Heterosis and Inbreeding Depression in Different Crosses of Forage Sorghum (*Sorghum bicolor* L. Moench).

Mona. Ghazy. M.F.
Forage Crops Res., Dept. Field Crops Res. Inst., Agric. Res. Center, Egypt

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ABSTRACT

The present study was carried out at Sakha Agric. Res. Station, ARC, Egypt, for studying the magnitude of heterosis and inbreeding depression in eight hybrids (F_1's) and (F_2's) made by crossing four cytoplasmic male-sterile lines; i.e, ICS20, ICS36, TX30 and 200243, by two sudangrass restorer lines; i.e, Pioneer and Qena, through line × tester mating design during 2007, 2008 and 2009 summer seasons. Observations were recorded on fresh forage yield, plant height, stem diameter, fresh leaf /stem ratio and dry leaf/stem ratio at two cuttings. The results indicated highly significant differences among genotypes for studied traits in both cuttings. Mean performances clarified that male sterile parents had lower values in fresh forage yield and plant height, while, F_1's were greater than parents for the remaining studied traits. Some of F_2's segregation populations were greater than parents and F_1's hybrids. Estimates of heterosis, relative to mid-parents, better parent and standard, were observed for different hybrids and indicated that the hybrid, P_4 xP_5 and P_4xP_6, were the highest positive (useful) heterosis for most studied traits. On the other hand, inbreeding depression estimated showed that F_2 population of P_3 xP_5 and P_3xP_6 hybrid might be used as a source of inbred line to synthesis of hybrids or synthetic sorghum varieties, since negative significant estimates had been recorded. The results, also, illustrated that the potence ratios were more than unity for most of the studied traits in hybrids, indicating overdominance for genes controlling these traits.

Key words: Heterosis, Inbreeding Depression, Forage Sorghum.

INTRODUCTION

Sorghum (*Sorghum bicolor* L.) is an important food and feed crop grown in several countries. Forage sorghum is considered the most important forage crop in summer season for feeding animals and could be grown well in Egypt.

In breeding programs, information on heterosis of parents and crosses are very important. By estimating the degree of heterosis, clues about desirable parents and important green yield traits will emerge, particularly, in those crops, which are amenable to commercial production of F_1 hybrid seed, using cytoplasmic male sterility. Sorghum is one of such crops.

Estimation of the average better parent heterosis for green yield in sorghum ranged from 9 % to 97.5 % and lower estimates were obtained with crosses of adapted parent lines (Amir, 1999; Abd EL-Mottaleb, 2004; Hovny *et al*, 2001 and Essa, 2009, while, high values were most often and resulted from studies, which involved exotic germplasm .

Prabhakar, 2001; AL-Nagger *et al*, 2002; Hovny *et al*, 2005; Abo-Zaid, 2007; Ali, 2000 and Essa, 2009 stated that the F_1 hybrids showed a range of heterosis with negative and positive values, which indicated the potential for developing hybrids superior to the mid–and better parents for plant height and yield. Also, Desai *et al*,1999; Carlos *et al*, 1998; Reddy and Joshi 1993 and Meenu Agarwal and Shrotria, 2005 found negative or positive inbreeding depression over F_2 segregating generation for fodder yield and its related traits in sorghum.

The objective of this study was to estimate the heterosis over three types (mid-parents, better parents and a standard check) as a measure for developing superior hybrids and studying the inbreeding depression over F_2 hybrids.

MATERIALS AND METHODS

Genetic materials:

This study was carried out at Sakha Agricultural Research Station, ARC, Egypt, during the three successive summer seasons of 2007, 2008 and 2009. Line ×tester mating design involving four cytoplasnic male-sterile lines (ICS 20, ICS36, TX30 and 200243) and two sudangrass restorer lines; i.e., Pioneer and Qena, was performed in 2007 and 2008 summer seasons. A yield trial was carried out at 2009 summer season, including 23 genotypes; namely, six parents, eight F_1hybrids, eight F_2 segregating populations, beside a check (local hybrid, 102). A randomized complete block design, with three replications, was adapted. Plot size was three rows of three meters long and 0.7 meter apart. Data were recorded for fresh forage yield, plant height, stem diameter, green leaf/stem ratio and dry leaf stem ratio at two cuttings.

