

Genetic Relationship & Diversity of 14 Alfalfa Populations Collected from Long-Term Grazing Sites

Hu Wang¹, Yuguang Bai¹, Bruce Coulman¹, Xiao Qiu² and Bill Biligetu¹

¹Department of Plant Sciences, University of Saskatchewan, Saskatoon, SK, S7N 5A8, Canada.

²Department of Food & Bioproduct Sciences, University of Saskatchewan, Saskatoon, SK, S7N 5A8, Canada.

Introduction

- Alfalfa is an important cash crop to Canadian economy with certified alfalfa seed export valued at \$61.2 million and alfalfa meal and pellet export at \$37.1 million in 2020 (Tridge, 2021).
- However, alfalfa stand is frequently affected by grazing (Smith et al., 1989), and extreme environmental conditions (Bélanger et al., 2006).
- Development of new alfalfa cultivars with high regional adaptation and persistence is an important research topic for enhancing alfalfa production and increasing profitability of the beef and dairy sectors in Canada.

Objectives

- To identify the genetic relationship of the 14 alfalfa populations from long-term grazing sites and the 11 commercial alfalfa cultivars released from 1926 to 1980.
- To evaluate genetic and phenotypic variations of alfalfa populations from long-term grazing sites.

Materials and methods

- Fourteen alfalfa-grass mixed stands with a minimum 25 years of grazing history were selected across Brown, Dark Brown, Black and Grey Wooded soil zones of Saskatchewan (SK), Canada (Fig 1).
- A nested randomized complete block design (RCBD) with two replications was established in June 2017, Saskatoon, Saskatchewan, Canada (Fig 2).
- Genotyping-by-sequencing (GBS) was applied in the genetic relationship and diversity analysis of the 14 alfalfa populations from long-term grazing sites and the 11 commercial alfalfa cultivars released from 1926 to 1980, and genotype-environment association (GEA) analysis of alfalfa populations from long-term grazing sites.

