Plant Archives Vol. 16 No. 2, 2016 pp. 588-593 ***ISSN 0972-5210***

COMBINING ABILITY STUDIES USING DIVERSE CYTOPLASM FOR GRAIN YIELD AND ITS COMPONENTS IN PEARL MILLET [*PENNISETUM GLAUCUM* (L.) R. BR.]

S. M. Rafiq*, B. Sunil Kumar and U. Prasada Rao[1]

Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalainagar – 608 002 (Tamil Nadu), India.

[1]Nuziveedu Seeds Limited, Hyderabad – 500 100 (Telangana), India.

Abstract

Investigation was carried out to study the combining ability of different (A_1 A_4 and A_5) cytoplasms of alloplasmic isonuclear lines of pearl millet. The results revealed that the lines with A_4 cytoplasm are significantly better general combiner for grain yield per plant, panicle weight, 1000 grain weight and productive tillers per plant than the lines with A_1 and A_5 cytoplasm. Among male parents NB 527 was the best general combiner followed by NB 799, NB 714, NB612 for grain yield per plant. A_4 cytoplasmic hybrids are more heterotic than A_1 and A_5 cytoplasm. The A_4 cytoplasm hybrids ICMA05666xNB647, ICMA05666x NB812 and ICMA05666xNB827 best specific combiner for grain yield per plant followed by CMA07999xNB652 and ICMA99444xNB526 belongs to A_5 and A_1 cytoplasm respectively. They produced significant and desirable SCA effects for most of the traits studied, indicating potential for exploiting hybrid vigour using diverse cytoplasm lines in breeding programme.

Key words: Peral millet, *gca*, *sca*, line × tester.

Introduction

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is a member of the family Poaceae with chromosome number 2n = 14. It is an important member of the genus Pennisetum, which has high importance for both food and fodder and it is the most drought tolerant major cereal. The grain is the main purpose of cultivation of pearl millet in India and other countries. However, it is also grown on small scale as high quality forage crop in India, USA, Australia, South America and South Africa. The share of pearl millet in total food grain production is to the tune of 10.7%. In India, it is grown on about 7.95 million hectares with an annual production of 8.90 million tones and productivity of 1106 kg/ha (Anonymous, 2013). It is widely cultivated in the states of Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Hariyana (Anonymous, 2013). Commercial hybrid seed in pearl millet is possible mainly through the development of hybrids by the utilization of cytoplasmic genetic male sterility system. Burton (1951) was the first to develop cytoplasmic male sterile line, Tift 23A. This opened up a new field for hybrid seed production in pearl millet. The use of CMS in pearl millet paved the way for grain yield augmentation with the development and release of the high yielding hybrids. An understanding of the combining ability and gene action is a pre-requisite for any successful plant breeding programme. Testing the parents for their combining ability is very important because many times the high yielding parents may not combine well to give good hybrids. Line × tester analysis helps in testing a large number of genotypes to assess the combining ability. Keeping the above fact in mind, the present investigation was conducted to assess the combining ability for yield and contributing traits, to determine the nature and magnitude of gene actions in a line × tester mating design with a view to identify good combiners including cms lines and restorers.

Materials and Methods

The experimental material consisting of three different cytoplasmic male sterile lines *viz.,* ICMA99444, ICMA05666 and ICMA07999 represent A_1, A_4 and A_5 cytoplasms respectively and fifty testers *viz*., NB525, NB526, NB527, NB528, NB530, NB 580, NB590,

