Herbicide + PeptiGro® Compatibility Study in Corn

(University of Missouri) - Technical Report No. 2021.3

Author

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Executive Summary

NF Protein LLC funded faculty at University of Missouri to evaluate the physical and functional compatibility of PeptiGro® with 10 commonly used herbicides in corn. Physical compatibility study was conducted in the laboratory and functional herbicide compatibility study was conducted in small plot field environments to determine the effectiveness of herbicide-specific weed control between herbicide-only" vs. "herbicide + PeptiGro®" on both selected grass and broadleaf weeds. These studies determined that adding PeptiGro® to commonly used herbicides in corn was physically compatible with all herbicide solutions evaluated and PeptiGro® had no impact on the effectiveness of respective-herbicide weed control.

Objectives

The objectives of this research study were to:

1) Evaluate physical mixing compatibility in the laboratory of 10 commonly used corn post emergence foliar herbicides when tank mixed with PeptiGro® vs. respective herbicide *per se* mixed in water.

2) Evaluate herbicide effectiveness *per se* vs. herbicides tank mixed with PeptiGro® for agronomic effectiveness of weed control and rate of weed kill over time. The dose rate used for each herbicide was the normally recommended rate for weed control in corn. PeptiGro dose rate was 1 quart/ac.

3) Evaluate the impacts of herbicide only vs. herbicide + PeptiGro on grain moisture, grain test weight, and grain yield (bu./ac. @15%).

PeptiGro® Product

Amino acids are the building blocks of plant proteins. PeptiGro® is a liquid mixture of beneficial amino acids and short-chain polypeptides that helps plants maximize yield in a variety of favorable and unfavorable environments, like times of stress from drought, heat, and herbicide injury. PeptiGro® is an exciting, new, proactive tool to use in your foliar and in-furrow fertilizer program. Based on PeptiGro® yield performance measured with >10,000 data points in 71 corn and 71 soybean trials across 10 States in 2020 and 2021, PeptiGro® provides a 2+ bu./ac. benefit in corn and a 1+ bu./ac. benefit in soybeans and can be applied as a standalone product in-furrow or foliar applied or can be tank mixed with herbicides, fungicides, and other foliar fertilizers.

Implementation

Study was conducted near Columbia, MO in 2021 on corn (*Zea mays*, Pioneer P1244AM with attributes of glyphosate-resistance and glufosinate-resistant) on silt loam soil (name was Mexico silt loam with 2.3% OM, pH 6.2, and CEC of 10.5 meq/100g) using a planting density of 32,000 seeds/ac. for corn in 30-inch row spacing. Foliar applications were applied at 15 gal./ac. volume using a compressed CO_2 backpack sprayer at V5 stage (~34 days after emergence; avg. Common water hemp height was 6 inches; avg. Common water hemp density was 18/m^2, avg. Common barnyard grass height was 12 inches, avg. barnyard grass height was 12 inches, and avg. barnyard grass density was 144/m^2). In the trial, Common water hemp (*Amaranthus tamariscinus*) and Common barnyard grass (*Echinochloa crus-galli*) were assessed at 7, 21, and 35 days after application (DPA) to determine the effectiveness of corn-specific herbicide weed control (0-100% complete weed control) for "herbicide only (Control)" vs. "herbicide + PeptiGro®" treatments.

Experimental Design & Treatments

SPLIT-PLOT DESIGN: Main Factor A (Corn Herbicides) and Sub-Factor B (Herbicide-only (Control) vs. Herbicide + PeptiGro®). Trial had 8 replications.

Factor	Level	Herbicide	Rate/A
A	1	Roundup (glyphosate)	2 QT/A
A	2	Atrazine 4L (triazine)	2 QT/A
A	3	Callisto (mesotrione)	3 FL OZ/A
A	4	Enlist One (2,4-D)	1 QT/A
A	5	Liberty (glufosinate)	1 QT/A
A	6	Steadfast Q (nicosulfuron, rimsulfuron)	1.5 OZ WT/A
A	7	Laudis (tembotrione)	3 FL OZ/A
A	8	Armezon PRO	20 FL OZ/A
A	9	Resource (flumiclorac)	6 FL OZ/A
A	10	DiFlex (dicamba)	10 FL OZ/A
B	1	Control (herbicide only)	As above
B	2	+ PeptiGro® (tank mixed with herbicide)	1 QT/A

List of Treatments in Corn Trial (University of Missouri)

TRT No.	Effect	Level	Herbicide
1	factor B[factor A]	[1]1	Roundup (glyphosate) - Control
2	factor B[factor A]	[1]2	Roundup (glyphosate) + PeptiGro®
3	factor B[factor A]	[2]1	Atrazine 4L (triazine) - Control
4	factor B[factor A]	[2]2	Atrazine 4L (triazine) + PeptiGro®
5	factor B[factor A]	[3]1	Callisto (mesotrione) - Control
6	factor B[factor A]	[3]2	Callisto (mesotrione) + PeptiGro®
7	factor B[factor A]	[4]1	Enlist One (2,4-D) - Control
8	factor B[factor A]	[4]2	Enlist One (2,4-D) + PeptiGro®
9	factor B[factor A]	[5]1	Liberty (glufosinate) - Control
10	factor B[factor A]	[5]2	Liberty (glufosinate) + PeptiGro®
11	factor B[factor A]	[6]1	Steadfast Q (nicosulfuron, rimsulfuron) - Control
12	factor B[factor A]	[6]2	Steadfast Q (nicosulfuron, rimsulfuron) + PeptiGro®
13	factor B[factor A]	[7]1	Laudis (tembotrione) - Control
14	factor B[factor A]	[7]2	Laudis (tembotrione) + PeptiGro®
15	factor B[factor A]	[8]1	Armezon PRO - Control
16	factor B[factor A]	[8]2	Armezon PRO + PeptiGro®
17	factor B[factor A]	[9]1	Resource (flumiclorac) - Control
18	factor B[factor A]	[9]2	Resource (flumiclorac) + PeptiGro®
19	factor B[factor A]	[10]1	DiFlex (dicamba) - Control
20	factor B[factor A]	[10]2	DiFlex (dicamba) + PeptiGro®

Corn Field Plot Layout. TRT No. is lower number in cells; 8 REPs and empty white cells represent border plots surrounding trial.
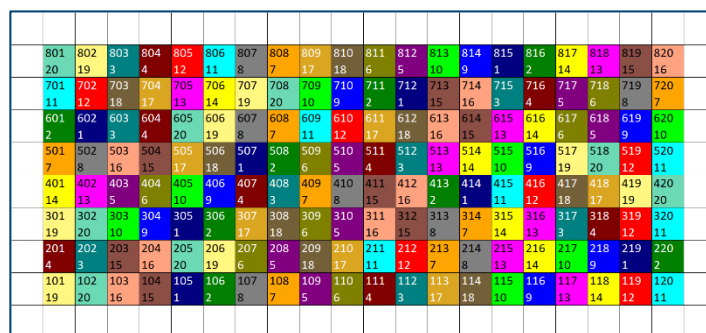
Physical Compatibility Measurements

There were no physical compatibility issues observed.

