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YIELD POTENTIAL AND STABILITY PERFORMANCE OF SIXTEEN EGYPTIAN CLOVER GENOTYPES GROWN UNDER DIFFERENT ENVIRONMENTS

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Abstract: A field study was conducted to evaluate the yield as well as the phenotypic and genotypic stability for 16 Egyptian clover genotypes at four locations (Sakha, Gemmiza, Serw and Sids) during 2003/2004 and 2004/2005 winter seasons. Results revealed that, genotypes Hatour, Sakha– 4, Gemmeza-1, Narmer and Giza-6 outyielded other genotypes with no significant differences among them regarding fresh herbage yield. However, no significant differences were detected among most of the entries in dry yields. The highest fresh and dry yields over two seasons were recorded at Sids location surpassing the other locations. The genotypes Sakha-96, Giza-15, Gemmiza-1, Sids Syn., Assiut Population., Cairo-3 and Hatour met the parameters of phenotypic and or genotypic stability.

Key words: Yield, stability, clover

Introduction

Berseem clover is the main winter forage crop in Egypt. It is cultivated for animal feed and improving soil fertility. Developing high yielding cultivars is mainly depending upon existing genetic variation among the germplasm under selection. Variations in herbage yields was recorded among local landraces, commercial varieties and several landraces surpassed the commercial cv.Giza-1 (Rammah *et al*. 1984 and Bakheit 1986).

The decision to release a variety is usually made on the basis of whether the variety performance is stable and satisfactory in comparison with the performance of commercial ones.

Consequently, to develop a variety with high yielding ability and consistency, high attention should be given to the importance of stability performance for the genotypes under different environments and their interaction as stated by Allard and Bradshaw (1964). The practical methods for determining the varietal stability varied between the simple methods (which use the fluctuations of the varietal means from one environment to another as an indicator for relative stability) and the recent advanced methods (which use the genotype × environment interaction for estimating phenotypic and genotypic stability for each genotype).

Finlay and Wilkinson (1963) proposed the average yield of all genotypes grown at particular site in a particular season as a measure of that environment where, they used the regression coefficient (b) of the varietal means on its environment as an indicator for its phenotypic stability and adaptation. They considered the variety with (b) greater than unity as better adapted to favorable environment and that with (b) less than unity as better adapted to less favorable environment, while the varieties with (b=1) were described as average in stability and either poorly or well adapted to all environments depending upon the variety mean yield.

Eberhart and Russell (1966) suggested that the regression coefficients (b) and deviations from regression (S^2d) may be considered as two parameters for measuring the varietal phenotypic stability.

Statistical analysis was carried out according to Tai (1971) who suggested partitioning the genotype × environment interaction effects of the i^{th} genotype into two statistics parameters namely (α) which measure linear response of a genotype to environmental effects and (λ) the deviation from the linear response of a genotype to the environmental effects. A perfectly stable genotype would be equivalent to stating that ($\alpha = -1$ and $\lambda = 1$). So that plant breeders have to be satisfied with obtainable levels of stability, i.e., average stability $\alpha > 0$ and $\lambda = 1$ whereas the values $\alpha > 0$ and $\lambda = 1$ will be below average stability and values $\alpha < 0$ and $\lambda = 1$ as above average stability. Concerning forage yields, significant differences were found among 56 Egyptian clover accessions due to environment, genotype and their interaction (Bakheit, 1985).

Khatri *et al*. (1991) performed stability performance test on 24 genotypes of berseem under different arrays of environments and poor stability parameters were detected. On the other hand, Bakheit and El-Hinnawy (1993), reported that most of the high yielding forage accessions out of 32 Egyptian clovers exhibited instability performance as they didn't meet the parameters of genotypic stability ($\alpha \neq 0$ and $\lambda \neq 1$) and they distributed out of the average area .

Abdel-Galil *et al*. (1998) reported that the Egyptian clover, Sakha-4 and Serw-1 were desired varieties to less favorable environment as the regression coefficient values were less than unity ($b < 1$) but Giza-6, Gemmiza-1, Giza15 and Helally varieties were better adapted to favorable environments (b > 1).

