Improving the genetic merit of perennial temperate forages

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Ruminant animals grazing mixed swards of white clover and perennial ryegrass are the foundation of our pastoral sector, contributing over one fifth of gross domestic product and over half of New Zealand's export earnings. Lifting the rate of genetic gain in these forages by integration of marker aided breeding, innovative field evaluation strategies, novel trait development, and introgression of genetic resources is the major objective of our grass and legume breeding programs.

Research has developed solutions for improvements in herbage yield and persistence, novel endophyte compatibility in perennial ryegrass, improved forage quality, abiotic stress tolerance, condensed tannin expression in legumes, and progression of pest tolerant genetics toward utilisation in improved grasslands-based production systems. This paper outlines specific plant breeding examples from the low-tech to the high-tech which are delivering forage-based solutions for the pastoral sector.

On the low-tech end of the spectrum, tailoring of evaluation conditions prior to selection has enabled significant genetic gain in red clover persistence under grazing, with new populations exhibiting viable and productive plant populations through four years of grazing.

We are pursuing discovery and utilisation novel genetic variation via inter-specific hybridisation in the genus *Trifolium* amongst an extensive secondary gene pool around white clover. These inter-specific hybrids offer radical new phenotypes influencing plant adaptation, resource use efficiency, and feeding value, creating substantial opportunities to improve the contribution of forage legumes in grasslands-based production systems.

Molecular markers indices in complex populations are providing plant breeders with new ways of selecting improved materials. Genome regions with effects of up to 24% for herbage yield, 28% for plant persistence factors, and 38% for seed yield have been identified in forage breeding populations and are being integrated in breeding programmes.

At the high-tech end of the spectrum, we are leveraging information on phylogeny, candidate genes, and transcription factors to genetically engineer condensed tannin expression into white clover and alfalfa. This achieves a long established plant breeding objective of providing condensed tannin in forage legumes suited to pastoral systems, offering the range of benefits to animal production and natural resource use efficiency on farm.

Systems level developments in our cultivar development process include genomic selection, with an initial focus on developing indices for perennial ryegrass and white clover in New Zealand pastoral conditions.