1.4 REGRESSION OF FORAGE YIELDS AGAINST A GROWTH INDEX AS A TOOL FOR INTERPRETATION OF MULTIPLE HARVEST DATA OF ALFALFA GENOTYPES

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Abstract

Twelve genotypes of alfalfa, *Medicago sativa* L., were evaluated for green and dry forage yields under calcareous soil in the farm of Nubaria Research Station during 2010 and 2011seasons. Yield was recorded for nine month separate per year, i.e.; winter (December, and February cuttings); spring (April, and May cuttings); Summer (June, July, and August cuttings) and Autumn season (September and November cuttings). Regressing yield against a growth index associated with harvest date was utilized to describe forage performance of a genotype in an easy and concise format. The growth index was calculated as the mean of all entries at a harvest date minus the grand mean. The obtained regression coefficient (*b*) described an entry yield response over several harvest dates and is indicative of entry performance over variable growth conditions.

Keywords: Forage yield, Alfalfa, Growth index, Regression.

INTRODUCTION

Forage performance can be presented in a concise and easily interpreted format by regressing yield against a growth index associated with harvest dates. The practical value of such a technique will increase as the number of cultivars evaluated in a test increases. Although we have demonstrated this technique on yield data, it should be as useful for interpreting other forage parameters, such as quality measures, for multiple harvest tests comparing large numbers of cultivars (Pedersen *et al.*, 1991). Forages used for grazing are best evaluated by means of grazing trials (Nelson, 1988).Grazing trials are costly in terms of labor, land, and money, however, so only a few cultivars are usually evaluated at any one time (Pedersen and Sleper, 1988). Most forage evaluation is therefore done in small plots with multiple harvests throughout the growing season. Data from multiple harvests are often summarized by presenting yearly totals for each cultivar in addition to the mean for each harvest date (Pedersen *et al.*, 1982). Such data summarization can be effective when evaluating a small number of cultivars. When comparing many cultivars with many harvest dates, however, such data summarization becomes burdensome to use and difficult to interpret.

Multi-environment trials play an important role in selecting the best cultivars and in assessing a cultivar's stability across environments before its commercial release (Vargas *et al.*, 1999). Also, multi-environment trials are important for testing general and specific cultivar adaptation. A cultivar grown in different environments may show significant fluctuation in yield performance relative to other cultivars. These changes are influenced by different environmental conditions and referred to as genetic x environment (GxE) interaction (Carlos and Krazanowski, 2003). Presence of GxE rules out simple interpretative models that have only additive main effects of genotypes and environments (Crossa, 1990 and Kang Magari, 1996).On the other hand, specific adaptation of genotypes in certain environments is fundamental issue to be studied in plant breeding because one genotype may perform well under specific environmental conditions and show poor performance under other conditions.

The more widely used method for detecting stable genotypes is the regression approach (Finlay and Wilkinson, 1963). According to the definition of Eberhart and Russell (1966), a stable preferred genotype would have, approximately, values of b=1, $S^2d=0$ and a high mean performance.

Our objective was to demonstrate how regressing yield against a growth index associated with harvest dates can be utilized to describe performance of forage genotypes over several harvests in a concise and easily interpreted format. This might help in selecting the high forage genotype(s) under the calcareous soil condition of Nubaria region.

MATERIALS AND METHODS

A field trial was conducted in Nubaria Agricultural Research Station (North West of Nile Delta, Egypt). Twelve alfalfa *"Medicago sativa,* L" genotypes were studied (Table 1). Soil physical and chemical properties are summarized in Table 2, whereas, meteorological data of Nubaria site is shown in Fig.1. A randomized complete block designs with four replicates was used. Plot size was 3.0 x 4.0 m with rows 20 cm apart. The seeding rate was 48 $kgha^{-1}$. Seeds were inoculated with *Rhizobium melolitii* prior to seeding. Starter dose of nitrogen (48 kg ha^{-1}) was applied directly after the full establishment. A base dose of super phosphate (15.5%P_2O_5) at the rate of 360 $Kgha^{-1}$ was applied before sowing. 120 $kgha^{-1}$of potassium sulphate (46%K_2O) was applied at three equal doses, yearly. Sowing date was June 9th, 2006. Harvesting date was at 10% blooming or when crown shoot length was 4-5 cm. Nine harvests were obtained each growth year. These harvest dates had covered four growth seasons as follows; winter (December and February cuttings); spring (April and May cuttings); Summer (June, July and August cuttings) and Autumn season (September and November cuttings).

