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Combining Ability Analysis for Fodder Yield and its Components in Pearl Millet (Pennisetum glaucum)

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ABSTRACT

The study with five male-sterile lines, eight pollinator lines, 40 F_1 crosses, which were generated through Line x Tester matings and one standard check PCB141 was conducted to assess the combining ability of newly developed inbred lines. The data was recorded on 9 morphological characters *viz.,* plant height, number of tillers per plant, leaves per plant, leaf length, leaf breadth, stem thickness, days to 50 per cent flowering, green fodder yield per plant and dry matter yield per plant. Three quality parameters: crude protein, oxalic acid and total ash were also estimated for all the genotypes. Analysis of variance for combining ability for different characters revealed significant differences among the female parents for all the characters except oxalic acid. Male parents also differed significantly for all the characters except oxalic acid and crude protein. Whereas for hybrids mean squares were significant for all the traits except for days to 50 % flowering and plant height. The cross PB 408A X PIB 258 was found to be very good specific combiner for green fodder yield per plant and was the second based on mean performance of hybrid.

Key words : Combining ability, Fodder pearl millet.

Pearl millet (*Pennisetum glaucum* (L.) is the fourth most important cereal in India after rice, wheat and sorghum. In the world, it is grown over 25 million ha with an annual production of 11 million tons. India and Africa together produce more than 90% of world output, where it is mostly grown for grain purpose, but in the U.S.A it is one of the best annual forage crops for the dry regions. In India, Rajasthan, Gujarat, Maharashtra and Uttar Pradesh are the chief producers of the crop accounting for 75% of the pearl millet area and production of the country. Its fodder forms an essential component of the crop livestock farming system in North-Western India (Govila *et* al 1996).

Early part of the varietal improvement in pearl millet was concentrated on the improvement of yield in the locally adapted material through simple mass selection. Later on, in order to exploit heterosis, attempts were made to breed 'chance hybrids' by taking advantage of the protogynous nature of flowering in pearl millet. But these hybrids did not become popular as hybrid seed amounted to only 40%, even if the two parents flowered at the same time. With the discovery of the cytoplasmic male sterility in Georgia, U.S.A in 1958, hybrid breeding received a major impetus and male sterile lines Tift 23A and Tift 18A were released (Burton 1958). Using the male sterile line Tift 23A, first grain hybrid HB1 was bred at Punjab Agricultural University, Ludhiana in India . Subsequently, many hybrids have been released resulting in substantial increase in grain production (Dave 1987).

Most pearl millet outside the major pearl millet growing areas of Africa, India and Pakistan is grown for forage and consists of F_1 single cross hybrids. Many hybrids with improved forage production potential have been developed and released for use in the United States and Australia. Gahi l, the first pearl millet forage hybrid released in U.S.A, yielded 52% more dry matter than Common and 35% more than Starr (Burton 1962). In an effort to produce 100% hybrid seed, Gahi-3, the first single cross forage hybrid was produced using cytoplasmic male sterility (Burton1983).

But, breeding for forage yield *per se* has not received much attention in India and Africa where local varieties are dual purpose providing both grain and dry fodder. Development of F_1 hybrid involves crossing of newly developed inbred lines to generate several cross combinations (F_1s) and subsequent evaluation of these F_1 plants in order to choose the best combination.

Development of a new variety with high biomass yield and low oxalic acid parameters is the prime objective of all bajra breeders. The first step in a successful breeding program is to select appropriate parents. Line x tester analysis provides a systematic approach for detection of appropriate parents and crosses superior in terms of degined traits. Combining ability describes the breeding value of parental lines to produce hybrids. Sprague and Tatum (1942) used the terms general combining ability (GCA) to designate the average performance of a line in hybrid combinations and specific combining ability (SCA) as deviation in performance of a cross combination from that predicted on the basis of the general combining abilities of the parents involved in the cross. In order to choose appropriate parents and crosses, and to determine the combining abilities of parents in early generation, the line x tester analysis method has been widely used by plant breeders. This method was applied to improve self and cross-pollinated plants. Selection of plants showing harmonious combination of desirable traits is facilitated if variation is controlled by additive gene effects. So the present investigation was carried to.the combining ability effects among the newly developed inbred lines for fodder yield and quality characters.

