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Estimation of gene action, combining ability and heterosis for yield and yield contributing traits in sorghum [*Sorghum bicolor* (L) Moench]

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Abstract
Combining ability effects, heterosis and gene action of selected sorghum lines for yield and yield contributing traits were assessed. Twenty hybrids were synthesized involving five lines and four testers through L x T mating design. The hybrids, parents and check variety CO 30, were evaluated in a randomized complete block design with three replications and seventeen traits were recorded. The analysis of variance for combining ability revealed that the mean sum of squares due to general combining ability was significant for all the traits. The ratio of $\sigma^2_{gca}/\ \sigma^2_{sca}$ revealed that non-additive gene action predominated in all the traits. On the basis of *gca* effects and *per se* performance of the parents *viz*., CO(S) 28, SPV 759 and IS 9807 exhibited significantly superior *gca* value and identified as a good general combiner for yield and yield contributing traits. The hybrids *viz.,* CO(S) 28 x IS 18551, SPV 2424 x IS 9807 and CO 30 x SPV 759 showed significant specific combining ability effects, significant and higher heterosis of all the three types and *per se* performance for studied traits. These hybrids were identified as promising hybrids and can be commercially exploited for heterosis breeding programmes.

Key words: Sorghum, *per se,* GCA, SCA and Heterosis

INTRODUCTION

Sorghum is a wonderful multi-purpose crop, which is used as food, fodder, fuel, sugar, fencing and brooms. Sorghum is the fifth most important cereal crop. In developing countries, sorghum is primarily used as a food (Bawazir, 2009) and fodder crop (Chakauya *et al*., 2006), because of its wide range of adaptability to various agro-ecological conditions. In global harvest, India share is about 8.89% (FAO, 2019 (official data alone). However, when compared to the potential yield (7–11 tons/ ha), the average yield per unit area is very low in farmer's fields (1193 kg/ha) (Reddy *et al*., 2010). Furthermore, there is a high demand for sorghum grain estimated at about 40 million tons in 2050 (ANSD, 2015), causing serious food insecurity in future, because of the increasing population and for poultry feed production. Therefore, there is a need to extend the production and productivity of sorghum.

Several studies revealed that compared to pure line varieties and landraces, hybrids have shown more productivity (Makanda *et al*., 2010). The result of first hybrid CHS1 proved a yield up to 50 to 100% higher than the farmer's local cultivar (Murty *et al*., 1995). To meet the future needs, developing hybrids is one of the rapid and best ideas to significantly increase production and productivity. In hybrid oriented breeding programmes, grain yield and yield contributing traits are come up with various complex genes with gene action (Jain and Patel, 2014). Studying gene action with combining ability give support to information regarding selecting parents and hybrid through L x T design to prevalent plant breeding plan for rapid improvement (Tariq *et al*., 2014). Which is also helps in confirming the accumulation of valuable fixable or unfixable gene effects (Nadarajan and Gunasegaram, 2005). The desirable gene combinations, organized in good combining lines determine the success of the breeding procedure. The *gca* effects measures mean performance of a genotype when crossed within a series of other genotypes, whereas *sca* effects measures performance of a cross can deviate from the average *gca* effects of two parental lines (Schlegel, 2010). On the other hand, breeding strategies on the basis of the selection of hybrids require an expected level of *sca* effects as well as heterosis. In view of the importance of the above strategy, the study envisaged assessing the gene action, general, specific combining ability and heterosis for yield, yield-related traits, for selecting superior parents and hybrids for the further breeding programme.

MATERIALS AND METHODS

In the present investigation, five diverse lines (CO(S) 28, CO 30, CSV 27, K 12 and SPV (2424) were crossed to each of the four testers (IS 88, IS 18551, IS 9807 and SPV 759) in line x T tester fashion to produce 20 experimental hybrids. The emasculation and crossing were done manually. The parental line was maintained by selfing. Twenty hybrids along with parents and check (CO 30) were evaluated in a randomized block design with three replication. Each entry was planted in 4 m row length each, spaced at 45 x 15 cm, respectively during the *kharif*, 2019 at Department of Millets, Tamil Nadu Agricultural University, Coimbatore (latitude 11.0231N, longitude 76.9286E). All the packages of practice were adopted to raise a healthy crop. At the time of physiological maturity in each replication, the biometrical observations were recorded on five randomly selected plants for the traits *viz.,* grain yield per plant (g), plant height (cm), stem diameter (mm), days to 50 per cent flowering, number of nodes/plant, number of leaves/plant, leaf length (cm), leaf breadth (cm), leaf area index, flag leaf length, flag leaf breath, flag leaf area, panicle length (cm), panicle exertion (cm), panicle weight (cm), days to maturity and hundred seed weight (g).

To test the significant differences among the crosses and parents (Snedecor and Cocharan, 1967; Panse and Sakhatme, 1961), the analysis of variance for combining ability was performed by using mean values (Kempthorne, 1957). In accordance with Singh and Chaudhary (1985) estimation of females and testers by general combining ability effects and hybrids were estimated by specific combining ability effects. As per Turner (1953) suggested procedure, the magnitude of relative heterosis, heterobeltiosis and standard heterosis was computed. The mid parent heterosis value and better parent heterosis value was tested and by the standard errors (Hays *et al.,* 1955). Data were analyzed using TNAUSTAT.

RESULTS AND DISCUSSION

The analysis of variance revealed that the genotypes taken for the study showed significant ($p < 0.01$) for all the 17 traits (**Table 1**), this confirms the existence of genetic diversity among the genotypes. The variance due to hybrids, lines and testers was highly significant for all the 17 traits except variance due to the tester for the number of leaves. However, the relative proportion additive and non-additive genetic variance for all the traits showed that the non-additive genetic variance was higher in magnitude than the additive genetic variance.

