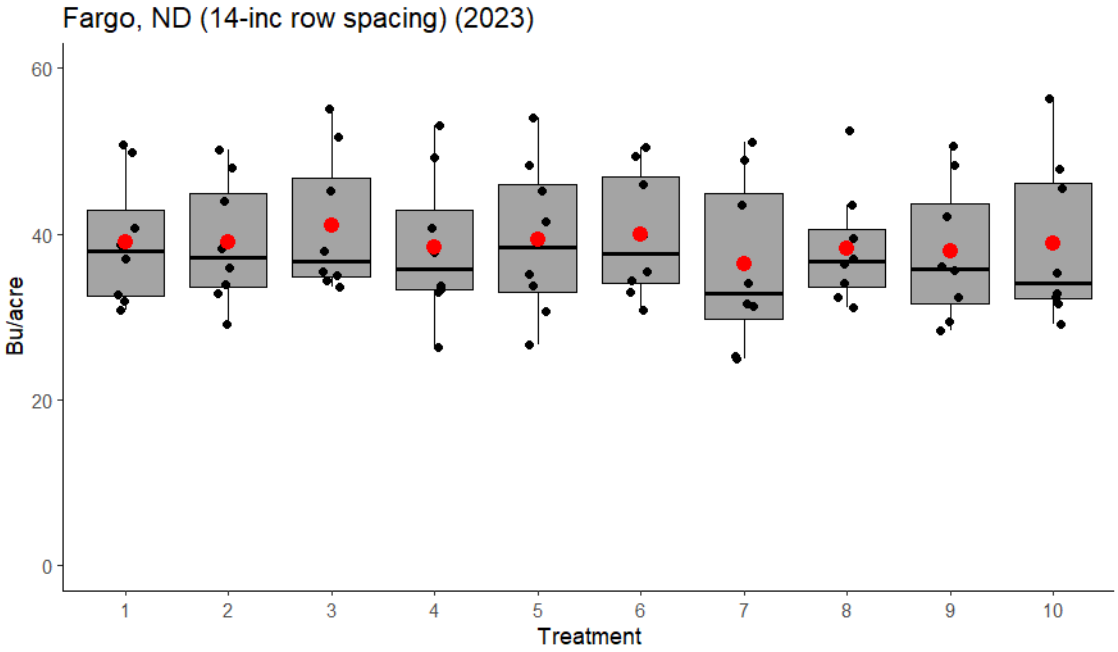



Union, NC (2023)
Yield (bu/acre)
100
50
0
1
2
3
4
5
6
7
8
9
10
Treatment

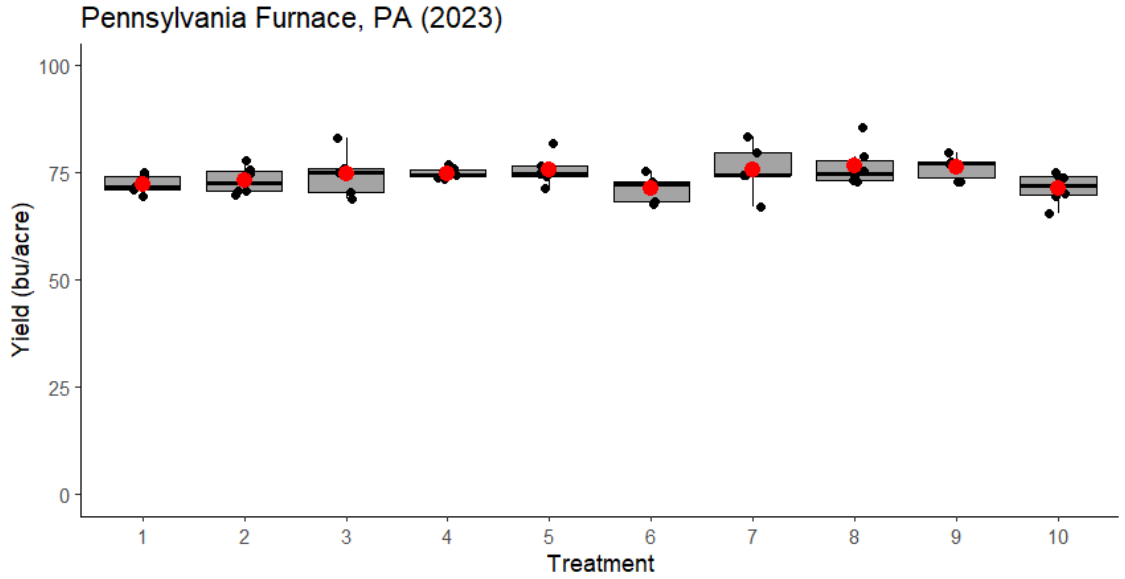

Yadkin, NC (2023)
Yield (bu/acre)
100
50
0
1
2
3
4
5
6
7
8
9
10
Treatment

North Dakota