Field Data Measurements

The following characteristics were evaluated to determine the effectiveness of herbicide-specific weed control between herbicide-only" vs. "herbicide + PeptiGro®" on both selected grass and broadleaf weeds:

1. STANDCNT_V2: total plant number in center 2 rows of 4-row plot at V2 stage.

2. VIGOR: rating 0-9 (index/scale) taken at V2 stage.

3. MAX.WHORL HEIGHT_V5: average maximum leaf whorl height of 5 plants in row 1 at V5 stage.

4. Common water hemp (*Amaranthus tamariscinus*) was assessed at 7, 21, and 35 days after application (DPA): measured as a rating 0-100% relative to 100% complete weed control.

5. Common barnyard grass (*Echinochloa crus-galli*) was assessed at 7, 21, and 35 days after application (DPA): measured as a rating 0-100% relative to 100% complete weed control.

6. Grain Moisture (MOICON): 0-100% moisture content of seed.

7. Grain Yield: BU/A @15%

Statistical Analysis

Outliers were determined and values converted to missing data points by the Box-Whisker definition where an outlier is defined as a data point that is located above 1.5 times the upper 75th percentile or located 1.5 times below the lower 25th percentile. Data were analyzed with SAS JMP v.16 Statistical Software using Restricted Maximum Likelihood (REML) method to estimate Fit Model variance components. Tukey HSD test (alpha 0.1) was performed to compare individual mean differences for main Factor A (herbicides) and for Subfactor B (herbicide-only as Control vs. herbicide + PeptiGro®). LSMean$_{(0.1)}$ values and Treatment Fixed Effects Prob(F) values are presented. Treatment means not sharing a Letter in common are significantly different. For measuring significance of Factor B effects (± PeptiGro®), compare Letters within common Factor A (herbicide) level.

Results
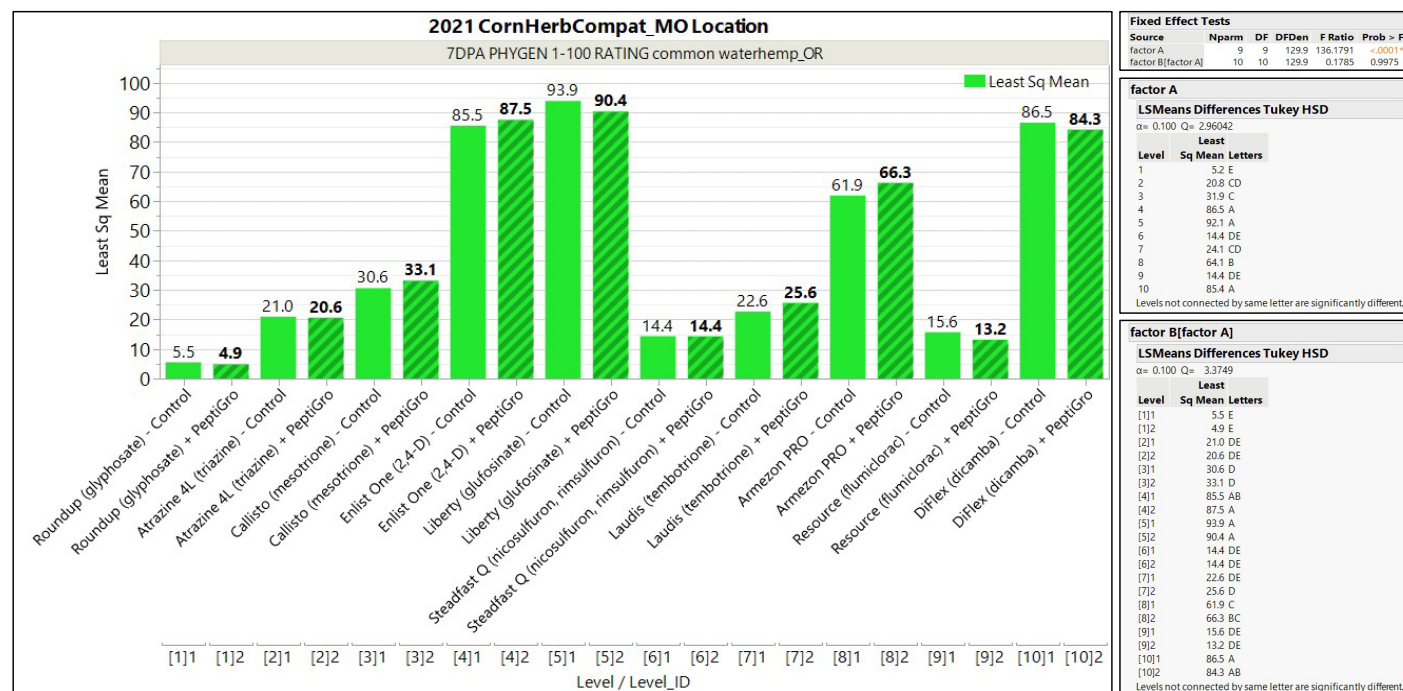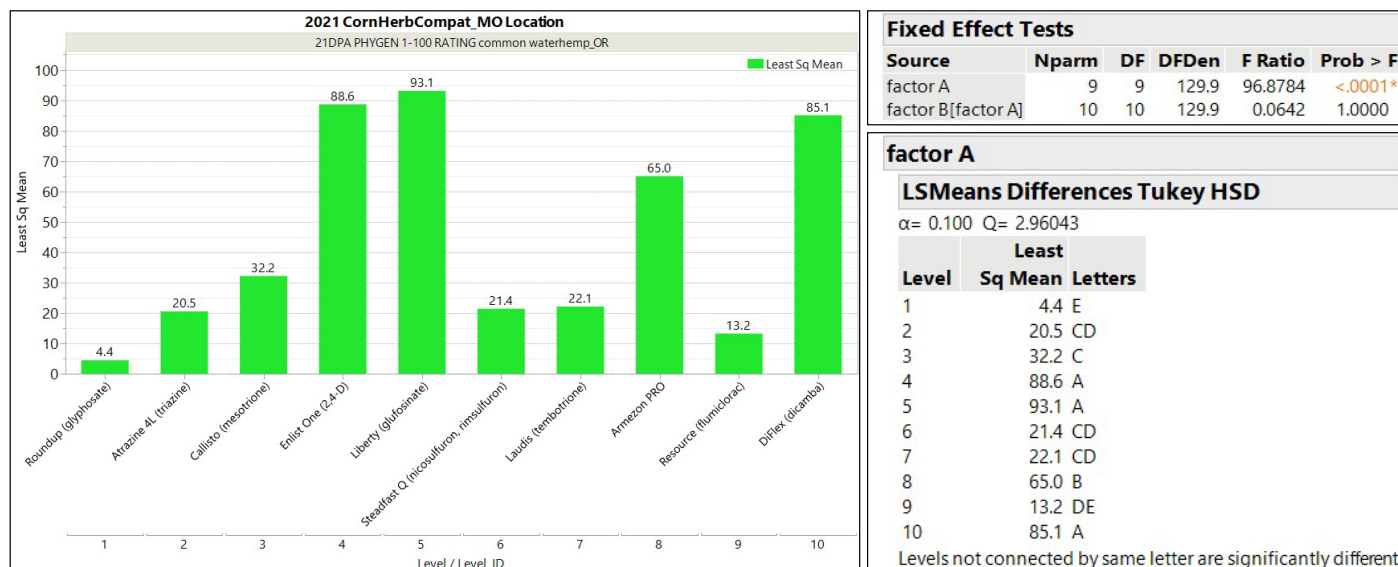
Field Data Measurements

1. STANDCNT_V2. **Non-significant herbicide effect** (Factor A) and **non-significant PeptiGro® effect** (Factor B, nested in Factor A). Data not shown.

