Egypt. J. Plant Breed 9(2): 1-20 (2005)

SEASONAL VARIATION IN FORAGE YIELD AND RELATED TRAITS AMONG NONDORMANT ALFALFA (*Medicago sativa* L.) CLONES

M.S. Radwan[1], A.M.Soliman[1] A.M.Rammah[2], and Hoda.E.M.Ibrahim[2]

1- Agronomy Dept. Fac. Agric., Cairo Univ., Giza
2- Forage Res. Section, FCRI, ARC, Giza

ABSTRACT

Forage yield and related traits of 169 diverse alfalfa clones and four check varieties were studied for two years in a replicated spaced clonal row trial (2001/02). Clones were studied for dry forage yield and per plant number of shoots, height, yield per shoot (YPS), shoot specific weight (SSW) and % leaves in each season, across seasons and years.

Clones differed widely in forage dry yield and related traits in each season and over seasons, and the distribution of annual forage yield over seasons. Range of variation among clones in number of shoots plant^{-1} and leafiness was greater in winter and spring than summer and fall, whereas YPS and SSW were more variable in summer than other seasons. Clones were significantly superior to checks in average performance per season and over seasons for forage yield and other traits. Growth season had the greatest effect on variability in yield and other traits. Genetic coefficient of variation (GCV, %) was highest for yield and seasonal fractions.

Estimates of broad-sense heritability (H^2) based on performance in one season were generally high for all traits and showed little variation among seasons. H^2 estimates were substantially reduced when performance in one season was averaged over years and were widely different among seasons and traits. They were higher in winter and spring than summer and fall for all traits except forage yield.

Forage yield plant^{-1} was positively associated with yield-contributing traits except % leaves. Plant height, YPS and SSW were negatively associated with % leaves. Seasonal yield fractions for clones were generally, not correlated with annual yield, but were negatively correlated between seasons suggesting that an increase in yield in one season would reduce yield in other seasons. Seasonal and annual yields of clones were strongly correlated to dry yield of one harvest in each season. Annual dry yield in first year was positively correlated with yield of the mid-winter and mid-summer harvests, and second year annual yield was positively correlated with yield of the mid-fall harvest of first year. But other traits of these same harvests showed variable associations with annual yield and its seasonal fractions. Results of simulated selection (10% intensity) suggest that a scheme of phenotypic selection by independent culling based on

dry yield of first year mid-winter harvest; the yield and number of shoots of the mid-summer harvest; yield, number of shoots and YPS of the fall harvest identified clones of higher annual yield in the first and second year with slightly more balanced production over seasons, than check varieties.

Key words: ***Alfalfa, Forage yield, Seasonal yield, Heritability, Correlation.***

INTRODUCTION

Alfalfa, a perennial forage legume of high quality, has been a traditional crop in the desert oases and southern valleys of Egypt because of its adaptation to high summer temperature and high levels of salinity. Recently, alfalfa has been included as a pioneer crop in desert reclamation projects for building soil fertility and improving the structure of virgin soils and as nutritious feed in dairy farms.

Due to relatively mild winter and long summers, nondormant and very-nondormant alfalfa types are adapted to Egyptian deserts, and several ecotypes have evolved through years of continuous alfalfa culture (Marble 1989).

A study of genetic variability between and within populations is a preliminary step in alfalfa breeding programs targeted to improve crop performance by phenotypic selection (Elgin *et al* 1970). Variability in yield and morphological traits occur between North African and Arabian alfalfa germplasm sources (Smith *et al* 1991) and between improved cultivars (Mousa *et al* 1996, Abdelhalim *et al* 1998 and Oushy *et al* 1999), but little information in available on variability within nondormant alfalfa populations (Radwan *et al* 2003).

Forage yield and yield-related traits of nondormant alfalfa varieties are influenced by seasonal growing conditions. Growth rate and forage production usually is lower in winter than fall, and is highest in spring and summer. (Smith *et al* 1991, Mousa *et al*1996, Abdelhalim *et al* 1998 and Oushy *et al* 1999). Nonhardy alfalfa accessions also differ in seasonal yield as a fraction of total annual yield (Smith *et al* 1991).

Alfalfa forage yield is generally positively associated with yield-related traits, except leaf/stem ratio (LSR). This is true for plant height, shoots plant^{-1}, yield shoot^{-1}(YPS), and shoot specific weight (SSW) (Frakes *et al* 1961, Liang and Riedl 1964, Volenec, 1985 and Volenec *et al* 1987). Volenec *et al* (1987) indicated that alfalfa yield is affected by number of shoots plant^{-1} and YPS, but YPS is always an important component of forage yield plant^{-1} especially at high plant density. The generally negative association between forage yield and LSR differs in strength between harvests (Julier *et al* 2000) and is affected by stage of maturity (Sheaffer *et al* 2000).

Reported estimates of heritability for alfalfa traits differed according to reference population and method of estimation. Dudley *et al* (1969) reported broad-sense heritability value of 0.73 among alfalfa clones for total forage yield, 0.77 for spring growth and 0.72 for fall growth.

The objectives of this study were to assess the extent of variability and estimate heritability and the degree of association between forage yield and yield-related traits of nondormant alfalfa clones.

MATERIALS AND METHODS

The study was carried out at the Research and Agricultural Experiments Station, Faculty of Agriculture, Cairo University, Giza, from 1999 through 2002, on a population of 221 plants derived from Egyptian and introduced germplasm sources from U.S.A and Australia. The plants were cloned under mist during the fall of 1999 in a plastic greenhouse. Fifty-two plants were recalcitrant to clone and study was limited to the 169 successfully propagated clones.

