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Combining Ability Analysis and Estimates of Heterosis for Grain Yield and Nutritional traits in Finger millet (*Eleusine coracana* (L.) Geartn)

P. Savitha*, A. Nirmalakumari, M. Maheswaran and T. Raguchander
Centre for Plant Breeding and Genetics,
Tamil Nadu Agricultural University, Coimbatore - 641 003

Finger millet (*Eleusine coracana* (L.) Gaertn.) is an important subsistence cereal in parts of Africa and South Asia. Finger millet is commonly called as "nutritious millet" as the grains are superior to many cereals providing fair amount of protein, minerals and vitamins in abundance to the people. The parental values of different traits in different crosses depend on their potential and their combining ability in different combinations. The concept of general and specific combining abilities is useful to characterize the hybrids in the breeding programme and also elucidate the nature and magnitude of gene actions involved in the trait of interest. Two hybrids namely CO (Ra) 14 x PR 202 and GPU 28 x K 7 were found to be superior for grain yield and other major yield components along with the protein content based on *per se* performance, *sca* effect and standard heterosis.

Key words: Heterosis, Combining ability, Hybrids, Additive gene action, *gca, sca*.

Finger millet is the primary food for millions in dry lands of eastern and central Africa and southern Asia. The most important development in plant breeding in recent years has been the use of heterosis or hybrid vigour in many self pollinated species and has been the object of considerable study as a mean of increasing productivity of wheat and other cereals (Malik *et al*., 1986). *Ragi* being a self pollinated crop, exploitation of heterosis is the best option to further improve the grain yield and nutritional characters. Evidences are available to confirm the potential use of heterosis and in self pollinated crops (Parashuram *et al.,* 2011). Exploitation of variability created by hybridization through recombination breeding is the next major approach adopted in finger millet improvement programme (Kadam *et al*., 2008). Among the several biometrical methods developed to identify superior parents for heterosis breeding, the line x tester analysis has received considerable attention. It is a technique employed to gain information on hybrid vigour, combining ability and nature of gene action from the study of first generation itself. Combining ability analysis of cultivars is thus important to exploit the relevant type of gene action for a breeding programme. Combining ability estimates can be used to evaluate the number of promising lines in F_1 and F_2 generations, which is quite helpful in selecting the potential parents for hybridization (Hennawy, 1996; Iqbal and Chowdary, 2000). It also helps in identifying the parents suitable for hybridization programme and deciding suitable the easiest ways of commercial exploitation of genetic potential breeding methodology (Senthil *et al.,* 2005). Though *per se* performance of parental lines provides clues, reliable information on the magnitude of heterosis for yield and yield attributing traits are of more helpful in selecting appropriate parents and desirable cross combinations for the exploitation of hybrid vigour (Shailaja *et al.,* 2010). Therefore, the present study was, undertaken to determine the combining ability, the extent of relative heterosis, heterobeltiosis and standard heterosis in fingermillet and to identify the most heterotic hybrids.

*Corresponding author email: saviagri @ gmail.com

Materials and Methods

The experiment was conducted in the Department of Millet, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore, during 2009 -2011. The experimental material consisted of ten parents and twenty one hybrid combinations obtained by crossing seven lines (female) *viz.,* CO (Ra) 14, RAU 8, PES 110, VR 708, GPU 28, GPU 48 and OEB 259 and with a set of three testers (male) *viz.,* PR 202, KM 252 and K 7 in line x tester mating design (Kempthorne,1957). The F_1's were raised in a randomised complete block design (RCBD) with three replications along with the parents during *kharif*, 2010. The observations on three randomly selected competitive plants for parents and hybrids were recorded for 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). Heterosis value was calculated by using the overall mean of each parent and hybrid in all three replications for each character. Relative heterosis was estimated as the percent deviation of the F_1 hybrid from its mid parental value. Heterobeltiosis for each character in each hybrid combination was expressed as per cent increase or decrease of F_1 value over better parental value. Standard heterosis was estimated as difference between the mean of the F_1 and that of the standard check CO (Ra) 14.

