Indian J. Genet., **65**(1): 12-14 (2005)

Heterosis and inbreeding depression in forage sorghum [*Sorghum bicolor* (L.) Moench]

Meenu Agarwal and P. K. Shrotria

Department of Genetics and Plant Breeding, G. B. Pant Univ. Agri. & Tech., Pantnagar 263 145

(Received: November 2004; Revised: February 2005; Accepted: February 2005)

Abstract

The present investigation in forage sorghum [*Sorghum bicolor* (L.) Moench] was carried for studying the magnitude of heterosis and inbreeding depression of fifty hybrids (F_1s) and their F_2s made by crossing of ten sudan grass restorer lines and 5 cytoplasmic male sterile lines in Line × Tester mating design. Observations were recorded on quantitative and qualitative traits *viz.*, plant height, leaf length, leaf width, fifth leaf area, stem diameter, total soluble solids (T.S.S.%), protein %, digestibility %, shootfly infestation, green and dry fodder yield. Variable magnitude of three types of heterosis (better parent, mid-parent and standard) were observed for different cross combinations for all the traits. Based on *per se* performance and heterotic response for green and dry fodder yield, the best crosses were *viz.*, ICSA 94 × Pant Chari-4, ICSA94 × SDSL92111, ICSA94 × SDSL92113, ICSA94 × SDSL92140, ICSA94 × Selection 984, ICSA95 × ICSV96062 and 296A × SDSL92111. Response of inbreeding depression for these traits was significant in positive direction except T.S.S.%, protein % and shootfly infestation.

Key words: Forage sorghum, heterosis, inbreeding depression, hybrids

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] has been a vital source of food to millions of people in semi-arid tropics. In India, it is an important *kharif* crop that is highly palatable and digestible as for as the nutritional quality is concern. For improving the genetic architecture of the crop through breeding efforts, utilization of heterosis is important for maximization of the yield in sorghum. To attain good seed and fodder yields and to exploit the fodder yield heterosis, the development of multicut sorghum hybrids between sorghum (*S. bicolor*) and sudangrass (*S. sudanense*) is an important area of research. The present investigation has been undertaken to study the heterosis in F_1 over better parent (BP), mid parent (MP) and standard check (SD) and inbreeding depression over F_2 segregating generation for fodder yield and its related characters in sorghum.

Materials and methods

The present study was pursued at the Live Stock Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar during *Kharif* seasons in the year 2000-2001. The experimental material consisted of fifty crosses (F_1s and F_2s) developed through Line × Tester mating design involving five cytoplasmic male sterile lines and ten sudangrass restorer lines. The F_1s and F_2s of fifty crosses with parents (lines and testers) and two checks *viz.*, HD-19 and PCH-106 were planted in compact family design with three replications on June 6, 2001. The plot size for each cross combination consisted of P1 (Parent 1 one row), P2 (Parent 2. one row), F_1 (hybrid, one row) and F_2 segregating population, 5 rows). The row length was kept at 3 meters and were spaced at 25 cm.

Ten competitive plants were randomly selected from P1, P2, and F_1 and 25 plants from F_2 population in each replication. Observations were recorded for plant height (cm), leaf length (cm), leaf width (cm), fifth leaf area (cm^2), stem diameter (cm), shootfly infestation (dead heart %), total soluble solids (T.S.S.%), protein%, digestibility%, green and dry fodder yield (q/ha) on these selected plants. The mean of different characters for the purpose of statistical analysis have been calculated on the basis of the individual data recorded for each character in each replication separately for each cross.

Results and discussions

Variable magnitude of three types of heterosis *viz.*, relative heterosis, heterobeltiosis and standard heterosis as exhibited by different cross combinations for all the characters indicated sufficient divergence in parental material for these traits (Table 1). For commercial exploitation of heterosis for fodder yield, seven crosses *viz.*, ICSA94 × Pant Chari-4, ICSA 94 × SDSL92111, ICSA94 × SD5292113, ICSA94 × SDSL92140, 1CSA94 × Selection 984, ICSA95 × ICSV96062 and 296A × SDSL92111 were identified as the best cross combinations as they showed significant heterosis in

Table 1. Summary of heterotic effects for various characters

S. No.	Character	Better Parent (BP)		Mid Parent (MP)		Standard Check (SD)	
1.	Plant height (cm)	29**;	11*	49**		-	
2.	Leaf length (cm)	13**;	5*	24**;	10*	9*	
3.	Leaf width (cm)	22**;	12*	44**;	3*	5*	
4.	Fifth leaf area (cm^2)	30**;	9*	45**;	2*	-	
5.	Stem diameter (cm)	11**;	5*	23**;	6*	-	
6.	Shootfly infestation (dead heart %)	1*		1**;	2*	7**;	2*
7.	T.S.S %	14**		22**;	2*	26**;	3*
8.	Protein %	16**;	3*	29**		24**;	4*
9.	Digestibility %	5**;	5*	11**;	10*	12**;	9*
10.	Green fodder yield (q/ha)	23**;	4*	40**;	1*	6**;	3*
11.	Dry fodder yield (q/ha)	21**;	4*	36**;	3*	17**;	3*

*,**Significant at 5% and 1% level, respectively.

desirable direction over the standard check, the released hyblied PCH-106.