Results

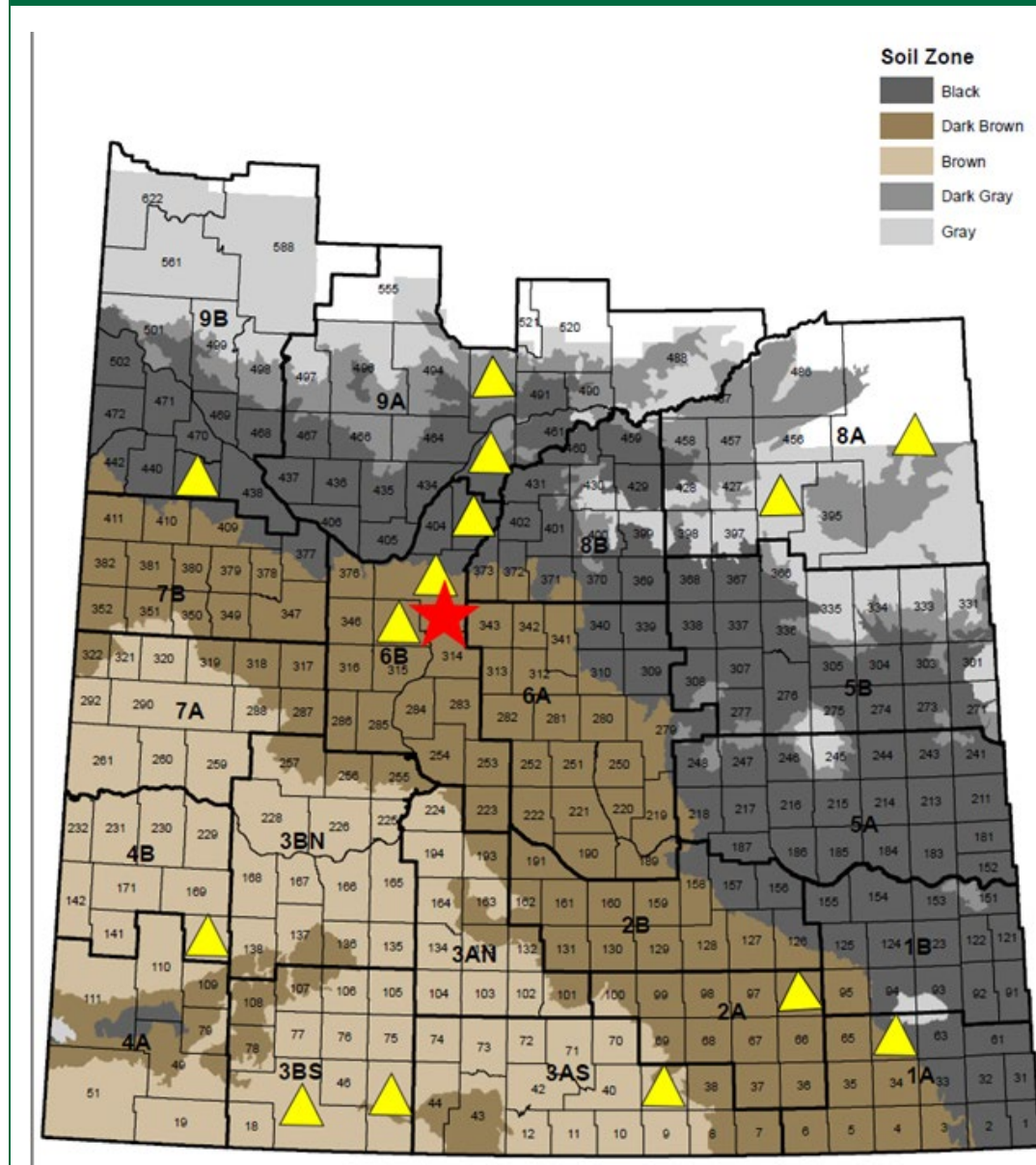


Fig 1. The 14 Alfalfa populations from long-term grazing sites (> 25yrs) across four soil zones, SK, Canada.



Fig 2. Spaced field experiment at Saskatoon, SK, Canada.