Results and Discussion

The results revealed that among the lines, CO(Ra)14 was superior for two important yield

Table 1. Parents with high *per se* performance and *gca* effect

Characters	*Per se*		*gca*		*Per se* and *gca*	
	Lines	Testers	Lines	Testers	Lines	Testers
Days to 50 per cent flowering	PES 110 GPU 28 OEB 259 RAU 8	---	VR 708 GPU 28 RAU 8	KM 252 K 7	GPU 28 RAU 8	---
Plant height (cm)	RAU 8 OEB 259 GPU 48 PES 110	KM 252	OEB 259 RAU 8 GPU 48	KM 252	RAU 8 OEB 259 GPU 48	KM 252
Number of productive tillers per plant	GPU 28 CO(Ra)14	PR 202	VR 708	K 7	---	-
Number of fingers per ear head	RAU8, GPU 48 CO(Ra)14 GPU 28	PR 202	CO(Ra)14 PES 110 GPU 28	PR 202	CO(Ra)14 GPU 28	PR 202
Longest finger length (cm)	RAU 8 CO(Ra) 14 PES 110 GPU 28	K 7	CO(Ra)14 GPU 28 GPU 48 VR 708	PR 202	CO(Ra)14 GPU 28	---
Thousand grain weight (g)	GPU 48 RAU 8 OEB 259	K 7	GPU 28 OEB 259 GPU 48	KM 252	GPU 48 OEB 259	---
Seed protein content (%)	CO(Ra)14 GPU 28 GPU 48 VR 708	K 7 KM 252 PR 202	CO(Ra)14 GPU 28 GPU 48	K 7	CO(Ra)14 GPU 28 GPU 48	K 7
Iron content (mg/100 g)	GPU 28 CO(Ra)14	PR 202 K 7	VR 708 GPU 28	PR 202	GPU 28	PR 202
Zinc content (mg/100 g)	VR 708	KM 252 PR 202	OEB 259 RAU 8	---	---	---
Harvest index (%)	GPU 48 CO(Ra)14 PES 110	PR 202 K 7	VR 708 PES 110	---	---	PES 110
Single plant dry fodder yield (g)	RAU 8 CO(Ra)14 PES 110	PR 202 K 7	VR 708 CO(Ra) 14 GPU 28	---	CO(Ra)14	---
Single plant grain yield (g)	CO(Ra)14 PES 110 GPU 48	PR 202 K 7	VR 708 CO(Ra)14 GPU 28 PES 110	K 7	CO(Ra)14 PES 110	K 7

related characters *viz.,* number of fingers per ear head and longest finger length. It showed high *per se* performance and high *gca* effects for plant height, protein content, dry fodder yield and grain yield (Table 1). Similar results were reported in finger millet by Ganapathy *et al.* (2011). The line, GPU 28 showed high *per se* performance along with high *gca* effects for days to 50 per cent flowering, plant

Table 2. Expression of Relative heterosis (di), Heterobeltiosis (dii) and standard heterosis (diii) for days to 50 per cent flowering, plant height, no. of productive tillers per plant and no. of fingers per ear head in finger millet

