

Available Forage and Cover Crop Varieties and Germplasms

Heathcliffe Riday

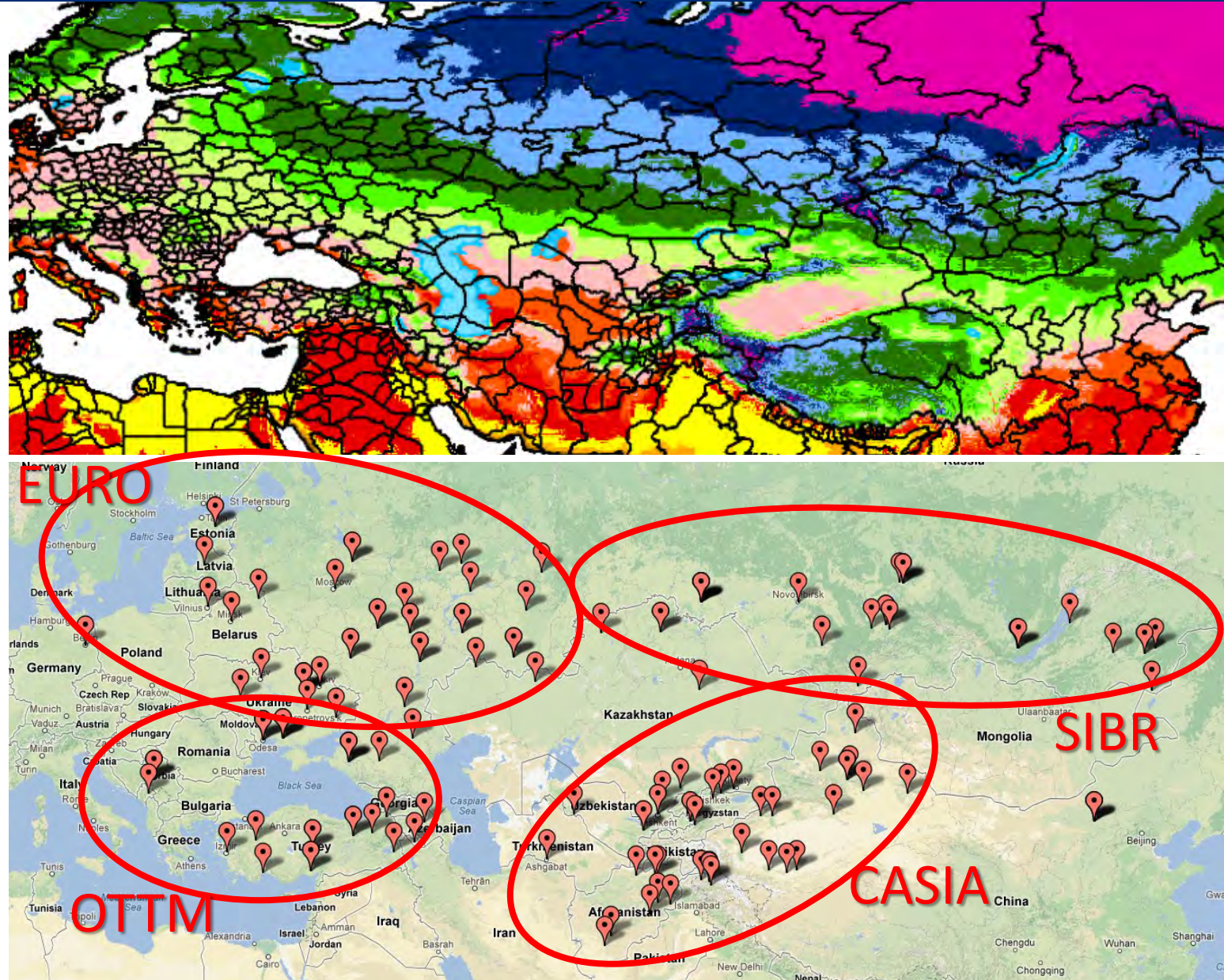
U.S. Dairy Forage Research Center



- Alfalfa
 - Pre-breeding program
 - subsp. falcata program
 - Corn-alfalfa intercropping program
 - Kernza-alfalfa intercropping program
- Red Clover
- Kura Clover
- Birdsfoot Trefoil
- Cover Crops

Alfalfa Pre-breeding program

- Goal: Pre-breed Eurasian plant introductions (PI) from winterhardness zones up to zone 5 “generally”
- Combine selected individuals from PIs into four breeding pools: CASIA, EURO, OTTM, and SIBR
- Continue breeding within pools; potentially evaluate additional Pis
- Funding support:
 - USDA-NIFA-ASAFS-2024-67012-42687
 - USDA-NIFA-ASAFS-2019-70005-30361
 - USDA-NIFA-ASAFS-2017-70005-27117
- NE1710 and NE2210



Alfalfa Pre-breeding program

- R1C1

- 150 PIs (“landraces” or “cultivars”)
- 2 Nurseries (Arlington, WI; Prairie du Sac, WI)(Est. 2013)
- Selections made fall 2014; persistence, general adaptation, and improved “agronomics”
- 4 polycrosses Conell, WA (2015)
- CASIA R1C1, EURO R1C1, OTTM R1C1, and SIBR R1C1