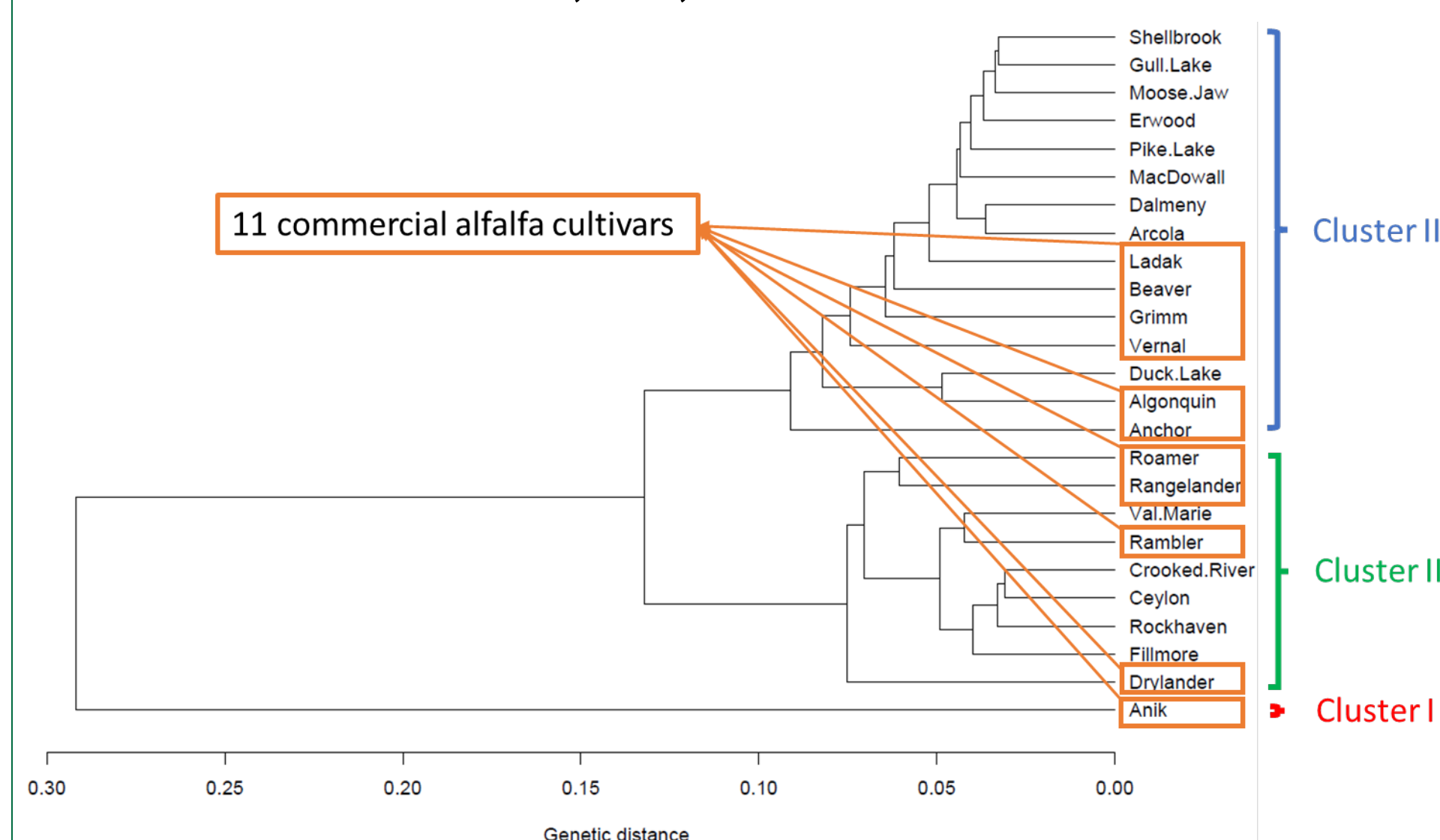


Fig 4. Genetic relationship of 25 alfalfa populations representing the 14 alfalfa populations from a long-term grazing sites and the 11 commercial alfalfa cultivars from 1926 to 1980 using the unweighted pair group method with arithmetic mean (UPGMA) dendrogram based on 19,853 SNPs.

Fig 6. Genotype-environment association (GEA) analysis of eight environmental factors with alfalfa populations from long-term grazing sites. The colored points represent individual genotype. Blue vectors represent eight environmental factors.

Table 1. Candidate genes associated with seven environmental factors for alfalfa populations from long-term (> 25yrs) grazing sites.

Environmental factor	Number of candidate gene	Putative function
Soil pH	4	Plant adaptation to environmental stresses such as drought, salinity, cold and nutrient deprivation
N	2	Pathogens resistance and drought tolerance
P	14	P stress and abiotic stresses
K	7	No direct association with K stress in plants
S	2	Pathogens resistance and drought tolerance
Summer extreme temperature	14	Heat stress
Growing season precipitation	10	Drought stress

