Egypt. J. Plant Breed. 14 (3): 175 – 187 (2010)

EFFECT OF TESTERS ON COMBINING ABILITY AND HETEROSIS FOR FORAGE YIELD IN PEARL MILLET

S. S. M. Abo Feteih, M. M. Azab and I.M.H. Awad
Forage Crops Res. Dept. , Field Crop Res. Institute, ARC, Giza, Egypt.

ABSTRACT

Gene action and combining ability for yield and its components of pearl millet were studied by line x tester analysis in thirty crosses involving ten S_3 inbred lines (females) and three open pollinated populations as testers (WCC75, ICMV 88908 and Sudan Pop.) (males), they were marked with serial numbers (1 to 13), respectively. In 2008, all possible top cross combinations (excluding reciprocals) were produced. All forty three genotypes (ten S_3 inbred lines, three tester cultivars and thirty F_1 hybrids) were evaluated for forage yield and its components during 2009 season. Mean squares due to lines x tester interactions were highly significant for most traits at the three cuts, except for stem diameter and leaf stem ratio. While the variability of parents vs. crosses contrast which is a test for heterosis was significant, indicating significant heterosis for all traits except stem diameter and leaf stem ratio. The ratio of σ^2_{GCA} to σ^2_{SCA} was less than one, indicating the importance of non-additive gene action for these characters. The line (no. 2) was the best general combiner in the three cuts, for the total dry forage yield. Similarly, inbred lines (no. 1, 4, 5 and 6) were the best general combiners at the average of cuts for No. of tillers, stem diameter, leaf stem ratio and plant height, respectively. Seven crosses revealed significant positive SCA effects for total dry yield. Such values were high in hybrid (6 x 12) for total dry yield and No. of tillers and stem diameter. On the other hand, SCA effects reveal that, for hybrid crop development, cross (9 x 13) could be considered the best hybrid, because it showed highest SCA effects for plant height and hybrid (10 x 12) which showed the highest SCA effects for No. of tillers. Non-additive genetic effect played the major role in the genetic expression for all studied traits, while the additive genetic effect had a minor role in the inheritance for these traits. Out of the total number of 30 F_1 hybrids, only 15, 6, 12, 2 and 4 top-crosses exhibited significant heterosis above their higher parent for total dry yield, plant height, No. of tillers, stem diameter and leaf stem ratio, respectively. Heterosis ranged from -36.57 to 50.15% for total dry yield with an average of 5.59%, from -57.93 to 50.77% for plant height with an average of 5.85% and from -33.03% to 79.43% for No. of tillers with an average of 38.72. Mean performance showed the best crosses with respect of forage yield involved WCC 75 as a common parent. It can use in producing high yielding commercial F_1 hybrids.

Key Words: ***Line x tester, Combining ability, Heterosis, Pearl millet.***

INTRODUCTION

Pearl millet (*Pennisetum glaucum* L.) has been grown most extensively as a forage crop in many countries. In Egypt, pearl millet plays an important role to increase forage demand in summer seasons. Developing high yielding cultivars of forage crops is one of the important mandates of the Forage Crops Res. Dept.

Estimation of combining ability variance and effects of quantitative characters through line x tester analysis is essential for plant breeding programs. Most of the studies on the choice of tester for estimating general combining ability have been related with the estimates the type of tester most suitable for evaluating combining ability of the germplasm. A tester with a low frequency of favorable alleles allows the expression, even in the presence of dominant gene effects of favorable alleles present in the lines. Such tester may not identify superior hybrids but it will probably identify inbred lines with good combining ability and use of a superior tester to identify superior crosses (Virk 1988, Rassi and Hallaer 1991, Maiti and Wesch-Ebeling 1997, Hasib *et al* 2002, Hammoud *et al* 2008 and Ghazy *et al* 2008 a and b).

The line x tester analysis method is used in both self and cross-pollinated plants to estimate favorable parents and crosses, and their general and specific combining abilities (Kempthorne 1957). Combining ability analysis is an important tool for the selection of desirable parents together with the information regarding nature and magnitude of gene effects controlling quantitative traits (Sharma *et al* 1999). General (GCA) and specific (SCA) combining ability which identify the hybrids with high yield are the most important criteria in breeding programs (Ceyhan *et al* 2008). The great efforts have been devoted to identify pearl millet cultivars with high combining abilities (Vetriventhan *el al* 2008).

Heterosis breeding has been recognized as the most suitable breeding methodology for developing yield in pearl millet. Selection of suitable parents and assessment of degree of heterosis in the resulting cross are important steps. An extensive survey of pearl millet literature reported 40 per cent average better parent heterosis for grain yield (Soliman 1994, El-Shahawy *et al* 2000 and Vetriventhan *el al* 2008).

The main objectives of this investigation were to study the performance of thirty hybrids resulting from the crossing ten lines with three testers of pearl millet, and to estimate the general and specific combining ability variances and effects and heterosis

MATERIALS AND METHODS

This study was conducted at Giza Exp. Stat., Forage Crops Research Department FCRD, Field Crops Research Institute FCRI, Agriculture Research Center ARC, Egypt during summer seasons 2008 - 2009. Ten of elite promising S_3 inbred lines derived from cv. Shandweel 1 pearl millet as females (lines) and three tester introduced populations from India and Sudan (WCC75, ICMV 88908 and Sudan pop.) representing a wide range of variability for most studied traits as males (testers), were used in this study and marked with serial numbers 1 to 13, respectively.

