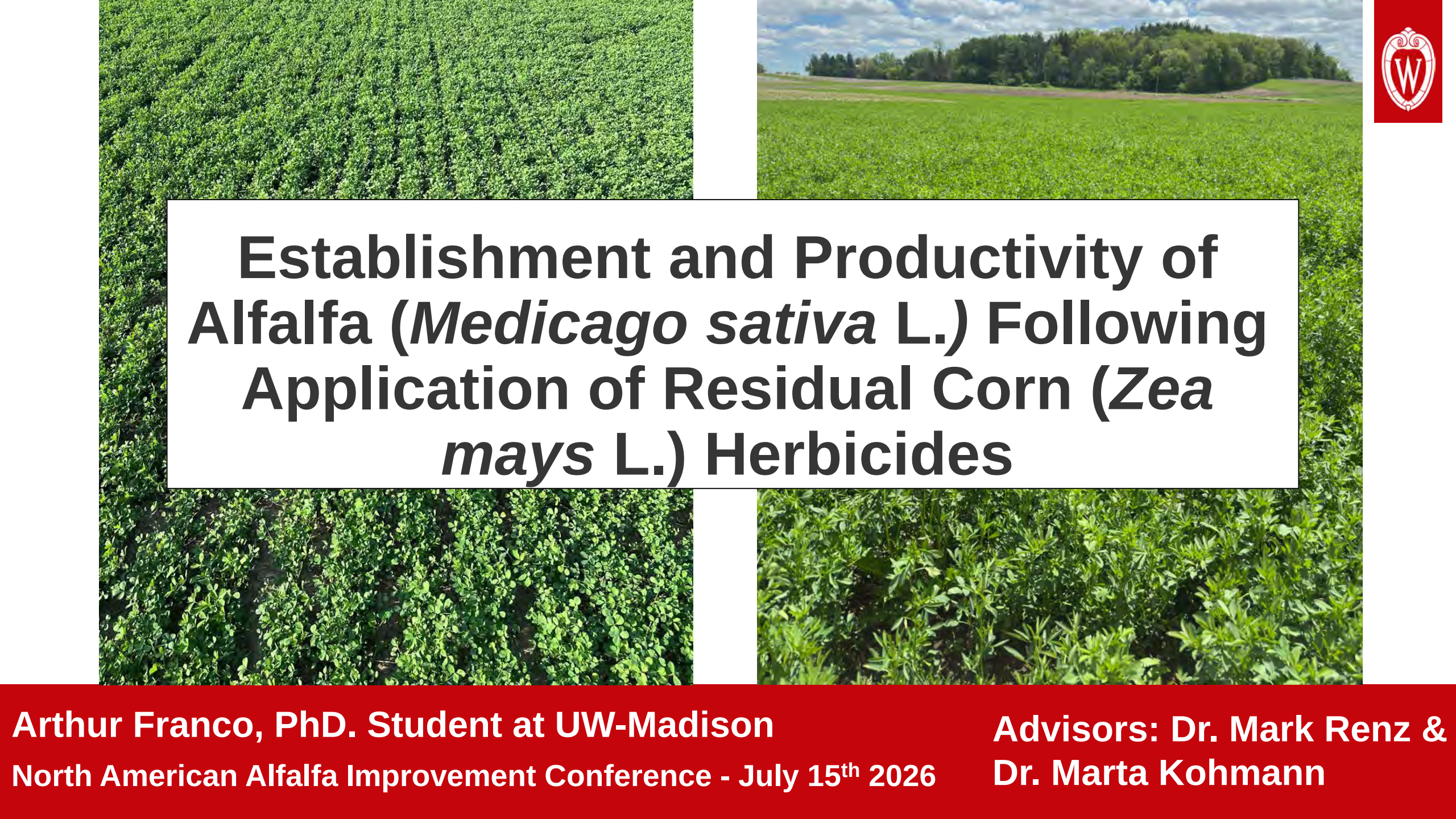


The background of the slide is a lush green alfalfa field. The top left and bottom left corners show close-up views of the dense alfalfa plants. The top right and bottom right corners show wider views of the field, with a line of trees in the distance under a blue sky with some clouds.

