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Evaluation of Some Alfalfa (*Medicago sativa* L.) Germplasm for Yield and Yield Component Traits

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FORTY-TWO alfalfa (*Medicago sativa* L.) landraces collected from different regions in Egypt and three commercial varieties were evaluated in this study. The data collected and analyzed were for plant height, number of tillers per m^2, leaf to stem ratio, green forage weight and dry matter weight. The results indicated that plant height, number of tillers per square meter (m^{-2}), green forage yield, and dry matter weight were higher in the second year than the first year. There was a strong positive correlation between green forage yield with plant height and number of tillers per m^2 in addition, between dry forage yield with plant height and number of tillers per m^2. There was also a highly significant positive relationship between green forage yield and dry forage yield. Using cluster analysis all genotypes were divided into two groups. The first group contained varieties Ismailia 1, Siwa and Nubaria, while the second group contained other genotypes collected from different regions. Maximum similarity index was recorded between genotypes (S18 and S09), while minimum similarity was between genotypes (D12 and Siwa).

Keywords: Alfalfa, Genotypes, Varieties, Egypt, Correlation, Cluster analysis, Maximum similarity and minimum similarity.

Alfalfa (*Medicago sativa* L.) is widely distributed worldwide and grown in highly contrasting environments. This extensive geographical adaptation promotes genetic variation and gives breeders the possibility of using highly diverse gene pools (Maureira *et al.,* 2004).

Genetic diversity among initial selection materials is essential for successful breeding and creation of new cultivars. For the estimation of genetic diversity, different criteria, as morphological, agronomic and physiological characters, pedigree records, molecular markers or a combination of criteria are used. Erosion of diversity in most of the cultivated species emphasizes the need to collect and investigate new germplasm as genetic resources for future breeding programs.

Crop improvement through plant breeding is greatly dependent upon the amount of genetic variation in the available breeding material, type of gene action, the extent of variation, and the heritability of the traits. Such knowledge may also suggest the ways to use germplasm to create new varieties (Bowley & Christie, 1981).

Alfalfa has high green and dry matter yield with considerably high protein and vitamin content (Sabanci, 2009). Yield of alfalfa is the result of yield components effect: number of plants per area, number of stems per plant, weight and height of individual stem (Fick *et al.*, 1988). In the western desert Oases of Egypt alfalfa is widely planted as a forage crop. Most often it is harvested for green fed hay, making silage and less frequently as pasture as it has the highest nutritive value among the forage crops. Alfalfa accessions collected from different geographic regions of the western desert Oases, showed high genetic variation as well as accession derived from the different ancestors (Arab & El Shal, 2013).

The objectives of this study were to determine the productivity of different alfalfa genotypes collected from different regions of the western desert in comparison with varieties. In addition, the genetic diversity among these genotypes was evaluated for further use in plant breeding.

Materials and Methods

Forty-two landraces of alfalfa of different geographic origin were evaluated in this study (Table 1). Three commercial varieties were also included namely Ismailia 1, Siwa and Nubaria. This study was carried out at the Experimental Fields of the New Valley Agricultural Research Station, during three seasons 2011, 2012 and 2013. The genotypes and varieties were sown in an augmented design on the second of November 2011. The field trial was arranged in a randomized complete block design with four replications. The plot area was $6m^2$ and the seed was sown at the rate of 20 kg fed^{-1} in rows 20 cm apart. Nine cuts were performed during the second growing season (2/02, 12/03, 22/04, 27/05, 1/07, 5/08, 10/09, 15/10, and 20/11in 2011/ 2012) and nine cuts during the third growing season (25/12, 10/02, 25/03, 12/05, 13/06, 15/07, 17/08, 18/09 and 20/10 in 2012/2013).

The characters recorded were plant height, number of tillers per m^2, leaf to stem ratio (%), green forage weight (ton fed^{-1}) and dry matter weight (ton fed^{-1}).

The statistical analysis and the relationship between the germplasm were measured by calculating their Euclidean distance and complete linkage using SYSTAT version 7.0 (Wilkinson 1997).