In 2008, all possible top cross combinations (excluding reciprocals) of the female parents (S_3 lines) and male parents (testers) were crossed according to (10 x 3) line x tester mating design to produce 30 F_1 hybrids through intercrossing one row from each line (female) with several rows representing only one tester (male) in an isolated area to prevent foreign pollen contamination, as outlined by Kempthorne (1957).

In the summer of 2009, the forty three genotypes (the ten S_3 lines, three tester cultivars and thirty F_1 hybrids) were evaluated at Giza Station in June in RCBD with 4 reps. Plots consisted of five rows 3 m long, 60 cm wide with hills spaced 20 cm sown at the seeding rate of 20 Kg fad^{-1}. The cultural practices were applied as recommended. Trail was fertilized with 20 kg P_2O_5 fed^{-1} added during land preparation, and 30 kg N fed^{-1} added before the first irrigation and after each cut. Three cuts were taken, the first after 60 days from sowing, second cut after 35 days and third cut after 40 day during summer season of evaluation. At each cut, data were collected for ten guarded plants on plant height, number of stems, stem diameter (cm), leaves/stems ratio %. Forage yield was determined by cutting the whole rows 20 cm above soil surface and dry yield was recorded following drying forage sub-samples from each plot.

The mean squares from line x tester design, the general combing ability (GCA), specific combing (SCA) variances and effects were calculated according to the procedures developed by Kempthorne (1957) and adopted by Singh and Choudhry (1980) and Falconer and Mackay (1996). The amount of heterosis was estimated as the percentage deviation of the F_1 hybrid over the better parent (B.P) [$H_{PB} = (((F1\text{-}B.P.)/B.P.) *100)$], and significance was determined using the least significance difference values (LSD) at 0.05 and 0.01 levels of significance.

RESULTS AND DISCUSSION

Performance parents vs. F_1's

Analysis of variances and the mean squares for the forty three genotypes (ten S_3 inbred lines, three tester cultivars and thirty F_1 hybrids) in 2009 are presented in Table (1).

Mean squares due to lines x tester interactions were highly significant for most studied traits at the three cuts, except for stem diameter and leaf stem ratio, indicating the presence of genetic variability within populations. Lines variance exhibited non significance for all traits except dry yield at cut 3. Non significant differences were observed among genotypes for leaf stem ratio, while the parent vs. cross contrast, which is a test for heterosis was significant, showed significant heterosis for all traits, except stem diameter and leaf stem ratio. Crosses showed significant, positive SCA effects for dry yield and its components, indicating non-additive gene action. Specific combining ability has previously been shown in pearl millet to be the major contributing factor for forage yield and yield components (Vetriventhan *el al* 2008).

Table 1. Mean squares for forage yield and its components of 30 testcrosses among 10 S_3 lines and three testers for studied traits at Giza on 2008.

SOV	Df	Dry yield t fed^{-1}				Plant height cm	No of tillers	Stem Diam. cm	Leaf stem ratio
		Cut 1	Cut 2	Cut 3	Total cuts				
Rep	3	0.41^{**}	0.78^{**}	0.32^{**}	4.32^{**}	2765.84^{**}	7.67^{**}	0.25^{**}	0.004^{ns}
Genotypes	42	1.51^{**}	0.37^{**}	0.79^{**}	3.72^{**}	3714.33^{**}	5.65^{**}	0.02^{**}	0.017^{ns}
Parents (P)	12	1.57^{**}	0.34^{**}	0.31^{**}	3.43^{**}	1328.21^{**}	5.78^{**}	0.01^{ns}	0.014^{ns}
P vs. C	1	0.12^{ns}	0.55^{**}	8.56^{**}	16.06^{**}	1259.24^{**}	22.39^{**}	0.001^{ns}	0.002^{ns}
Crosses (C)	29	1.53^{**}	0.38^{**}	0.72^{**}	3.41^{**}	4786.35^{**}	5.02^{**}	0.02^{ns}	0.019^{ns}
S_3 lines (L)	9	1.10^{ns}	0.57^{ns}	1.38^{*}	5.12^{ns}	1873.21^{ns}	9.09^{*}	0.02^{ns}	0.016^{ns}
Tester (T)	2	3.57^{**}	0.78^{*}	0.63^{ns}	4.65^{ns}	10861.63^{ns}	0.44^{ns}	0.07^{**}	0.001^{ns}
L x T	18	1.53^{*}	0.24^{**}	0.40^{**}	2.41^{**}	5567.88^{**}	3.50^{**}	0.02^{*}	0.023^{ns}
Error	126	0.07	0.07	0.03	0.30	266.97	0.26	0.01	0.015
Estimates of combining ability components									
GCA		0.0001	0.002	0.0045	0.014	10.95	0.121	0.00001	0.00001
SCA		0.365^{**}	0.042^{ns}	0.093^{**}	0.527^{*}	1325.25^{**}	0.808^{**}	0.003^{ns}	0.002^{ns}
GCA/SCA		0.0003	0.0476	0.0484	0.0484	0.0083	0.1498	0.0040	0.0054

