Available online at www.notulaebiologicae.ro
Print ISSN 2067-3205; Electronic 2067-3264
Not Sci Biol 2 (1) 2010, 84-87

Evaluation of Selection Indices for Alfalfa (*Medicago sativa* L.)

Hassan MONIRIFAR

East Azarbayjan Agriculture and Natural Resources Research Center, Tabriz, Iran; monirifar@yahoo.com

Abstract

In order to evaluate the efficiency of selection indices in alfalfa improvement, an experiment was conducted from 2000 to 2007 at East Azarbaijan Agricultural and Natural Resources Research Center, Iran. A set of 29 native ecotypes, which were collected in 2000 and 2001 from Azerbaijan (Iran), together with one improved variety were used to conduct a polycross nursery. For the purpose of random mating, a randomized complete block design was used with 12 replications arranged in this nursery. The resulting 30 half-sib families were planted individually in pots and the 30 days old seedlings were transplanted to the field in May, 2004. Each 3-row plot consisted of 45 HS plants. Several traits, such as individual plants' fresh weight and individual plants' dry weight (IPFW, IPDW), number of shoots per plant (NS) and plant height (PH) in each harvest and also, days until 10% flowering, the ratio of fresh and dry weight of leaves/plant and size of trifoliate leaves were measured for three cropping seasons. The results of analysis of variance showed large variation among polycross progenies. Six selection indices (I_i) with different number of traits at adult plant stage were evaluated. Based on the result of this investigation, if number of shoots and height of adult plant, excluding yield, are recorded, I_2 is suggested. If, in addition to fresh yield, height of adult plant is measured, I_6 is recommended. I_4 is useful when number of shoots and plant height with dry yield are included in the index. In conclusion, the importance of mature plant traits in selection indices was in the order of yield > plant height > number of shoots. The results provided more evidence that selection indices incorporating the component of dry yield are more advantageous. The most efficient selection index consisted of NS, IPDW and PH, having a relative efficiency of 280%.

Keywords: alfalfa, relative efficiency, selection

Introduction

The mathematical genetic theory, in the form of selection index, developed by Smith (1936) is the basis for simultaneous selection of several traits. A selection index most often aims at giving appropriate weight to the components maximizing gains from selection (Falconer, 1983).

Most breeders, either analytically or intuitively, practice multiple trait selection when developing cultivars. Those using the analytical approach have numerous methods at their disposal. In general, three multiple trait selection procedures are operated: (i) tandem selection, (ii) index selection, and (iii) independent culling levels (Baker, 1986).

Many multiple trait selection protocols utilize an aggregate score, or an index, as means of differentiating genotypes possessing superior trait combination. Index selection protocols utilize simultaneous selection on a series of traits as opposed to a sequential selection (Henning and Teuber, 1996). Some indices require the estimation of genetic variances, covariance, and the economic value for all traits undergoing selection. One of these is called the Smith-Hazel, or optimum index (Smith, 1936; Hazel, 1943). The optimum index is theoretically the most efficient of the three multiple trait selection methods with independent culling levels intermediate and tandem selection the least efficient (Hazel and Lush, 1942; Young, 1961).

Elgin *et al*. (1970) compared the tandem selection, modified independent culling levels, estimated index (Smith, 1936) and the base index (Williams, 1962) methods. They found the base index method to be the most effective when selecting for resistance to four alfalfa (*Medicago sativa* L.) foliar diseases and improved recovery after cutting. Although in many plant breeding practices, the use of selection indices has been more effective than direct selection (Smith, 1936; Paul *et al.,* 1976; Yousaf, 1977; Gaur *et al*., 1978; Singh and Dala, 1979; Openshaw and Hadley, 1984; Ravel *et al*., 1995; Ram *et al*., 1997; Rabiei *et al*., 2004), there are only few reports of index selection in alfalfa. Singh (1978) calculated several selection indices for seed yield in alfalfa, and concluded that none would be more efficient than direct selection for seed yield. The results were based on evaluation of progeny of a diallel cross among seven selected lines from a cross between two alfalfa cultivars.