TABLE 1. List of alfalfa germplasm, collection site and GPS data.

No	Name	Collection site from Egypt	Latitude N		Longitude E		Elevation (km)
1	D02	New Valley - El Dakhla	25	42	28	44	145
2	D03	New Valley - El Dakhla	25	28	28	17	118
3	D04	New Valley - El Dakhla	25	45	28	39	145
4	D05	New Valley - El Dakhla	25	53	28	29	92
5	D06	New Valley - El Dakhla	25	42	28	54	107
6	D07	New Valley - El Dakhla	25	42	28	54	107
7	D08	New Valley - El Dakhla	25	39	28	55	117
8	D09	New Valley - El Dakhla	25	36	28	54	101
9	D10	New Valley - El Dakhla	25	34	28	55	98
10	D12	New Valley - El Dakhla	25	37	28	52	113
11	D13	New Valley - El Dakhla	25	33	28	47	129
12	D16	New Valley - El Dakhla	25	30	28	2	117
13	D17	New Valley - El Dakhla	25	30	28	3	115
14	D18	New Valley - El Dakhla	25	32	28	8	137
15	F02	New Valley - Al Farafra	26	47	27	48	101
16	F03	New Valley - Al Farafra	26	49	27	51	96
17	F04	New Valley - Al Farafra	26	52	27	52	114
18	F05	New Valley - Al Farafra	27	3	27	55	67
19	F06	New Valley - Al Farafra	27	3	27	52	60
20	F07	New Valley - Al Farafra	27	4	27	54	61
21	F08	New Valley - Al Farafra	27	8	27	56	48
22	F09	New Valley - Al Farafra	27	3	27	57	46
23	F11	New Valley - Al Farafra	26	51	27	57	98
24	F12	New Valley - Al Farafra	27	4	27	57	77
25	F14	New Valley - Al Farafra	27	6	27	57	58
26	F18	New Valley - Al Farafra	26	50	27	51	95
27	F19	New Valley - Al Farafra	26	52	27	48	85
28	F21	New Valley - Al Farafra	27	7	27	57	51
29	S01	New Valley - El Dakhla	29	11	25	29	-15
30	S02	Matrouh- Siwa	29	11	25	29	-16
31	S04	Matrouh- Siwa	29	11	25	29	-15
32	S05	Matrouh- Siwa	29	11	25	29	-16
33	S06	Matrouh- Siwa	29	10	25	29	-15
34	S07	Matrouh- Siwa	29	12	25	29	-16
35	S08	Matrouh- Siwa	29	11	25	29	-17
36	S09	Matrouh- Siwa	29	12	25	29	-19
37	S10	Matrouh- Siwa	29	13	25	25	-13
38	S16	Matrouh- Siwa	29	16	25	18	-15
39	S18	Matrouh- Siwa	29	11	25	32	-16
40	S11	Matrouh- Siwa	29	13	25	24	-12
41	S12	Matrouh- Siwa	29	13	25	24	-9
42	S13	Matrouh- Siwa	29	13	25	24	-11
43	Ismailia 1	Variety					
44	Siwa	Variety					
45	Nubaria	Variety					

Results and Discussion

The results showed significant differences between the years for yield and yield components indicating the presence of differences among the genotypes for all characters.

Plant height

The average value of plant height (Table 2) show that maximum plant height was recorded for the variety Nubaria (52.35cm) followed by Ismailia 1 with (52.00cm) while the minimum plant height was recorded for D06 (45.78cm). Variation in plant height is genotypic character and; therefore, expressed in the form of better adaptability to environmental conditions.

Number of tillers

The average value of number of tillers per m^2 is presented in Table 2 revealed that maximum number of tillers per m^2 was noted in Nubaria (139.78) followed by Siwa with (137.54). Minimum number of tillers per m^2 (53.4 cm) was attained by genotype D06 (90.74). The differences among various genotypes and cultivars may be due to genetic makeup.