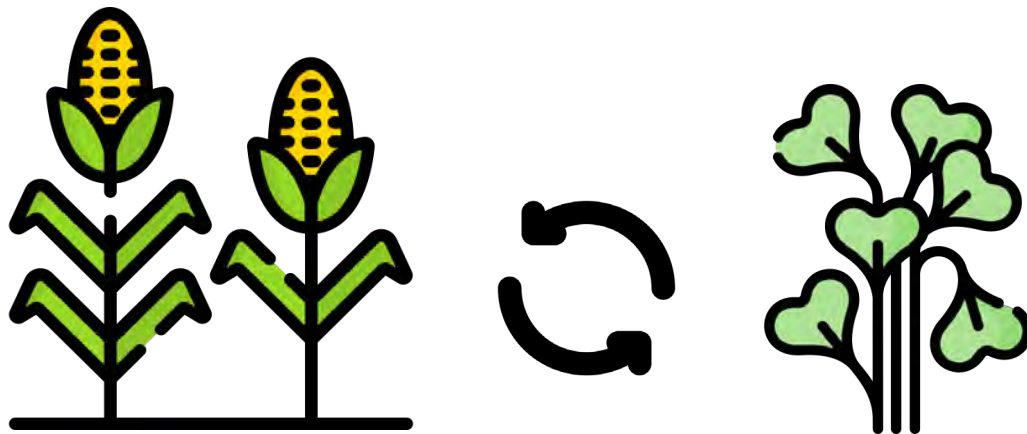
Establishment and Productivity of Alfalfa (*Medicago sativa* L.) Following Application of Residual Corn (*Zea mays* L.) Herbicides

Arthur Franco, PhD. Student at UW-Madison
North American Alfalfa Improvement Conference - July 15th 2026

**Advisors: Dr. Mark Renz &
Dr. Marta Kohmann**

Introduction

- The importance of alfalfa in Wisconsin (dairy state):
 - Important forage for milk production
 - ~ 336,000 hectares harvested annually
 - Grown in rotation with corn



Background

- Herbicides are widely used in corn
 - 96% nationally are treated with herbicides (2021)
 - >65% uses residual herbicides
 - Weed herbicide resistance – more active ingredients applied
 - Later applications
 - Products that contain clopyralid in tank mixes are more common
 - Reports of herbicide injury to alfalfa from corn residual herbicides in Wisconsin



Background

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 - Reports of herbicide injury to alfalfa from corn residual herbicides in Wisconsin





Background

- Reports of herbicide carryover from farmers in Wisconsin



Source: Crop Protection Network



Table 1: Time Interval between Resicore Application and Replanting or Planting of Rotational Crop

Rotational crop	Rotational Interval
Field corn Field seed corn Field silage corn Yellow popcorn	Anytime (1)
Wheat	4 months
Alfalfa (2) Barley Millet (pearl and proso) Oats Rice Rye Sorghum (3) Soybean (4, 5, 6) Sunflower (4) Sweet corn	10.5 months (7, 8)
Cotton	12 months
All other rotational crops	18 months



Rotational Crop Restrictions:
When tank mixing with other herbicides, follow the most restrictive crop rotation guidelines on the label of each product used. The following rotational crops may be planted as indicated:

Rotational Crop (1)	Timing or Interval
corn	Anytime - 0 months after application
wheat	4 months after application
alfalfa (2), barley, clover (2), dry beans (2, 3), lespedeza (2), oats, pea (4), popcorn, rye, soybean (2), vetch (2), wild rice	Spring Following Application
sorghum	12 months
potatoes, sunflower, sweet corn (5), tobacco	18 months
canola, sugar Beets, and all other crops	26 months (6)

Clopyralid + Acetochlor + Mesotrione

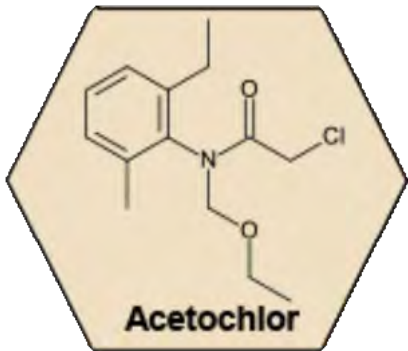
- (7) If Resicore is applied after June 1, rotating to crops other than corn or grain sorghum the next spring may result in crop injury.
- (8) In the High Plains and Intermountain areas of the West, where rainfall is sparse and erratic or where irrigation is required, use Resicore only when corn or sorghum is to follow field corn, or a crop of untreated corn or sorghum is to precede other rotational crops.