***,** & ns significant at 0.05 and 0.01 probability levels and non significant, respectively.**

The ratio of σ^2 GCA to σ^2 SCA was less than one for the studied traits, indicating the importance of non-additive gene action for these characters. However, for dry forage yield, both GCA and SCA were equally important, suggesting that additive and non-additive genetic effects have equal and significant contribution to yield. Results indicated that the non-additive genetic variances including dominance were larger than their corresponding additive genetic variance for all studied traits at the three cuts. The closer this ratio to one, the greater the chances of predicting progeny performance based on GCA (Allard 1960, Sharma *et al* 1967, Sharma *et al* 1999, Ahamd *et al* 2003 and Owolade 2009). SCA is more important than GCA for previously selected inbreds, whereas GCA is more important than SCA for unselected lines (Soengas *et al* 2003)

The mean performances for the forty five genotypes are presented in Table (2). As a group, the top crosses were significantly different from the mean of their parents in most of forage yield and its components. They were superior than their parents in dry yield at cut 1 (by 6.74%), dry yield at cut 2 (by 8.53%), dry yield at cut 3 (by 55.17%), total dry yield (by 14.99%), plant height (by 2.68%), No. of tillers (by 19.09%), stem diameter (by 0.93%) and leave stem ratio% (by -2.[illegible]%). Top crosses (F_1) performance was generally better than parental performance for all traits. The results indicated that the tester No. 12 was the best general combiner with the most of inbreds for total dry forage yield with a mean value of 5.26 t fed^{-1} with relative superiority over the crosses by 8.01%. On the other hand, for plant

Table 2. Mean performance of forage yield and its components for 43 pearl millet genotypes evaluated at Giza in summer season 2009.

No.	Tester	S_3 Line	Dry yield t fed^{-1}				Plant height cm	No of tillers	Stem Diam. Cm	Dry leaf stem ratio
			Cut 1	Cut 2	Cut 3	Total cuts				
1	11	1	1.18	1.55	1.52	4.25	94.34	6.51	0.99	0.57
2		2	2.14	2.32	1.52	5.98	161.67	6.43	1.09	0.39
3		3	2.00	1.65	1.18	4.83	148.53	5.19	1.11	0.48
4		4	1.50	1.72	1.67	4.89	118.97	6.23	1.16	0.33
5		5	1.98	1.74	1.29	5.01	160.03	4.83	1.04	0.40
6		6	2.49	1.17	0.97	4.63	189.73	4.03	0.95	0.53
7		7	1.82	1.44	0.93	4.19	129.87	4.44	1.04	0.45
8		8	1.60	1.91	1.25	4.76	122.11	5.31	1.02	0.53
9		9	1.54	1.40	1.01	3.95	121.06	5.77	0.92	0.34
10		10	1.49	1.91	1.27	4.67	120.47	4.95	1.04	0.37
Mean			**1.77**	**1.68**	**1.26**	**4.72**	**136.68**	**5.37**	**1.04**	**0.44**
11	12	1	2.57	2.13	1.73	6.43	150.78	6.41	1.02	0.46
12		2	3.08	2.28	2.4	7.76	125.60	8.56	1.05	0.42
13		3	1.20	1.86	0.60	3.66	97.78	3.73	1.09	0.51
14		4	2.10	1.59	0.89	4.58	161.67	4.16	1.13	0.45
15		5	1.61	2.21	0.90	4.72	124.05	4.37	1.06	0.46
16		6	3.19	1.84	1.79	6.82	154.37	6.55	1.17	0.43
17		7	1.38	1.85	1.01	4.24	103.15	4.86	1.08	0.43
18		8	0.84	1.79	1.68	4.31	64.34	5.26	1.23	0.36
19		9	1.87	1.41	0.82	4.10	133.45	5.42	1.15	0.46
20		10	2.30	2.41	1.26	5.97	145.40	6.38	1.20	0.42
			2.01	**1.94**	**1.31**	**5.26**	**126.06**	**5.57**	**1.12**	**0.44**
21	13	1	1.15	1.72	2.04	4.91	82.85	6.98	1.16	0.45
22		2	1.27	2.12	2.06	5.45	91.51	7.08	1.17	0.34
23		3	1.62	1.57	1.16	4.35	114.20	5.27	1.07	0.37
24		4	0.76	2.13	1.99	4.88	54.49	6.47	1.23	0.46
25		5	0.74	1.57	1.45	3.76	52.4	5.31	1.07	0.57
26		6	1.37	1.84	1.29	4.50	106.14	5.81	1.06	0.39
27		7	1.83	1.57	0.89	4.29	141.81	4.81	0.98	0.48
27		8	2.20	1.50	1.38	5.08	167.94	5.29	1.09	0.33
29		9	2.17	1.52	1.25	4.94	150.67	4.63	1.04	0.40
30		10	1.09	1.59	1.44	4.12	110.53	3.53	1.06	0.53
Mean			**1.42**	**1.71**	**1.50**	**4.63**	**107.25**	**5.52**	**1.09**	**0.43**
Mean of crosses			**1.74**	**1.78**	**1.35**	**4.87**	**123.33**	**5.49**	**1.08**	**0.44**
		1	1.15	1.17	0.36	2.68	95.24	2.95	1.03	0.45
		2	3.11	1.81	0.90	5.82	126.79	4.38	1.06	0.53
		3	1.66	1.53	0.53	3.72	121.81	7.75	1.08	0.34
		4	1.19	1.97	1.15	4.31	87.33	4.28	1.19	0.40
		5	1.51	1.78	0.77	4.06	112.85	4.32	1.04	0.52
		6	1.33	1.63	0.86	3.82	102.40	4.12	1.15	0.45
		7	1.92	1.49	0.72	4.13	138.68	3.77	1.06	0.46
		8	1.49	1.72	1.22	4.43	122.11	5.38	1.09	0.43
		9	1.65	2.29	1.26	5.20	121.06	5.69	1.10	0.36
		10	1.37	1.24	0.94	3.55	107.93	5.13	1.04	0.46
			1.64	**1.66**	**0.87**	**4.17**	**113.62**	**4.78**	**1.08**	**0.44**
	11 WCC75		1.39	1.59	0.89	3.87	125.84	3.99	1.03	0.40
	12 88908		2.88	1.74	1.15	5.77	152.95	5.45	1.13	0.46
	13Sudan millet		1.15	1.53	0.57	3.25	99.12	3.89	1.01	0.51
Mean of tester			**1.62**	**1.62**	**0.87**	**4.30**	**125.97**	**4.44**	**1.06**	**0.46**
Grand mean			**1.74**	**1.74**	**1.21**	**4.67**	**121.26**	**5.25**	**1.08**	**0.44**
$LSD_{0.05}$			0.36	0.38	0.25	0.77	22.86	0.72	0.09	ns

