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COMPATIBILITY AMONG MIXTURES COMPONENTS OF COWPEA AND SUMMER FORAGE GRASSES

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ABSTRACT

Inclusion of a summer forage legume of high compatibility was proposed as a practical approach to balance the feeding value of poor summer forage grasses. The objective of this study was to evaluate the performance of eleven diverse fodder cowpea cultivars, three summer forage grasses (i.e; millet, hybrid 585 sorghum and sweet sorghum) monocultures and their binary mixtures, using field data of 2004 and 2005 seasons. As an average over years and mixtures, dry forage yield was lower by 1.44 Mg ha^{-1} or about 9.76% in mixtures, compared with the average of both cowpea cultivars and grasses monocultures. For both dry forage yield and protein content, performance of mixtures was highly correlated with the average of the two component monocultures. Two- factor analysis for general mixing ability (GMA) showed that fodder cowpea cultivars and summer grasses differed in their ability to determine dry forage yield, protein content and cowpea percentage in harvested forage of mixtures. Three cowpea cultivars (K, D and F) were considered as good combiners of large GMA. Hybrid 585 sorghum was supposed to be the best summer grass for composing mixtures with fodder cowpea with the largest GMA for dry forage yield and protein content in harvested forage. The largest SMA was obtained with the mixture of hybrid 585 sorghum or sweet sorghum with cowpea cultivar K, for protein content and the mixture of millet with the same cultivar for cowpea percentage in harvested forage.

***Key words** : fodder cowpea, mixture, two-factor analysis, mixing ability, summer forage grasses.*

INTRODUCTION

Forage shortage in Egypt is basically pronounced during summer season. Imbalanced feeding, poor feeding value of available summer grasses (low in protein and calcium, but high in carbohydrates) and low digestibility are among the reasons for reduced animal productivity during that season. Inclusion of a summer forage legume of high compatability and yielding potentiality is, so far, the only practical approach.

The genus, *Vigna*, includes many species that have a wide range of adaptation. Such species were successfully used to provide both monocultures of palatable and digestible nourish forage (Bhatti *et al*, 1983, and Ahmed *et al*, 2000) and balanced mixtures with summer grasses (Abd EL-Rhaman and Abd EL-Rahim, (1980); Abd EL-Gawad *et al*,(1985); Abd EL-Aal *et al*, (1991); Mohamed (1992); Sardina, (2001) and EL- Zanaty (2006).

Not all mixtures are equivalent in yielding ability (Trenbath, 1974) and mixtures may perform equal to, better or worse than the mean of the components grown in monocultures (Ahmed, 1999). Thus, a method for estimating the performance of cultivars in mixtures would be of benefit to growers and breeders interested in selecting cultivars that perform well in mixtures.

One method of estimating the compatability of a cultivar in a mixture is to use two-factor analysis similar to combining ability procedure. Jensen and Federer (1965) used modell (methodl)of a combining ability analysis developed by Griffing (1956) on wheat cultivar mixtures. They found a significant general combining effect, which they termed general competing effect (GME), but no specific competing (combining) effect (SME). General competing ability was calculated as the average performance of a cultivar in mixtures. Specific competing ability was considered an indication of how well certain combinations performed, compared to that expected from their average abilities over all mixtures. Gizlice *et al* (1989) adapted method IV, modell of Griffing (1956), to estimate general blending ability (GBA) and an interaction term analogous to SCA of soybean (*Glycine max* L.) cultivars. These terms are analogous to those developed by Federer *et al* (1982) for use in mixtures.

Objectives of this research, hence, were to identify a type of grass that would be more suitable for selecting cowpea cultivars for formation of mixtures and to examine two-factor analysis to study mixing abilities (or compatibilities) of fodder cowpea cultivars.

