Balanced Parameters for Genotype X Environment Interaction in Some Alfalfa Genotypes

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ABSTRACT

Identification of alfalfa genotypes, with high yield potential and good forage quality along with the least seasonal fluctuation over a wide range of environments, is important for crop improvement programs. Trials were conducted to evaluate seven alfalfa (*Medicago sativa*, L) genotypes over three years at the Nubaria Agricultural Research Station Site. Field experiments were carried out in 2014, 2015 and 2016 seasons to evaluate fresh and dry forage yield, protein and fiber percentages and their stability employing parametric and non-parametric measures for the seven genotypes across environments. Results indicated that the local cultivar Ismailia-1 was superior to the introduced genotypes regarding its fresh and dry forage yield in addition to recording the least fiber percentage; however, MI reya produced higher protein percentage. When stability measures for the four traits was considered, Isamilia-1 was considered the most stable for fiber percentage based on four different measures tested. MI reya was most stable for protein percentage and more stable than Ismailia-1 for fresh and dry forage yield based on estimates from larger number of the tested stability measures, suggesting that MI reya is the most promising genotype among the introduced genotypes under study.

Key wards: Parametric and nonparametric stability, genetic stability, dry forage yield, Genotype x environment.

INTRODUCTION

Alfalfa (*Medicago sativa L.*) is a major forage crop in many countries around the world, where, it is cultivated over a wide range of climatic and edaphic conditions ranging from the semi-arid regions to the humid areas. It is recognized as high quality forage for all classes of livestock. In Egypt almost about 90 thousand feddans are grown to alfalfa annually, whereas, demand for the crop is on rise (CAPMAS 2019). Data on the crop showed that, about 18% increase in area devoted to alfalfa has been recorded from the growing season 2014/2015 to 2016/2017, however, the increase in production was only 7% suggesting the need for improvement in crop productivity. Because alfalfa is adapted to conditions of excess heat, drought and salinity, it is preferred than berseem clover in newly reclaimed areas of Nubaria, Ismailia and the 1.5 million feddan reclamation project launched by the Egyptian government in 2014. The need for new cultivars with higher productivity and better feed quality is necessary to cope with the increased demand on the crop.

The decision to select a variety is usually made on the basis of whether the variety's performance is stable and satisfactory in comparison to the performance of commercial ones. Consequently, to develop a variety with high yielding ability and consistency, high attention during selection should be given to the stability performance of the genotypes under different environments and their interaction (Allard and Bradshow 1964). Oushy *et al.* (1999) reported that alfalfa landraces from the New Valley were superior to the introduced genotypes and that the introduced genotypes could be used to reconstruct elite synthetic varieties. Furthermore, Bakheit (1988) reported that only two out of 18 introduced genotypes showed promising forage yields with good phenotypic and genotypic stability indices compared to local cultivars to be selected for ongoing breeding programs for alfalfa improvement.

To evaluate genotypes, Finally and Wilkinson (1963) proposed the average yield of all genotypes grown at particular site in a particular season as a measure of that environment, and used the regression coefficient (b) of the varietal means in its environment as an indicator for the phenotypic stability and adaptation. Nascimento *et al*. (2013), evaluated a methodology of adaptability and phenotypic stability of 92 alfalfa genotypes, where they obtained 20 cuttings along the growing seasons of Nov. 2004 to June 2006 and considered each cut as one environment. Different measures for stability are currently available including; non-parametric measures as the one described by Nassar and Huehn (1987), but also parametric measures for phenotypic stability including Wricke (1962), Eberhart and Russell, (1966), Shukla (1972) Pinthus (1973), and Francis and Kannenberg (1978). For genotypic stability, Tai (1971), suggested partitioning the Genotype x Environment interaction effects into "α", which measures the linear response to environmental effects and "λ" that describes the deviation from the linear response. Accordingly a stable genotype should have α=-1 and λ=1. These measures have often been used in various studies to identify genotypes with better stability to be integrated into breeding programs of different crop species.

This study aimed to identify promising alfalfa genotypes among six introduced alfalfa genotypes in comparison to a local genotype for future breeding program. Evaluation was based on their forage production and forage quality employing different stability measures to study the stability performance of genotypes along their growing period.

MATERIALS AND METHODS

A field trial was conducted at Nubaria Agricultural Research Station which represent calcareous soil type at the North West Delta, during the successive seasons 2014/2015 and 2015/2016. The stability performance of six introduced alfalfa genotypes across different environments in comparison to the local cultivar Ismailia-1was investigated. The introduced genotypes were; Us Stone, MI reya, WL903, WLML9, WL1111 and WL625 HQ, imported form the USA. All plant material was obtained from the Forage Crops Research Department at the Agriculture Research Center, Cairo, Egypt.

The trails were established in 2014 on December 19^{th} and proceeded till 2016 in randomized complete block design, with four replicates. The main soil physical and chemical properties are presented in Table (1) and the meteorological data for the experimental site is summarized in Table (2). Seeds were hand drilled at the rate of 20 Kg/fad. in rows of 20 cm apart and plot size was 12 m^2 (3x4). Seeds were inoculated, prior to seeding, with *Rhizobium melilotii*. A starter dose of nitrogen fertilizer of 20 kg/fad was applied directly, after emergence. Fertilizers applied were super-phosphate (150 kg/fad.) and potassium sulphate (50 kg/fad) each year. The super-phosphate fertilizer was applied once prior to seeding .The amount of potassium sulphate was divided into three doses. Annually, alfalfa cultivars were harvested at 1/10 bloom stage of maturity or when crown shoots reached 4-5 cm in length. Eighteen cuts were obtained starting from April 15^{th} in 2015 with an interval of 30-35 days between cuts and the last cut was on December 18^{th} in 2016. Each cut was considered an environment different from the other cuts according to Nascimento *et al*. (2013). The studied characters were; the mean plant height (cm), determined at harvest by averaging five measurements from each plot, and an average over all cuts was scored. Annual fresh forage yields (kg) were obtained by harvesting and weighing the plot summed over cuts to give total seasonal production and were converted into t/ha. Dry matter percentage (%) was determined from plot samples of about 250g of fresh forage dried in air flow oven at 70^0C for 48 hrs, averaged overall cuts. Annual dry forage yield (t/ha) calculated as the fresh forage yield (t/ha) x dry matter % for each cut and summed over cuts to. Protein percentage (%) was determined using standard methods (A.O.A.C., 1990). Annual protein yield (kg/ha) was calculated as the dry yield (kg/ha) x protein percentage (%) for each cut and summed over cuts. Fiber percentage (%) was determined using standard methods (A.O.A.C., 1990), while annual fiber yield (kg/ha) was estimated dry yield (kg/ha) x fiber percentage (%) for each cut and summed over cuts.