height, No. of tillers, stem diameter and leaf stem ratio, were also found better than the parental performance at three cuts. The obtained results are in line with those reported by El-Shahawy *et al* (2000), Mohamed (2000), Haggag *et al* (2000), and Abdel Galil and Oushy (2007).

General combining ability (GCA)

The estimated effects of general combining ability (GCA) for lines and testers are presented in Table (3). The line No. (2) revealed the best general combiner in the three cuts, and in the total dry forage yield. Similarly, the inbred S_3 lines No's. 1, 4, 5 and 6 were the best combiners at the average of cuts for No. of tillers, stem diameter, leaf stem ratio and plant height, respectively. Moreover, the tester No. 12 was the best combiner at the second cut and total fresh forage yield. Similarly, testers No's. 11, 12 and 13) were the best combiners at the average of cuts for plant height, No. of tillers, and stem diameter, respectively. There were no significant differences among testers for leaf stem ratio.

Inbred lines 1 and 2 had significantly greater positive effects of GCA for number of tillers than the other parents. Such positive GCA effects indicated that these two parents may be considered the best general combiners for dry yield.

Table. 3. GCA Effect for parents in line x tester analysis involving 10 S_3 inbred lines (females) and three populations (males) of pearl millet

S_3 Line	Dry yield t fed^{-1}				Plant height cm	No of tillers	Stem Diam. cm	Leave stem ratio
	Cut 1	Cut 2	Cut 3	Total cuts				
1	-0.10	0.02	0.41*	0.33*	-13.04**	1.15**	-0.02	0.06
2	0.43**	0.46*	0.64**	1.53**	3.90	1.87**	0.02	-0.05
3	-0.13*	-0.09	-0.38**	-0.59**	-2.19	-0.76**	0.01	0.02
4	-0.28*	0.04	0.16*	-0.09	-10.65*	0.13	0.09**	-0.02
5	-0.30	0.06	-0.14	-0.38**	-10.20*	-0.65**	-0.02	0.04
6	0.61**	-0.16*	-0.01	0.45*	27.72**	-0.02	-0.02	0.01
7	-0.06	-0.16*	-0.41**	-0.63*	2.58	-0.78*	-0.05*	0.02
8	-0.19**	-0.04	0.08	-0.15	-4.23	-0.20	0.03	-0.03
9	0.12	-0.34**	-0.31**	-0.53**	12.70*	-0.21	-0.05	-0.04
10	-0.11	0.02	-0.03	0.05	-6.57	-0.54*	0.02	0.00
SE $g_i - g_J$	**0.07**	**0.08**	**0.05**	**0. 16**	**4.71**	**0.15**	**0.03**	**0.04**
Tester								
11	0.04	-0.01	-0.09	-0.15	14.32**	-0.12	-0.05	0.00
12	0.28*	0.16	-0.05	0.39*	3.70	0.09	0.04*	0.00
13	-0.32**	-0.06	0.14	-0.24*	-18.01**	0.03	0.01	0.00
SE $g_i - g_J$	**0.041**	**0.13**	**0.09**	**0.09**	**2.58**	**0.08**	**0.02**	**0.02**

*** &** significant at 0.05 and 0.01 probability levels, respectively.**

Pearl millet tester No.11, (ICMV 88908) exhibited positive GCA effects for plant height, as well as tester No.12, (WCC 75) exhibited positive GCA effects for total dry yield. The millet tester WCC 75 demonstrates the ability to distinguish the advantage of the female lines. However, the higher GCA effects of female inbred line No. 2 and male tester (ICMV 88908) for majority of the studied traits indicate that both these parents may be preferred for hybridization followed by selection programs. Therefore, it could be concluded that the selection procedures based on the accumulation of additive effect would be successful in improving these traits. The obtained results are in line with those reported by Sharma *et al* (1999), Ahamd *et al* (2003) and Owolade (2009).

Specific combining ability (SCA)

Specific combining ability effects (SCA) of the thirty hybrids for the studied traits are presented in Table (4). Seven crosses revealed significant positive SCA effects for total dry yield.

Such values were high in the hybrid (6 x 12) for total dry yield, No. of tillers and stem diameter. On the other hand, SCA effects revealed that, for hybrid crop development, cross (9 x 13) millet could be considered the best hybrid showing the highest SCA estimates for plant height and hybrid (10 x 12) showing the highest SCA estimates for No. of tillers.