Clonal propagules and seedling plants of similar age from four check cultivars (Midia and Marina from France; Ismaelia-94 and Siwa-1, local cultivars) were transplanted in the field in Sept 2000 in a RCB design with two replications in clay-loam, typic torrifluvents soil. Plots were single ridges 3 m long, 50 cm wide with plants spaced 35cm apart. At planting, P_2O_5, K_2SO_4 and $(NH_3)_2SO_4$ were applied at the rate of 167, 356 and 74kg ha^{-1}, respectively. The trial was first harvested on 30 Jan. 2001(147 d from transplanting) and 10 harvests yr^{-1} were taken by hand-clipping to 7-cm stubble. Harvests of each year were assigned to four production seasons; two winter (15 Jan.– 20 Mar.) harvests, three spring (16 Apr.– 25 June) harvests, three summer (17 July- 28 Sept.) harvests, and two fall (18 Oct – 7 Nov.) harvests. Interval between harvest were about 31, 33 and 30 in spring, summer and fall, respectively, and an average of 55 d in winter. Three supplemental fertilizer doses were applied after the fourth, tenth and sixteenth harvests each at the rate of 111,178 and 122 kg ha^{-1} of the N P K fertilizers.

Data were recorded at each harvest on five guarded plants $plot^{-1}$ for: plant height, number of shoots $plant^{-1}$, fresh forage yield (%dry matter in fresh samples was determined by drying fresh forage at 70^{o} c to a constant weight), and % leafiness (leaf weight x 100/ (leaf + stem) dry weight, estimated from a random sub- sample of stems. Estimated dry forage yield, was used to compute yield shoot^{-1}(plant dry weight/number of shoots), shoot specific weight (yield shoot^{-1}/plant height) and seasonal yield fractions (the percentage contribution of forage production in each season to annual production = season total yield x 100 / annual yield.

Statistical analysis

Analysis of variance for traits other than forage yield was made on plot means over harvests in each season; for yield, totals of plot means summed over harvests in each season were analyzed. Lack of normality required log transformation for data of shoots plant^{-1}, yield shoot^{-1}and shoot specific weight, and $(x-4)^{1/2}$ transformation for yield data.

Analysis of variance for each trait and covariance analysis for pairs of traits were carried out on data of each season, each season over two years, over seasons in each year and over seasons and years, in the forms given in Table 1, using the computer program PLABSTAT (Statistical Analysis of Plant Breeding Experiments, Utz, 2004). In the combined analyses, replications were considered as fixed, and clone, seasons and years random effects.

Variation among clones was assessed by comparing trait means, ranges and genotypic coefficients of variation (GCV), calculated as $(\delta^2_c)^{1/2}$ x 100 / $\bar{x}$, where $\bar{x}$ is the general mean of clones. Trait inter-relationships were assessed by the phenotypic (r_p) and genotypic (r_g) correlation coefficients, respectively estimated from the phenotypic (δ_{pp}) and genotypic (δ_{gg}) covariances of two traits and their respective phenotypic (δ^2_p) and genotypic (δ^2_g) variances.

Broad-sense heritability on plot basis was computed as the ratio of total genotypic variance (δ^2_c) to total phenotypic variance (δ^2_p) among clones. The phenotypic variance of plot means comprised $\delta^2_c + \delta^2_e$ for data of one season, $\delta^2_c + \delta^2_{rc} + \delta^2_{cy} + \delta^2_e$ one season in two years, $\delta^2_c + \delta^2_{rc} + \delta^2_{cs} + \delta^2_e$ seasons in one year, and $\delta^2_c + \delta^2_{cy} + \delta^2_{rcy} + \delta^2_{cs} + \delta^2_{csy} + \delta^2_e$ for plot means combined over seasons and years. Components of variance were obtained by equating the linear functions of mean squares from Table 1 with their expectations and solving for the proper component.

Seasonal means over clones were separated by the Duncan's multiple-range test at the 5% probability level, and differences between general means of checks and clones were tested by the appropriate LSD test (Steel and Torrie, 1980).

Table 1. Analysis of variance and expectations of mean squares for single and combined analyses.

Source of variance	d.f	Expectation of mean square
One season		
Replications (r)	1	
Clones ((c)	168	$\delta^2_e + r\,\delta^2_c$
Replications x Clones	168	δ^2_e
One season over years/ Seasons in one year .#		
Replications (r)	1	
Clones ((c)	168	$\delta^2_e + r\delta^2_{cy} + y\,\delta^2_{rc}\,(r/r\text{-}1) + ry\,\delta^2_c$
Replications x Clones	168	$\delta^2_e + y\,\delta^2_{rc}\,((r/r\text{-}1)$
Years (y)	1	$\delta^2_e + r\,\delta^2_{cy} + rc\,\delta^2 y$
Years x Clones	168	$\delta^2_e + r\,\delta^2_{cy}$
Years x Replications / Clones	168	δ^2_e
Over seasons and years		
Replications	1	
Clones (C)	168	$\delta^2_e + r\,\delta^2_{csy} + ry\,\delta^2_{cs} + s\,\delta^2_{rcy} + rs\,\delta^2_{cy} + rsy\,\delta^2_c$
Error (a)	168	$\delta^2_e + s\,\delta^2 rcy + sy\,\delta^2_{rc}\,(r/r\text{-}1))$
Years (Y)	1	$\delta^2_e + r\,\delta^2_{csy} + rc\,\delta^2_{sy} + s\,\delta^2_{rc} + rs\,\delta^2_{cy} + rcs\,\delta^2_y$
C x Y	168	$\delta^2_e + r\,\delta^2_{csy} + s\delta^2_{rcy} + rs\,\delta^2_{cy}$
Error (b)	336	$\delta^2_e + s\,\delta^2 rcy$
Seasons (S)	3	$\delta^2_e + r\,\delta^2_{csy} + ry\,\delta^2_{cs} + rc\,\delta^2_{sy} + rcy\,\delta^2_s$
S x C	504	$\delta^2_e + r\,\delta^2_{csy} + ry\,\delta^2_{cs}$
S x Y	3	$\delta^2_e + r\delta^2_{csy} + rc\delta^2_{sy}$
S x C x Y	504	$\delta^2_e + r\,\delta^2_{csy}$
Error(e)	1011	δ^2_e

r, c, s and y denote replications, clones, seasons and years, respectively; δ^2_c, δ^2_{cs}, δ^2_{sy}, δ^2_{cy}, δ^2_{csy} and δ^2_e denote component of variance for clones, clones x seasons, seasons x years, clones x years, clones x seasons x years and error, respectively. Corresponding estimates of covariances were obtained from covariance analyses for pairs of traits.