Table 1: Soil physical and chemical properties of Nubaria Agriculture Research Station Farm.

Characteristics	Soil depth	
	0-30 cm	**30-60 cm**
Texture	Sandy loam	Sandy loam
pH	8.23	8.26
Soil past extract:		
EC (dS/m)	1.89	2.17
Cations (meq/L)		
Ca^{2+}	6.55	5.37
Mg^{2+}	1.92	1.69
K^+	1.72	2.34
Na^+	8.71	12.30
Anions (meq/L)		
CO_3^{2-}	-	-
HCO_3^-	5.57	6.50
CL^-	9.72	11.62
SO_4^{2-}	3.61	3.49
Total CaCO3 (%)	21.29	23.14
O.M (%)	0.52	0.37
C.E.C.(meq/100)	11.02	11.88
Total N (%)	0.023	0.025
Available P(mg/Kg)	16.03	10.53
Exchangeable K(mg/Kg)	112.6	88.3

Table 2: Number and date of alfalfa cuts and corresponding meteorological data at the experimental site.

Cutting noumber	Date of cut	Air temp.			Soil temp.		
		Max.	Min.	Average	Max.	Min.	Average
Cut1	15-4-2015	23.00	18.89	16.13	21.41	16.43	19.36
Cut2	15-5-2015	26.16	16.30	20.12	25.07	22.28	24.03
Cut3	13-6-2015	27.29	19.09	23.01	29.29	24.43	27.13
Cut4	13-7-2015	27.30	23.22	24.96	31.22	28.75	29.77
Cut5	15-8-2015	28.65	24.80	26.99	31.38	31.40	31.30
Cut6	20-9-2015	27.35	24.68	25.81	31.78	28.20	30.10
Cut7	30-10-2015	27.03	19.03	22.35	30.25	20.50	25.13
Cut8	20-12-2015	19.14	11.85	15.14	20.03	11.65	15.84
Cut9	12-2-2016	15.85	5.76	11.69	15.65	6.02	11.46
Cut10	18-3-2016	18.78	9.20	13.94	19.27	8.98	14.65
Cut11	29-4-2016	23.98	12.92	17.41	25.37	15.73	21.36
Cut12	28-5-2016	26.81	19.00	21.96	29.73	23.97	26.79
Cut13	24-6-2016	26.69	22.42	24.85	31.91	27.24	29.77
Cut14	16-7-2016	28.51	25.88	27.13	32.79	30.66	31.69
Cut15	13-8-2016	29.26	26.76	28.01	34.05	32.13	32.95
Cut16	24-9-2016	29.41	23.78	26.19	33.37	27.71	30.44
Cut17	4-11-2016	25.35	20.48	22.90	28.04	22.23	25.48
Cut18	18-12-2016	23.98	12.31	17.44	24.52	13.72	17.81

Statistical analysis:

A regular analysis of variance was applied on individual environment, as indicated by Snedecor and Cochran (1989). Combined analysis of variance was performed on seven varieties over eighteen cutting dates (environments) to estimate the effects of genotype x environment interactions on the yielding ability when the assumption of homogeneity of variance can't be rejected. Genotypes were considered fixed, while, cutting dates (environments) were considered random variables. The processes of the analyses were carried out, using SAS program (SAS Institute. 2014).

Stability analysis:

Genotypic stability was measured according to the method described by Tai (1971). Parametric phenotypic stability on the other hand was estimated using eight different measure namely; Wricke (1962), Eberhart and Russell (1966) and Shukla (1972), Lin and Binns (1988) and non-parametric stability according to Nassar and Huehn (1987). The analysis was done by using Gen stat version 18th edition software (VSN International, 2015).

RESULTS AND DISCUSION

Analysis of variance

Analysis of variance for the attributes studied (Table 3), have indicated highly significant differences among genotypes and among environments (cutting dates) for all studies traits. Genotype x environment interactions were highly significant for all traits with the exception of plant height.

1- Plant height:

Mean plant height for the seven tested varieties of alfalfa under different environments was presented in Table (4). The local variety Ismailia-1 showed the highest significant value for average plant height (59.53 cm) compared to the exotic varieties. The varieties WL625HQ, Us stone, WL1111, MI reya and WL903, on the other hand gave the least average plant height of 55.78, 55.90, 56.47, 56.76 and 57.28 cm, respectively. The effects of cutting date (environments), were significant where the environments E11 and E12 (April and May 2016) gave the highest significant average plant height (70.57 and 70.71 cm, respectively), with no significant differences between those two environments. The least average plant height (42.61 cm) was recorded for environment E9 (February 2016). In general, the average plant height across the tested varieties was higher in spring followed by summer. The winter months gave the least average plant height (Table 4). These results in agreement with those reported by Rammah *et al.* (1995) and Oushy *et al.* (2007).

2- Fresh and dry forage yield:

Both fresh and dry forage yields for the seven tested varieties of alfalfa under different environments were presented in Table (5) and Table (6), respectively. In general, the local cultivar, Ismailia-1, significantly outperformed all exotic genotypes recording the highest average fresh and dry forage yield over environments (11.10 t/ha and 2.243 t/ha, respectively).