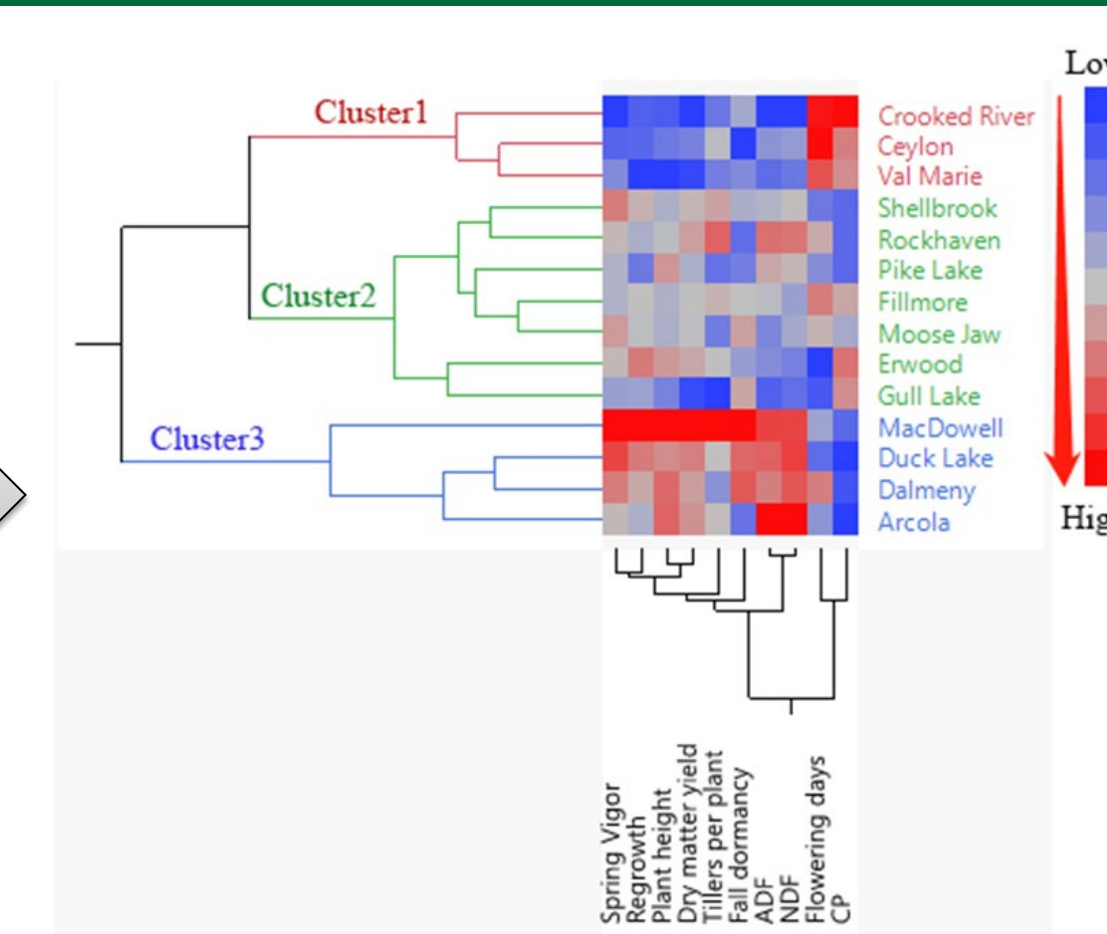


Fig 3. Two-way cluster of ten agronomic traits of 14 alfalfa populations from long-term grazing sites from 2018 to 2020 growing seasons.