These two analyses are similar; but in seasons in one year; seasons, clones x seasons, δ^2_s and δ^2_{cs} replace years, clones x years, δ^2_y and δ^2_{cy}, respectively.

Simple correlation coefficients were computed between forage yield of each harvest with total yield of the season to which the harvest belongs and to annual yield to determine the harvest most- correlated to yield in each season and annual yield performance. Phenotypic and genotypic correlations were also computed between annual forage yield and its seasonal fractions in first and second year, and between forage yield and related traits of the mid-winter and mid-summer, and mid-fall harvests in the first year with annual yield performance in first and second year.

RESULTS AND DISCUSSION

Variation among clones

The 169 clones differed widely in dry forage yield and related traits in each season and across seasons (Table 2). Genetic variability, measured by GCV over seasons and years, was expressed more in winter and spring than fall for all traits except forage yield. The lowest expression of genetic variation was observed during summer for all traits except % leafiness (Table 2). Clonal variability in seasonal growth and forage production are likely to result from differential response of clones to natural seasonal changes in temperature, photoperiod and light intensity (Cowett and Sprague 1962). Growth of some clones was decreased less by the decrease in temperature, photoperiod and light intensity in fall and winter, whereas other clones were more responsive to the gradual increase in the level of these factors in spring and summer.

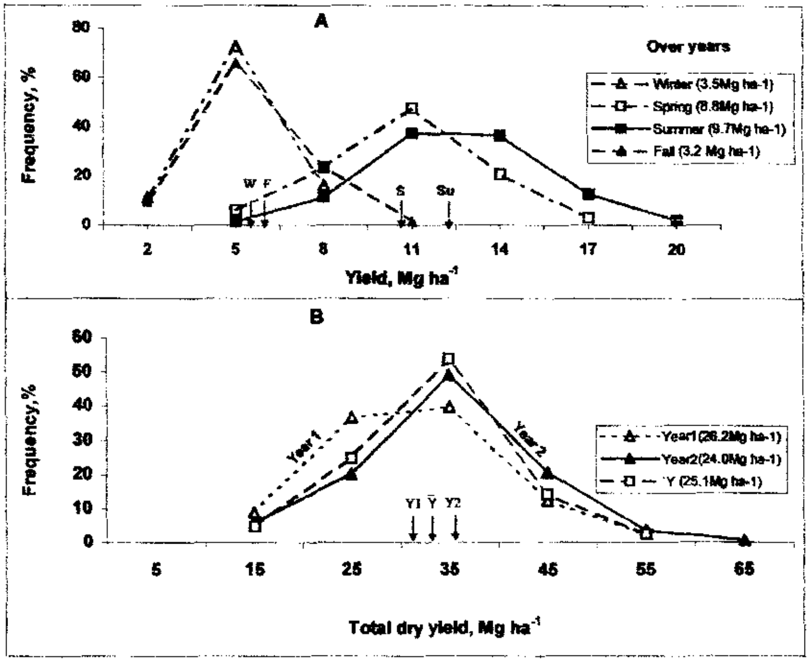
Seasonal differences among clones in the expression of variability is graphically shown for forage yield, plant height and seasonal yield fractions (Figs 1 and 2). It is clear from Table (2) and Fig (1and 2) that clones exhibited wider range of variation in forage yield in spring and summer than winter and fall. In contrast, clones showed similar variation in plant height in all seasons suggesting that seasonal yield variation is less affected by plant height. The range of variation among clones in number of shoots plant-1 and leafiness was greater in winter and spring than summer and fall, whereas YPS and SSW were more variable in summer than other seasons. These observations suggest that seasonal yield variation among clones is more related to the number of shoots and yield shoot-1 than plant height.

Table 2. Mean, range and genotypic coefficient of variation (G.C.V.) over two Years of dry forage yield and related traits of 169 alfalfa clones compared to four check cultivars.