Therefore, this investigation aimed to determine the yield potential of 16 Egyptian clover genotypes as well as estimate their phenotypic and genotypic stability performance under different environments.

Materials and Methods

A field experiment was carried out at Sakha, Gemmiza, Serw, and Sids Res. Stations, representing different locations in the Delta and Middle Egypt during the two successive seasons, 2003/2004 and 2004/2005 (eight environments).

The tested materials included; 1) Ten genotypes, Sakha-3, Sakha-4, Sakha-96, Hellaly, Giza-6, Giza-15, Gemmeza-1, Serw-1, Serw-2 and Sids Syn., obtained from Forage Crops Res. Program, Field Crops Res. Inst., ARC. 2) Six promising genotypes developed through the co-operation between Forage Crops Res. Program and both of Cairo and Assiut Univ. (Cairo-1, Cairo-2, Cairo-3, Narmer, Hatour and Assiut Population).

The randomized complete block design with four replicates was used. The plot size was 6m^2 and seeds at the rate of 20 kg/fed were hand drilled in rows 20cm apart. The planting dates in the first season (2003-2004) were in October, 11 at Sakha, Oct., 28 at Gemmezaa, Oct., 16 at Serw and Oct., 17 at Sids . In the second season (2004-2005) the planting dates were in October, 18 at Sakha, November,2 at Gemmeza, Oct., 12 at Serw and Oct., 12 at Sids.

The first cuts were obtained after 50 days from planting dates and the subsequent cuts were taken after 25-30 days from the first cuts. Cultural practices were maintained at optimum levels to maximize productivity. Four cuts were obtained from each location in each season and fresh forage yields were recorded. Sizeable samples of green forage from each cut were dried at 70 ^oC till a constant weight then the dry matter yields were calculated.

Statistical analysis

Individual analysis of variance was applied for each location and Barttlet test was used to determine the homogeneity for each season Then, the combined analysis for the total cuts over seasons and locations was carried out according to Snedecor and Chocran (1989). Data were analyzed using Mstat-C computer program (1986).

Stability analysis

Stability analysis was computed and the phenotypic stability parameters (b and S^2d) were detected using the model described by Eberhart and Russell (1966). Genotypic stability parameters (α and λ) were estimated according to Tai (1971)

Results and Discussion

Fresh and dry forage yields

The combined analysis of variance for fresh and dry forage yields (Table 1) shows significant differences among the tested genotypes, years, locations and its interaction, indicating that the tested genotypes were affected by the varying environments and the consistency of these entries are needed to be estimated for varying environments.

Table(1): Mean squares of combined analysis of variance over seasons and locations for fresh and dry forage yields of 16 Egyptian clover genotypes.

Source of Variation	d. f.	Mean Squares	
		Fresh Yield	Dry Yield
Years	1	213.219**	38.4625**
Locations	3	29133.6**	665.246**
Years × Locations	3	916.674**	50.8195**
Genotypes	15	43.380**	0.995106**
Locations × Genotypes	45	29.7876**	0.570892**
Years × Locations × Genotypes	45	23.3407**	0.366498**
Error	384	6.27699	0.137673**

** Significant at 1% level of probability

The average of total fresh and dry forage yields for 16 genotypes of Egyptian clover in 4 different locations over the two growing seasons; 2003/04 and 2004/05 are presented in Table (2). The genotypes Hatour, Sakha-4, Gemmeza-1, Narmer, Giza-6, Sakha-96 and Hellaly recorded higher forage fresh yield than the overall mean (45.98 t/fed). Hatour, Sakha-4 and Gemmeza-1 had the highest fresh forage yield (47.84, 47.49, and 47.20 t/fed) with no significant differences from Narmer, Giza-6, Sakha-96 and Hellaly (46.98, 46.60, 46.46, and 46.37 t/fed) and significant different from the other genotypes. Narmer, Giza-6, Sakha-96 and Hellaly were significantly higher than Sakh-3, Cairo-1 and Cairo-3 (44.98, 44.26 and 43.66 t/fed).

Significant differences among locations were detected; Sids location ranked the first (66.55 t/fed) and Serw location was the latest one (35.58 t/fed). These differences among genotypes express the genetic variability existing among Egyptian clover genotypes under evaluation.

