J. Agric. Sci. Mansoura Univ., 32 (5): 3303 - 3317, 2007

STABILITY OF PERFORMANCE OF SUMMER FORAGES UNDER DIFFERENT NITROGEN LEVELS

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ABSTRACT

Experimental evidence on forage yield stability of summer forage crops and their mixtures with legumes, in Egypt, is sparse. This study was carried out to examine the response and stability of seven summer forages; *i.e*, pearl millet "*Penissetum glaucum* L.", hybrid sorghum 102 "*Sorghum bicolor* L.", sweet sorghum "*Sorghum bicolor* L.", fodder cowpea "*Vigna unguiculata* L." and three grass-cowpea mixtures. Twelve trials were conducted from 2003 to 2005 in the Agricultural Experimental Farm of Alexandria University. All experiments were identical in design and treatments except for nitrogen fertilizer levels. A randomized complete block design with six replications was used to test the differences among the seven summer forages in each experiment. Forages differed for their regression on environmental index. Significant deviations from linearity of response were recorded for green and dry forage yields of hybrid sorghum 102-cowpea mixture and for dry forage yield of cowpea. Positive b_i values were obtained for green and dry forage yields, indicating that the studied forage crops might preferably be grown under a favorable environment; *i.e*, high nitrogen rates.

Hybrid sorghum 102 and its mixture with cowpea were the most responsive forage to changes in environment, whereas, cowpea was the least. Hybrid sorghum 102, millet-cowpea mixture and hybrid sorghum 102-cowpea mixture were suggested to be grown under high nitrogen levels, since it expressed moderate or high values of S^2_d and high levels of response (b_i). Cowpea that had the least rate of response and S^2_d values might be proposed to favor the low fertility environments. Medium fertility environments might be better to suite the remaining studied forage crops.

Keywords: Summer forages, nitrogen levels, forage yield, stability of performance.

INTRODUCTION

The role of mixing fodder legumes with poor quality summer grasses in improving feeding value is indispensable. This improvement, although desired by farmers, comes on the expense of total forage yield.

The cited review on mixing summer grass forages with legumes in Egypt had not ascertained the former claim. Many workers stated that mixtures produced higher forage yields than their component monocultures (Moursi *et al,*1980, with sorghum - cowpea; Mohamed, 1989, with maize-guar; Abdel-Gawad *et al,*1992, and Sherief and Said, 1999, with sorghum - cowpea; Sardina, 2001, with millet, sorghum and maize – cowpea; Zeidan *et al,*2003 with fodder maize – cowpea or fodder maize – guar). On the other hand, Abdel-Gawad *et al*,1985, Abdel-Aal *et al,* 1991 and Ahmed,2007, reported lower green and dry forages of sorghum and surdan mixtures with cowpea or guar than monocultures.

The magnitude of obtained forage yield from summer forage grass monocultures, as well as their mixtures with fodder legumes, varied among the literature because of ; a) The type of grass and / or legume species (Abdel-Aal *et al,* 1991; Abdel-Gawad *et al,* 2000; Sardina, 2001; Aly and

Mowafy, 2002; Zeidan, 2003 and EL-Zanaty, 2006 a), b) Sowing dates of forages(Zeidan *et al,* 2003), c) Water regimes (Sardina, 2001), d) Intercropping pattern (Abdel-Gawad *et al,*2000, Zeidan *et al,* 2003 and EL-Zanaty, 2006a and b) and e) Environment fertility level (Mahmoud *et al,* 1993; Bassal *et al,* 1997 and Gheit *et al,* 1999).

Experimental evidence on forage yield stability of summer forage crops and their mixtures is sparse. Trenbath, (1974), found that the improvement in forage mixtures stability was, at best, marginal. Lin *et al,* (1986), suggested that one obvious way to determine stability was to compare monocultures and mixtures performance over a wide range of environments. Rao and Willey, (1980) and 1981, using a regression technique applied to intercropping, demonstrated that intercrop yields were more stable than sole crop yield. They defined improved stability as less variability over different environments. However, they stated that quantification of the degree of stability was far from straightforward.

The objectives of the present study were to:

1) Examine yield responses of seven summer forage crops; namely, pearl millet "*Penissetum glaucum* L.", hybrid sorghum 102 "*Sorghum bicolor* L.", sweet sorghum "*Sorghum bicolor* L." and fodder cowpea "*Vigna unguiculata* L." and three grass-cowpea mixtures, to variable nitrogen rates and years.
2) Study adaptability and performance stability of green and dry forage yields in summer forage crops and grass-cowpea mixtures at different nitrogen levels and years.

MATERIALS AND METHODS

Twelve experiments were carried out during 2003, 2004 and 2005 summer seasons, in the Agricultural Experimental Farm of Alexandria University, Alexandria,Egypt. The twelve experiments were identical in design and treatments, except for nitrogen fertilizer levels (Table1a). A randomized complete block design, with six replications, was used to test the differences among the seven summer forage monocultures and mixtures. Treatments were as follows; (1). Monoculture of pearl millet (*Penissetum glaucum* L.), (2). Monoculture of hybrid sorghum 102 (*Sorghum bicolor* L.), (3). Monoculture of sweet sorghum (*Sorghum bicolor* L.), (4).Monoculture of fodder cowpea (*Vigna unguiculata* L.), (5). Mixture of millet and fodder cowpea, (6). Mixture of hybrid sorghum 102 and fodder cowpea, (7). Mixture of sweet sorghum and fodder cowpea. Seeds of each monoculture or mixture were hand-drilled in five ridges, 5-m plots with 0.60 m ridge spacing occupying an area of 15 m^2.