Hybrids	Days to 50 per cent flowering			Plant height (cm)			No. of productive tillers per plant			No. of fingers per ear head		
	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii
CO(Ra) 14 X PR 202	-2.58**	-5.03**	- 5.03**	1.04	- 0.00	- 0.00	41.67 **	30.77 **	54.55**	4.35	4.35	4.35
CO(Ra) 14 X KM 252	- 13.28 **	- 13.50**	- 13.07**	4.71*	- 4.79*	- 4.79*	10.00	- 0.00	- 0.00	16.28 *	8.70	8.70
CO(Ra) 14 X K 7	3.11 **	- 0.00	- 0.00	- 0.86	- 1.71	- 1.71	4.76	- 0.00	- 0.00	25.00 **	8.70	8.70
RAU 8 X PR 202	- 4.16 **	- 8.47**	- 13.07**	- 8.67**	- 17.13**	- 18.84**	- 13.04	- 23.08 *	- 9.09	8.33	4.00	13.04
RAU 8 X KM 252	- 2.15 **	- 9.00**	- 8.54**	5.08*	3.77**	- 15.07**	47.37**	40.00 **	27.27*	- 37.78**	- 44.00**	- 39.13**
RAU8 X K7	- 0.28	- 4.28**	- 10.05**	- 2.31	- 11.50**	- 13.01	- 10.00	- 10.00	18.18	- 23.81**	- 36.00**	- 30.43**
PES 110 X PR 202	- 1.46	- 10.58**	- 5.08**	2.26	- 5.24**	- 7.19**	21.74*	7.69	27.27*	21.95**	8.70	8.70
PES 110 X KM 252	7.34 **	-1 5.00**	- 4.52**	9.32**	8.20**	- 9.59**	5.26	0.00	- 9.09	15.79 *	10.00	- 4.35
PES 110 X K 7	6.74 **	- 2.67**	- 8.54**	2.82	- 4.88*	- 6.51**	40.00**	40.00	27.27 *	31.43 **	27.78 **	0.00
VR 708 X PR 202	5.82 **	1.06	- 4.02**	- 5.76**	- 8.39**	- 10.27**	39.13**	23.08 *	45.45 **	12.82	- 4.35	- 4.35
VR 708 X KM 252	- 8.60 **	- 15.00**	- 14.57**	- 1.38	- 7.04**	- 14.04**	5.26	0.00	- 9.09	-11.11	- 20.00*	- 30.43**
VR 708 X K 7	- 9.75 **	- 13.37**	- 18.59**	-3.77*	- 6.62**	- 8.22**	70.00**	70.00 **	54.55 **	- 21.21	- 23.53*	- 43.48**
GPU 28 X PR 202	4.30 **	- 3.70**	- 8.54**	- 3.97*	- 5.12**	- 4.79**	21.74*	7.69	27.27 *	2.33	- 4.35	- 4.35
GPU 28 X KM 252	- 1.11	- 11.00**	- 10.55**	6.77**	- 3.07	- 2.74	- 15.79	- 20.00	27.27 *	15.00 *	15.00	0.00
GPU28 XK7	- 2.59 **	- 9.63**	- 15.08**	- 8.62**	- 9.56**	- 9.25**	70.00 **	70.00 **	54.55 **	13.51	5.00	- 8.70
GPU 48 X PR 202	0.26	0.00	- 4.52**	- 2.09	- 9.79**	- 11.64**	- 20.00 *	- 23.08 *	- 9.09	- 20.83 **	- 24.00 **	- 17.39 *
GPU 48 X KM 252	- 6.67 **	- 9.00**	- 8.54**	0.83	0.41	- 17.12 **	4.76	- 8.33	- 0.00	- 24.44 **	- 32.00 **	- 26.09 **
GPU48 X K7	2.92 **	2.11*	- 2.51**	0.76	- 7.32 **	- 8.90 **	18.18	8.33	18.18	- 9.52	- 24.00 **	- 17.39 *
OEB 259 X PR 202	17.05 **	8.99**	3.52**	- 9.71**	- 17.13 **	-18.84 **	- 18.18	- 30.77 **	18.18	- 27.78 **	- 43.48 **	- 43.48 **
OEB 259 X KM 252	1.93 *	- 7.50**	- 7.04**	-12.13**	- 12.13 **	- 28.08 **	22.22	22.22	- 0.00	- 27.27 **	- 40.00 **	- 47.83 **
OEB259 XK7	1.14	- 5.35**	-11.06	- 8.37**	- 16.03 **	17.47 **	47.37 **	40.00 **	27.27 *	- 13.33	- 23.53 *	- 43.48 **

Table 2. Expression of Relative heterosis (di), Heterobeltiosis (dii) and standard heterosis (diii) for longest finger length, thousand grain weight, harvest index and protein content in finger millet (contd...,)