Table(2): Seasonal fresh and dry forage yields (t/fed) for 16 Egyptian clover genotypes evaluated at four locations over two seasons.

No.	Genotype	Forage yield (t/fed)									
		Fresh					Dry				
		Sakha	Gem.	Serw	Sids	Mean	Sakha	Gem.	Serw	Sids	Mean
1	Sakha 3	44.19	39.11	30.04	66.57	44.98	5.43	5.42	3.85	8.62	5.83
2	Sakha 4	44.59	38.46	38.83	68.08	47.49	5.51	6.41	3.98	8.85	6.19
3	Sakha 96	47.01	37.23	35.78	65.82	46.46	5.73	5.96	3.86	8.61	6.04
4	Helally	51.49	36.98	32.32	64.70	46.37	6.49	5.74	3.86	8.52	6.15
5	Giza 6	43.16	35.95	38.57	68.70	46.60	5.51	5.95	4.16	9.06	6.18
6	Giza 15	45.81	36.51	36.00	63.45	45.44	5.85	5.72	4.18	8.38	6.03
7	Gemmeza-1	45.23	38.32	39.66	65.57	47.20	5.62	6.29	4.16	8.71	6.20
8	Serw 1	41.16	37.03	36.96	66.49	45.41	5.19	5.86	4.10	8.95	6.03
9	Serw 2	43.11	35.83	37.90	64.96	45.45	5.03	6.11	3.46	8.65	5.81
10	Sids Syn.	45.02	34.73	35.31	68.58	45.91	5.65	5.73	3.68	8.97	6.01
11	Assiut Popn.	42.99	37.54	35.29	67.24	45.76	5.39	5.73	4.11	8.90	6.04
12	Cairo 1	43.88	34.58	32.50	66.07	44.26	5.55	5.95	3.45	8.78	5.93
13	Cairo 2	43.63	37.12	34.33	68.24	45.83	5.61	5.82	3.92	8.93	6.08
14	Cairo 3	42.50	34.50	32.60	65.03	43.66	5.21	5.50	3.53	8.47	5.68
15	Narmer	48.31	37.16	35.80	66.66	46.98	5.89	5.93	3.84	8.57	6.06
16	Hatour	48.26	37.02	37.36	68.70	47.84	6.11	5.76	3.88	8.94	6.18
Mean		45.02	36.75	35.58	66.55	45.98	5.61	5.87	3.88	8.75	6.03
L.S.D. at 5 % for Geno.		2.66	1.81	2.09	3.07	1.231	0.426	0.518	0.241	0.412	0.211
L.S.D. at 5% for Geno x L		0.616					0.912				

It is worth mentioning that the combined analysis of variance for dry yield over the two seasons of investigation showed no significant differences among the genotypes Gemmiza-1, Sakha-4, Hatour, Giza-6, Helally, Cairo-2, Narmer, Sakha96, Giza-15, Assiut Pop., Serw-1 and Sids Syn., ranging from 6.20 t/fed (Gemmiza-1) to 6.01 (Sids Syn). The genotypes Cairo-1, Sakha-3, Serw-2 and Cairo-3 gave the lowest dry yields and ranged from 5.93 t/fed. (Cairo-1) to 5.68 t/fed.(Cairo-3) without significant differences among them.

Significant differences in dry yield were detected among locations, where Sids ranked the first (8.75 t/fed.) followed by Gemmiza (5.87 t/fed.), Sakha (5.61 t/fed.) and Serw (3.88 t/fed.). In addition, significant differences were present among the tested genotypes at each and among locations over the two seasons.

At Sakha location, Hellaly variety gave the highest dry yield (6.49 t/fed.) followed by Hatour genotype with no significant differences between them. Meanwhile, at Gemmiza location, Sakha-4 produced the highest dry matter yield (6.41 t/fed.) followed by Gemmiza-1 (6.29 t/fed.) and

Serw-2 (6.11 t/fed) with no significant differences among them.