Clopyralid + Acetochlor + Flumetsulam

Active ingredients and symptomologies

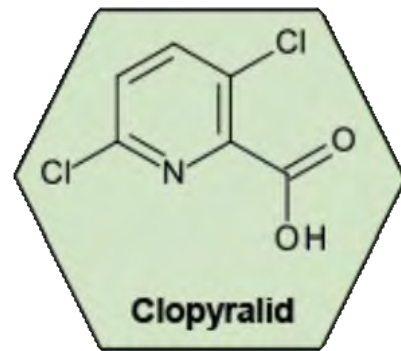
Group 15 – Inhibition of VLCFA

Plant stunting and
heart-shaped leaves



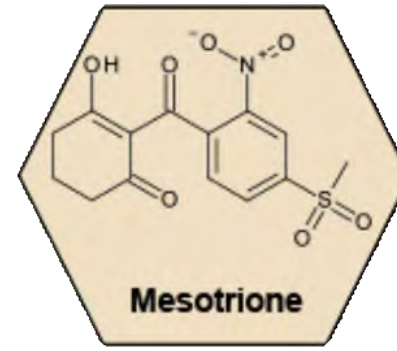
Group 4 – Auxin mimics

Epinasty and leaf
cupping



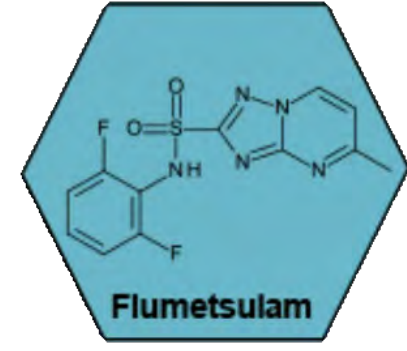
Group 27 – Inhibition of HPPD

Bleaching and necrosis



Group 2 – Inhibition of ALS

Reduction of internodes
length, but tend to be very
mild on legumes



Objective and hypotheses



Objective:

- Determine the impact residual corn herbicides that contain clopyralid have on alfalfa establishment and resulting forage harvested
- Within products, determine which active ingredient is driving injury

Hypothesis:

- Alfalfa establishment and forage harvested will be reduced when alfalfa is established on soils that received clopyralid application

Herbicide treatments



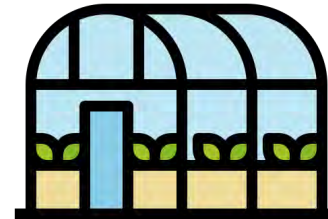
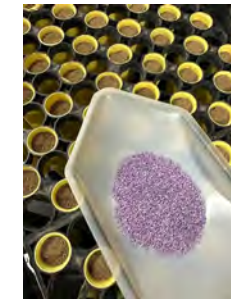
Herbicide treatments	Active ingredient	Application Rate (g ha ⁻¹)
NTC	-	-
Resicore	clopyralid + acetochlor + mesotrione	66 + 981 + 105
Stinger	clopyralid	66
Harness	acetochlor	981
Callisto	mesotrione	105
SureStart II	clopyralid + acetochlor + flumetsulam	61 + 790 + 25
Stinger	clopyralid	61
Harness	acetochlor	790
Python	flumetsulam	25

- 9 herbicide treatments were applied with 4 replications
- Applied June POST EARLY EMERGENCE of corn (V4)