Table 1. Analysis of variance for combining ability in L x T crosses for seventeen traits in sorghum

Source	df	Plant height	Stem diameter	Days to 50% flowering	Number of nodes	Number of leaves	Leaf length	Leaf breath	Leaf area index	Flag leaf length
Genotypes	28	3266.45**	29.14**	56.44**	2.64**	1.40**	481.57**	5.36**	0.12**	212.87**
Line [Cross]	4	3207.47**	52.32**	70.74**	2.00**	1.46**	1779.82**	8.08**	0.36**	182.39**
Tester [Cross]	3	4820.06**	21.00**	76.16**	3.30**	0.38	122.53**	8.48**	0.10**	252.43**
L x T [Cross]	12	3780.39**	20.51**	10.51**	2.64**	0.84**	140.42**	1.70**	0.04**	208.47**
Crosses	19	3823.93**	27.28**	33.56**	2.61**	0.89**	482.73**	4.15**	0.12**	209.92**
Parents	8	941.73**	30.37**	117.38**	3.04**	2.65**	456.00**	8..76**	0.13**	231.24**
Line [Parents]	4	471.64**	36.99**	59.64**	1.77**	2.90**	841.10**	13.72**	0.24**	319.00**
Tester [Parents]	3	1881.72**	31.58**	189.5**	2.08**	2.00**	67.90**	5.56**	0.03**	44.56**
Cross vs Parent	1	11272.10**	54.54**	3.66	0.04	1.08	664.14**	0.01	0.04	121.89**
Error	56	49.56	0.14	2.46	0.22	0.20	3.52	0.04	0.00	1.28
GCA variance		1.27	0.20	0.67	0.00	0.00	9.99	0.07	0.00	0.04
SCA variance		1239.56	6.79	2.68	0.80	0.21	45.79	0.55	0.01	69.13

*, ** Significance at P≤ 0.05 and 0.01 %, respectively.

Table 1. Continued..

Source	df	Flag leaf breath	Flag leaf area	Panicle length	Panicle exertion	Panicle weight	Days to maturity	Hundred seed weight	Grain yield/plant
Genotypes	28	7.36**	20192.40**	54.64**	49.47**	633.76**	57.68**	0.63**	276.12**
Line [Cross]	4	22.05**	51661.97**	19.68**	59.76**	980.48**	54.19**	1.89**	451.69**
Tester [Cross]	3	11.44**	15978.30**	177.63**	31.97**	977.99**	160.51**	0.15**	317.3**
L x T [Cross]	12	1.12**	8757.42**	39.09**	23.42**	554.26**	31.88**	0.20**	228.32**
Crosses	19	7.16**	18929.90**	56.88**	32.42**	710.89**	56.88**	0.55**	289.39**
Parents	8	8.77**	25560.00**	47.82**	92.53**	478.50**	62.65**	0.90**	242.49**
Line [Parents]	4	13.60**	38218.10**	25.66**	163.05**	409.84**	38.05**	0.96**	285.07**
Tester [Parents]	3	4.89**	7389.50**	76.96**	21.20**	62.19**	63.24**	0.06**	7.56**
Cross vs Parent	1	0.04	1239.68**	66.53**	28.95**	410.49**	33.15**	0.12	293.1**
Error	56	0.04	82.93	0.34	0.04	1.92	6.59	0.002	0.45
GCA variance		0.18	296.89	0.52	0.26	4.57	0.73	0.00	1.78
SCA variance		0.31	2898.19	12.90	7.79	184.04	8.41	0.06	75.93

Which highlighted that the role of non-additive gene action was more predominant for the traits studied and this was corroboration with Umakanth *et al*. (2012), Jain and Patel *et al.* (2014), Ingle *et al*. (2018), Gaddameedi *et al*. (2020), Totre *et al.* (2021) and Maiga *et al.* (2021) in sorghum.

Mean values are the primary criteria for the selection of desirable parents (Nguyen *et al*., 1997). Among the female parent, CO 30 exhibited significantly superior for fourteen traits than the general mean followed by CO(S) 28, CSV 27 and K 12 for twelve, ten and five traits, respectively. Out of four male parents, ten traits were significantly superior for SPV 759 followed by six traits for IS 18551 and IS 9807 and five traits for IS 88. Only CO 30 and IS 9807 showed significantly superior grain yield per plant (**Table 2**). Whereas, in hybrids, seven hybrids were evinced as significantly superior for grain yield per plant when compared to the general mean. The following crosses manifested highly superior than general mean for fourteen traits (CO(S) 28 x IS 18551) and ten traits (CO 30 x IS 18551, CO 30 x SPV 59 and SPV 2424 x IS 9807) (**Table 3).** According to *per se* performance the list of above parents was found to be the best to obtain superior segregants. The above crosses were adjudged as the best hybrids in this study.

Cruz and Vencovsky (1989) stated that, the estimate of *gca* effects is an effective criterion for the selection of parents. In segregating population, the desirable recombinants were obtained through the good general combiner parents for desirable traits (Gravois and McNew, 1993). In addition, the higher *gca* effects estimate to specify the comparison of general mean which are high or low to the parental mean (Kenga *et al*., 2004). None of the parents was recorded as a good general combiner for all the traits in this study. For grain yield per plant, the parents *viz*., CO 30 (9.79), IS 9807 (5.91) IS 18551 (1.35) and K 12 (0.58) exhibited significant towards desirable direction. Among the lines, the estimate of *gca* effects revealed that CO(S) 28 exhibited significantly favorable *gca* effects for twelve important traits. CO 30 possessed highly significant desirable *gca* effects for nine traits including grain yield per plant (9.799) and CSV 27 showed significant *gca* effects for eight traits. In testers, IS 9807 and SPV 759 evinced highly significant for nine and eight traits (**Table 4**), respectively. The *per se* performance along with the nature of combining ability revealed the criteria for choice of parents for hybridization (Harer and Bapat, 1982). The parents which perform in *per se* performance and *gca* effects can be considered as good parents, can produce superior hybrids. CO 30 evinced highly significant for 14 traits for *per se* performance and nine traits for *gca* effects including grain yield per plant followed by CO(S) 28 SPV 759 and IS 9807 and hence, considered as potential parent. This was in accordance with Umakanth *et al*. (2012)**,** Vekariya *et al*. (2017) and Ingle *et al*. (2018), Totre *et al*. (2021), Maiga *et al.* (2021) and Diatta *et al.* (2021) in sorghum.

