Integrating Handheld NIRS & Multi Trait Indices to Accelerate Breeding for Nitrogen Efficient Grasses

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Aurora handheld NIRS device in a Switchgrass field.
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Breeding perennial grass populations that require less nitrogen (N) is a key step toward more sustainable forage production systems. Traditional improvement efforts in forage grasses have been conducted under ample N availability. While this has boosted biomass production, they have not reported how genetic variation relates to nitrogen use efficiency (NUE). In this study, we assessed genetic differences in biomass yield, tissue N concentration, and total N removal within two switchgrass (*Panicum virgatum* L.) breeding populations – Hiawatha and Liberty – evaluated across two sites for two consecutive years. The N content of plant samples was rapidly estimated using a handheld near-infrared reflectance spectrophotometer (NIRS). Multiple selection strategies including single-trait, ratio-based, and multi-trait index approaches, were compared to project long-term breeding progress. Heritability estimates were highest for N removal (0.67 in Hiawatha and 0.41 in Liberty), though they varied widely depending on the selection method. Biomass yield and N concentration showed a weak negative association, while N removal was strongly and positively linked to both traits. Long-term simulations suggested that selecting solely for yield would more than double N demand over 20 breeding cycles. In contrast, index-based selection provided better overall outcomes, improving biomass yield while keeping increases in N demand at manageable levels. Handheld NIRS produced highly accurate predictions (R^2 > 0.90 with low error) compared with benchtop NIRS across four calibration sets, demonstrating its suitability for rapid N evaluation. Overall, the findings indicate that combining multi-trait selection with portable NIRS tools offers an effective path for developing switchgrass cultivars with enhanced NUE without sacrificing biomass gains. These findings could be applied to improve other grass and forage species with improved NUE and increased breeding efficiency.