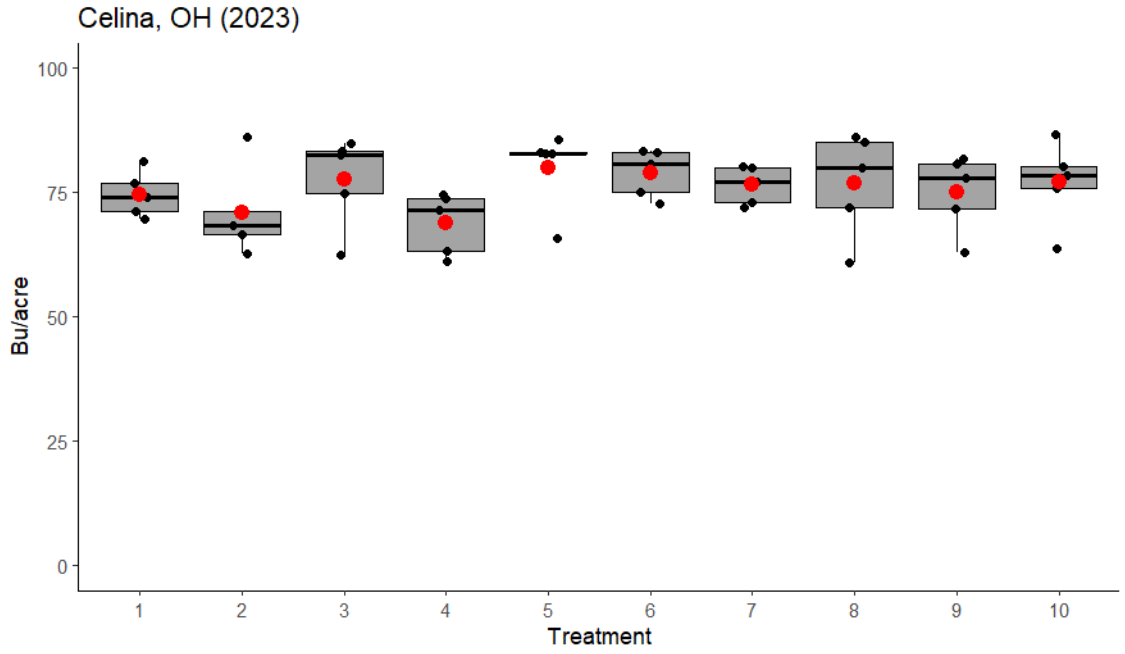


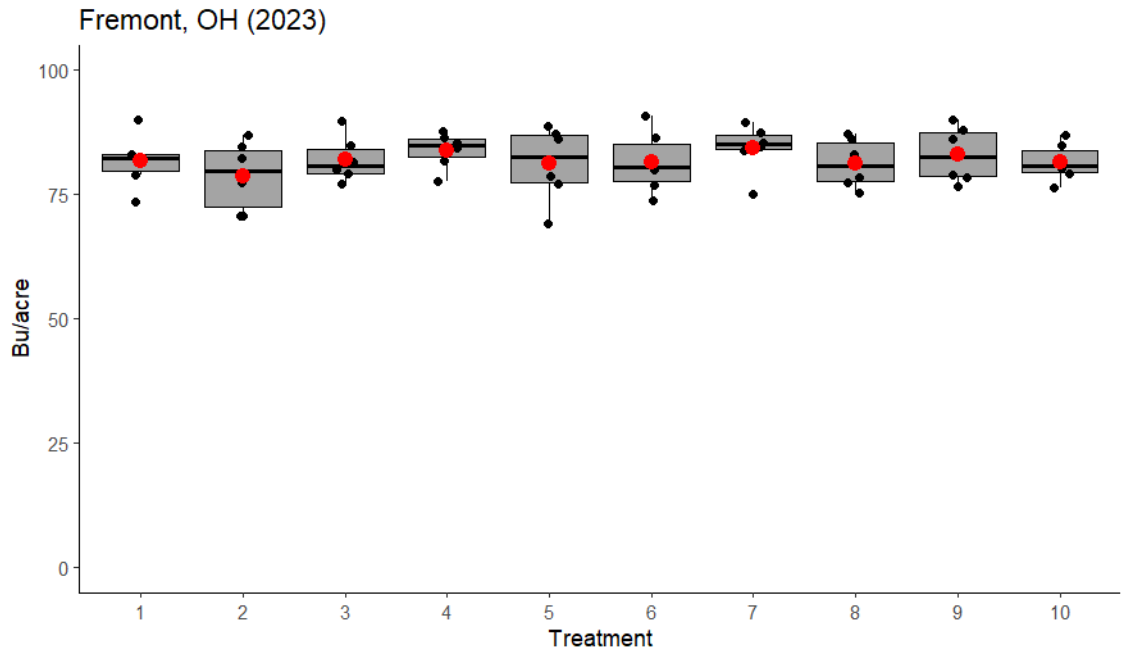


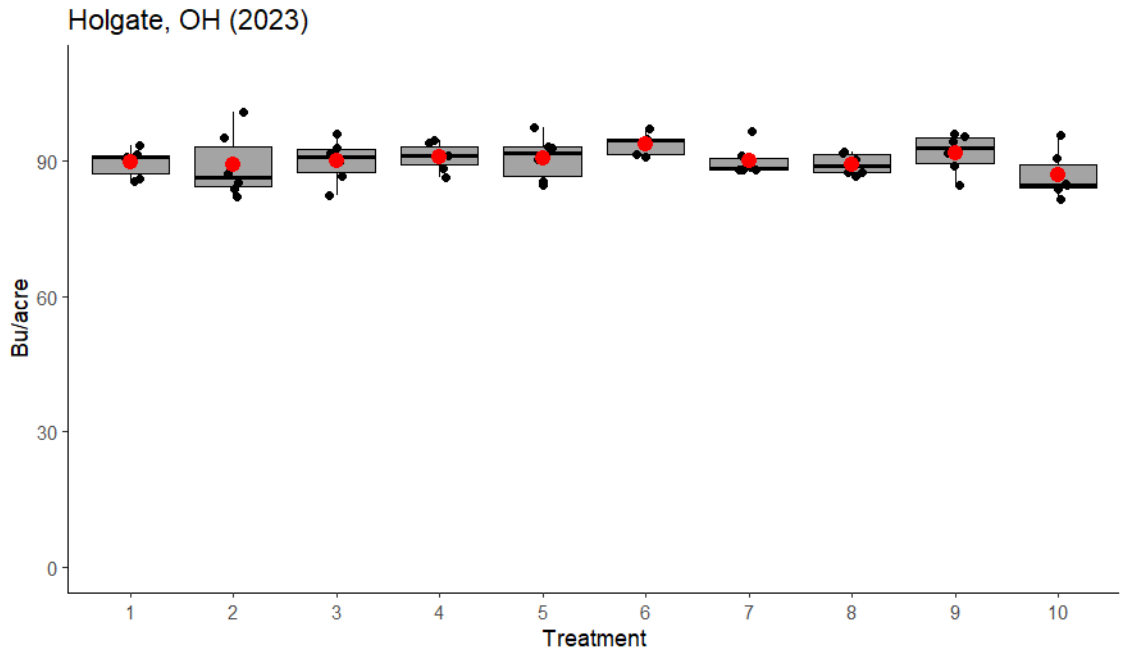
Pennsylvania

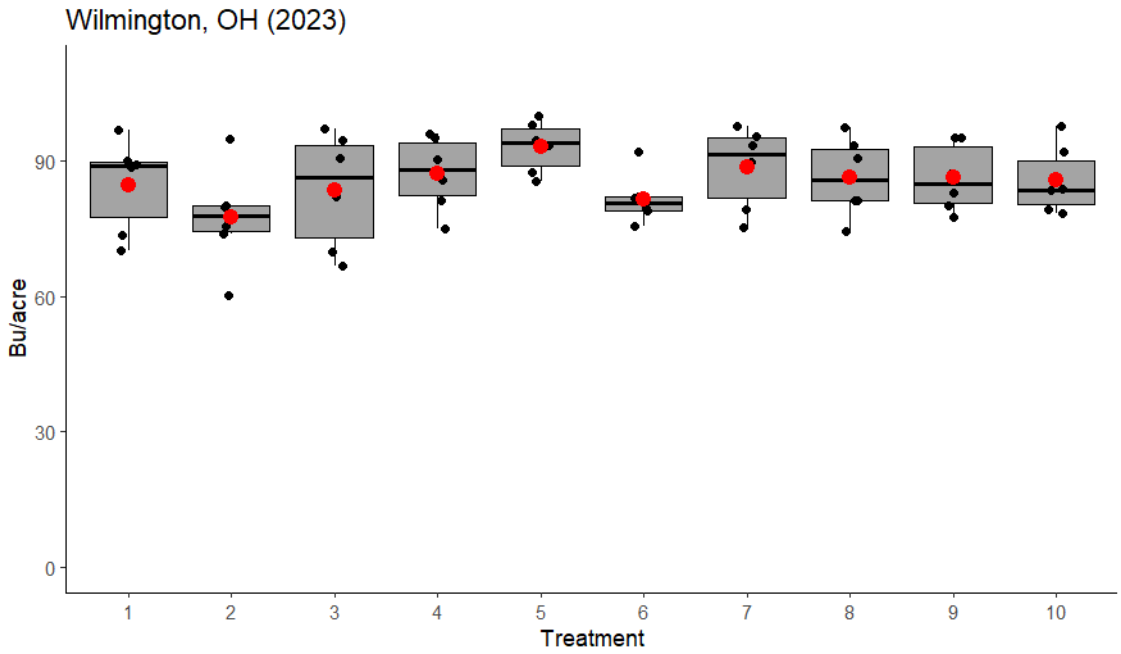


Ohio

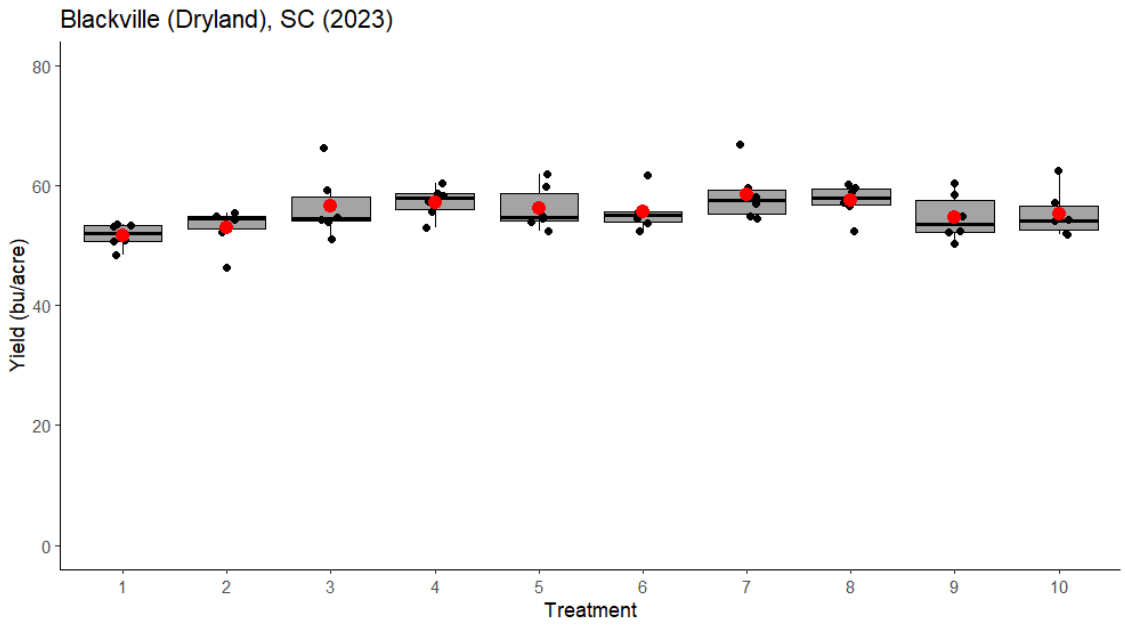


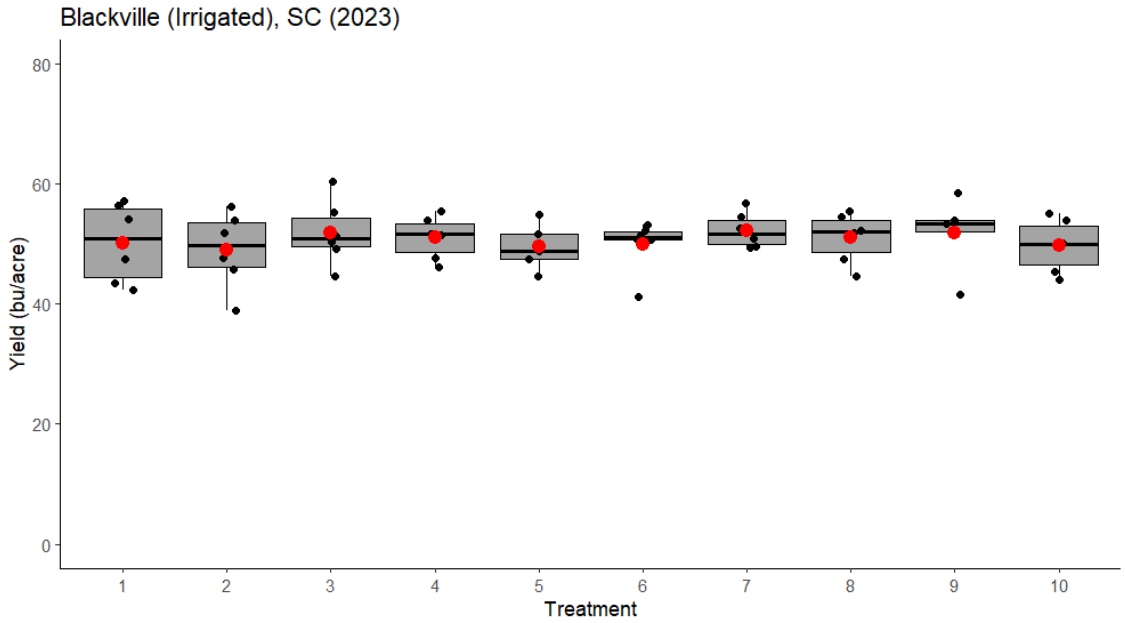