In compliance with Allard (1961), the digression performance of GCA is known as *sca* effects. Estimation of *sca* effects over twenty hybrids, eight hybrids were exhibited positive significant for grain yield per plant, in that SPV 2424 x IS 9897 (13.67), K 12 x IS 88 (13.52) and CO 30 x SPV 759 (12.47) showed highly significant for grain yield per plant. Six hybrids possessed positive significant *sca* effects for grain yield per plant. SPV 2424 x IS 9807 exposed to highly significant for fifteen traits including grain yield

Table 2. ***Per se*** **performance of parents for seventeen traits in sorghum**

Parents	Plant height (cm)	Stem diameter (mm)	Days to 50% flowering	Number of nodes	Number of leaves	Leaf length (cm)	Leaf breath (cm)	Leaf area index (cm²)	Flag leaf length (cm)	Flag leaf breath (cm)
CO 30	232.00*	14.85	62.60	7.67*	8.67*	88.87*	9.40*	0.93*	58.27*	7.80*
CO(S) 28	220.97*	21.14*	67.65	7.67*	9.67*	81.93*	8.63*	0.79*	52.47*	7.13
CSV 27	207.93	19.04*	58.00*	6.67	8.00	72.93*	9.77*	0.79*	52.97*	10.33*
K 12	200.97	12.60	64.50	7.67*	8.00	56.93	7.07	0.45	55.97*	7.07
SPV 2424	206.93	14.66	57.00*	6.00	7.00	48.93	4.53	0.25	32.47	4.37
Mean (lines)	213.76	16.46	61.95	7.13	8.27	69.92	7.88	0.64	50.43	7.34
S. E. (gi) (±) (lines)	3.21	0.15	0.64	0.20	0.18	0.71	0.09	0.01	0.42	0.08
CD of lines (0.05)	6.44	0.31	1.29	0.40	0.36	1.43	0.18	0.02	0.85	0.16
IS 88	233.97*	14.26	55.00	8.00	8.67	70.97*	7.77	0.61	37.97	7.67*
IS 9807	223.93*	12.83	59.00*	8.00	8.00	60.43	7.43	0.50	45.13*	6.37
IS18551	217.93	19.70*	67.50*	8.00	9.67*	69.47*	7.17	0.55	40.17	5.43
SPV 759	176.97	18.25*	48.50	9.67*	9.67*	64.97	10.13*	0.73*	45.93*	8.27*
Mean (Testers)	213.20	16.25	57.50	8.15	9.00	66.46	8.13	0.60	42.30	6.93
S. E. (gi) (±) (Testers)	2.87	0.14	0.57	0.18	0.16	0.64	0.08	0.01	0.38	0.07
CD of Testers (0.05)	5.76	0.28	1.16	0.35	0.32	1.28	0.16	0.02	0.76	0.14
Grand Mean	213.51	16.37	59.97	7.70	8.59	68.38	7.99	0.62	46.81	7.16

*, ** Significance at P≤ 0.05 and 0.01 %, respectively.

Table 2. Continued

Parents	Flag leaf area (cm²)	Panicle length (cm)	Panicle exertion (cm)	Panicle weight (g)	Days to maturity	Hundred seed weight (g)	Grain yield/plant (g)
CO 30	340.88*	25.73	6.87*	72.50*	100.50*	2.85*	44.60*
CO(S) 28	280.70	28.37*	8.28*	58.40*	109.50	2.84*	26.89
CSV 27	410.60*	27.97*	5.55*	42.30	102.50	1.48	20.35
K 12	296.64*	23.83	5.55*	51.68	101.50	2.59*	27.76
SPV 2424	106.32	21.37	22.85	47.40	102.50	2.37	21.30
Mean (lines)	287.03	25.45	9.82	54.46	103.30	2.42	28.18
S. E. (gi) (±) (lines)	3.24	0.26	0.09	0.60	1.05	0.02	0.30
CD of lines (0.05)	6.50	0.52	0.18	1.20	2.11	0.04	0.60
IS 88	218.29	21.93	4.26	38.60*	97.00	1.79*	17.56
IS 9807	215.54	29.43*	7.75	42.80*	98.65	1.55	19.50*
IS18551	163.68	22.47	10.36*	34.60	104.50*	1.70	16.70
SPV 759	284.78*	17.13	9.25*	32.50	93.50	1.89*	15.78
Mean (Testers)	220.57	22.74	7.91	37.13	98.41	1.73	17.39
S. E. (gi) (±) (Testers)	2.89	0.23	0.08	0.54	0.94	0.02	0.27
CD of Testers (0.05)	5.82	0.46	0.16	1.08	1.89	0.04	0.54
Grand Mean	257.49	24.25	8.97	46.75	101.13	2.12	23.35