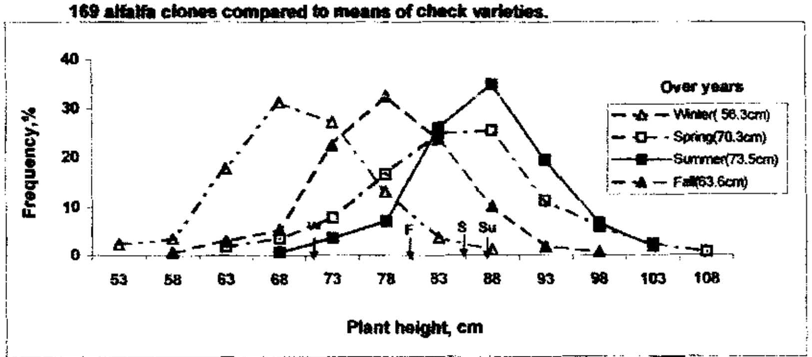
	Winter	Spring	Summer	Fall	Annual
			Yield, Mg ha^{-1}		
Mean	5.04d[@]	10.61b	12.30a	5.41c	33.36
Range	2.3-9.5	4.2-17.6	5.9-20.8	2.1-10.2	15.8-56.3
G.C.V.%	12.03	11.05	9.83	13.55	11.28
Check mean	3.45*	8.79*	9.68*	3.17*	25.09*
			Plant height, cm		
Mean	69.3c	84.0a	86.7a	77.9b	79.5
Range	51.0-89.0	63.0-107.0	70.0-102.0	60.0-96.0	63.0-98.0
G.C.V.%	8.27	8.56	5.62	6.89	7.34
Check mean	56.0*	69.6*	73.1*	63.2*	65.6*
			Shoots plant^{-1}		
Mean	50.8a	46.2c	42.1d	49.0b	47.0
Range	27.0-94.0	27.0-77.0	26.0-66.0	28.0-76.0	28.0-75.0
G.C.V.%	5.05	4.45	3.78	3.79	4.27
Check mean	44.7*	41.6*	39.2*	41.9*	41.9*
			Yield shoot^{-1},g.		
Mean	0.89d	1.37b	1.73a	1.00c	1.25
Range	0.41-1.60	0.67-2.43	0.95-2.93	0.44-1.90	0.71-
G.C.V.%	2.03				
Check mean	2.44	2.44	1.52	2.08	2.12
	0.69*	1.25*	1.47*	0.68*	1.2*
Mean			Shoot specific weight, mg		
Range	13.0c	16.5b	20.0a	12.9d	15.6
G.C.V.%	7.1-24.8	8.4-29.6	12.5-36.0	6.8-27.6	9.8-
Check mean	26.1				
	5.67	5.68	2.70	3.17	4.3
Mean	12.6	18.1*	20.2	10.8	15.4
Range			Leafiness, %		
G.C.V.%	48.2a	43.3b	42.6b	48.2a	45.6
Check mean	38.4-58.0	35.9-55.6	34.4-50.5	39.1-55.4	39.3-
	53.9				
Mean	6.25	6.10	3.79	2.80	4.73
Range	50.4*	43.4	43.7	50.5*	47.0*
G.C.V.%			Seasonal fractions, %		
Check mean	15.1d	31.8b	36.9a	16.2c	
	10.0-25.0	27.0-37.0	31.0-44.0	11.0-24.0	
	7.52	2.26	0.58	3.88	
	13.8	35.0*	38.7*	12.5*	

@ Means in row followed by same letter are not significantly different at the 0.05 probability level according to Duncan's MRT.

* Indicate significant difference between general means of clones and checks at 0.05 probability.



Fig(1): Frequency distribution of 2-yr average seasonal (A) and annual (B) dry forage yield of 169 alfalfa clones compared to means of check varieties.



Fig(2) : Frequency distribution of 2-yr average seasonal plant height of 169 alfalfa clones compared to means of check varieties.

↓ Average of clones.

( ) Average of checks.

Clones were significantly superior to checks in average performance per season and over seasons for forage yield, plant height, number of shoots $plant^{-1}$, YPS and the fall fraction of annual yield (Table 2).

Seasonal variation in forage production

Over all clones, forage production was almost twice as much in spring and summer as in winter and fall. On average, forage production accounted for 31.8 and 36.9% of annual yield during spring and summer and 15.1 and 16.2% in winter and fall, respectively. However, the clones were widely variable in their seasonal contribution to annual yield (seasonal fractions) in each production year and over years (Table 2, Fig.3). Non-dormant North African and Arabian alfalfa germplasms were also reported to show wide variation of seasonal fractions (Smith *et al*, 1991)

The seasonal fraction of annual yield of 87, 73, 78 and 71% of clones in winter, fall, spring and summer, respectively, were around the seasonal average. Only 13% of clones in winter and 18% in fall showed above average growth contributing 23 to 26% of annual yield, and only 9% of clones in spring and 2% in summer contributed slightly higher (32, 35%, respectively) than average to annual yield.

Heritability

Estimates of components of variance from the combined ANOVA over seasons and years (Table 3) indicated that for most traits the component of variance among seasons (σ^2_s) was considerably large compared to that of clones (σ^2_c) especially for forage yield. The components of variance for years (σ^2_y), seasons x years (σ^2_{sy}), clones x years (σ^2_{cy}) and clones x seasons (σ^2_{cs}) for all traits except leafiness and SSW were considerably small relative to σ2c. These estimates suggest that unbiased estimates of genotypic variance among clones for most traits may be obtained from evaluations over seasons in one year or one season over two years.

Estimates of broad-sense heritability based on performance in one season were generally high for all traits and showed little

