

Establishing a Multi-Environmental Alfalfa Evaluation Network for Climate Resilience and Variety Improvement



A. Odorizzi¹, V. Arolfo¹, A. Scarponi¹, P. Sipowicz² and E. Ríos²

¹INTA Manfredi, Argentina; ²Agronomy Department, UF, EE.UU.

Climate change will have major impacts on adaptation of species to agricultural systems around the world. The ability of breeders to select for traits that impart adaptability to climate resilience and diverse management practices will be critical for the future of livestock production.

Project "Defining and breeding for the target population of environments for non-dormant alfalfa".

Alfalfa (*Medicago sativa* L.) is planted in 7 million hectares in the US and in 3.5 million hectares in Argentina. The successful cultivation of alfalfa relies heavily on identifying cultivars (CV) that can thrive in various environmental conditions. This introduces the need for a comprehensive approach to evaluate alfalfa varieties across multiple environments; the process of establishing a network for multi-environmental evaluation and underlines its significance in advancing agricultural research and variety improvement. The aim is to improve adaptability, resilience to climate change and yield optimization. The design of the evaluation network involves careful sites selection considering soil type, climate, topography, etc. Management criteria focuses on coordinating activities and accurate data recording, while budgeting involves a detailed breakdown of costs and sourcing funding.

In Argentina, the Alfalfa Cultivar Evaluation Network (RECA) of the National Institute of Agricultural Technology (INTA) employs a standardized methodology involving trials sown according to fall dormancy (FD), followed by rigorous data collection and statistical analysis to evaluate performance. This network has been operational for 34 years and has been instrumental in providing valuable insights into alfalfa CV used in Argentina.

Evaluations conducted at RECA offer critical insights into the performance and adaptation of most of the 469 CV registered in the National Register of Cultivars. More than 210 distinct alfalfa CV or experimental populations were evaluated between 1990 and 2023 (Table 1).

Table 1. Trends in Alfalfa Cultivar at RECA in Argentina (1990-2023)

Years	Cultivars	FD	Sites	Seasons	Average Yield per cut by dormancy (MT DM/ha)		
					D (4-5)	SD (6-7)	ND (8-10)
1990	37	3 to 9	12	4			
1992	29	5 to 9	11	4			
1994	46	4 to 9	17	4			
1996	45	4 to 9	8	4	1.73	1.99	1.35
1998	41	4 to 9	12	4	1.17	1.24	1.67
2000	16	8 to 10	11	4			1.72
2002	18	5 to 9	13	3	1.51	2.04	2.18
2004	48	6 to 10	13	4		1.97	2.03
2006	61	5 to 10	13	4	1.70	1.82	2.04
2008	52	6 to 10	15	4		1.79	1.98
2010	47	6 to 10	16	4		1.95	1.99
2012	40	6 to 10	11	4		2.03	2.04
2014	44	5 to 10	12	4	1.90	1.90	1.94
2016	32	6 to 10	14	4		2.18	2.12
2018	44	5 to 10	12	4	2.31	2.26	2.21
2021	64	5 to 10	9	3	2.24	2.21	2.34
2022	28	5 to 10	4	1	1.59	1.77	1.97

