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Research Article

Elucidating combining ability, gene action and heterosis for yield and yield contributing traits in finger millet (*Eleusine coracana* L. Gaertn)

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Abstract
In order to explore the genetic architecture of finger millet through combining ability studies, the present investigation was carried out using 20 hybrids which were produced using five lines and four testers in a Line x Tester mating design. Among the parents, the line GPU 48 and the tester KMR 301 were found to be the good general combiners with significant *per se* for most of the traits studied. Hybrids *viz.,* GPU 48 x KMR 301, GPU 48 x PR 1506, PYR1 x KMR 301 and Udurumallige x PR 1506 showed significant positive values for *per se* performance, *sca* effect, mid parent heterosis and better parent heterosis for grain yield per plant. The cross GPU 48 x KMR 301 derived from high x high general combining parents exhibited higher positive significant value for all the three types of heterosis for grain yield per plant. The hybrids GPU 48 x KMR 301, GPU 48 x PR 1506, PYR1 x KMR 301 and Udurumallige x PR 1506 were good specific combiners for yield and yield contributing traits. In all these crosses, at least one good general combining parent is involved which indicates that good general combiners serve as the best tool in enlightening the crop yield by manipulating the genetic architecture. Combining ability variances indicated that even if GCA and SCA variances were profound, SCA variances were higher than GCA variances for all the characters studied representing the predominance of non-additive type of gene action in the inheritance of traits under present study.

Key words: Finger millet, Combining ability. *per se*, GCA, SCA and Heterosis

INTRODUCTION

Finger millet is the third important crop commonly known as "Ragi" or "Madua" and has greater potential to meet out the needs of dry land farmers. It is cultivated as rainfed crop in arid and semi-arid regions. It is mainly grown for its food grains, dry fodder and flexibility to adapt to wide range of geographical areas. Finger millet is nutritionally rich with almost all the nutrients like protein (9.2 %), carbohydrates (76.32 %) and fat (1.29%). Finger millet grain is rich in calcium, iron, methionine, and tryptophan forming a vital contribution in human diet in developing tropical countries where calcium deficiency and anaemia are prevalent (Babu *et al.,* 2013). Moreover, it is having the property of drought tolerance and its grain can be stored for many years without significant damage by storage pests. The information on combining ability and gene action on various traits of finger millet is very sparse. Information on general combining and specific combining abilities is more important to identify the right parents. Upon crossing right parents, the chance for obtaining the desirable segregants is higher. It also facilitates to elucidate the magnitude and nature of gene action which will help to frame breeding strategy to be followed in future segregating generations. Hence, the present research has been attempted to gain information on combining ability, heterosis and gene action.

MATERIALS AND METHODS

In the present investigation, five lines were crossed with four testers in a Line x Tester mating design to generate 20 hybrids. The hybrids along with parents and a standard check (GPU 67) were raised in a Randomized Block Design with two replications at Regional Research Station, Paiyur during *Kharif,* 2021. For emasculation, hot water method was followed and crossing was done through approach method. Each entry was grown in a single row with a spacing of 30 cm between rows and 10 cm between plants in a row with plot size of 4 m x 3 m. The following quantitative traits like days to 50 percent flowering, days to maturity, plant height, number of fingers per ear, finger length, ear head length, peduncle length, number of productive tillers per plant and grain yield per plant were recorded in five randomly selected plants. Proper crop management practices were followed in order to raise good crop. The Line x Tester analysis was carried out according to Kempthorne (1957). The magnitude of heterosis was estimated over mid parent, better parent and standard check. Heterosis and combining ability were estimated using the software TNAUSTAT.

RESULTS AND DISCUSSION

Analysis of variance exhibited significant difference for all the traits studied indicating the availability of the variability (**Table1**). With regard to the variances, significant values were observed for general and specific combining abilities for all the traits. The value of SCA: GCA variance was found to be greater than one which represents the predominance of non-additive gene action indicating that selection in early segregating generation will be favourable for exploiting non- additive gene action. In general, the GCA variance is associated with additive gene action, whereas SCA variance is related to dominant and epistatic gene action. The involvement of lines, testers and interactions to total variances are represented in **Table 2**. Among the nine traits studied four of them namely number of productive tillers per plant (52.49%), peduncle length (60.60%), ear head length (63.01%) and grain yield per plant (45.54%) were considered to contributing the highest by line x tester interaction. This indicated that the concerned characters were influenced by non-additive gene action.