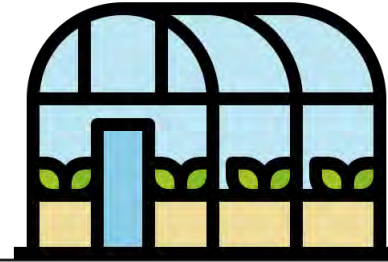
Materials and Methods



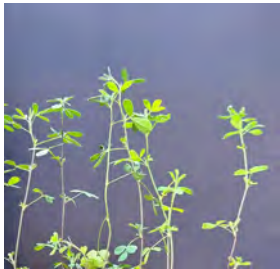
- 2 locations, Arlington and Lancaster, WI
 - Silt loam soils with 34 g/kg and 25 g/kg OM, respectively
- Soil collected in November 2023 for greenhouse trial
 - Severo et al. 2023
 - Three alfalfa cultivars for 50 d in the GH
- Alfalfa planted in April 2024 at the same location
- Field experiment repeated in 2025



Measurements

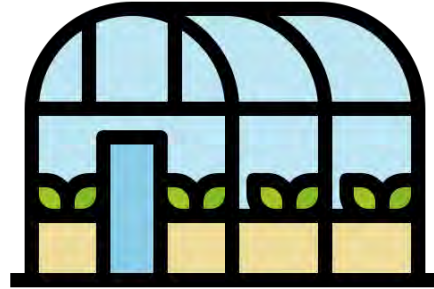


Measurements	Greenhouse		Field	
	Taken?	Shown here?	Taken?	Shown here?
Aboveground biomass	✓	✓	✓	✓
Belowground biomass	✓	✓	✓	✗
Stem counts	✓	✗	✓	✗
Heights	✓	✗	✗	✗



Statistics

- RCD with 3 factors:
 - Site
 - Cultivar treatments
 - Herbicide treatments
 - 10 reps



- Interactions were found
 - Site x Treatment
 - Herbicide and cultivar treatments
- $P \leq 0.05$
- Contrasts
- Bonferroni correction

- RCBD with 2 factors:

- Site
- Herbicide treatments
- 4 blocks
- $P \leq 0.05$
- Locations and years analyzed separately



- Two years, 2024 and 2025





Results - Weather

Arlington

Month	Precipitation (mm)		
	30 y	2023	2024
January	31	52	52
February	36	109	17
March	50	102	70
April	95	57	87
May	108	22	183
June	131	46	236
July	106	110	119
August	97	66	70
September	85	112	58
October	71	87	115
November	57	44	82
December	37	56	33
Total	904	863	1122

Lancaster

Month	Precipitation (mm)		
	30 y	2023	2024
January	33	65	48
February	36	60	9
March	51	48	47
April	99	54	112
May	106	86	177
June	134	40	178
July	107	132	141
August	111	43	59
September	104	78	52
October	71	79	52
November	60	11	111
December	43	43	47
Total	955	739	1033





Results – GH aboveground and belowground biomass

Lancaster						
Cultivars	C1		C2		C3	
	Aboveground					
Herbicide treatments	Mean	SE (±)	Mean	SE(±)	Mean	SE(±)
	———— g plant ⁻¹ ————					
NTC	0.130	0.008	0.153	0.010	0.147	0.019
CLOP (66) + ACET (981) + MESO (105)	0.117	0.007	0.122	0.014	0.109	0.008
CLOP (66)	0.148	0.020	0.159	0.007	0.158	0.012
ACET (981)	0.128	0.007	0.131	0.008	0.144	0.014
MESO (105)	↓0.096	0.004	0.145	0.009	0.137	0.012
CLOP (61) + ACET (790) + FLUM (25)	↓0.090	0.006	↓0.109	0.007	↓0.093	0.006
CLOP (61)	0.085	0.133	0.130	0.010	0.071	0.009
ACET (790)	0.101	0.004	0.116	0.006	0.091	0.008
FLUM (25)	0.139	0.01	0.152	0.009	↓0.095	0.009