2. VIGOR. All plots were rated as 5 out of 1-9 index/scale (statistics not applicable).

3. MAX.WHORL HEIGHT_V5. **Non-significant herbicide effect** (Factor A) and **non-significant PeptiGro® effect** (Factor B, nested in Factor A). Data not shown.

4. Herbicide control of Common water hemp (*Amaranthus tamariscinus*) was assessed at 7, 21, and 35 days after application (DPA) using 0-100% rating with 100% being complete weed control.

    a. Common water hemp @ 7 DPA – **Significant Herbicide Effect** (Factor A).
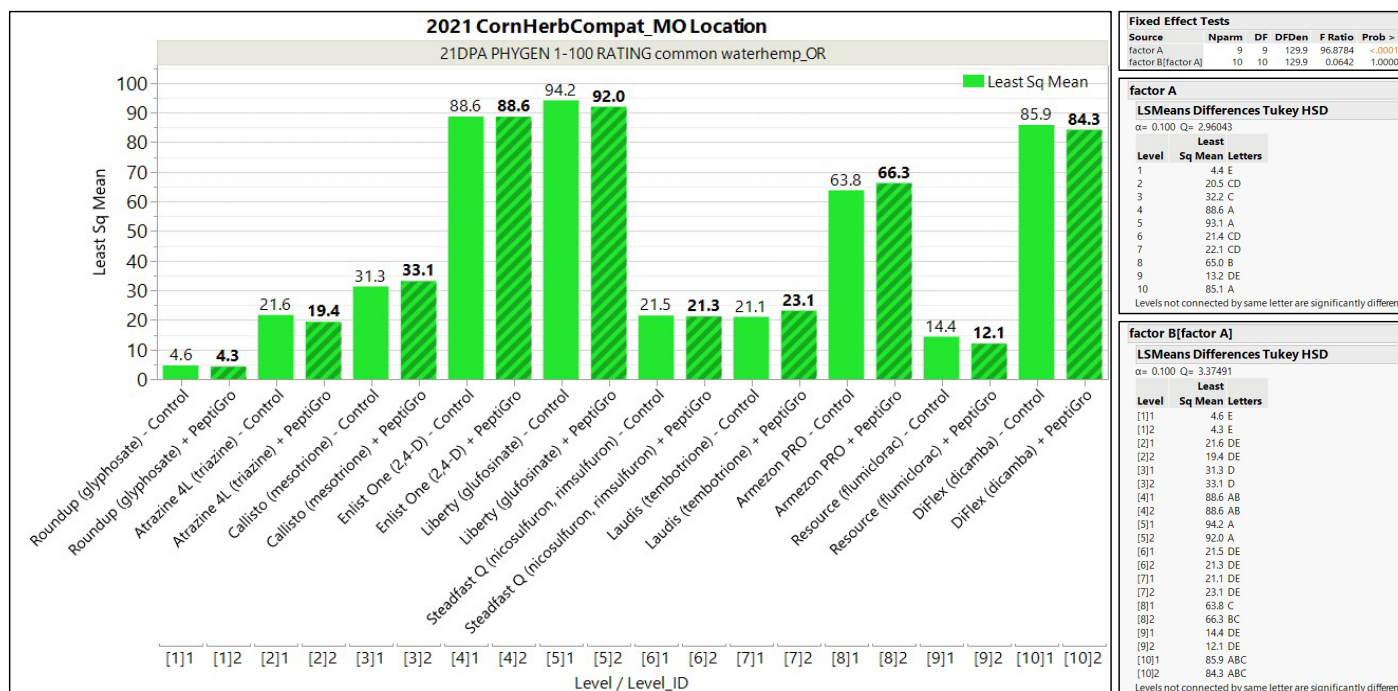

2021 CornHerbCompat_MO Location
7DPA PHYGEN 1-100 RATING common waterhemp_OR

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
factor A	9	9	129.9	136.1791	<.0001*
factor B[factor A]	10	10	129.9	0.1785	0.9975

factor A

LSMeans Differences Tukey HSD

α= 0.100 Q= 2.96042

Level	Least Sq Mean	Letters
1	5.2	E
2	20.8	CD
3	31.9	C
4	86.5	A
5	92.1	A
6	14.4	DE
7	24.1	CD
8	64.1	B
9	14.4	DE
10	85.4	A

Levels not connected by same letter are significantly different.

    b. Common water hemp @ 7 DPA – **Non-Significant PeptiGro® Effect** (Factor B nested in Factor A). For measuring significance of Factor B effects (± PeptiGro®), compare Letters within common Factor A (herbicide) level.

2021 CornHerbCompat_MO Location
7DPA PHYGEN 1-100 RATING common waterhemp_OR

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6	14.4	DE
7	24.1	CD
8	64.1	B
9	14.4	DE
10	85.4	A

Levels not connected by same letter are significantly different.

factor B[factor A]

LSMeans Differences Tukey HSD

α= 0.100 Q= 3.3749

Level	Least Sq Mean	Letters
[1]1	5.5	E
[1]2	4.9	E
[2]1	21.0	DE
[2]2	20.6	DE
[3]1	30.6	D
[3]2	33.1	D
[4]1	85.5	AB
[4]2	87.5	A
[5]1	93.9	A
[5]2	90.4	A
[6]1	14.4	DE
[6]2	14.4	DE
[7]1	22.6	DE
[7]2	25.6	DE
[8]1	61.9	C
[8]2	66.3	BC
[9]1	15.6	DE
[9]2	13.2	DE
[10]1	86.5	A
[10]2	84.3	AB

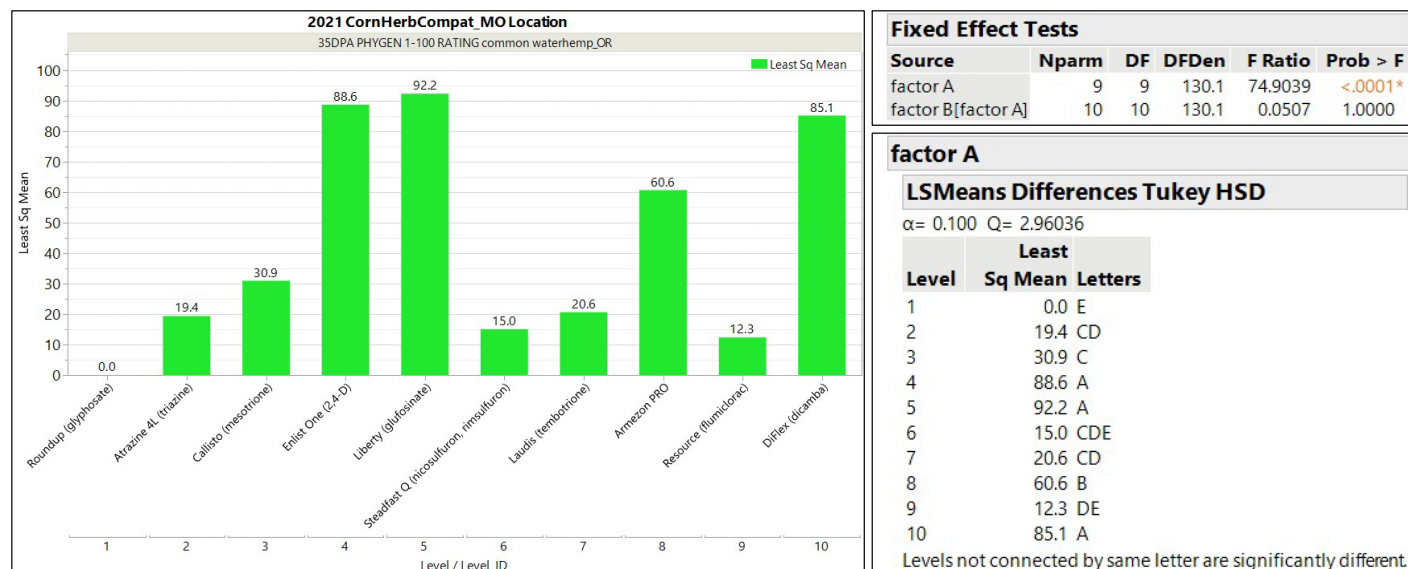Levels not connected by same letter are significantly different.