Influence of line was higher than that of interactions of line x tester for days to 50% flowering (81.68%), plant height (62.67%), finger length (62.73%) and number of fingers per (68.14%) demonstrating higher estimates of GCA variances for lines and further showed that lines donated more positive alleles for those characters having prevalence of additive gene action.

Table 1. Analysis of variance for combining ability for nine yield and yield contributing traits in finger millet

Source of variation	Df	Days to 50 percent flowering	Plant height	Number of productive tillers/ plant	Peduncle length	Finger length	Finger width	Earhead length	Number of fingers/ ear	Seed yield /plant
Replication	1	6.90	10.23	0.04	0.23	0.10	0.02	0.20	0.00	1.37
Genotypes	28	285.12**	248.82**	4.73**	56.34**	9.40**	0.04	16.62**	5.32**	488.99**
Parents	8	522.43**	158.84**	6.13**	34.22**	10.19**	0.01	29.86**	3.13*	290.25**
Lines	4	974.90**	197.22**	5.10**	37.64**	3.33*	0.00	11.66**	3.85*	537.59**
Testers	3	87.79**	153.64**	0.46	34.66**	22.75**	0.01	61.81**	3.17*	22.11**
Lines vs Testers	1	16.47**	20.92**	27.23**	19.24**	0.00	0.00	6.83*	0.10	105.26**
Crosses	19	198.49**	276.41**	3.87**	66.94**	9.22**	0.05	11.88**	6.52**	598.39**
Crosses vs Parents	1	32.56**	444.59**	9.94**	31.71**	6.57*	0.15	0.65	0.04	0.42
Error	28	0.93	41.46	1.10	9.97	0.39	0.01	0.97	0.62	27.49
GCA variance		6.72	6.71	0.03	0.12	0.20	0.0	0.26	0.15	7.31
SCA variance		22.16	35.00	1.28	28.05	2.13	0.02	2.50	1.32	202.41

*, ** Significant at P=0.05 and P=0.01 levels, respectively

Table 2. Proportional contribution of lines, testers and their interactions to total variance (%) for various traits in finger millet

Source	Days to 50% flowering	Plant height	Number of productive tillers/plant	Peduncle length	Finger length	Finger width	Ear head length	Number of fingers/ear	Seed yield / plant
Due to Line	81.68	62.67	42.86	28.14	62.73	27.14	63.01	68.14	36.77
Due to Tester	4.03	9.18	4.64	11.26	4.74	13.14	5.50	1.06	17.69
Due to Line x Tester	14.29	28.15	52.49	60.60	32.53	59.72	31.49	30.80	45.54

The *per se* performance of the nine parents and twenty hybrids is presented in the **Tables 3 and 4.** The primary criterion for selection of parents is based on the mean value and the second most important criterion is *gca* effects of parents. It may not be sure that the parents with greater mean values may have the capacity to transfer their superior traits to their progenies. Hence, parents with good reservoir of superior genes can be selected by choosing the parents having better combination of *per se* performance and *gca* effects (Shailaja *et al.,* 2010). *gca* effects for nine different yield and yield contributing traits are given in **Table 5**. The high *gca* effects depicts their additive gene effects. Munhot *et al*. (2000) compared *per se* and *gca* effects and their study indicated that parents with high *per se* performance also had high *gca* effects and they concluded that *per se* is an indicator for *gca* effects. Based on the above reports, the lines ML 365, GPU 48 and PYR 1 and the tester KMR 301 exhibited greater mean value for most of the traits. ML 365 showed high *per se* and *gca* effects for five traits namely days to 50 percent flowering, plant height, number of productive tillers per plant, finger length and ear head length.