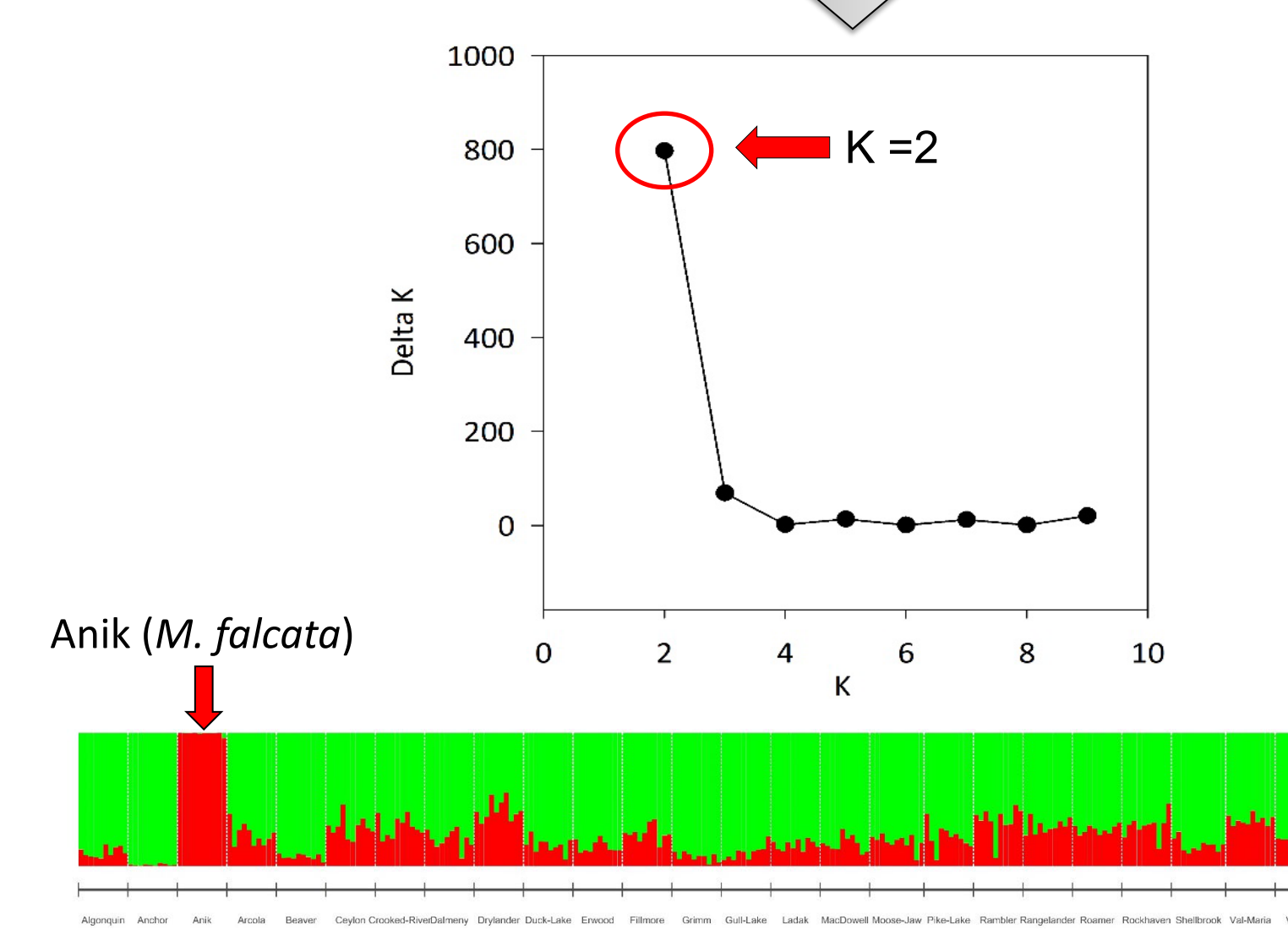
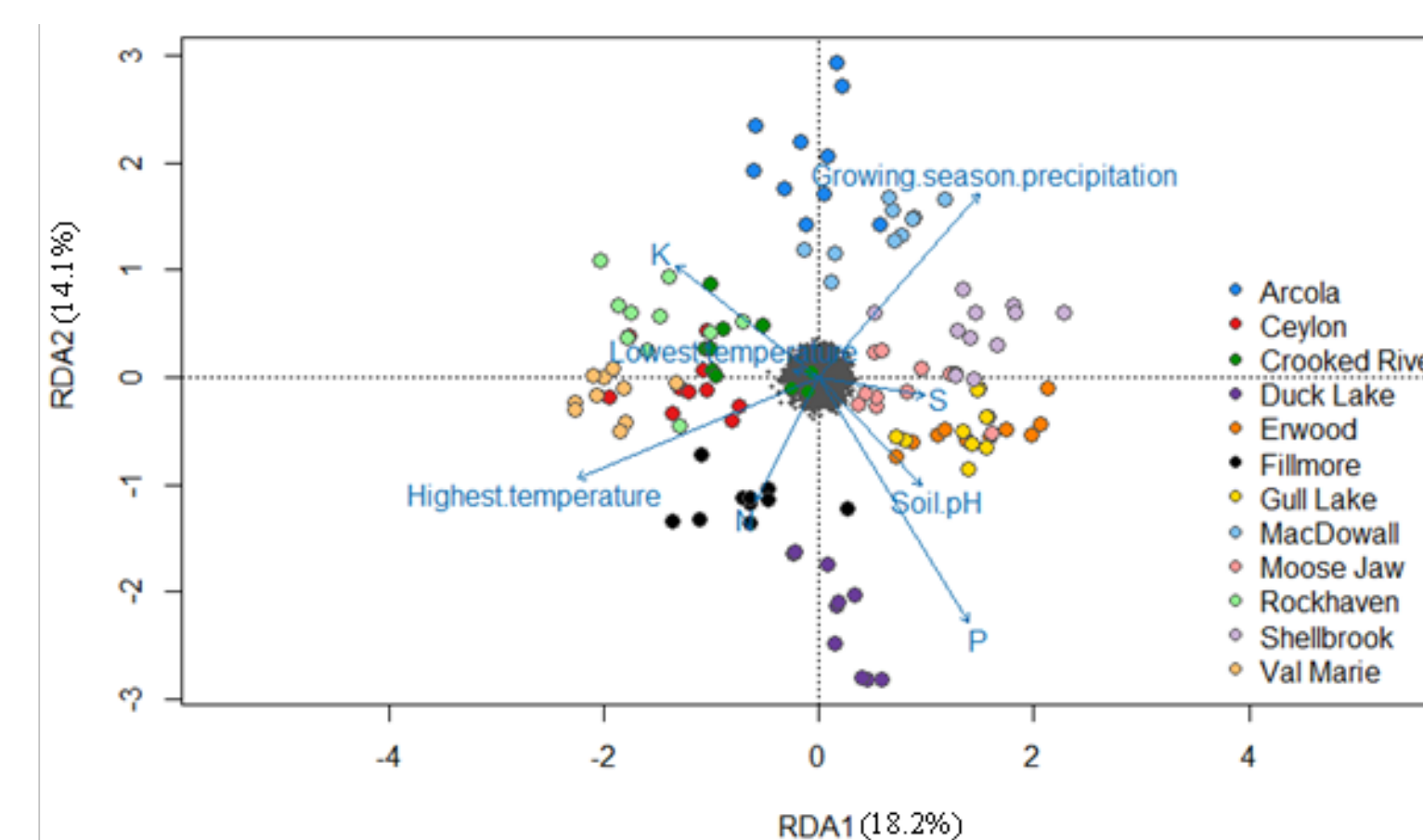