Table 3: Combined analysis of variance for alfalfa performance, during 2014/2015 and 2015/2016 growing seasons (18 environments).

Source of variation	d.f.	M.S.						
		Plant height	Dry forage yield	Green forage yield	Protein yield	Protein %	Fiber yield	Fiber %
Environments (cutting data) (E)	17	2251.830**	9.212**	186.519**	0.3349**	192.855**	0.62112**	88.465**
Rep/Environment	54	47.465 n.s.	0.105 n.s.	2.462	0.0044	3.128 n.s.	0.0061 n.s.	1.481 n.s.
Genotypes (G)	6	118.833**	1.095**	19.186**	0.0405**	2.638 n.s.	0.05308**	4.841**
G×E	102	24.030 n.s.	0.248**	5.714**	0.0149**	3.107**	0.01150**	1.082**
Combined error	324	22.139	0.082	1.840	0.0028	0.765	0.00428	0.264

Table 4: Mean performance of alfalfa genotypes for plant height (cm) over the 18 studied cuttings.

Environment (E)	Cutting date	Genotypes							
		Us Stone	MI reya	WL903	WLML9	WL1111	WL625HQ	Ismailia-1	Mean
E1	Cut1	46.75	45.50	50.25	46.25	44.25	43.75	46.50	46.179
E2	Cut2	45.75	46.25	51.25	47.50	44.00	44.50	48.75	46.857
E3	Cut3	64.50	64.00	62.75	63.00	64.25	62.75	68.50	64.250
E4	Cut4	66..75	59.25	63.50	65.25	69.00	67.50	71.25	66.250
E5	Cut5	61.75	61.00	64.50	60.50	62.00	59.50	65.50	62.107
E6	Cut6	50.00	52.75	52.00	52.50	49.50	53.00	53.25	51.857
E7	Cut7	48.00	49.25	49.00	49.50	46.50	49.75	50.25	48.893
E8	Cut8	50.25	51.75	54.00	53.25	52.00	51.00	54.75	52.429
E9	Cut9	39.75	47.75	43.00	44.50	39.75	38.50	45.00	42.607
E10	Cut10	44.25	49.25	48.50	48.50	43.50	44.00	55.75	47.679
E11	Cut11	70.25	70.00	66.25	67.00	68.50	71.25	80.75	70.571
E12	Cut12	69.25	67.50	72.00	73.75	71.00	68.25	73.50	70.714
E13	Cut13	66.00	68.75	66.25	69.50	68.25	66.00	66.50	67.643
E14	Cut14	61.75	67.50	65.50	66.50	65.00	63.50	69.00	65.536
E15	Cut15	55.25	52.00	54.00	54.00	55.75	54.25	52.00	53.893
E16	Cut16	53.00	55.50	52.00	59.00	56.25	54.25	58.50	55.500
E17	Cut17	51.75	55.00	57.75	57.00	58.25	54.50	53.00	55.321
E18	Cut18	59.00	59.00	58.50	60.25	59.00	57.75	57.50	58.679
Mean		55.903	56.764	57.278	57.653	56.472	55.778	59.528	57.054
$L.S.D_{0.05}$ Genotypes = 1.577									
$L.S.D_{0.05}$ Env. = 2.563									
$L.S.D_{0.05}$ GxEnv. = n.s									

Table 5: Mean performance of alfalfa genotypes as green forage yield over the 18 cuttings (environments)

Environment (E)	Cut date	Genotypes							
		Us Stone	MI reya	WL903	WLML9	WL1111	WL625HQ	Ismailia-1	Mean
E1	Cut1	3.990	6.840	5.640	6.960	6.450	5.385	7.020	6.040
E2	Cut2	14.900	12.100	10.700	9.350	14.500	9.375	10.550	11.639
E3	Cut3	16.200	13.500	13.350	12.750	13.500	12.000	12.750	13.435
E4	Cut4	10.435	10.465	10.215	9.210	10.420	10.810	13.050	10.657
E5	Cut5	9.120	9.170	8.015	9.090	8.760	9.810	12.200	9.452
E6	Cut6	11.450	11.275	10.660	11.650	10.975	10.775	11.060	11.120
E7	Cut7	10.325	10.170	9.250	10.310	9.800	9.570	9.650	9.867
E8	Cut8	6.600	6.750	6.600	5.950	8.803	6.903	9.450	7.293
E9	Cut9	4.640	6.300	4.950	5.580	4.870	4.124	8.450	5.560
E10	Cut10	5.700	8.250	7.500	7.680	7.950	6.450	12.825	8.050
E11	Cut11	9.600	11.350	10.200	11.925	6.900	8.730	14.250	10.422
E12	Cut12	15.300	15.350	13.550	14.450	13.950	14.250	15.725	14.653
E13	Cut13	15.600	13.200	15.350	13.500	14.700	15.400	15.025	14.682
E14	Cut14	10.250	9.650	10.275	9.630	10.315	10.100	10.490	10.101
E15	Cut15	11.000	10.390	11.275	10.575	11.250	11.075	11.475	11.005
E16	Cut16	9.910	8.690	9.030	9.113	7.890	8.967	8.935	8.933
E17	Cut17	10.000	10.560	9.730	9.380	9.535	9.930	8.460	9.656
E18	Cut18	8.005	7.400	7.750	8.340	7.625	8.270	8.230	7.945
Mean		10.168	10.078	9.668	9.746	9.899	9.551	11.088	10.028
$L.S.D_{0.05}$ bet. Genotypes = 0.724									
$L.S.D_{0.05}$ bet. Env. = 0.796									
$L.S.D_{0.05}$ GxEnv. = 1.918									

The least yielding genotype was the genotype WL625HQ, showing an average fresh forage yield of 9.55 t/ha and an average dry forage yield of 1.86 t/ha (Table 5). Because the interaction between cutting dates and genotype was significant, it was possible to compare genotypes under different cutting dates. The highest fresh forage yield (16.0 t/ha) was recorded for the genotype US-Stone cut in June-2015 (cut3), however this value did not significantly differ from cuts taken from the same genotype in May-2015 (cut2), May-2016 (cut12), June-2016 (cut13) or the genotype MI reya, WLML9, Ismailia-1 cut in May-2016 (cut12) and the genotypes WL903m, WL1111, WL625HQ and Ismailia-1 cut on June-2016 (cut13) as seen in Table (5). The least fresh forage yield values were recorded for the genotypes; US stone, WL903 and WL625HQ, either cut in the April-2015 (cut1) or February-2016 (cut9) and the genotype WLML9 cut in December-2015 (cut8) or in February-2016 (cut9).