Data were recorded for green forage yield (tha^{-1}). Representative samples was taken at each cut for determining dry matter percentage (65 °C) till weight constancy (A.O.A.C, 1980). Only, the results at the fourth (2010) and the fifth (2011) years of alfalfa growth were used in this study.

Statistical analysis:

Yield was regressed against a growth index calculated as the mean of all entries at a harvest date minus the grand mean .The resulting regression coefficient (b) is a descriptive of genotype yield response over several harvests. A coefficient (b) equal to one indicates that a genotype responds similarly with respect to the growth index over all harvests. Genotypes with b greater than one respond relatively well to favorable growth conditions but respond rather poorly when growth conditions are less than favorable. Conversely, genotypes with b less than one perform relatively well under unfavorable growth conditions but perform relatively poorly under favorable growth conditions. The hypothesis of b=1 was tested for each cultivar using a standard t-test (Steel and Torrie, 1980). Comparison of the regressions of all cultivars was made by testing the null hypothesis b1=b2=-----ba using analysis of covariance procedures (Zar, 1974). The standard error of the estimate ($S_{y \cdot x}$) is indicative of the accuracy of the regression. SAS program was used as a computer statistical program for the statistical analysis of the data (SAS Institute, 2002).

Table 1. The original of the studied alfalfa genotypes.

Genotypes designation	Pedigree
G. 1 – G. 2 – G.3	Land races farm Dahkhla oasis (El kasr in New valley)
G. 4 – G. 5	Land races farm Dahkhla oasis(Palat in New valley)
G. 6 – G. 7	Land races farm Dahkhla oasis(Moot in New valley)
G. 8	Land races farm Kaharga oasis (El farafra inNew valley)
G. 9	Land races farm Kaharga oasis
G. 10	Land races farm Siwa oasis (Marsa Matroh)
G. 11	Land races farm Elbharei oasis(Elgiza)
G. 12	French population

Table 2. Main characteristics of soil in Nubaria Agricultural Research Station.

Characteristic	Soil depth, cm	
	0-30	30-60
Texture	Sandy loam	Sandy loam
pH	8.23	8.26
Soil paste 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 $CaCO_3$,%	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

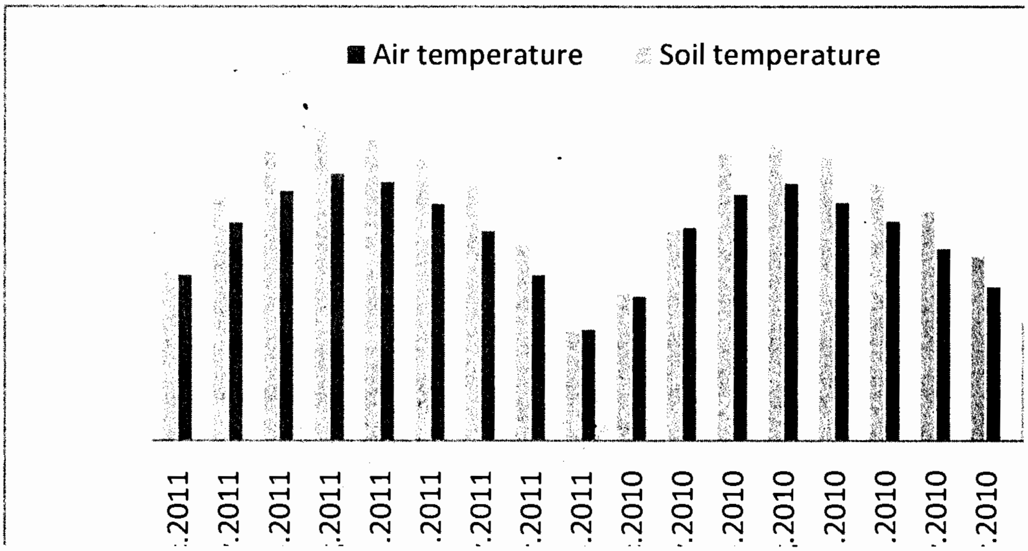

Fig. 1. Meteorological data of Nubaria region in 2010 and 2011 seasons.

RESULTS AND DISCUSSION

Data in Table (3) show the mean squares for green and dry forage yields of alfalfa genotypes as affected by variable environments (harvesting dates). Significant (p ≤0.01) differences among the studied harvesting dates had been detected in both green and dry forage yields. Also, the studied genotypes, showed significant (p ≤0.01) differences in both green and dry forage yields. In the meantime, the interaction between environments (harvesting dates) and genotypes was significant (p ≤0.01) in both green and dry forage yields. This might indicate variable response of genotypes in terms of magnitude or direction to each environment (harvesting dates).