Leaf/stem ratio %

The result presented in Table 2 revealed that all collected genotypes provided significantly higher leaf/stem ratio than the three varieties used in this study. There was great variability between collected genotypes for leaf/stem ratio.

Green forage yield

Green forage yield was higher in the second year (52.02-ton fed^{-1}) than the first (35.39-ton fed^{-1}), but the difference was not statistically significant. Because alfalfa is a perennial crop, it is possible to have greater yield in subsequent years compared to the previous year in the first 2-3 years. Maximum green forage was produced by Nubaria (65.88 ton fed^{-1}) followed by Ismailia 1 with (64.88 ton-fed^{-1}) while D06 (30.38-ton fed^{-1}) had the minimum green forage yield.

Dry forage yield

The mean dry forage yield for all genotypes (Table 3) showed that Nubaria produced maximum values of (18.74 ton fed^{-1}) followed by Siwa with (18.58 ton fed^{-1}), while genotype D06 produced the minimum dry forage yield (7.90 ton fed^{-1}).

TABLE 2. Mean performance for yield components of 45 alfalfa genotypes in 2011/12 and 2012/13 growing seasons.

Genotypes`	Plant height, cm			Number of tillers m^{-2}			Leaf/stem ratio%		
	2011/2012	2012/2013	Average	2011/2012	2012/2013	Average	2011/2012	2012/2013	Average
D02	47.70	48.16	47.93	90.68	106.84	98.76	43.85	43.09	43.47
D03	46.53	47.72	47.12	91.95	103.44	97.69	45.48	43.72	44.60
D04	49.50	47.91	48.70	105.38	106.28	105.83	42.78	43.88	43.33
D05	46.53	47.06	46.79	90.05	98.00	94.03	45.78	44.53	45.15
D06	44.50	47.06	45.78	81.98	99.50	90.74	47.15	44.59	45.87
D07	45.75	47.22	46.48	86.93	100.72	93.82	46.55	44.78	45.67
D08	47.58	48.00	47.79	94.00	106.78	100.39	44.65	44.06	44.36
D09	44.78	48.22	46.50	82.55	106.59	94.57	47.48	43.31	45.39
D10	44.98	48.09	46.53	101.93	107.28	104.60	47.15	43.41	45.28
D12	45.90	47.16	46.53	90.55	118.03	104.29	45.68	44.34	45.01
D13	46.15	48.56	47.36	86.38	113.84	100.11	45.98	42.88	44.43
D16	49.78	48.34	49.06	112.23	107.19	109.71	41.83	43.28	42.55
D17	51.53	49.09	50.31	122.60	116.44	119.52	41.50	42.28	41.89
D18	46.98	49.34	48.16	98.25	116.88	107.56	45.28	41.69	43.48
F02	48.85	49.41	49.13	110.55	115.00	112.78	42.58	41.16	41.87
F03	48.50	48.66	48.58	107.43	103.34	105.38	43.13	43.31	43.22
F04	46.38	49.34	47.86	95.63	112.34	103.98	45.78	42.56	44.17
F05	45.53	48.16	46.84	86.45	106.22	96.33	47.25	43.34	45.30
F06	45.95	49.28	47.62	90.25	112.22	101.23	46.30	43.00	44.65
F07	49.03	49.09	49.06	117.58	107.24	112.41	42.65	42.78	42.72
F08	51.05	49.44	50.24	127.30	113.91	120.60	41.50	42.47	41.98
F09	48.60	48.53	48.57	105.18	107.19	106.18	43.53	43.56	43.54
F11	47.60	49.97	48.78	99.95	115.59	107.77	44.23	42.09	43.16
F12	47.28	49.81	48.54	104.80	117.03	110.92	44.23	42.22	43.22
F14	49.65	49.50	49.58	109.93	114.41	112.17	42.53	42.78	42.65
F18	49.95	48.53	49.24	115.50	107.97	111.73	41.93	43.00	42.46
F19	50.65	47.69	49.17	116.30	99.66	107.98	41.23	44.13	42.68
F21	47.80	49.09	48.45	94.13	113.16	103.64	43.63	42.75	43.19
S01	47.43	48.94	48.18	93.70	111.50	102.60	44.65	42.66	43.65
S02	46.83	48.84	47.83	94.53	110.91	102.72	44.55	42.91	43.73
S04	47.33	47.97	47.65	90.50	100.59	95.55	44.83	44.19	44.51
S05	48.38	49.53	48.95	94.73	112.66	103.69	43.63	42.59	43.11
S06	50.40	48.78	49.59	112.85	106.91	109.88	41.38	43.25	42.31
S07	49.23	49.69	49.46	111.75	114.28	113.02	42.45	42.28	42.37
S08	49.25	49.50	49.38	109.75	115.16	112.45	42.65	42.09	42.37
S09	49.78	49.84	49.81	112.33	115.13	113.73	42.00	42.28	42.14
S10	48.80	49.38	49.09	111.55	113.38	112.46	42.65	42.44	42.54
S16	48.68	49.56	49.12	98.25	114.47	106.36	43.25	42.28	42.77
S18	48.53	50.78	49.65	106.20	120.63	113.41	43.30	41.19	42.24
S11	48.80	50.84	49.82	109.23	124.34	116.78	43.15	41.28	42.22
S12	49.13	51.06	50.09	111.43	123.25	117.34	42.63	39.81	41.22
S13	48.68	49.16	48.92	101.95	114.47	108.21	43.63	42.72	43.17
Ismailia 1	52.40	51.59	52.00	142.30	131.22	136.76	39.95	40.38	40.16
Siwa	52.10	49.94	51.02	142.18	132.91	137.54	40.08	40.59	40.33
Nubaria	52.80	51.91	52.35	142.98	136.59	139.78	39.45	40.19	39.82
Mean	48.30	49.02	48.66	104.50	112.25	108.38	43.68	42.71	43.20
LSD at 0.05	3.01	2.66	2	20.66	15.27	15.39	2.80	2.06	2.05