Table 3. *Per se* performance of hybrids for various traits

S.No.	Crosses	Plant height (cm)	Stem diameter (mm)	Days to 50% flowering	Number of nodes	Number of leaves	Leaf length (cm)	Leaf breath (cm)	Leaf area index (cm^2)	Flag leaf length (cm)
1	CO 30 x IS 88	218.53	12.58	60.00	7.67	8.67	77.30*	7.33	0.63	40.53
2	CO 30 x IS 9807	229.93	13.75	62.50	7.33	8.67	90.33*	9.17*	0.92*	60.47*
3	CO 30 x IS 8551	242.97	20.00*	68.00	8.00	9.00	92.27*	9.17*	0.94*	55.53*
4	CO 30 x SPV 759	255.97	21.50*	62.00	7.67	9.00	96.97*	9.73*	1.05	55.73*
5	CO(S) 28 x IS 88	231.97	20.50*	61.00	6.67	9.00	86.43*	8.37*	0.80*	41.47
6	CO(S) 28 x IS 9807	246.93	20.00*	65.00	7.67	9.67	79.43*	8.03	0.71	44.67
7	CO(S) 28 x IS 18551	347.97*	23.50*	63.00	9.67*	10.00*	89.93*	8.83*	0.88*	67.93*
8	CO(S) 28 x SPV 759	206.97	20.45*	62.00	7.67	9.00	84.97*	9.77*	0.92*	45.37
9	CSV 27 x IS 88	227.93	20.10*	57.00*	6.67	9.00	69.97	6.97	0.54	50.33*
10	CSV 27 x IS 9807	230.97	17.67	57.00*	6.33	8.33	54.97	6.37	0.39	54.97*
11	CSV 27 x IS 18551	228.97	19.10*	63.00	7.67	9.00	69.87	7.17	0.56	49.13
12	CSV 27 x SPV 759	197.97	18.00	60.00	7.33	8.67	65.93	8.53	0.63	55.63*
13	SPV 2424 x IS 88	229.93	14.00	55.00*	6.67	9.00	64.97	6.57	0.47	39.97
14	SPV 2424 x IS 9807	308.43*	20.00	55.00*	9.33*	9.67	78.43*	7.83	0.68	55.97*
15	SPV 2424 x IS 18551	232.93	18.00	60.00	7.67	8.00	64.83	6.57	0.47	29.93
16	SPV 2424 x SPV 759	230.97	20.40	60.00	6.67	8.00	72.63	7.33	0.59	47.93
17	K 12 x IS 88	245.57	17.60	58.50	8.33*	9.00	65.97	7.87	0.58	44.97
18	K 12 x IS 9807	247.97	14.40	57.60*	7.67	8.00	52.93	6.83	0.40	48.33
19	K 12 x IS 18551	210.47	14.56	63.70	7.67	8.67	60.97	6.93	0.47	48.67
20	K 12 x SPV 759	188.97	15.50	58.00	7.67	8.33	67.97	10.03*	0.76*	49.93
	Mean (Crosses)	238.20	18.08	60.42	7.66	8.83	74.35	7.97	0.67	49.37
	S. E. (gi) (±)	6.41	0.31	1.28	0.40	0.36	1.43	0.18	0.02	0.85
	CD (0.05)	12.88	0.62	2.58	0.79	0.72	2.87	0.36	0.05	1.70

*, ** Significance at P≤ 0.05 and 0.01 %, respectively.

Table 3. Continued

S.No.	Crosses	Flag leaf breath (cm)	Flag leaf area (cm^2)	Panicle length (cm)	Panicle exertion (cm)	Panicle weight (g)	Days to maturity	Hundred seed weight (g)	Grain yield/plant (g)
1	CO 30 x IS 88	7.17	217.79	23.57	4.87*	48.40	104.00	2.15*	23.78
2	CO 30 x IS 9807	4.60	208.61	30.13*	7.27*	68.50*	100.25	2.30*	38.50*
3	CO 30 x IS 8551	6.93	288.80*	25.07	5.56*	69.50*	106.00	2.50*	40.50*
4	CO 30 x SPV 759	7.93*	331.51*	28.37*	7.85	70.50*	109.00	2.77*	45.80*
5	CO(S) 28 x IS 88	8.03*	249.77	19.93	8.15	37.00	100.50	1.98	23.60
6	CO(S) 28 x IS 9807	6.97	233.38	34.47*	7.97	64.50*	103.00	2.44*	35.29*
7	CO(S) 28 x IS 18551	7.87*	400.78*	32.53*	5.57*	79.00*	107.50	2.00	33.00*
8	CO(S) 28 x SPV 759	7.97*	270.95	21.93	8.97	30.00	101.50	1.99	17.60
9	CSV 27 x IS 88	8.97*	338.52*	24.57	4.49*	40.00	98.50	1.30	19.40
10	CSV 27 x IS 9807	8.87*	365.53*	30.07*	4.85*	47.00	97.00*	1.40	22.50
11	CSV 27 x IS 18551	8.37*	308.31*	28.03*	8.86	44.00	99.50	1.34	26.70
12	CSV 27 x SPV 759	10.07*	420.03*	25.27	9.96	40.30	102.00	1.67	18.50
13	SPV 2424 x IS 88	5.83	174.86	19.93	14.98	44.00	98.00*	2.37*	20.00
14	SPV 2424 x IS 9807	4.73	198.67	33.53	3.47*	80.40*	97.50*	2.52*	47.51*
15	SPV 2424 x IS 18551	4.43	99.41	22.37	13.75	46.00	110.50	2.20*	20.90
16	SPV 2424 x SPV 759	6.77	243.11	26.37	13.97	49.00	108.00	2.20*	23.30
17	K 12 x IS 88	7.37	248.56	26.37	4.67*	56.50*	101.50	2.35*	32.58*
18	K 12 x IS 9807	5.60	202.99	26.33	6.09*	40.58	98.00*	1.90	22.50
19	K 12 x IS 18551	5.83	212.91	22.47	6.66*	43.50	108.50	1.44	22.55
20	K 12 x SPV 759	7.97*	298.52*	21.47	6.48*	30.28	98.50	1.90	12.50
	Mean (Crosses)	7.11	265.65	26.14	7.72	51.45	102.46	2.04	27.35
	S. E. (gi) (±)	0.16	6.47	0.52	0.18	1.20	2.10	0.04	0.60
	CD (0.05)	0.32	13.01	1.04	0.36	2.41	4.23	0.08	1.20

Table 4. Estimates of general combining ability effects (*gca*) of parents for seventeen traits

Parents	Plant height	Stem diameter	Days to 50% flowering	Number of nodes	Number of leaves	Leaf length	Leaf breath	Leaf area index	Flag leaf length
Lines									
CO 30	-1.27	-1.12**	2.71**	0.13	0	14.60**	0.88 **	0.22**	3.69**
CO(S) 28	20.34**	3.03**	2.33**	0.43**	0.58 **	10.84**	0.78 **	0.16**	0.49
CSV 27	-16.66**	0.64**	-1.16*	-0.66**	-0.08	-9.17**	-0.71 **	-0.14**	3.14**
K 12	12.45**	0.02	-2.91**	-0.08	-0.17	-4.14**	-0.89 **	-0.11**	-5.92**
SPV 2424	-14.87**	-2.57**	-0.97*	0.17	-0.33 *	12.40**	-0.05	-0.12**	-1.40**
S. E. (gi) (±)	2.26	0.1	0.45	0.14	0.13	0.5	0.06	0.01	0.3
Testers									
IS 88	-7.33**	-1.13**	-2.12**	-0.43**	0.1	-1.43**	-0.55 **	-0.06**	-5.92**
IS 9807	14.73**	-0.92**	-0.99*	0.04	0.03	-3.13**	-0.32 **	-0.05**	3.51**
IS18551	14.54**	0.95**	3.13**	0.64**	0.1	1.22**	-0.24 **	-0.01	0.87**
SPV 759	-21.95**	1.09**	-0.01	-0.26*	-0.23 *	3.34**	1.11 **	0.12**	1.55**
S. E. (gi) (±)	2.02	0.10	0.40	0.12	0.11	0.45	0.6	0.01	0.27

*, ** Significance at P≤ 0.05 and 0.01 %, respectively.

