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Research Article

Combining ability analysis for yield and yield attributing traits in Finger Millet (*Eleusine coracana* (L.) Gaertn.) Hybrids

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Abstract
Finger millet (*Eleusine coracana* (L.) Gaertn) 2n = 4x = 36, belongs to the tribe Chloridae of the family Poaceae. Finger millet is commonly called as "nutritious millet" as the grains are nutritiously superior to many cereals providing fair amount of protein, minerals, calcium and vitamins in abundance to the people. In the present investigation, seven female lines were crossed with three testers during *rabi* 2009-2010 and the resultant twenty one hybrids along with their parents were utilized for combining analysis during *kharif* 2010. Data were recorded for yield and yield contributing agronomic characters in each entry throughout the replications and mean values were subjected to line x tester analysis. The genotypes were found highly significant for all the traits which indicated that the treatments used in this study were significantly varied from each other. The ratio of *gca* and *sca* variances were found to be less than unity for all the characters indicating the predominance of non-additive gene action in the control of these traits. The estimates of *gca* effects indicated that all female parents and among males K 7 and KM 252 were good general combiners for grain yield per plant. High *sca* effects were observed in the crosses CO(Ra) 14 X PR 202, CO(Ra) 14 X K 7, RAU 8 X KM 252, RAU 8 X K 7 , VR 708 X KM 252 and OEB 259 X PR 202 and they were found to be the best combinations for grain yield per plant and quality traits.

Key words: Combing ability, Analysis of variance, Line × Tester, *gca*, *sca*, Finger millet.

Introduction

Finger millet is third in its importance with respect to area and production among millets in India after sorghum and pearl millet. Among millets, finger millet has a unique place and is the only millet which has been able to touch an average productivity level of more than 1.5 tonne per hectare (Priyadershini, 2010). It is cultivated mostly as a rainfed crop in India under diverse production environments (Priyadharshini *et al*., 2011). It is a hardy crop with minimum disease and pest problems and assures reasonable economic return from adverse growing conditions (John Joel *et al*., 2005). The concept of general and specific combining abilities is useful to characterize the hybrids in the breeding programme and also elucidates the nature and magnitude of gene actions involved in the trait of interest (Sumalini, 2010). Success of any plant breeding programme depends on the choice of appropriate genotypes as parents in the hybridization programme. The combining ability studies of the parents provide information which helps in the selection of better parents for effective breeding. Combining ability analysis also provides information on additive and dominance variance. Its role is important to decide parents, crosses and appropriate breeding procedure to be followed to select desirable segregants (Salgotra *et. al.,* 2009). Accordingly, the present investigation was undertaken to get an idea of the combining ability for yield and quality traits with a view to identify good combiners which may be used to create a population with favorable genes for yield and quality traits in finger millet.

Material and Methods

The experimental material consisted of twenty one hybrid combinations which were obtained by crossing seven lines (female) *viz.,* CO (Ra) 14, RAU 8, PES 110, VR 708, GPU 28, GPU 48 and OEB 259 with a set of three testers (male) *viz.,* PR 202, KM 252 and K 7 employed in line x tester mating design and adopting a spacing of 30x10 cm at Department of millets, Tamil Nadu Agricultural University, Coimbatore during *rabi* 2009-2010. The F_1's along with ten parents were raised in a randomised block design with three replications during *kharif*, 2010. Observations were recorded on days to 50 per cent flowering, plant height (cm), number of productive tillers per plant, number of fingers per ear head, longest finger length (cm), thousand grain weight (g), grain protein (%), iron and zinc contents (mg/100g), harvest index (%), single plant dry fodder yield (g) and single plant grain yield (g). The data were recorded from each entry in all the replications and mean values were subjected to line x tester analysis.

Results and Discussion

Analysis of variance for combining ability (Table 1) revealed that the mean squares due to the genotypes were significant for all the traits which indicated that the treatments used in this study were significantly varied from each other. Variances due to parents were highly significant for most of the traits studied indicating good amount of genetic differences among the parents. Variances due to hybrids were highly significant for all the traits studied. The ratio of variances due to general and specific combining ability ranged from 0.011 for single plant dry fodder yield to 0.890 for iron content. The mean squares due to males (testers) were found non significant for all the characters. Combining ability analysis revealed that both *gca* and *sca* variances were important for inheritance of various traits studied. It further revealed the importance of additive and non-additive types of gene actions. The *sca* variances were higher than the *gca* variances for almost all the characters, which is similar with earlier findings of Saravanan *et al.* (2006), Anandkumar *et al.* (2004) and Vanaja *et al.* (2003).

An overall appraisal of *gca* effects (Table 2) revealed that among lines, significant positive *gca* effect was observed in VR 708 (1.10), CO (Ra)14 (0.69), GPU 28 (0.56) and PES 110 (0.47) for grain yield per plant. Among the testers, K 7 (0.41) recorded positive significant *gca* effects for grain yield per plant. Tamilcovane (1994) reported additive gene action while Suresh (1988) reported presence of both additive and non-additive gene action for thousand grain weight and pre-dominance of additive gene action.