Observing the dry forage yield in Table (6) indicated that the highest value (3.43 t/ha) was recorded for the genotype US-stone cut in May-2016 (cut12). This value did not differ significantly from that observed for the same genotype in May-2015 (cut2), or the genotypes MI reya, WL111, WL625HQ and Ismailia-1 cut in May-2016 (cut12) and that of the genotypes MI reya, WL903, WL625HQ and Ismailia-1 cut in June-2016 (cut13). The least value for the dry forage yield (0.68 t/ha) was recorded for the US stone cut in April-2015 (cut1) and that value did not differ significantly from the values for the same genotype cut in December, February and March-2106 (cuts 8, 9 and 10, respectively). At the same time these values did not significantly differ from the values obtained for the genotype WL903 or WL635HQ in cut9 as indicated in Table (6).

The genotype US-Stone seemes to be quite different from all tested genotypes where it produces it maximum forage yield (fresh and dry) very early after plant establishment (cuts 2 and 3) and delivers high yields once again in cut 12, as most genotypes did. Although, US Stone ranks second in both dry and fresh yield after the local cultivar Ismailia-1, the distribution of forage production along the 18 environments experienced high fluctuations compared to Ismailia-1 that presented stability and continuity in forage production along the environments (Table 5 and 6). These results are in full agreement with Abdel-Galil and Hamed (2008), who indicated that the cultivar Ismailia-1 expressed significant performance and wide range of adaptability compared to exotic cultivars.

Table 6: Mean performance of alfalfa genotypes for dry forage yield over the 18 cuttings (environments).

Environment (E)	Cut date	Genotypes							
		Us Stone	MI reya	WL903	WLML9	WL1111	WL625HQ	Ismailia-1	Mean
E1	Cut1	0.677	1.233	1.106	1.330	1.075	0.905	1.189	1.073
E2	Cut2	3.129	2.424	1.810	1.815	2.687	1.868	2.083	2.259
E3	Cut3	2.838	2.129	2.254	2.451	2.542	2.230	2.548	2.442
E4	Cut4	2.224	2.128	2.148	1.958	2.193	2.207	2.707	2.223
E5	Cut5	1.914	2.008	1.550	2.024	1.928	1.732	2.526	1.954
E6	Cut6	2.312	2.170	1.865	2.045	2.107	1.770	2.134	2.057
E7	Cut7	1.998	1.872	1.545	2.063	1.756	1.569	1.801	1.801
E8	Cut8	1.070	1.181	1.180	1.098	1.620	1.220	1.587	1.279
E9	Cut9	0.929	1.353	0.987	1.141	0.956	0.783	1.743	1.127
E10	Cut10	0.975	1.488	1.471	1.484	1.305	1.075	2.176	1.427
E11	Cut11	2.244	2.689	2.425	2.296	1.541	2.070	3.226	2.356
E12	Cut12	3.427	3.141	2.918	3.117	2.678	3.192	3.251	3.103
E13	Cut13	2.868	2.967	3.162	2.714	2.786	3.150	2.983	2.947
E14	Cut14	2.115	2.134	2.304	2.160	2.334	2.098	2.335	2.212
E15	Cut15	2.492	2.363	2.619	2.299	2.350	2.319	2.573	2.413
E16	Cut16	2.163	1.860	1.946	1.931	1.642	1.734	1.975	1.893
E17	Cut17	2.031	2.169	2.034	1.902	1.965	2.014	1.893	2.001
E18	Cut18	1.347	1.339	1.411	1.612	1.443	1.448	1.653	1.465
Mean		2.042	2.036	1.930	1.969	1.940	1.860	2.243	2.003
L.S.D$_{0.05}$ Genotypes = 0.153									
L.S.D$_{0.05}$ Env. = 0.165									
L.S.D$_{0.05}$ GxEnv. = 0.404									

3- Protein yield and protein percentage:

The highest protein percentage was exhibited by MI-reya, where, it gave 19.38% (Table7). The least protein content was US-Stone, which gave 18.093%. It was valuable to note that, the highest percentage of protein matched with harvests, which corresponded to low temperature. Contrary to the productivity, which increased with the increase in temperature. The highest protein percentage were provided by WL1111, WL 625HQ in December-2015 (cut 8), where it was 23.98 and 23.71, respectively. The least protein percentage was resulted from Ismailia-1 in cut 5 (13.04%).

Total protein yield for seven tested varieties of alfalfa under different environments were presented in (Table 8). Ismailia-1recorded the highest protein yield over environments (0.409 t/ha) with insignificantly difference from the variety MI reya (0.392 t/ha). While, the variety WL625HQ gave the least forage protein yield (0.339 t/ha).

Significant high protein yield were obtained under the 12th cutting (May-2016) (0.641 t/ha), Followed significantly by the 13th and 11th cuttings (June and April-2016) (0.528 and 0.514 t/ha). The least protein yield (0.183 t/ha) obtained from first cutting (April-2015).

The highest protein yield obtained from Ismailia-1 (0.761t/ha) under 11th cutting (April-2016) insignificantly by Ismailia-1 and Us- Sotne in 12th cutting (May-2016) (0.722 and 0.726 t/ha respectively). While, first cutting the variety Us Stone gave the least protein yield (0.106 t/ha) followed in significant by WL625HQ (0.146 t/ha).