Hybrids	Longest finger length (cm)			Thousand grain weight (g)			Harvest index (%)			Protein content (%)		
	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii
CO(Ra) 14 X PR 202	12.06 **	4.17	4.17	2.42 **	- 0.29	5.28 **	2.73 *	2.73	2.73	8.46 **	3.72 **	3.72 **
CO(Ra) 14 X KM 252	10.79 **	- 3.28	- 3.28	0.23	- 0.15	0.60	2.02	- 0.48	- 0.48	6.40 **	1.95 *	1.95 *
CO(Ra) 14 X K 7	- 1.39	- 3.77	- 3.77	- 2.83 **	- 12.18 **	8.75 **	- 0.06	- 0.69	- 0.69	13.11**	10.80 **	10.80 **
RAU 8 X PR 202	- 9.57 **	- 19.80 **	- 10.95 **	- 4.61 **	- 7.97 **	4.52 **	2.31	- 1.65	- 1.64	3.62 **	- 2.91 **	- 11.39 **
RAU 8 X KM 252	- 14.18 **	- 28.26 **	- 20.35 **	- 5.28 **	- 10.62 **	1.51 **	5.92 **	4.34 **	- 0.76	3.22 **	- 3.46 **	- 11.53 **
RAU8 X K7	- 24.38 **	- 29.78 **	22.03 **	- 17.03 **	- 20.46 **	- 1.51 **	- 0.08	- 3.36 *	- 4.57 **	- 0.80	- 9.14 **	- 12.86 **
PES 110 X PR 202	5.68 *	2.17	- 5.98 *	- 1.36 **	- 1.57 **	3.92 **	2.40	1.40	1.41	0.53	- 0.28	- 8.99 **
PES 110 X KM 252	- 6.84 *	- 15.66 **	- 22.38 **	3.59 **	1.43 **	6.64 **	3.22 *	1.67	- 0.30	1.42	0.40	- 8.00 **
PES 110 X K 7	- 7.36 **	- 8.90 **	- 13.30 **	- 4.87 **	- 12.06 **	8.90 **	3.99 **	3.63 *	2.33	- 0.44	- 3.61 **	- 7.55 **
VR 708 X PR 202	19.47 **	17.13 **	0.62	13.45 **	8.43 **	14.48 **	5.02 **	1.66	1.67	0.04	- 0.04	- 8.62 **
VR 708 X KM 252	18.93 **	13.21 **	- 6.56 *	- 4.44 **	- 6.59 **	- 5.88 **	5.10 **	4.27 **	- 0.83	- 1.17	- 1.29	- 9.54 **
VR 708 X K 7	- 10.70 **	- 16.63 **	- 20.66 **	- 1.30 **	- 12.30 **	8.60 **	6.79 **	4.01 **	2.70	- 2.60 **	- 4.88 **	- 8.77 **
GPU 28 X PR 202	8.50 **	6.68 *	- 5.19 *	3.49 **	- 0.57	4.98 **	3.70 **	0.66	0.67	2.73 **	0.04	- 3.65 **
GPU 28 X KM 252	11.01**	2.09	- 9.26 **	32.83 **	30.54 **	31.52 **	3.15 *	2.63	- 2.39	1.59	- 0.88	- 4.53 **
GPU28 XK7	2.50	- 0.88	- 5.67 *	7.09 **	- 4.38 **	18.40 **	6.09 **	3.62 *	2.32	- 1.05	- 1.26	- 4.90 **
GPU 48 X PR 202	26.81 **	16.77 **	0.31	- 9.44 **	- 15.30 **	2.71 **	- 2.65 *	- 2.73	- 2.56	1.21	- 0.66	- 5.86 **
GPU 48 X KM 252	21.24 **	19.37 **	- 10.95 **	11.96**	2.49 **	24.28 **	1.06	- 1.50	- 1.33	2.23 **	0.54	- 4.72 **
GPU48 X K7	4.18	- 8.34 **	- 12.77 **	-13.23 **	-14.13 **	6.33 **	0.79	0.07	0.25	0.21	- 0.38	- 4.46 **
OEB 259 X PR 202	14.56 **	1.29	12.99 **	13.48 **	12.68 **	20.66 **	- 1.26	- 4.19 **	- 4.19 **	- 3.28 **	- 8.84 **	- 16.80 **
OEB 259 X KM 252	- 5.80	- 11.23 **	- 33.78 **	3.19 **	0.14	7.24 **	3.72 **	3.15 *	- 1.90	- 7.46 **	- 12.95 **	- 20.23 **
OEB259 XK7	- 34.05 **	- 44.15 **	- 46.85 **	- 3.72 **	- 10.23 **	11.16**	3.50 **	1.05	- 0.22	1.69	- 6.34 **	- 10.17 **

