

STUDY OF GENOTYPE X ENVIRONMENT INTERACTION IN ALFALFA FORAGE YIELD

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ABSTRACT

The response of alfalfa (*Medicago sativa* L.) forage yield to eight Alberta test sites was studied for the 1990 and 1991 production years. Cluster analysis was used to group locations and cultivars. Analyses of variances indicated genotype x environment (location) interaction for the first cut yield, the total yield and the difference between first and second cut yields. The Brooks, Bow Island (irrigation), Bow Island (dryland) and Provost locations always clustered together indicating that three of these four test sites may be eliminated without sacrificing reliability.

INTRODUCTION

Alfalfa (*Medicago sativa* L.) is the most widely grown forage crop in western Canada. No one alfalfa cultivar is suitable for the diverse soil and climatic conditions of the region. Alfalfa cultivars are recommended on the basis of three years of yield data from replicated multilocation trials. Analysis of genotype x location (GL) interactions (Lin and Butler, 1988) for forage yield can provide information on those locations in which cultivars respond similarly. Methods for analysing the contribution of location for sampling regional variability have been assessed for annual crops (Kibite et al., 1988, Lynch and Kozub, 1988, Lin and Morrison, 1992 and May and Kozub, 1995). These methods may not be completely appropriate for alfalfa because year effects are confounded with age of stand effects (Hill and Baylor, 1983). Some workers have examined the GL interaction using data averaged over years to select locations (Saindon and Schaalje, 1993). May and Kozub (1993) came to the conclusion that when data from only a few years are available examinations of the GL interaction for individual years is advisable.

The objective of this study was to examine genotype x environment (location) interactions for forage yield based on alfalfa cultivar trials at eight Alberta sites. These results will aid in rationalizing the location of test sites and evaluating the performance of cultivars across the entire area.

METHODS

This study used cultivar recommendation tests established in 1990 and 1991 at eight Alberta locations (Table 2). Forage yield data were collected for three production years following the establishment year. At each location a number of cultivars (Table 1) were established in randomized complete block designs with four replications. Within each production year, up to three cuts were taken at a location and the yields were expressed as dry matter yield per hectare (DM). For each test x production year combination, analyses of variance for forage yield variables were conducted by location and over locations (Cochran and Cox, 1957) to determine the effect of cultivar and cultivar x location (CL) interactions. The variables analysed included: first cut (C1) yield, total yield of the first two cuts (C12) and yield change between the cuts ($D12 = \% (C1 - C2)/C1$) (Rowell and Walters, 1976). Data from only the first two cuts were used to maximize the number of locations for studying CL interactions. Since the DM differed widely among locations and the means were positively correlated with variances, the yields were transformed to logarithms to achieve homogeneous variances. Using Method 3 of Lin and Butler (1990) for interpreting two-way classification data, approximate groupings of the cultivars were obtained. The cultivars within a group had similar mean levels and displayed no CL interaction.

Locations were grouped using Method 4, for which clustering was based only on the CL interaction. The results were examined for the collective test x production year combinations to understand the extent and nature of the CL interactions.

RESULTS AND DISCUSSION

Significant cultivar and CL interactions for C1 and C12 were evident ($P < 0.05$) in about half of the test x production year environments (Table 1). For the 1990 test, the effect of cultivar and the CL interactions were significant for C1 in production year one and three. The mean yields and response over locations in the production years were not the same (they belonged to different clusters). In the 1991 test, although the CL interaction was not significant for C1 the cultivars clustered differently in different production years. This may have been due to genotype x year interactions which can be confounded by the effect of age of the stand in a perennial crop like alfalfa (Hill and Baylor, 1983). The results for the total yield of the first two cuts (C12) were similar to C1. The check cultivar Beaver appears to be the most consistent performer in the region in both the tests. For yield change D12, the CL interaction was only significant in production year three for both 1990 and 1991 tests. Although D12 was relatively consistent over the locations for individual cultivars, there were significant differences among the cultivars. The nonsignificant CL interaction effects (Table 1) for C1 and C12 indicated that cultivars frequently responded similarly at the locations in particular tests and production years. When there was a significant CL interaction, cluster analysis indicated groups of locations where cultivars responded similarly. The cultivars responded similarly for C1 and C12 at Brooks, Bow Island (Irrigated), Bow Island (Dryland) and Provost in both tests in all three production years (Table 2). The remaining locations had inconsistent cultivar responses in some test x production year combinations and therefore cannot be excluded without losing reliability. Since, these four locations appear to provide the same information with regard to performance of alfalfa cultivars, it may be more efficient to use only one of the four locations. The testing resources saved through rationalization of these sites will be better utilized by including locations that show unique cultivar responses.