At Serw location Giza-15, Giza-6, Gemmiza-1 and Serw-1 were the highest productive genotypes (4.18, 4.16, 4.16 and 4.10 t/fed) with no significant differences between them, this is may be due to the source of the seed which had been propagated in Sakha Res. St. which distinguished with relatively high level of salinity. At Sids location, Giza-6 gave the highest dry yield (9.06 t/fed.) followed by Sids Syn. (8.97 t. /fed.), Serw-1 (8.95 t/fed.) and Hatour (8.94 t/fed.). In general, the highest dry forage yield of the evaluated genotypes was obtained at Sids location with highly significant differences from the other locations.

Phenotypic stability for fresh and dry forage yield:

Mean squares of the genotypes, environments and their interactions were highly significant for fresh and dry forage yield (Table3), indicating that there is wide variability among genotypes and environments and their interaction. This significant interaction had brought out difficulty in identifying superior forage yielding clover genotypes over environments, (Bakheit, 1985 and Bakheit and El-Hinnawy1993).

Table(3): Stability analysis of variance for fresh and dry forage yield of 16 Egyptian clover genotypes under different environments using two methods.

Eberhart and Russell method (1966)				Tai's method (1971)			
Source of variation	d.f.	Mean square		Source of variation	d.f.	Mean square	
		Fresh Yield	Dry Yield			Fresh Yield	Dry Yield
Genotypes	15	43.38**	0.7598 **	Environments	7	2699.02**	277.26**
Env + Geno. × Env.	112	204.84**	4.476**	Rep/Env.	24	20.87**	0.542**
Env. (Linear)	1	2223.44**	485.213**	Genotypes	15	43.38**	0.7598**
Geno.× Env. (Linear)	15	4.22**	0.0646**	Env. x Geno	105	27.39**	0.6148**
Pooled deviation	96	6.83**	0.1579	Error	360	6.29	0.1573
Pooled error	384	1.80	0.0453				

** Significant at 0.01 levels of probability

In addition, the significance of the genotype x environment interaction indicated that the location had the major effects on the relative genotypic potential for either fresh and or dry yield. This means that, for reliable evaluation of berseem yield, it would be necessary to evaluate the genotypes with great emphasis on multi-location testing as reported by Gray (1982) and Abdel-Galil *et al.* (1998). Consequently, stability performance should be identified to get acquainted with the reaction and the response of each genotype to environmental change.

It could be stated from the values of regression coefficients (b) and deviation from regression mean squares (S^2d) that the genotypes Sakha-96, Gemmeza-1 and Hatour had met the parameters of stability whereas, (b) values didn't differ significantly from unity (b=1) and (S^2d) didn't differ significantly from zero ($S^2d = 0$) and they had higher fresh yield than the overall mean (Table 2 and 4). Therefore, these genotypes could be considered phenotypicaly stable for fresh forage yield trait.

Concerning the stability parameters for dry forage yield Table (4), the values of regression coefficient (b) for the tested genotypes revealed no significant differences than unity (b=1) and the deviation from regression mean square values didn't differ significantly from zero ($S^2d=0$). Hence, the genotypes Sakha-4, Hellaly, Giza-6, Giza-15, Gemmeza-1 and Hatour could be considered as stable genotypes as they met the parameters of Eberhat and Russell (1966).

Genotypic stability for fresh and dry forage yield

The mean squares of environment, genotype and their interaction were significant for fresh yield trait (Table 3), indicating that the genotypic stability parameters should be estimated to determine the most stable genotypes for such environment. The estimates of the linear response to environmental effects (α) and deviation from linear response (λ) are presented in (Table 4).

Table(4): Estimates of phenotypic (b and S^2d) and genotypic (α and λ) stability parameters for fresh forage yield of 16 Egyptian clover genotypes.