The variability of testcrosses was mainly due to variability of SCA of inbred lines. The contribution of line x tester interaction of testcrosses indicated that non-additive genetic effects are important for dry yield, plant height and No. of tillers. Therefore, for these traits dominant effects were important. Moreover, SCA is more important than GCA for previously selected inbred lines, while, GCA is more important than SCA for unselected lines. The obtained results are in line with those reported by Soliman (1994), El-Shahawy *et al* (2000) and Soengas *et al* (2003).

Heterosis of top crosses over better parents

Heterosis over better parents at the three cuts is presented in Table (5). Most of crosses exhibited significant positive heterosis over better-parent for total dry yield, plant height, No. of tillers, stem diameter and leaf stem ratio. Out of total number of 30 F_1's, only 15, 6, 12, 2 and 4 top-crosses exhibited significant heterosis above their higher parent for total dry yield, plant height, No. of tillers, stem diameter and leaf stem ratio, respectively. Heterosis ranged from -36.57 to 50.15% for total dry yield with a mean of 5.59%, -57.93 to 50.77% for plant height with a mean of 5.85%, -33.03% to 79.43% for No. of tillers with a mean of 38.72, -17.39 to 23.65% for stem diameter with a mean of 11.13%, and -35.29 to 26.67% for leaf stem ratio with a mean of -8.02%.

Table 4. Estimates of SCA effect for hybrids in line x tester analysis involving 10 S_3 lines (females) and three populations (males) of pearl millet.

No.	Teste r	Line	Dry yield t fed^{-1}				Plant height cm	No of tillers	Stem Diam. cm	Leave stem ratio
			Cut 1	Cut 2	Cut 3	Total cuts				
1	11	1	-0.49**	-0.15	-0.15	-0.79*	-29.30*	-0.01	-0.02	0.07
2		2	-0.06	0.17	-0.38**	-0.26	21.09*	-0.80**	0.03	0.01
3		3	0.35*	0.05	0.29**	0.70*	14.05	0.58*	0.07	0.03
4		4	0.01	0.00	0.25*	0.26	-7.05	0.73*	0.03	-0.08
5		5	0.50**	0.00	0.17	0.67*	33.55**	0.11	0.03	-0.08
6		6	0.10	-0.35*	-0.29*	-0.54*	25.34*	-1.32**	-0.07	0.08
7		7	0.10	-0.08	0.08	0.10	-9.39	-0.15	0.06	-0.01
8		8	0.01	0.27*	-0.09	0.20	-10.34	0.14	-0.04	0.12
9		9	-0.35*	0.05	0.07	-0.23	-28.31*	0.62*	-0.07	-0.07
10		10	-0.17	0.04	0.04	-0.10	-9.64	0.11	-0.01	-0.07
11	12	1	0.65**	0.17*	0.02	0.84**	37.76**	-0.31	-0.07	-0.04
12		2	0.63**	-0.12	0.46**	0.97**	-4.36	1.12**	-0.09	0.03
13		3	-0.68**	0.01	-0.33**	-1.00**	-26.09	-1.09**	-0.04	0.05
14		4	0.37*	-0.38*	-0.56**	-0.60*	46.26**	-1.54**	-0.08	0.03
15		5	-0.11	0.21*	-0.27*	-0.17	8.20	-0.55	-0.03	-0.02
16		6	0.57**	0.07	0.49**	1.12**	0.59	1.00**	0.08	-0.02
17		7	-0.57**	0.07	0.11	-0.39	-25.49*	0.08	0.01	-0.03
18		8	-0.98**	-0.11	0.29*	0.08	-57.49**	-0.11	0.08	-0.05
19		9	-0.27*	-0.20*	-0.17	-0.64*	-5.30	0.06	0.08	0.06
20		10	0.39	0.28**	-0.01	0.67*	25.91*	1.34**	0.06	-0.02
21	13	1	-0.17	-0.01	0.14*	-0.04	-8.46	0.32	0.09	-0.04
22		2	-0.58**	-0.05	-0.08	-0.07	-16.74	-0.31	0.06	-0.04
23		3	0.33*	-0.06	0.04	0.30	12.04	0.51*	-0.03	-0.08
24		4	-0.38*	0.38*	0.33**	0.34	-39.21**	0.82*	0.05	0.05
25		5	-0.39*	-0.21	0.09	-0.50*	-41.75**	0.44	0.01	0.10
26		6	-0.66**	0.29*	-0.20	-0.58*	-25.93*	0.32	-0.01	-0.05
27		7	0.47*	0.01	-0.20	0.29	34.88*	0.07	-0.07	0.03
27		8	0.97**	-0.17	-0.20	0.60*	67.82**	-0.03	-0.04	-0.07
29		9	0.62**	0.14	0.10	0.87*	33.62*	-0.68*	-0.01	0.01
30		10	-0.22	-0.32*	-0.03	-0.57*	-16.27	-1.46**	-0.05	0.09
SE SCA effects			0.13	0.13	0.09	0.27	8.17	0.26	0.05	0.06
SE (gi - gj) line			0.06	0.06	0.04	0.12	3.65	0.12	0.02	0.03
SE (gi - gj) tester			0.11	0.11	0.07	0.22	6.67	0.21	0.04	0.05
SE (Sij – Ski)			0.18	0.19	0.13	0.38	11.55	0.36	0.07	0.09

*,** significant at 0.05 and 0.01 probability levels, respectively.

Table 5. Heterosis (%) over mid parent of forage yield and its components in pearl millet hybrids.