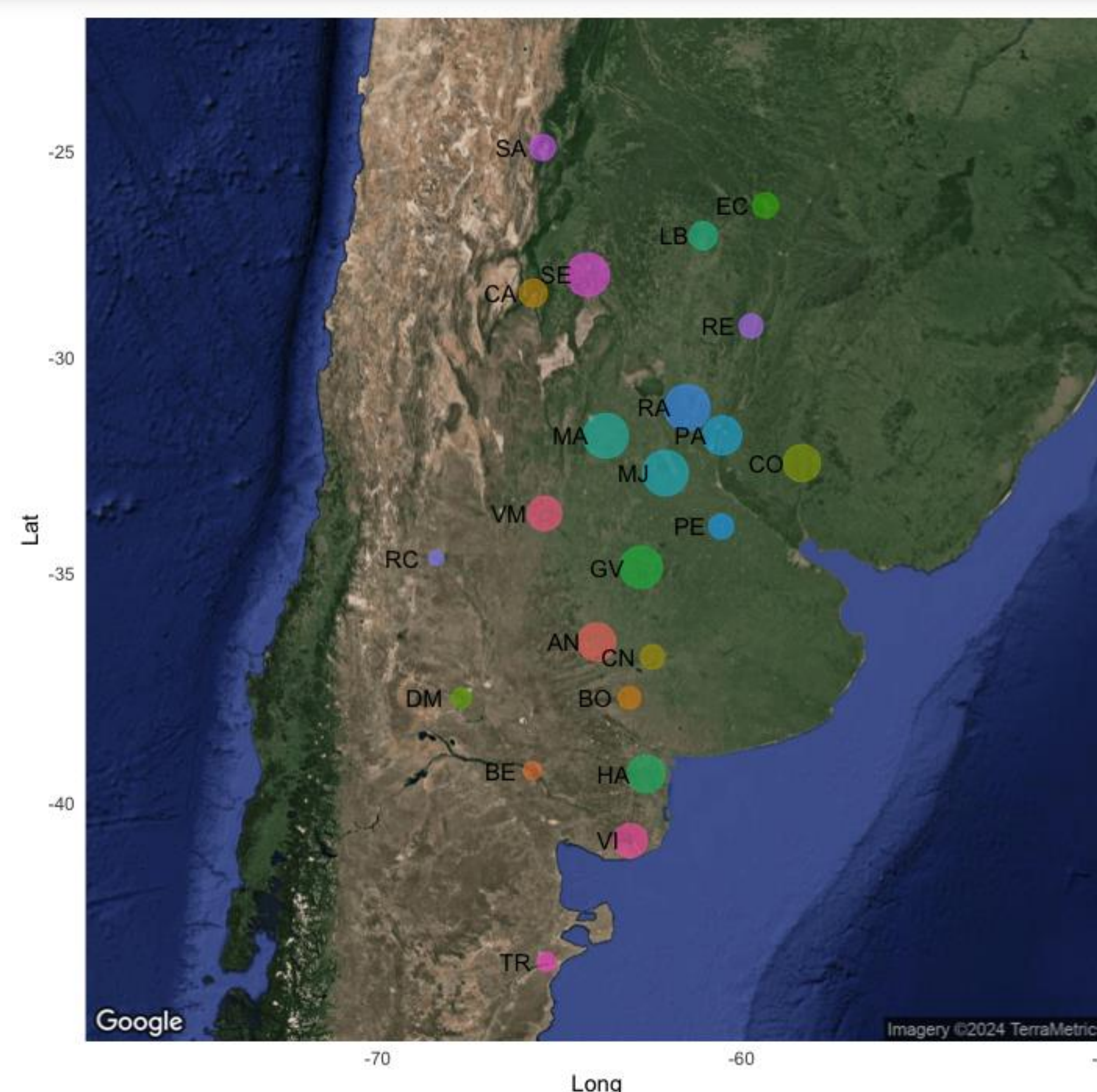


Figure 1. Yield observations number in Argentinian sites.

References listed in order of the number of observations, from highest to lowest: RA = Rafaela; MJ = Marcos Juárez; MA = Manfredi; SE = Santiago del Estero; GV = General Villegas; PA = Paraná; AN = Anguil; HA = Hilario Ascasubi; CO = Concepción del Uruguay; VM = Villa Mercedes; VI = Viedma; LB = Las Breñas; CA = Catamarca; SA = Salta; EC = El Colorado; PE = Pergamino; CN = Casbas; RE = Reconquista; BO = Bordenave; DM = 25 de Mayo; TR = Trelew; BE = Luis Beltrán; RC = Rama Caída. The terrain map background highlights the physical geography of the region.

Fluctuations in the number of CV evaluated suggest dynamic shifts in market preferences over time but also peaked in certain years, possibly reflecting economic factors influencing cultivar evaluation among seed companies. RECA evaluations have encompassed CV ranging from FD 3 to 10. Interestingly, there has been a notable decline in the participation of CV exhibiting intermediate FD levels over the years. This trend indicates a shift towards evaluating CV with reduced FD or even non-dormants (ND), underscoring advancements in breeding for improved winter hardiness and forage yield and quality. At RECA, the number of evaluation sites reflects the geographic scope and environment diversity. Variations in site numbers across years highlight shifts in genetic-environment interaction, expansion into new regions, or logistical considerations affecting experimental plot availability.