Soil samples were taken at random from experimental field area at a depth of 0 – 30cm from soil surface before preparation for both mechanical and chemical analysis (Table 1 - b)

Monocultures were seeded 0n both sides of the ridges, whereas, mixtures were seeded alternatively on ridge sides of fodder cowpea and grass. Seeding rates of mixtures were 50% of both grass and fodder cowpea seeding rate. Seeding rates were 36.0, 48.0, 36.0 and 60.0 $kg.ha^{-1}$ for monocultures of pearl millet, hybrid sorghum 102, sweet sorghum and fodder cowpea, respectively.

Table 1-a: Trials, years and nitrogen fertilizer levels of summer forage monocultures and mixtures in twelve trials.

Trials	Years	Nitrogen fertilizer level ($kg.ha^{-1}$)				Preceding crop	Designation
		Before 1st cut	After 1st cut	After 2nd cut	Total		
1	2003	8	8	8	24	Barseem clover	Env.1
2	2003	32	32	32	96	Barseem clover	Env.2
3	2003	56	56	56	168	Barseem clover	Env.3
4	2003	80	80	80	240	Barseem clover	Env.4
5	2004	8	8	8	24	Barseem Italian rye-grass	Env.5
6	2004	32	32	32	96	Barseem Italian rye-grass	Env.6
7	2004	56	56	56	168	Barseem Italian rye-grass	Env.7
8	2004	80	80	80	240	Barseem Italian rye-grass	Env.8
9	2005	8	8	8	24	Italian rye-grass	Env.9
10	2005	32	32	32	96	Italian rye-grass	Env.10
11	2005	56	56	56	168	Italian rye-grass	Env.11
12	2005	80	80	80	240	Italian rye-grass	Env.12

Table 1-b: Soil analysis for experimental sites during the three years of study.

Character	Year 1	Year 2	Year 3
PH	8.3	8.6	8.5
E.C (ds / m)	1.9	2.2	2.1
Ca CO_3 (%)	0.8	1.0	1.2
Sand (%)	46.0	49.0	52.0
Silt (%)	24.0	23.0	20.0
Clay (%)	30.0	31.0	28.0
N (mg / 100g soil)	180	90	70
P (mg / 100g soil)	1.8	1.4	1.2
K (mg / 100g soil)	62.0	58.0	56.0

Sowing dates were May2nd, May 5th and May 17th in the three successive seasons, respectively. Nitrogen doses were applied in the form of urea (46.5%N) in all seasons. Three center ridges of each plot were end trimmed to 4.0 meters. Seasonal green forage yield was determined by harvesting two random longitudinal meters for three cuts at 60, 100 and 130 days from planting. Dry matter samples were taken at the time of harvest for plot component (s), weighed immediately, and then dried at 70 ̊ C until weight constancy. Percent of dry matter was used for determining seasonal dry forage yield. Data were transformed to mega gram per hectare ($Mg.ha^{-1}$) before analysis.

Data of green and dry forage yields were analyzed, using a combined analysis of variance over environments (Nitrogen x Year) (MSTAT-C package, 1996), since Bartlett's test of homogeneity (F-test) indicated the validity of combined analysis over experiments. Both nitrogen and forages were considered fixed, whereas, year's effect was considered random. Yield stability parameters were studied, following Eberhart and Russell's (1966) regression technique, using the following model with forage (monocultures and mixtures):

$$\mathbf{Y_{ij} = \mu + b_{Ij}\, I_j + d_{ij}}$$

Where, $\mathbf{Y_{ij}}$ = Mean of the $\mathbf{i^{th}}$ forage in the $\mathbf{j^{th}}$ environment (i = 1,2,3,... 7 ; j= 1,2,3,…., 12); **μ** = Mean of the $\mathbf{i^{th}}$ forage over all environments; **b** = Stability parameter for regression in the environmental index $\mathbf{I_j}$, $\mathbf{d_{ij}}$ = Deviation from regression of the $\mathbf{i^{th}}$ forage in the $\mathbf{j^{th}}$ environment.

For each forage crop, a linear regression was fitted between yield and an environmental index, calculated for any given environment by subtracting the mean yield of all environments from that particular experiment mean.

A stable forage is defined as one with a regression coefficient (b) equals to 1.00 and a deviation from regression as small as possible ($S^2{}_d$=0).