MATERIALS AND METHODS

Field data:

Eleven genetically diverse cowpea cultivars were chosen for this study (Table 1). This collection represents a wide array of germplasm suitable for use by fodder cowpea breeders. The eleven cultivars were mixed with each of pearl millet "*Pennesitum glaucum* L.", hybrid 585 sorghum "*Sorghum bicolor* L." and a local sweet sorghum "*Sorghum bicolor* L." in two-way combinations so that 33 mixtures were developed. The components were represented in equal proportions within a mixture. Mixtures and cultivar monocultures were tested in two years. Alexandria University Experimental Farm was the site of test in 2004 and 2005 summer seasons. A randomized complete block design was used. Six replicates were employed in each year. Seeds of each monoculture or mixture were hand –drilled in three – ridge, 5-m plots, with 0.60 m ridge

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spacing. Monoculture seeds were planted on both sides of ridge, whereas, in case of mixtures, alternative ridge sides were planted to fodder cowpea and grass species. Seeding rates for binary mixtures were represented by 50% of grass species seeding rate plus 50% of fodder cowpea seeding rate.

Table 1: List of fodder cowpea cultivars included in the study.

Species	Source	Seed color	1000- seed weight (g)	Designation
Vigna unguiculata L.	ITTA	Light green	65.19	A
Vigna unguiculata L.	ITTA	Dark green	58.48	B
Vigna unguiculata L.	ITTA	Green reddish	63.41	C
Vigna unguiculata L.	Sudan	Variegated	72.70	D
Vigna unguiculata L.	ITTA	Grey green	46.81	E
Vigna unguiculata L.	Texas, USA	Red	82.91	F
Vigna sinensis L.	California, USA	Pale green, black hillum	142.2	G
Vigna sinensis L.	Texas, USA	Pale green, larg black hillum	176.2	H
Vigna sinensis L.	California, USA	Bage, no hillum	161.3	I
Vigna radiate L.	Somalia	Green yellowish	64.65	J
Vigna mungo L.	Kenya	Bage, small black hillum	180.4	K

Because of variability in seed index and germination among the studied fodder cowpea cultivars, germination tests were applied prior to planting. Depending on the tests results, seeding rate was approximately fourteen germinable seeds m^{-1} of ridge for all entries. Accordingly, stand density was approximately justified for all cowpea entries. Seeding rates for pearl millet, hybrid 585 sorghum and local sweet sorghum were the recommended rates; i.e, 36.0, 48.0 and 36.0 kg. ha^{-1}.

Sowing dates were May 15th and May 17th in the two successive seasons. Central ridges were end trimmed to 4.0 m and seasonal green forage yield was determined by harvesting two random longitudinal meters for three cuts at 60, 100 and 135 days from planting. A 0.5 m was hand separated to grass and cowpea to determine cowpea by weight. Data of cowpea percentage were presented as averages of the three cuts.

Dry matter samples were randomly taken at the time of harvest for plot component (s), weighed immediately, then, dried at 70 C until weight constancy. Dry matter percentages of mixtures were determined by weighing dry matter components times components percentage in mixture. These figures were used for determining seasonal dry forage yield. Data were transformed to ton. ha^{-1} before analysis. Dried samples were used for determining crude protein (CP) content, according to A.O.A.C. (1980).

Statistical analysis:

Analyses of variance were performed on dry forage yield, protein content and fodder cowpea percentages by using MSTAT-C package (Michigan State University, 1996). Bartlett test of homogeneity (F-test) indicated the validity of combined analysis of data over both seasons. Two -factor analysis provides a method for estimating general and specific mixing ability, which will be referred to as general mixing ability (GMA) and specific mixing ability (SMA) when applied to the performance of forage mixtures. General mixing ability is the average performance of a cultivar in a mixture, and is calculated according to the following model:

$$\overline{X}_{ij} = \mu + g_i + g_j + S_{ij}$$

And, consequently, the g_i, g_j and S_{ij} were calculated as:

$$g_i = \overline{X}_{i\cdot} - \overline{X}_{\cdot\cdot}$$
$$g_j = \overline{X}_{\cdot j} - \overline{X}_{\cdot\cdot}$$
$$S_{ij} = \overline{X}_{ij} - \overline{X}_{i\cdot} - \overline{X}_{\cdot j} + \overline{X}_{\cdot\cdot}$$

Where:

$\overline{X}_{ij}$ = mean of a mixture ij, over replications and years,

$\overline{X}_{i\cdot}$ = mean of all mixtures having cowpea cultivar i,

$\overline{X}_{\cdot j}$ = mean of all mixtures having a grass species j,

$\overline{X}_{\cdot\cdot}$ = overall mean of all the mixtures.