Table 4. Continued

Parents	Flag leaf breath	Flag leaf area	Panicle length	Panicle exertion	Panicle weight	Days to maturity	Hundred seed weight	Grain yield/plant
Lines								
CO 30	-0.46**	-3.97	0.64**	-1.34**	12.78**	2.35**	0.39**	9.79**
CO(S) 28	0.60**	23.07**	1.08**	-0.06	1.18**	0.66	0.07**	0.02
CSV 27	1.95**	92.44**	0.84**	-0.68**	-8.62**	-3.21**	-0.61**	-5.58**
K 12	-1.67**	-86.64**	-0.59**	3.82 **	3.40**	1.04	0.29**	0.58**
SPV 2424	-0.42**	-24.90**	-1.98**	-1.75**	-8.73**	-0.84	-0.14**	-4.82**
S. E. (gi) (±)	0.05	2.29	0.18	0.06	0.42	0.74	0.01	0.21
Testers								
IS 88	0.36**	-19.75**	-3.27**	-0.29**	-6.27**	-1.96**	-0.01	-3.48**
IS 9807	-0.96**	-23.81**	4.77**	-1.79**	8.75**	-3.31**	0.08**	5.91**
IS18551	-0.43**	-3.61	-0.04	0.36**	4.95**	3.94**	-0.14**	1.38**
SPV 759	1.03**	47.17**	-1.46**	1.72**	-7.43**	1.34	0.07**	-3.81**
S. E. (gi) (±)	0.05	2.05	0.16	0.06	0.38	0.67	0.01	0.18

*, ** Significance at P≤ 0.05 and 0.01 %, respectively.

per plant (1.97), except days to 50% flowering and days to maturity. The crosses CO(S) 28 x IS 18551 and K 12 x IS 88 exhibited significant *sca* effects for fourteen traits. The cross CO 30 x SPV 759 and CO 30 x IS 18551 evinced significant for eleven and nine traits, respectively (**Table 5**). Based on *sca* effects along with *per se* performance, the hybrids *viz*., CO(S) 28 x IS 18551, SPV 2424 x IS 9807, CO 30 x SPV 759 and CO 30 x IS 18551 exhibited positively significant for grain yield per plant in *per se* performance and *sca* effects. In sorghum, this result was in uniform with Umakanth *et al*. 2012, Sandeep and Biradar (2020), Mengistu *et al*. (2020), Totre *et al*. (2021) and Maiga *et al.* (2021).

Table 5. Estimates of specific combining ability effects (*sca*) of hybrids for various traits

S. No.	Crosses	Plant height	Stem diameter	Days to 50% flowering	Number of nodes	Number of leaves	Leaf length	Leaf breath	Leaf area index	Flag leaf length
1	CO 30 x IS 88	-10.99**	-3.25**	-1.01	0.47	-0.27	-10.49**	-0.97**	-0.19**	-6.61**
2	CO 30 x IS 9807	-21.65**	-2.29**	0.37	-0.33	-0.20	4.25**	0.64**	0.08**	3.89**
3	CO 30 x IS 8551	-8.43	2.09**	1.75	-0.27	0.07	1.83	0.55**	0.06**	1.60*
4	CO 30 x SPV 759	41.06**	3.45**	-1.11	0.13	0.40	4.41**	-0.23	0.05**	1.12
5	CO(S) 28 x IS 88	-19.16**	0.51*	0.37	-0.99**	-0.52*	2.67*	0.17	0.04*	-2.47**
6	CO(S) 28 x IS 9807	-26.26**	-0.19	3.24**	-0.46	0.22	-2.62*	-0.39**	-0.07**	-8.7**
7	CO(S) 28 x IS 18551	74.96**	1.44**	-2.88**	1.61**	0.48	3.52**	0.32*	0.06**	17.21**
8	CO(S) 28 x SPV 759	-29.54**	-1.75**	-0.74	-0.16	-0.18	-3.57**	-0.09	-0.02	-6.04**
9	CSV 27 x IS 88	13.80**	2.51**	-0.14	0.09	0.15	6.21**	0.26*	0.08	3.74**
10	CSV 27 x IS 9807	-5.22	-0.13	-1.26	-0.71*	-0.45	-7.08**	-0.57**	-0.09**	-1.06
11	CSV 27 x IS 18551	-7.04	-0.57*	0.62	0.03	0.15	3.46**	0.14	0.03*	-4.25**
12	CSV 27 x SPV 759	-1.54	-1.81**	0.77	0.59*	0.15	-2.59*	0.17	-0.02	1.57*
13	SPV 2424 x IS 88	-13.31**	-2.98**	-0.38	-0.49	0.23	-3.82**	0.04	-0.02	2.44**
14	SPV 2424 x IS 9807	43.14**	2.82**	-1.51	1.71**	0.97**	11.35**	1.08**	0.18**	9.01**
15	SPV 2424 x IS 18551	-32.18**	-1.05**	-0.63	-0.56	-0.77**	-6.60**	-0.27*	-0.08**	-14.38**
16	SPV 2424 x SPV 759	2.35	1.21**	2.51**	-0.66*	-0.43	-0.92	-0.85**	-0.08**	2.94**
17	K 12 x IS 88	29.65**	3.21**	1.17	0.93**	0.40	5.44**	0.50**	0.09**	2.91**
18	K 12 x IS 9807	9.99*	-0.20	-0.86	-0.21	-0.53*	-5.89**	-0.76**	-0.10**	-3.15**
19	K 12 x IS 18551	-27.32**	-1.91**	1.12	-0.81**	0.07	-2.21*	-0.75**	-0.08**	-0.18
20	K 12 x SPV 759	-12.33**	-1.1**	-1.14	0.09	0.07	2.67*	1.01**	0.09**	0.41
	S. E. (gi) (±)	4.53	0.22	0.91	0.28	0.25	1.01	0.13	0.02	0.60

*, ** Significance at P≤ 0.05 and 0.01 %, respectively.