****Author for correspondence :*** E-mail: smrafiq123@gmailcom

NB595, NB600, NB611, NB612, NB614, NB616, NB619, NB624, NB627, NB645, NB647, NB648, NB652, NB 653, NB654, NB656, NB657, NB667, NB670, NB693, NB714, NB717, NB718, NB720, NB732, NB 733, NB734, NB737, NB747, NB782, NB785, NB788, NB789, NB797, NB799, NB803, NB805, NB809, NB812, NB815, NB816, NB826, NB827. All these fifty parents were crossed to produce 150 F_1 hybrids according to the line × tester mating design developed by Kempthorne (1957). The experiment was carried out at Nuziveedu Seeds Research Farm, Hyderabad during *Kharif* season of 2015. A total of 204 treatments comprising 3 male sterile lines (female parents), 50 restorers (male parents), 150 F_1's were grown in a randomized block design with three replication. Each entry was planted in a 4 meter long row with inter and intra row spacing of 50 × 15 cm. One row of each entry was planted in each replication. Five competitive plants were randomly selected to record the observations on nine character *viz.,* days to 50 per cent flowering, days to maturity, plant height (cm), number of productive tillers per plant, panicle length (cm), panicle weight (g), panicle girth (cm), 1000-grain weight (g) and grain yield per plant (g) were recorded for statistical analysis. Data was subjected to analysis of variance to find significant differences among genotypes for the recorded data. After obtaining the data on parents and their F_1's was statistically analyzed for combining ability as per the method suggested by Kempthorne (1957).

Results and Discussion

Analysis of variance for combining ability was done for nine characters and presented in table 1. The mean squares due to line were highly significant for all the traits studied except grain yield per plant. Variations due to tester were significant for days to 50 per cent flowering, days to maturity, plant height, number of productive tillers per plant, panicle length, panicle weight (g), panicle girth (cm) and grain yield per plant (g). The significant mean squares due to the line × tester interaction indicated that hybrids differed significantly in their *sca* effects for all the traits studied.

Estimates of *GCA* variance and *SCA* variance revealed that the ratio between *GCA* and *SCA* variance was less than unity for days to 50 per cent flowering, days to maturity, plant height, number of productive tillers per plant, panicle length, panicle weight, panicle girth, 1000-grain weigh and grain yield per plant suggesting that these characters were predominately under the genetic control of non-additive gene action. The findings of the present investigation for grain yield per plant and its attributing traits are in close conformity with the findings of Rasal and Patil (2003), Vaghasiya *et al*. (2008), Chaudhary *et al*. (2012), Bhadalia *et al.* (2014) and therefore, heterosis breeding will be rewarding.

The general combining ability effects for grain yield per panicle was significant and positive in A_4 and A_5 cytoplasm and significant negative for A_1. The lines with A_4 cytoplasm also expressed significant gca effect for panicle weight, 1000- grain weight and no of productive tillers per plant. The A_1 cytoplasmic based lines showed positive and significant *gca* effect for plant height panicle girth and 1000 grain weight and negative significant gca effect for five traits. On the other hand, A_5 cytoplasmic based lines exhibited no significant *gca* effect for seven traits (table 2). These results revealed that combining ability is strongly influenced by the type of cytoplasm. Of the three CMS sources used in this study, A_4 and A_5

Table 1 : Analysis of variance for combining ability for nine characters in pearl millet.

Source of variations	Df	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of productive tillers per plant	Panicle length (cm)	Panicle girth (cm)	Panicle weight (g)	1000 grain weight (g)	Grain yield per plant (g)
Replicates	2	3.27	11.24**	17.99**	1.36**	5.46**	3.27**	15.40**	0.06	11.85**
Line	2	431.00**	430.89**	2599.81*	7.90**	295.82**	1.30*	217.95*	36.86**	188.69
Tester	49	32.41**	34.41**	1721.88**	0.95**	48.54**	0.74**	351.53**	5.44	294.01*
Line × Tester	98	12.84**	12.68**	542.56**	0.53**	22.63**	0.37**	361.14**	4.19**	261.95**
Error	298	0.03	0.16	0.16	0.08	0.05	0.03	0.17	0.83	0.17
σ^2 *gca*		2.91	2.92	27.18	0.06	2.17	0.01	3.58	0.26	3.03
σ^2 *sca*		4.27	4.17	180.8	0.15	7.52	0.11	120.32	1.12	87.26
σ^2 *gca*/σ^2 *sca*		0.68	0.70	0.15	0.40	0.29	0.09	0.03	0.23	0.03

* Significant at 5% probability level, ** Significant at 1% probability level.

Table 2 : General combining ability effects of parents.

Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of productive tillers/ plant	Panicle length (cm)	Panicle girth (cm)	Panicle weight (g)	1000 grain weight (g)	Grain yield/ plant(g)
A_1 cytoplasm (ICMA99444)	-0.085**	-0.084 **	3.713 **	-0.263 **	-1.170 **	0.076 **	-0.300 **	0.236 **	-1.194 **
A_4 cytoplasm (ICMA 05666)	-1.651**	-1.651 **	-4.501 **	0.157 **	-0.387 **	-0.104 **	1.327 **	0.333 **	1.031 **
A_5 cytoplasm (ICMA 07999)	1.736**	1.735 **	0.787 **	0.107 **	1.557 **	0.028 **	-1.027 **	-0.570 **	0.163 **
SE ±	**0.014**	**0.033**	**0.033**	**0.023**	**0.019**	**0.014**	**0.034**	**0.074**	**0.034**
NB 525	3.589**	3.189 **	4.603 **	-0.020 **	2.544 **	0.607 **	-0.181 **	0.402 *	1.849 **
NB 526	4.479**	4.079 **	20.713**	-0.131 **	2.298 **	0.737 **	4.312 **	1.135 **	6.816 **
NB 527	4.586**	4.852 **	27.157**	-0.353 **	1.528 **	0.447 **	12.949 **	0.269	14.182 **
NB 528	3.252**	3.852 **	32.267**	-0.131 **	4.438 **	-0.240 **	-1.311 **	0.619 *	-1.238 **
NB 530	2.476**	2.409 **	22.823**	-0.409 **	1.108 **	0.080 **	4.725 **	-0.948 **	6.982 **
NB 580	-3.078**	-3.478 **	-22.953**	-0.464 **	-2.902 **	-0.197 **	-2.791 **	0.919 **	-5.208 **
NB 590	-2.858**	-3.258 **	-5.510 **	-0.187 **	-0.029 **	-0.030 **	-4.871 **	0.791 **	-3.688 **
NB 595	-0.968**	-0.701 **	-1.513 **	-0.076 **	2.088 **	-0.163 **	-4.585 **	0.985 **	1.182 **
NB 600	-1.414**	-0.815 **	-0.843 **	0.313 **	-0.116 **	-0.073 **	2.382 **	0.002	-3.234 **
NB 611	-1.524**	-1.591 **	5.710 **	-0.020 **	2.551 **	-0.173 **	-3.391 **	-0.448 **	-0.274 **
NB 612	-1.744**	-2.145 **	10.823 **	0.313 **	-1.902 **	0.007	15.019 **	0.385 *	8.356 **
NB 614	-0.971**	-1.371 **	8.377 **	-0.242 **	4.098 **	-0.287 **	0.105 *	-0.820 **	-1.381 **
NB 616	0.589**	0.852 **	4.823 **	0.036 *	-1.912 **	-0.037 **	-0.498 **	0.419 *	-3.868 **
NB 619	3.252**	3.852 **	2.487 **	0.369 **	-2.692 **	-0.283 **	-1.215 **	1.152 **	-1.131 **
NB 624	1.362**	1.299 **	8.377 **	-0.076 **	4.541 **	0.017 *	5.105 **	-0.737 **	4.862 **
NB 627	-2.414**	-2.815 **	-19.067**	0.758 **	-2.349 **	-0.030 **	4.442 **	1.513 **	4.609 **
NB 645	-0.524**	-0.925 **	0.710 **	-0.131 **	0.868 **	-0.363 **	-5.565 **	-0.948 **	-1.628 **
NB 647	0.366**	0.632 **	24.933 **	-0.353 **	2.308 **	0.083 **	13.642 **	1.213 **	6.032 **
NB 648	0.476**	1.075 **	4.153 **	0.091 **	-0.349 **	0.013 *	0.302 **	-0.598 **	2.839 **
NB 652	-0.304**	-0.368 **	2.043 **	-0.020 **	-0.126 **	0.047 **	0.032	0.919 **	-1.884 **
NB 653	0.699**	0.299 **	7.710 **	-0.076 **	-6.312 **	-0.353 **	0.372 **	-0.865 **	-2.541 **
NB 654	0.696**	0.295 **	-1.733 **	-0.131 **	2.408 **	0.240 **	8.189 **	0.152	-2.648 **
NB 656	-0.528**	-0.258 **	5.823 **	-0.187 **	-0.192 **	-0.317 **	6.885 **	0.324	3.362 **
NB 657	1.142**	1.742 **	11.823 **	0.147 **	3.318 **	-0.183 **	-6.718 **	-1.565 **	-4.641 **
NB 667	1.142**	1.075 **	-0.067 **	0.091 **	0.208 **	0.070 **	-10.388 **	0.352	-7.484 **
NB 670	-1.748**	-2.148 **	9.597 **	-0.131 **	-1.919 **	-0.217 **	-3.718 **	-0.465 **	0.152 **
NB 693	-1.304**	-1.705 **	-10.063**	0.147 **	-0.359 **	-0.193 **	-7.065 **	0.413 *	-6.938 **
NB 714	-1.304**	-1.035 **	-15.067**	-0.020 **	-0.352 **	0.203 **	6.229 **	0.035	9.569 **
NB 717	-0.858**	-0.258 **	0.377 **	0.313 **	0.198 **	-0.097 **	-5.698 **	-0.148 **	-6.571 **

