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Estimate of Genetic Parameters and Correlation Coefficient in Sudan Grass (*Sorghum sudanense*, (Piper) Staff)

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ABSTRACT

This investigation was laid out during 2013 and 2014 seasons at Sids Agricultural Research Station, Agricultural Research Center, Egypt. The aim of this study were to (1) assess the magnitude of genetic variability parameters and heritability among sixteen exotic genotypes of Sudan grass as compared with two check varieties (Giza 1 and Giza 2) (2) determine correlation among forage yield and its component of Sudan grass genotypes (3) select the appropriate genotype (s) that are suited to Egypt environment. Significant mean squares due to genotypes, years and genotype × year interaction for fresh and dry forage yields at each cut and total yield were observed across the two years. Over the first and second seasons, the genotype IS 3214 was superior and significantly exceeded the check variety (Giza 2) by 6.3% for total fresh forage yield and the genotype IS 720 (Piper) was superior and significantly exceeded the check variety (Giza 1) by 6.6% for total dry forage yield. Tests of significance of mean squares showed significant differences for genotypes, years and genotype × year interaction for most of morphological characters. The genotype of Sudan grass IS 720 (Piper) gave the highest values of number of leaves and leaf /stem ratio while the genotype IS 3214 gave the highest values of number of tillers and leaf/stem ratio. In general phenotypic coefficient of variation (PCV) estimates were higher than genotypic coefficient of variation (GCV) estimates for all the studied characters. Heritability (H^2%) estimates were generally moderate for some studied characters and recorded values 45.429% for total dry forage yield, 59.083 % for plant height but number of leaves, stem diameter and leaf/stem ratio were low and recorded 5.494, 9.523and 33.333% respectively. Fresh forage yield had high positive and significant correlation with dry forage yield, plant height and number of tillers (r= 0.926^{**}, r= 0.613^{**} and r=0.998^{**}, respectively). Consequently, the genotypes IS 720 (Piper) and IS 3214 deserves further testing before being recommended for commercial use under Egypt conditions.

Keywords: Forage sorghum, Sorghum sudanense, Sudan grass, Exotic genotypes, Forage yield, Phenotypic and genotypic coefficient, Heritability, Genetic advance, Correlation coefficient.

INTRODUCTION

Sorghum as a forage crop is considered one of the most important summer forage crops in Egypt. Moreover, Sudan grass is a fast growing with narrow leaves, and adapted to a wide range of soil and climatic conditions. It has higher genetic variability in terms of genetic and germplasm resources to develop new cultivars adapted to different agro-ecological regions of world Zhang *et al* (2010). Greet efforts have been made to develop new strains of Sudan grass using recurrent selection among several populations and varieties in Egypt. Line selection for forage yield in Sudan grass was made by Radwan *et al* (1997). Assessing the genetic variability for the characters present in germplasm collections is important for a successful Sudan grass breeding program. The progress of selection is more important in any crop improvement and this progress depends on the existence of genetic variability for yield and its component and their heritability Allard (2000). Berwal and Khairwal (1997) concluded that heritability in conjunction with genetic advance has a greater role to play in determining the effectiveness of selection of a character. A study of the relationship of different characters with yield will be of great significant in planning successful breeding strategies in any crop plant. Therefore, the objectives of this study were to determine the amount of genetic variability, heritability in broad sense, genetic advance and strength of association of yield related traits among eighteen genotypes of Sudan grass in two consecutive seasons as well as to obtain the appropriate genotype(s) characterized with high productivity to be used as a parent in breeding programs for forage yield and could be released as commercial variety in Egypt.