The line PYR1 showed significant *per se* and *gca* effects for days to 50 per cent flowering, finger length and ear head length. Significant *per se* and *gca* effects were found for days to 50 percent flowering, peduncle length and grain yield per plant with GPU 48 and for number of productive tillers plant, peduncle length and seed yield with GPU 67. The tester KMR 301 recorded higher significant *per se* and *gca* effects for days to 50 per cent flowering, peduncle length, finger length, ear head length and seed yield per plant. Hence, these parents can be better utilized in future hybridization programme for identification of superior genotypes. Hybridization helps in combining favourable genes from different parents into a single genotype. Tamilcovane and Jayaraman, (1994) and Ravikumar (1986) also reported good general combiners in finger millet.

The estimates for specific combining ability are given in **Table 6**. It is observed that none of the cross combinations have constant significant *sca* effects for all the characters studied. Out of 20 crosses, 12 hybrids exhibited significant and positive *sca* effects for seed yield per plant. The cross combinations namely Udurumallige x PR 1506 (22.71**), PYR1 x KMR 301, GPU 48 x KMR 301 (12.76**), GPU 48 x PR 1506 (11.4*), ML 365 x GPU 28 (10.97**), PYR1 x GE4449 (10.84**) were found better for grain yield per plant. The cross GPU 48 x PR 1506 exhibited positive significant *sca* effects for seven traits namely days to 50 per cent flowering, number of productive tillers per plant, finger length, finger width, ear head length, number of fingers per ear and seed yield per plant. The cross PYR 1x KMR 301 exhibited positive significant *sca* effects for four traits *viz.,* days to 50 percent flowering, peduncle length, finger length and seed yield per plant followed by the cross GPU 48 x KMR 301 which showed significant positive *sca* effect for days to 50 percent flowering, finger length and seed yield per plant. Positive significant *sca*

Table 3. *Per se* performance of nine parents for nine traits in finger millet

Parents	Days to 50 percent flowering	Plant height (cm)	Number of productive tillers/plant	Peduncle length (cm)	Finger length (cm)	Finger width (cm)	Earhead length (cm)	Number of fingers/ ear	Seed yield / plant (g)
Lines									
ML 365	100.50**	99.80*	7.00*	26.40	8.85	1.05	12.80**	9.00**	36.47
PYR1	108.50**	96.95	4.00	29.05	9.95*	1.05	11.60**	6.50	24.96
GPU 48	115.00**	75.58	6.50	34.04**	8.17	1.05	7.55	7.50	41.60*
GPU 67	98.50**	91.60	8.00**	34.80**	7.10	0.95	7.45	6.00	60.19**
UDURUMALLIGE	58.50	83.60	5.00	25.30	6.80	1.00	10.65	9.00	17.65
Mean (lines)	96.20	89.51	6.10	29.92	8.17	1.02	10.01	7.60	36.17
CD (0.05)	0.81	7.62	0.85	2.98	0.73	0.12	1.01	0.76	5.39
S. E. (gi) (±) (Lines)	0.39	3.65	0.41	1.43	0.35	0.06	0.48	0.36	2.58
Testers									
KMR 301	103.50**	95.50*	3.50	33.95**	13.15**	1.10	18.95**	9.00**	36.19*
GE4449	89.00	89.40	3.00	26.30	6.10	0.95	7.25	6.00	30.61
GPU 28	97.50	89.55	4.00	26.50	7.30	1.05	11.70	8.00	29.44
PR 1506	102.50**	74.90	4.00	24.60	6.10	1.00	7.10	8.00	29.00
Mean (Testers)	98.13	87.34	3.63	27.84	8.16	1.03	11.25	7.75	31.31
CD (0.05)	0.73	6.81	0.76	2.66	0.65	0.11	0.90	0.68	4.82
S. E. (gi) (±) (Testers)	0.35	3.26	0.36	1.27	0.31	0.05	0.43	0.32	2.31

*, ** Significant at P=0.05 and P=0.01 levels, respectively

Table 4. ***Per se*** **performance of twenty hybrids for nine traits in finger millet**

