REPEATIBILITY AND GENOTYPIC STABILITY IN ALFALFA CULTIVAR EVALUATION

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Introduction

Results from agronomic evaluation based on successive cuts are widely used in alfalfa to identify cultivar phenotypic superiority. In this context, defining the number of evaluations needed to determine perdurable differences among cultivars is probably the most important challenge. To solve the problem, the estimation of the repeatability coefficient (R) of a trait, which is a function of trait measurements repeated over time, has been proposed. Based on R, the number of necessary evaluations to predict the real value of a genotype or a cultivar can be calculated (1). Since R expresses how much of the phenotypic variation is due to genetic differences, it can be assimilated to heritability, thus providing an interesting tool for assisting selection and breeding.

Objectives

I- To estimate the repeatability coefficient for relevant agronomic traits using different statistical procedures; and
II- To estimate the number of evaluations necessary to obtain a coefficient of determination compatible to genotypic stability.

Materials and Methods

A field experiment evaluating 92 alfalfa cultivars was conducted at Embrapa Pecuária Sudeste, Sao Carlos (SP, Brazil), using a complete randomized block design with two replicates. The evaluated traits were: dry matter production (PMS); plant height at cutting (APC); disease tolerance (TD); and general phenotypic appearance (AF). A total 11 cuts were made: five in the rainy season (November to March) and six in the dry season (April to October).

Repeatability coefficient (R) for each trait were calculated according to four distinct methods: a) analysis of variance (ANOVA), in which the temporary environmental effect was removed from the error term; b) principal components calculated from the correlation matrix (CP correl); c) principal components calculated from the covariance matrix (CP cov); and d) structural analysis (AE) based on theoretical eigenvalues from the correlation matrix or average correlation. All the estimated R values, without genotypic stability, are shown in Tables 1 (dry season) and 2 (rainy season).

Tables 1 (Dry season) and 2 (Rainy season). Coefficients of repeatability (R) and genotypic determination (R^2) for dry matter production (PMS), plant height at cutting (APC), disease tolerance (TD), and general phenotypic appearance (AF) estimated by different methods.

Table 1

Methods	PMS		APC		TD		AF	
	R	R^2	R	R^2	R	R^2	R	R^2
ANOVA[1]	0.74	94.54	0.85	97.24	0.55	88.08	0.72	93.89
CP (cov)[2]	0.80	95.97	0.91	98.29	0.61	90.50	0.73	94.16
CP (correl)[3]	0.76	95.11	0.89	98.03	0.56	88.59	0.73	94.15
AE (cov)[4]	0.76	94.93	0.89	98.03	0.56	88.44	0.73	94.13

Table 2

Methods	PMS		APC		TD		AF	
	R	R^2	R	R^2	R	R^2	R	R^2
ANOVA[1]	0.56	86.50	0.68	91.47	0.25	62.77	0.18	51.52
CP (cov)[2]	0.61	88.68	0.73	93.18	0.33	71.08	0.41	77.76
CP (correl)[3]	0.61	88.69	0.69	91.68	0.27	64.44	0.36	73.90
AE (cov)[4]	0.61	88.59	0.67	91.17	0.24	61.10	0.16	49.14

[1] Analysis of variance; [2] –Principal components from covariance matrix; [3] Principal components from correlation matrix; [4] Structural analysis based on theoretical eigenvalues from the correlation matrix or average correlation.

Results and Discussion

For all traits, R values for the dry season were higher than for the rainy season. The lack of significant variation among R values from the different methods indicates that all of them were similarly efficient.

Tables 3 (dry season) and 4 (rainy season) depict the number of evaluations for every trait that are necessary to obtain a certain value for the coefficient of determination (R^2). Information provided by the 6 cuts during the dry season was enough to obtain $R^2 \geq 90\%$ for PMS, APC and AF, but < 90 % for TD (Table 3). On the contrary, the 5 cuts in the rainy season provided R^2 close to 90% only for APC.

Tables 3 (Dry season) and 4 (Rainy season) (**Parts I and II**). Number of evaluations for dry matter production (PMS), plant height at cutting (APC), disease tolerance (TD), and general phenotypic appearance (AF) necessary to attain specific R^2 values estimated by different methods.

Table 3.

Methods	PMS			APC			TD			AF		
	0.9	0.95	0.99	0.9	0.95	0.99	0.9	0.95	0.99	0.9	0.95	0.99
ANOVA[1]	3.12	6.59	34.33	1.53	3.24	16.87	7.31	15.43	80.38	3.51	7.42	38.63
CP (cov)[2]	2.27	4.79	24.93	0.94	1.98	10.32	5.67	11.97	62.39	3.35	7.07	36.81
CP (correl)[3]	2.78	5.86	30.56	1.08	2.29	11.92	6.96	14.68	76.51	3.53	7.08	36.88
AE (cov)[4]	2.88	6.08	31.70	1.09	2.29	11.95	7.06	14.90	77.61	3.37	7.11	37.07