The competitive effect for each mixture combination was calculated as the difference between the mean of the mixture ($\overline{X}_{ij}$) and the expected mean as an average of its two monoculture components as follows:

$$\text{Competitive effect} = \overline{X}_{ij} - (\overline{X}_{mi} + \overline{X}_{mj})/2$$

Where:

$\overline{X}_{mi}$ = the mean of the monoculture i cowpea,

$\overline{X}_{mj}$ = the mean of the monoculture j grass.

The average of all mixtures of a certain grass species was calculated.

RESULTS AND DISCUSSION

Combined analysis of variance for dry forage yield, protein content and cowpea percentage in mixtures (weight / weight) of eleven monocultures of fodder cowpea, three monocultures of summer grasses and all 33 binary mixtures (total of 47 forages) are presented in Table 2.

Table 2: Combined analysis of variance for dry forage yield protein content and cowpea percentage in mixtures of eleven monocultures of fodder cowpea, three monocultures of summer grasses and all 33 binary mixtures grown in 2004 and 2005 summer seasons.

Sources of variation	d.f.	Mean squares		Fodder cowpea (%)	
		Dry forage yield ($Mg.ha^{-1}$)	Protein content (%)	d.f.	M.S.
Years (Y)	1	69.188*	28.819Ns	1	1112.3Ns
Reps / (Y)	10	12.663	12.467	10	293.8
Forages (F):	46	177.418**	79.823**	32	563.2**
Monocultures (monocul)	13	432.4**	107.10**	-	-
Moncul vs. mixt.	1	820.8**	1539.40**	-	-
Mixtures (mixt)	32	53.39**	23.13**	32	563.2**
GMA cowpea cultivars (cowpea)	10	15.19**	34.81**	10	1555.4**
GMA summer grasses (grass)	2	77.49**	170.03**	2	443.7**
SMA (cowpea x grass)	20	7.75**	42.56**	20	6921.0**
YxF	46	1.677Ns	0.104Ns	32	16.50Ns
Combined error	460	2.260	266.4	320	20.95

* and **; indicate significance at 0.05 and 0.01 levels, respectively.
Ns; Not significantly different.
GMA; General mixing ability, SMA; Specific mixing ability.

Years effect, was only significant ($p \geq 0.05$) for dry forage yield. Differences among forages were highly significant ($p \geq 0.01$) for all studied characters. The interaction between years and forages had not reached the level of significance for all studied traits. Orthogonal partition of variation among forages resulted in significant three components; monocultures, monocultures vs. mixtures and among mixtures. The variations among mixtures were analyzed, using two-factor analysis, showing general mixing ability (GMA) cowpea, GMA grass and specific mixing ability (SMA). All these components were significant.

Since the interactions among forages and years were not significant for any of the studied characters, it seems that the performance of monocultures and mixtures did not change under different years. Consequently, partitioning of forages x years interaction to years x GMA and years x SMA were considered insignificant. The insignificant GMA x years effect indicated that relative ability of cowpea cultivar or summer grass to affect the studied characters was uniform across years. Also, the insignificant SMA x years effect indicated that interactions among monoculture components in mixtures resulted in dry forage yield, protein content and cowpea percentage that were similar to that predicted by the GMA of each component monoculture.

Means of dry forage yield, protein content and fodder cowpea percentage of eleven fodder cowpea cultivars, three summer grasses and 33 binary mixtures, combined over the two seasons of study, are shown in Table 3.

Table 3: Means of dry forage yield, protein content and fodder cowpea percentage of eleven fodder cowpea cultivars, three summer grasses and 33 binary mixtures combined over the two growing seasons.