↓  Significant alfalfa biomass decrease



Results – GH aboveground and belowground biomass

Lancaster												
Cultivars	C1		C2		C3		C1		C2		C3	
	Aboveground						Belowground					
Herbicide treatments	Mean	SE (±)	Mean	SE(±)	Mean	SE(±)	Mean	SE(±)	Mean	SE(±)	Mean	SE(±)
	g plant ⁻¹											
NTC	0.130	0.008	0.153	0.010	0.147	0.019	0.118	0.007	0.153	0.016	0.159	0.016
CLOP (66) + ACET (981) + MESO (105)	0.117	0.007	0.122	0.014	0.109	0.008	↑0.163	0.010	0.162	0.008	0.140	0.015
CLOP (66)	0.148	0.020	0.159	0.007	0.158	0.012	0.154	0.016	0.163	0.020	↓0.153	0.014
ACET (981)	0.128	0.007	0.131	0.008	0.144	0.014	0.141	0.008	0.162	0.014	0.138	0.010
MESO (105)	↓0.096	0.004	0.145	0.009	0.137	0.012	0.134	0.006	0.175	0.009	0.156	0.007
CLOP (61) + ACET (790) + FLUM (25)	↓0.090	0.006	↓0.109	0.007	↓0.093	0.006	0.128	0.007	0.128	0.010	0.135	0.011
CLOP (61)	0.085	0.133	0.130	0.010	0.071	0.009	0.085	0.013	0.117	0.012	↓0.068	0.009
ACET (790)	0.101	0.004	0.116	0.006	0.091	0.008	0.136	0.010	0.130	0.011	0.119	0.011
FLUM (25)	0.139	0.01	0.152	0.009	↓0.095	0.009	↑0.172	0.021	0.188	0.011	0.115	0.013

↓ Significant alfalfa biomass decrease

↑ Significant alfalfa biomass increase



Results – GH aboveground and belowground biomass

Arlington						
Cultivars	C1		C2		C3	
	Aboveground					
Herbicides treatments	Mean	SE	Mean	SE	Mean	SE
	g plant ⁻¹					
NTC	0.141	0.009	0.146	0.010	0.130	0.007
CLOP (66) + ACET (981) + MESO (105)	0.112	0.009	0.168	0.006	0.154	0.006
CLOP (66)	0.145	0.008	0.161	0.006	↑ 0.166	0.007
ACETO (981)	0.118	0.005	0.145	0.006	0.158	0.009
MESO (105)	0.124	0.010	0.149	0.009	0.141	0.014
CLOP (61) + ACET (790) + FLUM (25)	0.157	0.009	0.136	0.007	0.148	0.008
CLOP (61)	0.172	0.010	0.180	0.010	↑ 0.177	0.012
ACET (790)	0.135	0.010	0.138	0.005	0.120	0.006
FLUM (25)	↑ 0.190	0.009	↑ 0.198	0.011	↑ 0.183	0.016

↑  Significant alfalfa biomass increase



Results – GH aboveground and belowground biomass

Arlington								
Cultivars	C1		C2		C3		-	
	Aboveground						Belowground	
Herbicides treatments	Mean	SE	Mean	SE	Mean	SE	Mean	SE
	g plant ⁻¹							
NTC	0.141	0.009	0.146	0.010	0.130	0.007	0.183	0.008
CLOP (66) + ACET (981) + MESO (105)	0.112	0.009	0.168	0.006	0.154	0.006	0.193	0.011
CLOP (66)	0.145	0.008	0.161	0.006	↑0.166	0.007	↑0.231	0.008
ACETO (981)	0.118	0.005	0.145	0.006	0.158	0.009	0.210	0.009
MESO (105)	0.124	0.010	0.149	0.009	0.141	0.014	0.205	0.011
CLOP (61) + ACET (790) + FLUM (25)	0.157	0.009	0.136	0.007	0.148	0.008	0.195	0.010
CLOP (61)	0.172	0.010	0.180	0.010	↑0.177	0.012	↑0.237	0.007
ACET (790)	0.135	0.010	0.138	0.005	0.120	0.006	0.185	0.007
FLUM (25)	↑0.190	0.009	↑0.198	0.011	↑0.183	0.016	↑0.233	0.007