Statistical analysis:

Statistical analysis was performed, according to Snedecor and Cochran (1989).

Genetic analysis:

Estimates of heterosis were determined as the percentages of F_1's deviation from the average of the mid-parents (M.P.), the average of better parent (B.P.) and the check commercial hybrid (useful heterosis). The following equations were used:

$$H(M.P) = \overline{F1} - \overline{M.P.} / \overline{M.P} \times 100$$

$$H(B.P) = \overline{F_1} - \overline{B.P.} / \overline{B.P} \times 100$$

$$H(useful) = \overline{F_1} - \overline{Ch} / \overline{Ch} \times 100$$

The significance of heterosis was tested, using the least significant difference value (L.S.D.) at 0.05 level.

Inbreeding depression (I.D.) for each cross was calculated, as follows:

$$I.D. = \overline{F_2} - \overline{F_1} / \overline{F_2} \times 100$$ (Liang *et al.*, 1972)

Dominance relations:

Potence ratio (P) was calculated from the formula given by Smith (1952), as follows:

$$P = (\overline{F_1} - \overline{M.P})/ (\overline{P_2} - \overline{P_1}) /2 \times 100$$

RESULTS AND DISCUSSION

Mean squares for all studied traits were presented in Table (1). The results indicated highly significant differences among genotypes for all studied traits in the first and second cuttings.

Mean performances of the studied genotypes were presented in Table (2). The results illustrated that male-sterile parents were highly significantly ($P \geq 0.01$) lower in fresh forage yield and plant height than the two restorer testers in both studied cuttings. Also, differences within male-sterile lines or between the two restores had not reached the level of significance. In the meantime, P_4 by any of the restorer hybrids, significantly yielded higher green yield at the first cutting than P_1 x P_6, P_2 x P_5 and P_3 x P_5 hybrids. The green yields of the aforementioned two hybrids were not significantly different from the best hybrids. By the second cutting, P_4 x P_6 hybrid, significantly yielded ($P \geq 0.05$) higher yield than P_4 x P_5, P_2 x P_6, P_2 x P_5, and P_1xP_6 hybrids, while, the four other hybrids were significantly similar. Regarding plant height, P_1 x P_5, P_3 x P_6, P_4 x P_5, and P_4 x P_6 hybrids significantly ranked the first at the first cutting. Whereas, P_3 x P_5, and P_4 x P_6 hybrids significantly occupied the first rank at the second cutting. $F_2$7segeregating population significantly gave the highest green yield and plant height at the first cutting. That was true at the second cutting with insignificant differences with $F_2$8 and $F_2$4 populations, regarding green forage yield.

As for stem diameter, $P_1$and P_2 gave the most significant ($P \geq$o.o5) girthy stems in both studied cuttings (2.43, 2.40 and 2.02, 1.95 cm), for the two parents at the two subsequent cuttings, respectively. The second significant stem girth rank ($P \geq$o.o5) was occupied by P_1 x P_5 in the first cutting, P_2 x P_6 and P_3 x P_5, P_4 x P_5 and P_4 x P_6, in both cuttings, F_2 population of P_1 x P_5 in the first cutting, F_2 population of P_1 x P_6 in the second cutting, F_2 populations of P_3 x P_5 and P_3 x P_6, in the second cutting, and F_2 population in the first cutting. Other studied genotypes significantly ($P \geq$o.o5) ranked the third, except for P_5 and P_6 parents that had the least significant values of stem diameter in both studied cuttings (1.04,1.12 and 0.82,0.83 cm) for the two parents at the two successive cuttings, respectively.

Means of fresh leaf/stem ratio showed that P_1 gave the highest significant values for the character in both studied cuttings (59.85, 50.34) and for dry leaf/stem ratio. P_2 and P_1 gave the highest values for the first and second cuttings, respectively (72.70 and 77.21%).