RESULTS AND DISCUSSION

Combined analysis of green and dry forage yields:

Combined analysis of variance for green and dry forage yields of summer forages, over twelve environments (three years x four nitrogen levels), was presented in Table 2. Highly significant differences were detected among environments ($p \geq 0.01$) for both characters. These differences were illustrated by significant highly significant differences among environment components; *i.e.*, years ($p\geq 0.05$), nitrogen levels ($p \geq 0.05$) for both triats and the interaction between years and nitrogen ($p \geq 0.01$for the two studied characters). Summer forages yielded highly significantly different ($p \geq 0.01$) green and dry forages. The interaction among the studied environments and summer forages were highly significant ($p \geq 0.01$) for green and dry forage yields. Such significant interaction resulted from three different interactions; *i.e.*, years x forages,($p\geq 0.05$), nitrogen x forages ($p\geq 0.05$) and year x nitrogen x forages ($p\geq 0.01$) for both green and dry forage yields. The results of significant interaction among forage crops and environments were reported by many workers. Among them, the findings of Dangi *et al* (1980), Faris *et al* (1983), Lodhi *et al* (1984), Sharma *et al* (1984), Blade *et al* (1992) and Ahmed *et al* (2002).

Nitrogen effects and interactions:

Green forage yield:

Green forage yields of summer forages over three years, significantly increased with an increase in nitrogen rate from 24 to 96 $kg.ha^{-1}$ by 13.72 Mg. ha^{-1} (Table 3). This value represented 24.0% of the yield obtained from 24 kg. ha^{-1} of nitrogen and amounted to about 191 kilograms green forage per kilogram of nitrogen fertilizer per hectare. The second increaments (96 – 168 $kg.ha^{-1}$)gave an increase of 7.69 $Mg.ha^{-1}$, which amounted to 10.8% of the yield obtained from lower nitrogen rate (96 $kg.ha^{-1}$) and represented about 166.8 kilograms green forage per kilogram of nitrogen per hectare. The third increaments (168 – 240 $kg.ha^{-1}$) yielded higher green forage by 8.43 $Mg.ha^{-1}$.

This yield increase expressed about 11.2% and valued 117.1 kilograms green forage per kilogram of nitrogen per hectare.

Table 2: Combined analysis of variance for green and dry forage yields of summer forages as affected by twelve environments (three years x four nitrogen levels).

S.O.V	d.f.	M.S.	
		Green forage yield (Mg. ha^{-1})	Dry forage yield (Mg.ha^{-1})
Environments (E)	11	6025.81**	1026.82**
Years (Y)	2	883.92*	64.58*
Nitrogen (N)	3	4474.36*	799.60*
Y x N	6	667.53**	162.64**
Reps / Environments	60	215.10	15.84
Forages (F)	6	12540.72**	711.50**
E x F	66	1135.84**	84.57**
Y x F	12	402.53*	26.79*
N x F	18	439.66*	34.71*
Y x N x F	36	293.72**	23.07*
Pooled error	360	178.90	11.44

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

Table 3: Green forage yield over summer forages as affected by nitrogen x year's interaction.

Nitrogen (kg.ha^{-1})	Green forage yield (Mg.ha^{-1})			
	Year 1	Year 2	Year 3	Average
24	62.39	53.69	55.97	57.35
96	77.62 (15.23)* {211.50}¶	69.12 (15.43) {214.40}	66.45 (10.48) {145.60}	71.06 (13.72) {190.50}
168	85.61 (8.00) {11.10}	77.72 (8.60) {119.40}	72.90 (6.45) {89.60}	78.75 (7.69) {166.75}
240	91.98 (6.36) {88.40)	88.40 (10.68) {148.40)	81.16 (8.26) {114.70}	87.18 (8.43) {117.10}
Average	79.40	72.23	69.12	70.39

LSD (0.05) for years: 3.2. **LSD (0.05) for nitrogen: 3.21.**
LSD (0.05) for year x nitrogen: 6.4.
*** Yield increase due to increasing nitrogen level (Mg.ha^{-1}): (yield – yield of lower N level).**
¶ Nitrogen use efficiency (NUE) (kg. kg N^{-1}. ha^{-1}): yield increase (kg) ÷ kg increase in nitrogen level.

Commonly, the highest green forage yield increase was obtained from the first increament in nitrogen rate (24 – 96 kg.ha^{-1}). Whereas, the further increament in nitrogen rates (from 96 to 168 and from 168 to 240) gave an increase in green yield of about 56 and 61% of the former increament, respectively. In the meantime, green forage yield of summer forages, differently responded to nitrogen rates with different years. That was expressed by different yield increase with nitrogen increament from year to another. These results might explain the year x nitrogen interaction and, consequently, the differences among environments.

Nitrogen x forages interaction was shown on Table 4. Green forage of summer grasses, over nitrogen levels and years, was significantly descending from hybrid sorghum 102 (90.12 $Mg.ha^{-1}$), sweet sorghum (82.95 $Mg.ha^{-1}$) to pearl millet (74.20 $Mg.ha^{-1}$).

A yield reduction of 3.47 (insignificant), 14.96 and 8.48 $Mg.ha^{-1}$ (significant), were obtained due to mixing millet, hybrid sorghum 102 and sweet sorghum with cowpea, respectively, over nitrogen levels and years. In the meantime, the yields of hybrid sorghum 102 – cowpea and sweet sorghum – cowpea mixtures were insignificantly different and superior to millet-cowpea mixtures. Cowpea monoculture gave the least green forage yield of 41.91 $Mg.ha^{-1}$ over nitrogen levels and years (Table 4).