No.	Genotype	$\bar{x}$	b	S^2d	α	λ
1	Sakha 3	44.981	1.0650	6.243 +	0.0651	6.4611*
2	Sakha 4	47.488	1.0004	2.691+	0.0004	2.8160*
3	Sakha 96	46.447	0.9844	1.373	-0.0157	1.4368
4	Helally	46.516	0.9887	12.843+	-0.0113	13.4444*
5	Giza 6	46.594	1.0225	6.384 +	0.0226	6.6820*
6	Giza 15	45.456	0.8959	1.319	-0.1043	1.3786
7	Gemmiza 1	47.000	0.8769	1.358	-0.1233	1.4177
8	Serw 1	45.441	0.9906	5.227 +	-0.0094	5.4717*
9	Serw 2	45.394	0.9640	4.131 +	-0.0361	4.3239*
10	Sids Syn.	44.963	0.9907	1.469	-0.0094	1.5372
11	Assiut Pop.	45.713	0.9985	1.889	-0.0015	1.9679
12	Cairo 1	44.263	1.0648	3.449 +	-0.0650	3.6097*
13	Cairo 2	45.834	1.0797	4.447 +	-0.0798	4.6533*
14	Cairo 3	43.678	1.0404	0.831	0.0405	0.8696
15	Narmer	46.980	1.0127	5.598 +	0.0127	5.8599*
16	Hatour	47.844	1.0248	1.539	0.0248	1.6111

* λ values significant at 0.05 level of probability
+ S^2d values significantly varied from zero at 0.05 level of probability.

The genotypes differed greatly in the amount of diviation from the linear response (λ) and to a less extent in the response (α) for fresh yield. This variation suggested that the relatively unpredictable components of the genotype × environment interaction variance may be more important than the relatively predictable component of variation for those genotypes which showed different degree of stability as mentioned by Bakheit (1985).

The genotypes No. 1, 2, 4, 5, 8, 9, 12, 13 and 15 had deviated significantly from the linear response (λ) for the total fresh yield (Table 4). In addition, the distribution of the α^ and λ^ for the previous genotypes were located out of the average stability area (Figure1). Therefore, they were considered unstable genotypes according to Tai's theory (1971).

Moreover, the genotypes No. 3, 6, 7, 10, 11, 14 and 16 did not deviate significantly from the linear response and the values of α (which measures the linear response to environmental effect) were not significantly different from zero. Accordingly, the values of α and λ for the seven genotypes were distributed in the average stability area in the hyberbola graph (Fig.1). Consequently, the seven genotypes; Sakha-96, Giza-15, Gemmiza-1, Sids Syn., Assiut Poplatio, Cairo-3 and Hatour were considered stable genotypes.

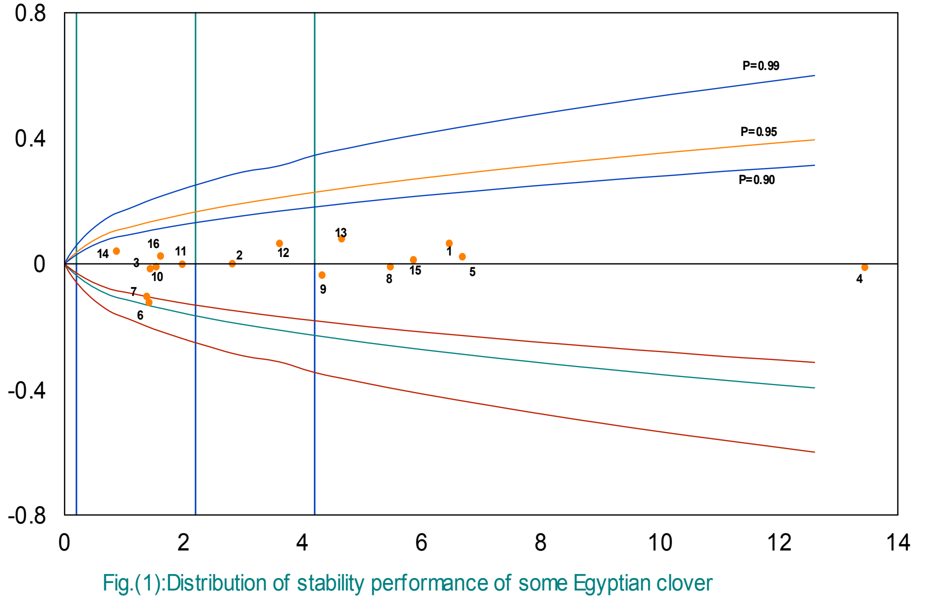

Fig.(1):Distribution of stability performance of some Egyptian clover

It is worth mentioning that the genotypes, Giza-15, Sids Syn., Assiut pop., and Cairo-3 had met the parameters of genotypic stability (α and λ) but they yielded less than the overall mean (45.98 t/fed). However, the genotypes; Sakha-4, Hellaly, Giza-6 and Narmer did met the stability parameters of Tai (1971) and or Eberhart and Russell (1966) whereas, they had higher fresh yield than the overall mean.