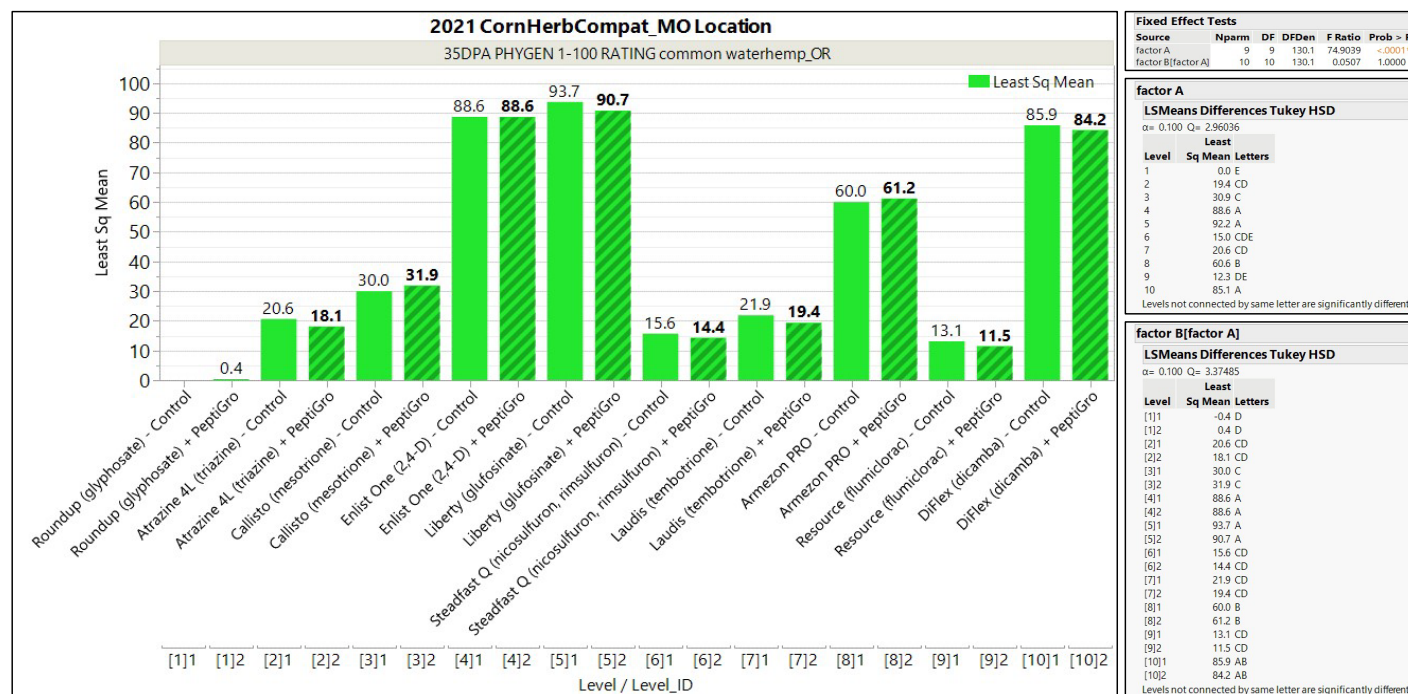c.   Common water hemp @ 21 DPA – **Significant Herbicide Effect** (Factor A).

d.   Common water hemp @ 21 DPA – **Non-Significant PeptiGro® Effect** (Factor B nested in Factor A). For measuring significance of Factor B effects (± PeptiGro®), compare Letters within common Factor A (herbicide) level.

e. Common water hemp @ 35 DPA – **Significant Herbicide Effect** (Factor A).

2021 CornHerbCompat_MO Location
35DPA PHYGEN 1-100 RATING common waterhemp_OR

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
factor A	9	9	130.1	74.9039	<.0001*
factor B[factor A]	10	10	130.1	0.0507	1.0000

factor A

LSMeans Differences Tukey HSD

α= 0.100 Q= 2.96036

Level	Least Sq Mean	Letters
1	0.0	E
2	19.4	CD
3	30.9	C
4	88.6	A
5	92.2	A
6	15.0	CDE
7	20.6	CD
8	60.6	B
9	12.3	DE
10	85.1	A

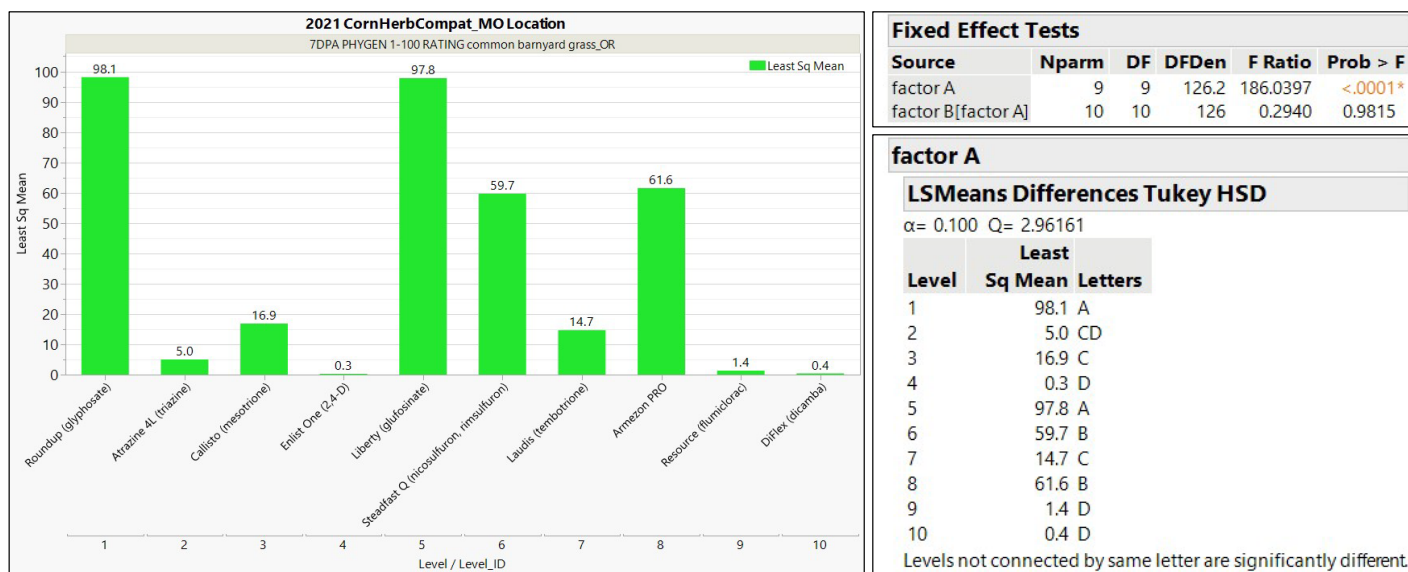Levels not connected by same letter are significantly different.

f. Common water hemp @ 35 DPA – **Non-significant PeptiGro® Effect** (Factor B nested in Factor A). For measuring significance of Factor B effects (± PeptiGro®), compare Letters within common Factor A (herbicide) level.