These values were not significantly different from those of fresh leaf/stem ratio of P_2 at the second cutting and dry leaf/stem ratio of P_2, P_3 and P_5 at the second cutting. F_1 hybrid exhibited, significantly, lower mean values for both characters at the two studied cuttings.

Table 1: Mean squares for fresh forage yield, plant height, stem diameter, fresh leaf/stem ratio and dry leaf/stem ratio during two successive cuttings of the study.

Source of variation	d.f	Fresh forage yield		Plant height		Stem diameter	
		1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting
Replication	2	12.43	51.33**	98.1	240.0*	0.0959*	0.0033
Genotypes	22	155.44**	138.18**	10478.5**	6873.4**	0.2904**	0.2456**
Error	44	8.28	3.77	59	65.8	0.0207	0.0129

Source of variation	d.f	Fresh leaf/stem ratio		Dry leaf/stem ratio	
		1st cutting	2nd cutting	1st cutting	2nd cutting
Replication	2	112.56**	86.95**	12.9*	1.1
Genotypes	22	139.49**	82.72**	338.9**	426.0**
Error	44	6.85	8.98	18.4	15

*, ** Significant and highly Significant at 0.05 and 0.01 levels of probability, respectively.

Table 2: Mean performances of parents, F_1 hybrids, F_2 populations and a check hybrid for all studied traits during 2009summer season.

Genotype	Pedigree	Fresh forage yield (Kg/plot)		Plant height (cm.)		Stem diameter (cm.)		Fresh leaf/stem ratio%		Dry leaf/stem ratio%	
		1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting
P_1	ICS20	15.99	8.09	74.74	53.56	2.43	2.02	59.85	50.34	72.70	77.21
P_2	ICS36	15.72	7.52	68.92	54.84	2.40	1.95	43.47	48.38	75.15	76.85
P_3	TX30	17.96	7.29	75.18	54.01	1.79	1.75	32.75	39.15	54.59	71.13
P_4	2002-43	17.95	7.91	62.91	48.31	1.79	1.80	33.93	34.25	61.33	64.26
P_5	Pioneer	26.06	13.16	207.00	154.00	1.04	0.82	32.27	32.40	61.76	73.42
P_6	Qena	24.97	15.95	199.67	155.50	1.12	0.83	29.96	34.91	63.08	72.70
F_{15}	P_1x P_5	34.30	19.35	230.00	160.00	2.08	1.47	35.80	39.40	53.07	54.93
F_{16}	P_1x P_6	29.21	23.19	213.00	175.00	1.75	1.70	31.60	35.50	53.90	52.00
F_{25}	P_2x P_5	28.18	19.20	218.00	160.00	1.58	1.52	38.50	40.60	52.47	53.20
F_{26}	P_2x P_6	32.20	22.17	221.00	170.00	1.89	1.66	33.20	37.20	55.67	52.53
F_{35}	P_3x P_5	30.22	24.21	215.00	188.00	1.87	1.75	34.40	36.60	52.00	50.27
F_{36}	P_3x P_6	33.25	21.45	225.00	164.00	1.80	1.60	36.60	38.50	58.67	53.07
F_{45}	P_4x P_5	36.19	22.11	236.00	172.67	2.09	1.65	32.50	33.00	48.27	48.07
F_{46}	P_4x P_6	36.21	25.57	235.00	191.00	1.96	1.82	30.30	31.50	50.73	44.40
$F_2$1	Selfed F_{15}	32.00	16.75	220.67	154.33	1.93	1.40	39.77	42.14	71.26	81.58
$F_2$2	Selfed F_{16}	35.77	29.07	214.00	179.67	1.70	1.63	33.76	37.46	70.63	63.42
$F_2$3	Selfed F_{25}	25.68	16.81	206.67	158.33	1.66	1.57	29.17	32.95	60.89	74.10
$F_2$4	Selfed F_{26}	34.82	27.50	229.00	182.00	1.78	1.47	37.21	39.68	63.97	64.68
$F_2$5	Selfed F_{35}	25.12	21.79	205.33	170.00	1.71	1.65	27.41	34.69	49.34	50.01
$F_2$6	Selfed F_{36}	30.66	17.39	206.67	154.00	1.79	1.64	31.05	29.16	52.79	62.75
$F_2$7	Selfed F_{45}	43.90	30.46	247.67	207.67	1.99	1.60	45.00	44.88	75.02	85.98
$F_2$8	Selfed F_{46}	33.85	23.46	231.67	181.67	1.76	1.64	32.86	33.49	67.49	66.32
check	Local hybrid 102	28.11	18.50	215.50	166.12	1.82	1.35	34.02	32.83	51.95	48.23
LSD(0.05)		4.734	3.195	12.640	13.348	0.237	0.187	4.307	4.932	7.058	6.373