- R1C2

- 4 nurseries (R1C1 - CASIA, EURO, OTTM, and SIBR) x 5 Sites (Ithaca, NY; Lethbridge, AB; Lévis, QC; Prairie du Sac, WI; Tulalake, CA)(Est. 2016)
- Selection made 2018-2019; persistence, general adaptation, and improved “agronomics”
- 20 polycrosses made 2019-2020 (5 locations x 4 pools)
- Prosser, WA 2021; equal progeny from 5 location x 4 pool polycrosses into 4 “final” polycrosses by pool
- CASIA R1C1, EURO R1C2, OTTM R1C2, and SIBR R1C2

Alfalfa Pre-breeding program

- R2C1

- 106 PIs (“landraces” or “cultivars”) & R1C1 CASIA, EURO, OTTM, and SIBR
- 3 Nurseries (Ithaca, NY; Prairie du Sac, WI; Tulelake, CA)(Est. 2018)
- Selections made 2021; persistence, general adaptation, and improved “agronomics”
- 12 polycrosses made from selections (3 locations x 4 pools)
- Prosser, WA 2023 & 2024; equal progeny from 3 location x 4 pool polycrosses into 4 “final” polycrosses by pool
- CASIA R2C1, EURO R2C1, OTTM R2C1, and SIBR R2C1

- PI Pooled DNA genomic selection projects

- Based on USDA-ARS individual PI pooled DNA DArT genotypic data (Breeding Insights) genomic prediction models were generated based on historic USDA-NPGS data in GRIN Global
- Models were used to predict PI phenotypic performance on all PIs with pooled DNA DArT data
- Equal progeny from the top PIs for seven models were polycrosse to create seven synthetics in Prosser, WA 2025
- PI25-Digest, PI25-Disease1, PI25-Disease2, PI25-Insect1, PI25-Insect2, PI25-Salt, and PI25-SeedVig

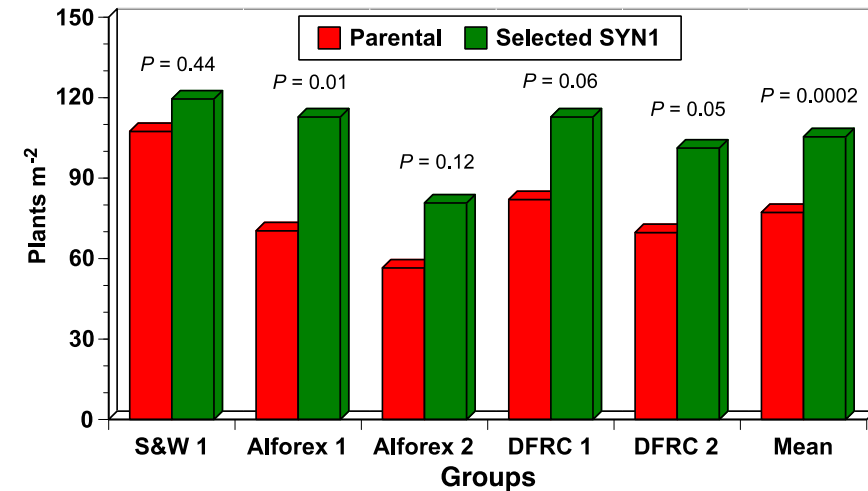
Alfalfa subsp. *falcata*

- Yellow flowered alfalfa or falcata
 - Pre-breeding: biomass, upright growth habit, less fall dormancy, better seasonal yield distribution.
- Early generation material: IAMF101 and IAMF102
- More advanced generations: IAFAL-C3, HC2, PFALTM
- Larry15:
 - 'Wisfal' planted 1990s on Larry Smith farm into pastures (Driftless, south of Viroqua, WI)
 - Pastures grazed for 15+ years.
 - Summer of 2015 superior falcata plants were dug from pastures and intermated to form Larry15.



Alfalfa-Corn Intercropping

- Cycle 1
 - **AVC9** selected Arlington, WI Oct 2017 out of 2015 & 2016 est. plots (SW 315, 55V50, and FSG 329)
 - **AVC14** selected Arlington, WI Oct 2017 out of 2015 & 2016 est. plots (55Q27, Rebound 6XT, Ameristand 427TQ, WL365 HQ, Barricade SLT, and BGI 529)
- Cycle 2
 - **INTALF20** selected Arlington May 2020, out of 2019 est. plots (AVC9 76.9%, AVC9-Base 11.5%, AVC14 7.7%, AVC14-Base 3.8%)
- Cycle 3
 - WI22WA-IntAlf20 & WI22WI-IntAlf20 (Syn1; Identical parents) selected Arlington and Prairie du Sac, WI Oct 2022, out of 2022 est. plots (INTALF20 100%)
 - **INTALFC3 (Syn2)** (72.3% WI22WA-IntAlf20, 27.7% WI22WI-IntAlf20) large quantities of seed available for agronomic management studies and corn-intercropping on-farm demonstrations
- Cycle 4
 - **WA25C4IntAlf20 & WI25C4IntAlf20 (Syn1s)** selected Arlington and Prairie du Sac, WI Oct 2024 out of 2024 est. plots (WI22WA-IntAlf20 100%)