TABLE 3. Mean performance for yield components of 45 alfalfa genotypes in 2011/12 and 2012/13 growing seasons.

Genotypes	Green forage yield ton fed^{-1}			Dry forage yield ton fed^{-1}		
	2011/2012	2012/2013	Average	2011/2012	2012/2013	Average
D02	22.75	48.50	35.63	6.00	12.92	9.46
D03	24.00	47.50	35.75	6.46	12.57	9.51
D04	38.25	47.25	42.75	10.42	12.58	11.50
D05	25.25	41.50	33.38	6.31	11.11	8.71
D06	17.25	43.50	30.38	4.26	11.54	7.90
D07	19.25	43.00	31.13	5.18	11.48	8.33
D08	26.00	47.50	36.75	7.03	12.84	9.93
D09	15.75	48.50	32.13	3.99	12.97	8.48
D10	19.00	49.00	34.00	4.89	12.98	8.94
D12	21.75	42.25	32.00	5.70	11.18	8.44
D13	21.00	53.75	37.38	5.60	14.55	10.07
D16	42.75	48.75	45.75	11.82	13.04	12.43
D17	52.75	56.00	54.38	14.90	15.39	15.15
D18	29.25	55.25	42.25	8.14	14.97	11.55
F02	40.75	54.50	47.63	11.36	14.95	13.15
F03	37.50	46.00	41.75	10.36	12.09	11.23
F04	26.25	53.50	39.88	7.11	14.57	10.84
F05	18.25	47.25	32.75	4.85	12.62	8.74
F06	21.75	52.50	37.13	5.84	14.21	10.02
F07	46.25	50.25	48.25	12.83	13.46	13.14
F08	55.25	53.75	54.50	15.53	14.60	15.07
F09	36.00	49.25	42.63	10.08	13.20	11.64
F11	30.75	55.25	43.00	8.55	15.27	11.91
F12	34.00	56.00	45.00	9.59	15.44	12.52
F14	40.75	53.25	47.00	11.39	14.32	12.86
F18	47.50	48.00	47.75	13.45	12.81	13.13
F19	47.75	43.00	45.38	13.56	11.32	12.44
F21	27.25	52.75	40.00	7.39	14.42	10.91
S01	26.25	51.25	38.75	7.09	13.72	10.40
S02	28.25	51.00	39.63	7.72	13.74	10.73
S04	25.00	43.50	34.25	6.91	11.53	9.22
S05	28.75	53.50	41.13	7.99	14.57	11.28
S06	44.00	49.00	46.50	12.31	13.30	12.81
S07	43.25	54.25	48.75	12.12	14.68	13.40
S08	43.50	54.50	49.00	12.19	15.04	13.62
S09	42.25	54.50	48.38	11.89	14.90	13.40
S10	42.00	53.00	47.50	11.71	14.34	13.02
S16	31.25	54.75	43.00	8.79	15.06	11.92
S18	38.50	59.25	48.88	10.91	16.38	13.65
S11	41.75	61.50	51.63	11.95	17.14	14.55
S12	44.00	61.00	52.50	12.71	17.01	14.86
S13	35.75	53.50	44.63	9.83	14.44	12.14
Ismailia 1	63.50	66.25	64.88	18.21	18.87	18.54
Siwa	65.50	65.00	65.25	18.83	18.33	18.58
Nubaria	64.25	67.50	65.88	18.42	19.05	18.74
Mean	35.39	52.02	43.71	9.83	14.12	11.97
LSD at 0.05	17.40	10.93	11.73	5.15	3.07	3.59