Regarding the dry forage yield, all the genotypes had the same performance of stability (Table 5) and the genotypes No.3, 6, 7, 10, 11 and 14 distributed in the average area of stability in the hyberbola graph except Hatour genotype which deviated significantly from the linear response (λ≠1) and distributed out of the stability area Fig.(2).

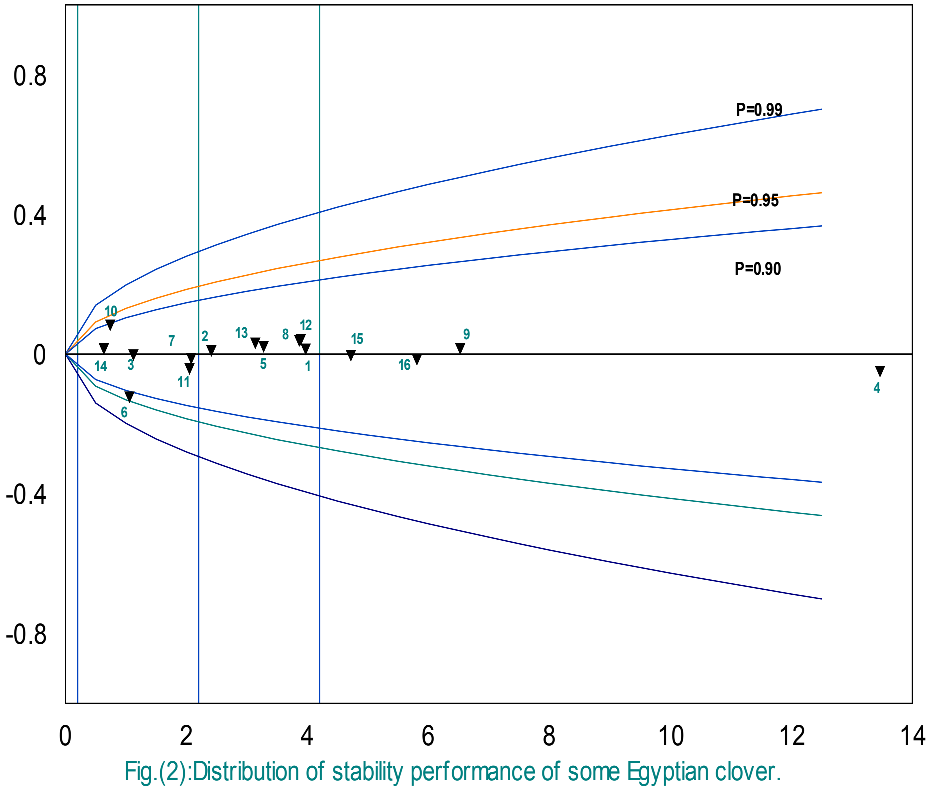

Fig.(2):Distribution of stability performance of some Egyptian clover.

Table(5): Estimates of phenotypic (b and S^2d) and genotypic (α and λ) stability parameters for dry forage yield of 16 Egyptian clover genotypes.

No.	Genotype	$\bar{x}$	b	S^2d	α	λ
1	Sakha 3	5.83	1.040	0.1220	0.0403	3.8902*
2	Sakha 4	6.19	1.008	0.0584	0.0084	2.4120*
3	Sakha 96	6.04	0.996	0.0030	0.0038	1.1230
4	Helally	6.15	0.949	0.5338	0.0510	13.4671*
5	Giza 6	6.18	1.020	0.0956	0.0202	3.2764*
6	Giza 15	6.03	0.876	0.0003	0.1243	1.0587
7	Gemmiza 1	6.20	0.957	0.0429	0.0434	2.0505
8	Serw 1	6.03	1.013	0.1254	0.0130	3.9711*
9	Serw 2	5.81	1.019	0.2353	0.0142	6.5260*
10	Sids Syn.	6.01	1.082	0.0134	0.0818	0.7402
11	Assiut Pop.	6.04	0.986	0.0441	0.0139	2.0803
12	Cairo 1	5.93	1.037	0.1209	0.0370	3.8653*
13	Cairo 2	6.08	1.030	0.0897	0.0302	3.1392*
14	Cairo 3	5.68	1.014	0.0180	0.0139	0.6362
15	Narmer	6.06	0.995	0.1576	0.0054	4.7187*
16	Hatour	6.18	0.983	0.2045	0.0170	1.8104*