4- Fiber yield and fiber percentage:

Average of fiber percentage of the 18 environments (Table 9). MI reya (22.96%). Had significant similar fiber percentage as US- Stone (22.645%). The least fiber percentage provided by Ismailia-1, which (22.08%). The highest percentage of fibers was recorded for US- Stone in 14th cutting, (26.53%) 15th cutting, (26.43%). The MI reya showed fiber percentages 26.18%, at cutting 15 and 14, respectively, percentage of the fibers obtained from Ismailia-1 in 9th cutting, (19.56%).

Fiber yield for seven tested varieties of alfalfa under different environments were presented in (Table 10). Ismailia-1 recorded the highest fiber yield over environments (0.498 t/ha) followed significantly MI reya (0.473 t/ha). The variety WL625HQ in gave the least fiber yield (0.416 t/ha). The highest fiber yield were obtained under the 13th cutting (April 2016 (0.721 t/ha), Followed in significantly by the 12th cutting (May 2016) (0.708 t/ha). The least fiber yield (0.222 t/ha) was obtained from the 9th cutting (Fib.-2016).

Table 7: Mean performance of alfalfa genotypes for protein percentage over the 18 cuttings (environments).

Environment (E)	Cutting date	Genotypes							
		Us Stone	MI reya	WL903	WLML9	WL1111	WL625HQ	Ismailia-1	Mean
E1	Cut1	15.700	17.582	17.112	16.690	18.695	16.137	17.082	16.999
E2	Cut2	17.690	18.885	16.922	17.382	20.690	16.530	16.610	17.815
E3	Cut3	15.330	17.435	15.222	13.827	15.805	16.212	15.735	15.652
E4	Cut4	14.172	16.245	13.905	13.157	14.900	16.330	16.095	14.972
E5	Cut5	13.942	14.665	13.752	13.067	13.425	13.702	13.080	13.661
E6	Cut6	16.110	17.700	16.187	16.750	14.767	16.712	16.107	16.333
E7	Cut7	17.550	19.797	18.642	20.757	17.557	18.682	17.595	18.652
E8	Cut8	21.230	21.765	19.605	22.945	23.850	23.605	22.965	22.280
E9	Cut9	20.315	23.230	20.320	22.110	23.195	22.722	21.285	21.882
E10	Cut10	19.662	22.735	20.167	21.287	22.247	22.135	21.057	21.327
E11	Cut11	20.077	21.277	22.340	20.145	21.787	23.100	23.655	21.768
E12	Cut12	21.267	21.787	20.875	19.822	19.172	19.220	22.252	20.627
E13	Cut13	18.222	19.522	19.775	17.685	16.907	17.742	15.540	17.913
E14	Cut14	16.167	17.357	18.800	17.147	17.675	15.902	16.637	17.097
E15	Cut15	18.075	16.925	18.710	17.240	18.607	17.140	16.235	17.561
E16	Cut16	19.242	19.220	20.132	18.775	19.260	17.675	17.157	18.780
E17	Cut17	18.805	20.682	21.160	22.320	19.557	18.845	18.332	19.957
E18	Cut18	22.115	22.047	21.425	21.310	22.022	22.157	22.287	21.909
Mean		18.093	19.381	18.614	18.467	18.895	18.586	18.317	18.622
$L.S.D_{0.05}$ Genotypes = 0.575									
$L.S.D_{0.05}$ Env. = 0.457									
$L.S.D_{0.05}$ GxEnv. = 1.210									

Table 8: Mean performance of alfalfa genotypes for protein yield (t/ha) over the 18 cuttings (environments).

Environment (E)	Cutting date	Genotypes							
		Us Stone	MI reya	WL903	WLML9	WL1111	WL625HQ	Ismailia-1	Mean
E1	Cut1	0.106	0.216	0.189	0.222	0.201	0.146	0.203	0.183
E2	Cut2	0.554	0.457	0.307	0.299	0.556	0.310	0.345	0.404
E3	Cut3	0.436	0.375	0.344	0.337	0.401	0.378	0.399	0.381
E4	Cut4	0.315	0.346	0.297	0.257	0.325	0.360	0.435	0.334
E5	Cut5	0.267	0.293	0.212	0.264	0.259	0.238	0.330	0.266
E6	Cut6	0.372	0.382	0.301	0.343	0.311	0.295	0.344	0.336
E7	Cut7	0.351	0.371	0.288	0.429	0.308	0.293	0.317	0.337
E8	Cut8	0.226	0.257	0.231	0.251	0.386	0.288	0.363	0.286
E9	Cut9	0.188	0.313	0.200	0.252	0.222	0.178	0.371	0.246
E10	Cut10	0.191	0.338	0.296	0.315	0.294	0.238	0.458	0.304
E11	Cut11	0.450	0.571	0.539	0.462	0.334	0.478	0.761	0.514
E12	Cut12	0.726	0.684	0.610	0.617	0.515	0.613	0.722	0.641
E13	Cut13	0.522	0.584	0.622	0.478	0.470	0.559	0.463	0.528
E14	Cut14	0.341	0.370	0.432	0.370	0.412	0.333	0.388	0.378
E15	Cut15	0.450	0.400	0.490	0.396	0.436	0.397	0.417	0.427
E16	Cut16	0.416	0.357	0.391	0.363	0.316	0.306	0.338	0.355
E17	Cut17	0.381	0.448	0.431	0.424	0.384	0.379	0.346	0.399
E18	Cut18	0.298	0.295	0.303	0.343	0.317	0.320	0.368	0.321
Mean		0.366	0.392	0.360	0.357	0.358	0.339	0.409	0.369
$L.S.D_{0.05}$ Genotypes = 0.0283									
$L.S.D_{0.05}$ Env. = 0.0407									
$L.S.D_{0.05}$ GxEnv. = 0.0720									

Table 9: Mean performance of alfalfa genotypes for fiber percentage over the 18 cuttings (environments).