Table 2. Expression of Relative heterosis (di), Heterobeltiosis (dii) and standard heterosis (diii) for iron content, zinc content, single plant dry fodder yield and single plant grain yield in finger millet (contd...,)

Hybrids	Iron content (mg/ 100 g)			Zinc content (mg/ 100 g)			Single plant dry fodder yield (g)			Single plant grain yield (g)		
	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii
CO(Ra) 14 X PR 202	85.77 **	70.88 **	103.49 **	- 5.98 **	- 11.80 **	0.66	5.76 **	4.44	7.12 **	10.59 **	9.06 **	12.16 **
CO(Ra) 14 X KM 252	87.54 **	43.68 **	43.68 **	4.31 **	- 2.84 **	12.60 **	6.88 **	4.36	4.36	10.03 **	3.53	3.53
CO(Ra) 14 X K 7	123.08**	101.34**	101.34**	0.83	- 4.06 **	6.24 **	0.44	- 0.04	- 0.04	1.07	- 1.18	- 1.18
RAU 8 X PR 202	201.10**	116.14**	157.39**	4.35 **	2.40 **	16.87 **	- 5.15 *	- 6.13 **	- 3.91	- 1.84	- 9.08 **	- 6.49 *
RAU 8 X KM 252	141.94 **	138.89 **	27.15 **	4.03 **	1.32 **	17.42 **	5.13 *	2.63	2.68	15.30 **	14.97 **	1.39
RAU8 X K7	94.31 **	59.77 **	28.63 **	- 3.48 **	- 3.86 **	6.46 **	- 3.80	- 4.29	- 4.24	- 3.24	- 7.23 *	- 11.36 **
PES 110 X PR 202	25.98 **	- 7.22 **	10.48 **	- 8.26 **	- 8.83 **	4.05 **	1.97	0.26	2.83	5.90 *	2.37	5.28 *
PES 110 X KM 252	134.85**	128.40 **	28.63**	- 2.06 **	- 3.40 **	11.94**	1.63	- 0.34	- 1.21	6.76 **	2.43	- 1.69
PES 110 X K 7	148.53**	111.19**	70.03 **	- 0.98 *	- 1.85 **	10.62 **	3.78	3.73	2.83	11.74**	11.49**	7.00 **
VR 708 X PR 202	108.28**	101.35**	139.78**	- 8.46 **	- 18.50 **	19.17 **	7.38 **	5.02 *	7.71 **	16.15 **	7.74 **	10.81 **
VR 708 X KM 252	441.25**	435.10**	184.81**	- 23.28 **	- 31.24 **	0.55	3.62	2.16	0.16	12.18 **	12.03 **	- 1.20
VR 708 X K 7	266.73**	201.84**	143.01**	- 17.22 **	- 27. 27 **	6.35 **	8.46 **	7.92 **	6.88 **	22.24 **	17.39 **	12.16 **
GPU 28 X PR 202	157.26**	157.11**	206.18**	- 16.23 **	- 17.75 **	- 6.13 **	2.07	- 0.59	1.96	8.09 **	0.31	3.16
GPU 28 X KM 252	181.50**	103.73**	142.34**	- 7.95 **	- 10.30 **	3.94 **	2.30	1.28	- 1.53	8.19 **	8.10 **	- 4.67
GPU28 XK7	70.62 **	43.05 **	70.16 **	6.20 **	5.84 **	17.20 **	11.39**	10.37**	9.30 **	23.86 **	18.99 **	13.69 **
GPU 48 X PR 202	108.41 **	39.84 **	66.53 **	- 3.18 **	- 3.45 **	10.19 **	- 3.31	- 5.38 *	- 2.96	- 5.97 *	- 9.54 **	- 6.96 *
GPU 48 X KM 252	216.74**	179.55 **	48.79**	- 15.47 **	- 16.35 **	- 3.07 **	5.11*	3.58	1.66	8.55 **	4.64	- 0.55
GPU48 X K7	107.10 **	55.93 **	25.54 **	- 6.89 **	- 8.01 **	4.38 **	0.98	0.53	- 0.44	4.94 *	4.66	- 0.00
OEB 259 X PR 202	106.01 **	39.39 **	65.99 **	4.89 **	1.82 **	16.21 **	- 6.26 **	- 10.78 **	- 8.50 **	- 8.07 **	- 17.11 **	- 14.75 **
OEB 259 X KM 252	222.99 **	189.14 **	53.90 **	9.37 **	5.39 **	22.12 **	2.86	1.45	- 3.34	9.74 **	6.27 *	- 6.28 *
OEB259 XK7	130.48 **	75.46 **	41.26 **	3.92 **	2.37 **	13.36 **	6.71 **	3.28	2.28	14.50 **	6.75 *	2.00