Whereas,F_2 populations of P_3 x P_5 and P_3 x P_6 hybrids, significantly exhibited the least fresh leaf/stem ratio at the first and the second cuttings, respectively. Meanwhile, F_2 population of P_3 xP_5 hybrid showed the least dry leaf/stem ratio at the second cutting.

Estimates of heterosis, relative to mid-parent (M.P.), were presented in Table (3). Significant useful (positive) heterosis, in fresh forage yield, was obtained by both P_4x P_5 and P_4 xP_6 hybrids, in the first cutting, and P_1 xP_6 in the second cutting. The second magnitude of significant positive heterosis, in fresh forage yield, was shown by P_1xP_5 and P_3xP_6 hybrids, in the first cutting, and P_4xP_6 hybrid in the second cutting. Significant positive heterotic effect, in plant height, was expressed by P_4xP_6 hybrid, in both cuttings, and P_3x P_5 hybrid in the second cutting. Positive significant heterosis, in plant height, but of lower magnitude, was expressed by P_3xP_6 hybrid at the first cutting. The highest significant heterosis in stem diameter, relative to mid-parent, was expressed by P_4xP_5 hybrid, in the first cutting, and P_4xP_6 hybrid in the second cutting. The latter hybrid showed significant positive heterotic effect at the first cutting, but of lower significant magnitude. The only significant positive heterosis, relative to mid-parent in fresh and dry leaf to stem ratio, were presented by P_2xP_5 hybrid in both cuttings. P_2xP_6 hybrid showed similar positive heterosis only at the second cutting. Other positive heterosis estimates were of small magnitudes. These results were in agreement with the findings of several authors (Desai *et al.*, 1999; Reddy and Joshi, 1993; Carlos *et al.*, 1998; Meenu Agarwal and Shrotria, 2005 and Ghazy Mona *et al*, 2008).

Estimates of heterosis, relative to better-parent (B.P.), were presented in Table (4). Significant useful (positive) heterosis, in fresh forage yield, was presented by P_4 x P_5 and P_4 xP_6 hybrid, in the first cutting, and P_1xP_6 in the second cutting. The second magnitude of significant positive heterosis, in fresh forage yield, was shown by P_2x P_6 in the second cutting. Significant positive heterotic effects, in plant height, was expressed by P_4x P_6 hybrid, in both cuttings, and P_4 xP_5 in the first cutting, as well as P_3 xP_5 . in the second cutting. The highest significant heterosis, in stem diameter, relative to better- parent, was expressed by P_4xP_5 hybrid, in the first cutting, and the latter hybrid showed significant positive heterosis, presented by P_4 xP_6 hybrid. The only significant positive heterotic effect, at the first cutting for fresh leaf/stem ratio, was found in the hybrid, P_2xP_5. These results are in agreement with several others, among them, Hovny *et al*, 2001 and 2005; Amir, 1999; Desai *et al*, 1999 and Mahdy *et al*, 2011.