(Grabber et al., 2023)

Alfalfa-Kernza Intercropping

- In addition to corn-alfalfa interseeded system there's interest in alfalfa in mixture with grass
- Kernza (intermediate wheatgrass) interseeded with alfalfa
 - USDA-NIFA-ASAFS-2021-70005-35692
- Fall 2017 est. Kernza-Alfalfa intercropped variety comparison plots (Arlington, WI; Rosemont, MN)
 - Univ. MN, Univ. WI, and Land Institute
- Plants selected May 2021 from alfalfa plots in WI and MN
 - “High” group – Magnum 7, Gunner, Hybriforce 3400, and Shuttle II
 - “Low” group – Amerigraze 401+Z, Pasture Plus, FF LH.4022, Wisfal x Legacy
- 4 polycrosses (Syn1) Prairie du Sac, WI 2021
- Prosser, WA (2022)(Syn2): IWAF-WI21L, IWAF-WI21H, IWAF-MN21L, IWAF-MN21H



Red Clover Experimental Varieties



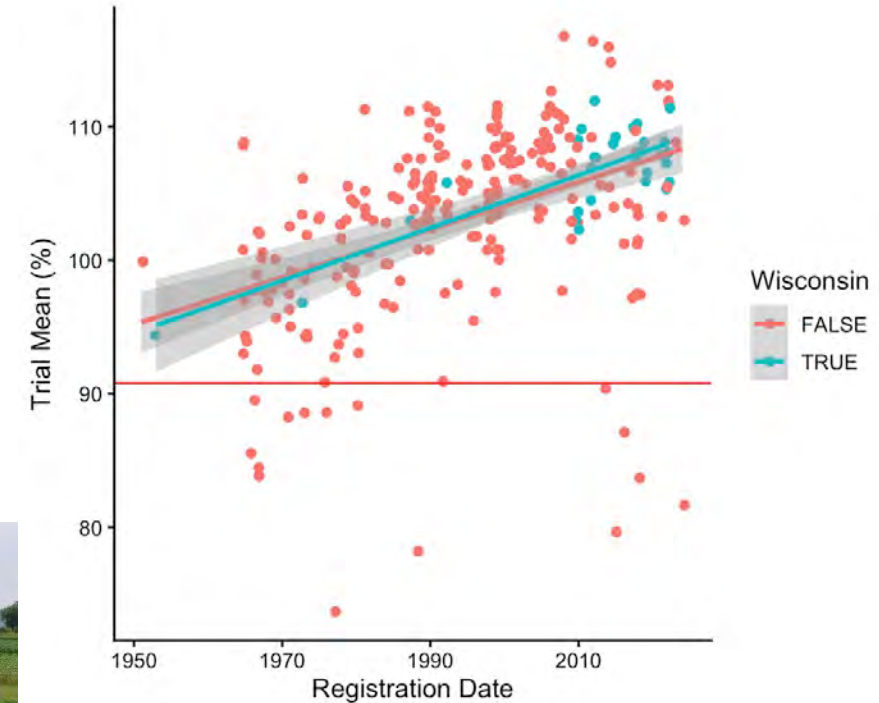
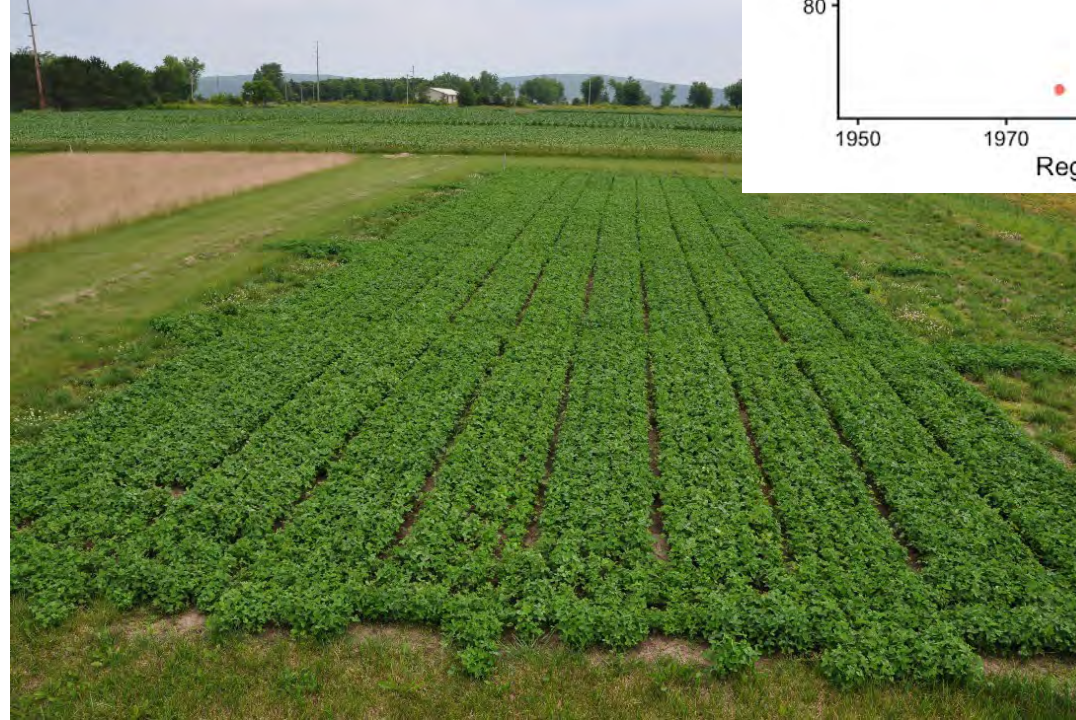
- 15 to 20 breeding polycrosses/year at Prairie du Sac, WI (Syn1) pre-breeder seed
- Syn1 to Syn2 experimental variety breeder seed
 - Equal bulk of seed from each parent with sufficient seed (~70%-80%) from Syn1 sent to Western U.S. for isolation polycross
 - 2015 – 2020 Caldwell, ID
 - 2021 – present Prosser, WA
- Goal: 3 – 5 experimental red clover varieties per year (3 – 5 lbs. seed)
- 32 experiment varieties available (DFRC11 – DFRC42)