height, number of finger per ear head, longest finger length and grain iron and zinc content. Among the lines, PES110 showed superior *per se* performance and high *gca* effects for harvest index and grain yield.

The line, GPU 48 gave high *per se* performance along with high *gca* effects for protein content. The results revealed that among the lines, RAU 8 recorded high *per se* performance and high *gca* effect for days to 50 per cent flowering. The line, OEB 259 showed high *per se* performance along with high *gca* effect for longest finger length.

Among the testers, PR 202 showed high *per se* performance along with high *gca* effects for number of fingers per ear head and iron content. The results revealed that among the testers, K 7 was a superior and stable performer for plant height, protein content and yield.

However, the hybrid CO(Ra)14 x PR 202 showed high significant *per se* performance for most of the characters like plant height, productive tillers, number of fingers per ear head, harvest index, dry fodder yield and protein content and stood first. The hybrid, VR 708 x PR 202 ranked second and showed the superior performance for number of productive tillers per plant, longest finger length, harvest index, dry fodder yield, protein content and grain yield. The third best hybrid was PES 110 x PR 202 showing high *per se* performance for days to 50 per cent flowering, number of fingers per ear head, harvest index and grain yield. The two hybrids, CO (Ra)14 x KM 252 and VR 708 x K 7 expressed high *per se* performance for days to 50 per cent flowering, number of fingers per ear head, and dry fodder yield. Considering single plant yield alone, CO (Ra)14 x PR 202, VR 708 x PR 202, CO(Ra)14 x KM 252 and VR 708 x K7 were found to be superior combinations. These crosses could be advanced futher and selection of desirable plant progenies could be made in the later generations (Table 3). Similar results were also given by Priyadharshini *et al.* (2011).

Table 3. Superior hybrids with high *per se* performance, high *sca* value, mid parent heterosis, better parent heterosis and standard heterosis