Efficiency of a selection index depends not only on the kind of crop plant and considered traits, but also on the base population used for the estimation of coefficients in selection indices. The objective of the present study was to

Received 10 September 2009; accepted 10 February 2010

construct suitable selection indices for Azerbaijan alfalfa germplasm.

Materials and methods

The experiment was carried out at East Azerbaijan Agriculture and Natural Resources Research Center (AZARAN), (38°, 15'N, 46°, 45'E), Tabriz, Iran on a loamy- clay soil, pH 6.8. Twenty-nine native ecotypes of alfalfa from northwest of Iran and one improved cultivar were used to establish the base population in 2002 (Tab. 1). Ecotypes 1 to 29 were collected in 2000 and 2001 from farmers that had been multiplying their seed for at least 30 years. In order to random mate the ecotypes in the polycross nursery; randomized complete block with 12 replications were arranged using honeybees and complete isolation. Each plot consisted of a 3^{-m} long row. Polycross seeds were harvested from maternal rows. The resulting half-sib (HS) progenies were planted in a green house on 15 March 2004, in individual pots containing a mixture of sandy-loam soil, peat and sand with 2:1:1 ratio. From every HS family, 135 plants (45 HS plants for each plot) were transplanted into the field in 2004.

Characters such as plant height (PH), number of shoots (NS), individual plant fresh weight (IPFW) and dry weight (IPDW), the ratio of fresh and dry weight of leaves/plant were measured on 10 randomly selected plants. Days until 10% flowering and size of trifoliate leaves were also measured in the experimental plots. Additive genetic variances and covariances were estimated (Nguyen and Sleper, 1983) and utilized in the construction of genotypic and phenotypic variance-covariance matrices. For the aim of constructing indices, index coefficients were calculated as $b = P^{-1} Ga$ in which b is the vector of index coefficients, P^{-1} the inverse of phenotypic variance-covariance matrix, 'G' the genotypic variance-covariance matrix and 'a' the vector of economic weights.

The relative efficiency of selection based on an index compared to direct selection for the primary trait itself was estimated as:

$$\frac{R_I}{R_A} = \frac{[b'G]\sigma_{P(A)}}{[b'Pb]^{0.5}\sigma^2_{G(A)}}$$

In this formula $\sigma_{P(A)}$ is the phenotypic standard deviation, and $\sigma^2_{G(A)}$ is the genotypic variance for trait A (Baker, 1986).

Results and discussion

Using multiple regression analysis for fresh and dry yield of adult plants, only plant height (PH) and number of shoots (NS) remained in the models and selection indices were constructed. Other traits such as days to 10% flowering were excluded from the models. The correlation coefficients of PH and NS with fresh and dry yield were used as the economic weights for $I_1 = 0.91NS + 0.11PH$ and $I_2 = 0.83 NS + 0.09PH$, respectively. Results of selection with I_1 and I_2 are given in Tab. 2. The gains from I_1 or I_2 were almost same. Neither I_1 nor I_2 had significant effects on forage quality shown as weight of fresh and dry leaves/plant (Tab. 2).

Furthermore, four indices were calculated for different character combinations and fresh and dry yield were taken as dependent variables. All indices had higher efficiency than selection based on yield alone (Tab. 3).

Index 6 which included number of shoots (NS), individual plant dry yield (IPDW) and plant height (PH) showed the highest relative efficiency. I_5 had higher relative efficiency compared to I_6. This shows that when dry yield, rather than fresh weight, was included in the index, the relative efficiency is increased. Excluding number of shoots (NS) from I_5 and I_6 didn't considerably decrease the relative efficiency.