The highest responses to the first increament of nitrogen rate from 24 to 96 $kg.ha^{-1}$ were obtained with hybrid sorghum 102, either in monoculture or mixture with cowpea (20.54 and 22.58 $Mg.ha^{-1}$ for the former and the latter, respectively). These figures corresponded to about 285 and 314 kilograms forage per kilogram per hectare of nitrogen fertilizer, respectively. Meanwhile, the lowest responses were expressed by monoculture of cowpea (5.68 $Mg.ha^{-1}$) and sweet sorghum- cowpea mixture (6.17 $Mg.ha^{-1}$). These lowest figures corresponded to about 79 and 86 kg forages per kilogram per hectare of applied nitrogen. The highest responses to the second increament (96 – 168 $kg.ha^{-1}$) were maintained by hybrid sorghum 102 and its mixture with cowpea, but, only as 13.50 and 10.98 $Mg.ha^{-1}$ or bout 188 and 153 kilograms of forages per kilogram per hectare of nitrogen. The yield of cowpea monoculture was reduced by 0.46 $Mg.ha^{-1}$ with the second increament in nitrogen rate. While, the third increament in nitrogen rate gave a yield increase of 2.53 $Mg.ha^{-1}$ which represented only 44.5% of the yield increase due to the first increament (24 – 96 kg nitrogen. ha^{-1})

A substantial green forage yield increase was significant with the third increament in nitrogen rate (196 – 240 $kg.ha^{-1}$) for forage mixtures and was the highest for hybrid sorghum 102 – cowpea mixture (10.35 $Mg.ha^{-1}$ or about 144 kg forage per hectare per kilogram nitrogen). It is valuable to notice that the obtained green yields from forage monocultures, with the third increament in nitrogen (168 – 240 $kg.ha^{-1}$), were significantly higher than the corresponding values at the first increament (24 – 96 $kg.ha^{-1}$), except for cowpea.

As for years x forages interaction, green forage yield of summer forages, over all nitrogen levels, maintained, approximately, the same rank within years. But, the magnitude of yields markedly varied among years. This may explain the significance of that interaction, since yields of the second and the third years were significantly less, amounting to about 91 and 87% of the first year.

T4

This might be affected by the preceding crop in different years, which were barseem clover, barseem – Italian rye-grass mixture and Italian rye–grass in the three successive years, respectively (Table 1-a), and it was further clarified by soil analysis of experiment sites (Table 1-b).

Dry forage yield:

Dry forage response to nitrogen increase was more obvious than the green one (Table 5). The first increament of nitrogen rate (from 24 to 96 $kg.ha^{-1}$) yielded more 4.75 $Mg.ha^{-1}$. That yield increase represented about 45% of the lower nitrogen rate yield (10.56 $Mg.ha^{-1}$). The second and third increaments, (96 to 168 and 168 to 240 $kg.ha^{-1}$) added significantly different yield increases amounted to about 16% of the yield obtained with lower nitrogen rate, for each. So that, nitrogen use efficiency, as kilograms of dry forage per kilogram per hectare of nitrogen, was the highest with the first increament of nitrogen (about 66 kg. kg N^{-1} .ha^{-1}), whereas, only about 35 and 42 kg. kg N^{-1} . ha^{-1} resulted from further increament until 240 kg N . ha^{-1}. Such yield increase, due to increasing nitrogen until 240 kg $N.ha^{-1}$, were about 53 and 64% of the initial yield increase due to the first increament of nitrogen rate (from 24 to 96 $kg.ha^{-1}$).

Table 5: Dry forage yield over summer forages as affected by nitrogen x years interaction.

Nitrogen ($kg.ha^{-1}$)	Dry forage yield ($Mg.ha^{-1}$)			
	Year 1	**Year 2**	**Year 3**	**Average**
24	11.66	9.59	10.44	10.56
96	17.31 (5.65) {78.40}	14.64 (5.05)* {70.14}¶	13.99 (3.55) {49.33}	15.31 (4.75) {65.96}
168	20.62 (3.31) {45.90}	17.18 (2.54) {35.30}	15.60 (1.60) {22.30}	17.80 (2.48) {34.50}
240	23.77 (3.15) {43.80}	19.68 (2.50) {34.80}	18.99 (3.40) {47.30}	20.82 (3.02) {41.90}
Average	18.34	15.27	14.76	16.12

LSD (0.05)fort years: 0.87 **LSD (0.05)for nitrogen: 3.21**
LSD (0.05)for years x nitrogen: 1.74
*** Yield increase due to increasing nitrogen level ($Mg.ha^{-1}$): (yield – yield of lower N level).**
¶ Nitrogen use efficiency (NUE) (kg. kg N^{-1}. ha^{-1}): yield increase (kg) ÷ kg increase in nitrogen level.