Estimates of heterosis, relative to the check (CK.), were presented in Table (5). Significant useful (positive) heterosis, in fresh forage yield, was presented by both P_4x P_5 and P_4 xP_6 hybrids, in the first cutting and P_4 ×P_6 in the second cutting. Significant positive heterosis effect, in plant height, was expressed by P_4 x P_5 and P_4 xP_6 hybrids, in the first cutting, and P_3 x P_5 and P_4 xP_6 in the second cutting. The highest significant heterosis, in stem diameter relative to the check, was expressed by P_1 x P_5 and P_4 x P_5 hybrids, in the first cutting, and P_4 x P_6 hybrid, in the second cutting. The other hybrid that, showed significant positive hetterotic effect, in the second cutting, was P_3 x P_6. The only significant heterosis (useful heterosis), relative to check in fresh leaf/stem ratio, was that of P_2 x P_5 hybrid in the first cutting, as well as P_1 x P_5 and P_2 x P_5 hybrids in the second cutting. Significant positive heterosis (useful heterosis) for dry leaf/stem ratio, in the second cutting only was that of P_1 x P_5 hybrid. These results are in agreement with those of Meenu Agarwal and Shrotria (2005) and Ghazy Mona *et. al*, (2008).

The Inbreeding depression percentage of the studied traits, for the eight populations of forage sorghum was presented in Table (6). The estimated Inbreeding depression clarifed that F_2 population of P_3 x P_5 and P_3xP_6 hybrids might be used as a source of inbred line to synthesis of hybrids or synthetic sorghum varieties, since negative significant estimates had been recorded. Meanwhile, the other populations with positive inbreeding depression estimates were not promising for isolating high yield lines of sorghum. This result was supported by the inbreeding estimates for plant height, since F_2 population of P_3 xP_5 hybrid recorded negative significant estimates. It was worthy to notice that most of the studied populations were suitable to segregate girth stinted inbreed lines, since the estimates of inbreeding depression was mostly negative or insignificant. This trend was true for fresh leaf/stem ratio, since F_2 populations of P_2xP_5 and P_4 xP_5 hybrids were expected and were considered promising sources of fresh leafy inbred line. The aforementioned populations had expressed negative and significant I.D. estimates. The results of dry leaf/stem ratio indicated less potentiality to isolate inbreds of high dry leaf/stem ratio from any of the studied F_2 populations, since most of the I.D. estimates were positive. These results are in agreement with the results of Arun Bhatt, 2008; Carlos *et al*, 1998; Reddy and Joshi, 1993 and Meenu Agarwal and Shrotria, 2005.

The potence ratio (type of dominance) for the eight hybrids was presented in Table(7). The results clarified that the potence ratios were more than unity for most of the studied traits in hybrids. These results illustrated that overdominance genes might control these traits in the two cuttings.

Table 3: Estimated heterosis relative to mid-parents (M.P) for all studied traits.

Hybrids	Fresh forage yield		Plant height		Stem diameter		Fresh leaf/stem ratio		Dry leaf/stem ratio	
	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting
P_1x P_5	63.15**	82.11**	63.27**	54.17**	19.66**	3.64	-22.28**	-4.77	-31.29**	-27.06**
P_1x P_6	39.87**	124.34**	54.39**	67.59**	1.74	23.13**	-16.56**	-12.11*	-21.26**	-30.79**
P_2x P_5	28.05**	87.81**	54.51**	53.84**	11.53	18.60**	18.42**	13.48*	-9.81	-26.39**
P_2x P_6	46.36**	110.41**	63.76**	68.06**	33.65**	26.72**	0.31	11.63	-9.55	-23.69**
P_3x P_5	47.57**	101.39**	56.70**	79.86**	4.97	22.95**	-23.39**	-14.13**	-33.24**	-32.94**
P_3x P_6	63.43**	82.76**	67.54**	55.94**	2.46	15.25**	-0.31	-7.55	-15.12**	-29.03**
P_4x P_5	68.59**	90.28**	71.73**	64.83**	43.71**	28.24**	3.65	-10.88	-17.96**	-33.16**
P_4x P_6	68.73**	114.33**	79.00**	87.43**	34.78**	38.40**	-5.14	-8.90	-18.44**	-35.16**
L.S.D (0.05)	4.101	2.767	10.946	11.560	0.205	0.162	3.730	4.271	6.113	5.519

*, ** Significant and highly Significant at 0.05 and 0.01 levels, respectively

Table 4: Estimated heterosis relative to the better parent (B.P) for all studied traits.