2021 CornHerbCompat_MO Location
35DPA PHYGEN 1-100 RATING common waterhemp_OR

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
factor A	9	9	130.1	74.9039	<.0001*
factor B[factor A]	10	10	130.1	0.0507	1.0000

factor A

LSMeans Differences Tukey HSD

α= 0.100 Q= 2.96036

Level	Least Sq Mean	Letters
1	0.0	E
2	19.4	CD
3	30.9	C
4	88.6	A
5	92.2	A
6	15.0	CDE
7	20.6	CD
8	60.6	B
9	12.3	DE
10	85.1	A

Levels not connected by same letter are significantly different.

factor B[factor A]

LSMeans Differences Tukey HSD

α= 0.100 Q= 3.37485

Level	Least Sq Mean	Letters
[1]1	-0.4	D
[1]2	0.4	D
[2]1	20.6	CD
[2]2	18.1	CD
[3]1	30.0	C
[3]2	31.9	C
[4]1	88.6	A
[4]2	88.6	A
[5]1	93.7	A
[5]2	90.7	A
[6]1	15.6	CD
[6]2	14.4	CD
[7]1	21.9	CD
[7]2	19.4	CD
[8]1	60.0	B
[8]2	61.2	B
[9]1	13.1	CD
[9]2	11.5	CD
[10]1	85.9	AB
[10]2	84.2	AB

Levels not connected by same letter are significantly different.

5. Herbicide control of Common barnyard grass (*Echinochloa crus-galli*) was assessed at 7, 21, and 35 days after application (DPA) using 0-100% rating with 100% being complete weed control.
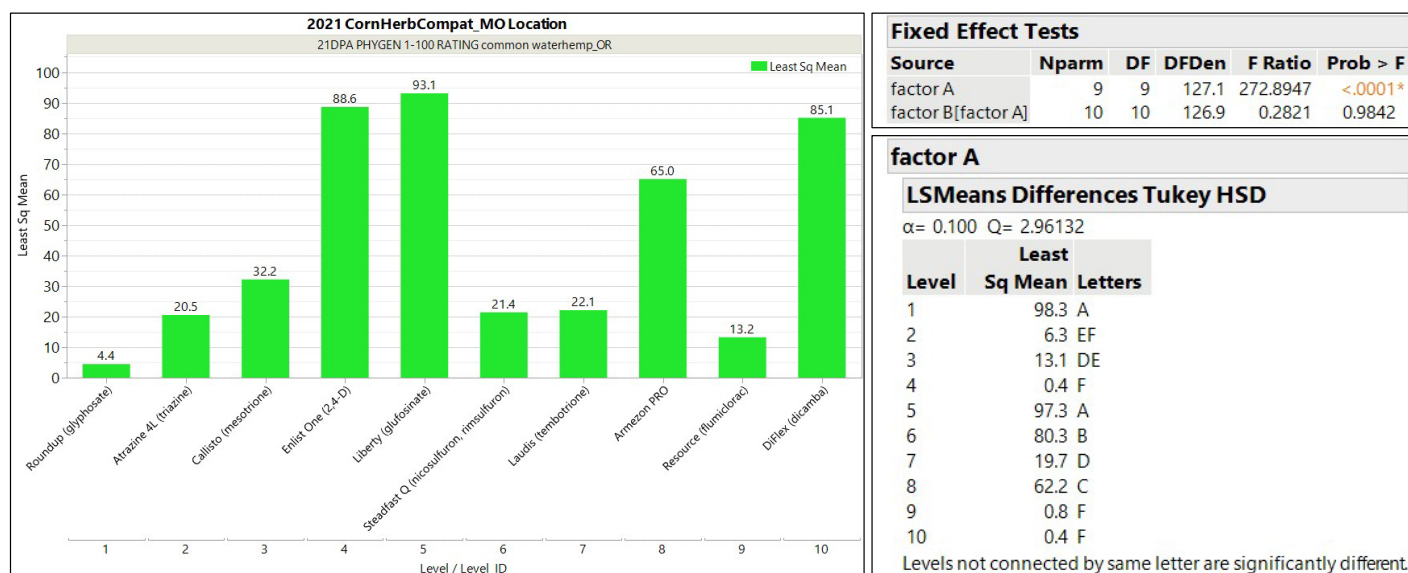
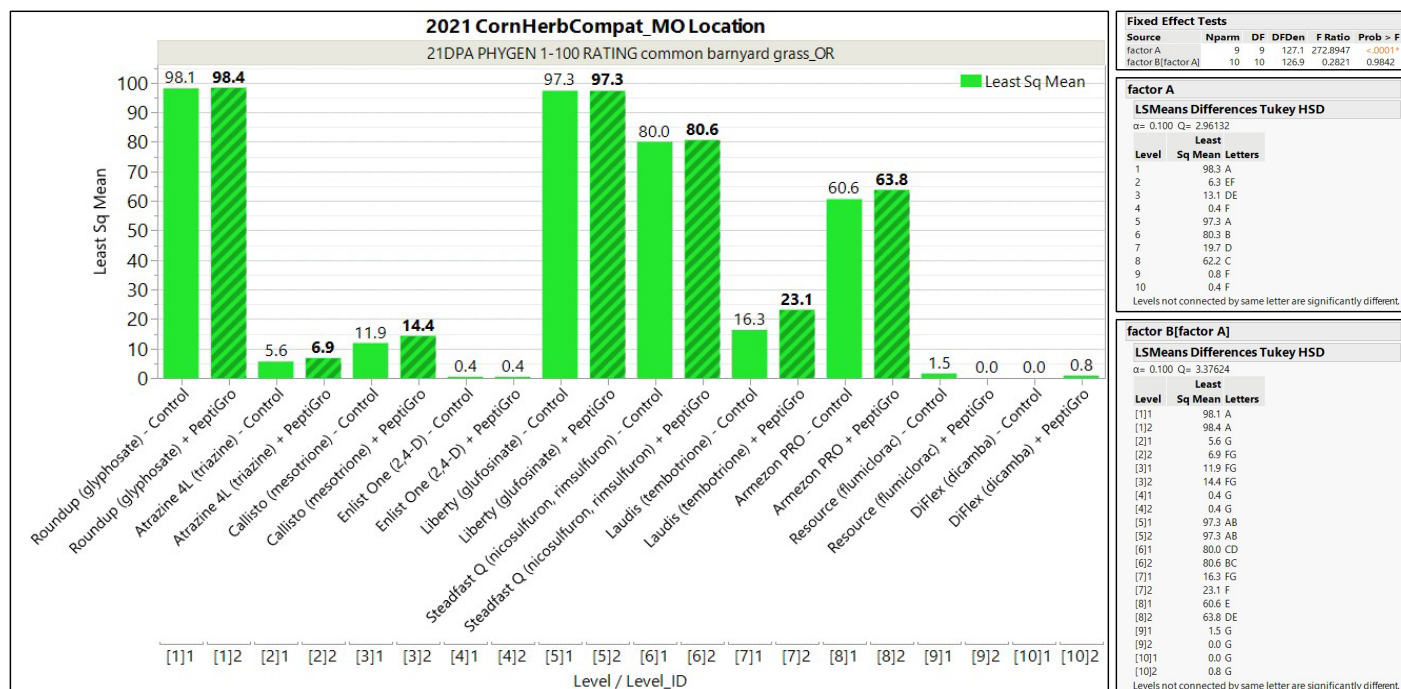   a. Common barnyard grass @ 7 DPA – **Significant Herbicide Effect** (Factor A).