Experimental Varieties



- Experimental varieties are tested in university monoculture sward biomass yield trials (possible sites: WI, NY, KY, MI, PA, NH, ND, and OH)
- Preliminary determination 2 – 3 trials
- Promising experimental 5 – 7 trials
- Candidate varieties 9 trials +
- Evaluation traits: biomass yield, % stand, maturity/% flower, height, foliage color (indicative of plant health/leafhopper susceptibility)



Kura Clover

- USDA-ARS & University of Wisconsin breeding program 2004-2016
 - Variety trials est. 2017&2018, harvest years 2018-2021&2019-2022
 - Best candidates **ARL16-K14**, **ARL16-K01**, and **ARL16-K09**



Location Avg. Prairie du Sac, WI & Stratford, WI	Total Biomass Yield (T/Ac DM)	Density (3 - High; 1 - Low)	Spreading (4 - High; 1 - Low)	Prairie du Sac, WI 2018	Total (T/Ac DM)	7/26/23 %Density	Spread Index	Height Index	2019 %Stand (Year2)	2020 %Stand (Year3)	2021 %Stand (Year4)	6/14/22 %Density	Leaf Size Ind. (4 - Big; 1 - Small)	Avg. %Flower	2019 Total (T/Ac DM)	2020 Total (T/Ac DM)	2021 Total (T/Ac DM)	2022 Total (T/Ac DM)	Stratford, WI 2017	Total (T/Ac DM)	5/5/22 Density (Score)	5/5/22 Spreading (Score)	2018 Total (T/Ac DM)	2019 Total (T/Ac DM)	2020 Total (T/Ac DM)	2021 Total (T/Ac DM)
ARL16-K14	16.43	2.17	2.45	ARL16-K14	11.35	64	2.6	3.1	60	77	76	84	2.5	20	3.96	2.28	2.85	2.21	ARL16-K14	21.50	2.2	2.3	5.85	6.21	4.53	5.38
ARL16-K01	15.87	2.48	2.00	ARL16-K01	10.60	74	1.9	3.2	45	67	78	85	2.6	7	3.60	2.26	2.76	2.06	ARL16-K15	21.48	1.6	2.3	5.46	6.16	4.17	5.53
ARL16-K09	15.57	2.70	3.45	ARL16-K09	10.38	66	4.2	2.4	37	63	80	91	2.8	13	3.76	2.16	2.65	1.72	ARL16-K01	21.14	2.5	2.1	5.23	6.46	4.62	5.50
ARL16-K02	15.54	2.17	1.90	ARL16-K05	10.34	60	3.3	3.0	37	70	83	84	2.7	13	3.55	2.15	2.53	2.08	Everlast14	21.09	2.0	2.9	5.57	5.96	4.59	5.26
ARL16-K13	15.49	2.50	3.20	ARL16-K02	10.28	73	2.0	2.6	38	72	74	95	2.2	11	3.73	2.07	2.50	1.91	ARL16-K13	21.04	3.0	2.4	5.76	6.13	4.38	5.50
Everlast14	15.42	1.65	2.50	ARL16-K03	10.17	59	3.8	2.3	32	67	80	87	2.5	9	3.63	1.99	2.39	2.06	ARL16-K02	20.79	1.9	1.8	5.57	5.94	4.89	5.36