MATERIALS AND METHODS

This study was laid out at Sids Agricultural Research Station, Agricultural Research Center (ARC), Egypt during the summer seasons 2013 and 2014. Sixteen exotic genotype of Sudan grass from the International Crops Research Institute for the Semi –Arid Tropics (ICRISAT), Indian namely IS 720 (Piper), IS 3112, IS 3199, IS 3203, IS 3214, IS 3222, IS 3229, IS 3231, IS 3237, IS 3353, IS 14299, IS 18841, IS 18842, IS 18844, IS 18846, IS 18847 and the local varieties Giza 1 and Giza 2 as check varieties were used in this study. Three replications in a Randomized Complete Block Design (RCBD) were used and the experimental plot area was 10.5 m2. Each plot consisted of five ridges with 70 cm wide and 3 m long. Grains were planted in hills 20 cm apart with 20 kg fad-1 seeding rate. Planting was done at 15 May and 22 May in 2013 and 2014, respectively. Agronomic field practices applied at the proper time as recommended for forage sorghum were followed during the two growing seasons. Three cuts were taken at each season, the first, second and third cuts were taken after 50, 90, 130 day from sowing, respectively. Data were recorded for the properties affecting the forage yield as plant height in centimeter, number of tillers m-2, number of leaves per stem, stem diameter in centimeter, leaf/stem ratio, fresh and dry forage yields (t fad-1).

Statistical analyses:

Analysis of variance was carried out by PLABSTAT computer software (Utz 2004) according to the procedures described by Snedecor and Cochran (1989) for each season individually and for the combined seasons. Before combined analysis homogeneity test of variance was computed by Bartlett's test (1937). GCV and PCV % were done using the formulae suggested by Burton (1952). Broad sense heritability (H2 %) was calculated as per Hanson *et al* (1956). Genetic advance (GA) from selection as percent of men was estimated by the method suggested by Johanson *et al* (1955). Phenotypic correlations among all studied characters were calculated according to the procedure of Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The performance of genotypes

The combined analysis of variance across 2013 and 2014 seasons for fresh and dry forage yields are presented in Table 1. Tests of significance of mean squares showed high significant differences for genotypes, years and genotype × year interaction for each cut and total cuts except the effect of year on dry forage yield at 1st cut. This variation could be attributed to effect of genetic, environmental as well as their interaction.

Table 1. The combined analysis of variance and mean squares across 2013 and 2014 seasons for fresh and dry forage yields of the 18 Sudan grass genotypes.

SOV	d.f.	Fresh forage yield (t fad^{-1})				Dry forage yield (t fad^{-1})			
		1st cut	2nd cut	3rd cut	Total cuts	1st cut	2nd cut	3rd cut	Total cuts
Years (Y)	1	198.42**	842.61**	48.14**	3653.64**	0.556	2.379**	1.118**	11.192**
Reps/years	4	8.63	3.91	0.61	13.78	0.179	0.056	0.026	0.420
Genotypes (G)	17	20.64**	7.39**	23.72**	48.88**	0.385**	0.214**	0.699**	1.455**
G X Y	17	14.50**	4.20**	16.11**	25.84**	0.299**	0.135**	0.474**	0.794**
Error	68	1.42	1.24	0.38	3.50	0.049	0.041	0.027	0.103

***and ** indicate significance at 5% and 1% probability level, respectively.**

Performance of the genotypes regarding fresh and dry forage yield at each cut and total yield as well as their relative to check variety across 2013 and 2014 seasons are presented in Table 2. Data revealed significant differences among the 18 genotypes in each cut and total forage yield. The average performance of the 18 genotypes was the highest in the first cut for fresh and dry forage yields (19.8 and 2.569 t fad^{-1}, respectively).

In the first cut, fresh forage yield of the 18 genotypes ranged from 15.70 to22.79 fad^{-1} with an average of 19.87 t fad^{-1} and for dry forage yield ranged from 1.97 to2.95 t fad^{-1} with an average of 2.569 t fad^{-1}. The genotype IS 3214 gave the highest yield for fresh and dry (22.79and 2.95 t fad^{-1}., respectively).

In the second cut, fresh forage yield of the 18 genotypes ranged from 13.42 to17.87 t fad^{-1} with an average of 15.23 t fad^{-1} and for dry forage yield ranged from 1.63 to2.21 t fad^{-1} with an average of 1.995 t fad^{-1}. The genotype IS 18841 gave the highest fresh and dry forage yields (17.87 and 2.21 t fad^{-1}., respectively).