In general, plant height is an important yield component for alfalfa and it is often used as a criterion when choosing superior genotypes in an early stage of selection (Tuckak *et al.,* 2008). Green yield was higher in the second year (53.56 t ha^{-1}) than the first (46.27 t ha^{-1}) which is in accordance with the results reported by Sabanci *et al.* (2013). Alfalfa forage yield depends upon three factors including plant numbers per unit area, stem numbers per plant and single-stem yield (Smith & Hamel, 2005). Alfalfa yield is the result of yield components effect: number of plants per unit area, number of stems per plant, weight and height of individual stem (Fick *et al*., 1988), while alfalfa quality is a complex trait determined by morphological, chemical and physiological composition (Kirilov, 2001).

Correlations of yield with different yield components of alfalfa genotypes

The correlation coefficients calculated from our results revealed a strong positive correlation between green forage yield with plant height and number of tillers per m^2 as well as between dry forage yield with plant height and number of tillers per m^2. There was also a highly significant positive relationship between green forage yield and dry forage yield (Table 4) .

TABLE 4. Correlation coefficients of yield and some yield components of 45 alfalfa genotypes .

	Plant height	Number of tillers	Leaf/stem ratio	Green forage yield
Number of tillers	0.925**			
Leaf/stem ratio	-0.981**	-0.925**		
Green forage yield	0.969**	0.974**	-0.965**	
Dry forage yield	0.969**	0.974**	-0.965**	0.999**

Selection of promising genotypes in a breeding program based on various criteria, most importantly final crop yield and its quality. Relationships between yield and yield contributing traits also plays an important role (Diz *et al*., 1994; Guler *et al*., 2001; Mohammadi *et al*., 2003 and Rabiei *et al*., 2004).

Cluster analysis

Measurement of genetic distance should be very important for breeding when it is based on a broad range of traits relevant to breeding objectives. Cluster analysis for investigated traits showed diversity among investigated alfalfa genotypes. All genotypes are divided into two groups at a distance of 9.004. The first group contains varieties Ismailia 1, Siwa and Nubaria. The second group contains other genotypes collected from different regions. Leaf/stem ratio is valuable in splitting the studied genotypes into two groups less to 40.33 % included the first group, however up than 40.33 % included the second group (Fig.1).

The second group was divided into two subgroups at a distance of 2.020. The remaining accessions of El Dakhla (D10 and D12) delimited in a separate subgroup, while other accessions were separated in the other subgroup. Maximum similarity was recorded between genotypes (S18 and S09). Minimum similarity was computed between genotypes (D12 and Siwa).