Table 2 continued...

Table 2 continued...

NB718	-2.748 **	-2.815 **	1.263 **	0.480 **	-1.256 **	-0.630 **	3.049 **	0.169	3.299 **
NB720	-0.968 **	-1.258 **	-7.730 **	0.369 **	-1.602 **	-0.220 **	3.615 **	-1.181 **	5.869 **
NB732	2.032 **	1.632 **	-1.623 **	-0.242 **	0.321 **	-0.207 **	0.832 **	-1.398 **	5.842 **
NB733	1.142 **	1.189 **	26.823 **	-0.353 **	0.981 **	-0.050 **	-1.078 **	0.041	-3.768 **
NB734	-0.634 **	-0.148 **	-2.287 **	0.758 **	1.078 **	-0.430 **	-6.288 **	-1.159 **	-6.164 **
NB737	0.032 **	0.185 **	15.933 **	0.202 **	-1.569 **	-0.283 **	-10.871**	-0.231 **	-14.444 **
NB747	1.812 **	1.522 **	5.600 **	0.202 **	-0.129 **	0.383 **	-2.635 **	-0.131 **	-1.544 **
NB782	-1.301 **	-1.701 **	-12.843**	-0.131 **	-1.256 **	-0.240 **	-0.001 **	-0.715 **	-1.581 **
NB785	2.142 **	2.189 **	-1.847 **	0.202 **	-2.349 **	0.097 **	7.962 **	0.669 **	8.239 **
NB788	-1.638 **	-1.148 **	-21.287**	-0.576 **	-0.226 **	0.013 *	2.055 **	0.463 *	2.426 **
NB789	-2.968 **	-2.811 **	-21.180**	0.202 **	-1.249 **	-0.130 **	-4.101 **	-1.304 **	-0.631 **
NB797	0.699 **	0.409 **	-10.177**	0.202 **	-0.022 **	0.073 **	-0.075 **	-0.292 **	-0.914 **
NB799	0.476 **	0.075 *	-1.510 **	-0.687 **	-1.972 **	0.183 **	12.059 **	0.069	13.172 **
NB803	-2.081 **	-2.035 **	-19.623**	0.147 **	-5.119 **	0.297 **	-11.638 **	0.219	-8.918 **
NB805	-1.081 **	-0.591 **	-13.180**	-0.742 **	1.968 **	0.060 **	-8.221 **	0.519 *	-5.784 **
NB809	0.366 **	0.519 **	-15.070**	0.480 **	-0.642 **	0.293 **	-1.571 **	-0.098 **	-5.558 **
NB812	1.252 **	0.965 **	-9.400 **	-0.353 **	-2.652 **	0.527 **	-7.235 **	-0.192 **	-5.938 **
NB815	-0.634 **	-1.035 **	-19.623**	0.147 **	3.884 **	0.497 **	5.092 **	-0.359 **	0.996 **
NB816	0.256 **	0.295 **	2.823 **	-0.020 **	-1.576 **	0.017 *	0.575 **	-0.981 **	-0.161 **
NB826	-2.081 **	-1.591 **	-16.290**	-0.076 **	-1.922 **	0.527 **	-2.625 **	1.530 **	-1.828 **
NB827	-0.634 **	-0.481 **	-17.287**	0.369 **	2.318 **	-0.097 **	-5.588 **	-0.092 **	0.946 **
SE ±	**0.058**	**0.134**	**0.135**	**0.093**	**0.078**	**0.058**	**0.138**	**0.304**	**0.138**

appeared to have positive effect on many of the productive traits followed by A_1. Yadav (1999) reported that lines with A_3 and A_4 cytoplasm are significantly better combiners for grain yield than A_1 cytoplasm in pearl millet. Virk and Brar (1993) also reported significant effect of diverse cytoplasm on the combining ability in pear millet.