Table 3. Mean squares of green and dry forage yields of twelve alfalfa genotypes as affected by harvesting dates across two years (environments).

S.O.V	d.f.	M.S.	
		Green forage yield (tha^{-1})	Dry forage yield (tha^{-1})
Environments (Env.)	17	435.18**	40.148**
Rep/ Env.	54	7.28	0.471
Genotypes (G)	11	54.47**	3.427**
Env.*G.	187	3.86**	0.329**
Error	594	1.599	0.109

**Significant at p≤0.01

As for green forage yield (Table 4) alfalfa genotypes expressed variable green forage yield in various harvest dates. Meanwhile G.3, G.7, G.10 and G.11 relatively produced higher green forage yield during the period of unfavorable conditions (Autumn and Winter). On the other hand, alfalfa genotypes G.5, G.6, G.7, G.8 and G.12 gave relatively lower green yield during the period of favorable conditions (Spring and Summer).

As for dry forage yield (Table 5), all the studied genotypes produced less than 1.5 tha^{-1} dry forage in December harvest. Meanwhile, the recorded dry forage yield reached maximum in May, June and July harvests (≤ 2.5 tha^{-1}). In the meantime, genotypes: G_2, G_4, G_5, G_{10} and G_{11} maintained higher dry yield productivity in most harvesting dates. Also, G_{10} and G_{11} genotypes produced reasonably high dry yield in Autumn harvesting dates (August, September and November).

Regression of alfalfa genotypes green forage yield against a growth index associated with 18 harvest dates in Nubaria location during 2010 and 2011 years(Table 6) showed that 8 regression coefficients were more than a unity included the G.1, G.2, G.3, G.4, G.5, G.7, G.9 and G.11. This might indicate that, those genotypes respond relatively well with respect to the growth index when the growth condition was favorable, but respond rather poorly when growth condition was less favorable. Genotypes G.6, G.8, G.10 and G12, significantly expressed a regression coefficient less than unity, which might indicate that, these genotypes performed relatively well under unfavorable growth conditions, but performed relatively poor under favorable growth conditions.

Regarding the dry forage yield, values of regression coefficient against growth index associated with 18 harvest dates at Nubaria location during 2010 and 2011 years (Table 7) indicated that five alfalfa genotypes designates G.2, G.3, G.4, G.10 and G.11 significantly expressed a regression coefficient of dry forage yield against growth index more than unity. This might indicate a relatively well response to favorable conditions, along with poor response when growth conditions were less than favorable. Meanwhile, the rest of the studied genotypes (G.1, G.5, G.6, G.7, G.8, G.9 and G.12) showed a significant regression coefficient less than unity, which might indicate that, these genotypes produce relatively good dry forage yields under unfavorable growth conditions, but, produce relatively poor dry forage yield under favorable conditions. The results are confirmed with the results obtained by (Vargas *et al*, 1999; Carlos and Krazanowski, 2003; Crossa, 1990 and Kang Magari, 1996.)

The fact that, alfalfa genotypes vary regarding tolerance to low temperature and potentiality to produce tillers, consequently yield, directed research towards assessing the stability of forage production through variable growth conditions. It seemed from the obtained results that, sorting of genotypes with respect to production sustainability might vary depending upon the measured parameter (green or dry forage field). That is meaning full, when considering either grazing on green vegetation or storing dry hay.

Mean performance of alfalfa genotypes whether in each separate harvest date or as a year mean, seemed insufficient to guide the genotype sustainability over variable growth conditions. The regression coefficient (b) between yield of each harvest and a growth index, proved to be more efficient in separating genotype groups regarding sustainability.

Table 4. Means of alfalfa genotypes green forage yield (t ha-1) as affected by harvesting dates during 2010 and 2011 seasons.