ARL16-K15	15.38	1.55	1.45	ARL16-K12	10.13	52	2.0	2.7	22	63	73	82	2.5	13	3.54	2.10	2.46	2.07	ARL16-K09	20.76	3.2	2.7	5.67	5.59	4.42	5.44
ARL16-K05	15.19	2.15	3.20	ARL16-K13	9.93	60	4.0	2.0	32	70	77	82	1.9	16	3.49	2.00	2.55	1.89	ARL16-K11	20.45	3.1	3.0	5.79	5.60	4.62	5.36
ARL16-K10	15.15	1.93	2.10	ARL16-K10	9.89	71	2.8	2.5	39	69	77	80	2.6	16	3.63	2.10	2.35	1.91	ARL16-K06	20.44	1.6	2.2	5.14	5.93	4.35	5.36
ARL16-K03	15.07	2.33	3.60	ARL16-K07	9.84	45	1.9	2.5	29	63	75	78	2.9	14	3.33	1.86	2.65	2.08	ARL16-K10	20.41	1.5	1.4	5.44	5.83	4.13	5.30
ARL16-K11	15.07	2.28	2.30	Everlast14	9.75	39	2.1	2.8	45	66	72	82	2.6	16	3.28	1.92	2.45	2.14	ARL16-K08	20.10	1.6	1.5	5.27	5.64	4.33	5.46
ARL16-K12	15.04	1.77	2.00	ARL16-K04	9.72	83	1.9	3.5	48	83	86	88	3.1	18	3.40	2.11	2.47	1.91	ARL16-K07	20.09	1.6	1.8	5.06	5.98	4.32	5.53
ARL16-K07	14.97	1.55	1.85	ARL16-K08	9.72	54	3.1	2.4	28	57	66	62	2.3	14	3.28	2.06	2.22	2.16	Cossack	20.05	2.4	3.2	5.22	5.59	4.25	5.23
ARL16-K06	14.96	1.83	1.90	ARL16-K11	9.69	44	1.6	2.0	22	33	46	55	2.3	8	3.39	1.85	2.55	1.75	ARL16-K05	20.03	2.3	3.1	5.43	5.74	4.63	5.08
ARL16-K08	14.91	1.70	2.30	ARL16-K06	9.47	62	1.6	1.9	22	44	67	64	2.5	13	3.25	1.87	2.33	1.92	ARL16-K03	19.97	2.7	3.4	5.37	6.05	4.08	5.31
Cossack	14.68	1.87	2.80	Cossack	9.30	40	2.4	1.8	9	21	51	55	2.1	8	3.48	1.84	2.21	1.69	ARL16-K12	19.94	1.8	2.0	5.17	5.13	4.29	5.36
ARL16-K04	14.63	2.78	2.40	ARL16-K15	9.28	45	0.6	2.4	45	62	66	73	1.8	19	3.10	1.81	2.44	1.82	ARL16-K04	19.53	2.8	2.9	5.06	5.86	4.38	5.03
KTA202	13.15	1.43	1.85	KTA202	7.19	23	1.6	1.7	5	13	33	38	2.1	16	2.82	1.27	1.77	1.40	KTA202	19.10	2.1	2.1	5.51	5.15	4.12	5.15
LSD	1.05	1.02	1.51	LSD	1.49	25	1.6	0.7	16	19	22	27	0.5	10	0.55	0.41	0.66	0.32	LSD	1.83	1.5	1.3	0.72	0.92	0.48	0.68
MEAN	15.14	2.05	2.40	MEAN	9.79	53	2.3	2.6	35	57	66	71	2.4	14	3.50	2.00	2.40	1.87	MEAN	20.22	2.2	2.4	5.43	5.81	4.32	5.21
Residual	0.25	0.23	0.51	Residual	5.08	473	1.7	0.9	276	220	206	431	0.4	67	0.33	0.37	0.49	0.27	Residual	5.69	2.18	1.76	0.43	0.57	0.55	0.74
CV	3.3	23.6	29.8	CV	23.0	41.4	56.1	36.9	47.0	26.1	21.8	29.3	24.9	57.0	16.3	30.4	29.0	27.6	CV	11.79	65.66	54.65	12.07	12.95	17.12	16.56

