Acid Soil Adaptation Index (ASAI): a field selection approach for improving low pH tolerance in alfalfa

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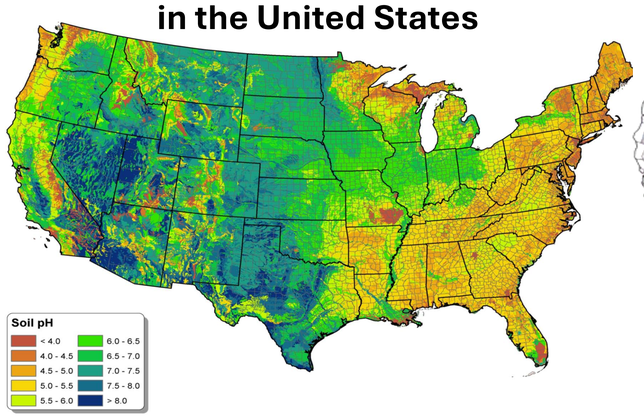
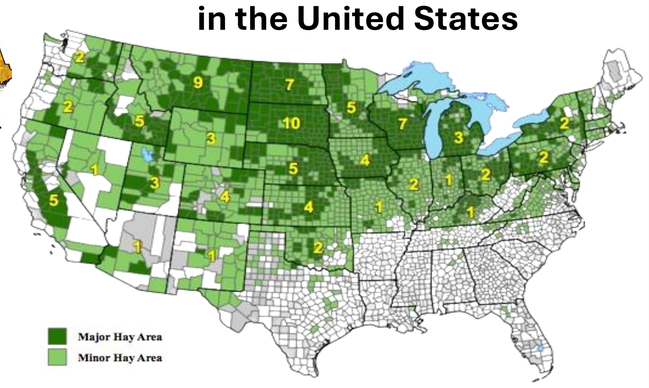
Low pH soils significantly limit alfalfa production

Soil pH in the United States

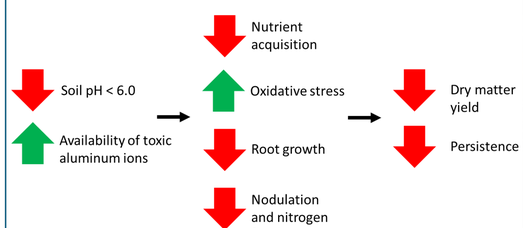


Alfalfa production in the United States



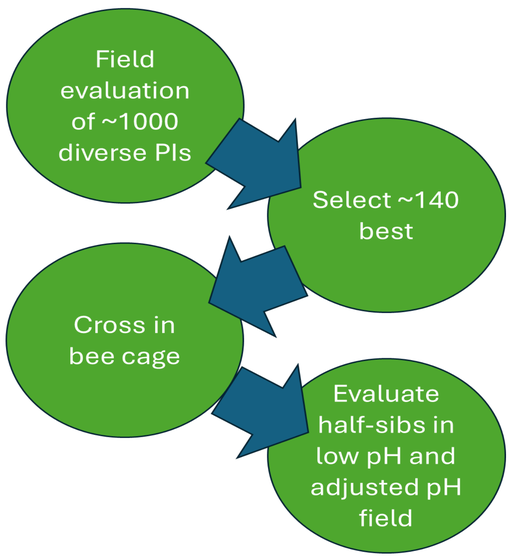
Source: Oregon State University Forage Information System; USDA World Agricultural Outlook Board, NASS (2007).

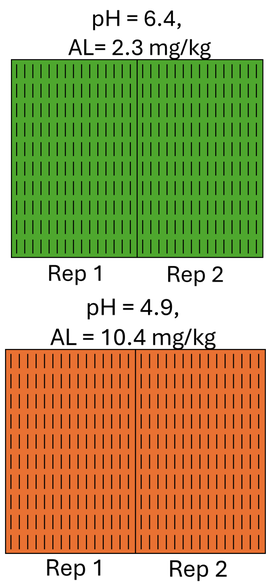
Low pH and aluminum toxicity in alfalfa

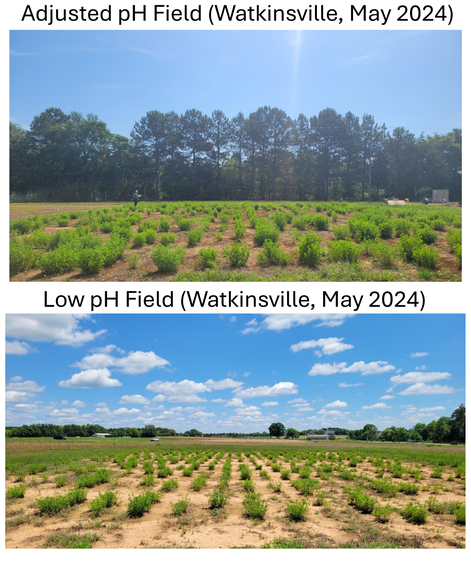


Source: Khu, D.-M., Reyno, R., Brummer, E.C. and Monteros, M.J. (2012), Screening Methods for Aluminum Tolerance in Alfalfa. Crop Science, 52: 161-167; Adapted from Fig. 1 Lee et al., (2019), showing response after 72 hours of stress exposure