Environment (E)	Cutting date	Genotypes							
		Us Stone	MI reya	WL903	WLML9	WL1111	WL625HQ	Ismailia-1	Mean
E1	Cut1	21.502	20.857	20.360	20.745	20.260	21.755	20.402	20.840
E2	Cut2	20.895	19.960	20.860	21.860	22.290	22.325	20.767	21.279
E3	Cut3	22.905	21.837	23.240	20.702	21.045	20.322	21.372	21.631
E4	Cut4	23.240	23.307	23.235	22.217	22.130	21.725	22.167	22.574
E5	Cut5	24.297	24.955	24.825	24.907	25.072	24.112	23.840	24.572
E6	Cut6	22.240	23.207	22.045	21.145	23.242	22.025	22.422	22.332
E7	Cut7	21.025	21.202	21.727	21.252	21.262	22.055	21.052	21.367
E8	Cut8	20.242	20.200	21.270	21.110	20.125	20.042	19.212	20.314
E9	Cut9	20.080	19.715	19.442	19.902	19.680	20.267	19.282	19.766
E10	Cut10	20.707	21.080	20.305	20.122	20.457	20.510	20.135	20.473
E11	Cut11	21.717	22.220	19.745	20.867	21.807	21.135	20.750	21.177
E12	Cut12	22.312	23.762	23.315	23.375	23.270	22.300	21.750	22.869
E13	Cut13	25.222	24.937	26.037	23.732	24.127	23.072	24.190	24.473
E14	Cut14	26.262	26.217	25.205	25.840	25.080	24.345	25.052	25.428
E15	Cut15	25.805	26.040	24.385	24.972	25.240	25.112	25.280	25.262
E16	Cut16	24.042	25.325	24.190	25.247	24.192	24.547	25.047	24.655
E17	Cut17	23.035	25.207	22.420	23.230	22.192	21.275	22.742	22.871
E18	Cut18	22.085	23.327	22.852	22.370	22.050	22.330	22.100	22.444
Mean		22.645	22.964	22.525	22.422	22.418	22.180	22.087	22.463
$L.S.D_{0.05}$ Genotypes = 0.339									
$L.S.D_{0.05}$ Env. = 0.268									
$L.S.D_{0.05}$ GxEnv. = 0.711									

Table 10: Mean performance of alfalfa genotypes for fiber yield (t/ha) over the 18 cuts studied.

Environment (E)	Cutting date	Genotypes							
		Us Stone	MI reya	WL903	WLML9	WL1111	WL625HQ	Ismailia-1	Mean
E1	Cut1	0.145	0.257	0.225	0.276	0.217	0.196	0.242	0.223
E2	Cut2	0.653	0.483	0.377	0.396	0.599	0.415	0.432	0.480
E3	Cut3	0.650	0.467	0.525	0.507	0.534	0.473	0.544	0.529
E4	Cut4	0.517	0.497	0.499	0.434	0.485	0.478	0.599	0.501
E5	Cut5	0.464	0.501	0.385	0.503	0.483	0.417	0.601	0.479
E6	Cut6	0.514	0.503	0.411	0.432	0.490	0.389	0.478	0.460
E7	Cut7	0.420	0.396	0.335	0.439	0.373	0.346	0.379	0.384
E8	Cut8	0.216	0.238	0.251	0.231	0.326	0.244	0.304	0.259
E9	Cut9	0.186	0.266	0.191	0.226	0.188	0.159	0.335	0.222
E10	Cut10	0.201	0.313	0.298	0.298	0.270	0.221	0.438	0.291
E11	Cut11	0.487	0.597	0.478	0.478	0.334	0.437	0.668	0.497
E12	Cut12	0.764	0.746	0.679	0.727	0.623	0.711	0.706	0.708
E13	Cut13	0.723	0.739	0.823	0.644	0.672	0.726	0.721	0.721
E14	Cut14	0.555	0.559	0.580	0.558	0.585	0.510	0.585	0.562
E15	Cut15	0.642	0.615	0.638	0.574	0.593	0.582	0.650	0.613
E16	Cut16	0.520	0.472	0.470	0.488	0.397	0.425	0.494	0.466
E17	Cut17	0.467	0.547	0.456	0.442	0.436	0.428	0.430	0.458
E18	Cut18	0.297	0.312	0.323	0.360	0.318	0.323	0.365	0.328
Mean		0.468	0.473	0.441	0.445	0.440	0.416	0.498	0.4549
L.S.D0.05 Genotypes = 0.0349									
L.S.D0.05 Env. = 0.0357									
L.S.D0.05 GxEnv. = 0.0925									

WL903 gave the highest fiber yield (0.823t/ha) under the 13th cutting (June-2016) followed insignificantly by Us Stone and MI reya at the 12th cutting (0.764 and 0.746 t/ha) and MI reya in 13th cutting (0.739t/ha). While Us Stone in 1st cutting recorded the least fiber yield (0.0.145 t/ha).

In the first year of experiment a lower content of crude protein was obtained compared to second year for the different harvest stages, because in the first year of the experiment the alfalfa is installing for yield potentiality and most of the nitrogen is used for this. The same effect was pointed out by Decmyenaere *et al*., (2008) and Stanacev *et al*., 2010. According to the harvest stage it was observed a reduction of CP and an increase in CF in the late harvest which could be explained by the evolution of stems and leaves containing more CP and less CF than stems. Moreover Heinriches, 1970, and Babinec *et al*., 2001, pointed- out that, losses of leaves are important because the protein concentration was higher in leaves than in stems. The crude protein content and the crude fiber contents vary between very wide limits depending largely on the development stage alfalfa (Dale, 2011). Crud fiber concentration varied in response to the growing season. Spring and summer growth had higher crude fiber concentration than winter and autumn (Abd El-Halim *et al.* 1992).

Stability analysis:

Combined analysis over environments for fresh and dry forage yield, protein % and fiber % of seven varieties of alfalfa were presented in Table 11. Analysis of variance across genotypes and environments showed that mean squares due to genotypes were highly significant for all traits except for protein %. The environment effect represented a highly significant mean squares for all traits. The environment x genotype interaction was only significant for fresh and dry forage yield, (Protein % and fiber % were not significant).