Incidentally the above set of crosses also showed significantly heterosis over better parent as well as over mid parental values for green fodder yield and dry fodder yield indicating the presence of non additive gene action (dominance and epistasis) (Table 2).

heterosis for yield, also showed for plant height, leaf length, leaf width, fifth leaf area and stem diameter, the major yield contributing characters (Table 3). The findings of the present investigation on the magnitude of heterosis for green and dry fodder yield are consistent with the earlier reports of Jeyprakash and Das [1], Desai *et al.* [2] Shaug *et al.* [3], Desai *et al.* [4] and Laxman [5].

Table 2. Best crosses on the basis of *per se* performance and heterosis (%) for yield

Cross	*Per se* performance		Heterosis (%)					
			Green Fodder Yield (GFY) (q/ha)			Dry Fodder Yield (DFY) (q/ha)		
	GFY	DFY	BP	MP	SD	BP	MP	SD
ICSA94 × Pant chari-4	1022.20	202.37	27.07**	48.62**	16.87**	49.24**	64.79**	38.03**
ICSA94 × SDSL92111	1066.65	195.56	37.93**	58.67**	21.95**	40.84**	57.14**	33.33**
ICSA94 × SDSL92113	799.99	177.99	50.60**	69.77**	27.03**	55.78**	73.46**	46.81**
ICSA94 × SDSL92140	977.76	208.44	25.28**	44.68**	11.78**	32.89**	56.20**	42.12**
ICSA94 × Selection 984	1044.73	203.34	42.42**	60.13**	19.41**	72.51**	78.43**	38.63**
ICSA95 × ICSV96062	977.75	182.00	57.14**	74.05**	11.78**	57.31**	77.92**	24.09**
296A × SDSL92111	1088.87	203.99	40.80**	78.63**	24.49**	46.92**	80.31**	39.09**

* ** Significant at 5% and 1% level, respectively.

Among the different characters studied, the extent of positive heterosis over the better parent for green fodder yield and dry fodder yield ranged from 12. 18% to 57.14% and 22.13% to 72.51% respectively. For green fodder yield maximum better parent heterosis was recorded in the cross ICSA95 × ICSV96062 (57.14%) closely followed by ICSA94 × SDSL92113 (50.60%) and ICSA84 × Selection 984 (42.42%). For dry fodder yield maximum positive heterobeltiosis was observed in the cross ICSA94 × Selection 984 (72.51%) followed by ICSA95 × M19 (68.16%) and ICSA95 × ICSV96062 (57.31%). These hybrids were also superior in *per se* performance.

Heterosis for end product i.e. fodder yield is being manifested as the cumulative effect of heterosis for component traits. In the present investigation, the elaborative study of seven crosses revealed this fact as most of crosses that showed positive and significant

For shootfly infestation, measured through dead heart percentage count where negative heterosis is desirable, occurrence of only one positive and significant estimate of heterosis over better parent suggested preponderance of non additive gene action for this trait. Substantial magnitude of positive heterosis (better parent, relative and standard) in number of crosses for total soluble solids (T.S.S.%) and digestibility % were observed. Similar findings are also reported by [Shaug and Lo [6], Carlos *et al.* [7] and shang *et al.* [3].

One of the characteristics of heterosis is that the increase in vigour is confined to F_1 generation. There is considerable depression from F_1 to F_2 and later generations. Shull [8] reported that high inbreeding depression (positive) is the reflection of higher heterosis especially in cross-pollinated crop like maize.