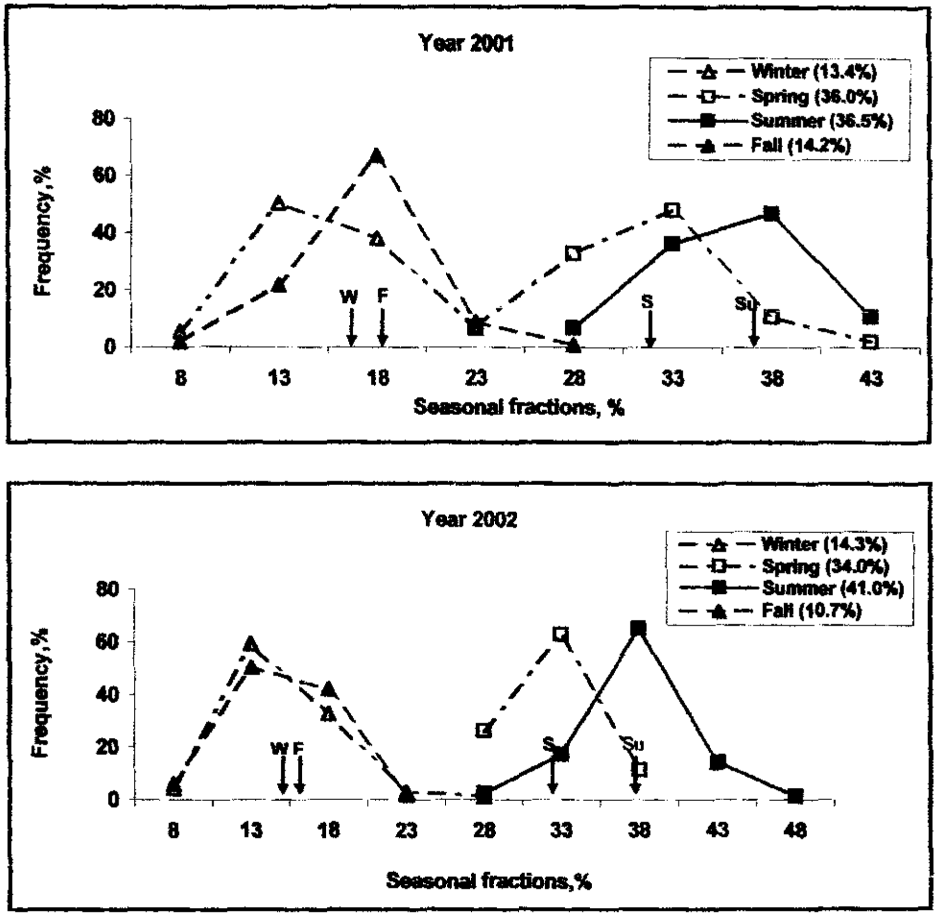


Fig.(3): Frequency distribution of average contribution of seasonal to annual yield in first and second year for 169 alfalfa clones .

↓ Average of clones.

( ) Average of checks.

W = Winter, S = Spring , Su = Summer, F = Fall

Table 3. Components of variance from combined ANOVA over seasons and years for forage yield and related traits of 169 alfalfa clones.

Trait	$^{2}_{c}$ @	$^{2}_{rc}$	$^{2}_{y}$	$^{2}_{cy}$	$^{2}_{rcy}$	$^{2}_{s}$	$^{2}_{sy}$	$^{2}_{cs}$	$^{2}_{csy}$	$^{2}_{e}$
Total dry yield, g plant^{-1}	1.7**	0.047**	0.137	0.417**	0.013**	7.392**	0.130**	0.052	0.863**	0.083
Plant height, cm	34.1**	6.298**	6.854	2.406**	1.118**	54.990*	7.989**	2.563**	12.969**	12.108
Shoot plant^{-1}	0.005**	0.0002**	0.0005**	0.0005**	0.0001	0.001**	0.0000	0.0015**	0.002	0.0012
Yield shoot^{-1}, mg	0.004**	0.0002**	-0.0001	0.034**	0.0003	0.0178**	0.0005**	0.0009**	0.0066	0.001
Shoot specific weight, mg	0.0025**	0.0003**	-0.0001	0.0035**	0.0004	0.0086*	0.001**	0.0011**	0.0067	0.0014
Leafiness, %	4.66**	0.366**	-2.199	6.617**	-0.0517	4.944	8.927	0.824*	4.641**	5.092

*,** indicate variance component associated with a significant mean square at the 0.05 and 0.01 probability level F test, respectively.

@ component designation as per Table 1.

variation among seasons. These estimates were obviously biased upward because the genotypic component of variance among clones was inflated by interactions of genotypes with seasons or years or both seasons and years (Allard, 1960). However, H^2 estimates were substantially reduced when performance in one season was averaged over years and were widely different among seasons and traits. They were higher in winter (from 0.33 to 0.63) and spring (from 0.33 to 0.73) than summer (0.13 to 0.59) and fall (0.10 to 0.50) for all traits except forage yield. Considerably greater clone x year interactions were observed for these traits in summer and fall than winter and spring. H^2 estimates for yield, plant height and shoots plant^{-1} were generally similar from evaluations over seasons in one year or one season over years and not much different from estimates based on both seasons and years. The lowest H^2 estimates were obtained for YPS, SSW and leafiness especially in summer and fall (data not shown).

Trait inter-relationships

In both study years, forage yield of one or more harvests in each season was strongly positively correlated to the total season yield (r=0.88 to 0.98) as well as annual yield (r=0.76 to 0.94), but the closest correlations were obtained for the summer harvests in each year.

In both study years, associations among seasonal fractions were negative and significant except for the summer-fall association in the first year and a significant positive spring-summer association in second year. Simple correlations between seasonal fractions computed from data of six non-dormant alfalfa varieties (Abdelhalim *et al*, 1998) were also generally negative. These negative associations indicate that increased contribution to annual forage yield from enhanced growth in one season likely would take place at the cost of decreased growth in other seasons. However, seasonal fractions of annual yield in years one and two were not generally correlated to annual yield except for the fall and summer fractions (Table 4). In both years, the fall fraction exhibited positive but weak correlation with annual yield. Only, in the second year, the summer fraction was negatively associated with annual yield (Table 4), suggesting that greater second year summer fraction is shown for clones having lower annual yield in second year.

Phenotypic and genotypic correlations between traits were generally similar in sign and magnitude. Dry forage yield was more strongly positively correlated with YPS and number of shoots plant^{-1} than

Table 4. Phenotypic (above) and genotypic (below) correlation coefficients between annual forage yield and seasonal yield fractions for alfalfa clones in year 1 (above diagonal) and year 2 (below diagonal).

Annual yield fraction	Annual yield fraction				Annual
	Winter	Spring	Summer	Fall	yield
Winter		-0.40** -0.41‡	-0.41** -0.40‡	-0.44** -0.44‡	-0.09 -0.09
Spring	-0.39** -0.38‡		-0.29** -0.30‡	-0.34** -0.34‡	-0.02 -0.02
Summer	-0.63** -0.63‡	0.34** 0.36‡		-0.08 -0.07	-0.04 -0.03
Fall	-0.24** -0.24‡	-0.58** -0.59‡	-0.42** -0.43‡		0.17** 0.17‡
Annual yield	0.07 0.07	-0.08 -0.07	-0.32** -0.32‡	0.25** 0.25‡	

***and ** significant phenotypic correlation at 0.05 and 0.01 levels of probability, respectively.**

‡ genotypic correlation coefficient exceeding twice its standard deviation.

plant height. Yield was also more strongly correlated with YPS than SSW (Table 5). The weaker association between dry yield and SSW than YPS suggests that YPS and SSW my influence yield in different ways. Volenec *et al* (1987) stressed the importance of YPS as a selection criterion for forage yield. However, in this study, shoots plant^{-1} was not correlated with YPS on annual basis and was negatively associated with SSW. In contrast, plant height was positively correlated with forage yield, shoots plant^{-1} and SSW. Thus it may be deduced that the positive relationships between forage yield and shoots plant^{-1}, YPS and SSW is conditioned by their association with plant height. Path-coefficient analysis would reveal more of these relationships.