Table 11: combined analysis over environments for fresh and dry forage yields, protein % and fiber% of seven varieties of alfalfa.

Source of variation	d.f.	M.S.			
		Green forage yield	dry forage yield	Protein %	Fiber %
Total	125	7.737	0.3801	7.222	3.2869
Genotypes	6	4.795**	0.2688**	0.653	1.2148**
Env +Gen. * Env.	119	7.885	0.3857	7.553	3.3914
Env (linear).	1	792.703**	39.286**	819.600**	376.015**
Gen*Env (linear).	6	3.807*	0.1928*	0.609	0.1319
Pooled deviations.	112	1.097	0.0487	0.675	0.2390
Pooled error	377	0.4824	0.0211	0.2758	0.1097

**P≤ 0.01.

Stability measures

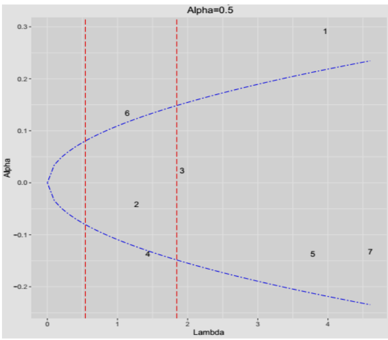
Results on phenotypic stability of the seven genotypes are presented in Table (12). The different stability parameters had inconsistent indications regarding most of the traits. For fresh forage yield MI reya was declared the most stable genotype according to the parameters suggested by Eberhart and Russell (1966). However, the genotype WL903 appeared to be the most stable based on the low variance indicated by the estimates of Wircke (1962) and Shulka (1972), while the genotype Ismailia-1 appeared to be more stable according to the measure of Lin and Binns (1988). The non-parametric method of ranking proposed by Nassar and Huehn (1978) once again favored WL903 as the most stable genotype (Table 12). As to the genotypic stability for the fresh forage yield, Figure (1) plots the relationship between the two estimates λ and α according to Tai (1971) and suggests that the genotypes MI reya and WL903 were located in the average stability area, indicating their genetic stability compared to the other genotypes.

In case of dry forage yield, the genotypes MI reya and WL903 were suggested as the most stable genotypes according to Eberhart and Russell (1966). MI reya was declared also to be the most stable genotype according to the measure of Wircke (1962) and as stable as the genotype WL625HQ according to Shulka (1972). The local genotype Ismailia-1 was declared most stable according to Lin and Binns (1988) estimates and to the estimates of Nassar and Huehn (1987), which also considered WL1111 and WL625HQ to be stable genotypes. Based on the results shown in Figure (1) the genotype MI reya, could be considered genetically stable for that trait than the remaining genotypes.

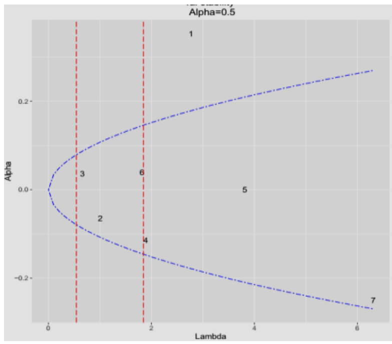
Table 12: Stability parameters of seven alfalfa genotypes across eighteen cuts and their mean values forage green and dry forage yield and protein and fiber percentage.

Genotype	Mean	Parametric stability parameters					Non-parametric stability parameter	
		Eberhart & Russell		Wricke	Shukla	Lin	Nassar & Huehn	
		bi	S^2di	Wi	σ^2	Pi	$Si^{(1)}$	$Si^{(2)}$
Fresh forage yield								
Us Stone	10.167*	1.348*	0.7117*	2.7689	2.389**	3.372	0.2	4.72
MI reya	10.078*	0.937	-0.0369	1.0090	0.309	2.294	0.2	3.84
WL903	9.669	1.036	-0.1821	0.6632	0.093	3.533	0.12	2.54
WLML9	9.747	0.887*	0.3333	1.8905	0.879**	3.586	0.31	5.07
WL1111	9.900	1.000	1.1394**	3.8166	1.822**	3.555	0.22	3.01
WL625HQ	9.551	1.038	0.303	1.8206	0.734**	4.529	0.2	3.53
Ismailia-1	11.089 *	0.753*	2.1906**	6.3112	3.776**	1.037	0.2	4.49
Dry forage yield								
Us Stone	2.042*	1.288*	0.054	3.9631	0.124**	0.130	0.27	5.71
MI reya	2.036*	0.959	0.003	1.2736	0.020	0.089	0.21	3.29
WL903	1.930	1.024	0.016	1.9209	0.035	0.170	0.2	3.94
WLML9	1.969	0.865*	0.006	1.4337	0.032	0.147	0.33	4.06
WL1111	1.941	0.865*	0.051	3.7841	0.090	0.178	0.18	3.24
WL625HQ	1.861	1.132*	0.001	1.1408	0.024	0.209	0.19	2.65
Ismailia-1	2.243*	0.869*	0.066*	4.6060	0.110	0.041	0.2	2.53
Protein percentage								
Us Stone	18.093	0.894*	0.547*	9.8467	0.668**	2.830	0.18	3.29
MI reya	19.381	0.897*	0.450*	8.2929	0.533**	0.682	0.19	2.65
WL903	18.614	0.872*	1.354*	22.7668	1.781**	2.052	0.16	4.29
WLML9	18.468	1.110*	1.174*	19.8971	1.503**	2.110	0.2	3.76
WL1111	18.896*	1.066	1.369	23.0313	1.685**	1.563	0.2	4.47
WL625HQ	18.586	1.063	0.883*	15.2446	1.041**	2.079	0.24	3.59
Ismailia-1	18.317	1.098*	1.279**	21.5741	1.616**	2.725	0.24	4.53
Fiber percentage								
Us Stone	22.645*	1.006	0.288	11.662	0.327**	0.475	0.24	3.65
MI reya	22.964*	1.156*	0.459**	17.893	0.659**	0.327	0.15	3.12
WL903	22.526	1.003	0.644**	24.681	0.795**	0.735	0.26	4.18
WLML9	22.422	1.015	0.298	12.006	0.340**	0.790	0.25	3.06
WL1111	22.418	0.966	0.255	10.453	0.288**	0.812	0.2	3.47
WL625HQ	22.181	0.781	0.440*	17.168	0.739**	1.36	0.26	5.59
Ismailia-1	22.087	1.073*	0.096	4.602	0.096	1.046	0.17	2.12