Characters	High *per se* performance	High *sca* effects	Mid parent heterosis	Better parent heterosis	Standard heterosis
Days to 50 per cent flowering	VR 708 x K 7 PES 110 x PR 202 GPU 28 x K 7 VR 708 x KM 252	PES 110 x PR 202 VR 708 x K 7 OEB 259 x K 7 RAU 8 x PR 202	CO (Ra)14 x KM 252 VR 708 x K 7 VR 708 x KM 252	VR 708 x KM 252 CO(Ra)14 x KM 252 VR 708 x K 7	VR 708 x K 7 PES 110 x PR 202 VR 708 x KM 252
Plant height (cm)	OEB 259 x KM 252 OEB 259 x PR 202 RAU 8 x PR 202	GPU 28 x K 7 OEB 259 x KM 252 RAU 8 x PR 202	OEB 259 x KM 252 OEB 259 x PR 202 RAU 8 x PR 202	RAU 8 x PR 202 OEB 259 x PR 202 OEB 259 x K 7	OEB 259 x KM 252 RAU 8 x PR 202 OEB 259 x PR 202
Number of productive tillers per plant	CO (Ra)14 x PR 202 VR 708 x K 7 VR 708 x PR 202	RAU 8 x KM 252 CO(Ra)14 x PR 202 GPU 28 x K 7	VR 708 x K 7 GPU 28 x K 7 RAU 8 x KM 252	VR 708 x K 7 GPU 28 x K7 OEB 259 x K 7	CO(Ra)14 x PR 202 VR 708 x K 7 GPU 28 x K 7
Number of fingers per ear head	RAU 8 x PR 202 C O(Ra)14 x KM 252 CO(Ra) 14 x K 7 PES110 x PR 202	VR 708 x PR 202	PES 110 x K 7 CO(Ra) 14 x K 7 PES 110 x K 7	PES 110 x K 7	---
Longest finger ength cm)	CO (Ra)14 x PR 202 VR 708 x PR 202 GPU 48 x PR 202	OEB 259 x PR 202 GPU 28 x K 7 PES 110 x K 7	GPU 48 x PR 202 GPU 48 x KM 252 VR 708 x PR 202	GPU 48 x KM 252 VR 708 x PR 202 GPU 48 x PR 202	RAU 8 x K 7 OEB 259 x PR 202
Thousand grain weight (g)	GPU 28 x KM 252 GPU 48 x KM 252 OEB 259 x PR 202	GPU 28x KM 252 GPU 48 x KM 252 OEB 259 x PR 202	GPU28x KM 252 VR 708 x PR 202 OEB 259 x KM 252	GPU 28 x KM 252 OEB 259 x PR 202 VR 708 x PR 202	GPU 28 x KM 252 GPU 48 x KM 252 OEB 259 x PR 202
Seed protein content (%)	CO(Ra)14 x K 7 CO(Ra)14 x PR 202 CO(Ra)14 x KM 252	OEB 259 x K 7 CO(Ra)14 x K 7	CO(Ra)14 x K 7 CO(Ra)14 x PR 202 CO(Ra)14 x KM 252	CO(Ra)14 x K 7 CO(Ra)14 x PR 202 CO(Ra)14 x KM 252	CO(Ra)14 x K 7 CO(Ra)14 x PR 202 CO(Ra)14 x KM 252
ron content mg/100g)	GPU 28 x PR 202 VR708 x KM 252 RAU 8 x PR 202	RAU 8 x PR 202 GPU 28 x PR 202 VR 708 x KM 252	VR 708 x KM 252 VR 708 x K 7 OEB 259 x KM 252	VR 708 x KM 252 VR 708 x K 7 OEB 259 x KM 252	GPU 28 x PR 202 VR 708 x KM 252 RAU 8 x PR 202
Zinc content mg/100g)	OEB 259 x KM 252 VR 708 x PR 202 RAU 8 x KM 252	GPU 28 x K 7 VR 708 x PR 202 GPU 48 x PR 202	OEB 259 x KM 252 GPU 28 x K 7 OEB 259 x PR 202	GPU 28 x K 7 OEB 259 x KM 252 OEB 259 x K 7	OEB 259 x KM 252 VR 708 x PR 202 RAU 8x KM252
Harvest index (%)	CO(Ra)14 x PR 202 PES 110 x K 7 GPU 28 x K 7 VR 708 x K 7	RAU 8 x KM 252 CO(Ra)14 x PR 202	VR 708 x KM 252 RAU 8 x KM 252 VR 708 x K 7	VR 708 x KM 252 RAU 8x KM 252 VR 708 x K 7	---
Single plant dry odder yield (g)	GPU 28 x K 7 VR 708 x PR 202 CO(Ra)14 x PR 202	RAU 8x KM 252 GPU 28 x K 7 CO(Ra)14 x PR 202	GPU 28 x K 7 VR 708 x K 7 VR 708 x PR 202	GPU 28 x K 7 VR 708 x K 7 VR 708 x PR 202	GPU 28 x K 7 VR 708 x PR 202 CO(Ra)14 x PR 202
Single plant grain yield (g)	GPU 28 x K 7 CO(Ra)14 x PR 202 VR 708 x K 7	RAU 8 x KM 252 CO(Ra)14 x PR 202	GPU 28 x K 7 VR 708 x K 7 VR 708 x PR 202	GPU 28 x K 7 VR 708 x K 7 RAU 8x KM252	GPU 28 x K 7 CO(Ra)14 x PR 202