Fremont, OH (2023)
Bu/acre
100
75
50
25
0
1
2
3
4
5
6
7
8
9
10
Treatment


Holgate, OH (2023)
Bu/acre
90
60
30
0
1
2
3
4
5
6
7
8
9
10
Treatment

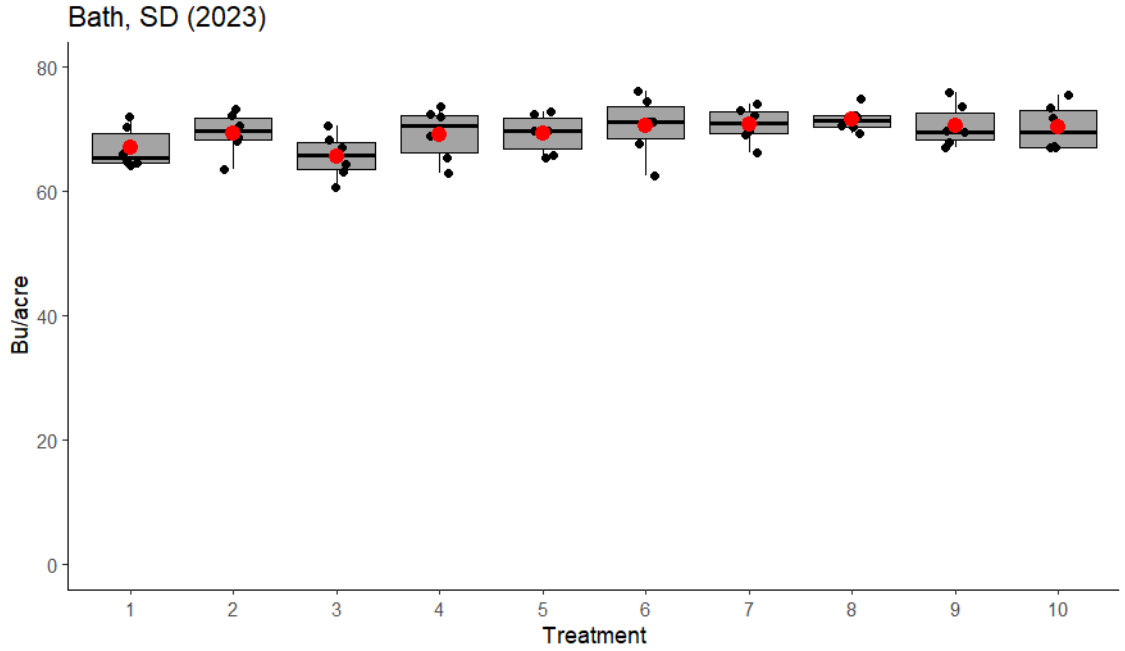


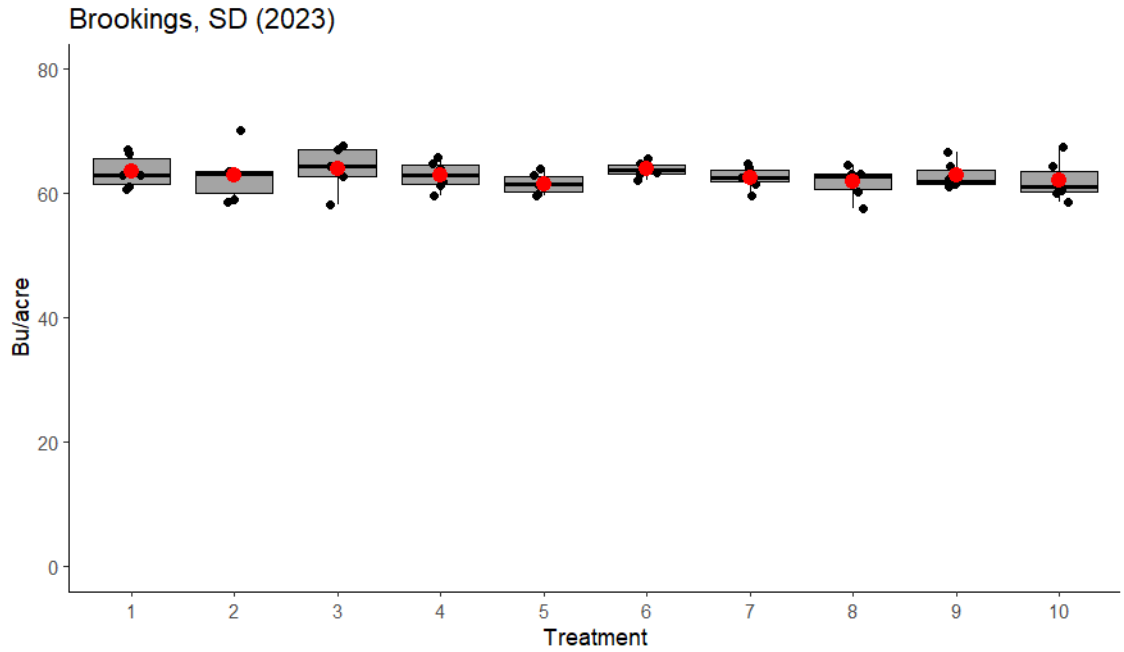
South Carolina