MATERIAL AND METHODS

The experimental material consisted of five male sterile lines viz, Pb 220A, Pb 311A, Pb 408A, Pb 502 and Pb 601 belonging to different cytoplasmic male sterile sources and 8 different restorer lines viz, PIB 250, PIB 253, PIB 258, PIB 262, PIB 280, PIB 314, PIB 366, PIB 481 and one standard check PCB 141.

All the lines were sown in the experimental area during Kharif, 1999. Each of the five male sterile lines was crossed with all 8 pollinators in a Line x Tester mating design to generate 40 F_1 hybrids. The resulting F_1 hybrids along with their 13 parental lines and the standard check PCB 141 were evaluated in a Randomized Complete Block Design (RBD) with three replications at the experimental area during Summer, 2000. Each entry had one row of 3m length in a replication. The plants were spaced 45 cm between the rows and 10 cm within the row. All the recommended cultural practices were followed to raise a healthy crop. The data was recorded on five random, competitive plants per entry for the characters plant height, number of tillers per plant, number of leaves per plant, leaf length, leaf breadth, stem thickness, days to 50 percent flowering, green fodder yield at flowering and dry matter yield. In addition estimates were also made for crude protein, oxalic acid and total ash content.

The data were recorded on per plant basis for all the characters and then this data was averaged over all the plants of a particular entry in each replication. All the biometrical analyses were performed on the basis of progeny mean in each replication.The combining ability analysis for different traits was calculated as per the model suggested by Kempthorne (1957).

RESULTS AND DISCUSSION

Combining ability analysis

The analysis of variance for combining ability for different characters is presented in Table-1. The results indicated that the mean squares due to females were significant for all the characters except stem thickness and oxalic acid content. Male parents also differed significantly for all the characters except oxalic acid content and crude protein. Mean squares due to hybrids were non-significant for days to flowering and plant height but for all other characters the mean squares were found to be significant.

General combining ability

Estimates of general combining ability effects of the parents for various characters are given in the Table-2.

Among all the five females, only one Pb220A was found to be good general combiner for plant height. Two of the eight male parents were found to be good general combiners for plant height. For number of tillers per plant only one female parent Pb311A was found to be good combiner. On the other hand Pb408A was found to be poor combiner for this trait. For all other female parents gca effects were found to be non-significant. Among the male parents PIB250 and PIB262 were found to be good combiners. Two male parents PIB366 and PIB481 were found to be poor combiners.

Pb220A was the only female that was found to be good combiner for leaf number. Although the other female Pb502A reported a positive has significant value. Among the male parents two parents appeared to be good combiners for leaf number.

Table 1. Analysis of variance for combining ability for various characters.

Source	D.F.	Days to flower-ing	Green fodder yield (g/plant)	Dry matter yield (g/plant)	Crude protein %	Oxalic acid %	Ash content %
		Mean Square					
Replication	2	4.6	32771.73*	108.58	0.583	0.077	3.165
Females	4	127.697**	249010.3**	2097.13**	4.278**	0.132	6.945**
Males	7	145.047**	157091.1**	2628.17**	0.588	0.301	3.828**
F x M	28	18.757	62680.20**	1515.36**	4.398**	1.197**	2.598*
Error	78	13.198	5584.96	249.38	0.494	0.24	1.286

* p ≤ 0.05 ** p ≤ 0.01

Table 2. Estimates of general combining ability effects of parents for various characters in Pearl millet.