In this research the correlation coefficients of the traits with yield were used as economic weights. Other research-

Tab. 1. Origin of the ecotypes of alfalfa ecotypes studied to construct selection indices

Ecotype	Origin	Name
1.	Jolfa	'Marzad'
2.	Kaleibar	'Gran-chay'
3.	Ahar	'Leghan'
4.	Marand	'Zonorag'
5.	Marand	'Sivan'
6.	Oskou	'Khor-khor'
7.	Tabriz	'Sattelou'
8.	Malekan	'Smail-abad'
9.	Maraghe	'Koul-tapa'
10.	Ajab-shir	'Almalou'
11.	Maraghe	'Kordadeh'
12.	Tabriz	'Sefidkhan'
13.	Bostan-abad	'Gara-baba'
14.	Hasht-roud	'Zolbin'
15.	Hasht-roud	'Zavie'
16.	Hasht-roud	'Seviar'
17.	Hasht-roud	'Akram-abad'
18.	Miane	'Balsin'
19.	Bostan-abad	'Bash-kand'
20.	Bostan-abad	'Ein-aldin'
21.	Sarab	'Baftan'
22.	Sarab	'Ilan-jough'
23.	Heris	'Khaje'
24.	Heris	'Goravan'
25.	Varzegan	'Dizaj-safarali'
26.	Ahar	'Kordlou'
27.	Varzegan	'Khosrovanagh'
28.	Varzegan	'Chalnab'
29.	Varzegan	'Almard'
30.	Tabriz	'Gara-yonjeh'

Tab. 2. Coefficient of correlation of traits in adult plant stage with I_1 and I_2 and percentage increase of the traits when selecting the top 10% of plant for I_1 and I_2 as compared to the population mean.

Trait	Gain (%)		Correlation coefficient with	
	I_1	I_2	I_1	I_2
IPFW	41.5**	42.1**	0.770**	0.763**
IPDW	34.9**	35.2**	0.643**	0.646**
NS	44.7**	45.7**	0.917**	0.923**
PH	15.9**	15.2**	0.629**	0.611**
Weight of fresh leaves/plant	-	-	-0.070	-0.063
Weight of dry leaves/plant	-	-	-0.115	0.110

IPFW = Individual Plant Fresh Weight; IPDW= Individual Plant Dry Weight; NS=Number of Shoots; PH=Plant Height
**Significant at P≤0.01

ers have also used correlation coefficients as the reliable economic weights for constructing general and specific selection indices in sugarcane (Ram *et al*., 1997). At the adult plant stage, only plant height (PH) and number of shoots (NS) were remained in the multiple regression models with fresh and dry yield of plants as dependent variables and selection indices were constructed using correlation coefficients of PH and NS with fresh and dry yield as the economic weights. However, none of I_1 and I_2 showed significant effects on forage quality. Other indices were calculated for different character combinations with fresh and dry yield as dependent variables, all showed higher efficiencies than selection based on yield alone (Tab. 3). Especially, the index I_4 comprising the number of shoots (NS), dry yield (IPDW) and plant height (PH) as components showed the highest relative efficiency (R.E.=221%). I_5 had higher relative efficiency than I_6. This indicates that dry yield increases the relative efficiency more effectively than fresh weight, when include in the index. When the number of shoots (NS) was excluded from I_5 and I_6, the relative efficiency wasn't considerably decreased. It could be concluded that yield dominates other components when included in the index. Pillai and Ethirajan (1993) while constructing selection indices for sugarcane reported that yield dominates other traits when it was included in the model and in this case the index had a high relative

Tab. 3. Selection indices, correlation coefficients with yield and relative efficiency (RE) in adult plant stage

Index	Correlation Coefficient with		RE (%)
	IPFW	IPDW	
I_3= 0.390 NS+ 1.4 IPFW+ 0.79 PH	0.979**	0.876**	221
I_4= 0.301 NS+ 1.64 IPDW+ 0.91 PH	0.846**	0.964**	280
I_5= 2.25 IPDW+ 0.84 PH	0.856**	0.481**	273
I_6= 2.15 IPFW+ 0.61 PH	0.971**	0.823**	219

**Significant at P≤0.01

efficiency. Xie *et al*. (1997) evaluated 78 red clover half-sib families for seedling traits, canopy height and individual plant dry weight recorded at initial growth and regrowth stages. They examined alternative selection schemes with different number of traits at different stages and noticed that relationships between most seedling and mature plant traits were weak.

