Unlocking Forage Yield & Stand Persistence Potential of Alfalfa in Low pH Soils

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Alfalfa (*Medicago sativa*) yield is reduced in low-pH soils, exacerbated by Aluminum toxicity. Genetic improvement of low pH and aluminum tolerance in alfalfa has been the focus of extensive research over the past four decades. However, phenotyping based on lab and greenhouse screening for AL-tolerance failed to translate to improved cultivars due to low forage yields in field conditions.

In this Alfalfa Seed and Alfalfa Forage Systems Research Program (ASAFS) funded project, we have taken a reverse approach, evaluating large collections of germplasm for forage yield in field conditions with low pH and high Aluminum, select and recombine the top performers and evaluate the half-sib progeny in low and adjusted pH to identify the entries with equal or better performance in low pH condition to undergo further recurrent selection. The aim of the proposed project is to identify alfalfa germplasm with optimal yield and stand persistence in low-pH soils in four states (Alabama, Georgia, South Carolina, and Minnesota), and to develop genomic resources and strategies to improve the resilience and sustainable production of alfalfa in regions with low-pH soils in the USA, thereby expanding alfalfa acreage. This project builds on a preliminary study to characterize the effects of low-pH soils on yield and fall dormancy, persistence, and to test the feasibility of the reverse evaluation approach. A panel of 133 genotypes was selected following the evaluation of 966 diverse accessions from the NPGS collection for 3 years in a low-pH field environment. Half-sib families resulting from intermating these selections were evaluated in row plots in natural low-pH soil (4.9-5.2, extractable aluminum=10.41-11.38 mg kg-1) and an adjusted-pH soil (6.37-7.07, extractable aluminum=0.01-2.29 mg kg-1) in two locations (Athens and Tifton, GA). The results revealed that acid stress significantly reduced the mean yield by 61 g dry matter per cut per plot ($p < 0.01$) and fall dormancy ratings by 1.47 classes ($p < 0.01$). An Acid Soil Adaptation Index (ASAI) based on yield data across low- and adjusted-pH conditions identified 16 acid-tolerant half-sib families across all 6 environments.

Despite significant variability across environments and genotype-by-environment interactions, high heritability estimates were observed for yield (0.80-0.90) and ASAI (0.854), suggesting that selections from this germplasm panel can be leveraged to develop regionally adapted, acid- and aluminum-tolerant cultivars.