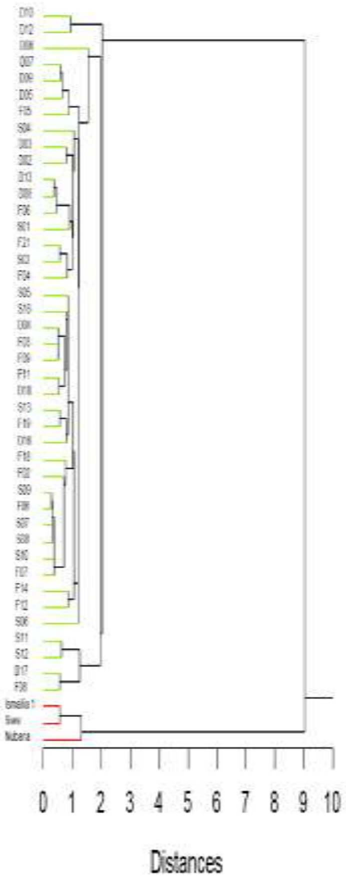

Fig. 1. Phenogram showing the relationships between 45 genotypes of alfalfa, using distance metric of 1- Euclidean correlation coefficient and average linkage method.

Conclusion

It could be concluded that the three commercial varieties take different branchES from the forty-two germplasm. In addition, forty-two germplasm was divided into different branches and indicated that the collections germplasm will widen the genetic base of alfalfa in Egypt and will help plant breeders for the possibility of using highly diverse gene pools to induce new varieties for yield and yield components using suitable methods of hybridization.

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تقييم بعض التراكيب الوراثية من البرسيم الحجازي للمحصول ومكوناته

سليمان عبد المعبود عرب ، محمد حلمي الشال و ناصر محمد حامد*
البنك القومي للجينات والموارد الوراثية و*قسم بحوث محاصيل العلف – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – القاهرة – مصر.

أجرى هذا البحث على إثنيـــن وأربعين مورد وراثي من البـــرسيم الحجازي (*Medicago sativa* L.) بالإضافة إلى ثلاثة أصناف تجارية (إسماعيلية١، سيوة ونوبارية) فى مزرعة محطة البحوث الزراعية بالخارجة بمحافظة الوادى الجديد وذلك فى الفترة من ٢٠١١ حتى٢٠١٣ فى تصميم القطاعات الكاملة العشوائية فى ثلاث مكررات وكانت الصفات المدروسة (إرتفاع النبات – عدد الأفرع في المتر مربع – نسبة الأوراق للسيقان – المحصول الاخضر طن/ف-محصول المادة الجافة طن/ف). أظهرت النتائج ارتفاع معظم القيم للصفات تحت الدراسة (إرتفاع النبات – عدد الأفرع في المتر مربع – المحصول الاخضر طن/ف- محصول المادة الجافة طن/ف) في الموسم الثاني بالمقارنة بالموسم الأول. أظهرت النتائج أن هناك ارتباط قوي بين المحصول الأخضر طن/ف وإرتفاع النبات وأيضا عدد الأفرع في المتر مربع بالإضافة إلى أنه ظهر هناك ارتباط موجب بين كل من محصول المادة الجافة طن/ف وبين ارتفاع النبات وعدد الأافرع في المتر مربع. كما أظهرت علاقة موجبة معنوية بين المحصول الاخضر طن/ف ومحصول المادة الجافة طن/ف. النتائج الموضحة من خلال الشجرة العنقودية أظهرت أن تحليل الشجرة العنقودية قد قسم جميع الموارد الوراثية إلى مجموعتين بحيث أن الثلاث أصناف (إسماعيلية ١، النوبارية وسيوة) من البرسيم الحجازي قد أخذت أحد الفروع منفردة عن الإثنين وأربعين مورد وراثي والتي تم جمعهم من مناطق مختلفة. أظهرت النتائج أن أقصى درجة تقارب وراثي ظهرت بين السلالتين (S18 and S09) وعلى العكس من ذلك وجد أن أقل درجة تقارب وراثي كانت بين السلالتين (D12 and Siwa).