Forage yield showed weak but significant, negative phenotypic and genotypic correlations with leafiness only in winter,

Table 5. Phenotypic[@] correlations between traits of 169 alfalfa clones, averaged over two years

Trait	Winter	Spring	Summer	Fall	Annual
		Forage yield vs.			
Plant height, cm.	0.39**	0.42**	0.55**	0.55**	0.56**
Shoots plant^{-1}.	0.58**	0.48**	0.59**	0.54**	0.63**
Leafiness, %	-0.19*	0.03	0.08	0.04	-0.04
Yield shoot^{-1},g.	0.60**	0.68**	0.68**	0.76**	0.70**
Shoot specific weight, mg cm^{-1}	0.46**	0.54**	0.51**	0.65**	0.53**
Seasonal fraction, %	0.50**	0.31* *	0.01	0.64**	_
		Plant height vs.			
Shoots plant^{-1}.	0.12	0.19*	0.38**	0.29**	0.28**
Leafiness, %	-0.29**	0.08	-0.05	-0.20**	-0.23**
Yield shoot^{-1}, g.	0.35**	0.30*	0.32**	0.45**	0.48**
Seasonal fraction, %	-0.08	-0.01	-0.14	0.29**	_
		Shoot plant^{-1} vs.			
Yield shoot^{-1},g.	-0.31**	-0.30**	-0.18*	-0.13	-0.11
Shoot specific weight, mg cm^{-1}	-0.38**	-0.40**	-0.34**	-0.24**	-0.25**
Leafiness, %	-0.10	0.07	0.13	0.05	0.01
Seasonal fraction, %	0.32**	-0.06	-0.23**	0.14	_
		Yield shoot^{-1} vs.			
Shoot specific weight, mg cm^{-1}	0.92**	0.92**	0.93**	0.95**	0.92**
Leafiness, %	-0.07	-0.03	-0.02	0.04	-0.05
Seasonal fraction, %	0.31**	0.29**	0.17*	0.64**	_
		Shoot specific weight vs.			
Seasonal fraction, %	0.35**	0.30**	0.23**	0.59**	_

@ genotypic correlation are not presented because they were generally similar in sign and magnitude to the phenotypic correlations.

* and ** significant phenotypic correlation at 0.05 and 0.01 levels of probability, respectively.

but both traits were not correlated in other seasons or over seasons (Table 5). Plant height generally exhibited significant positive association with YPS and weak to moderate positive associations with number of shoots plant^{-1}. Leafiness and plant height were not associated in spring and summer but were weakly negatively associated in winter and fall and over seasons. Leafiness also showed very weak significant negative genotypic correlation with number of shoots plant^{-1} in winter and positive correlation in summer (Table 5). Shoots plant^{-1} was moderately negatively associated with SSW in all seasons and with YPS in winter and spring and to a lesser degree in summer. Shoots plant^{-1} exhibited significant positive and negative associations, respectively, with both winter and summer yield fractions and annual forage yield, whereas the fall yield fraction was associated positively with fall plant height. In contrast, YPS and SSW were generally positively associated significantly with all seasonal fractions but, relatively more strongly, with the fall yield fraction.

Association between seasonal performance and seasonal yield fractions

If has been shown earlier that forage yield of one particular harvest in each season showed a very strong correlations with both yield in that season and annual yield. As the alfalfa breeder may not usually have the resources to evaluate performance of his material in all seasons, it was desirable to study the associations of yield and yield- related traits measured at one harvest in one season with annual yield and its distribution over seasons. In addition, information on how measurements made at one season in first year are related to annual yield and its seasonal fractions in the second year was also needed because of observed differences among clones in performance in first and second year.

Heritability values and trait associations suggest that selection for yield or its components during each season is expected to enhance the season's forage production, but how selection in one season would impact performance in other seasons, as well as annual yield, is not clear. More insight of the direct and indirect effects of selection in each season is gained from correlation coefficients between traits of the harvest most-related to annual yield in each season with yield performance in the same and other seasons.

Phenotypic and genotypic correlations were computed between forage yield and yield- related traits of the first year winter and summer harvests most correlated with annual yield, with annual yield and its fractions in the first year. The same was done for traits of the first year fall harvest with second year annual yield and its fractions. (Table 6).

Forage yield and all yield-related traits, except leafiness, of the first year mid-winter and mid-summer harvests were positively correlated with first year annual forage yield. The same was true also for the associations of traits of the first year fall harvest with second year annual yield and its seasonal fractions (Table 6). These relationships are consistent with the associations between these traits as shown in Tables 4 and 5. But the relationship between the yield-related traits and seasonal fractions differed widely for the winter, summer and fall harvests.

Forage yield and number of shoots plant^{-1} in the first winter harvest were significantly positively associated with the first winter yield fraction and negatively with the spring and summer fractions. Plant height in winter was only significantly correlated negatively with the first summer fraction. YPS was positively correlated with the winter fraction and negatively with the fall fraction. SSW exhibited no significant association with any seasonal fraction, whereas leafiness % showed a significant negative correlation with the first year winter fraction.

At the mid-summer harvest of first year, forage yield showed a negative significant association with the winter fraction and a positive association with the summer fraction. Plant height and shoots plant were negatively associated with the winter fraction and positively with the fall fraction. In contrast, YPS was positively associated only with the summer fraction, whereas SSW was also positively associated with the summer fraction but negatively associated with the fall fraction. Leafiness in summer was negatively related to the first year winter fraction (Table 6).