Hybrids	Fresh forage yield		Plant height		Stem diameter		Fresh leaf/stem ratio		Dry leaf/stem ratio	
	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting
P_1x P_5	31.62**	47.01**	11.11**	3.90	-14.52**	-27.23**	-40.19**	-21.73**	-42.76**	-28.85**
P_1x P_6	12.11	76.24**	2.90	13.6**4	-26.98**	-12.65**	-27.31**	-26.62**	-28.28**	-32.33**
P_2x P_5	8.16	45.92**	5.31	3.90	-11.73	-12.98*	17.55*	3.70	-15.05*	-27.54**
P_2x P_6	23.59*	68.44**	6.76*	10.39*	5.77	-7.95	-2.14	8.62	-9.87	-28.45**
P_3x P_5	21.03*	51.73**	7.68*	20.90**	-23.29**	-13.37**	-42.53**	-27.29**	-43.91**	-34.90**
P_3x P_6	33.15**	34.43**	12.69**	5.47	-24.76**	-17.95**	-15.81**	-20.42**	-21.94**	-30.94**
P_4x P_5	44.93**	38.61**	18.20**	11.04*	16.95*	-5.53	-0.77	-15.71*	-23.48**	-33.88**
P_4x P_6	45.01**	60.30**	17.70**	22.83**	9.68	0.92	-10.69	-8.02	-19.57**	-38.93**
L.S.D (0.05)	4.734	3.195	12.640	13.348	0.237	0.187	4.307	4.932	7.058	6.373

*, ** Significant and highly Significant at 0.05 and 0.01 levels, respectively

Table 5: Estimated heterosis relative to the check (CK) for all studied traits.

Hybrids	Fresh forage yield		Plant height		Stem diameter		Fresh leaf/stem ratio		Dry leaf/stem ratio	
	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting
P_1x P_5	22.01*	4.58	6.73*	-3.68	14.50*	8.89	5.23	20.01*	2.15	13.90*
P_1x P_6	3.92	25.3**7	-1.16	5.35	-3.67	26.1**7	-7.11	8.13	3.75	7.82
P_2x P_5	0.26	3.80	1.16	-3.68	-13.03*	12.59	13.17*	23.67**	0.99	10.30
P_2x P_6	14.56	19.82*	2.55	2.34	4.22	22.96**	-2.41	13.31	7.15	8.92
P_3x P_5	7.51	30.85**	0.00	13.17**	2.75	29.63**	1.12	11.48	0.10	4.22
P_3x P_6	18.27*	15.93	4.41	-1.28	-0.73	18.52**	7.58	17.27*	12.93	10.03
P_4x P_5	28.74**	19.53*	9.51**	3.94	15.23*	22.22**	-4.47	0.52	-7.09	-0.34
P_4x P_6	28.82**	38.23**	9.05**	14.98**	8.07	34.81**	-10.93	-4.05	-2.34	-7.94
L.S.D 0.05	4.734	3.195	12.640	13.348	0.237	0.187	4.307	4.932	7.058	6.373

*, ** Significant and highly Significant at 0.05 and 0.01 levels, respectively

Table 6: Inbreeding depression percent (I.D.) of the studied traits for eight F_2 populations of forage sorghum in the two cuttings.