Genotype	Dry forage yield (Mg. ha^{-1})	Protein content (g. kg^{-1})	Fodder cowpea (%) (w/w)
Grass monocultures :			
Millet (M)	17.70	105.8	-
Sorghum 585 (sorg585)	24.61	127.0	-
Sweet sorghum (S.S)	21.50	109.3	-
Average	21.27	114.0	-
Fodder cowpea monocultures:			
A	6.016	175.7	-
B	6.122	178.3	-
C	5.842	173.4	-
D	9.912	187.9	-
E	8.082	184.6	-
F	10.850	187.6	-
G	6.833	182.0	-
H	7.640	182.8	-
I	7.509	184.4	-
J	9.306	184.6	-
K	11.400	188.1	-
Average	8.137	182.7	-
Mixtures:			
Millet - A	9.673	116.3	13.37
- B	9.678	118.4	13.83
- C	9.649	115.1	13.45
- D	14.180	126.7	24.62
- E	11.850	123.5	19.33
- F	14.920	130.3	31.94
- G	10.533	120.8	14.54
- H	11.374	120.8	18.43
- I	11.378	121.9	17.62
- J	13.150	127.1	22.58
- K	15.830	128.5	39.38
Sorg. 585 -A	12.611	133.0	13.63
- B	12.292	133.9	13.25
- C	12.018	133.2	13.76
- D	15.916	154.8	24.65
- E	14.363	143.5	18.76
- F	16.797	161.1	28.09
- G	12.904	135.8	15.73
- H	14.159	140.8	18.66
- I	15.520	138.5	18.96
- J	15.378	150.1	20.59
- K	17.527	165.1	34.05
Sweet sorghum – A	11.362	113.4	14.06
- B	11.224	114.0	12.97
- C	10.829	113.9	12.28
- D	15.515	140.2	27.01
- E	13.544	130.0	17.05
- F	16.21	144.4	24.14
- G	11.864	118.6	13.15
- H	12.666	125.3	14.97
- I	12.908	124.2	14.61
- J	14.508	135.9	19.47
- K	17.02	151.4	23.04
Average	13.314	131.8	19.55
L.S.D. (0.05)	1.203	10.306	3.663

Hybrid sorghum 585 was the highest yielding summer grass, with an average dry forage yield of 24.61 Mg ha^{-1}, while millet was the lowest, with an average yield of 17.70 Mg ha^{-1}. Dry forage yield of fodder cowpea cultivars differed from 5.842 Mg ha^{-1}, for cultivar "C", to 11.400 Mg ha^{-1} ,for cultivar "K". Four cowpea cultivars could be considered as good yielders in monocultures, with an average dry forage yield of ≥ 9.0 Mg ha^{-1}. These were "D" , "F" , "J" and "K" cultivars. Dry forage yield of mixtures ranged from 9.649 Mg ha^{-1}, for millet- "C", to 17.527 Mg ha^{-1} for hybrid sorghum 585 – K. Dry forage yield of binary mixtures could be approximated by an average yield of the two component monocultures. The correlation between dry forage yield of binary mixtures and the average yield of their two component monocultures were over 0.95** (data not shown). Significant differences in dry forage yield among both monocultures and mixtures (Table 2) were obvious in Table (3). The average dry forage yield of all binary mixtures was significantly different from the average of all cowpea cultivars and the average of summer grasses monocultures. Over all mixtures, mixtures were 5.177 Mg ha^{-1} (or about 63.62%) higher yielding than fodder cowpea monocultures, while, they were 7.956 Mg ha^{-1} (or about 37.41%) lower yielding than summer grasses monocultures. In the meantime, of mixtures was 1.440 Mg.ha^{-1} (or about 9.76%), lower than the average of both cowpea and grasses monocultures (Table 3) and the reduction was significant (monoculture vs. mixture). Dry forage yield in mixtures was affected by intraspecific competition among components from early development until cutting time. Apparently, competitive relationships among mixture components for growth habit, shading and tillering potentiality were responsible for the decreased dry forage yield of mixtures. This was in agreement with findings of Abd EL-Aal *et al,* 1991, Yadov and Sharma (1995),Costa and Marinho (2000) and EL-Zanaty (2006).

General mixing ability (GMA) effects in dry forage yield were significant for forage grasses and fodder cowpea cultivars, indicating that some grasses and fodder cowpea cultivars tended to decrease dry forage yield of mixtures differently than others. Specific mixing ability (SMA) effects, also, were significant, indicating that the GMA of either grass and fodder cowpea mixtures did not account for the differences in dry forage yield observed among mixtures.