Bridsfoot Trefoil

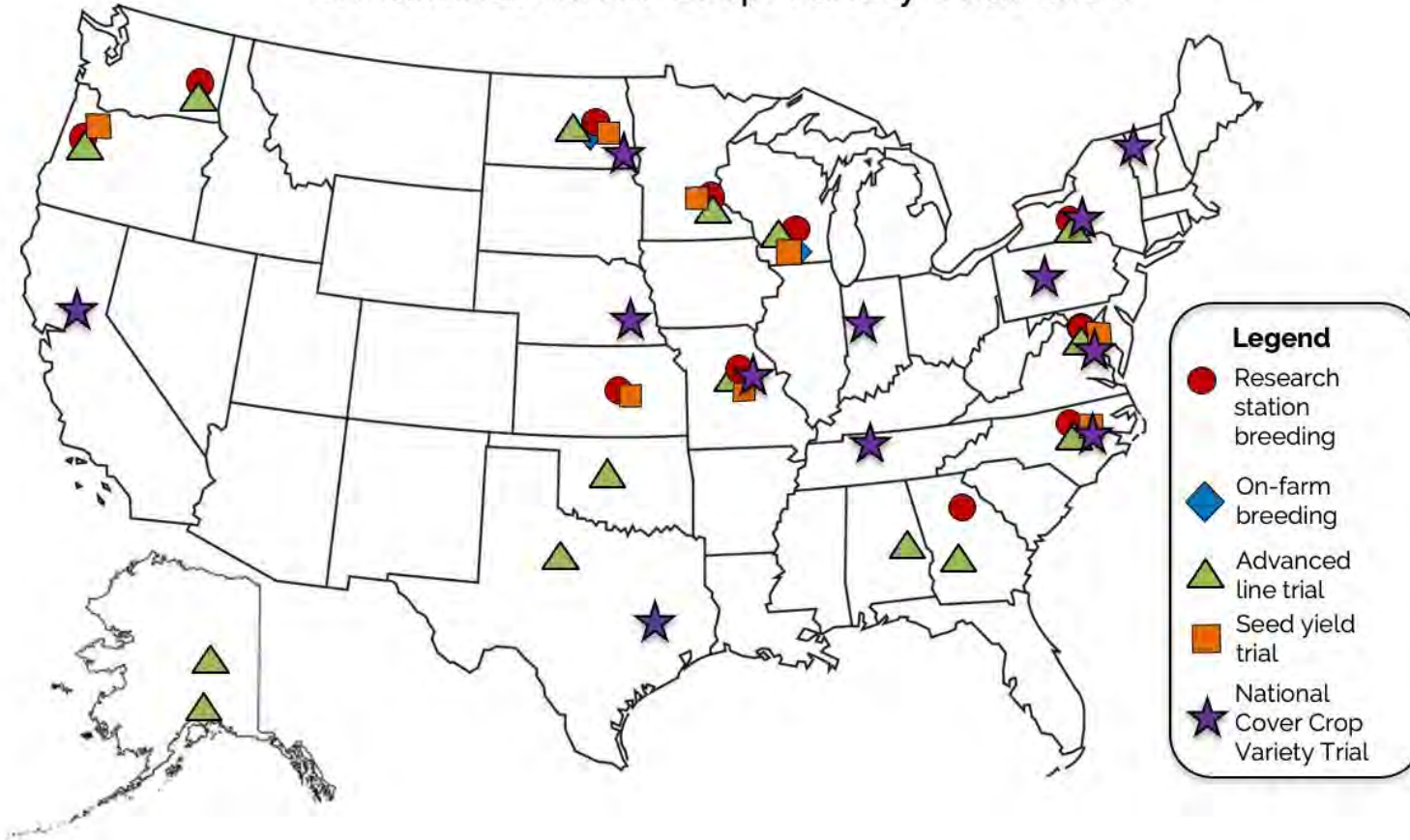
- 2005 Prairie du Sac, WI varieties 'Lotar' and 'Latanovia' drill planted (Grabber et al., 2014; 2015)
- 2009 Superior surviving plants selected and polycrossed (2 polycrosses; halvesib seed harvest)
- Superior seed yielding halvesib families from 2009 polycrosses included in bridsfoot trefoil 2010 Prairie du Sac, WI space planted nurseries (2 sites) (Riday and Brummer, 2014)
- Agronomically desirable plants were tested for condensed tannin (CT) content. 21 plants with the highest and the lowest CT amounts were transplanted to 2 polycrosses (Syn1) May 2014 and intermated.
- Syn2 synthetics H-TAN-2015, L-TAN-2015 Prairie du Sac, WI 2015
- Syn3 synthetics H-TAN(MSP4106) and L-TAN(MSP4105) produced in St. Paul, MN 2017 & 2018.





Cover Crop Breeding (CCB) Network

2024-25 CCB Network Breeding and Trial Sites
& National Cover Crop Variety Trial Sites



- National coordinated cover crop breeding and variety evaluation program (2015-2026)

- Cover crops: Winter Pea, Canola, Cereal Rye, Crimson Clover, and Hairy Vetch

- Participants: USDA-ARS, Universities, USDA-NRCS-PMCs, and NGOs

- Funding

USDA-NIFA-OREI-2015-51300-24192

USDA-NIFA-OREI-2018-51300-28424

USDA-NIFA-AFRI-2018-67013-27570

USDA-NIFA-OREI-2021-51300-34899

USDA-NIFA-SAS-CAP-2023-68012-38993



- Mature breeding program with many experimental varieties available for the seed industry to take to U.S. farmers
- Based on seed industry input starting in 2026 a yearly “Variety Release Availability List” will be publicly available of experimental varieties that the CCB Network feels have been tested enough and could be released as varieties
 - https://www.covercropbreeding.com/_files/ugd/1bd2ad_e39b724b3b0749b1b7f90eb1d03a53de.pdf
 - Posted on the web and distributed to American Seed Trade Association (ASTA)
- In 2026:
 - 6 Winter Pea experimentals are listed ('CCB Doudlah Diehard', 14WPX1551-1-3-0-0/ALT19, 18PodWP-41-0/ALT42, 14WPX1541-1-0-0P-1T-0/ALT68, 16WPX1761-0-a-0-1T-0/ALT70, and 'CCB Elsa')
 - 5 Hairy Vetch experimentals are listed (21MDS, 17NCL, 22OR, 23WI and 22MDS)
 - 4 Crimson Clover experimentals are listed (20NCCCLH, 20WICC, 17MDCCS, and 20NCCCE)
- All varieties coming out the program will have CCB at the start of the released variety name.