S.No.	Crosses	Days to 50 percent flowering	Plant height (cm)	Number of productive tillers/plant	Peduncle length (cm)	Finger length (cm)	Finger width (cm)	Earhead length (cm)	Number of fingers/ ear	Seed yield / plant (g)
1	ML365 x KMR 301	104.00**	103.72	3.33	33.20	9.30	1.20	10.85	7.00	40.69
2	ML365 x GE4449	97.50	92.68	3.00	29.15	9.05	1.10	11.15	8.00	30.53
3	ML365 x GPU28	103.50**	105.58	3.67	35.83	10.13	1.20	12.35	7.75	41.46
4	ML 365 x PR 1506	101.00**	97.85	3.00	32.45	10.85*	1.10	13.72**	8.00	37.25
5	PYR1 x KMR 301	100.50*	105.40	5.17	37.48*	10.68*	1.18	12.43	8.75	61.24**
6	PYR1 x GE4449	101.50**	100.95	4.33	44.55**	10.25	1.25	12.65	8.50	42.28
7	PYR1 x GPU28	107.00**	95.91	4.80	28.63	11.13*	0.95	12.43	7.25	27.72
8	PYR1 x PR 1506	104.00**	83.30	3.00	27.35	8.70	1.15	11.20	8.00	21.44
9	GPU 48 x KMR 301	112.00**	104.08	5.33	33.20	12.30**	1.35	12.50	9.00	71.77**
10	GPU 48 x GE4449	99.00	97.08	5.00	33.25	8.15	1.05	11.10	8.50	27.90
11	GPU 48 x GPU28	107.00**	119.60**	4.50	30.05	9.10	1.05	10.00	9.50*	33.47
12	GPU 48 x PR 1506	112.00**	109.65	7.50**	28.90	12.65**	1.60	14.73**	12.00**	65.40**
13	GPU 67 x KMR 301	92.50	84.11	3.33	31.45	7.90	1.15	13.30*	8.00	30.05
14	GPU 67 x GE4449	97.50	83.23	3.33	20.40	7.50	1.00	9.60	7.50	25.78
15	GPU 67 x GPU28	103.50**	92.08	3.33	27.00	9.20	1.15	10.85	8.50	16.70
16	GPU 67 x PR 1506	103.00**	79.40	2.50	34.00	5.95	1.05	7.95	5.00	18.75
17	UDURUMALLIGE x KMR 301	77.00	88.00	2.50	27.90	7.50	0.95	8.09	5.00	14.08
18	UDURUMALLIGE x GE4449	87.00	74.25	4.50	32.70	6.45	0.90	7.30	5.50	10.81
19	UDRUMALLIGE x GPU28	77.00	79.10	3.00	17.70	4.15	1.15	5.00	4.00	16.66
20	UDRUMALLIGE x PR 1506	87.00	94.60	7.00**	26.65	7.00	1.10	8.60	6.50	49.95**
	Mean (Crosses)	98.68	94.53	4.11	30.59	8.90	1.13	10.79	7.61	34.19
	CD (0.05)	1.62	15.25	1.70	5.96	1.46	0.25	2.01	1.52	10.79
	S. E. (gi) (±)	0.78	7.30	0.81	2.85	0.70	0.12	0.96	0.73	5.16

*, ** Significant at P=0.05 and P=0.01 levels, respectively

Table 5. Estimates of general combining ability effects (*gca)* of parents for nine traits in finger millet

Parents	Days to 50 percent flowering	Plant height	Number of productive tillers/plant	Peduncle length	Finger length	Finger width	Earhead length	Number of fingers/ ear	Seed yield / plant
Lines									
ML 365	2.83**	5.43*	-0.86**	2.06	0.93**	0.02	1.23**	0.08	3.29
PYR1	4.57**	1.86	0.22	3.91**	1.29**	0	1.39**	0.51	3.97*
GPU 48	8.82**	13.07**	1.47**	0.76	1.65**	0.13**	1.29**	2.14**	15.44**
GPU 67	0.45	-9.82**	-0.98**	-2.38*	-1.26**	-0.04	-0.36	-0.36	-11.38**
UDURUMALLIGE	16.67**	-10.54**	0.15	-4.35**	-2.62**	-0.11*	-3.54**	-2.36**	-11.32**
S. E. (gi) (±)	0.28	2.58	0.29	1.00	0.25	0.04	0.34	0.26	1.82
Testers									
KMR 301	-1.48**	2.53	-0.17	2.05*	0.64**	0.03	0.64*	-0.06	9.37**
GE4449	-2.17**	-4.89*	-0.07	1.42	-0.62*	-0.07	-0.43	-0.01	-6.74**
GPU 28	0.93**	3.92	-0.25	-2.75**	-0.16	-0.03	-0.66*	-0.21	-6.99**
PR 1506	2.72**	-1.57	0.5	-0.72	0.13	0.07	0.45	0.29	4.36*
S. E. (gi) (±)	0.25	2.30	0.26	0.90	0.22	0.04	0.30	0.23	1.63