High *sca* effect results (Table 3) mostly from dominance and interaction effects. The important criterion for the evaluation of the hybrids is the *sca* effects. According to Virmani (2000), *sca* is an index to determine the usefulness of a particular cross combination. The *sca* effect along with *per se* performance of hybrids would give an idea about the practical utility of hybrid combinations for heterosis breeding. In the present study, the hybrid, CO (Ra) 14 x PR 202 showed high significant *sca* effect for most of the characters like number of fingers per ear head, harvest index, dry fodder yield, and grain yield followed by GPU 28 x K 7 which showed significant *sca* effects for days to 50 per cent flowering, productive tillers per plant, longest finger length, dry fodder yield and zinc content. These combinations could be used for exploitation of heterosis in further hybrid breeding program.

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Table 1. ANOVA for combining ability analysis for yield and yield attributing traits in finger millet

Source	Days to 50 per cent flowering	Plant height (cm)	Number of productive tillers per plant	Number of fingers per ear head	Longest finger length (cm)	1000 Grain weight (g)	Harvest index (%)	Single plant dry fodder yield (g)	Single plant grain yield (g)	Protein content (%)	Iron content (mg/100 g)	Zinc content (mg/100 g)
GCA	---	2.685	---	0.126	0.048	---	0.012	0.010	0.023	0.025	0.073	---
SCA	13.963	8.160	0.883	0.702	0.192	0.040	0.414	0.907	1.286	0.045	0.082	0.05
GCA/SCA	---	0.329	---	0.179	0.25	---	0.028	0.011	0.017	0.555	0.890	---

***Significant at 5 % level; ** Significant at 1% level; Negative values of GCA variances are not indicated in the table**

Table. 2 Estimates of general combining ability (*gca*) effects for yield and its related traits in finger millet

Parents	Days to 50 per cent flowering	Plant height (cm)	Number of productive tillers per plant	Number of fingers per ear head	Longest finger length (cm)	1000 Grain weight (g)	Protein content (%)	Iron content (mg/100 g)	Zinc content (mg/100 g)	Harvest index (%)	Single plant dry fodder yield (g)	Single plant grain yield (g)
CO (Ra) 14	1.67 **	8.46 **	0.21	1.71 **	0.86 **	- 0.08 **	1.13 **	- 0.02 **	- 0.08 **	0.36	0.67 *	0.69 **
RAU 8	- 1.33 **	- 4.65 **	- 0.46 *	- 0.29	- 0.40 **	- 0.16 **	- 0. 45 **	- 0.32 **	0.14 **	- 0.79 **	- 0.73 **	-1.06 **
PES 110	- 0.56 *	3.02 **	0.10	1.27 **	- 0.11	- 0.05 **	- 0.11 **	- 1.18 **	- 0.01	0.62 **	0.09	0.47 *
VR 708	- 2.56 **	0.02	0.65 **	- 0.84 **	0.27 **	- 0.07 **	- 0.18 **	1.79 **	- 0.01	0.63 **	0.94 **	1.10 **
GPU 28	- 1.89 **	5.13 **	0.21	0.83 **	0.43 **	0.21 **	0.23 **	1.38 **	- 0.12 **	0.23	0.53 *	0.56 *
GPU 48	2.22 **	- 1.65 *	- 0.35	- 0.40	0.35 **	0.05 **	0.18 **	- 0.91 **	- 0.16 **	- 0.34	- 0.42	- 0.56 *
OEB 259	2.44 **	- 10.32 **	- 0.35	- 2.29 **	- 1.41 **	0.10 **	- 0.79 **	- 0.75 **	0.25 **	- 0.70 **	- 1.07 **	- 1.21 **
S.E. (Female)	0.2368	0.6975	0.1787	0.2180	0.0788	0.0049	0.0396	0.0020	0.0016	0.2271	0.2592	0.2142
PR 202	1.24 **	0.62	0.16	0.68 **	0.61 **	- 0.01 **	- 0.04	0.58 **	- 0.01 **	0.04	- 0.13	- 0.05
KM 252	- 0.67 **	- 2.14 **	- 0.56 **	- 0.37 *	- 0.21 **	0.02 **	- 0.10 **	- 0.20 **	0.01	- 0.31 *	- 0.18	- 0.36 *
K 7	- 0.57 **	1.52 **	0.40 **	- 0.32 *	- 0.41 **	- 0.00	0.14 **	- 0.38 **	0.00	0.27	0.31	0.41 **
S.E. (Male)	0.1550	0.4566	0.1170	0.1427	0.0516	0.0032	0.0260	0.0013	0.0042	0.1487	0.1697	0.1402

Table. 3 Estimates of specific combining ability (*sca*) effects for yield and its related traits in finger millet