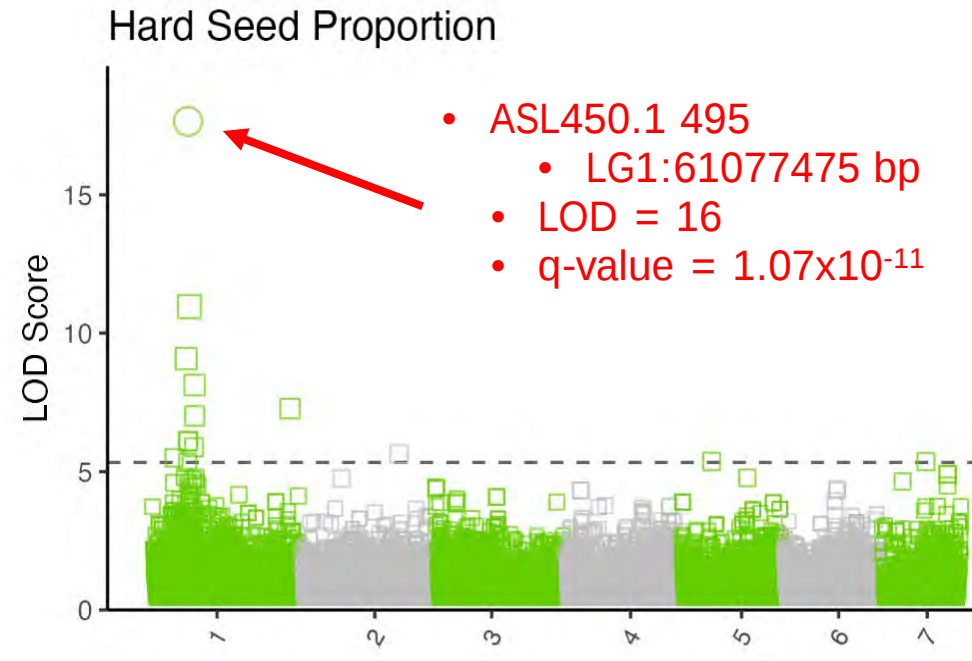
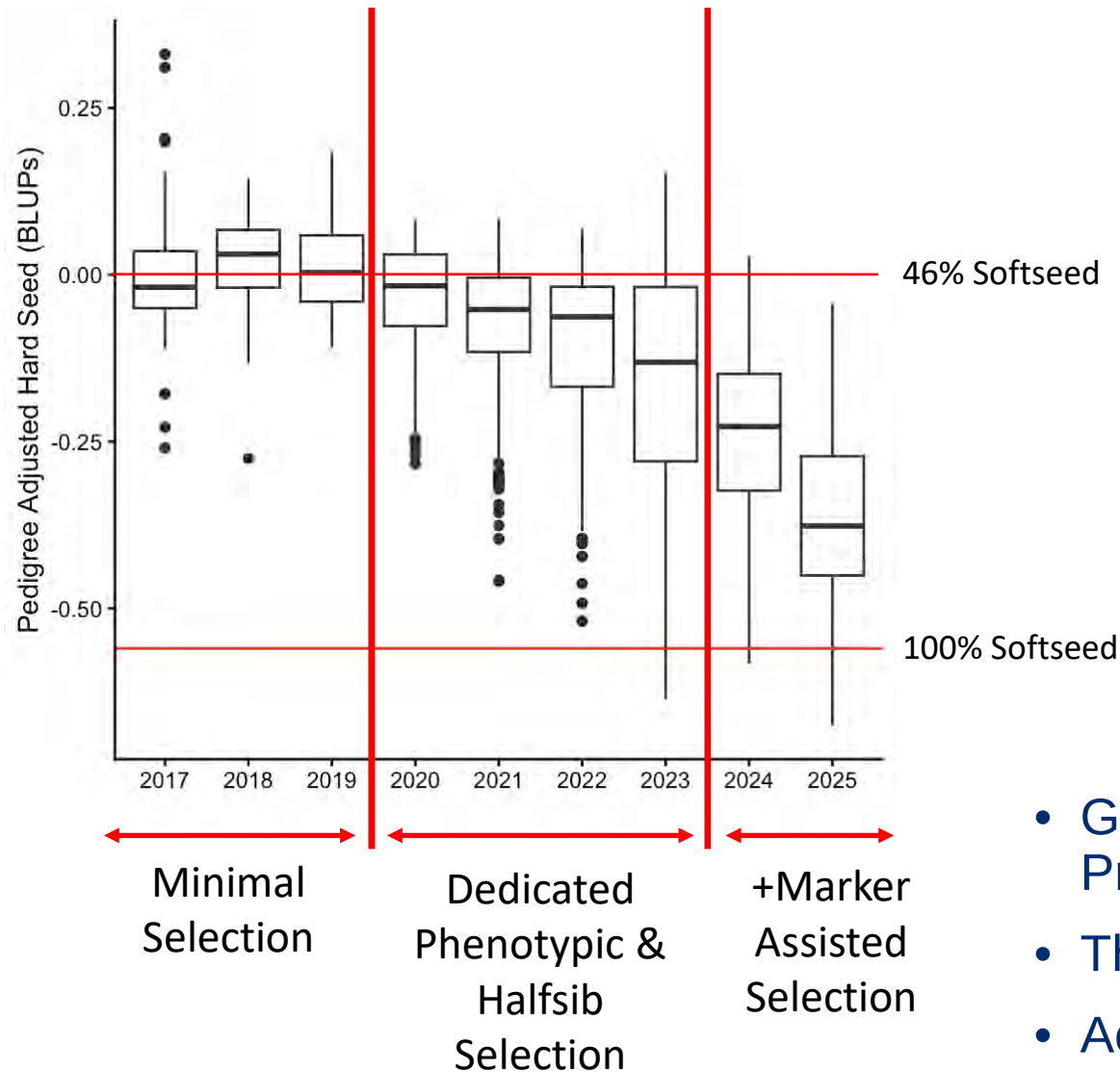
CCB Breeding Targets