*, ** Significant at P=0.05 and P=0.01 levels, respectively

Table 6. Specific combining ability effects of hybrids for nine traits in finger millet

S.No.	Crosses	Days to 50 percent flowering	Plant height	Number of productive tillers/plant	Peduncle length	Finger length	Finger width	Earhead length	Number of fingers/ ear	Seed yield / plant
1	ML365 x KMR 301	3.97**	1.23	0.26	-1.51	-1.17*	0.02	-1.81*	-0.63	-6.16
2	ML365 x GE4449	-1.83**	-2.38	-0.17	-4.92*	-0.17	0.02	-0.44	0.33	-0.22
3	ML365 x GPU28	1.07	1.7	0.66	5.92**	0.45	0.08	1	0.27	10.97**
4	ML 365 x PR 1506	-3.22**	-0.54	-0.74	0.52	0.88	-0.12	1.25	0.02	-4.59
5	PYR1 x KMR 301	-1.27*	6.48	1.02	0.92	-0.15	0.01	-0.39	0.69	13.7**
6	PYR1 x GE4449	0.43	9.45	0.08	8.63**	0.68	0.19*	0.9	0.38	10.84**
7	PYR1 x GPU28	2.83**	-4.41	0.72	-3.12	1.09*	-0.15	0.91	-0.66	-3.45
8	PYR1 x PR 1506	-1.97**	-11.52*	-1.82**	-6.43**	-1.62**	-0.05	-1.42*	-0.41	-21.09**
9	GPU 48 x KMR 301	5.98**	-6.05	-0.08	-0.2	1.11*	0.05	-0.23	-0.69	12.76**
10	GPU 48 x GE4449	-6.32**	-5.63	-0.51	0.48	-1.78**	-0.14	-0.55	-1.24*	-15**
11	GPU 48 x GPU28	-1.42*	8.07	-0.84	1.45	-1.29*	-0.18*	-1.42	-0.04	-9.17*
12	GPU 48 x PR 1506	1.78**	3.62	1.43*	-1.73	1.97**	0.27**	2.2**	1.96**	11.4**
13	GPU 67 x KMR 301	-5.15**	-3.13	0.38	1.18	-0.38	0.03	2.23**	0.81	-2.14
14	GPU 67 x GE4449	0.55	3.42	0.28	-9.23**	0.48	-0.02	-0.4	0.26	9.7*
15	GPU 67 x GPU28	3.45**	3.45	0.45	1.54	1.72**	0.09	1.09	1.46*	0.87
16	GPU 67 x PR 1506	1.15*	-3.74	-1.12	6.51**	-1.82**	-0.11	-2.92**	-2.54**	-8.43*
17	UDURUMALLIGE x KMR 301	-3.53**	1.48	-1.58*	-0.39	0.59	-0.11	0.2	-0.19	-18.16**
18	UDURUMALLIGE x GE4449	7.17**	-4.85	0.32	5.04*	0.79	-0.05	0.48	0.26	-5.33
19	UDRUMALLIGE x GPU28	-5.93**	-8.81	-1	-5.79**	-1.97**	0.16	-1.58*	-1.04	0.78
20	UDRUMALLIGE x PR 1506	2.27**	12.18*	2.25**	1.13	0.59	0.01	0.9	0.96	22.71**
	S. E. (gi) (±)	0.55	5.16	0.58	2.02	0.50	0.08	0.68	0.51	3.65

*, ** Significant at P=0.05 and P=0.01 levels, respectively

effect was observed in the cross Udurumallige x PR 1506 for number of productive tillers per plant and seed yield per plant. The hybrids *viz.,* PYR1 x KMR 301, GPU 48 x PR 1506 were developed from low x high, combiner parents for seed yield. It indicated the presence of both additive and non-additive types of gene action. Several crosses were with high x high general combiners which were utilized for development of good specific cross combinations for many characters in which additive type of gene action was prominent. In the present study, the cross GPU 48 x KM 301 had evolved from high x high general combining parents.