No.	Tester	Line	Dry yield t fed-1				Plant height	No of tillers	Stem diam.	Leaf stem ratio
			Cut 1	Cut 2	Cut 3	Total cuts				
1	11	1	-15.11*	-2.52	70.79**	9.82*	-25.03*	63.16**	-3.88	26.67**
2		2	-31.19**	28.18**	68.89**	2.75	27.51*	46.80*	2.83	-26.42**
3		3	20.48*	3.77	32.58**	29.84**	18.03*	-33.03	2.78	20.00*
4		4	7.91	-12.69*	45.22**	13.46*	-5.46	45.56*	-2.52	-17.50*
5		5	31.13**	-2.25	44.94	23.40**	27.17*	11.81	0.00	-23.08*
6		6	79.14**	28.22**	8.99	19.64*	50.77**	-2.18	-17.39*	17.78*
7		7	30.94**	-9.43	4.49	1.45	-6.35	11.28	-1.89	-2.17
8		8	7.38	11.05	2.46	7.45	-2.96	-1.30	-6.42	23.26*
9		9	-6.67	-38.86**	-19.84*	-24.04**	-3.80	1.41	-16.36*	-15.00*
10		10	7.19	20.13	35.11**	20.67**	-4.27	-3.51	0.00	-19.57*
Mean			**13.12***	**-3.09**	**29.36****	**10.44***	**7.56**	**14.00***	**-4.29**	**-1.60**
11	12	1	-10.76	22.41**	50.43	11.44*	-1.42	57.61**	-9.73	0.00
12		2	-0.96	25.97*	108.70**	34.49**	-17.88*	57.06**	-7.08	-20.75*
13		3	-58.33**	6.90	-47.83	-36.57**	-36.07**	-51.87	-3.54	10.87
14		4	-27.08**	-19.29*	-22.61	-20.62*	5.70	-23.67	-5.04	-2.17
15		5	-44.10**	24.16*	-21.74	-18.20*	-18.90*	-19.82	-6.19	-11.54
16		6	10.76	5.75	55.65	18.20*	0.93	20.18	1.74	-6.52
17		7	-52.08**	6.32	-12.17	-26.52**	-32.56**	-10.83	-4.42	-6.62
18		8	-70.83**	2.87	46.09	-25.30**	-57.93**	-3.49	8.85	-21.74*
19		9	-35.07**	-38.43**	-28.70	-28.94**	-12.75	-4.75	1.77	0.00
20		10	-20.14	38.51	9.57	3.47	-4.94	17.06	6.19	-8.70
			-30.86**	**7.52**	**13.74****	**-8.86**	**-17.58***	**-0.25**	**-1.75**	**-6.71**
21	13	1	0.00	12.42	257.89**	51.08**	-13.01	79.43**	12.62*	-11.76
22		2	-59.16**	17.13*	128.89**	-6.36	-27.83*	61.64**	10.38*	-35.85**
23		3	-2.41	2.61	103.51**	16.94*	-6.25	-32.00	-0.93	-27.45*
24		4	-36.13**	8.12	73.04**	50.15**	-45.03**	51.17**	3.36	-9.80
25		5	-50.99*	-13.73	88.31*	-7.39	-53.57**	22.92*	2.88	9.62
26		6	3.01	12.88	50.00**	17.80*	3.65	41.02*	-7.83	-23.53*
27		7	-4.69	2.61	23.61	3.87	2.26	23.65*	-7.55	-5.88
27		8	47.65**	-12.79	13.11	14.67*	37.53**	-1.67	0.00	-35.29*
29		9	31.52*	-33.62**	-0.79	-5.00	24.46*	-18.63*	-5.45	-21.57*
30		10	-20.44*	3.92	53.19**	16.06*	2.41	-31.19**	1.92	3.92
Mean			-9.17	**-0.04**	**79.08****	**15.18***	-7.54	**19.63***	0.94	**-15.76***
Mean of crosses			-8.97	1.46	40.73**	5.59	5.85	11.13*	-1.70	-8.02

***,** & ns significant at 0.05 and 0.01 and probability levels non significant, respectively.**

The remaining of cases involved heterotic effect for one or more trait other than forage yield. Cross (1 x 13) exhibited 51.94% heterosis above the better parent for total dry yield, 79.43% for No. of tillers and 12.62% for stem diameter. Similarly, the cross (4 x 13) showed 50.15% heterosis for total dry yield and 51.17% for no of tillers. The cross (2 x 12) showed 34.49% heterosis for forage yield, 57.06% for No. of tillers but only -17.88% for plant height. The above mentioned results showed that the traits which seemed to be most related to forage yield are plant height, No. of tillers and stem diameter, as these traits, singly or together, accounted for heterotic forage yield shown by 15 out of 30 top crosses.

The tester No. 12, (WCC 75) followed by tester No. 11 (ICMV 88908) exhibited significant heterobeltiosis (15.18 and 10.44%, respectively) for total dry yield. This shows non additive genetic effects responsible for heterotic response of these hybrids.

However, the test of potential of parent for the expression of heterosis would be better conducted over a number of environmental conditions to get more accurate results. This shows that non additive genetic effects are responsible for the heterotic response of these hybrids. The obtained results are in line with those reported by El-Shahawy and Gheit (1999), Haggag *et al* (2000), Mohamed (2000) , Abdel Galil and Oushy (2007), Younis *et al* (2010).