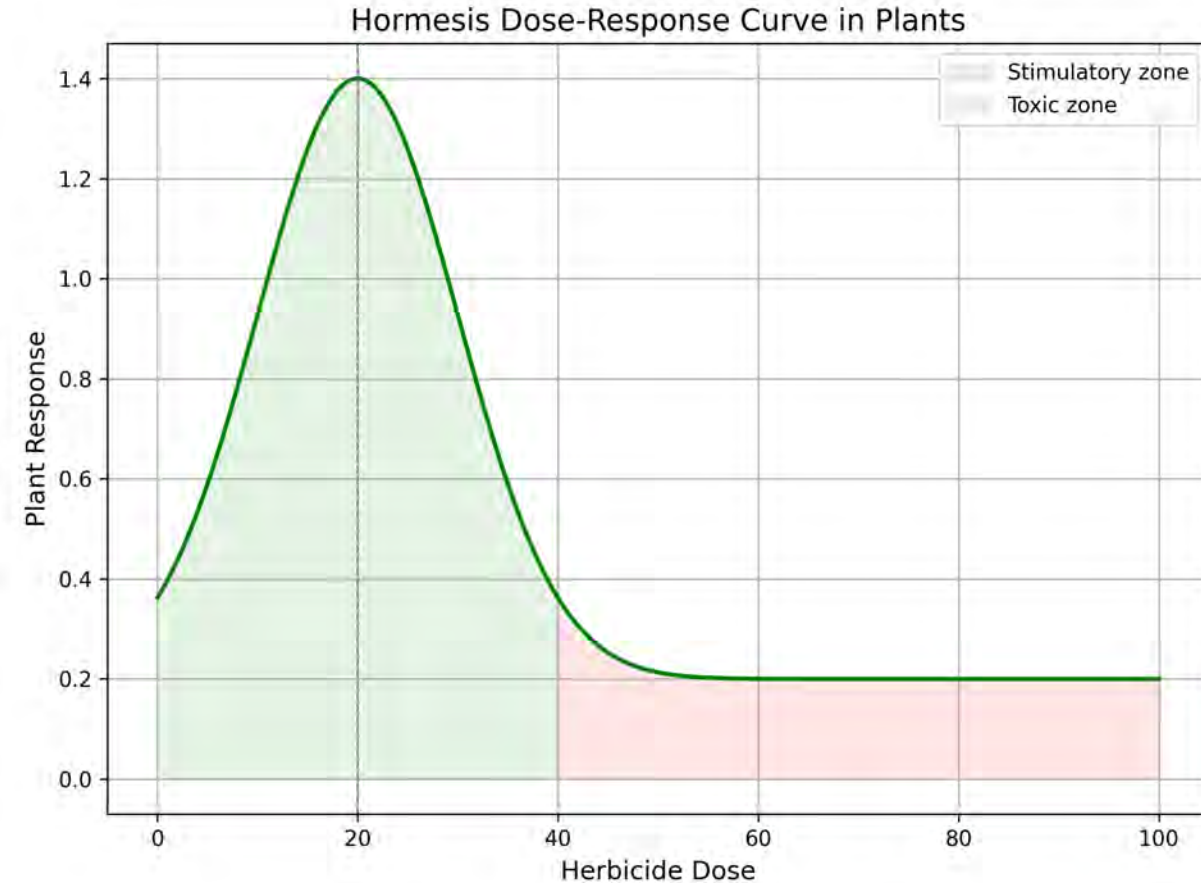
↑  Significant alfalfa biomass increase

Greenhouse summary

- No clear pattern of biomass across sites
 - At Lancaster Surestart II reduced
 - At Arlington flumetsulam increased
- Cultivar tolerance
 - Cultivars often behaved differently
- Difference between sites
 - *Aphanomyces* spp. interaction

Greenhouse summary

- Hormesis may explain increase in biomass
 - Flumetsulam and clopyralid
- Confirm in field experiment





Results – Field aboveground biomass – Both locations

	Lancaster 2024		Lancaster 2025		Arlington 2024		Arlington 2025	
	First harvest				First harvest			
	Aboveground biomass							
Herbicide treatments	Mean	SE	Mean	SE	Mean	SE	Mean	SE
	g m ⁻²							
NTC	105	27	380	27	238	24	234	36
CLOP (66) + ACET (981) + MESO (105)	151	39	420	19	253	7	303	41
CLOP (66)	156	43	387	20	269	12	260	27
ACET (981)	143	46	418	36	268	41	306	19
MESO (105)	207	38	369	23	223	41	346	16
CLOP (61) + ACET (790) + FLUM (25)	184	36	454	14	257	4	306	20
CLOP (61)	178	22	415	42	218	15	289	25
ACET (790)	163	46	453	23	274	14	320	27
FLUM (25)	166	15	440	46	265	38	337	38
P-value	0.06		0.24		0.44		0.25	



Conclusions

- Could not confirm residual herbicides were impacting alfalfa
 - GH results were mixed
 - Field results were similar for biomass and alfalfa plant density among treatments
- Cultivars vary in their tolerance to herbicides
 - Inform breeding programs and growers



Conclusions

- Site-specific factors may drive responses
 - Precipitation
 - Soil OM
 - Temperature
 - *Aphanomyces* spp.
- More research is needed to evaluate many more environments to elucidate which factors are more important
- Recommend producers to follow product labels
 - Including fine print

Thank you!