The tendency for binary mixtures to perform lower than the average of their component monocultures was uniform across years as forage x year interaction was not significant (Table 2). Generally, mixtures tended to perform relatively lower than the mean of their component monocultures, irrespective of the grass forage (Table 4). However, although the average dry forage yield of mixtures was 14.5 , 13.42 and 12.04 Mg ha^{-1} , for hybrid 585 sorghum, sweet sorghum and millet, respectively, the differences between dry forage yield of mixtures and the mean yield of both component monocultures were descending in the same order (-1.87, -1.40 and -0.88 Mg ha^{-1}, respectively). Thus, it is unrealistic to expect that binary mixtures of fodder cowpea, with any grass forage, would yield higher than the highest yielding component monoculture. In the meantime, millet, that had the least contribution in lowering dry forage yield of mixture, seemed to be the least competitive grass species.

Table 4: Average of the two component monocultures and competitive effects of cowpea cultivars in mixtures with summer forage grasses for dry forage yield (Mg.ha^{-1}) over the two seasons of study.

Cowpea cultivar	Average of the two component monocultures (Mg.ha^{-1})			*Competitive effect (Mg.ha^{-1})		
	Millet	$Sorghum_{585}$	S. sorghum	Millet	$Sorghum_{585}$	S. sorghum
A	11.858	15.313	13.781	-2.185	-2.702	-2.419
B	11.91	15.366	13.811	-2.232	-3.074	-2.587
C	11.771	15.226	13.671	-2.122	-3.208	-2.842
D	13.806	17.261	15.706	+0.374	-1.345	-0.191
E	12.891	16.346	14.791	-1.041	-1.983	-1.247
F	14.275	17.73	16.175	+0.645	-0.933	+0.035
G	12.267	15.72	14.167	-1.734	-2.816	-2.303
H	12.67	16.125	14.57	-1.096	-1.966	-1.904
I	12.605	16.059	14.505	-1.227	-0.539	-1.597
J	13.503	16.958	15.403	-0.353	-1.580	-0.985
K	14.55	18.005	16.45	+1.280	-0.478	+0.570
Average	12.919	16.374	14.730	-0.881	-1.875	-1.398

* Competitive effect = $\overline{X}_{ij} - (\overline{X}_i + \overline{X}_j)/2$

Moreover, significant differences, that existed among monocultures and mixtures for protein content (Table 2), were obvious in differences among average of grasses (114.0 g.kg^{-1}), fodder cowpea (182.7 g.kg^{-1}) and mixtures (131.8 g.kg^{-1}) (Table 3). Complementary relationships between grass-forage protein content and cowpea cultivars contributed to mixture protein content (Table3). The simple correlation coefficient between protein content of mixtures and the average protein of the two component monocultures were ≥ 0.83, (data not shown). This may suggest that it would be relatively easy to select components of a mixture that would result in an optimum protein level, based on protein level of monoculture components. Grass species, as well as fodder cowpea cultivars, participated differently to mixtures protein content and cowpea percentage in mixture (w/w) (significant GMA for grasses and cowpea). Meanwhile, the differences in protein content and cowpea percent among mixtures were due to both GMA and SMA (Table 2).

Fodder cowpea cultivar (K) had the highest GMA for dry forage yield, protein content and cowpea percent (w/w) (Table 5), and was clearly superior to all other cowpea cultivars, as a component in mixtures. Cowpea cultivars (F) and (D) could be considered as good combiners with summer grasses, since they had positive GMA values in all studied characters. The least GMA was expressed by cowpea cultivar (C) in the three studied characters.

Table 5: General mixing ability for dry forage yield, protein content and cowpea percentage for 33 binary mixtures of eleven fodder cowpea cultivars and three summer grasses over the two seasons.