Table 5. Continued

S. No.	Crosses	Flag leaf breath	Flag leaf area	Panicle length	Panicle exertion	Panicle weight	Days to maturity	Hundred seed weight	Grain yield/plant
1	CO 30 x IS 88	0.15	-24.14**	0.05	-1.23**	-9.56**	1.15	-0.28**	-9.89**
2	CO 30 x IS 9807	-1.10**	-29.25**	-1.42**	2.67**	-4.47**	-1.25	-0.20**	-4.55**
3	CO 30 x IS 8551	0.7**	30.73**	-1.67**	-1.18**	0.32	-2.75	0.21**	1.97**
4	CO 30 x SPV 759	0.25*	22.66**	3.04**	-0.26*	13.71**	2.85	0.27**	12.47**
5	CO(S) 28 x IS 88	-0.03	-19.2**	-4.02**	0.78**	-9.36**	-0.66	-0.12**	-0.29
6	CO(S) 28 x IS 9807	0.22	-31.52**	2.48**	2.10**	3.13**	3.19*	0.26**	2.01**
7	CO(S) 28 x IS 18551	0.58**	115.67**	5.36**	-2.46**	21.42**	0.44	0.04	4.25**
8	CO(S) 28 x SPV 759	-0.77**	-64.94**	-3.83**	-0.42**	-15.19**	-2.97	-0.18**	-5.96
9	CSV 27 x IS 88	-0.46**	0.17	0.85*	-2.26**	3.44**	1.21	-0.12**	1.1*
10	CSV 27 x IS 9807	0.76**	31.24**	-1.69**	-0.40**	-4.57**	1.06	-0.10**	-5.19
11	CSV 27 x IS 18551	-0.27*	-46.18**	1.10**	1.46**	-3.78**	-3.69*	0.05	3.55**
12	CSV 27 x SPV 759	-0.03	14.76**	-0.26	1.20**	4.91**	1.41	0.17**	0.54
13	SPV 2424 x IS 88	0.03	15.60**	-2.35**	3.72**	-4.58**	-3.54*	0.05	-4.45**
14	SPV 2424 x IS 9807	0.25*	43.47**	3.22**	-6.28**	16.8**	-2.69	0.12**	13.67**
15	SPV 2424 x IS 18551	-0.58**	-75.99**	-3.14**	1.85**	-13.80**	3.06*	0.02	-8.41**
16	SPV 2424 x SPV 759	0.30*	16.93**	2.28**	0.70**	1.58	3.16*	-0.19**	-0.82
17	K 12 x IS 88	0.31**	27.57**	5.47**	-1.01**	20.05**	1.84	0.46**	13.52**
18	K 12 x IS 9807	-0.13	-13.94**	-2.59**	1.91**	-10.88**	-0.31	-0.08*	-5.94**
19	K 12 x IS 18551	-0.43**	-24.23**	-1.65**	0.32**	-4.17**	2.94	-0.32**	-1.36**
20	K 12 x SPV 759	0.25*	10.6*	-1.23**	-1.22**	-5.00**	-4.46**	-0.06*	-6.22**
	S. E. (gi) (±)	0.11	4.57	0.37	0.13	0.85	1.49	0.03	0.42

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Table 6. Estimates of heterosis for various traits (in per cent)

Cross	Plant height			Stem diameter			Days to 50 % flowering			Number of nodes			Number of leaves		
	MP	BP	SP	MP	BP	SP	MP	BP	SP	MP	BP	SP	MP	BP	SP
1	-6.20**	-6.60**	-5.80*	-13.57**	-15.29**	-15.29**	2.04	-4.16*	-4.16	-0.00	-2.08	2.17	0.00	0.00	-0.00
2	0.86	-0.89	-0.89	-0.64	-7.41**	-7.41**	2.80	-0.15	-0.15	-4.26	-6.25	-2.17	4.00	0.00	0.00
3	8.00**	4.73	4.73	15.79**	1.54	34.7**	4.54**	0.75	8.63**	4.26	2.08	6.52	-1.82	-6.90	3.85
4	25.18**	10.33**	10.33**	29.91**	17.81**	44.78**	11.61**	-0.96	-0.96	-11.54**	-20.69**	0.00	-1.82	-6.90	3.85
5	1.98	-0.85	-0.01	15.79**	-3.06*	38.02**	-0.53	-9.83**	-2.56	-14.89**	-16.67**	-13.04*	-1.82	-6.90	3.85
6	11.01**	10.27**	6.44*	17.77**	-5.39**	34.7**	2.65	-3.92*	3.83	-2.13	-4.17	0.00	9.43**	0.00	11.54**
7	58.56**	57.47**	49.99**	15.09**	11.16**	58.27**	-6.77**	-6.87**	0.64	31.91**	29.17**	34.78**	3.45	3.45	15.38**
8	4.02	-6.34*	-10.79**	3.82**	-3.28*	37.71**	6.76**	-8.35**	-0.96	-11.54**	-20.69**	0.00	-6.90*	-6.90	3.85
9	3.16	-2.58	-1.75	20.72**	5.57**	35.35**	0.88	-1.72	-8.95**	-9.09*	-16.67**	-13.04*	8.00*	3.85	3.85
10	6.96**	3.14	-0.45	10.9**	-7.20**	18.99**	-2.56	-3.39	-8.95**	-13.64**	-20.83**	-17.39**	4.17	4.17	3.85
11	7.53**	5.06	-1.31	-1.39	-3.05	28.62**	0.40	-6.67**	0.64	4.55	-4.17	0.00	1.89	-6.90	3.85
12	2.87	-4.79	-14.67**	-3.46*	-5.46**	21.21**	12.68**	3.45	-4.15*	-10.20*	-24.14**	-4.35	-1.89	-10.34**	-0.00
13	5.73*	-1.72	-0.89	4.24*	-1.82	-5.72**	-7.94**	-14.72**	-12.14**	-14.89**	-16.67**	-13.04*	8.00*	3.85	3.85
14	45.18**	37.73**	32.95**	57.34**	55.95**	34.7**	-10.93**	-14.73**	-12.14**	19.15**	16.67**	21.74**	20.83**	20.83**	11.54**
15	11.21**	6.88*	0.40	11.48**	-8.61**	21.23**	-9.09**	-11.11**	-4.15*	-2.13	-4.17	0.00	-9.43**	-17.24**	-7.69
16	22.23**	14.93**	-0.45	32.27**	11.80**	37.4**	6.19**	-6.98**	-4.15*	-23.08**	-31.03**	-13.04*	-9.43**	-17.24**	-7.69
17	11.39**	4.96*	5.85**	21.72**	20.05**	18.52**	4.46*	2.63	-6.55**	19.05**	4.17	8.7	14.89**	3.85	3.85
18	15.10**	10.73**	6.88**	4.80*	-1.75	-3.01	-0.69	-2.37	-7.99**	9.52*	-4.17	0.00	6.67	0.00	-7.69
19	-0.93	-3.43	-9.28**	-15.25**	-26.09**	-1.95	2.33	-5.63**	1.76	9.52*	-4.17	0.00	4.00	-10.34**	-0.00
20	-1.55	-8.68**	-18.55**	-5.80**	-15.07**	4.38*	9.95**	1.75	-7.35**	-2.13	-20.69**	0.00	0.00	-13.79**	-3.85
S. E. (gi) (±)	4.97	5.74	6.25	0.26	0.30	0.30	1.10	1.28	1.26	0.33	0.36	0.39	0.32	1.53	1.54