In the third cut, fresh forage yield of genotypes under study ranged from 9.07 to 15.91 t fad^{-1} with an average of 12.27 t fad^{-1}and for dry forage yield ranged from 1.34 to 2.57 t fad^{-1}with an average of 1.852 t fad^{-1}. The genotype IS 720 (piper) gave maximum fresh and dry forage yields (15.91 and 2.57 t fad^{-1} respectively).

Total fresh forage yield of the 18 genotypes ranged from 43.05 to 53.96 t fad^{-1}with an average of 47.37 t fad^{-1}and for total dry forage yield ranged from 5.72 to 7.39 t fad^{-1} with an average of 6.415 t fad^{-1}. The genotype IS 3214 gave the highest total fresh (53.96 t fad $^{-1}$) and the genotype IS 720 (Piper) gave the highest total dry forage yield (7.39 t fad $^{-1}$).

Generally, over the first and second seasons, the genotype IS 3214 was superior and significantly exceeded the best check variety (Giza 2) by 6.3% for total fresh forage yield and the genotype IS 720 (Piper) was superior and exceeded the best check variety (Giza 1) by 6.6 % for total dry forage yield, respectively.

Table 2. Fresh and dry forage yields of three and total cuts for the 18 Sudan grass genotypes (combined analysis across 2013 and 2014).

Genotype	Fresh yield (t fad^{-1})				Relative to the highest check variety	Dry yield (t fad^{-1})				Relative to the highest check variety
	1st	2nd	3rd	Total		1st	2nd	3rd	Total	
IS 720 (Piper)	19.61	15.79	15.91	51.31	101.0	2.62	2.20	2.57	7.39	106.6
IS 3112	19.55	16.08	14.24	49.88	98.2	2.53	2.01	2.26	6.80	98.1
IS 3199	21.35	15.34	10.56	47.25	93.0	2.88	2.00	1.62	6.50	93.8
IS 3203	20.11	14.66	10.89	45.66	89.9	2.44	2.01	1.60	6.05	87.3
IS 3214	22.79	15.67	15.50	53.96	106.3	2.95	2.08	2.21	7.24	104.5
IS 3222	15.70	13.42	14.69	43.81	86.3	1.97	1.70	2.25	5.93	85.6
IS 3229	19.75	13.87	10.52	44.15	86.9	2.58	1.63	1.51	5.72	82.5
IS 3231	18.46	14.12	10.46	43.05	84.8	2.36	1.88	1.56	5.80	83.7
IS 3237	20.16	15.55	10.63	46.34	91.3	2.66	2.12	1.59	6.37	91.9
IS 3353	21.70	14.64	11.50	47.84	94.2	2.84	1.76	1.74	6.35	91.6
IS 14299	21.88	14.48	9.07	45.44	89.5	2.69	1.76	1.34	5.79	83.5
IS 18841	17.05	17.87	10.98	45.91	90.4	2.21	2.21	1.54	5.96	86.0
IS 18842	19.18	15.15	13.44	47.78	94.1	2.48	2.13	1.99	6.59	95.1
IS 18844	18.49	14.51	13.17	46.17	90.9	2.33	1.91	1.96	6.20	89.5
IS 18846	18.16	14.50	13.41	46.07	90.7	2.45	1.90	2.10	6.45	93.1
IS 18847	21.70	15.35	10.39	47.44	93.4	2.82	2.20	1.61	6.63	95.7
Giza 1	20.13	16.95	12.83	49.92	98.3	2.60	2.19	2.14	6.93	100.0
Giza 2	21.87	16.22	12.69	50.78	100.0	2.83	2.19	1.74	6.76	97.5
Mean	19.87	15.23	12.27	47.37		2.569	1.995	1.852	6.415	
LSD 0.05	1.374	1.288	0.718	2.156		0.255	0.233	0. 189	0.369	

The combined analysis of variance across 2013 and 2014 seasons for morphological characters of the 18 Sudan grass genotypes are presented in Table 3. Tests of significance of mean squares showed significant differences for genotypes, years and genotype × year interaction for most characters. This variation could be attributed to effect of genetic and environmental as well as their interactions.