- Winter Pea: winter survival, fall biomass, spring biomass
- Hairy Vetch: winter survival, fall biomass, spring biomass, seed yield, softseeded, non-shattering, early flowering (some systems), some smooth vetch breeding
- Crimson Clover: winter survival, fall biomass, spring biomass, seed yield, softseeded (some systems), hardseeded (some systems), early flowering (some systems), late flowering (some systems)
- Cereal Rye: winter survival, fall biomass, spring biomass, forage quality, low allelopathy (some systems), high allelopathy (some systems), differing maturities (depending on system)
- Canola: winter survival, fall biomass, spring biomass
- Pennycress, Camelina, Red Clover, and Smooth Vetch
- In all legume cover crops increased biomass equals increased biological nitrogen fixation (BNF)
- Newer CCB trait topic: breeding cover crops for grazing systems





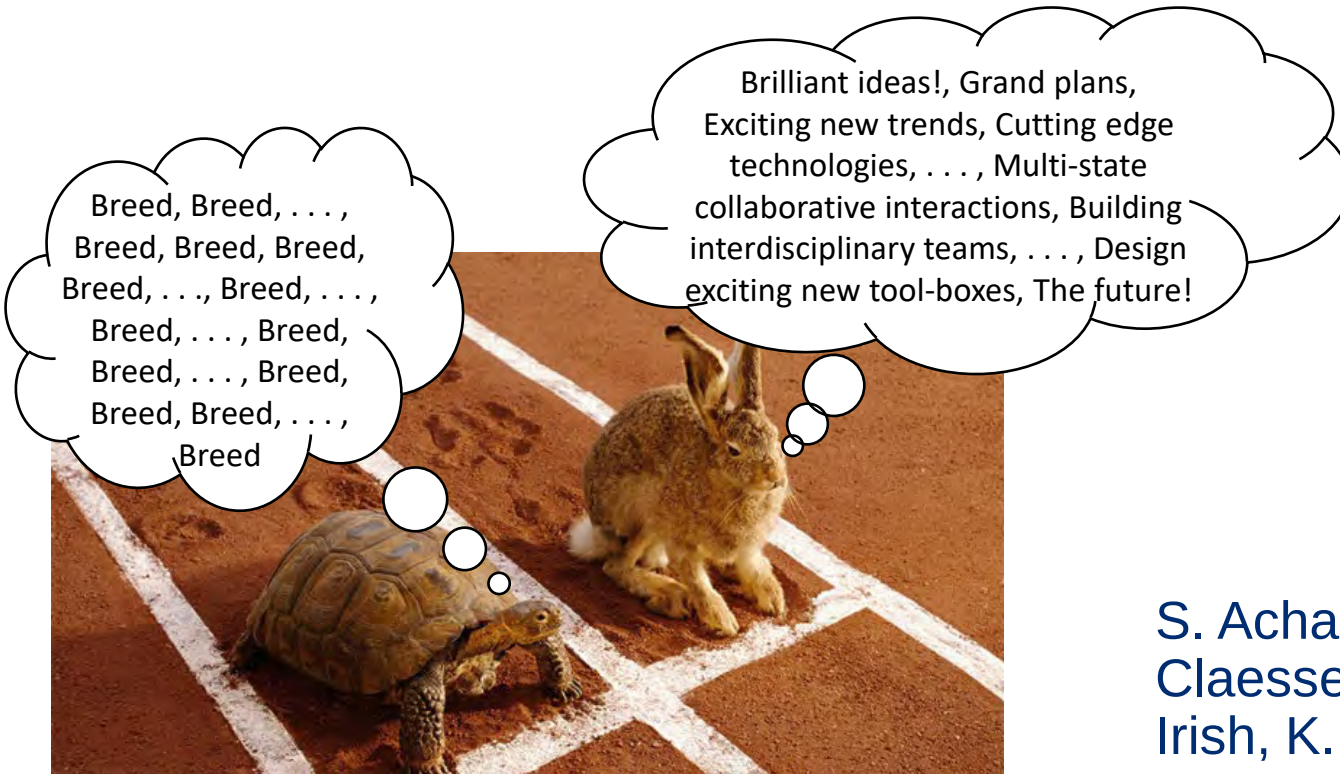
Progress Towards Softseeded Hairy Vetch



- Germplasm evaluated @ Prairie du Sac, WI (2017-2025)
- Three phases
- Accelerating progress



Questions?



S. Acharya, K.A. Albrecht, E.C. Brummer, A. Claessens, N. Ehlke, J. Grabber, S. Hanson, B. Irish, K. Kucek, S.B. Mirsky, D. Michelson, V. Moore, H. Poudel, C. Reberg-Horton, L. Smith, M. Smith, N. Tilhou, and D. Viands