* λ values significant at 0.05 level of probability

+ S^2d values significantly varied from zero at 0.05 level of probability.

Concerning the adaptation point of view according to Finlay and Wilkinson (1963) who proposed the regression coefficient of the varietal means on its environment as an indicator for phenotypic stability and adaptation, it could be stated that Sakha-4, Sakha-96, Hellaly, Giza-6, Gemmiza-1, Narmer and Hatour genotypes are widely adapted to all environments as the values of regression coefficient equaled unit (b=1) and the means of yield were higher than the average (Fig 3).Almost, the same performance was found regarding the regression coefficient values of dry forage yield trait Fig (4). Whereas, the genotypes Sakha-4, Sakha-96, Hellaly, Giza-6, Gem.-1, Assiut pop., Cairo-2 , Narmer and Hatour are widely adapted to all environments.

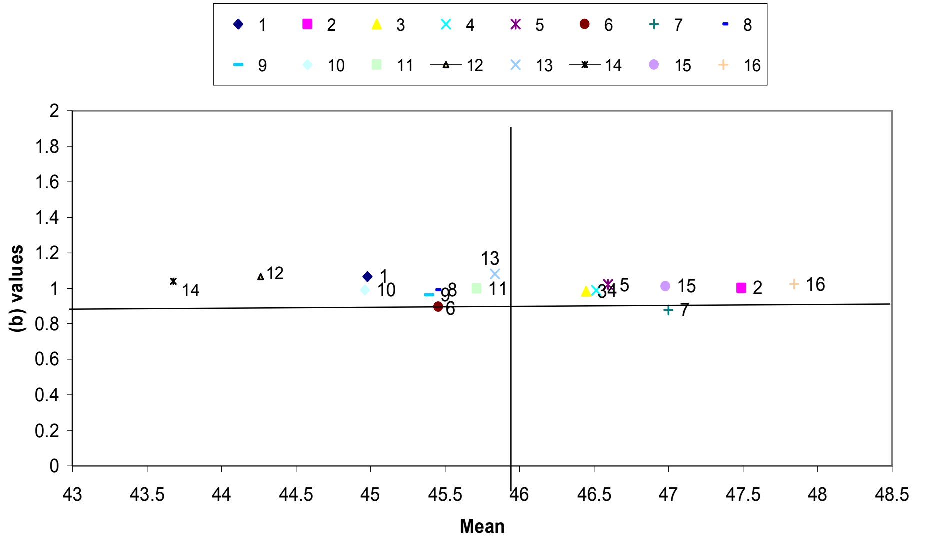

Fig.(3) Destribution of regression coefficient and mean values for genotypes for fresh forage yield