The means of morphological characters obtained by the eighteen Sudan grass genotypes are presented in Table 4. Morphological characters that can be measured easily could be used by plant breeder as selection criteria. Data revealed significant differences among the 18 genotypes for morphological characters studied.

Maximum plant height of 139.8 cm. was observed in check variety Giza 1 and exceeded significantly that of the genotype IS 14299 (133.4 cm.). While the minimum of 114.7cm. was recorded with IS 3222 genotype

Tillering capacity per square meter recorded the highest value in IS 3214 genotype (88.3) and exceeded significantly that of the highest check variety Giza 2 (82.8) while the lowest one was recorded with IS 3231 genotype (69.8).

The genotypes IS 720 (Piper), IS 18846 and IS 18847 produced the maximum number of leaves per stem

(7.8) and exceeded insignificantly that of the highest check variety Giza 2 (7.5). The lowest one was recorded with IS 3237 genotype (7.2).

Sudan grass genotype IS 3203 produced the highest value of stem diameter (1.36cm.) and exceeded significantly the other genotypes. The lowest value of stem diameter was recorded with IS 18846 (1.07 cm.). This variation in stem diameter may be due to difference in genetic background of the accessions

Table 3. The combined analysis of variance and mean squares across 2013 and 2014 seasons for morphological characters of the 18 Sudan grass genotypes.

SOV	d.f.	Plant height (cm)	Number of tillers	Number of leaves	Stem diameter (cm)	Leaves/stem ratio
Years (Y)	1	2614.0**	791.6**	7.503**	0.035**	0.001
Reps/years	4	116.0	41.9	0.142	0.002	0.004
Genotypes (G)	17	287.9**	148.4**	0.182*	0.021**	0.003**
G X Y	17	117.8**	78.36**	0.172**	0.019**	0.002*
Error	68	18.9	10.29	0.084	0.004	0.001

***and ** indicate significance at 5% and 1% probability level, respectively.**

Table 4. Mean performance of morphological characters for 18 Sudan grass genotypes (combined analysis across 2013 and 2014 seasons).

Genotype	Plant height (cm)	Number of tillers	Number of leaves	Stem diameter (cm)	Leaves/ Stem ratio
IS720 (Piper)	131.7	84.5	7.8	1.25	0.74
IS 3112	122.5	81.5	7.5	1.27	0.71
IS 3199	125.2	77.1	7.5	1.22	0.66
IS 3203	131.1	74.1	7.6	1.36	0.71
IS 3214	132.8	88.3	7.7	1.25	0.74
IS 3222	114.7	71.1	7.3	1.26	0.73
IS 3229	115.8	71.3	7.6	1.23	0.73
IS 3231	121.6	69.8	7.6	1.26	0.71
IS 3237	125.9	75.6	7.2	1.27	0.68
IS 3353	126.1	77.8	7.4	1.23	0.71
IS 14299	133.4	73.4	7.5	1.29	0.68
IS 18841	122.2	74.3	7.3	1.24	0.73
IS 18842	126.9	78.1	7.4	1.18	0.71
IS 18844	131.3	75.1	7.7	1.31	0.68
IS 18846	127.2	75.3	7.8	1.07	0.73
IS 18847	132.6	77.6	7.8	1.29	0.69
Giza 1	139.8	81.8	7.4	1.23	0.72
Giza 2	139.0	82.8	7.5	1.28	0.69
Mean	127.7	77.185	7.534	1.251	0.709
LSD 0.05	5.009	3.696	0.333	0.072	0.036