Table 4. Part I

Methods	PMS				APC			
	0.8	0.9	0.95	0.99	0.8	0.9	0.95	0.99
ANOVA[1]	3.12	7.02	14.83	77.25	1.87	4.20	8.86	46.16
CP (cov)[2]	2.55	5.75	12.13	63.20	1.47	3.30	6.96	36.26
CP (correl)[3]	2.55	5.74	12.11	63.10	1.82	4.08	8.63	44.94
AE (cov)[4]	2.58	5.79	12.23	63.74	1.94	4.36	9.20	47.95

Table 4. Part II

Methods	TD				AF			
	0.8	0.9	0.95	0.99	0.8	0.9	0.95	0.99
ANOVA[1]	11.86	26.69	56.34	293.54	18.82	42.34	89.39	465.78
CP (cov)[2]	8.14	18.31	38.66	201.44	5.72	12.87	27.18	141.61
CP (correl)[3]	11.04	24.84	52.44	273.22	7.06	15.89	33.55	174.81
AE (cov)[4]	12.74	28.66	60.50	315.21	20.70	46.58	98.33	512.35

[1] Analysis of variance; [2] Principal components from covariance matrix; [3] Principal components from correlation matrix; [4] Structural analysis based on theoretical eigenvalues from the correlation matrix or average correlation.

In this study, the number of evaluations for PMS and APC were adequate to obtain $R^2 \geq 90$, both in the dry and rainy seasons. However, < 80% was obtained for TD and AF, indicating that more evaluations would be needed in order to reach acceptable precision levels. When cultivar genotypic stability (based on principal components from the correlation matrix as a function of cultivars) was taken into account for the dry season, PMS and APC were estimated with high precision using only cuts #3 (June), #4 (July) and #5 (August) (Table 5). In the same way, satisfactory estimations for TD and AF were obtained by using only three (#2, #3 and #4) and two (#4 and #5) cuts, respectively. Regarding the rainy season, the incorporation of genotypic stability increased 5% the precision for PMS, APC and TD utilizing only data from cuts #4 (February) and #5 (March) (Table 6). For AF, using only cuts #3 (Jan) and #4 (Feb) increased precision from 51 to 78%.

Tables 5 (Dry season) and 6 (Rainy season). Genotypic stability, estimated as coefficient of repeatability (R) and coefficient of genotypic determination (R^2), for dry matter production (PMS), plant height at cutting (APC), disease tolerance (TD), and general phenotypic appearance (AF).

Table 5

Evaluations	PMS		APC		TD		AF	
(pairs of cuts)	R (*)	R^2 (*)	R	R^2	R	R^2	R	R^2
1 – 2	0.86	92.26	0.88	93.83	0.61	76.09	0.78	87.52
2 – 3	0.86	92.25	0.88	93.66	0.74	84.91	0.70	82.47
3 – 4	0.87	93.32	0.95	97.32	0.66	79.65	0.65	78.48
4 – 5	0.91	95.42	0.95	97.35	0.62	76.41	0.88	93.51
5 – 6	0.66	79.26	0.88	93.79	0.54	69.72	0.76	86.60
1 – 3	0.84	94.00	0.88	95.80	0.65	84.63	0.71	88.19
2 – 4	0.86	94.90	0.90	96.55	0.68	86.48	0.71	87.92
3 – 5	0.89	95.87	0.94	97.98	0.61	82.59	0.73	89.00
4 – 6	0.72	88.28	0.90	96.52	0.58	80.41	0.80	92.36
1 – 4	0.83	95.03	0.89	97.07	0.63	87.10	0.71	90.92
2 – 5	0.87	96.53	0.92	97.74	0.62	86.65	0.73	91.65
3 – 6	0.75	92.25	0.91	97.54	0.59	85.05	0.73	91.60
1 – 5	0.84	96.30	0.90	97.90	0.59	87.77	0.73	93.06
2 – 6	0.77	94.42	0.90	97.76	0.59	87.88	0.73	93.11
1 – 6	0.76	95.11	0.89	98.03	0.56	88.59	0.73	94.15

Table 6

Evaluations	PMS		APC		TD		AF	
(pairs of cuts)	R (*)	R^2 (*)	R	R^2	R	R^2	R	R^2
1 – 2	0.69	81.59	0.46	63.14	0.12	21.17	0.17	29.43
2 – 3	0.49	66.17	0.52	68.04	0.42	58.91	0.19	32.60
3 – 4	0.70	82.21	0.86	92.43	0.50	66.49	0.64	78.18
4 – 5	0.83	90.49	0.91	95.42	0.57	72.78	0.47	64.21
1 – 3	0.57	80.14	0.58	80.73	0.29	55.01	0.24	48.23
2 – 4	0.55	78.70	0.62	82.91	0.40	66.69	0.37	63.80
3 – 5	0.74	89.61	0.87	95.06	0.42	68.13	0.53	77.23
1 – 4	0.57	83.98	0.64	87.86	0.30	63.10	0.31	63.91
2 – 5	0.63	87.03	0.69	89.76	0.34	66.95	0.40	73.09
1 – 5	0.61	88.69	0.69	91.68	0.27	64.44	0.36	73.90

(*) Estimated by PC from the correlation matrix as a function of cultivars

Conclusions

The incorporation of genotypic stability in trial data analyses made feasible to attain adequate experimental precision (> 90% on PMS and APC; and 70-80% on TD and AF) using only half of the cuts in each evaluation season (dry and rainy).

REFERENCES
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