Hybrids with high *sca* effects are expected to exhibit high heterosis. The range of heterosis for nine traits expressed by twenty hybrids was estimated and represented in **Table 7**. Efficient hybrids are the one which exhibits significant positive value for all the three types of heterosis studied. For days to 50 percent flowering the crosses *viz.*, GPU67 x KMR 301, Udurumallige x KMR 301 and Udurumallige x GPU 28 recorded significant negative values for all the type of heterosis suggesting the contribution of dominant gene action with negative effects. The early reports clarified that early maturing types can be obtained from crosses with negative heterosis. The results are in line with the findings of Konstantinov and Linnik (1985) & Ramesh (1990) in proso millet and Parashuram *et al.* (2011) in finger millet. The cross Udurumallige x GE4449 recorded significant negative value for heterosis for plant height which will be beneficial to develop plants with dwarf nature. Significant positive heterosis was observed in PYR1 x GE4449 for peduncle length, ML365 x PR 1506, GPU 48 x PR 1506 and GPU 67 x GPU 28 for finger length, GPU48 x KMR 301for finger width, GPU 48 x GE4449, GPU 48 x PR 1506 and GPU 67 x GE4449 for ear head length and PYR1 x GE4449& GPU 48 x PR 1506 for number of fingers per ear. In the present study, the hybrid GPU 48 x KMR 301 exhibited higher positive significant value for all the three types of heterosis for grain yield per plant which outlined its vigorous performance while for the same cross, the values of mid parent heterosis were found significant for all the nine traits studied. Among 20 hybrids, five hybrids showed positive significant value for mid parent and better parent heterosis.

All of the yield-contributing traits were discovered to have GCA:SCA ratio less than unity, which may be beneficial for hybrid development and may be controlled by non-additive gene action. The *per se* performance, *sca* effects

Table 7. Estimates of heterosis for nine traits in finger millet (in per cent)

S.No.	Crosses	Days to 50 percent flowering			Plant height			Number of productive tillers/plant		
		MP	BP	SP	MP	BP	SP	MP	BP	SP
1	ML365 x KMR 301	1.96*	0.48	5.58**	6.21	3.92	13.23	-36.57*	-52.43**	-58.38**
2	ML365 x GE4449	2.9**	-2.99**	-1.02	-2.03	-7.13	1.18	-40*	-57.14**	-62.5**
3	ML365 x GPU28	4.55**	2.99**	5.08**	11.51	5.79	15.26*	-33.36	-47.64**	-54.19**
4	ML 365 x PR 1506	-0.49	-1.46	2.54*	12.02	-1.95	6.82	-45.45*	-57.14**	-62.5**
5	PYR1 x KMR 301	-5.19**	-7.37**	2.03*	9.53	8.72	15.07*	37.73	29.12	-35.44*
6	PYR1 x GE4449	2.78**	-6.45**	3.05**	8.34	4.12	10.2	23.71	8.25	-45.87**
7	PYR1 x GPU28	3.88**	-1.38	8.63**	2.85	-1.08	4.7	20	20	-40**
8	PYR1 x PR 1506	-1.42	-4.15**	5.58**	-3.05	-14.08*	-9.06	-25	-25	-62.5**
9	GPU 48 x KMR 301	2.52**	-2.61**	13.71**	21.67**	8.98	13.62	6.6	-18	-33.38*
10	GPU 48 x GE4449	-2.94**	-13.91**	0.51	17.68*	8.59	5.98	5.16	-23.15	-37.56**
11	GPU 48 x GPU28	0.71	-6.96**	8.63**	44.85**	33.55**	30.56**	-14.38	-30.85	-43.81**
12	GPU 48 x PR 1506	2.99**	-2.61**	13.71**	45.73**	45.07**	19.71**	42.86*	15.38	-6.25
13	GPU 67 x KMR 301	-8.42**	-10.63**	-6.09**	-10.09	-11.93	-8.18	-42.09*	-58.37**	-58.37**
14	GPU 67 x GE4449	4**	-1.02	-1.02	-8.03	-9.14	-9.14	-39.45*	-58.38**	-58.38**
15	GPU 67 x GPU28	5.61**	5.08**	5.08**	1.66	0.52	0.52	-44.5**	-58.38**	-58.38**
16	GPU 67 x PR 1506	2.49**	0.49	4.57**	-4.62	-13.32	-13.32	-58.33**	-68.75**	-68.75**
17	UDURUMALLIGE x KMR 301	-4.94**	-25.6**	-21.83**	-1.73	-7.85	-3.93	-41.18	-50*	-68.75**
18	UDURUMALLIGE x GE4449	17.97**	-2.25*	-11.68**	-14.16*	-16.95*	-18.94*	12.5	-10	-43.75**
19	UDRUMALLIGE x GPU28	-1.28	-21.03**	-21.83**	-8.63	-11.67	-13.65	-33.33	-40	-62.5**
20	UDRUMALLIGE x PR 1506	8.07**	-15.12**	-11.68**	19.37*	13.16	3.28	55.56*	40	-12.5
	S. E. (gi) (±)	0.84	0.97		5.58	6.44		0.91	1.05	