b. Common barnyard grass @ 7 DPA – **Non-Significant PeptiGro® Effect** (Factor B nested in Factor A). For measuring significance of Factor B effects (± PeptiGro®), compare Letters within common Factor A (herbicide) level.
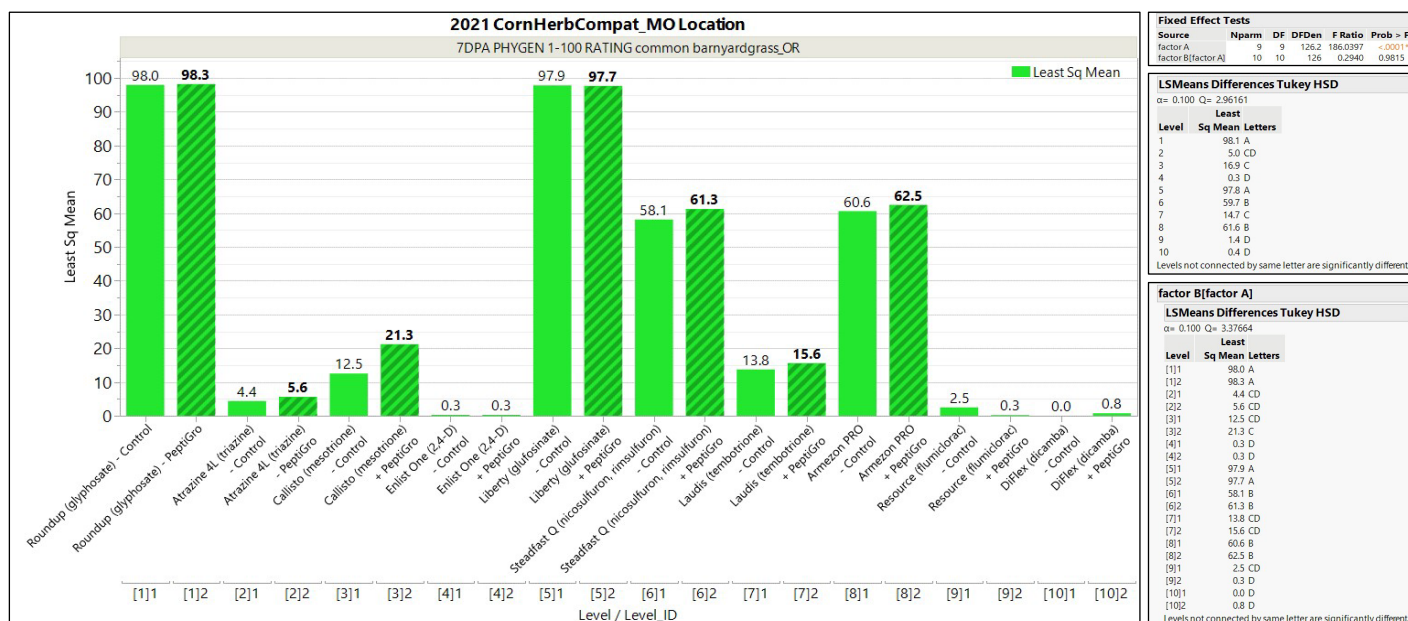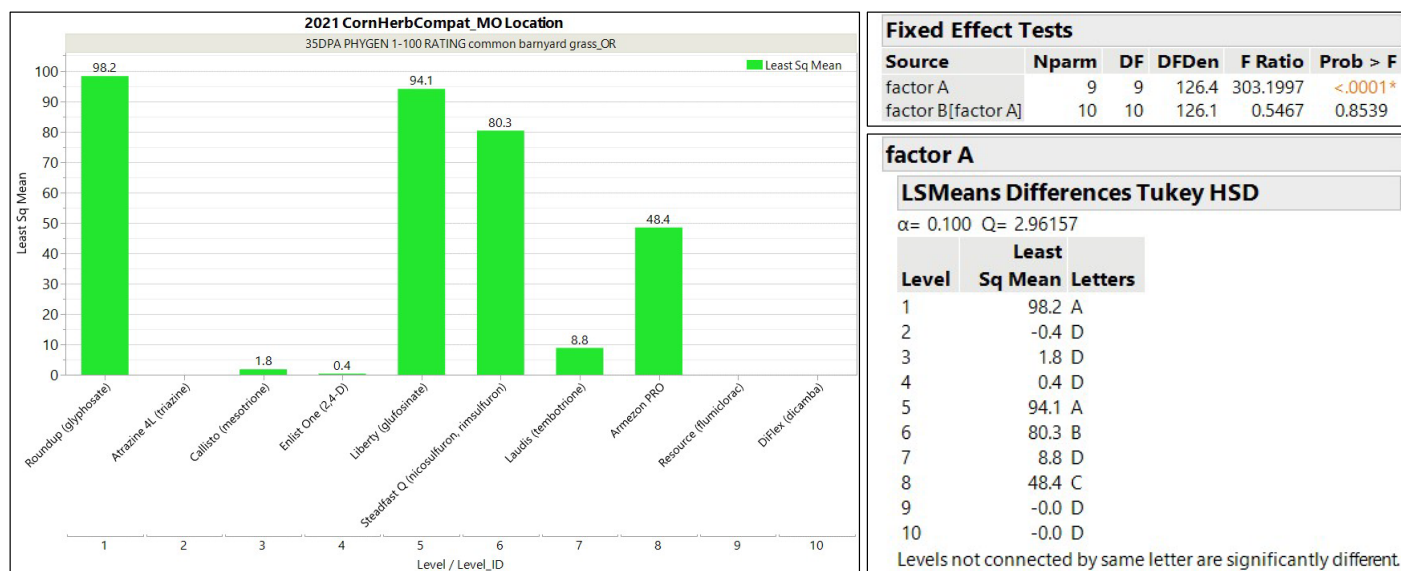
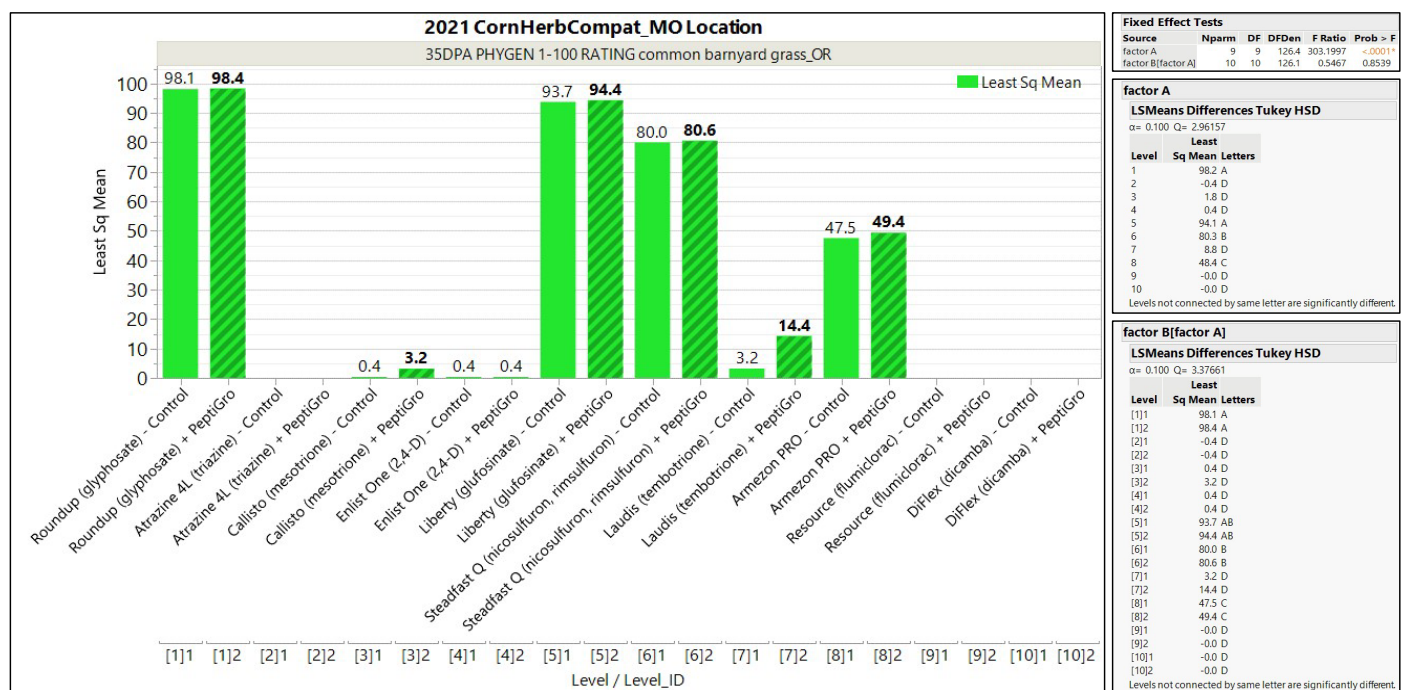c. Common barnyard grass @ 21 DPA – **Significant Herbicide Effect** (Factor A).