*, ** Significance at P≤ 0.05 and 0.01 %, respectively. For cross name refer Table 5.

Table 6. Estimates of heterosis for various traits (Conti…) (in per cent)

Cross	Leaf length			Leaf breath			Leaf area index			Flag leaf length		
	MP	BP	SP	MP	BP	SP	MP	BP	SP	MP	BP	SP
1	-3.27	-13.02**	-13.02**	-14.56**	-21.99**	-21.99**	-18.18**	-32.01**	-32.01**	-15.76**	-30.43**	-30.43**
2	21.01**	1.65	1.65	8.91**	-2.48	-2.48	28.97**	-0.72	-0.72	16.96**	3.78*	3.78*
3	16.55**	3.83*	3.83*	10.66**	-2.48	-2.48	27.03**	1.44	1.44	12.83**	-4.69**	-4.69**
4	26.08**	9.12**	9.12**	-0.34	-3.95*	3.55	26.76**	13.31**	13.31**	6.97**	-4.35**	-4.35**
5	13.06**	5.49**	-2.74	2.03	-3.09	-10.99**	14.76**	2.12	-13.31**	-8.29**	-20.97**	-28.83**
6	11.59**	-3.05	-10.62**	0.00	-6.95**	-14.54**	9.84**	-10.17**	-23.74**	-8.47**	-14.87**	-23.34**
7	18.8**	9.76**	1.20	11.81**	2.32	-6.03**	31.34**	11.86**	-5.04*	46.67**	29.48**	16.59**
8	15.68**	3.70	-4.39*	4.09**	-3.62*	3.90*	21.76**	17.37**	-0.36	-7.79**	-13.53**	-22.14**
9	-2.76	-4.07	-21.27**	-20.53**	-28.67**	-25.89**	-23.04**	-31.65**	-41.73**	10.70**	-4.97**	-13.62**
10	-17.57**	-24.63**	-38.15**	-25.97**	-34.81**	-32.27**	-39.53**	-50.63**	-57.91**	12.06**	3.78*	-5.66**
11	-1.87	-4.2*	-21.38**	-15.35**	-26.62**	-23.76**	-17.12**	-29.54**	-39.93**	5.51**	-7.24**	-15.68**
12	-4.38*	-9.6**	-25.81**	-14.24**	-15.79**	-9.22**	-17.98**	-21.1**	-32.73**	12.50**	5.03**	-4.52**
13	1.59	-8.45**	-26.89**	-11.46**	-15.45**	-30.14**	-10.69**	-22.83**	-48.92**	-14.90**	-28.59**	-31.41**
14	33.66**	29.78**	-11.74**	8.05**	5.38*	-16.67**	44.37**	36.67**	-26.26 **	10.72**	0.00	-3.95*
15	2.58	-6.67**	-27.04**	-7.73**	-8.37**	-30.14**	-5.33	-14.46**	-48.92 **	-37.73**	-46.52**	-48.63**
16	19.17**	11.8**	-18.27**	-14.73**	-27.63**	-21.99**	0.28	-19.18**	-36.33 **	-5.92**	-14.35**	-17.73**
17	10.04**	-7.05**	-25.77**	27.91**	1.29	-16.31**	34.11**	-5.98	-37.77 **	27.69**	18.44**	-22.83**
18	-3.20	-12.41**	-40.44**	14.21**	-8.07**	-27.3**	7.14	-20.00**	-56.83 **	24.57**	7.09**	-17.05**
19	2.98	-12.24**	-31.4**	18.52**	-3.26	-26.24**	17.50**	-15.06**	-49.28 **	34.01**	21.16**	-16.48**
20	19.34**	4.62	-23.52**	36.82**	-0.99	6.74**	54.95**	3.65	-18.35 **	27.38**	8.71**	-14.3**
S. E. (gi) (±)	0.14	0.16	0.18	0.02	0.02	0.02	0.80	0.92	0.89	0.13	0.16	0.16

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Table 6. Estimates of heterosis for various traits (Conti…) (in per cent)