The tester (WCC 75) has the ability to identify the merits of the female lines. However, the highest GCA effects of the female line No. 2 and male tester (WCC 75) for majority of the traits indicate that both these parents may be preferred for hybridization and selection programs. The SCA effects reveal that, for hybrid crop development, crosses (line 1 x WCC 75) and (line 5 x WCC 75) for forage yield, (line 1 x ICMV 88908) and (line 1 x WCC 75) could be considered the best choice for number of tillers, (line 1 x sudan pop.) for stem diameter, and (line 1 x ICMV 88908) for leaf stem ratio.

Selection of lines based in the performance in top-crosses, 50% of them could be discarded without a serious danger of losing valuable material. In addition, any type of tester can be used to discard 50% of lines. These results indicate that an unrelated inbred line is more reliable for ranking lines for GCA than a line with a high GCA derived from the related population (Rassi and Hallauer 1991). Mean performance showed that two crosses with respect to forage yield involved WCC 75 as a common parent. Thus, they can be used as high yielding commercial F_1 hybrids.

REFERENCES

Ahmed E.A., H.S. Ibn Oaf and A.E. El Jack (2003). Combinig ability and heterosis in line x tester crosses of summer squash (*Cucurbita pepo* L.). Cucurbit Genet. Cooperative Rep. 26: 54-56

Allard, R. W. (1960). Principles of Plant Breeding. John Wiley and Sons, Inc., New York.

Abdel-Galil, M. M. and H. S. Oushy (2007). Recurrent S_1 progeny selection to improve pearl millet. Egypt J. Agric. Res. 85(3): 917-924.

Ceyhan E., M.A. Avci and S. Karads (2008). Line x tester analysis in pea (*Pisum sativum* L.): Identification of suprior parents for seed yield and its components. African J. Biotech. 7 (16): 2810-2817.

El-Shahawy, A.E. and G.S. Gheit (1999). Evalution and screening of some pearl millet [(*Pennistum americanum* (L.) Leeke] genotypes. J. Aric. Res., Tanta Univ. 25 (2) 236-247.

El-Shahawy, A. E., Z. M. Marie, I. A. Hana and N.S. Meawad (2000). Estimates of some genetic parameters in forage pearl millet. J. Agric. Sci. Mansoura Univ. 25 (6): 3157-3166.

Falconer, D.S. and T.F.C. Mackay (1996). Introduction to Quantative Genetics. 4th edition, Longman, Edinburgh, London.

Haggag, M. El-H., E. S. S. Soliman, M. M. Abdel-Galil, Z. M. Marei and A. E. ElShahawy (2000). Evaluation of mean performance, genetic parameters and nutritive values for some selected strains of forage sorghum. J. agric. Sci., Mansoura Univ. 25(11): 6767-6786.

Hammoud, S.A.A., I.S.M. El-Degwy, S.E.M. Sedeek and B.A. Zayed (2008). Line x tester analysis for some quantititive traits in rice. The Second Field Crop Confer. FCRI, ARC, Giza, Egypt, 14-16 Oct. 121-140.

Hasib K.M., P.K. Ganguli and P.C. Kole (2002). Line x tester analysis for yield and its components in scented rice. Madras Agric. J. 89 (4-6): 278-281.

Ghazy, M.M.F. , F.M. Ali, Z.M. El-Diasty and M.S. Hamada (2008a). Estimation of some genetic parameters of economic traits in sorghum. I. Gene action and heritability. The Second Field Crop Confer. FCRI, ARC, Giza, Egypt, 14-16 Oct. 31-45.

Ghazy, M.M.F. , F.M. Ali, Z.M. El-Diasty and M.S. Hamada (2008b). Estimation of some genetic parameters of economic traits in sorghum. II. Heterosis. The Second Field Crop Confer. FCRI, ARC, Giza, Egypt, 14-16 Oct. 47-58.

Kempthorne, O. (1957). An Introduction to Genetic Statistics. Iowa State Univ. John Wiley and Sons Inc. New York.

Maiti, R. K. and P. Wesch-Ebeling (1997). Pearl Millet Science. Science Publishers, Inc. U.S.A.

Mohamed, A.K. (2000). Behaviour of some millet varieties from Niger under Egyptian climatic conditions. M.Sc. of African Studies in Plant Resources Instit. African Res. and Dep. of Natural Resources. Cairo Univ. Eygpt.

Rassi R. d. and A.R. Hallaer (1991). Evaluation of four testers for evaluating maize (*Zea mays* L.) lines in hybrid development program. Rev. Brasil. Genet. 14(2) 467-481.

Owolade, O.F. (2009). Line x tester analysis for resistance to Cassava Anthracnose disease. Electronic J. Env. Agr. And food chem. 8(1): 52-60.

Sharma D., J. P. Tandon and J. N. Batra (1967). Effect of tester on combining estimate of maize germplasm complexes. Euphytica 16: 370-376.

Sharma D.K., B. Adarsh and D.R. Chaudhary (1999). Studues on combining ability and gene action in pea (*Pisum sativum* L.). Indian J. Hill Far. 12:32-36.

Singh, R.K. and B. D. Chaudhary (1985). Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi, Ludhiana, India.

Soengas P., B. Ordas, R.A. Malvar, P. Revilla and A. Ordas (2003). Performance of flint maize in crosses with testers from different heterotic groups. Maydica 48: 85-91.

Soliman, A. M. (1994). Comparison of performance and combining ability of forage sorghum breeding lines. Ph.D. Thesis, Fac. of Agric., Cairo University, Egypt.