At the first year fall harvest, forage yield showed a negative correlation with the second year summer fraction, whereas plant height and leafiness showed no significant associations with any seasonal fraction. Shoots plant^{-1} was negatively associated with the second year summer fraction and positively with the fall fraction. YPS showed positive and negative associations, respectively, with the winter and summer fractions, but SSW was only positively associated with the winter fraction.

Second year's annual forage yield was positively associated with all traits of the first year's fall harvest (Table 6). Correlations with seasonal fractions suggest that selection for increased first year fall plant height would have no effect on second year annual yield distribution over seasons. In contrast, selection for more shoots in fall would decrease next winter yield fraction and increase next fall fraction. Increasing first fall YPS would increase second winter yield fraction and decrease its summer fraction,

Table 6. Phenotypic correlation coefficients between forage yield and related traits of first year winter (W1) harvest (15 Mar.) and summer (S1) harvest (15 Aug.) on first year seasonal yield fractions and annual forage yield for 169 alfalfa clones and between first year fall (F1) harvest with seasonal fraction and annual yield in second year.

Trait	Yield			Plant height			Shoot plant^{-1}		
	W1	S1	F1	W1	S1	F1	W1	S1	F1
Annual yield fractions									
Winter	0.47**	-0.22**	0.12	0.10	-0.20**	0.05	0.45**	-0.27**	-0.05
Spring	-0.19*	-0.07	-0.08	0.10	0.03	-0.02	-0.25**	0.03	-0.07
Summer	-0.27**	0.34**	-0.25**	-0.20**	0.03	0.10	-0.27**	0.04	-0.16*
Fall	-0.14	0.03	0.15	-0.05	0.19*	0.04	-0.05	0.26**	0.23**
Annual forage yield	0.74**	0.86**	0.62**	0.26**	0.39**	0.35**	0.51**	0.34**	0.44**

Table (6): Continued.

Trait	Yield shoot^{-1}			Shoot specific weight			Leafiness		
	W1	S1	F1	W1	S1	F1	W1	S1	F1
Annual yield fractions									
Winter	0.22**	0.02	0.17*	0.13	0.08	0.15*	-0.18*	-0.16*	0.06
Spring	-0.01	-0.12	–0.01	-0.08	-0.13	0.00	0.14	0.13	-0.06
Summer	-0.11	0.25**	-0.15*	0.04	0.23**	-0.13	-0.02	-0.03	–0.05
Fall	-0.16*	-0.12	–0.03	-0.11	-0.16*	-0.05	0.01	0.08	0.03
Annual forage yield	0.50**	0.58**	0.39**	0.30**	0.48**	0.32**	0.03	0.07	0.07

*** and ** significant phenotypic correlation at 0.05 and 0.01 levels of probability, respectively.**

whereas increased fall SSW would only enhance the second year winter fraction.

The above relationships suggest that in winter of the first year, forage yield, is the most favorable selection criterion for increasing the winter fraction and annual yield, though at the cost of reducing first year spring and summer yields. Selection in first year summer would favor yield, shoot plant^{-1} and YPS because of the positive associations these traits have with summer and fall yield fractions, respectively. In fall of first year, selection for greater yield, shoots plant^{-1} and YPS would produce desirable effect on second year annual yield and its fall and winter fractions and slightly negative effects on the summer fraction.

The six traits, identified above were used to simulate selection among clones by independent culling levels at 10% selection intensity (selection of 0.681 of clones at each level). Selection identified 17 clones whose performance is shown in Table (7). The selected clones averaged 33.42 and 19.3% more total yield in year 1 and 2, respectively, over the 169 clonal population, and exhibited better yield distribution over seasons to the 169 clonal population. These result suggest that restricting the selection to three harvests in the first year would realize the objective of identifying suitable clones for recurrent phenotypic selection program for improving forage yield and its seasonal distribution during first and second year. Independent culling would also entail greater saving in resources for field evaluation, and enable testing for disease and insect tolerance on fewer plants in first year.

Table 7. Mean seasonal and annual forage yields for 17 clones selected by independent culling levels compared to original population and checks.

	Forage yield, Mg ha^{-1}					Seasonal yield fractions			
Year (Y)	Winter	Spring	Summer	Fall	Annual	Winter	Spring	Summer	Fall
Selected									
Y1	6.28	12.86	15.27	7.70	42.10	14.91	30.55	36.26	18.28
Y2	6.54	13.34	15.26	6.80	41.94	15.60	31.81	36.37	16.22
Population									
Y1	4.82	9.90	11.42	5.43	31.57	15.28	31.35	36.18	17.20
Y2	5.25	11.32	13.18	5.39	35.15	14.95	32.22	37.49	15.34
Checks									
Y1	3.50	9.41	9.54	3.73	26.17	13.36	35.94	36.46	14.24
Y2	3.40	8.17	9.82	2.62	24.00	14.15	34.02	40.92	10.91

REFERENCES

Abdelhalim, A. Z., A.M. Rammah, M. A. EL-Nahrawy and G.S.Mikhiel (1998). Evaluation of alfalfa cultivars in sandy and calcarcous soils. Egypt J. Plant Breeding. 2:35-42.

Allard, R.W. (1960). Principles of plant breeding. John Wiley and Sons, Inc., New York, U.S.A.

Cowett, E.R. and M.A.Sprague.(1962). Factors affecting tillering in alfalfa. Agron.J.54:294-297.

Dudley, J. W., T. H. Busbice and C. S. Levings, III. (1969). Estimates of genetic variance in'Cherokee' alfalfa (*Medicago sativa* L.). Crop Sci. 9:228-231.

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

Frakes,R.V., R.L.Davis, and F.L.Patterson (1961). The breeding behavior of yield and related variables in alfalfa: II. Associations between characters. Crop Sci. 1:207-209.