By conducting evaluations across diverse latitudinal and longitudinal gradients, breeders can assess cultivar performance under varying environmental conditions, thereby enhancing regional adaptability and resilience. Consistent evaluation across multiple seasons is crucial for robust cultivar assessment. RECA's evaluation protocol, with four replications over nearly four years (Seasons) per trial, ensures reliable data collection and analysis. This standardized approach enables breeders to discern cultivar performance trends across varying climatic conditions and management practices, facilitating informed cultivar recommendations for growers.

The map in Figure 1, displays the geographical locations of yield observation sites in Argentina. Each point represents a specific site, with its size corresponding to the number of observations recorded at that site. The background map provides a terrain view, offering a detailed representation of the physical features of the region. The map also highlights arid zones (brown) and humid areas (green) of Argentina. Each site on the map includes records of various climatic characteristics such as precipitation, temperatures, etc., over the years. Figure 2 shows the average forage yield per cut of all cultivars grouped by dormancy.

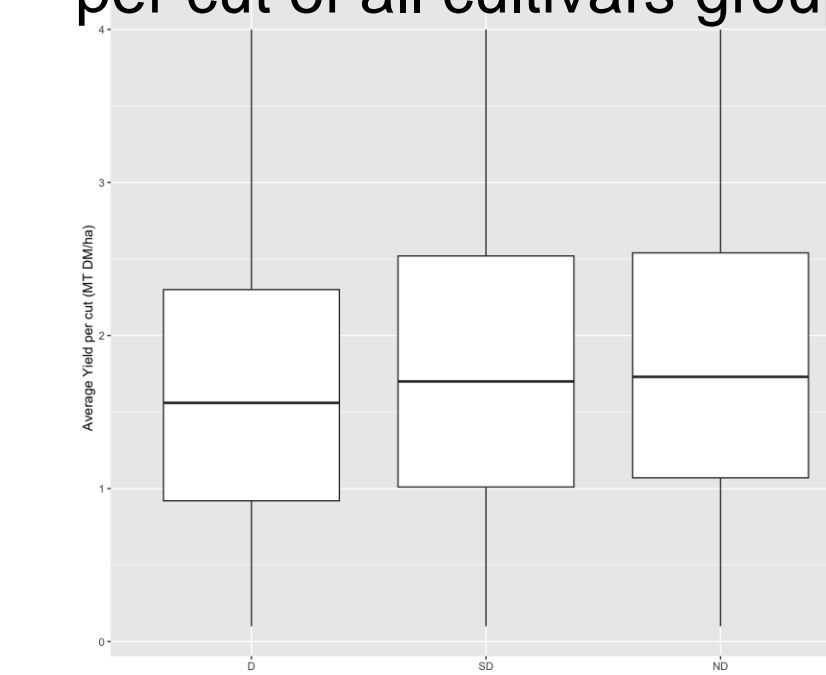


Figure 2. Average forage yield per cut by dormancy.

References: D= Dormant 4-5, SD= Semi-Dormant 6-7 and ND= Non-Dormant 8-10. Yield= metric tons of dry matter per hectare (MT DM/ha)

This extensive phenotypic database with more than 350,000 observations, will serve as a foundation for the project "Defining and Breeding for the Target Population of Environments for Non-dormant Alfalfa". Advanced breeding lines from the UF breeding program will be entered into the network of variety trials from INTA and in variety testing programs across the southeastern US in Fall 2024 and 2025. Data from these trials will be used to propose new cultivar releases, coming from a combination of germplasm screening, genomics, enviromics, and phenomics to improve yield and persistence for non-dormant alfalfa, and expand the market area for UF cultivars beyond the deep South (Florida, Georgia, Alabama) and Argentinian cultivation regions.

References:

R Core Team (2024). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: <https://www.R-project.org/>.
Kahle, D., & Wickham, H. (2013). ggmap: Spatial Visualization with ggplot2. The R Journal, 5(1), 144-161. URL: <https://journal.r-project.org/archive/2013-1/kahle-wickham.pdf>.