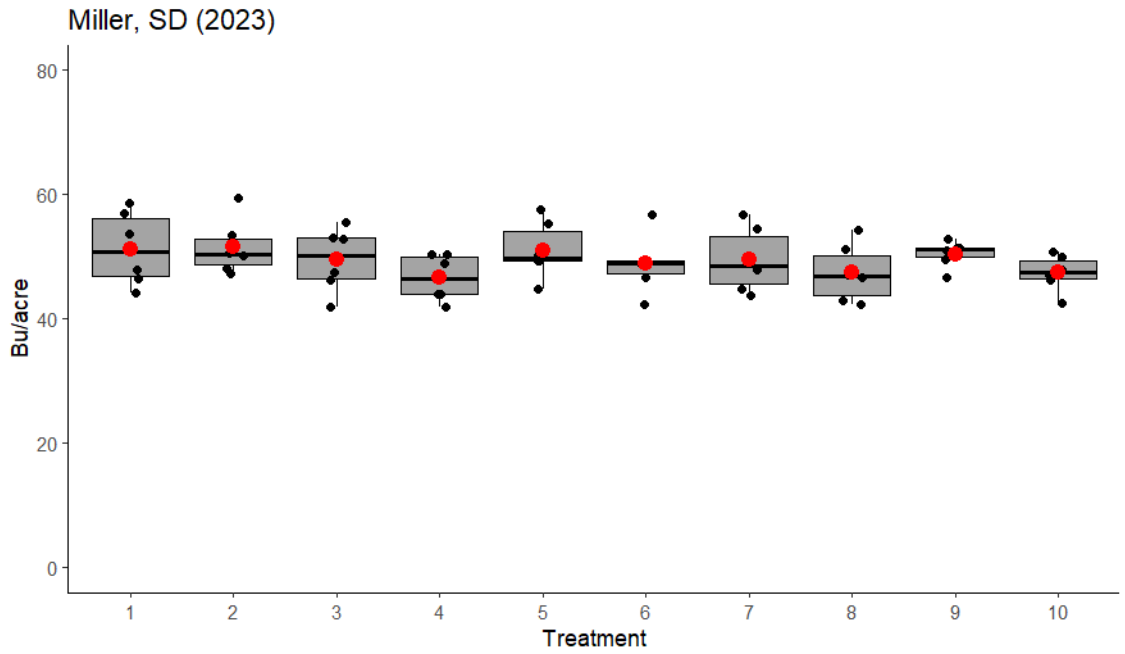

Blackville (Dryland), SC (2023)
Yield (bu/acre)
0
20
40
60
80
1
2
3
4
5
6
7
8
9
10
Treatment

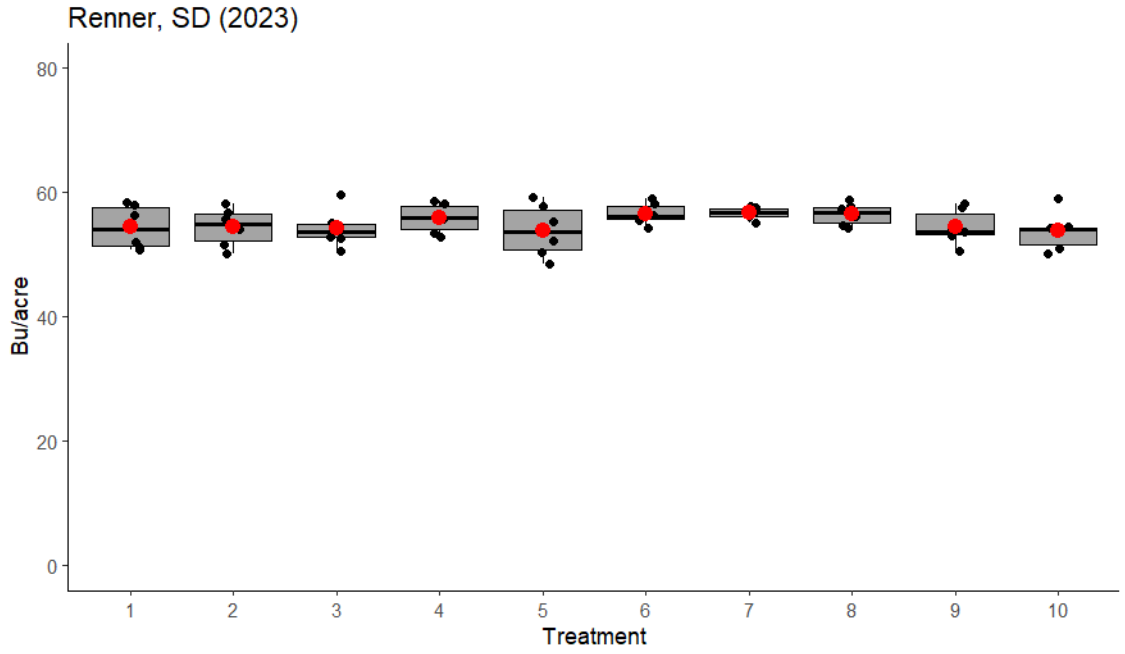

Blackville (Irrigated), SC (2023)
Yield (bu/acre)
0
20
40
60
80
1
2
3
4
5
6
7
8
9
10
Treatment