Fig 5. Genetic backgrounds of individual genotypes representing the 14 alfalfa populations from long-term grazing sites and the 11 commercial alfalfa cultivars from 1926 and 1980 using STRUCTURE based on 19,853 SNPs.



Conclusions

- The UPGMA (Fig 4) and STRUCTURE (Fig 5) analyses showed that the 14 alfalfa populations had varying percentages of the alfalfa sub-species *Medicago sativa* and *M. falcata*. Most importantly, the four highest forage dry matter yielding populations (MacDowall, Duck Lake, Dalmeny, and Arcola) belonging to the *M. sativa* sub-species were clustered closely according to the best linear unbiased prediction (BLUP) values of ten agronomic traits (Fig 3).
- The GEA analysis (Fig 6) found that 70 SNPs were significantly associated with seven environmental factors of the long-term grazing sites. The 53 candidate genes (Table 1) underlying these environmental factors were associated with a variety of proteins, which were involved in plant growth and development, and plant responses to abiotic stresses, i.e., high salinity, drought, and cold, and biotic stress, i.e., defense against pathogens.

References

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- Smith et al. 1989. Alfalfa persistence and regrowth potential under continuous grazing. *Agronomy Journal*. 81: 960-965.
- Bélanger et al. 2006. Winter damage to perennial forage crops in eastern Canada: causes, mitigation, and prediction. *Canadian Journal of Plant Science*. 86: 33-47.

Acknowledgements

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