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The XX International Grassland Congress took place in Ireland and the UK in June-July 2005. The main congress took place in Dublin from 26 June to 1 July and was followed by post congress satellite workshops in Aberystwyth, Belfast, Cork, Glasgow and Oxford. The meeting was hosted by the Irish Grassland Association and the British Grassland Society.

Proceedings Editor: D. A. McGilloway

Publisher: Wageningen Academic Publishers, The Netherlands

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QTL analysis of mineral content and grass tetany potential in *Leymus* wildryes

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Keywords: QTLs, potassium, calcium, magnesium, grass tetany

Introduction Grass tetany is a metabolic ailment in ruminants, occurring when animals graze rapidly growing C_3 grasses with a K/(Mg+Ca) ratio (KRAT) greater than 2.2. High KRAT values have been documented in several forage grasses including diploid Russian wildrye (Jefferson *et al*., 2001). The objective of this experiment was to identify quantitative trait loci (QTLs) controlling KRAT in allotetraploid wildryes.

Materials and methods Full-sib mapping populations, TTC1 (164 genotypes) and TTC2 (170 genotypes), were derived from crosses of two *L. cinereus* x *L. triticoides* F_1 hybrids (TC1 and TC2) backcrossed with one common *L. triticoides* tester plant (T-tester). The F_1 hybrids were derived from crosses of the Acc:636 *L. cinereus* and Acc:641 *L. triticoides* accessions. The linkage maps include 1583 AFLP markers and 50 anchor loci in 14 linkage groups (LGs) (Wu *et al*., 2003). Concentrations (% dry weight) of Mg, Ca, K, and other minerals were evaluated by ICP-OES of acidified forage dry ash samples harvested May 28, 2003 from clonally replicated plants on 2-m centres in randomized complete blocks (2 reps) at the Utah Agriculture Experiment Station, Richmond. Defined using equivalent units; KRAT = (%K)(0.0257) / [(%Ca)(0.0499) + (%Mg)(0.0823)]. A log of the odds (LOD) threshold of 3 was used to declare significant QTLs. Possible pleiotropy effects and correspondence between populations (homologies) were identified where QTLs overlap with LOD > 2.

Results The Acc:636 accession displayed greater %K ($p<0.001$), less %Ca ($p<0.0001$), and less %Mg ($p<0.01$) relative to Acc:641 (Table 1). Thus, Acc:636 displayed substantially higher KRAT values ($p<0.0001$), relative to the Acc:641 (Table 1). Likewise, the TC1 and TC2 hybrids also showed less %Ca ($p<0.005$) and greater KRAT ($p<0.05$) than the *L. triticoides* T-tester (Table 1). Correlations (*r*) among TTC1 clones were 0.42, 0.61, 0.45, and 0.52 for K, Ca, Mg, and KRAT respectively; and 0.45, 0.47, 0.46, and 0.39 respectively among the TTC2 clones. The range of values (averages of 2 clones per genotype) for K, Ca, Mg, and KRAT varied 1.6-, 2.3-, 2.0-, and 2.3-fold respectively in the TTC1 population; and 1.5-, 2.5-, 1.9-, and 2.1-fold in the TTC2 population.

	%K	%Ca	%Mg	KRAT
Acc:636 (13 genotypes)	3.58 (0.50)	0.225 (0.057)	0.157 (0.018)	3.85 (0.63)
Acc:641 (20 genotypes)	2.90 (0.32)	0.362 (0.097)	0.182 (0.029)	2.30 (0.44)
TC1 (13 clones)	3.16 (0.42)	0.281 (0.040)	0.202 (0.035)	2.68 (0.49)
TC2 (12 clones)	3.16 (0.25)	0.273 (0.052)	0.217 (0.023)	2.61 (0.43)
T-tester (12 clones)	3.28 (0.13)	0.370 (0.072)	0.225 (0.026)	2.29 (0.20)
TTC1 (164 genotypes[#])	3.36 (0.32)	0.364 (0.060)	0.185 (0.026)	2.64 (0.41)
TTC2 (170 genotypes[#])	3.32 (0.24)	0.367 (0.058)	0.201 (0.024)	2.49 (0.34)

Table 1 Means (standard deviations) for mineral concentration and grass tetany potential

[#]Averages of two clones per genotype

Significant %K QTLs were detected on TTC1 LG2a and LG3a; TTC2 LG1b and LG2b; and corresponding regions of TTC1 and TTC2 LG1a. Significant %Ca QTLs were detected on TTC1 LG1b and LG2a; TTC2 LG2a and LG6a; and corresponding regions of TTC1 and TTC2 LG3b. Significant %Mg QTLs were detected on TTC1 LG5x and LG7a in addition to TTC2 LG1b, LG3a, and LG3b. Significant KRAT QTLs were detected on TTC1 LG2a; TTC2 LG7b; and corresponding regions of TTC1 and TTC2 LG3b. Possible pleiotropy for %Ca and KRAT on TTC1 LG2a; %K and %Mg on TTC2 LG1b; and %Ca and KRAT on TTC1 and TTC2 LG3b.

Conclusions This experiment identified QTLs for all three minerals (i.e. K, Ca, and Mg) contributing to grass tetany potential, including a major QTL effect for %Ca and KRAT on LG3b in both populations. Interestingly, the LG3b region and homoeologous regions of LG3a also have major effects on rhizome proliferation (results unpublished). Like Russian wildrye, *L. cinereus* is a tall caespitose grass with relatively high grass tetany potential whereas *L. triticoides* is a strongly rhizomatous grass with relatively low grass tetany potential. These evaluations identified plant materials and methods to reduce grass tetany potential in perennial wildryes.

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