Response of summer forages to nitrogen rates over years are shown in Table 6. Hybrid sorghum 102 (19.95 $Mg.ha^{-1}$) and sweet sorghum (20.93 $Mg.ha^{-1}$) were insignificantly different and gave the highest dry forage yield over all nitrogen rates.

T6

Although, yield increase, due to increament of nitrogen rate from 24 to 96 $kg.ha^{-1}$, in hybrid sorghum 102 was 1.6 times the corresponding figure in sweet sorghum (7.85 vs. 4.88 $Mg.ha^{-1}$), sweet sorghum yielded significantly 1.3 times higher dry yield than hybrid sorghum 102 under the low rate of nitrogen (14.66 vs.10.95 $Mg.ha^{-1}$). In the meantime, hybrid sorghum 102 – cowpea mixture yielded significantly the highest dry forage among mixtures over all nitrogen levels (16.35 $Mg.ha^{-1}$). The aforementioned mixture recorded a significant response to nitrogen rate increase only from 24 to 96 and from 168 to 240 $kg.ha^{-1}$. Cowpea, that yielded the least dry forage over nitrogen rates and years (8.52$Mg.ha^{-1}$), insignificantly responded to increased rate of nitrogen from 24 to 240 $kg.ha^{-1}$. Meanwhile, the only significant difference was recorded between 24 and 240 $kg.N.ha^{-1}$.

The fact that the highest yield response was recorded, when nitrogen rate increased from 24 to 96 $kg.ha^{-1}$, was more obvious in hybrid sorghum 102, that exhibited significantly the highest nitrogen use efficiency, whether in monoculture (109.1 kg. kg $N.ha^{-1}$) or in mixture with cowpea (97.7 kg. kg $N.ha^{-1}$). Whereas, cowpea expressed the lowest insignificant value of 26.1 kg. kg $N.ha^{-1}$. Dry forage increases with increasing nitrogen from 168 to 240 $kg.N.ha^{-1}$ were, generally, higher than those from 96 to 168 $kg.N.ha^{-1}$, although several exceptions were noticed.

Regarding years x forages interaction, forages significantly produced higher dry forage in the first year of study, except for hybrid sorghum 102 – cowpea mixture that gave significantly similar yields during the three years and both of cowpea, and sweet sorghum – cowpea mixture that significantly produced similar yields in the second and third years.

Yield stability over environments:

The analysis of variance, presented in Table 2, was further extended, so that, the total sum of squares was partioned into various parts, as shown in Table 7. The analysis showed that the differences among forages were highly significant ($p \geq 0.01$) for green and dry forage yields. Variations, due to forages x environments (linear) (due to regression), were highly significant ($p \geq 0.01$)for both traits, which means that forages differed for their regression on environmental index. Pooled deviations (deviation from linearity of response) were insignificant for the studied traits. Significant deviations from linearity of response were recorded for green and dry forage yields of hybrid sorghum 102 – cowpea mixture and for dry forage yield of cowpea (highly significant).

In Table 8, b_i (regression coefficient) is considered as a parameter of response and S^2_d as a second parameter of stability for the variation in micro changes. All forages showed positive b_i values for green and dry forage yields, indicating that forages might preferably be grown under favorable environments; *i.e.*, high nitrogen fertilizer rates. Hybrid sorghum 102 and its mixture with cowpea showed a tendency for more change in green and dry forage yields per unit change in environmental index (high values of b_i as 1.6433, 1.4212 and 1.559, 1.113 for the two successive forages in green and dry forage yields.).Sweet sorghum, which showed less response behavior of green forage yield (b_i = 0.8671) to change in environments, was of more response dry forage yield. (bi = 1.298). Millet, sweet sorghum, millet – cowpea and sweet sorghum – cowpea mixtures were of less responsive green forage yield. That trend also, was, true for dry forage yield, except for sweet sorghum. Cowpea had the least responsive green and dry yields to the change in environments (fertility and years).

Table 7: Analysis of variance with stability model for green and dry forage yields of summer forages when stability parameters were estimated.

S.O.V.	d.f.	M.S.	
		Green forage yield ($Mg.ha^{-1}$)	Dry forage yield ($Mg.ha^{-1}$)
Forages (F)	6	2090.12**	118.58**
Env. + (F x Env.)	77	1834.41	219.18
Environments (Linear)	1	12128.012	1515.195
Forages x Env. (Linear)	6	354.97**	35.881**
Pooled deviations	70	15.955^{Ns}	1.7606^{Ns}
Millet	10	11.912^{Ns}	0.6772^{Ns}
Sorghum	10	18.135^{Ns}	0.9055^{Ns}
Sweet sorghum	10	14.134^{Ns}	0.2972^{Ns}
Cowpea	10	7.743^{Ns}	5.038**
Millet – cowpea	10	16.315^{Ns}	1.558^{Ns}
Sorghum – cowpea	10	33.378*	2.239*
Sweet sorghum - cowpea	10	10.599^{Ns}	1.610^{Ns}
Pooled error	360	29.817	2.179

*** and ** : significant at 0.05 and 0.01 levels, respectively.**
Ns : not significantly different.

Green forage yield of cowpea, that showed the least values of S^2_d and b_i , seemed to be more stable and less responsive to the change in nitrogen rates or growing year. In the meantime, dry forage yield of that forage crop recorded a high value of S^2_d, but a very low rate of response to environment fertility. So, it might be advised to grow cowpea forage, at a low or medium fertility (nitrogen), environment.

