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Carbon isotope discrimination , selection response , and forage production of tall Fescue in contrasting environments

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Introduction Carbon isotope discrimination (Δ) usually correlates with the dry matter to transpiration ratio (transpiration efficiency, TE) in C3 species, with low Δ corresponding high TE. But its heritability and relationship to forage production is less clear. In a four year study of tall fescue (*Festuca arundinacea* Schreb.) at Pullman, WA (relatively cool with low humidity) and Ardmore, OK (relatively hot with high humidity) we determined 1) if Δ differences in divergently selected populations made on single plants were maintained in solid seeded plots, and 2) how Δ in selected populations and a set of four cultivars was related to forage production.

Materials and methods At Pullman WA (46.72446 N and 117.13554 W) and Ardmore OK (34.19250 N and 97.08556 W) plots 4.6 x 1.5 m were established. The seeding rate was 28.7 kg seed ha⁻¹ at both locations. Seven tall fescue entries were randomized in complete blocks with three replications at both locations and plots were maintained under dry-land conditions according to locally recommended fertility rates and procedures. Prior to each harvest, samples of upper, fully emerged leaves were collected from 10-12 plants per plot, dried at 70°C to constant weight, and carbon isotope discrimination was determined at the Augustana College (Sioux Falls, SD, USA) stable isotope laboratory. At Ardmore, plots were harvested in Jan. 2003, May 2003, Jan. 2004, July 2004, Dec. 2004, and June 2005. At Pullman, harvests were in Sept. 2002, and July 2003, 2004, and 2005. For each date, forage from each plot was cut about 7.5 cm above ground level, removed, dried, and forage production calculated on a dry weight basis.

Table 1 Forage production and carbon isotope discrimination for seven entries of tall fescue averaged over four harvest dates from 2002 to 2005 at Ardmore OK and Pullman, WA.

Entry [†]	Ardmore		Entry	Pullman	
	Dry wt.	Δ		Dry wt	Δ
	Kg ha ⁻¹	‰		Kg ha ⁻¹	‰
JesupE+	2397a [‡]	20.25c	K31 low	6937a	18.47d
K31 base	2088ab	20.41bc	Alta	6931a	19.03b
K31 low	2084ab	19.99d	JesupE+	6885a	19.08b
K31 C	2066b	20.51b	Fawn	6583ab	19.46a
Alta	1940bc	20.52b	K31 base	6535ab	18.82c
Fawn	1916bc	20.58ab	K31 C	6438ab	19.20b
K31 high	1697c	20.75a	K31 high	6329b	19.43a

[†] Within a site, means followed by different letters are different at the P<0.05 level.

[‡] K31 refers to the cv. Kentucky 31; low and high refer to selections for high and low Δ , respectively; base to the initial selection population; K31 C refers to a commercial source of Kentucky 31; and E+ to highly endophyte infected germplasm.

Results Differences in Δ for low and high Δ populations selected on spaced plants (Johnson and Li Yangyang, 1999) were maintained in solid seeded plots at both Pullman and Ardmore (Table 1). At Pullman, the low Δ selection (high TE) had higher production than the high Δ selection (low TE) with the base population intermediate. Partial correlations with all entries between Δ and forage production, controlling for harvest date effects, were not significant. However, partial correlation between Δ and forage production on the selected and base populations was significant ($r = -0.59^*$, $n = 12$) at Pullman, although not at Ardmore.

Conclusions The data show selection for low Δ (high transpiration efficiency) is possible and may improve forage production in some environments, but not consistently. Therefore, selection for Δ should not be the main focus of a breeding program despite its heritable nature. For breeding tall fescue, one cycle of phenotypic selection for low Δ in advanced material is recommended.

Reference

Johnson, R.C. and Li Yangyang. 1999. Water relations, forage production, and photosynthesis in tall fescue divergently selected for carbon isotope discrimination. *Crop Sci.* 39:1663-1670.