Julier, B., C. Huyghe, and C. Ecalle (2000). Within-and among-cultivar genetic variation in alfalfa: forage quality, morphology, and yield. Crop Sci. 40:365-369.

Liang, G.H.L. and W.A. Riedl (1964). Agronomic traits influencing forage and seed yield in alfalfa. Crop Sci. 4:394-396.

Marble, V.L. (1989). Fodders for the Near East: Alfalfa, FAO Plant Production and Protection Paper 97/1. FAO, Rome.

Mousa, M. E., I. A. Hanna, and Z. M. Marei (1996). Evaluation of some alfalfa (*Medicago sativa* L.) cultivars for growth and yield in sandy soil at North East of Egypt. Zagazig J. Agric. Res. 23(1):29-49.

Oushy, H. S., O. Niemelainen, M. A. El-Nahrawy and I. A. Hanna (1999). Seasonal variation in performance of alfalfa genotypes under sandy soil condition. II. Quality and related traits. Egypt. J. Plant Breed. 3: 297-312.

Radwan,M.S., A.M.Rammah, A.M.Soliman and S.S.M.Abo-Feteih (2003). Selection of alfalfa (*Medicago sativa* L.) for tolerance to frequent harvest. Egypt. J.Plant.Breed.7(1):593-605.

Sheaffer, C.C., N.P.Martin, J.F.S.Lamb, G.R.Cuomo, J.G.Jewett, and S.R.Quering (2000). Leaf and stem properties of alfalfa entries. Agron.J. 92: 733-739.

Smith, S.E., A.Al-Doss and M.Warburton (1991). Morphological and agronomic variation in North African and Arabian alfalfas. Crop Sci. 31:1159-1163.

Steel, R.G.D. and J.H. Torrie (1980). Principles and Procedures of Statistics. A Biometerical Approach, 2nd Ed., Iowa State Univ. Press. Ames, Iowa, USA.

Volenec, J.J. (1985). Leaf area expansion and shoot elongation of diverse alfalfa germplasms. Crop Sci. 25:822-827.

Volenec, J. J., J. H. Cherney, and K. D. Johnson. (1987). Yield components, plant morphology, and forage quality of alfalfa as influenced by plant population. Crop Sci. 27:321-326.

Utz, H.F. (2004). PLABSTAT, a computer program for statistical analysis of plant Breeding experiments .Institute of Plant Breeding, Seed Science and Population Genetics, Hohenheim Univ., Stuttgart, F.R. Germany.

التغير الموسمى فى محصول العلف والصفات المتعلقة به بين سلالات الألفالفا (البرسيم الحجازى)

محمد السيد رضوان[١] ، أحمد منجد سليمان[١]، أحمد محروس رماح[٢] و هدى امام ابراهيم[٢]
١-قسم المحاصيل - كلية الزراعة - جامعة القاهرة
٢-قسم بحوث العلف – معهد المحاصيل الحقلية- مركز البحوث الزراعية

أجريت هذه الدراسة بمحطة التجارب والبحوث الزراعية بكلية الزراعة جامعة القاهرة بالجيزة على ١٦٩ سلالة خضرية بالاضافة الى أربعة أصناف مقارنة من البرسيم الحجازى. بهدف تقدير الاختلافات الموسمية بين السلالات فى محصول العلف ومكوناته، وتقديركفاءة التوريث والارتباط المظهرى والوراثى بين الصفات. ولهذا الغرض زرعت نباتات فردية فى تجربة مكررة وتم تقييم السلالات الخضرية مع أصناف المقارنة خلال موسمى ٠١ و ٢٠٠٢ .

وقد أظهرت النتائج اختلاف السلالات فى المحصول ومكوناته فى كل موسم ومجموع المواسم. كان مدى الاختلاف بين السلالات فى عدد الفروع و نسبة الأوراق أكبر فى الشتاء والربيع منها فى الصيف والخريف، بينما زاد الاختلاف بين وزن الفرع ووزنه النوعى فى الصيف عن المواسم الأخرى. تفوقت السلالات على أصناف المقارنة فى محصول العلف ومكوناته. كما كان معامل الاختلاف الوراثى للمحصول ونسبة توزيعه على المواسم أكبر مايمكن.

كانت كفاءة التوريث عالية لكل الصفات فى كل موسم وبدرجة محدودة من الاختلاف بين المواسم. وكانت كفاءة التوريث أعلى فى موسمى الشتاء والربيع عنها فى الصيف والخريف لكل الصفات ماعدا المحصول. كما أظهرت النتائج أن محصول العلف يرتبط ايجابيا مع مكوناته ماعدا نسبة الأوراق كما ارتبط ارتفاع النبات ، محصول الفرع والوزن النوعى سلبيا مع نسبة الأوراق . ولم يكن هناك ارتباط بين المحصول ونسب توزيعه الموسمية كما وجد ارتباط سالب بين هذه النسب. كان الارتباط بين المحصول الموسمى والمحصول الكلى السنوى قوي. ارتبط محصول العلف الجاف الكلى للسنة الأولى ايجابيا مع محصول الحشة فى الشتاء والصيف بينما ارتبط محصول العلف الجاف الكلى للسنة الثانية ايجابيا مع محصول كل حشة فى خريف السنة الأولى وأظهرت الصفات الأخرى ارتباطات مختلفة مع محصول العلف السنوى ونسب توزيعه.

وجد أن انتخاب ١٠ % على اساس الاستبعاد المستقل بناء على المحصول الجاف لحشة شتوية فى السنة الأولى، ثم المحصول وعدد الأفرع فى حشة صيفية ثم المحصول وعدد الأفرع ومحصول النبات الفردى فى حشة خريفية يفرز سلالات أعلى فى محصولها الكلى فى السنتين الأولى والثانية مقارنة بالعشيرة الأصلية مع توزيع أفضل نوعا على مدار السنة.

المجلة المصرية لتربية النبات ٩(٢): ١-٢٠ (٢٠٠٥).