Forage	General mixing effects		
	Dry forage yield (Mg.ha^{-1})	Protein content (g.kg^{-1})	Cowpea (%) (w/w)
Fodder cowpea:			
$\hat{g}_A$	-2.099	-10.93	-1.092
$\hat{g}_B$	-2.249	-9.73	-0.975
$\hat{g}_C$	-2.482	-11.10	-1.108
$\hat{g}_D$	+1.890	+8.74	+0.877
$\hat{g}_E$	-0.062	+0.50	+0.047
$\hat{g}_F$	+2.662	+13.44	+1.347
$\hat{g}_G$	-1.547	-6. 76	-0.673
$\hat{g}_H$	-0.581	-2.86	-0.283
$\hat{g}_I$	-0.045	-3.63	-0.363
$\hat{g}_J$	+1.031	+5.87	+0.587
$\hat{g}_K$	+3.482	+16.46	+1.647
Grasses:			
$\hat{g}$ Millet	-1.249	-9.16	-0.918
$\hat{g}$ Sorghum 585	+1.185	+12.70	+1.269
$\hat{g}$ Sweet sorghum	+0.109	-3.54	-0.352
L.S.D (0.05) for g_i (cowpea)	0.709	1.114	2.158
L.S.D (0.05) for g_j (grasses)	0.370	0.582	1.127

Hybrid sorghum 585 had the highest GMA for dry forage yield and cowpea percent, whereas, millet had the least value. Millet had the highest GMA for protein content, followed by hybrid sorghum 585, and sweet sorghum was the least. Commonly, hybrid sorghum 585 had the highest GMA for the three studied characters.

SMA effects were, generally, small relative to GMA effects, although several exceptions were observed (Table 6). SMA effects for dry forage yield were negative. The largest SMA effect for dry forage yield was the interaction between millet and any of cowpea cultivars (K, D and F in that order).

The largest SMA effect for protein content was the mixture between hybrid sorghum 585 and cowpea cultivar D. Millet, that expressed the largest GMA for protein content, had the most frequent positive SMA effects with cowpea cultivars, and it was the highest with cultivar K.

Table 6: Specific mixing ability for dry forage yield, protein content and cowpea percentage for 33 binary mixtures of eleven fodder cowpea cultivars and three summer grasses over the two seasons.

Cowpea cultivar	Specific mixing effects								
	Dry forage yield ($Mg.ha^{-1}$)			Protein content ($g.Kg^{-1}$)			Cowpea percent (%) (w/w)		
	M*	S_{585}	S.S	M	S_{585}	S.S	M	S_{585}	S.S
A	-0.245	+0.211	+0.038	+4.56	-0.060	-3.97	-1.88	-0.53	+2.39
B	-0.085	+0.042	+0.050	+5.46	-0.90	-4.52	-1.08	-0.57	+1.64
C	+0.111	+0.001	-0.105	+3.53	-0.23	-3.30	-1.28	+0.12	+1.13
D	+0.270	-0.465	+0.194	-4.69	+1.53	+3.16	-0.37	-2.25	+2.60
E	-0.105	-0.065	+0.174	+0.33	-1.53	+1.20	-0.61	-0.09	+0.69
F	+0.238	-0.355	+0.116	-5.76	+3.13	+2.66	+2.32	-0.44	-1.9
G	+0.060	-0.045	-0.016	+4.89	-1.97	-2.94	-1.49	+0.79	+0.70
H	-0.065	+0.241	-0.184	+0.99	-0.87	-0.14	-0.48	+0.84	-0.36
I	-0.595	+1.066	-0.475	+2.86	-2.40	-0.47	-1.00	+1.43	-0.43
J	+0.099	-0.145	+0.047	-1.44	-0.30	+1.73	+0.14	-0.76	+0.61
K	+0.334	-0.450	+0.110	-10.67	+4.07	+6.60	+5.67	+1.43	-7.09
L.S.D (0.05) SMA effects		0.753			13.33			3.737	

* M; millet, S_{585}; Hybrid sorghum 585, S.S; Sweet sorghum.

The largest SMA effect for cowpea percentage was the mixture between millet and cowpea cultivar K.