Questions?



Cultivar used

- Cultivar 1, AFX 460, Alforex
- Cultivar 2, 54VR12, Pioneer
- Cultivar 3, SpringPearl, Renk



Results – Field Belowground Biomass – Both locations

Treatment (herbicide rate) ^a	Lancaster belowground biomass (g m ⁻²)			Arlington belowground biomass (g m ⁻²)		
	First harvest	Second harvest	Total	First harvest	Second harvest	Total
NTC ^b	228	260	488	256	276	532
CLOP (66) + ACET (981) + MESO (105)	222	307	529	216	276	492
CLOP (61) + ACET (790) + FLUM (25)	164	330	494	187	298	485
P-value	0.40	0.93	0.74	0.11	0.18	0.18

Results- clopyralid leaching trial – aboveground biomass

		Depth (cm)											
		2.5		5.1		7.6		10.2		12.7		15.2	
Treatment (herbicide rate) ^a	Application timing	Aboveground biomass (g plant ⁻¹) ^b											
NTC ^c	-	0.185	a	0.173	a	0.193	a	0.193	0.194	b	0.181	a	
CLOP (420)	June	0.274	b	0.257	b	0.243	a	0.183	0.206	b	0.245	b	
CLOP (420)	October	0.269	ab	0.172	a	0.242	a	0.177	0.140	a	0.192	ab	
P-value		0.02		<0.01		0.04		0.51		<0.01		0.04	



Results – clopyralid leaching trial – belowground biomass

		Depth (cm)											
		2.5		5.1		7.6		10.2		12.7		15.2	
Treatment (herbicide rate) ^a	Application timing	Belowground biomass (g plant ⁻¹) ^b											
NTC ^c	-	0.127	a	0.113		0.126	a	0.148	a	0.133		0.129	
CLOP (420)	June	0.183	ab	0.119		0.091	a	0.090	a	0.108		0.154	
CLOP (420)	October	0.210	b	0.143		0.181	b	0.148	a	0.102		0.150	
P-value		0.01		0.15		<0.01		<0.01		0.13		0.51	



Results – GH aboveground and belowground biomass - ARS

Arlington

Treatment (herbicide rate) ^d	C1 ^a	C2 ^b	C3 ^c	g plant ⁻¹
	Aboveground			Belowground
NTC ^e	0.141	0.146	0.130	0.183
CLOP (66) + ACET (981) + MESO (105)	0.112	0.168	0.154	0.193
CLOP (66)	0.145	0.161	↑ 0.166	↑ 0.231
ACETO (981)	0.118	0.145	0.158	0.210
MESO (105)	0.124	0.149	0.141	0.205
CLOP (61) + ACET (790) + FLUM (25)	0.157	0.136	0.148	0.195
CLOP (61)	0.172	0.180	↑ 0.177	↑ 0.237
ACET (790)	0.135	0.138	0.120	0.185
FLUM (25)	↑ 0.190	↑ 0.198	↑ 0.183	↑ 0.233
Contrasts	p-value			
NTC ^b vs. CLOP (61, 66) ^f	0.77	0.20	<0.01	<0.01
NTC ^b vs. CLOP (66) + ACET (981) + MESO (105)	0.16	0.57	0.39	2.71
NTC ^b vs. CLOP (61) + ACET (790) + FLUM (25)	1.42	2.89	1.04	1.76
NTC ^b vs. MESO(105)	1.12	4.73	2.40	5.42
NTC ^b vs. ACET(981, 790) ^g	1.29	4.13	2.67	3.69
NTC ^b vs. FLUM(25)	<0.01	<0.01	<0.01	<0.01