Population development and field phenotyping



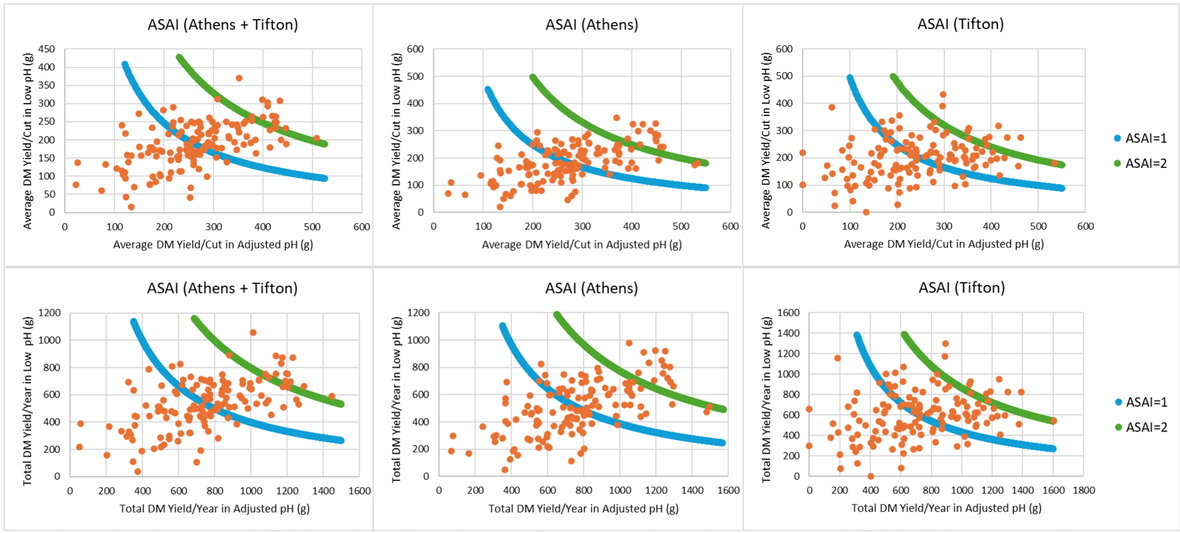




Field was established in Athens in 2020 and clonally replicated to establish a second location in Tifton, GA in 2022. Dry matter yield (DMY) per plot was evaluated in Athens, GA throughout the growing seasons of 2021, 2022, and 2023 and in Tifton, GA in 2023.

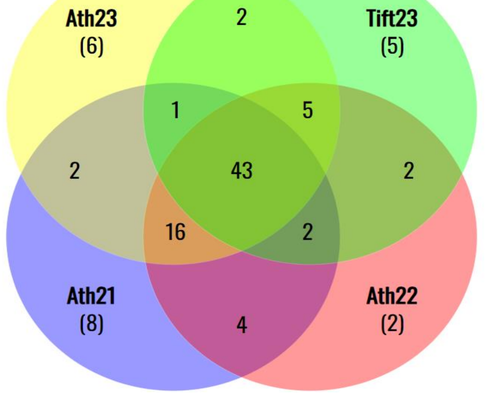
Measuring tolerance: Acid soil adaptability index (ASAI)

$$ASAI = \frac{Yield\ in\ low\ pH\ condition\ * Yield\ in\ normal\ pH\ conditions}{Average\ yield\ in\ low\ pH\ condition * Average\ yield\ in\ normal\ pH\ condition}$$

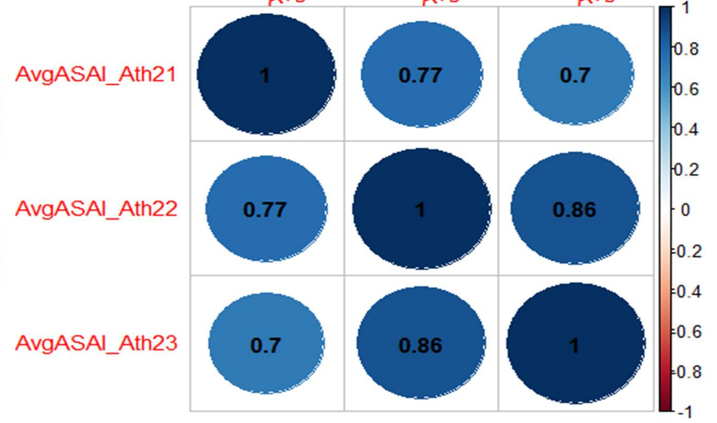


Blue line indicates ASAI=1 (well-adapted), green line indicates ASAI=2 (very well-adapted), and orange dots indicate each half-sib family entry.

Tolerant Families Identified Across Years and Locations



Multi-Year Stability Analysis for ASAI



43 half-sib families were identified as acid-tolerant (ASAI>1) across all years and locations. ASAI values are highly stable across years in Athens (correlations ranging from 0.7-0.86).

Comparing broad-sense heritabilities

Total DM Yield/year	Average DM Yield/cut	ASAI
0.434	0.459	0.704

The ASAI phenotype has a much higher heritability in this population than DM yield alone.

The significant phenotypic variation displayed by this population can also be leveraged in genome wide association analysis (GWAS) to identify associations with molecular markers and develop genomic selection models to accelerate genetic gain for this complex, elusive trait.

Altet-4
Developed in the lab

Experimental half-sib family
Developed in the field

ASAI is a stable and highly heritable trait that can be used in recurrent phenotypic selection to develop an acid-tolerant alfalfa cultivar.

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