Sudan grass genotypes IS 720 (Piper) and IS 3214 produced the highest value of leaf/stem ratio (0.74) and exceeded significantly that of the check variety Giza 2 (0.69), while genotype IS 3199 produced lowest value of leaf/stem ratio (0.66)

Generally, the genotype of Sudan grass IS 720 (Piper) scored the highest values of number of leaves and leaf /stem ratio, while the genotype IS 3214 scored the highest values of number of tillers and leaf/stem ratio. These results are in agreement with Kumar and Singhania (1984), Bakheit (1990). Soliman (1994) and Haggag *et al* (1999)

Genetic parameters

Genetic parameters across two years for the studied characters are presented in Table 5. The analysis of variance showed highly significant differences among the genotypes for all studied characters except number of leaves showed significant differences among the genotypes, indicating the presence of sufficient variability in the experimental materials of Sudan grass. In general, phenotypic coefficient of variation (PCV) was higher than corresponding genotypic coefficient of variation (GCV) for all characters because of the influence of environment. High genotypic coefficients of variation observed for total dry forage yield, number of tillers m^{-2}, plant height and total fresh forage yield, indicated high magnitude of variability present in the genetic material studied for these characters. On the other hand, the other characters leaf /stem ratio, stem diameter and number of leaves displayed relatively less genotypic coefficient of variation.

Table 5. Genetic parameters for forage yield and some yield traits of the 18 Sudan grass genotypes across 2013 and 2014 growing seasons.

Character	V_g	V_{ph}	GCV	PCV	H^2%	GA%
Plant height (cm)	28.3500	47.9833	4.169	5.423	59.083	6.603
Number of tillers m^2	11.6833	24.7333	4.428	6.443	47.237	6.269
Number of leaves	0.0016	0.0303	0.530	2.309	5.494	0.261
Stem diameter (cm.)	0.0003	0.0035	1.454	4.724	9.523	0.928
Leaf/stem ratio	0.0001	0.0005	1.819	3.153	33.333	2.165
Total fresh forage yield (t fad^{-1})	3.8400	8.1470	4.135	6.024	47.131	5.851
Total dry forage yield (t fad^{-1})	0.1101	0.2420	5.173	7.669	45.429	7.190

V_g=Genotypic variance, V_{ph} = phenotypic variance, GCV= genotypic coefficient of variability, PCV= phenotypic coefficient of variability, H^2%= heritability in broad sense and GA% = genetic advance as percent of mean.

Heritability (H2%) estimates were generally moderate for some studied characters and recorded values of 45.429% for total dry forage yield to 59.083 % for plant height but number of leaves, stem diameter and leaf/stem ratio were low recorded 5.494, 9.523and 33.333% respectively. Burton (1952) reported that genotypic coefficient of variation along with heritability estimates would be better for efficient selection.

Genetic advance as percent of mean (GA %) recorded high values 5.851% for total fresh forage yield and 7.190 %for total dry forage yield. Number of leaves, stem diameter and leaf/ stem ratio recorded low values 0.261, 0.928 and 2.165% respectively. Relative comparison of heritability estimates and expected genetic advance as percent of mean gives an idea about the nature of gene action governing a particular character. Similar results were also reported by Amirthdevarathinam *et al* (1990) and Ramswamy *et al* (1991) for green fodder yield and Henry *et al* (1983) for green and dry fodder yield.

Correlation coefficient:

In general, in a forage crop, the fodder yield, which is ultimately harvested, is influenced by number of vegetative plant characters. The knowledge of association between yield and other biometrical characters and the association among the component traits themselves would greatly help in indirect effective selection for high fodder yield. In the present investigation, fresh forage yield was positively and highly significantly correlated with dry forage yield, plant height and number of tillers ($r= 0.926^{**}$, $r= 0.613^{**}$ and $r=0.998^{**}$, respectively). Dry forage yield was positively and significant with plant height ($r=0.560^{*}$) and positive and highly significant with number of tillers ($r=0.946^{**}$). Plant height recorded a positively highly significant association with number of tillers ($r=0.611^{**}$). The finding of the present study agreed with the Jain *et al.* (2011) and Jain and Patel (2012). Positive and significant relationship of dry yield with fresh yield, plant height and number of tillers suggested that the dry yield production can be increased by simple selection of these characters.