HYBRIDS	Days to 50 per cent flowering	Plant height (cm)	Number of productive tillers per plant	Number of fingers per ear head	Longest finger length (cm)	1000 Grain weight (g)	Protein content (%)	Iron content (mg/100 g)	Zinc content (mg/100 g)	Harvest index (%)	Single plant dry fodder yield (g)	Single plant grain yield (g)
CO(Ra) 14 X PR 202	- 0.57	1.49	1.17 **	- 0.90 *	- 0.23	0.02 **	- 0.12	- 0.07 **	- 0.17 **	0.86 *	0.95 *	1.30 **
CO(Ra) 14 X KM 252	- 4.00	- 0.41	- 0.11	0.48	0.03	- 0.11 **	-0.22 **	- 0.77 **	0.18 **	- 0.09	0.32	0.14
CO(Ra) 14 X K 7	4.57 **	- 1.08	- 1.06 **	0.43	0.20	0.09 **	0.34 **	0.84 **	- 0.01	- 0.77	- 1.27 **	- 1.43 **
RAU 8 X PR 202	- 2.90 **	-3.73 **	- 0.49	1.76 **	- 0.10	0.08 **	0.09	1.56 **	0.11 **	0.24	- 0.39	- 0.12
RAU 8 X KM 252	2.00 **	2.70 *	1.56 **	- 1.19 **	0.01	- 0.02	0.14	- 0.89 **	0.11 **	0.95 *	1.30 **	1.53 **
RAU 8 X K 7	0.90 **	1.03	- 1.06 **	- 0.57	0.09	- 0.07 **	-0.22 **	- 0.68 **	- 0.22 **	- 1.19 **	- 0.91 *	- 1.41 **
PES 110 X PR 202	- 5.02 **	- 0.06	0.29	- 0.13	- 0.02	- 0.04 **	- 0.04	- 1.22 **	- 0.13 **	0.07	0.46	0.35
PES 110 X KM 252	3.89 **	0.37	- 0.33	- 0.08	- 0.43 **	- 0.01	0.12	0.01 **	0.09 **	- 0.28	- 0.49	- 0.53
PES 110 X K 7	1.13 **	- 0.30	0.05	0.21	0.45 **	0.05 **	- 0.08	1.21 **	0.05 **	0.21	0.03	0.18
VR 708 X PR 202	4.32 **	- 0.06	0.04	0.98 *	0.10	0.21 **	0.07	- 0.98 **	0.33 **	0.16	0.82	0.66
VR 708 X KM 252	- 0.78	- 0.97	- 0.89 **	0.03	0.38 **	- 0.27 **	0.05	0.92 **	- 0.26 **	- 0.50	- 1.00 *	- 1.08 **
VR 708 X K 7	- 3.54 **	1.03	0.49	- 1.02 **	- 0.48 **	0.06 **	- 0.12	0.06 **	- 0.08 **	0.34	0.18	0.42
GPU 28 X PR 202	0.65	0.16	0.17	- 0.68	- 0.50 **	- 0.28 **	0.10	1.07 **	- 0.33 **	0.15	- 0.19	- 0.10
GPU 28 X KM 252	1.22 **	4.92 **	- 1.11 **	0.70	0.02	0.28 **	0.09	0.27 **	- 0.04 **	- 0.74	- 1.01 *	- 1.12
GPU 28 X K 7	- 1.87 **	- 5.08 **	0.94 **	- 0.02	0.48 **	0.00	-0.06 **	- 1.34 **	0.37 **	0.59	1.20 *	1.22
GPU 48 X PR 202	- 0.79	0.27	- 0.60	- 0.46	- 0.00	- 0.17 **	- 0.04	- 0.09 **	0.21 **	- 0.59	- 0.46	- 0.71
GPU 48 X KM 252	- 1.56 **	- 2.30	0.44	- 0.08	- 0.03	0.28 **	0.13	0.25 **	- 0.22 **	0.27	0.74	0.69
GPU 48 X K 7	2.35 **	2.03	0.16	0.54	0.03	- 0.10 **	- 0.09	- 0.15 **	0.01	0.32	- 0.27	0.01
OEB 259 X PR 202	4.32 **	1.94	- 0.94 **	- 0.57	0.76 **	0.18 **	- 0.06	-0.27 **	- 0.02	- 0.89 *	- 1.19 *	-1.38 **
OEB 259 X KM 252	- 0.78	- 4.30 **	0.44	0.14	0.01	- 0.14 **	-0.30 **	0.21 **	0.14	0.40	0.14	0.37
OEB 259 X K 7	- 3.54 **	2.37	0.49	0.43	- 0.77 **	- 0.04 **	0.36 **	0.07 **	- 0.12	0.49	1.05 *	1.01
S.E	0.402	1.2081	0.3095	0.3776	0.1365	0.0084	0.0687	0.0035	0.0110	0.3934	0.4490	0.3709

***Significant at 5 % level; ** Significant at 1% level**