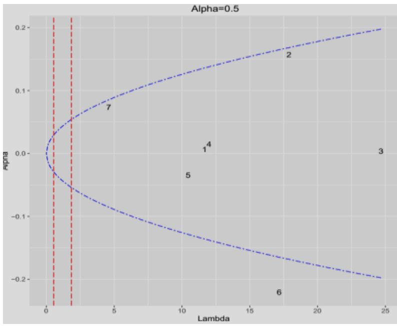
* and ** indicates significance at 0.05 and 0.01 levels, respectively.



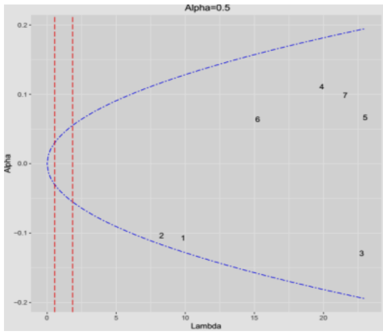
Dry forge yield



Green forge yield



Fiber %



Protein %

Fig.1: Distribution of estimates of genotypic stability parameters of 7 alfalfa cultivars

Phenotypic stability measures for protein percentage almost showed consensus of the stability of MI reya (Table 12). Similar to Eberhart and Russell (1966) estimates, the genotypic estimates according to Tai (1971), as observed from Figure (1), no obvious stability could be declared among the seven studied genotypes. On the other hand the consensus among the stability parameters were in favor of Ismailia-1 for the fiber percentage except for the estimate of Lin and Binns (1988) that recognized MI reya as the most stable genotype. No genotype could reach the threshold of genetic stability as seen in Figure (1), for the fiber percentage trait.

The results presented here indicated that the local cultivar Ismailia-1 was superior to the introduced genotypes regarding its fresh and dry forage yield in addition to recording the least fiber percentage; however, MI reya produced higher protein percentage. When stability measures for the four traits was considered, Isamilia-1 was considered the most stable for fiber percentage based on four different measures tested. MI reya was most stable for protein percentage and more stable than Ismailia-1 for fresh and dry forage yield based on estimates from larger number of the tested stability measures, suggesting that MI reya is the most promising genotype among the introduced genotypes under study. Ismailia-1 remains the superior genotype due to its significantly higher yields compared to the newly introduced genotypes.

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الملخص العربي

معالم المتوازنة للتفاعل بين التركيب الوراثي والبيئة فى بعض التراكيب الوراثية للبرسيم الحجازى

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[١]قسم بحوث العلف مركز البحوث الزراعية – النوبارية

[٢]المعمل المركزي لبحوث التصميم والتحليل الإحصائي - مركز البحوث الزراعية – الجيزة

تهدف هذه الدراسة الى تقييم بعض التراكيب الوراثية المستوردة من البرسيم الحجازى من ناحية الإنتاجية و الجودة مع تقدير بعض معالم الثبات المختلفة. تم تقييم ستة تراكيب وراثية بالإضافة الى الصنف المحلى إسماعيلية ١ في ثمانى عشر بيئة (١٨ حشة) بمحطة بحوث التجارب الزراعية بالنوبارية خلال موسمى الزراعة (٢٠١٥-٢٠١٦ و٢٠١٦-٢٠١٧) في تجربة تصميم القطاعات الكاملة العشوائية في اربعة مكررات. وقد درست العلاقة بين المحصول وأهم عوامله بإستخدام تحليل التباين. إستخدمت خمسة طرق لتقدير معالم الثبات والمظهري وطريقة واحدة لتقدير معالم الثبات الوراثي للصفات تحت الدراسة بهدف إستخدام المعلومات المتاحة من هذه التقديرات لتوجيه برامج التربية. وكانت الصفات تحت الدراسة هي (محصول العلف الاخضر ومحصول العلف الجاف ونسبة البروتين ونسبة الألياف) ويمكن تلخيص النتائج كما يلى: كان تأثير الصنف والبيئة والتفاعل بينهما عالي المعنوية لجميع الصفات تحت الدراسة ما عدا طول النبات حيث لم يكن التفاعل معنوياً.

أوضحت النتائج أن الصنف المحلى إسماعيلية١ قد تفوق معنوياً على التراكيب الوراثية المستوردة فى جميع الصفات المدروسة ماعدا إنتاجية البروتين ونسبة البروتين فى العلف حيث لم يختلف التركيب المستورد MI reya عن الصنف المحلى معنوياً فى إنتاجية البروتين بل وتفوق MI reya على إسماعيلية١ معنوياً فى نسبة البروتين. أما بالنسبة للثبات المظهرى والوراثى للتراكيب الوراثية المستوردة والصنف المحلى فقد إتضح وجود تباين كبير بين مقاييس سلوك الثبات المختلفة تحت الدراسة. وبناء على التوافق ما بين أكبر عدد من المقاييس المدروسة يمكن الوصول إلى الإستنتاجات التالية: الصنف المحلى إسماعيلية ١ هو الأكثر ثباتاً فيما يتعلق بنسبة الألياف بينما التركيب الوراثى MI reya هو الأعلى ثباتاً لصفة نسبة البروتين و يتفوق على الصنف إسماعيلية ١ فى الثبات لصفة المحصول الأخضر والجاف وعليه ينصح بإستعماله في برامج التربية كأصل وراثي حيث يتمتع بقدرة ثبات مرتفعة.