Table 6. Estimates of phenotypic correlation coefficient for yield and yield component in Sudan grass genotypes across two years.

Ch.#	X_2	X_3	X_4	X_5	X_6	X_7
X_1	0.926^{**}	0.613^{**}	0.998^{**}	0.288	-0.010	0.186
X_2		0.560^{*}	0.946^{**}	0.353	-0.152	0.202
X_3			0.611^{**}	0.335	0.197	-0.246
X_4				0.301	-0.031	0.191
X_5					-0.132	0.221
X_6						-0.271

 # Characters: X_1- Total fresh forage yield, X_2- Total dry forage yield, X_3- Plant height, X_4-Number of tillers m^{-2}, X_5-Number of leaves stem $^{-1}$, X_6- Stem diameter, X_7- Leaf/stem ratio.
***and**indicate significance at 5% and 1% probability level, respectively.**

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تقدير القياسات الوراثية والارتباط فى حشيشة السودان

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تم اجراء هذة الدراسة خلال الموسمين الزراعيين 2013 و 2014 في محطة بحوث سدس بهدف نقدير الاختلافات الوراثية وكفاءة التوريث بالمعني الواسع والتحسين الوراثي بالانتخاب في حشيشة السودان لعدد ستة عشر تركيب وراثي مستوردة مقارنة بالاصناف المقارنة جيزة 1 وجيزة 2 وكذلك الارتباطات المظهرية بين حاصل العلف والصفات المورفولوجية للحصول علي افضل هذة التراكيب من حيث الانتاجية المرتفعه. وتتلخص اهم النتائج المتحصل عليها فيما يلي :- اظهرت التراكيب الوراثية في التحليل المشترك للموسمين تباينا معنويا في كل من حاصل العلف الطازج والجاف في كل حشة ومجموع الحشات الثلاث – تفوق التركيب الوراثي IS 3214 تفوقا معنويا عن الصنف المقارن جيزة 2 بزيادة قدرها 6.3% لحاصل العلف الطازج بينما تفوق التركيب الوراثي IS 720 تفوقا معنويا ايضا عن الصنف المقارن جيزة 1 بنسبة 6.6% لحاصل العلف الجاف – اظهرت الدراسة وجود اختلافات معنوية بين التراكيب الوراثية وكذلك السنوات وايضا التفاعل بين التراكيب الوراثية والسنوات لمعظم الصفات تحت الدراسة – اعطي التركيب الوراثي IS 720 اعلي قيم فى عدد الاوراق و نسبة الاوراق للسيقان بينما اعطي التركيب الوراثي IS 3214 اعلي عدد من الاشطاء و نسبة الاوراق للسيقان – كانت قيم معامل الاختلاف المظهري اكبر من قيم معامل الاختلاف الوراثي في جميع الصفات تحت الدراسة كما كانت قيم معامل التوريث بالمعني العام متوسطة لجميع الصفات وتراوحت بين 45.4% لصفة حاصل العلف الجاف الكلي و 59.08% لصفة ارتفاع النبات وباستثناء صفة عدد الاوراق وقطر الساق ونسبة الاوراق للسيقان والتي سجلت 5.45 ، 9.52 ، 33.3% علي الترتيب .لوحظ وجود ارتباط وراثي معنوي موجب بين حاصل العلف مع الحاصل الجاف و ارتفاع النبات وعدد الاشطاء وكانت قيم هذا الارتباط هي 0.926 ، 0.613 و 0.998 علي الترتيب ومن ثم يكون افضل التراكيب الوراثية من حيث حاصل العلف الاخضر هو 3214 ISومن حيث حاصل العلف الجاف هو (Piper) IS 720 ونوصي بأعادة تقييمهما لاستخدامهما كأصناف تجارية .