Table 7 continued

S.No.	Crosses	Peduncle length			Finger length			Finger width		
		MP	BP	SP	MP	BP	SP	MP	BP	SP
1	ML365 x KMR 301	10.02	-2.21	-4.6	-15.45**	-29.28**	30.99**	11.63	9.09	26.32*
2	ML365 x GE4449	10.63	10.42	-16.24	21.07**	2.26	27.46**	10	4.76	15.79
3	ML365 x GPU28	35.44**	35.19**	2.95	25.39**	14.41	42.61**	14.29	14.29	26.32*
4	ML 365 x PR 1506	27.25*	22.92	-6.75	45.15**	22.6**	52.82**	7.32	4.76	15.79
5	PYR1 x KMR 301	18.98*	10.4	7.7	-7.58	-18.82**	50.35**	9.3	6.82	23.68
6	PYR1 x GE4449	60.98**	53.36**	28.02**	27.73**	3.02	44.37**	25*	19.05	31.58*
7	PYR1 x GPU28	3.06	-1.46	-17.74	28.99**	11.81	56.69**	-9.52	-9.52	0
8	PYR1 x PR 1506	1.96	-5.85	-21.41*	8.41	-12.56	22.54*	12.2	9.52	21.05
9	GPU 48 x KMR 301	-2.34	-2.47	-4.6	15.38**	-6.46	73.24**	25.58**	22.73*	42.11**
10	GPU 48 x GE4449	10.21	-2.32	-4.45	14.23	-0.24	14.79	5	0	10.53
11	GPU 48 x GPU28	-0.73	-11.72	-13.65	17.65*	11.38	28.17**	0	0	10.53
12	GPU 48 x PR 1506	-1.43	-15.1	-16.95	77.3**	54.83**	78.17**	56.1**	52.38**	68.42**
13	GPU 67 x KMR 301	-8.51	-9.63	-9.63	-21.98**	-39.92**	11.27	12.2	4.55	21.05
14	GPU 67 x GE4449	-33.22**	-41.38**	-41.38**	13.64	5.63	5.63	5.26	5.26	5.26
15	GPU 67 x GPU28	-11.91	-22.41*	-22.41*	27.78**	26.03**	29.58**	15	9.52	21.05
16	GPU 67 x PR 1506	14.48	-2.3	-2.3	-9.85	-16.2	-16.2	7.69	5	10.53
17	UDURUMALLIGE x KMR 301	-5.82	-17.82	-19.83*	-24.81**	-42.97**	5.63	-9.52	-13.64	0
18	UDURUMALLIGE x GE4449	26.74*	24.33	-6.03	0	-5.15	-9.15	-7.69	-10	-5.26
19	UDRUMALLIGE xGPU28	-31.66**	-33.21**	-49.14**	-41.13**	-43.15**	-41.55**	12.2	9.52	21.05
20	UDRUMALLIGE x PR 1506	6.81	5.34	-23.42*	8.53	2.94	-1.41	10	10	15.79
	S. E. (gi) (±)	2.74	3.16		0.54	0.63		0.10	0.11	