Table 3. Summary of desirable heterotic effect and estimates of inbreeding depression of seven crosses for yield and component characters

Cross		Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Fifth leaf area (cm^2)	Stem diameter (cm)	Shoofly infestation (%)	T.S.S. %	Protein %	Diges-tibility %	Green fodder yield (q/ha)	Dry fodder yield (q/ha)
ICSA 94 × Pant chari-4	H	**	**	**	**	-	**	*	-	**	**	**
	ID	8.50	17.67	20.88	35.61	06.77	18.21	14.96	9.21	23.38	23.91	37.00
ICSA 94 × SDS 292111	H	**	-	**	**	-	-	**	**	**	**	**
	ID	12.90	14.72	11.21	24.26	15.49	48.45	13.42	25.54	55.75	25.00	41.59
ICSA 94 × SDS 292113	H	**	**	**	**	**	-	-	**	-	**	**
	ID	24.73	23.65	08.17	30.39	23.31	53.64	20.60	25.82	7.14	47.19	59.38
ICSA 94 × SDSL 92140	H	**	**	**	**	**	-	-	*	**	**	**
	ID	12.94	22.01	15.82	34.75	11.66	49.94	82.24	19.65	13.16	28.83	44.56
ICSA 94 × Selection 984	H	**	**	**	**	**	**	**	**	-	**	**
	ID	21.19	18.49	27.06	40.64	37.32	56.75	25.12	19.28	13.04	27.65	42.01
ICSA 95 × ICSV 96062	H	**	**	**	**	**	-	-	*	-	**	**
	ID	20.78	17.06	24.18	36.88	26.57	59.47	141.33	14.75	16.67	30.45	51.58
296 A × SDSL 92111	H	**	-	**	-	-	-	*	**	**	**	**
	ID	24.44	15.02	01.85	25.51	15.50	23.08	00.55	20.44	34.52	24.08	39.43

*,** Significant at 5% and 1% level, respectively. H: Heterotic effect ID: Inbreeding depression.

It may be seen from the present study that the hybrid combinations, that showed higher estimates of heterosis, in general found to show substantial inbreeding depression (Table 3). In present study, all the heterotic hybrids for green fodder yield and dry fodder yield exhibited significant inbreeding depression in F_2 generation. The magnitude of inbreeding depression varied for green and dry fodder yields from 23.91% to 47.19% and 37.00% to 59.38% respectively. Similar findings were also reported by Carlos *et al.* [7] Reddy and Joshi [9], in sorghum and Sheoran *et al.* [10] in pearl millet.

Negative and significant estimates of inbreeding depression have been observed for total soluble solids (T.S.S.%) and protein %. It may be attributed to the occurrence of transgressive segregants in the F_2 population. The formation of new gene combination as a result of segregation may lead to increase expression of the trait in the F_2 population. For the crosses, showing negative and significant inbreeding depression these is a scope for selection of desirable plants in the F_2 population for improvement of these traits.

Only one cross ICSA 94 × Pant Chari-4 having negative and significant estimates (desirable) of three types of heterosis, was found to show positive inbreeding depression of substantial magnitude which further suggested the role of non additive gene action for imparting resistance to shootfly in sorghum.

References

1. **Jeyprakash P. and Das L. D. V.** 1994. Effect of heterosis in sorghum for leaf area and dry fodder yield. Sorghum Newsletter, **35**: 78.
2. **Desai S. A., Singh R. and Shrotria P. K.** 1999. Heterosis and correlation in sorghum × sudan grass interspecific crosses. Journal of Maharashtra Agricultural Universities, **24**: 138-142.
3. **Shaug S. P., Lin J. B. and Chen Y. Y.** 2000. Selection of F_1 hybrid in forage sorghum. Journal of Taiwan Live Stock Research, **33**: 154-164.
4. **Desai S. A., Singh R. and Shrotria P. K.** 2000. Variability and heterosis for forage yield and its component in interspecific crosses of forage sorghum. Karnataka Journal Agricultural sciences, **13**: 315-320.
5. **Laxman S.** 2001. Studies on Heterosis and combining ability in sorghum [*Sorghum bicolor* (L.) Moench] through L × T analysis. The Journal of Research ANGRAU, **XXIX**: 12-17.
6. **Shaug S. P. and Lo K. D.** 1995. Evaluation of combining ability for chemical component of forage sorghum. Journal of Taiwan Live Stock Research, **28**: 207-214.
7. **Carlos A. S., Jose A. S. R., Cosme D. C., Paulo R. C., Jose I. R. and Alessaudus L. B.** 1998. Genetic effects, Heterosis and inbreeding depression in forage sorghum characters. Bragantia compinas, **57**: 81-94.
8. **Shull G. H.** 1914. Duplicate genes for capsule form in bursa, Bursa Nastosis Zeitscher Induktiv Abstanim-u Vererbunglehana, **12**: 97-149.
9. **Reddy J. N. and Joshi P.** 1993. Heterosis, inbreeding depression and combining ability in sorghum [*Sorghum bicolor* (L.) Moench]. Indian J. of Genet., **53**: 138-146.
10. **Sheoran R. K., Govila O. P. and Singh B.** 2000 Genetic architecture of yield and yield contributing traits in pearl millet. Annals of Agricultural Research, **21**: 443-445.