The early maturing varieties are desirable in finger millet under rainfed condition. The cross, VR 708 x K 7 was the most promising combination for early duration since it showed highly significant negative heterosis of all the three types of heterosis (Table 2). Dwarf varieties are highly favourable as they confer resistance to lodging and also preferred for mechanization. Hence, negative heterosis for plant height is utilized in finger millet. The hybrid, OEB 259 x PR 202 and RAU 8 x PR 202 showed highly significant negative heterosis for all the three types of heterosis for plant height. The hybrid, OEB 259 x KM 252 showed highly significant negative relative heterosis and standard heterosis for plant height.

For number of productive tillers per plant, the hybrids VR 708 x K 7 and GPU 28 x K 7 showed highly significant positive heterosis of all the three types of heterosis. The hybrid, CO (Ra) 14 x PR 202 recorded highly significant standard heterosis for productive tillers per plant. Regarding number of fingers per ear head, none of the hybrids showed significant heterosis for any of the three types of heterosis by which it is inferred that heterosis could not be exploited for improving the finger number per ear head. Similar results were reported by Priyadharshini *et al.* (2010). Alternatively, number of productive tillers per plant and test weight of the grains had to be chosen for productivity enhancement (Parashuram *et al.* 2011).

In case of thousand grain weight, the hybrid, GPU 28 x KM 252 showed highly significant positive heterosis for all the three types of heterosis (Table 3). The hybrid, OEB 259 x PR 202 recorded highly significant positive heterobeltiosis and standard heterosis. For grain protein content, three hybrids *viz.,* CO(Ra)14 x PR 202, CO(Ra)14 x KM 252 and CO(Ra)14 x KM 252 were found to be significant for all the three types of heterosis. These results confirmed the findings of Priyadershini *et al*. (2010) and Ganapathy *et al.* (2011). In case of iron content, the hybrid, VR 708 x KM 252 recorded significant positive heterosis for all the three types of heterosis.

For harvest index, none of the hybrids showed significant heterosis for any of the three types. For single plant dry fodder yield, two hybrids *viz.,* GPU 28 x K 7 and VR 708 x PR 202 were found to be significant for all the three types of heterosis. In case of single plant grain yield, GPU 28 x K 7 recorded significant positive heterosis in all three types of heterosis. Similar observation has been reported by Sumathi *et al.* (2005).

Selection of hybrids combining superior *per se* performance, *sca* effect and heterosis is desirable for breeding programmes to get satisfactory results (Sumathi *et al.,* 2007). In the present investigation, CO(Ra)14 x PR 202 was identified as the superior hybrid as it recorded high magnitude of standard heterosis for single plant grain yield, number of productive tillers per plant, seed protein content and single plant dry fodder yield with high *sca* effect and *per se* performance for many of the traits studied. The hybrid, GPU 28 x K 7 also recorded high standard heterosis, *sca* effect and high *per se* for number of productive tillers per plant, fodder yield and single plant grain yield. This was in agreement with the findings of Priyadharshini *et al.* (2010). Similar results of *per se* performance, *sca* effect and standard heterosis were used to identify as the best hybrids for grain yield by Shailaja *et al*. (2010). Gupta and Kumar *et al.* (2009) reported higher heterosis for grain yield for finger millet. Increasing the yield potential is an ultimate objective for plant breeders. In the present study, two hybrids *viz*., CO (Ra) 14 x PR 202 and GPU 28 x K 7 showed favorable heterosis of all the three types for grain yield and hence may be utilized in future finger millet yield improvement.

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