Genotype	Feb.		April		May		June		July		August		September		November		December		Total	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
1	8.211	5.772	13.626	9.699	16.065	10.353	13.566	9.163	7.140	9.818	5.415	8.806	7.616	7.194	9.520	8.509	3.035	2.975	84.180	73.007
2	9.996	6.906	13.566	10.234	17.017	11.008	14.875	8.092	9.996	10.294	10.175	8.628	7.140	7.140	7.795	9.877	3.927	2.975	94.486	75.149
3	9.401	8.628	12.912	10.948	18.386	13.209	16.839	14.387	9.282	11.543	6.605	9.223	9.223	9.223	8.806	9.282	6.605	6.129	98.056	91.820
4	7.914	7.735	12.912	9.342	16.065	9.044	15.232	9.282	7.973	9.401	5.355	7.140	7.557	7.557	7.914	8.092	3.868	3.392	84.788	70.984
5	11.067	7.259	13.388	9.580	15.054	9.699	15.054	9.996	8.568	10.770	4.820	7.497	7.914	7.914	8.925	11.067	4.879	4.225	88.530	78.004
6	8.983	6.724	8.152	8.568	15.768	7.795	14.339	9.223	8.509	7.914	6.486	6.128	6.426	6.426	8.271	8.806	3.868	2.797	80.800	64.379
7	11.484	8.866	11.305	9.866	18.981	10.591	15.351	10.532	8.390	11.722	7.259	8.509	7.735	7.735	9.996	11.186	5.653	5.772	96.151	84.788
8	7.497	7.438	12.555	9.249	14.161	8.628	11.305	7.081	7.973	8.628	5.058	7.319	6.248	6.248	6.902	7.021	3.749	3.094	74.196	64.748
9	10.472	7.616	13.031	10.770	17.790	10.948	14.816	10.710	7.319	9.104	6.426	9.104	8.271	8.271	8.509	10.294	5.653	4.165	92.463	80.980
10	8.806	8.481	13.150	10.056	15.708	10.889	13.864	11.900	8.509	9.758	7.199	6.306	7.795	7.200	9.104	8.985	6.962	4.046	91.095	77.648
11	9.877	7.081	13.745	9.163	17.077	10.828	16.244	11.127	9.818	8.952	4.939	8.330	9.044	9.044	9.520	9.818	5.593	5.296	93.475	79.610
12	7.914	7.438	11.781	6.902	12.674	8.330	12.198	9.580	7.557	8.211	5.891	7.616	6.843	6.843	8.509	7.616	4.522	4.046	77.886	66.581
L.S.D (genotype)	1.8865	1.172	1.580	1.774	2.511	2.129	2.772	2.029	1.703	1.590	2.428	1.281	1.132	1.214	1.448	2.177	1.146	1.519	7.508	8.437

L.S.D (Month) 2010 = 0.198 L.S.D. (Month) 2011 = 0.118

L.S.D (Genotype*month) 2010 = 0.934 L.S.D. (Genotype * month) 2011 = 0.823

Table 5. Means of alfalfa genotypes dry forage yield (t ha-1) as affected by harvesting dates during 2010 and 2011 seasons.

Genotype	Feb.		April		May		June		July		August		September		November		December		Total	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
1	1.963	1.187	3.501	2.284	3.812	2.402	4.254	2.476	1.887	2.653	1.431	2.088	1.929	1.928	2.291	2.223	0.728	0.806	21.797	18.046
2	2.412	1.380	4.148	2.364	4.143	2.543	4.631	2.187	2.694	2.792	2.635	2.073	1.704	1.772	1.838	2.306	0.869	0.595	25.073	17.960
3	2.293	1.856	3.382	2.348	4.243	2.832	5.233	3.893	2.469	3.070	1745	2.055	2.121	2.121	2.199	2.212	1.435	1.432	25.044	21.817
4	1.734	1.580	3.964	2.274	3.922	2.185	4.594	2.655	1.914	2.448	1.353	1.438	1.849	1.848	1.718	1.646	0.946	0.711	21.993	16.784
5	2.544	1.456	3.585	2.227	3.549	2.438	3.736	2.672	2.122	3.013	1.259	1.547	1.961	1.907	2.077	2.365	1.127	0.896	21.960	18.510
6	2.099	1.305	2.781	1.995	3.792	1.815	4.087	2.671	2.456	2.292	1.751	1.439	1.585	1.585	2.028	1.983	0.913	0.561	21.491	15.646
7	2.812	1.777	3.070	2.353	4.315	2.708	4.486	2.948	2.333	3.282	1.782	1.986	1.719	1.719	2.131	2.621	1.345	1.283	23.993	20.933
8	1.644	1.553	3.872	1.923	3.556	1.869	3.549	1. 643	1.851	2.003	1 .228	1.612	1 .425	1.424	1.568	1.502	0.835	0.696	19.572	14.225
9	2.600	1.552	3.767	2.460	4.489	2.501	4.041	2.521	1.723	2.143	1.603	2.268	1.980	1.980	1.944	2.483	1.206	0.874	23.361	18.890
10	2.440	1.787	4.211	2.325	3.648	2.819	4.758	3.410	2.292	2.703	1.975	1.804	1.982	1.949	2.183	2.499	1.636	0.905	25.123	20.166
11	2.167	1.452	4.225	2.026	4.052	2.689	5.065	3.160	2.781	2.534	1.311	1.770	2.173	2.173	2.034	2.062	1.309	1.112	25.108	19.001
12	1.967	1.541	3.913	1.764	2.872	2.130	4.103	2.533	1.990	2.170	1.473	1.929	1.644	1.643	1.938	1.866	1.018	0.890	20.919	16.464
L.S.D (genotype)	0.447	0.241	0.485	0.430	0.546	0.509	0.843	0.610	0.568	0.426	0.611	0.320	0.293	0.277	0.348	0.512	0.265	0.437	2.172	20.027