Younis, A.A., I. M. Ahmed and A. H. Fahmy (2010). Using cytoplasmic male sterility in producing forage pearl millet hybrids. Egypt. J. Plant Breed. 14(1): 345-355.

Vetriventhan M., A. Nirmalakumari and S. Ganapathy (2008). Heterosis for grain yield components in pearl millet (*Pennisitum glaucum* (L.) R. Br.). World J. Agric. Sci. 4 (4): 657-660.

Virk, D.S., (1988). Biometrical analysis in pearl millet. A review. Crop Improvement, 15: 1-29.

تأثير السلالات الكشافة على القدرة على الائتلاف وقوة الهجين لانتاج العلف في محصول الدخن.

صلاح سالم محمد أبوفتيح – مصطفى محمد عزب – أبراهيم محمد حسن عوض

قسم بحوث محاصيل العلف – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – جيزة – مصر

يرجع اهمية دراسة تحليل السلالة x الكشاف الى دراسة الفعل الجيني والقدرة على الائتلاف للمحصول ومكوناتة. ولتحقيق هذا الغرض تم دراسة تحليل السلالة x الكشاف على ثلاثين هجين من الدخن. استخدم عشر سلالات ناتجة من جيل الاخصاب الذاتي الثالث (S_3 lines) اشتقت من صنف شندويل-١ (كامهات) مع ثلاثة اصناف كشافة مفتوحة التلقيح مستوردة من الهند والسودان وهي (ICMV 88908 و WCC75 وعشيرة السودان) (كاباء) واعطيت ارقام من (١ : ١٣) على التوالي. في صيف ٢٠٠٨ تم انتاج ثلاثون من الهجن القمية top crosses (١٠ سلالات x ٣ كشافات). وفي الموسم التالي (٢٠٠٩) تم تقييم ثلاثة واربعون تركيب وراثي وهي (عشرة سلالات ابوية S_3 lines وثلاثة اصناف كشافة وثلاثون هجين F_1 hybrids) للمحصول الاخضر ومكوناتة في محطة تجارب البحوث الزراعية بالجيزة التابعة لمركز البحوث الزراعية. اشارت النتائج الى معنوية التفاعل بين السلالة x الكشاف لمعظم الصفات المدروسة باستثناء قطر الساق ونسبة الاوراق للسيقان مما يشير الى وجود التباين الوراثي داخل العشائر. كان تباين الاباء مقابل الهجن معنويا لمعظم الصفات المدروسة حيث يعطي دلالة على قوة الهجين. كانت النسبة بين تباين القدرة على الائتلاف العام والخاص اقل من واحد صحيح مما

يشير الى اهمية الاليلات غير المضيفة لهذه الصفات. كانت السلالة رقم ٢ احسن السلالات في القدرة العامة على التآلف خلال الحشات الثلاثة والمحصول الجاف الكلي. وبالمثل كانت السلالات رقم ١ و ٤ و ٥ و ٦ احسن السلالات في القدرة الائتلافية العامة بالنسبة لعدد الفروع و قطر الساق ونسبة الاوراق للسيقان وطول النبات على التوالي. اظهرت سبعة من الهجن قدرة خاصة على الائتلاف موجبة للمحصول الكلي الجاف. كذلك كانت كل تاثيرات القدرة الخاصة على الائتلاف مرتفعة للهجين (سلالة ٦ x كشاف ١٢) وبالنسبة للمحصول الاخضر الكلي وعدد الفروع وقطر الساق. على الجانب الآخر سجل الهجين (سلالة ١٠ x كشاف ١٢) قيم مرتفعة موجبة من القدرة الخاصة على الائتلاف بالنسبة لعدد الفروع. تلعب الجينات غير المضيفة دورا رئيسيا في تعبير الصفات بينما تلعب الجينات المضيفة دورا ثانويا في وراثة هذه الصفات. من اجمالي ٣٠ هجين تفوق عدد (١٥ و ٦ و١٢ و٢ و٤) من الهجن في قوة الهجين عن الاب الاعلى بالنسبة للمحصول الكلي الجاف وطول النبات وعدد الفروع وقطر الساق ونسبة الاوراق للسيقان، على التوالي. وتراوحت قوة الهجين من -٣٦.٥٧ الى ٥٠.١٥ ٪ للمحصول الجاف الكلي بمتوسط ٥.٥٩ % ومن -٥٧.٩٣ لتصل الى ٥٠.٧٧ ٪ لطول النبات بمتوسط -٥.٨٥ % ومن -٣٢.٠٣ الى ٧٩.٤٣ ٪ لعدد الفروع بمتوسط ٣٨.٧٢ % . اظهرت القدرة على التآلف الخاص تفوق بعض من الهجن المتميزة في صفة او اكثر على سبيل المثال الهجين (line 1 x WCC 75) والهجين (line 5 x WCC 75) بالنسبة لمحصول الاخضر والهجين (line 1 x ICMV 88908) والهجين (line 1 x WCC 75) بالنسبة لعدد الفروع والهجين (line 1 x Sudan Pop.) بالنسبة لقطر الساق واخيرا الهجين (line 1 x ICMV 88908) لصفة نسبة الاوراق للسيقان. ويتضح من هذه النتائج ان السلالة الكشافة WCC 75 اثبتت تفوقها في معظم الهجن مما يدل على امكانية استخدامها في انتاج هجن تجارية.

المجله المصريه لتربية النبات ١٤(٣) : ١٧٥ - ١٨٧ (٢٠١٠)