South Dakota

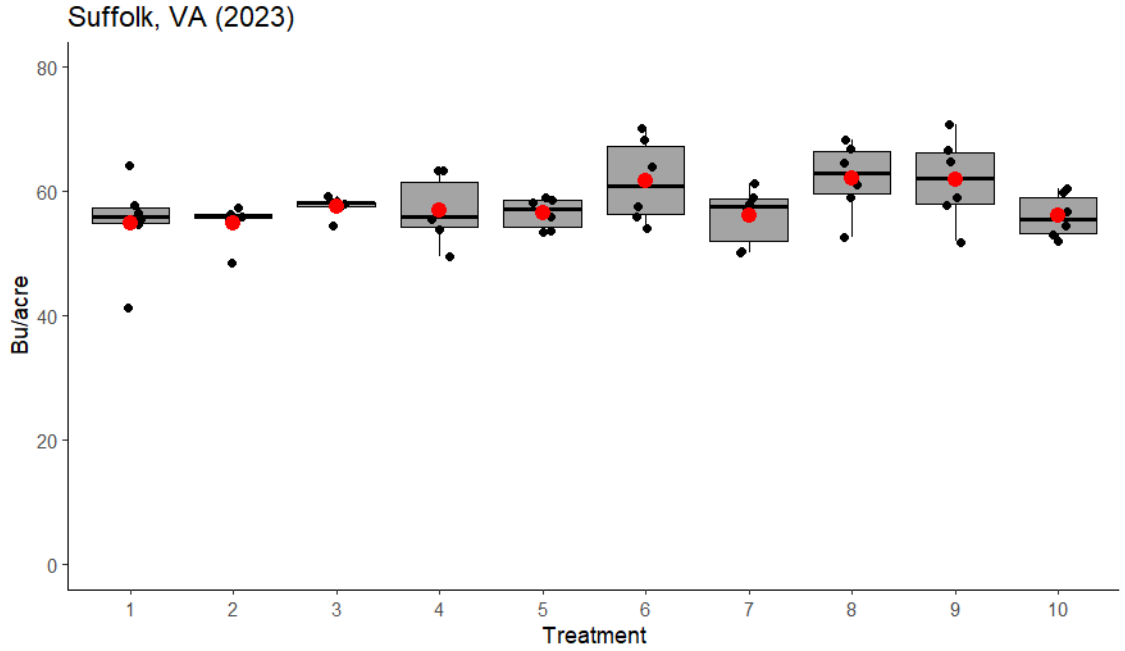




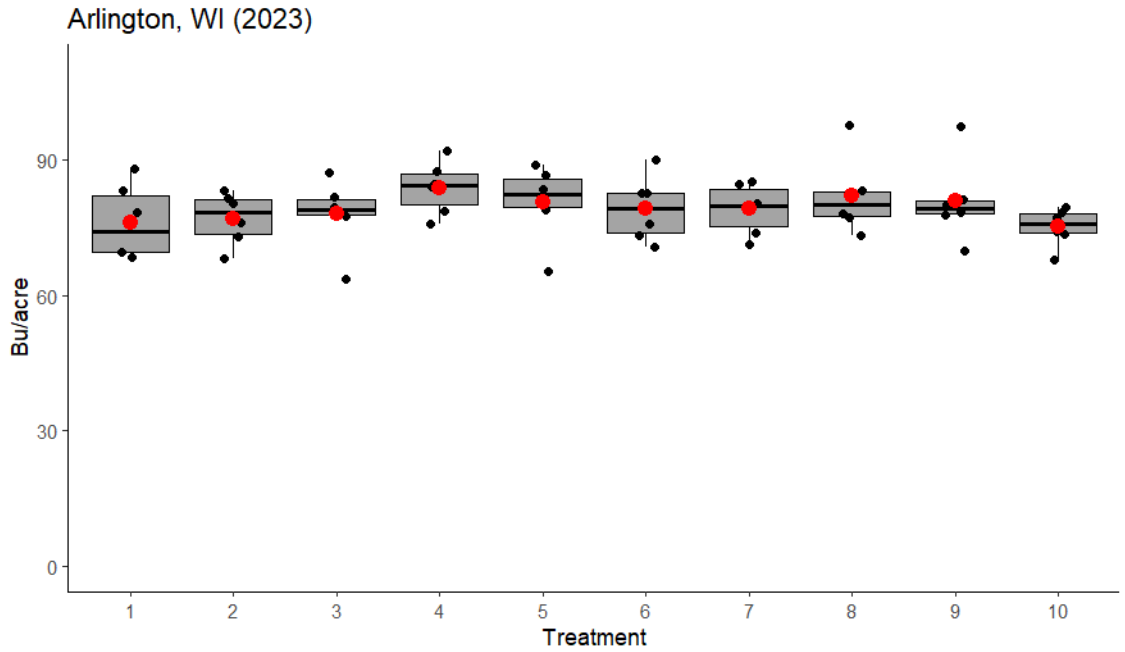

Miller, SD (2023)
Bu/acre
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
Treatment

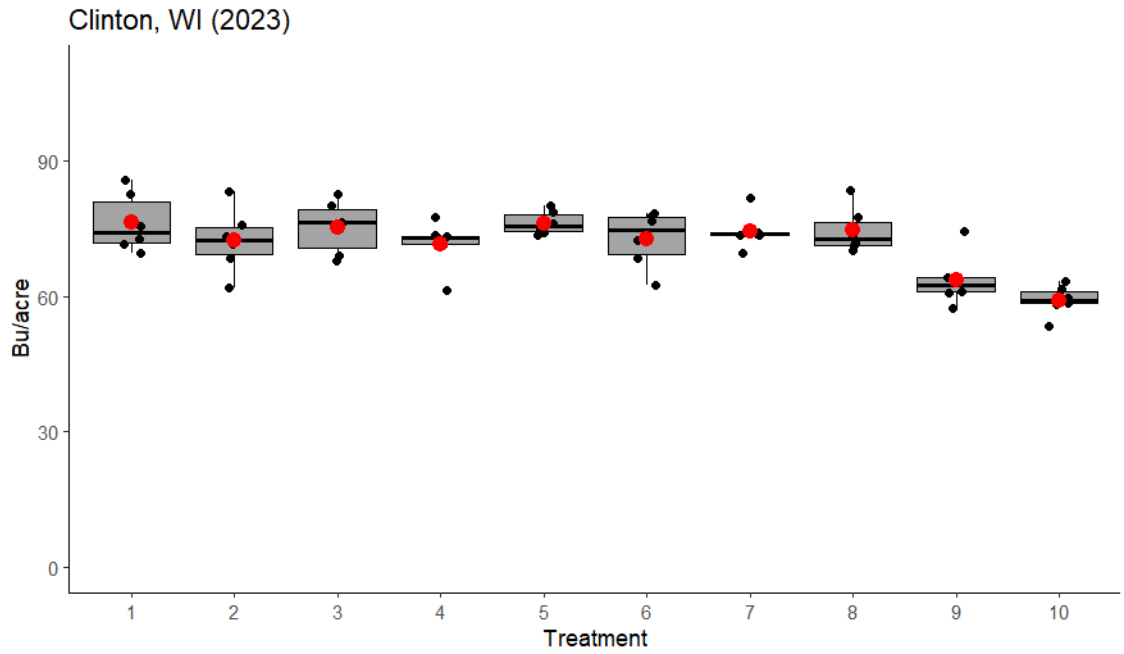

Renner, SD (2023)
Bu/acre
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
Treatment