Among male parent NB527 was also a good general combiner for grain yield per plant, panicle weight and plant height. In addition to above, NB799 and NB693 were also good general combiners for grain yield per plant and panicle weight. NB528, NB614, NB624 and NB657 proved to be good general combiner for number of tillers per plant. From the results on gca effects, the male parents NB527, NB799, NB714 and NB612 may be used in the hybrid breeding to generate more number of transgressive segregants in the subsequent generations for grain yield and its components, which may be exploited.

Sprague and Tatum (1942) reported that the *sca* effect is due to non-additive genetic proportion. It is an important parameter for judging and selecting superior cross combinations, which might be exploited through heterosis breeding programme. The crosses which showed highest significant positive *sca* effects for grain yield per plant presented in table 3.

The cross ICMA0566 × NB647 exhibited highest significant *sca* effects for grain yield per plant in desired direction followed by the cross ICMA05666 × NB812, ICMA05666 × NB827, ICMA07999 × NB652 and ICMA99444 × NB526. The top ranking fifteen crosses on the basis of grain yield per plant with their *sca* effects and *gca* effects and *per se* performance of their parents are presented in table 3. The examination of table 3 clearly indicated that most of the promising crosses had A_4 cytoplasm and significant *sca* effects and involved atleast one parent with better combining ability and high *per se* performance. All the top ranking twenty cross combinations involved high × high, high × low, low × high and low × low *gca* effects of the parents involved in the crosses. The proper choice of the parents based on combining ability and *per se* performance of the parents thus is necessary for heterosis breeding. Similar findings have also been reported by Lakshmana *et al.* (2003) and Yadav *et al.* (2002). Out of these top ranking crosses, two crosses *viz.*, ICMA05666 × NB527 and ICMA05666 × NB647 belonging to A_4 cytoplasm showed high mean performance, significant *sca* effect and involved atleast one parent with significant *gca* effects for grain yield per plant and hence appeared to be best for further exploitation. Similar results were observed by Patel *et al.* (2008).

The result revealed that A_4 based hybrids had maximum heterosis for grain yield per plant and other

Table 3 : Mean performance and specific combining ability effects of top ranking twenty crosses with *gca* effects and mean performance of their parents for grain yield per plant.

S. no.	Crosses	Cytoplasm	Grain yield (g)	*SCA*	GCA of parents		Mean performance of parents (g/plant)	
					P 1	P2	P 1	P2
1.	ICMA05666xNB527	A_4	93.27	12.15**	1.03**	14.18**	39.50	53.10
2.	ICMA05666xNB647	A_4	90.10	17.13**	1.03**	6.03**	39.50	63.75
3.	ICMA99444xNB526	A_1	86.33	14.80**	-1.19**	6.81**	48.19	56.25
4.	ICMA07999xNB627	A_5	84.24	13.56**	0.16**	4.60**	46.68	57.50
5.	ICMA05666xNB827	A_4	84.21	16.32**	1.03**	0.94**	39.50	43.79
6.	ICMA99444xNB799	A_1	83.67	5.78**	-1.19**	13.17**	48.19	51.75
7.	ICMA07999xNB717	A_5	83.52	0.174	0.16**	3.29**	46.68	58.30
8.	ICMA05666xNB624	A_4	83.27	11.47**	1.03**	4.86**	39.50	47.09
9.	ICMA99444xNB527	A_1	83.07	4.17**	-1.19**	14.18**	48.19	53.10
10.	ICMA05666xNB717	A_4	81.63	8.10**	1.03**	3.29**	39.50	58.30
11.	ICMA99444xNB530	A_1	81.21	9.51**	-1.19**	6.98**	48.19	48.36
12.	ICMA07999xNB732	A_5	80.38	8.47**	0.16**	5.84**	46.68	49.26
13.	ICMA07999xNB652	A_5	79.42	15.23**	0.16**	-1.88**	46.68	54.68
14.	ICMA05666xNB612	A_4	78.68	3.38**	1.03**	8.35**	39.50	48.92
15.	ICMA05666xNB656	A_4	77.77	7.47**	1.03**	3.36**	39.50	48.85