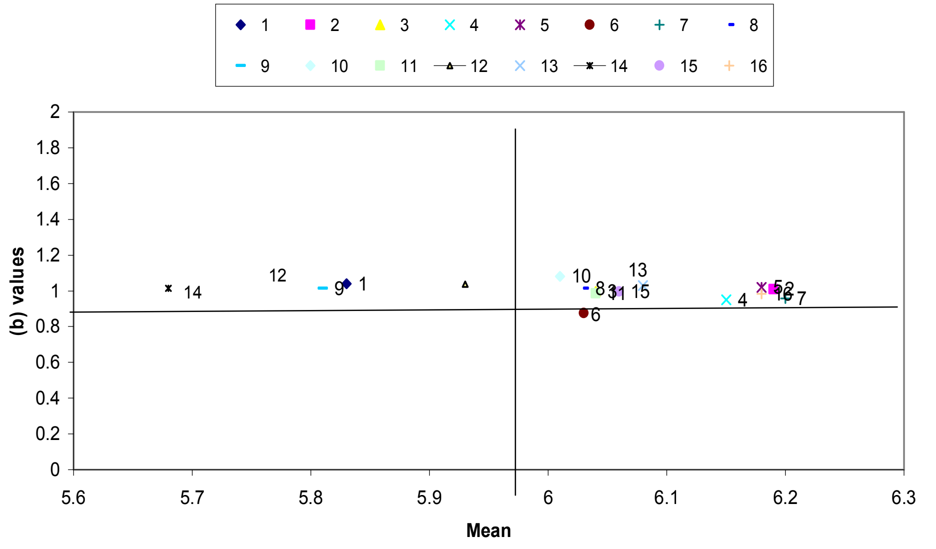

Fig.(4) Destribution of regression coefficient and mean values for genotypes for dry forage yield

In conclusion, the genotypes Sakha-96, Gemmeza-1 and Hatour are the distinguished genotypes phenotypically and genotypically where they met the parameters of Eberhart and Russell (1966) and Tai (1971). Although Giza-15, Sids Syn., Assiut.Pop and Cairo-3 genotypes had met the same parameters they had less yield potential than the overall mean and should be subjected to yield improvement.

Furthermore, Sakha-4, Giza-6, Hellaly and Narmer genotypes had high yielding abilities but more efforts should be directed to improve its stability performance to be widely adapted to all environments as it have highly yielding potential and could contribute in raising the total yield of winter forages. Although Sakha-3, Serw-1, Serw-2, Sids Syn., Cairo-1, Cairo-2 and Cairo-3 genotypes are considered as poorly adapted to all environments (Fig.3).

It is worth to mention from the practical point of view that these genotypes are highly promising genotypes as their yields ranged from 43.7 to 45.8 t/fed which are higher than the known averages of berseem growers. Hence, the efforts could be directed to develop it under specific regions. The estimates of (b) and (S^2d) values with their corresponding (α) and (λ) values indicate that the phenotypic and genotypic stability estimates were quite close to each other for most genotypes. Consequently, the two methods of stability analysis had similar trend in agreement with those reported by Nawar (1985) and Bakheit (1993).

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القدرة المحصولية وسلوك الثبات لستة عشر تركيب وراثي للبرسيم المصرى تحت ظروف بيئية مختلفة

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تم اجراء تجربة حقلية خلال موسمى ٢٠٠٣/٢٠٠٤ ، ٢٠٠٤/٢٠٠٥م فى أربعة مواقع مختلفة (سخا – الجميزة – السرو – سدس) لتقييم القدرة المحصولية لعدد ١٦ تركيب وراثى (أصناف و عشائر) من البرسيم المصرى ، بالإضافة إلى تقييم سلوك الثبات المظهرى والوراثى تحت الظروف البيئية للمواقع المختلفة. أشارت النتائج الى وجود فروق معنوية فى المحصول الأخضر والجاف وأن التراكيب الوراثية هاتور – سخا–٤ – جميزة–١ – نارمر – جيزة–٦ قد أنتجت أعلى محصول أخضر بدون فروق معنوية بينهمومتفوقه على التراكيب الوراثية الاخرى. كما أوضحت النتائج عدم وجود فروق معنوية بين معظم التراكيب الوراثية فى المحصول الجاف.

وقد أوضحت القيم المقدرة لمقاييس الثبات المظهرى والوراثى على أساس الأداء المظهرى والتركيب الوراثي وتفاعل التراكيب الوراثية مع البيئات المختلفة لصفة المحصول الأخضرأن كل من التراكيب الوراثية سخا–٩٦، جميزة–١ وهاتور تعتبر ثابتة مظهريا ووراثيا بينما اظهرت نتائج تحليل الثبات المظهرى والوراثى لصفة المحصول الجاف أن التراكيب الوراثيه سخا–٩٦، جميزا–١، جيزا–١٥، تركيبى سدس، عشيرة اسيوط وقاهره–٣ يمكن اعتبارها ثابته مظهريا" ووراثيا".