d. Common barnyard grass @ 21 DPA – **Mainly Non-Significant PeptiGro® Effect** (Factor B nested in Factor A). Only [2]1 vs. [2]2 had significant differences where Roundup + PeptiGro® had better weed control than Roundup-only treatment. For measuring significance of Factor B effects (± PeptiGro®), compare Letters within common Factor A (herbicide) level.

e. Common barnyard grass @ 35 DPA – **Significant Herbicide Effect** (Factor A).


f. Common barnyard grass @ 35 DPA – **Non-Significant PeptiGro® Effect** (Factor B nested in Factor A). For measuring significance of Factor B effects (± PeptiGro®), compare Letters within common Factor A (herbicide) level.
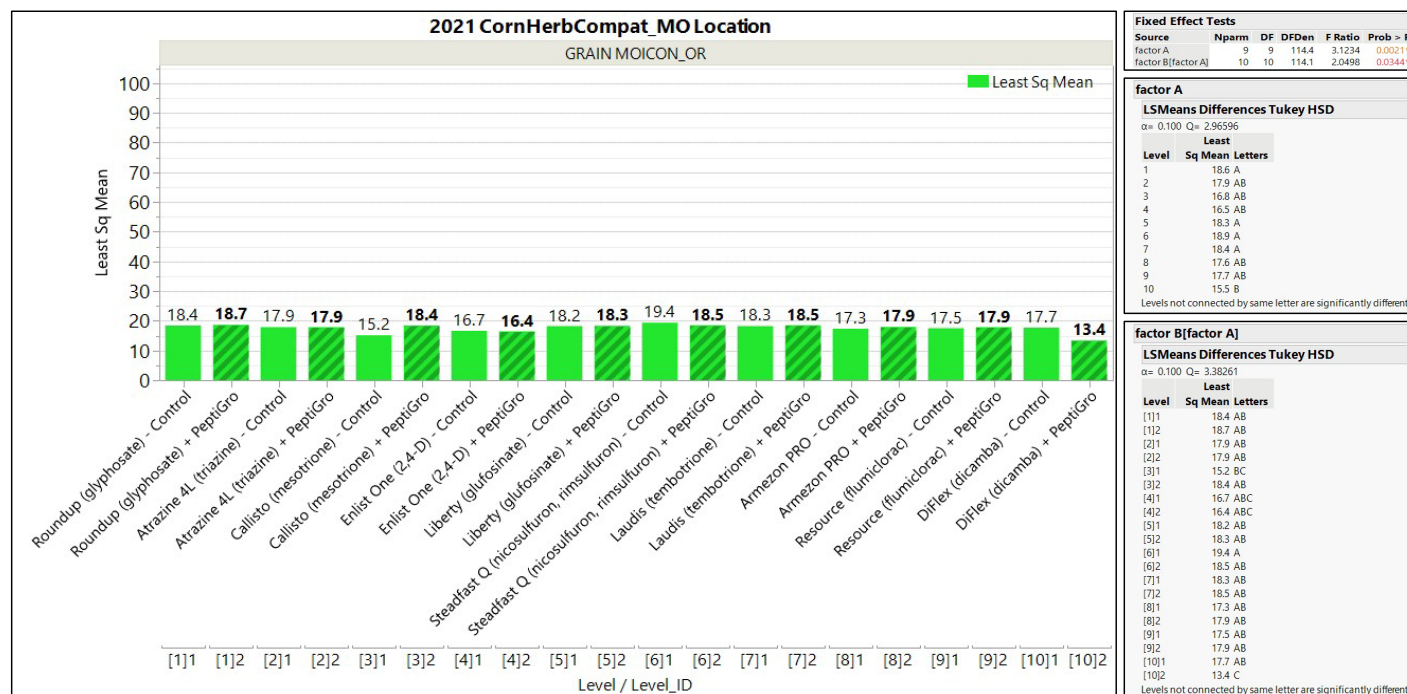
6. Grain Moisture (MOICON). **Significant herbicide effect** (Factor A) and **significant PeptiGro® effect** (Factor B, nested in Factor A).
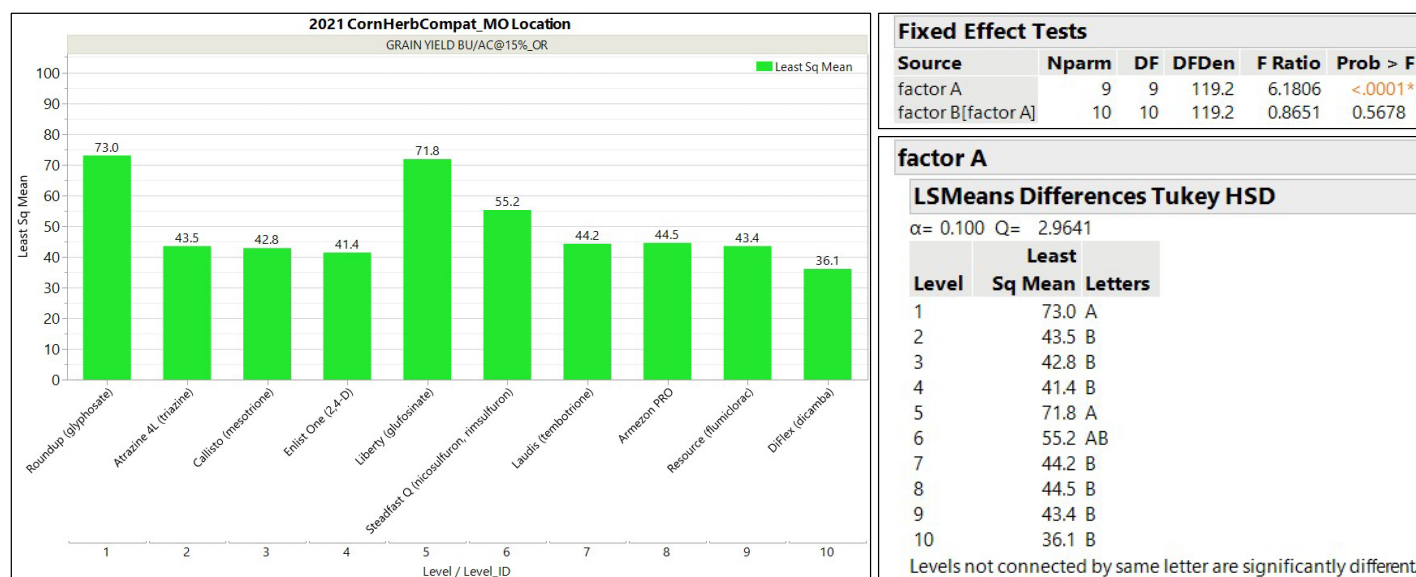
a.   Grain Moisture (MOICON) – **significant herbicide effect** (Factor A).
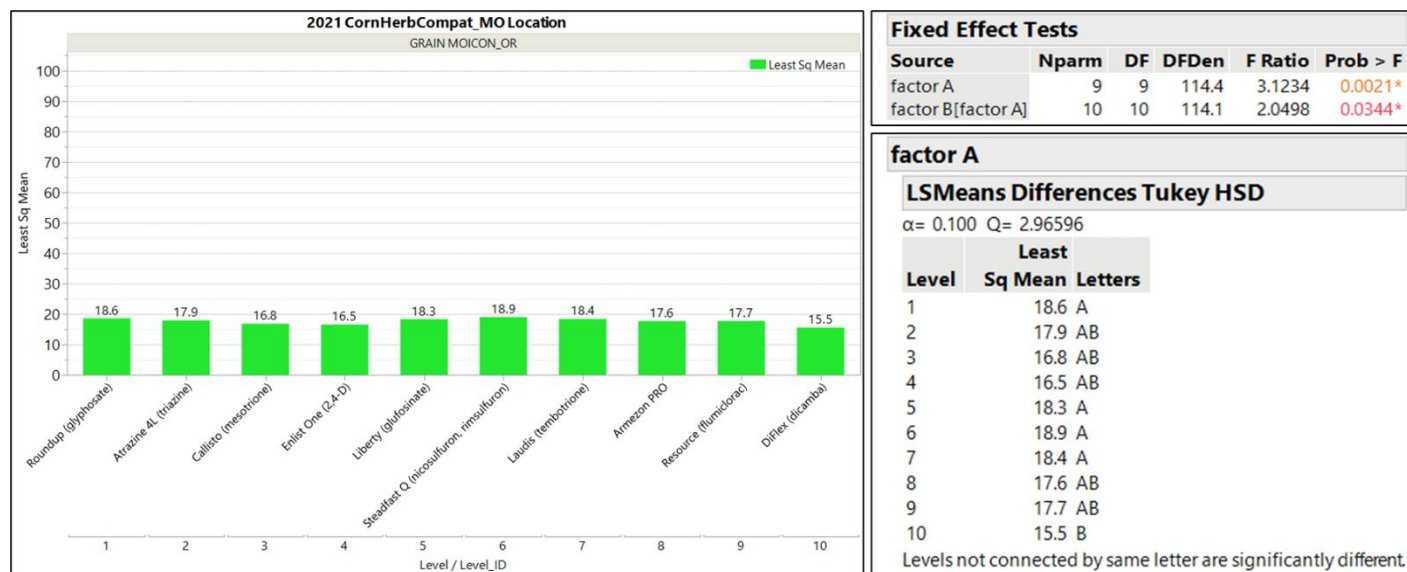
b.   Grain Moisture (MOICON) – **Significant PeptiGro® effect** (Factor B, nested in Factor A). All herbicides were non-significant, except DiFlex + PeptiGro had a significantly lower grain moisture than DiFlex alone.