panicle components, followed by A_5 and A_1 indicating a distinct advantage of these cytoplasms. However, other equally important consideration in the use of any CMS source at commercial scale depends upon its stability, availability of strong and agronomically superior restorers. Elaborate studies conducted across wide range of environments have established that A_4 and A_5 sources are more stable than A_1, but the utility of these sources has been constrained by the lack of availability of restorers (Gowda *et al*., 2006). However, by intensifying the restorer-breeding programme on these sources, the cytoplasmic base of the hybrids in pearl millet can be diversified successfully.

The study may be useful for selecting good combiners for grain yield per plant. Among three cytoplasm A_4 and A_5 cytoplasm and among males lines NB527, NB612, NB714 and NB799 showed good general combining ability for grain yield per plant and other yield contributing characters. These parents can be further utilized in Pearl Millet experimental hybrid development programme for the exploitation of their good general combining ability. Similarly, the crosses ICMA05666 × NB527 and ICMA05666 × NB647 showed superior performance for grain yield per plant along with positive significant *sca* effects. So, these crosses can be commercially exploited using heterosis breeding after their thorough evaluation in multilocation trials.

References

Anonymous (2013). Annual Report, All India Coordinated Pearl Millet Improvement, Indian Council of Agricultural Research. Project Coordinating Unit, Agricultural research Unit, Mandore, Jodhpur-342304, India.

Bhadalia, A. S., K. K. Dhedhi, H. J. Joshi and J. S. Sorathiya (2014). Combining ability studies through diallel analysis in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. *Inter. J. Agric. Sci.*, **10(1)** : 57-60.

Burton, G. W. (1951). Cytoplasmic male sterility in pearl millet. *Agron. J.*, **50** : 230-234.

Chaudhary, V. B., K. K. Dhedhi, H. J. Joshi and J. S. Sorathiya (2012). Genetic variability for grain iron, zinc, protein, yield and yield attributes in pearl millet (*Pennisetum glaucum* (L) R. Br.). *Madras Agric. J.*, **99(7-9)** : 465-468.

Gowda, C. L. L., K. N. Rai, B. V. S. Reddy and K. B. Saxena (2006). *Hybrid Parent Research at ICRISAT*. Publishers Int. Crops Res.Institute for semi Arid Tropics, Patencheru, Andra Pradesh (India). pp. 24-46.

Kempthorne, O. (1957). *An Introduction to Genetic Statistics*. John Willey & Sons. Inc., New York.

Lakshmana, D., P. Surendra and R. Gurumurthy (2003). Combining ability studies in pearl millet. *Res. on Crops*, **4 (3)** : 358-362.

Patel, K. Y., G. U. Kulkarni and D. R. Patel (2008). Heterosis and Combining ability studies for grain yield and its components in pearl millet. *J. Maharashtra Agric. Univ.*, **33 (1)** : 12-15.

Rasal, P. N. and H. S. Patil (2003). Line × tester analysis in pearl millet. 1. Yield component characters. *Res. on Crops*, **4(1)** : 85-90.

Sprague, G. F. and L. A. Tatum (1942). General vs specific combining ability in single cross of corn. *Jour. Amer. Soc. Agron*., **34** : 923-32.

Vaghasiya, V. D., C. J. Dangaria and K. K. Dhedhi (2008). Combining ability studies in BxR crosses for selection of superior female parents for 'A' line development in pearl millet. *Intl. J. Pl. Sci*., **3(2)** : 329-333.

Virk, D. S. and J. S. Brar (1993). Assessment of cytoplasmic difference of near isonuclear male sterile lines in pearl millet. *Theor. Appl. Genet*., **87** : 106-112.

Yadav, O. P. (1999). Heterosis and combining ability in relation to cytoplasmic diversity in pearl millet. *Indian J.Genet*., **59** : 445-450.

Yadav, H. P., P. S. Sabharwal and C. R. Beniwal (2002). Combining ability study for some newly developed male sterile lines for forage attributes in pearl millet. *Forage Res*., **27(4)** : 277-280.