Commonly, forage crops, that expressed moderate or high values of S^2_d and high levels of response to environmental change (b_i) in both green and dry forage yields; *i.e.*, hybrid sorghum 102, millet – cowpea and hybrid sorghum 102 – cowpea mixtures might be suggested to be grown under favorable environmental conditions; *i.e.*, high nitrogen levels. Meanwhile, all forage crops under study showed stable performance for the micro changes in the environments where their estimate of S^2_d was equal to zero, except for sorghum-cowpea and cowpea for both green and dry forage yields and cowpea for dry forage yield.

Also, mean green and dry forage yields, over the studied environments, could be a valuable guide to identify the potential green and dry forage yields under wide environmental condition. In such cases, the important parameters would be the mean yield and b value. Thus, either for green or dry forage yields, the forage crop of grass – cowpea mixture could be selected.

Table 8: Means and stability parameters for green and dry forage yield of summer forage grasses.

Forages	Green forage yield			Dry forage yield		
	$\overline{X}$ (Mg.ha^{-1})	b_i	S^2_{di}	$\overline{X}$ (Mg.ha^{-1})	b_i	S^2_{di}
Millet	74.20	0.9012	-17.89$^+$	16.12	0.9946	-1.230
Sorghum	90.12	1.6433	-11.68	19.95	1.559	-1.001
Sweet sorghum	82.95	0.8671	-15.68	20.93	1.298	-1.610
Cowpea	41.91	0.2184	-22.07	8.52	0.2604	+3.131
Millet – cowpea	70.74	1.0632	-13.50	14.99	0.9724	-0.3491
Sorghum – cowpea	75.16	1.4212	+3.566	16.35	1.113	+0.3324
Sweet sorghum - cowpea	74.47	0.8758	-19.75	15.99	0.7984	-0.2972
Average	73.59	1.000	-13.86	16.12	1.000	-0.1463
S.E	1.58	0.0960		0.43	0.0902	

+ Negative estimates denotes zero variance.

Summary and conclusions:

I: Green and dry forage yields of summer forage monocultures and grass – cowpea mixtures were significantly affected by environment components (years, nitrogen and years x nitrogen interaction). Forages x environments interaction also was significant, indicating different suitable environments for each forage crop. Over forages and years, the highest green forage increase was obtained from the first increament in nitrogen rate (24 – 96 kg.ha^{-1}), whereas, further increase in nitrogen rate (from 96 to 168 and from 168 to 240) gave a lower increase in green yield, amounted to 56 and 61% of the former increase. The magnitude of increase in green forage of forage crops, due to increaments of nitrogen rate, was variable with years, inducing significant years x nitrogen interaction. Over nitrogen levels and years, green yields of forage crops were significantly descending as: hybrid sorghum 102 (90.120 Mg.ha^{-1}), sweet sorghum (82.948 Mg.ha^{-1}) and millet (74.203 Mg.ha^{-1}). Mixtures yielded less green forage than grass monocultures. Meanwhile, mixtures of hybrid sorghum 102 or sweet sorghum with cowpea were insignificantly different and superior to millet – cowpea mixture. Cowpea monoculture gave the least green forage yield of 41.905 Mg.ha^{-1}. Hybrid sorghum 102, whether monoculture or in mixture, recorded the highest green forage response to increasing nitrogen rate from 24 to 96 or from 96 to 168 kg.ha^{-1} (about 285, 188 and 314, 153 kilograms forage per kilogram per hectare of nitrogen for monocultures and mixtures from the first and second increaments, respectively). The lowest responses were recorded by monocultures of cowpea and sweet sorghum – cowpea mixture (79 and 86 kilograms forage per kilogram per hectare of nitrogen applied).

II: Over forage crops and years, the first increament of nitrogen rate gave 45% higher dry forage than lower rates. Whereas, the second and third nitrogen increaments yielded about 16% higher dry yield each. These increases amounted to 66, 35 and 42 kg. kg $N^{-1}.ha^{-1}$ for the three increases in nitrogen rates, respectively. Hybrid sorghum 102 and its mixtures with cowpea recoded the highest dry forage increase with the first increament in nitrogen rate. Cowpea yielded the least dry forage over nitrogen rates and years and was insignificantly affected by increasing nitrogen rate. Over all forages, dry forage increase, with increasing nitrogen from 168 to 240 $kg.N.ha^{-1}$, were, generally, higher than with those from 96 to 168 kg $N.ha^{-1}$.

III: Forages differed for their response to environmental index. Significant deviations from linearity of response were recorded for green and dry forage yields of hybrid sorghum 102 – cowpea mixture and for dry forage yield of cowpea. Positive b_i values for green and dry forages indicated that the studied forage crops might preferably be grown under favorable environments; *i.e.*, high nitrogen rate. Hybrid sorghum 102 and its mixture with cowpea were the most responsive to change in environments, whereas, cowpea had the least response green and dry forage yields. When considering the values of S^2_d, it was suggested to grow hybrid sorghum 102, millet – cowpea and hybrid sorghum 102 – cowpea mixture under high nitrogen levels, since it expressed moderate or high values of S^2_d and high levels of response (b_i). Cowpea that recorded the least rate of response and S^2_d value, might be advised to low fertility environment. Medium fertility environments might better suite the remaining studied forage crops.