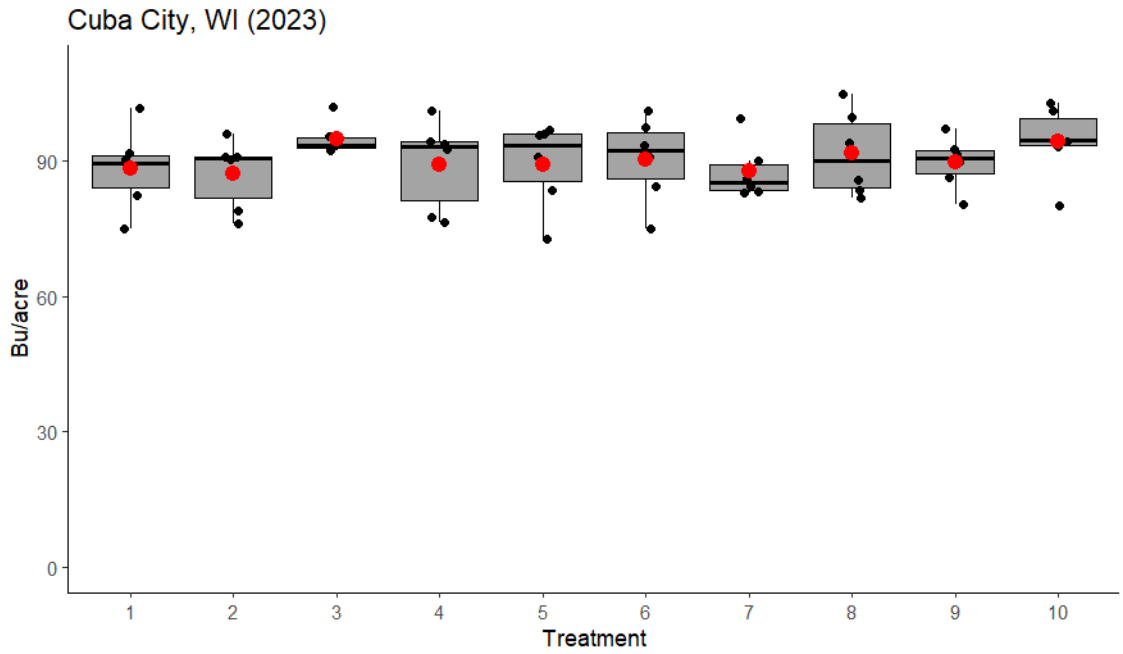
Virginia

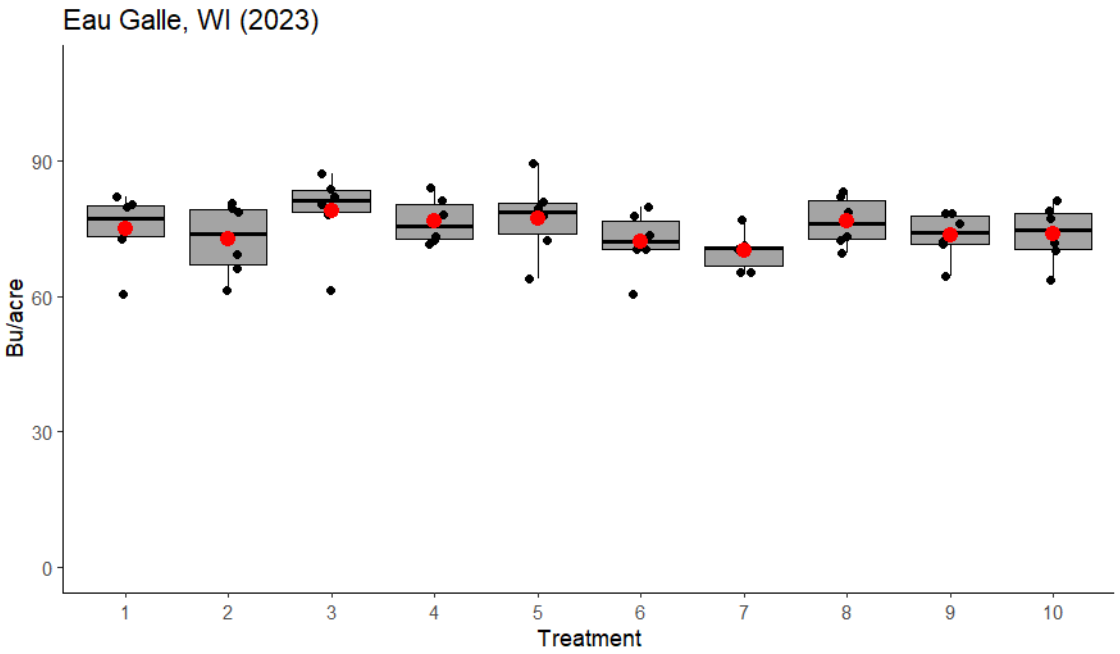


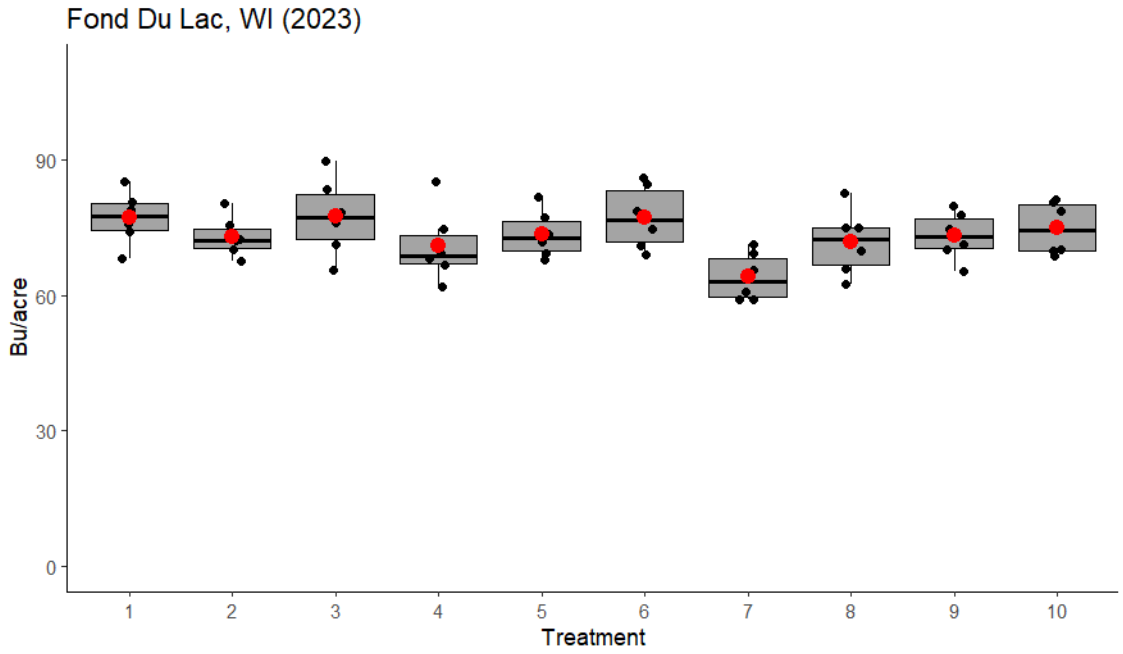
Wisconsin

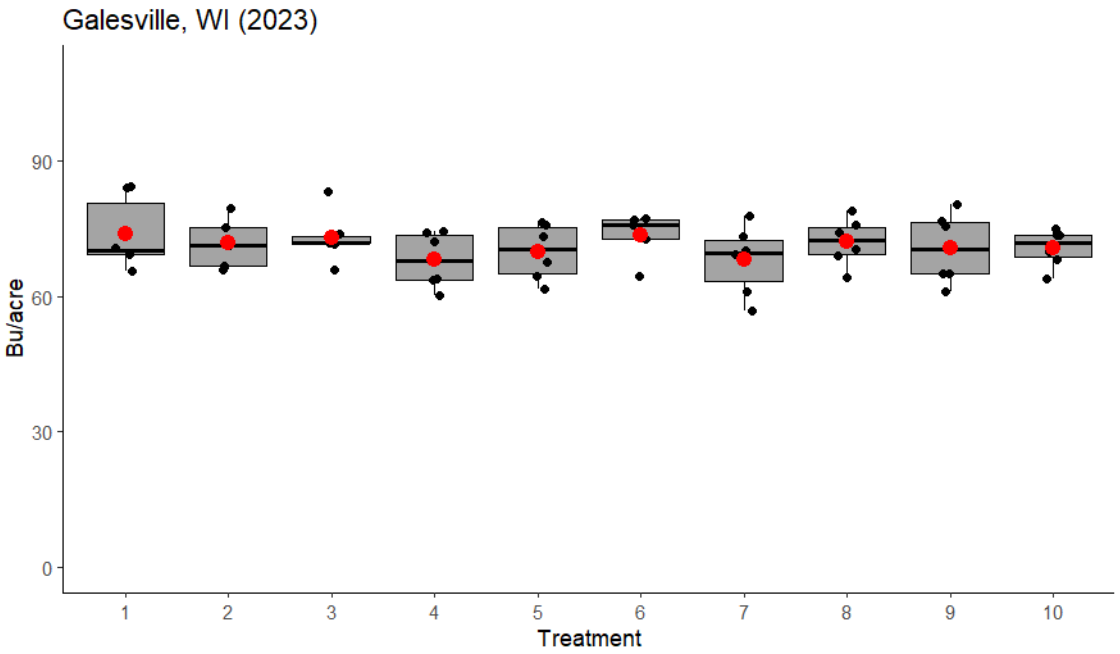


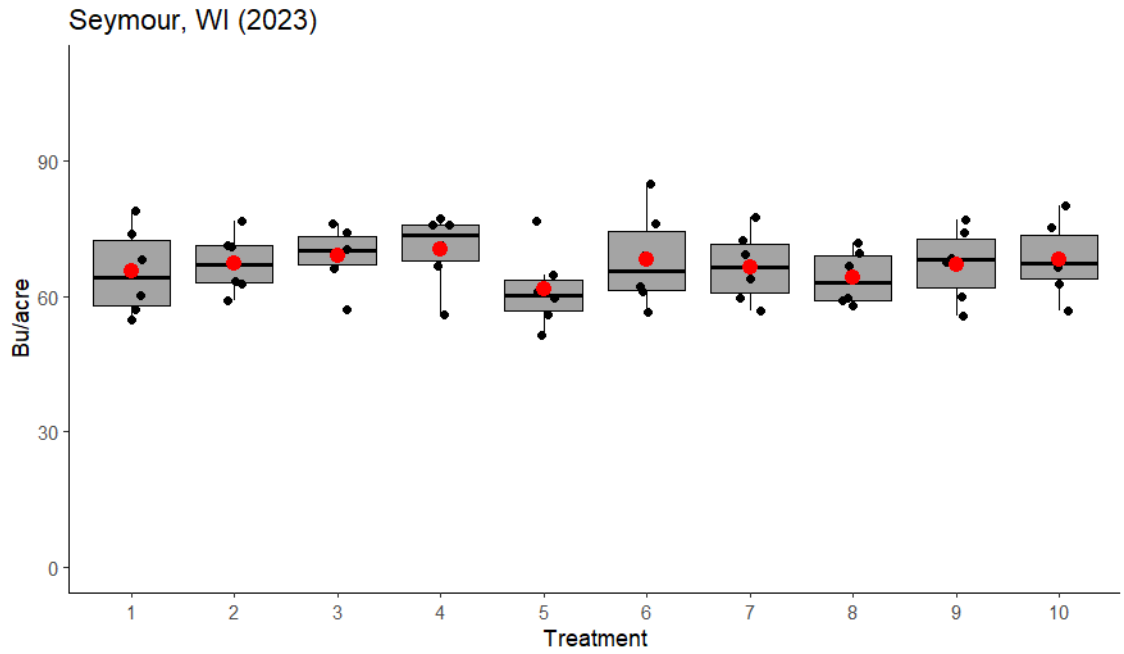

Clinton, WI (2023)
Bu/acre
90
60
30
0
1
2
3
4
5
6
7
8
9
10
Treatment

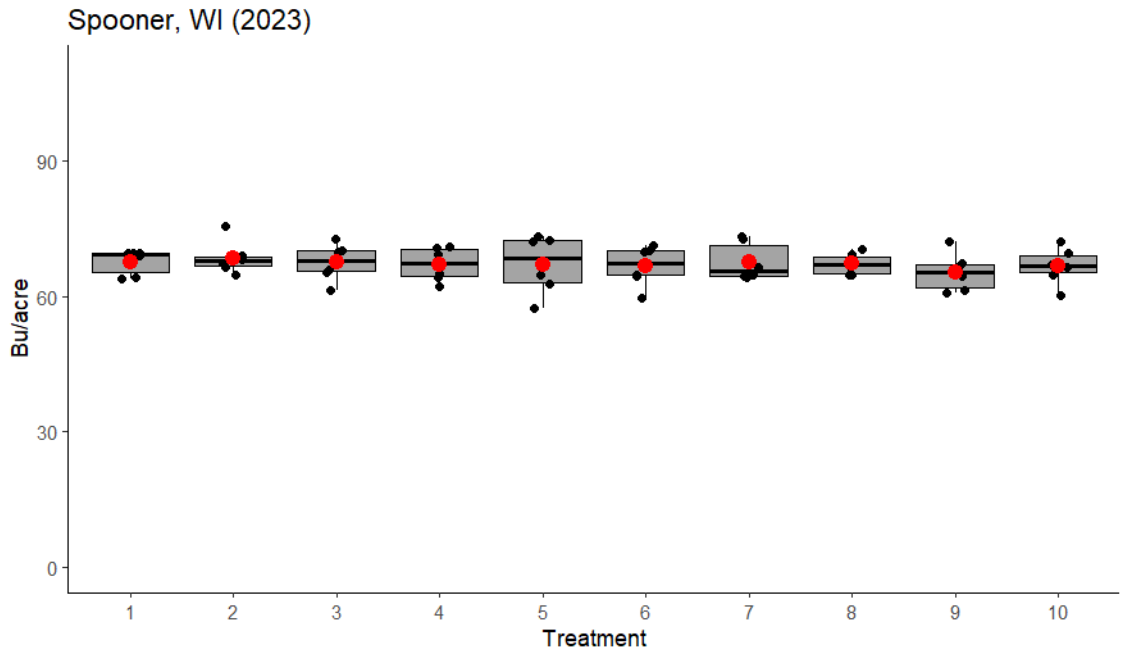