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Table 1
Clustering of cultivar for yield (kg/ha) of first cut (C1), total yield of the first and second cuts (C12), and yield change between the first and second cuts (D12), for each reduction

Test	Cultivars	Yield of first cut (C1)			Total yield of cuts 1 & 2 (C12)			% yield change (D12)			
		PY 1	PY 2	PY3	PY1	PY 2	PY3	PY1	PY2	PY3	
		mean cl	mean cl	mean cl	mean cl	mean cl	mean cl	mean cl	mean cl	mean cl	
1990	ANCHOR	6153 b	5057 a	5889 a	10418 b	9183 a	9948 b	52.1 b	33.6 b	26.1 a	
	BEAVER	6769 a	5142 a	5982 a	10980 a	8962 a	10016 a	58.6 a	39.2 a	26.9 a	
	526	6562 b	5230 a	5714 a	10960 b	9232 a	9886 b	55.3 b	32.8 c	23.9 b	
	5432	6043 b	5008 a	5382 c	10225 b	9059 a	9259 b	52.2 b	29.7 c	25.3 b	
	HORIZON	6244 b	5002 a	5313 c	10600 b	8861 a	9234 b	50.9 b	29.0 c	24.5 b	
	IMACT	6493 b	5207 a	5748 a	10806 b	8995 a	9776 b	55.0 b	35.9 b	27.4 a	
	OAC MINTO	6291 b	5509 a	5817 a	10763 b	9382 a	10068 b	50.5 b	38.8 a	23.6 b	
	PEACE	6242 b	4743 a	5496 b	10298 b	8537 a	9307 b	56.3 a	35.9 b	24.0 a	
	PROFIT	6278 b	5085 a	5384 b	10499 b	8846 a	6230 c	52.8 b	36.8 b	26.4 a	
	SURE	6186 c	5298 a	5263 c	10670 c	9234 a	9458 b	47.9 c	29.8 c	17.3 c	
	SURPASS	6161 b	5164 a	5541 a	10449 b	9264 a	9493 b	50.6 b	28.6 c	25.8 b	
	EFFECT										
		Cultivar	<0.001	>0.05	<0.01	>0.05	>0.05	<0.01	<0.001	<0.001	>0.05
1991	ANCHOR	5653 a	5503 b	4835 a	10278 a	9747 b	10175 a	30.1 b	17.7 c	14.8 c	
	BEAVER	6059 a	5891 a	4970 a	10612 a	9989 b	9629 a	39.8 a	26.2 a	21.8 b	
	5311	5736 b	5391 b	4795 a	10397 a	9649 b	9635 a	31.5 b	17.5 c	24.4 b	
	5364	6029 a	5485 b	4822 a	10755 a	9918 b	9696 a	34.8 b	14.1 c	18.7 c	
	AC CARIBOU	5734 a	5980 a	5081 a	10144 a	10128 a	10070 a	35.8 b	28.6 a	22.3 c	
	CENTURION	5513 b	5321 b	4867 a	10161 a	9547 b	9816 a	30.1 b	15.6 c	28.1 b	
	GARST 636	5484 b	5654 b	4552 a	9967 a	9781 b	9504 a	31.1 b	22.5 b	17.5 c	
	LEGEND	5456 c	5015 c	4618 a	10051 a	9046 c	9487 a	28.4 c	15.3 c	21.2 b	
	STAMEDER	5676 a	5543 b	4839 a	10306 a	9719 b	9720 a	33.7 b	20.0 b	14.9 c	
	THOR	5883 a	5773 b	5031 a	10702 a	10210 b	10011 a	34.0 b	15.5 c	24.7 b	
	EFFECTS										
		Cultivar	<0.01	<0.001	>0.05	>0.05	<0.001	>0.05	<0.01	<0.001	>0.05
		Cultivar x Location	>0.05	>0.05	>0.05	>0.05	<0.01	>0.05	>0.05	>0.05	<0.001

Table 2 Clustering (cl) of locations for yield (kg/ha -1) of first cut, total yield of first and second cuts and yield change between the first and second cuts for each production year in two tests.

A. Yield of first cut

Location	Production Year 1		Production Year 2		Production Year 3	
	1990	1991	1990	1991	1990	1991
	mean cl	mean cl	mean cl	mean cl	mean cl	mean cl
Brooks	10941 a	8138 a	6485 a	6797 a	6386 a	4902 a
Bow Island (irr)	9448 a	9016 a	8182 a	8373 a	7875 a	6213 a
Bow Island (dry)	9825 a	7329 a	9240 a	10083 a	9938 a	7559 a
Provost (dry)	7348 a	6087 a	5610 a	5216 a	7621 a	4593 a
Standard (dry)	4011 b	6304 a	4686 a	4597 a	3128 a	3069 a
Vegerville (dry)	3460 c	2180 a	2287 a	3090 a	3347 b	6758 a
Olds (dry)	-	4072 a	-	3239 a	-	3621 a
Lac La Biche (dry)	1027 a	2651 a	1515 a	3051 a	3720 a	2013 a
Westlock (dry)1	4430 a	-	3046 a	-	2734 c	-