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ثبات سلوك الأعلاف الصيفية تحت مستويات مختلفة من الأزوت

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في مصر، هناك حاجة لدليل تجريبي عن مدي ثبات المحصول الناتج عن محاصيل الأعلاف الصيفية ومخاليطها مع محصول بقولي. وقد أجريت هذه الدراسة لاختبار مدي استجابة وثبات إنتاجية سبعة محاصيل أعلاف صيفية وهي: الدخن "*Penisseitum glaucum* L." وهجين سورجم ١٠٢ "*Sorghum bicolor* L." والذرة السكرية "*Sorghum bicolor* L." ولوبيا العلف "*Vigna unguiculata* L." بالإضافة إلي ثلاثة مخاليط لنجيليات العلف السابقة مع لوبيا العلف. وقد نفذت اثنتي عشرة تجربة خلال الفترة من ٢٠٠٣ إلي ٢٠٠٥ في المزرعة التجريبية لجامعة الإسكندرية جمعيها متماثلة في التصميم والمعاملات فيما عدا مستويات التسميد الأزوتي التي طبقت عليها. وقد استخدم في كل تجربة تصميم القطاعات العشوائية الكاملة في ستة مكررات لاختبار الفروق بين محاصيل الأعلاف الصيفية السبعة. وقد أوضحت النتائج أن الأعلاف اختلفت في درجة ارتدادها علي معامل البيئة. كما سجلت انحرافات معنوية عن الاستجابة الخطية لكل من محصولي العلف الأخضر والجاف الناتجين عن مخلوط "هجين سورجم ١٠٢ مع لوبيا العلف" وكذلك لمحصول العلف الجاف الناتج عن لوبيا العلف. ومدلول القيم الموجبة لمعامل الارتداد (b_i) المسجلة لكل من محصول العلف الأخضر والجاف للأعلاف المدروسة، أن المحاصيل المدروسة قد يفضل زراعتها تحت ظروف بيئات موافقة كتلك الناتجة عن مستوي الأزوت المرتفع. وقد كان هجين السورجم ١٠٢ ومخلوطة مع لوبيا العلف أعلي المحاصيل المدروسة استجابة لتغير بيئة الزراعة (مستوي الأزوت)، بينما سجلت لوبيا العلف أقل مستوي للاستجابة.

وقد ينصح بزراعة كل من هجين سورجم ١٠٢ ومخلوط الدخن مع لوبيا العلف ومخلوط هجين سورجم ١٠٢ مع لوبيا العلف تحت مستويات الأزوت المرتفعة، حيث أنها سجلت قيم S^2_d مرتفعة أو متوسطة ومستويات مرتفعة من درجة الاستجابة (b_i). وكذلك فإن لوبيا العلف التي أظهرت أقل قيم من S^2_d واقل درجة استجابة (b_i) فإنه ينصح بزراعتها في ظروف الخصوبة المحدودة. أما باقي المحاصيل المدروسة فيناسبها بيئات متوسطة الخصوبة.

3303 3304 3305 3306 3307 3308 3309 3310 3311 3312 3313 3314 3315 3316 3317

Table 4: Total green forage yield (Mg.ha^{-1}) of summer forage monocultures and their mixtures with cowpea under twelve environments (three years x four nitrogen levels) .

Environments / Forages	Environments												Nitrogen levels				Years			Forages average
	Year 1				Year 2				Year 3											
	Nitrogen levels				Nitrogen levels				Nitrogen levels								Year 1	Year 2	Year 3	
	24	96	168	240	24	96	168	240	24	96	168	240	24	96	168	240				
Pearl millet (M)	36.94	82.75	88.06	94.13	55.61	68.39	75.75	85.89	60.20	67.11	71.28	77.33	59.91	72.75 {178.3}¶ (12.84)	78.36 {77.99} (5.62)	85.79 {103.1} (7.42)*	82.22	71.41	68.98	74.20
Sorghum (S)	70.60	96.37	108.65	127.13	59.50	86.88	101.98	113.67	62.53	70.99	84.11	99.04	64.21	84.75 {285.2} (20.54)	98.25 {187.5} (13.50)	113.28 {208.8} (15.03)	100.69	90.51	79.17	90.12
Sweet sorghum (S.S)	74.38	86.04	98.30	101.64	66.26	84.75	88.31	90.58	62.57	73.04	78.99	90.51	67.74	81.28 {188.1} (13.54)	88.54 {100.8} (7.26)	94.24 {79.3} (5.71)	90.09	82.48	76.30	82.95
Cowpea	37.50	45.49	42.21	47.10	34.89	37.74	42.13	41.46	39.34	45.52	43.05	46.42	37.24	42.92 {78.9} (5.68)	42.47 (-0.01} (-0.46)	44.93 {35.1} (2.53)	43.08	39.06	43.58	41.905
Millet- cowpea	61.97	75.47	86.90	87.45	48.59	65.49	70.95	91.97	50.73	64.33	70.69	74.31	53.76	68.43 {203.7} (14.67)	76.18 {107.6} (7.75)	84.57 {116.6} (8.40)	77.95	69.25	65.01	70.74
Sorghum- cowpea	60.48	83.18	93.12	96.70	52.57	76.01	89.09	107.44	54.31	75.91	85.84	94.96	55.78	78.37 {313.7} (22.58)	89.35 {152.5} (10.98)	99.70 {143.7} (10.35)	83.37	81.28	77.76	75.16
Sweet sorghum-cowpea	67.88	74.04	82.09	89.75	58.39	64.75	75.82	88.80	62.12	68.27	76.36	85.55	62.79	68.96 {85.7} (6.17)	78.09 {116.8} (9.13)	88.03 {138.1} (9.94)	73.44	71.89	73.07	74.47
Environment average	62.39	77.62	85.62	91.98	53.69	69.12	77.72	88.40	55.97	66.45	72.90	81.16					79.40	72.23	69.12	