Cuba City, WI (2023)
Bu/acre
90
60
30
0
1
2
3
4
5
6
7
8
9
10
Treatment

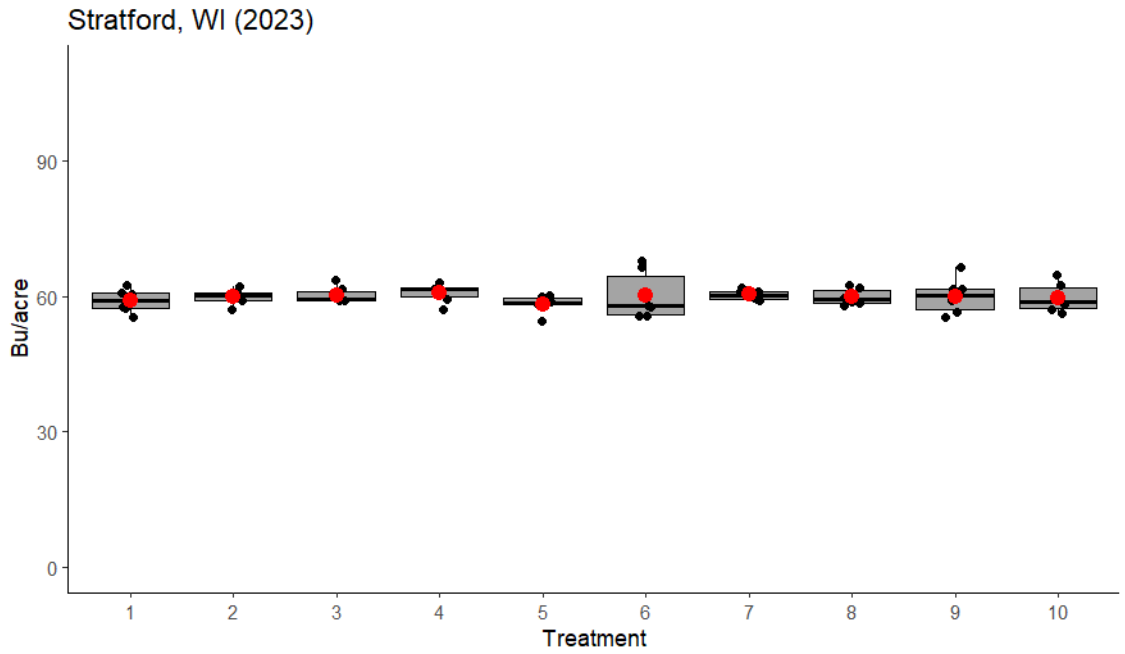

Eau Galle, WI (2023)
Bu/acre
90
60
30
0
1
2
3
4
5
6
7
8
9
10
Treatment

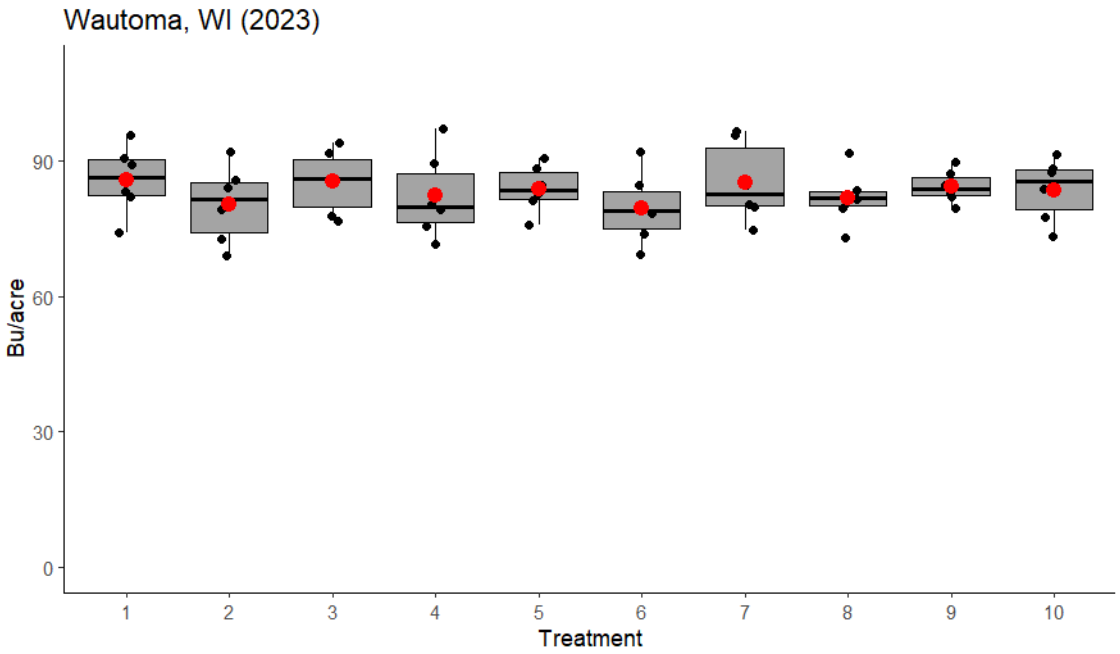

Fond Du Lac, WI (2023)
Bu/acre
90
60
30
0
1
2
3
4
5
6
7
8
9
10
Treatment


Galesville, WI (2023)
Bu/acre
90
60
30
0
1
2
3
4
5
6
7
8
9
10
Treatment


Seymour, WI (2023)
Bu/acre
90
60
30
0
1
2
3
4
5
6
7
8
9
10
Treatment


Spooner, WI (2023)
Bu/acre
90
60
30
0
1
2
3
4
5
6
7
8
9
10
Treatment


Stratford, WI (2023)
Bu/acre
90
60
30
0
1
2
3
4
5
6
7
8
9
10
Treatment


Wautoma, WI (2023)
Bu/acre
90
60
30
0
1
2
3
4
5
6
7
8
9
10
Treatment