Populations	Fresh forage yield		Plant height		Stem diameter		Fresh leaf/stem ratio		Dry leaf/stem ratio	
	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting
F_2 of P_1x P_5	-6.69	-13.44	-4.06	-3.54	-7.37	-4.76	11.09	6.95	34.28**	48.51**
F_2 of P_1x P_6	22.43**	25.35**	0.47	2.67	-2.67	-4.31	6.84	5.51	31.04**	21.97**
F_2 of P_2x P_5	-8.88	-12.48	-5.20	-1.04	5.27	3.07	-24.23**	-18.85**	16.05*	39.29**
F_2 of P_2x P_6	8.14	24.07**	3.62	7.06	-5.99	-11.45*	12.09	6.66	14.92*	23.13**
F_2 of P_3x P_5	-16.87*	-9.98	-4.50	-9.57**	-8.57	-5.52	-20.33**	-5.23	-5.11	-0.50
F_2 of P_3x P_6	-7.77	-18.92*	-8.15	-6.10	-0.74	2.71	-15.15*	-24.26**	-10.02	18.24**
F_2 of P_4x P_5	21.31**	37.73**	4.94**	20.27**	-4.78	-2.83	38.47**	35.99**	55.43**	78.88**
F_2 of P_4x P_6	-6.52	-8.28	-1.42	-4.89	-10.19	-9.89	8.45	6.31	33.04**	49.37**
L.S.D 0.05	4.734	3.195	12.640	13.348	0.237	0.187	4.307	4.932	7.058	6.373

*, ** Significant and highly Significant at 0.05 and 0.01 levels, respectively

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Table 7: Potence ratio for the studied traits for eight hybrids of forage sorghum in the two cuttings.

Hybrids	Fresh forage yield		Plant height		Stem diameter		Fresh leaf/stem ratio		Dry leaf/stem ratio	
	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting	1st cutting	2nd cutting
P_1x P_5	2.637	3.439	1.348	1.119	-0.492	-0.086	0.744	0.220	1.562	10.756
P_1x P_6	1.611	4.556	1.087	1.424	-0.044	-0.565	1.120	0.612	2.174	13.502
P_2x P_5	1.526	3.059	1.167	1.120	-0.438	-0.513	-24.781	-1.430	-1.591	-16.634
P_2x P_6	2.516	4.431	1.194	1.303	-1.277	-0.709	-0.123	-4.204	-27.341	-3.560
P_3x P_5	2.169	3.098	1.245	1.638	-0.135	-0.547	0.703	0.781	1.748	10.948
P_3x P_6	2.789	2.302	1.388	1.169	-0.068	-0.377	0.017	0.467	1.730	10.469
P_4x P_5	4.203	2.422	1.584	1.338	-1.910	-0.790	-0.819	1.901	-2.489	-30.314
P_4x P_6	4.202	3.392	1.517	1.662	-1.520	-1.034	0.827	-9.282	-13.133	-5.706

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الملخص العربى

قوة الهجين ومعامل التربية الداخلية لبعض الهجن المختلفة لسورجم العلف

منى محمد فتحي غازي
قسم بحوث محاصيل العلف- معهد بحوث المحاصيل الحقلية- مركز البحوث الزراعية- مصر

النباتات الطبية هى المصدر الطبيعي لمضادات الأكسدة وظروف الإجهاد هى التي تحفز إنتاج مضادات الأكسدة مثل الجفاف، الحرارة، تركيز الأس الهيدروجيني السالب والضوء. كل هذا يؤدى الى تكوين تركيزات عالية من مضادات الأكسدة وخاصة التربينات الثنائية. حمض الروزمارينيك يعتبر من أشهر التربينات الثنائية وهو منتشر بكثرة فى العائلة الشفوية. وحيث ان تأثير الأس الهيدروجيني السالب فى بيئة الزراعة على إنتاج مضادات الأكسدة فى زراعة الأنسجة لم يدرس بصورة واضحة، فان الهدف من هذا البحث هو دراسة تأثير الأس الهيدروجيني السالب على إنتاج حمض الروزمارينيك فى زراعة الكالس معمليا وذلك لأربعة أصناف من العائلة الشفوية(حصا لبان، المريمية، البردقوش، الزعتر) وكذلك دراسة تأثير التغيرات الموسمية وعدد تكرارات الزراعة على إنتاج حمض الروزمارينيك معملياً وحقلياً وذلك فى خلال الفترة من شتاء 2009 الى خريف2010.