The result of this investigation indicated that if number of shoots and height of adult plant, excluding yield, is recorded, I_2 is suggested. If, in addition to fresh yield, height of adult plant is measured, I_6 is recommended. I_4 is suggested when number of shoots, plant height and dry yield are included in the index. The importance of mature plant traits in selection indices was in the order of yield> plant height>number of shoots. This provided more evidence that selection indices incorporating dry yield as a component are more advantageous.

Acknowledgements

The research was carried out in the framework of the project" 101-12-81149" funded by Iranian Ministry of Jahade Agriculture, AREEO (Agricultural Research, Education and Extension Organization), SPII (Seed and Plant Improvement Institute).

References

Baker, R. J. (1986). Selection indices in plant breeding. CRC Press, Inc., Boca Raton, Florida.

Elgin, J. H., R. R. Hill and K. E. Zeiders (1970). Comparison of four methods of multiple trait selection for five traits in alfalfa. Crop Sci. 10:190-193.

Falconer, D. S. (1983). Introduction to quantitative genetic. 2_{nd} ed. Longman Group Limited, New York.

Gaur, P. C., H. Kihore and P. K. Gupta (1978). Studies on character association in potatoes. J. Agric. Sci. 90:215-219.

Hazel, L. N. (1943). The genetic basis for constructing selection indices. Genetics. 28:476-490.

Hazel, L. N. and J. L. Lush (1942). The efficiency of three methods of selection. J. Heredity. 33:393-399.

Henning, A. A. and R. Teuber (1996). Modified convergent improvement: A breeding method for multiple trait selection. Crop Sci. 36:1-8.

Nguyen, H. T. and D. A. Sleper (1983). Theory and application of half-sib mating in forage breeding. Theor. Appl. Genet. 64:187-196.

Openshaw, S. J. and H. H. Hadley (1984). Selection index to modify protein concentrations of soybean seeds. Crop Sci. 24:1-4.

Paul, N. K., O. I. Jarred and A. M. Eons (1976). Genotypic and phenotypic variability and correlation studies in Brassica Juncea L. Z. Pflanzenzueche. 77:145-151.

Pillai, S. V. and A. S. Ethirajan (1993). Selection indices for sugarcane improvement at three stages of selection.

Euphytica. 71:155-159.

Rabiei, B., M. Valizadeh, B. Gharayazie and M. Moghaddam (2004). Evaluation of selection indices for improving rice grain shape. Field Crops Research. 89:359-367.

Ram, B., B. S. Chaudharyb and D. K. Yadav (1997). General and specific selection indices for single stool stage of selection in sugarcane. Euphytica. 95:39-44.

Ravel, C., G. Charmed, F. Bal Fourier, B. Debote, J. C. Vezine and C. Astir (1995). Comparison of predicted and observed response to selection in two breeding populations of perennial ryegrass. Plant Breeding. 114:262-264.

Singh, S. M. (1978). Genetic basis of selecting in alfalfa. Theor. Appl. Genet. 51:297-301.

Singh, C. B. and M. A. Dala (1979). Index selection in soybean. Indian J. Genet. Plant Breeding. 39:234-237.

Smith, H. F. (1936). A discriminate for selection. Ann Eugene. 1:240-250.

Williams, J. S. (1962). Some statistical properties of a genetics selection index. Biometrica. 49:325-337.

Xie, C., S. Xu and J. A. Mosjidis (1997). Multistage selection indices for maximum gain and economic efficiency in red clover. Euphytica. 48:75-82.

Young, S. S. Y. (1961). A further examination of the relative efficiency of three methods of selection for genetic gains under less restricted conditions. Genet Res. 2:106-121.

Yousaf, M. (1977). The use of selection indices in maize (*Zea mays* L.). Genetic Diversity in Plant. Plenum Press, New York.