7. Grain Yield. **Significant herbicide effect** (Factor A) and non-significant PeptiGro® effect - only 8 REPs; (Factor B, nested in Factor A; data not shown; **for PeptiGro® yield performance in 2020 and 2021 across 71 corn trials in 10 states, refer to PeptiGro® brochure on Cibari Biosciences website**).

2021 CornHerbCompat_MO Location
GRAIN YIELD BU/AC@15%_OR

Levels and Least Sq Means: 1 = Roundup (glyphosate) 73.0; 2 = Atrazine 4L (triazine) 43.5; 3 = Callisto (mesotrione) 42.8; 4 = Enlist One (2,4-D) 41.4; 5 = Liberty (glufosinate) 71.8; 6 = Steadfast Q (nicosulfuron, rimsulfuron) 55.2; 7 = Laudis (tembotrione) 44.2; 8 = Armezon PRO 44.5; 9 = Resource (flumiclorac) 43.4; 10 = DiFlex (dicamba) 36.1

Fixed Effect Tests

Source	Nparm	DF	DFDen	F Ratio	Prob > F
factor A	9	9	119.2	6.1806	<.0001*
factor B[factor A]	10	10	119.2	0.8651	0.5678

factor A

LSMeans Differences Tukey HSD

α= 0.100 Q= 2.9641

Level	Least Sq Mean	Letters
1	73.0	A
2	43.5	B
3	42.8	B
4	41.4	B
5	71.8	A
6	55.2	AB
7	44.2	B
8	44.5	B
9	43.4	B
10	36.1	B

Levels not connected by same letter are significantly different.

Conclusions from this Trial

Ten commonly used corn herbicides (Factor A in trial design) differed in their ability to control Giant ragweed and Common barnyard grass (measured at 7, 14, and 21 DPA). Tank mixing of PeptiGro® with each of the 10 different corn herbicides was physically compatible and results from a field study showed PeptiGro® (Factor B in trial design) had no impact on the functional ability of 10 herbicides to control weeds. Degree of weed control for herbicides *per se* was significantly different and subsequent weed pressure levels impacted grain yields. See other herbicide + PeptiGro compatibility studies in corn and soybeans on cibaribiosciences.com website.

Key Conclusions across all 4 different Herbicide + PeptiGro® Compatibility Studies (corn and soybean studies at Purdue University and corn and soybean studies at University of Missouri)

- In each study, PeptiGro® was physically compatible when tank-mixed with each herbicide tested.

- In each study, main effect of herbicide (Factor A) was significant; indicating that corn and soybean herbicides differed in their ability to control weeds and degree of weed control significantly impacted subsequent grain yields.

- In each study, PeptiGro® effect (Factor B, nested in Factor A) was non-significant for all agronomic variables measured including degree of herbicide weed control taken 3 times between 7-35 DPA; indicating that PeptiGro® had no impact on the functional ability of each herbicide to control target weeds.

- Individual study reports can be downloaded on cibaribiosciences.com.

BUILDING BLOCKS FOR HIGHER YIELD