وقد وجد أن اعلي تركيز لحمض الروزمارينيك فى الكالس كان خلال النقل الثانى للكالس المنزرع فى فصل الصيف للأربعة أصناف موضع الدراسة.

ووجد أيضا أن للأس الهيدروجيني السالب تأثير كبير على تراكم حمض الروزمارينيك فى الكالس فى الأربعة أصناف وكان أفضل تركيز للأس الهيدروجيني السالب 6.8 فى كل الأصناف ماعدا المريمية حيث كان 5.8.

أيضا وجد ان اعلي تركيز لتراكم حمض الروزمارينيك حقلياً كان فى اوراق نبات المريمية ثم الحصا لبان ثم الزعتر ثم البردقوش على التوالى(0.048، 0.045، 0.035، 0.026 ملجم/جم وزن رطب). بينما كان اعلي تركيز لتراكم الحامض فى الكالس خلال ثاني زراعة للكالس للحصا لبان، ثم الزعتر ثم البردقوش ثم المريمية على التوالى. أجريت هذه الدراسة فى محطة البحوث الزراعية بسخا- مصر- لتقدير قوة الهجين ومعامل التربية الداخلية لعدد ثمانية هجن فى الجيل الاول بالاضافة الى نسل الجيل الثانى لهذه الهجن والناتجة من التهجين بين اربع سلالات عقيمة سيتوبلازمية وهى (ICS20 : ,TX30, ICS36 و200243) مع اثنين من اصناف حشيشة السودان (بايونير وقنا) خلال نظام التزاوج (السلالات× الكشافات) وذلك خلال المواسم الصيفية 2007،2008 و2009. اخذت القراءات على صفات(محصول العلف الأخضر وارتفاع النبات وسمك الساق ونسبة الورق للسيقان اخضر بالاضافة لنسبة الورق الى السيقان جاف) على حشتين متتاليتين. اظهرت النتائج ان هناك اختلافات عالية المعنوية بين كل التراكيب الوراثية لكل الصفات تحت الدراسة فى كلا الحشتين. وأظهرت تقدير متوسطات اداء الاباء والهجن ان السلالات العقيمة ذكريا كانت اقل قيم بالنسبة للمحصول الاخضر وارتفاع النبات.وتفوق الجيل الاول على الاباء فى كل الصفات المدروسة، فيما عدا صفة سمك الساق بالاضافة الى تفوق بعض عشائر الجيل الثانى عن هجن الجيل الأول، وكذلك الآباء فى بعض الصفات.

تم تقدير قوة الهجين على اساس متوسط الاباء وافضل الاباء وكذلك قوة الهجين القياسية بالنسبة للهجين التجاري. وأظهرت تقديرات قوة الهجين ان الهجين (200234 x بايونير) كان اكثر الهجن تفوقا وذو قيمة معنوية

عالية لقوة الهجين للثلاث طرق ويمكن استخدامه كهجين على نطاق تجارى. ايضا على الجانب الأخر، بالنسبة لقياسات الانحدار الناتج عن التربية الداخلية فى نسل الجيل الثاني، وجد ان هناك هجن ذات قيم وعامل تربية داخلية سالبة وعالية المعنوية لمعظم الصفات المدروسة، وبالتالي يمكن الانتخاب فى نسل هذه الهجن وانتخاب نباتات متفوقة ناتجة عن الانعزال متعدى الحدود يمكن استخدامها كأصناف او كآباء فى برامج التربية لتحسين محصول العلف فى السورجم. وأوضحت قياسات معامل السيادة أن معظم القيم لمعظم الهجن ومعظم الصفات كانت عالية واكبر من الوحدة وهذا يدل على ان الفعل الجينى غير المضيف له التأثير الأكبر فى توريث هذه الصفات تحت الدراسة.