LSD (0.05)for environments: 6.40 LSD (0.05)for environments x forages: 15.45 LSD(0.05)for nitrogen x forage : 11.43
LSD(0.05)for year x forage: 7.72 LSD(0.05)for forages: 6.99

*** Yield increase due to increasing nitrogen level (Mg.ha^{-1}): (yield – yield of lower N level). ¶ Nitrogen use efficiency (NUE) (kg. kg N^{-1}. ha^{-1}): yield increase (kg) ÷ kg increase in nitrogen level.**

Table 6: Total dry forage yield (Mg.ha^{-1}) of summer forage monocultures and their mixtures with cowpea under twelve environments (three years x four nitrogen levels).

Environments / Forages	Environments																			
	Year 1				Year 2				Year 3								Years			Forages average
	Nitrogen levels				Nitrogen levels				Nitrogen levels				Nitrogen levels				Year 1	Year 2	Year 3	
	24	96	168	240	24	96	168	240	24	96	168	240	24	96	168	240				
Millet (M)	11.53	17.77	21.61	24.73	9.51	14.98	16.27	20.32	10.22	13.93	15.06	17.48	10.42	15.56 (5.14)* {71.40}¶	17.65 (2.09) {29.00}	20.84 (3.20) {44.39}	18.91	15.27	14.17	16.12
Sorghum (S)	12.40	22.46	26.12	33.19	9.94	17.32	22.15	25.35	10.52	16.65	19.26	24.06	10.95	18.81 (7.85) {109.1}	22.51 (3.70) {51.43}	27.54 (5.03) {69.8}	23.54	18.69	17.62	19.95
Sweet sorghum (S.S)	15.95	22.49	28.67	32.14	13.39	18.29	21.64	23.83	14.63	17.84	19.06	23.18	14.66	19.54 (4.88) {67.79}	23.12 (5.58) {49.9}	28.38 (3.26) {45.28}	24.81	19.29	18.68	20.93
Cowpea	7.28	10.34	9.87	10.97	6.30	7.25	7.94	7.65	7.32	9.10	8.50	9.72	9.97	8.90 (41.93) {26.08}	8.77 (-0.128) {-1.78}	9.45 (0.68) {9.40}	9.62	7.28	8.66	8.52
Millet- cowpea	10.97	16.07	20.91	21.07	8.17	13.42	17.95	20.24	9.02	12.14	14.00	15.99	9.39	13.88 (4.49) {62.31}	17.62 (3.75) {52.01}	9.10 (1.48) {20.51}	17.26	14.94	12.79	15.00
Sorghum- cowpea	9.80	16.73	18.18	22.85	8.65	16.76	17.96	21.30	9.46	15.52	17.09	21.86	9.30	16.34 (7.04) {97.7}	17.75 (1.41) {19.6}	52.00 (4.26) {59.1}	16.72	16.17	15.98	16.35
Sweet sorghum- cowpea	13.72	15.32	18.94	21.42	11.13	14.42	16.31	19.07	11.91	12.77	16.20	20.71	12.25	14.17 (1.92) {26.6}	17.15 (2.98) {41.4}	20.40 (6.25) {86.8}	17.35	15.23	15.40	15.99
Environment average	11.66	17.31	20.62	23.77	9.60	14.64	17.18	19.68	10.44	13.99	15.60	19.00	10.56	15.31	17.80	20.82	18.34	15.27	14.76	16.12

LSD (0.05)for environments: 4.60 LSD (0.05)for environments x forages: 3..91 LSD(0.05)for nitrogen x forage : 3.20
LSD(0.05)for year x forage: 1.95 LSD(0.05)for forages: 1.96
*** Yield increase due to increasing nitrogen level (Mg.ha^{-1}): (yield – yield of lower N level). ¶ Nitrogen use efficiency (NUE) (kg. kg N^{-1}. ha^{-1}): yield increase (kg) ÷ kg increase in nitrogen level.**