Summary and conclusions:

The present results showed an overall dry forage yield reduction of 1.44 Mg ha^{-1} (or about 9.76%) of mixtures, compared with the average of both cowpea cultivars and grasses monocultures mixtures components. The high correlation of dry forage yield or protein content, in mixtures, and the respective average of the two component monocultures indicated that dry forage yield and protein content of mixture could accurately be predicted from information from monocultures. Mixing ability analysis by two-factor analysis successfully identified fodder cowpea cultivar K as the best combiner for dry forage yield, protein content and cowpea percent (w/w) in mixtures with summer forage grasses, since it had the largest GMA values. The same cultivar maintained the largest SMA effect for cowpea percentage in harvested forage from the mixing with millet. Cowpea D and F cultivars that showed positive GMA in all studied characters were considered as good combiners. Regarding grasses, hybrid sorghum 585 was supposed to be the best summer grass for composing mixtures with fodder cowpea, since it had the highest GMA for dry forage yield, protein content and cowpea percent in harvested forage. Millet, that expressed the least GMA for protein content, had the most frequent positive SMA effects for that character with cowpea cultivars.

Depending on the recent results, it could be concluded that mixing ability analysis was useful in identifying both the type of grass and cowpea cultivar compatability for composing mixtures. For example, high compatability cowpea varieties, as D,F and K, were suitable for high dry forage mixtures with any of the three studied grass species. A mixture of hybrid sorghum 585 or sweet sorghum with cowpea K cultivar was suitable for high protein content forage. A mixture of cowpea K cultivar with millet was suitable for high cowpea percentage forage.

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الملخص العربي

التوافق بين مكونات المخاليط من لوبيا العلف والنجيليات الصيفية

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خلط محصول علف بقولي صيفي علي درجة عالية من التوافق هو أسلوب عملي مقترح لتحقيق اتزان في القيمة الغذائية لنجيليات الأعلاف الصيفية الفقيرة. هدف الدراسة الحالية هو تقييم أداء أحدي عشر صنفا مختلفا من لوبيا العلف وثلاثة نجيليات علف صيفية (الدخن وهجين سورجم ٥٨٥ والذرة الرفيعة السكرية) في زراعات منفردة وفي مخاليط ثنائية من العلف البقولي والنجيلي اعتمادا علي نتائج تقييم حقلي خلال موسمي صيف ٢٠٠٤ و ٢٠٠٥ كمتوسط للسنوات والمخاليط المدروسة، كان محصول العلف الجاف أقل بمقدار ١,٤٤ طن / هكتار (أو ما يقابل ٩,٧٦%) في المخاليط مقارنة بمتوسط محصول الزراعات المنفردة لأصناف اللوبيا والمحصول النجيلي المكونان للمخلوط. وقد كان أداء المخاليط مرتبطا ارتباطا قويا مع متوسط أداء الزراعات المنفردة لمكوناتها وذلك لصفات محصول العلف الجاف ومحتوي العلف من البروتين. وقد أظهر تحليل القابلية للخلط من خلال تطبيق "تحليل عاملين two-factor analysis"أن أصناف لوبيا العلف ونجيليات العلف الصيفية اختلفت في قدرتها (GMA) علي تحديد كل من محصول العلف الجاف والمحتوي من البروتين ونسبة لوبيا العلف في العلف المحصود وذلك للمخاليط. وقد أعطت ثلاثة أصناف من لوبيا العلف قيم مرتفعة من الـــــــ GMA وهي الأصناف "K و D و F" مما يدعو للاعتقاد بأنها ذات قدرة جيدة علي خلط صفاتها لإعطاء مخاليط العلف. كما يعتقد بأن هجين السورجم ٥٨٥ من أفضل نجيليات العلف المدروسة لتكوين مخاليط مع أصناف لوبيا العلف حيث أظهر أعلي قيم للـ GMA لصفات محصول العلف الجاف ومحتوي العلف من البروتين. سُجلت أفضل قيم للـــــSMA للمخلوط "هجين سورجم ٥٨٥ أو الذرة الرفيعة السكرية مع صنف اللوبيا "K" من حيث المحتوي من البروتين، وكذلك للمخلوط "الدخن مع نفس صنف اللوبيا K" لصفة نسبة اللوبيا في العلف المحصود.