Cross	Days to 50 percent flowering	Green fodder yield	Oxalic acid %	Dry matter yield (g/plant)	Crude protein %	Ash content %
Pb 220 A	-2.08**	-44.15**	0.05	-2.21*	0.16	0.47*
Pb 311 A	3.76**	139.68**	0.01	-0.64	0.63**	0.05
Pb 408 A	-0.95	19.39	-0.1	14.33**	-0.11	-0.28
Pb 502 A	0.55	23.35*	0.09	0.3	-0.16	-0.76**
Pb 601 A	-1.28**	-138.28**	-0.05	-11.78**	-0.51**	0.53**
S.E.	1.14	23.46	0.15	4.95	0.21	0.35
PIB 250	0.96	93.21**	-0.28**	12.79**	-0.13	0.01
PIB 253	4.49**	93.41**	-0.02	5.01*	0.12	0.37
PIB 258	2.56**	21.94	0.06	3.86	-0.28	-0.1
PIB 262	0.76	110.01**	0.16	12.16**	-0.25	-0.39
PIB 280	-1.31	-187.93**	0.06	-22.65**	0.16	-0.44
PIB 314	-2.51**	-63.66**	0.13	9.87**	0	1.01**
PIB 366	0.62	-4.33	-0.11	-15.18*	0.17	0.07
PIB 481	-5.58**	-62.66**	0	-5.86	0.21	-0.53*
S.E.	1.5	31.04	0.19	6.55	0.29	0.47

* p ≤ 0.05 ** p ≤ 0.01

Only one female Pb220A was found to be good combiner for leaf length. Among the males, PIB250, PIB253 and PIB258 were found to be good general combiners for leaf length. Among the females, Pb220A and Pb601A appeared to be good general combiners for early flowering, whereas the female Pb311A for delayed flowering. Among the males PIB258 and PIB250 appeared to be good combiners for early flowering. Male parents PIB253, PIB258 were found to be good general combiners for delayed flowering.

Two females Pb311A and Pb502A appeared to be good combiners for green fodder yield with GCA estimate of 139.68 and 23.35% respectively. Female parents Pb220A and Pb601A were found to be poor combiners for green fodder yield.

In case of male parents PIB262, PIB253 and PIB250 were found to be good combiners for green fodder yield. Three male parents PIB280, PIB314 and PIB481 were found to be poor combiners for green fodder yield.

Among the female parents only Pb408A was appeared to be good combiner for dry matter content. Female parents Pb220A and Pb601A were found to be poor combiners. Four out of eight male parents were good general combiners. Two male parents PIB280 and PIB366 were found to be poor combiners.

Female parent Pb311A was found to be good combiner, where as Pb601A was poor combiner for crude protein. Among males none were found to be good combiners for this trait. None of the female parents were found to be good general combiners for oxalic acid content. Among the males, only one PIB250 was found to be significant and it was good combiner for low oxalic acid content. Among female parents Pb601A and Pb211A were found to be good combiners for total ash where as the female parent Pb502A was found to be poor combiner for this trait. Among the males only one parent PIB250 was found to be good combiner.

Specific combining ability

Estimates of specific combining ability (SCA) effects for different characters as follows:

For plant height five out of the forty crosses showed significant positive sca effects. Two crosses showed negative sca effects. Maximum sca effect was shown by the cross Pb220A x PIB366(14.26). Only two crosses (Pb311A x PIB262; Pb502A x PIB250) were found to be positive specific combiners for number of tillers per plant with an estimate of 1.61 and 0.98 respectively. For number of leaves per plant four crosses showed significant positive sca effects. Out of the four cross combinations a maximum of 14.53 sca effect was given by the cross Pb311A x PIB262. Maximum sca effect for leaf length was shown by the cross Pb220A x PIB258. Only two crosses showed significant negative sca effects for days to flowering. The cross combination Pb601A x PIB253 recorded a highest negative sca effect of -4.12, whereas, the cross Pb220A x PIB250 recorded a highest positive sca effect of 4.21. Ten out of forty crosses were found to be good specific combiners for green fodder yield. As high as 307.81 sca effect was shown by the cross Pb408A x PIB258.For oxalic acid content seven out of forty crosses showed significant positive sca effects where as negative sca effects were observed in nine crosses. The cross combination Pb502A x PIB262 showed a maximum of 1.04 sca effect where as the cross combination Pb601A x PIB262 showed a maximum of -1.18 negative sca effect. For total ash content four out of forty crosses showed positive sca effects ranging from 0.9 to 1.87. Seven crosses showed negative sca effects. The maximum sca effect was shown by the cross Pb220A x PIB366 and the maximum negative sca effect was shown by Pb408A x PIB258.

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