L.S.D (Month) 2010 = 0.053 L.S.D. (Month) 2011 = 0.179

L.S.D (Genotype*month) 2010 = 0.250 L.S.D. (Genotype * month) 2011 = 0.209

Table 6. Regression of alfalfa genotypes green forage yield against a growth index associated with 18 harvest dates, at Nubaria location during 2010 and 2011years.

Genotype	Green forage yield		
	Mean. (tha^{-1})	b^{+}	$S_{y.x.}$ (tha^{-1})
G.1	8.733	1.094	0.771
G.2	9.424	1.068	1.733
G.3	10.590	1.070	1.271
G.4	8.654	1.087	0.283
G.5	9.315	1.009	0.777
G.6	8.073	0.958	1.171
G.7	10.052	1.029	0.986
G.8	7.787	0.883	0.758
G.9	9.636	1.071	0.462
G.10	9.373	0.915	0.774
G.11	9.748	1.065	0.716
G.12	8.026	0.750	0.423
SE	0.216	0.074	

+b is a regression coefficient that describes cultivar yield response to a varying growth index (the mean of all cultivars at a harvest date minus the grand mean).

$S_{y.x.}$ is the standard deviation from regression for each cultivar.

Table 7. Regression of alfalfa genotype dry forage yield against a growth index associated with 18 harvest dates, at Nubaria location during 2010 and 2011 years.

Genotype	Dry forage yield		
	Mean. (tha^{-1})	b	$S_{y.x.}$ (tha^{-1})
G.1	2.213	0.999	0.044
G.2	2.391	1.109	0.121
G.3	2.603	1.054	0.106
G.4	2.154	1.246	0.039
G.5	2.249	0.884	0.057
G.6	2.063	0.929	0.068
G.7	2.492	0.941	0.091
G.8	1.875	0.923	0.083
G.9	2.341	0.981	0.093
G.10	2.518	1.020	0.052
G.11	2.450	1.149	0.065
G.12	2.077	0.885	0.059
SE	0.064	0.072	

+b is a regression coefficient that describes cultivar yield response to a varying growth index (the mean of all cultivars at a harvest date minus the grand mean).

$S_{y.x.}$ is the standard deviation from regression for each cultivar.

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علاقه الانحداربين محصول العلف ومعامل النمو كوسيله لتفسير بيانات الحش المتعدد للبرسيم الحجازى

مفيدة عبد القادرصيام ، شرين محمد النحراوى

قسم بحوث محاصيل العلف ، معهد المحاصيل الحقليه ، مركز البحوث الزراعية

تم تقييم أثنتى عشرة تركيب وراثى من البرسيم الحجازى *Medicago sativa,* L. من حيث إنتاجية العلف الأخضر والجاف تحت ظروف التربة الجيرية لمزرعة محطة بحوث النوبارية خلال أعوام ٢٠١٠، ٢٠١١. رصدت قياسات المحصول لتسع حشات لكل عام تضمنت الآتى: حشات الموسم الشتوى (ديسمبر وفبراير) وحشات موسم الربيع (إبريل ومايو) وحشات موسم الصيف (يونيه ويوليو وأغسطس) وحشات موسم الخريف (سبتمبر ونوفمبر). استخدم حساب معامل ارتداد المحصول على دليل النمو المرتبط بميعاد الحصاد لوصف سلوك التركيب الوراثى بطريقة بسيطة ومختصرة. حسب دليل النمو على أنه الفرق بين متوسط إنتاجية كل من التراكيب الوراثية فى ميعاد الحصاد والمتوسط العام للإنتاجية . وقد ساعد معامل الارتداد المحسوب فى وصف استجابة إنتاجية التركيب الوراثى لتغير مواعيد الحش وهو بذلك يعبر عن تغير الإنتاجية مع تغير الظروف البيئية.