Table 7. continued

S.No.	Crosses	Earhead length			Number of fingers/ear			Seed yield /plant		
		MP	BP	SP	MP	BP	SP	MP	BP	SP
1	ML365 x KMR 301	-31.65**	-42.74**	45.64**	-22.22**	-22.22*	16.67	12	11.57	-32.4**
2	ML365 x GE4449	11.22	-12.89	49.66**	6.67	-11.11	33.33*	-8.97	-16.29	-49.28**
3	ML365 x GPU28	0.82	-3.52	65.77**	-8.82	-13.89	29.17*	25.79	13.67	-31.13**
4	ML 365 x PR 1506	37.84**	7.15	84.09**	-5.88	-11.11	33.33*	13.8	2.14	-38.11**
5	PYR1 x KMR 301	-18.66**	-34.43**	66.78**	12.9	-2.78	45.83**	100.28**	69.2**	1.74
6	PYR1 x GE4449	34.22**	9.05	69.8**	35.92**	30.69*	41.58**	52.16**	38.13*	-29.76**
7	PYR1 x GPU28	6.65	6.2	66.78**	0	-9.38	20.83	1.91	-5.84	-53.95**
8	PYR1 x PR 1506	19.79*	-3.45	50.34**	10.34	0	33.33*	-20.54	-26.07	-64.39**
9	GPU 48 x KMR 301	-5.66	-34.04**	67.79**	9.09	0	50**	84.51**	72.51**	19.23*
10	GPU 48 x GE4449	50**	47.02**	48.99**	25.93*	13.33	41.67**	-22.72	-32.93*	-53.65**
11	GPU 48 x GPU28	3.9	-14.53	34.23*	22.58*	18.75	58.33**	-5.77	-19.54	-44.39**
12	GPU 48 x PR 1506	101.09**	95.1**	97.72**	54.84**	50**	100**	85.28**	57.21**	8.66
13	GPU 67 x KMR 301	0.76	-29.82**	78.52**	6.67	-11.11	33.33*	-37.64**	-50.07**	-50.07**
14	GPU 67 x GE4449	30.61*	28.86*	28.86*	25*	25	25	-43.21**	-57.17**	-57.17**
15	GPU 67 x GPU28	13.32	-7.26	45.64**	21.43*	6.25	41.67**	-62.75**	-72.26**	-72.26**
16	GPU 67 x PR 1506	9.28	6.71	6.71	-28.57**	-37.5**	-16.67	-57.95**	-68.85**	-68.85**
17	UDURUMALLIGE x KMR 301	-45.34**	-57.31**	8.59	-44.44**	-44.44**	-16.67	-47.72**	-61.11**	-76.62**
18	UDURUMALLIGE x GE4449	-18.44	-31.46**	-2.01	-26.67**	-38.89**	-8.33	-55.22**	-64.7**	-82.05**
19	UDRUMALLIGE x GPU28	-55.26**	-57.26**	-32.89*	-52.94**	-55.56**	-33.33*	-29.26	-43.43*	-72.33**
20	UDRUMALLIGE x PR 1506	-3.1	-19.25*	15.44	-23.53**	-27.78**	8.33	114.15**	72.25**	-17.02
	S. E. (gi) (±)	0.85	0.99		0.68	0.79		4.54	5.24	

*, ** Significant at P=0.05 and P=0.01 levels, respectively

and degree of hybrid heterosis are major elements in utilising hybrid vigour. Selection purely based on one of these factors could not be successful. Therefore, all three criteria must be used in the selecting process. From this study, it can be concluded that the non-additive gene action favouring hybridization to some extent and the hybrids, GPU 48 x KMR 301, GPU 48 x PR 1506, PYR1 x KMR 301and Udurumallige x PR 1506 were found to be the best crosses for grain yield and most of the yield contributing characters.

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