Cross	Flag leaf breath			Flag leaf area			Panicle length			Panicle exertion		
	MP	BP	SP	MP	BP	SP	MP	BP	SP	MP	BP	SP
1	-7.33**	-8.12**	-8.12**	-22.10**	-36.11**	-36.11**	-1.12	-8.42**	-8.42**	-12.44**	-29.08**	-29.08**
2	-35.06**	-41.03**	-41.03**	-25.02**	-38.80**	-38.8**	9.24**	2.38	17.1**	-0.57	-6.24**	5.83*
3	4.79*	-11.11**	-11.11**	14.48**	-15.28**	-15.28**	4.01*	-2.59	-2.59	-35.46**	-46.35**	-19.03**
4	-1.24	-4.03*	1.71	5.97**	-2.75	-2.75	32.35**	10.23**	10.23**	-2.65	-15.2**	14.27**
5	8.56**	4.78*	2.99	0.11	-11.02**	-26.73**	-20.74**	-29.73**	-22.54**	30.07**	-1.53	18.74**
6	3.21	-2.34	-10.68**	-5.94*	-16.86**	-31.53**	19.26**	17.1**	33.94**	-0.52	-3.70	16.12**
7	25.2**	10.28**	0.85	80.38**	42.78**	17.57**	28.00**	14.69**	26.42**	-40.28**	-46.28**	-18.93**
8	3.46	-3.63	2.14	-4.17	-4.86	-20.51**	-3.59	-22.68**	-14.77**	2.32	-3.06	30.63**
9	-0.37	-13.23**	14.96**	7.66**	-17.6**	-0.69	-1.54	-12.16**	-4.53*	-8.43**	-19.10**	-34.61**
10	6.19**	-14.19**	13.68**	16.75**	-10.98**	7.23**	4.76**	2.15	16.84**	-27.02**	-37.38**	-29.32**
11	6.13**	-19.03**	7.26**	7.37**	-24.91**	-9.55**	11.17**	0.24	8.94**	11.35**	-14.51**	29.03**
12	8.24**	-2.58	29.06**	20.81**	2.30	23.22**	12.05**	-9.65**	-1.81	34.61**	7.67**	45.10**
13	-20.81**	-23.91**	-25.21**	-32.08**	-41.05**	-48.7**	-12.89**	-16.36**	-22.54**	205.40**	169.75**	118.16**
14	-29.53**	-33.02**	-39.32**	-22.42**	-33.03**	-41.72**	25.91**	13.93**	30.31**	-47.78**	-55.18**	-49.42**
15	-29.07**	-37.26**	-43.16**	-56.81**	-66.49**	-70.84**	-3.38	-6.15**	-13.08**	72.82**	32.71**	100.29**
16	-11.74**	-18.15**	-13.25**	-16.37**	-18.04**	-28.68**	28.72**	10.63**	2.46	88.74**	51.01**	103.5**
17	22.44**	-3.91	-5.56*	53.15**	13.87**	-27.08**	21.79**	20.21**	2.46	-65.55**	-79.57**	-31.99**
18	4.35	-12.04**	-28.21**	26.14**	-5.82	-40.45**	3.67*	-10.53**	2.33	-60.20**	-73.35**	-11.31**
19	19.05**	7.36*	-25.21**	57.71**	30.08**	-37.54**	2.51	0.00	-12.69**	-59.92**	-70.87**	-3.06
20	26.12**	-3.63	2.14**	52.66**	4.82	-12.43**	11.52**	0.47	-16.58**	-59.61**	-71.63**	-5.58*
S. E. (gi) (±)	6.44	7.44	6.98	0.42	0.47	0.51	0.15	0.17	0.18	0.98	1.13	1.20

*, ** Significance at P≤ 0.05 and 0.01 %, respectively. For cross name refer Table 5.

Table 6. Estimates of heterosis for various traits (Conti…) (in per cent)

Cross	Panicle weight			Days to maturity			Hundred seed weight			Grain yield/plant		
	MP	BP	SP	MP	BP	SP	MP	BP	SP	MP	BP	SP
1	-12.87**	-33.24**	-33.24**	5.31**	3.48	3.48	-7.47 **	-24.68 **	-24.68 **	-23.48**	-46.68**	-46.68**
2	18.82**	-5.52**	-5.52**	0.68	-0.25	-0.25	4.55 **	-19.30 **	-19.30 **	20.12**	-13.68**	-13.68**
3	29.79**	-4.14**	-4.14*	3.41	1.44	5.47	10.04 **	-12.16 **	-12.16 **	32.13**	-9.2**	-9.2**
4	34.29**	-2.76	-2.76	12.37**	8.45**	8.45**	16.82 **	-2.92*	-2.92 *	51.71**	2.69*	2.69
5	-23.71**	-36.64**	-48.97**	-2.66	-8.21**	0.00	-14.41 **	-30.20 **	-30.53**	6.19**	-12.25**	-47.09**
6	27.47**	10.45**	-11.03**	-1.03	-5.93**	2.49	11.25**	-13.98**	-14.39**	52.12**	31.22**	-20.87**
7	69.9**	35.28**	8.97**	0.47	-1.82	6.96**	-11.83**	-29.49**	-29.82**	51.4**	22.71**	-26.01**
8	-33.99**	-48.63**	-58.62**	0.00	-7.31**	0.99	-15.6**	-29.73**	-30.06**	-17.51**	-34.56**	-60.54**
9	-1.11	-5.44*	-44.83**	-1.25	-3.90	-1.99	-20.49**	-27.37**	-54.39**	2.36	-4.67	-56.50**
10	10.45**	9.80**	-35.17**	-3.55	-5.37*	-3.49	-7.59**	-9.68**	-50.88**	12.91**	10.57**	-49.55**
11	14.43**	4.02	-39.31**	-3.87*	-4.79*	-1.00	-15.72**	-21.18**	-52.98**	44.13**	31.2**	-40.13**
12	7.75**	-4.73	-44.41**	4.08*	-0.49	1.49	-0.79	-11.48**	-41.4**	2.41	-9.09**	-58.52**
13	-2.53	-14.86**	-39.31**	-1.26	-3.45	-2.49	8.22**	-8.49**	-16.84**	-11.73**	-27.95**	-55.16**
14	70.2**	55.58**	10.90**	-2.57	-3.94	-2.99	21.74**	-2.70	-11.58**	101.04**	71.15**	6.52 **
15	6.63**	-10.99**	-36.55**	7.28**	5.74**	9.95**	2.56	-15.06**	-22.81**	-5.98**	-24.71**	-53.14 **
16	16.42**	-5.19*	-32.41**	10.77**	6.4**	7.46**	-1.71	-15.06**	-22.81**	7.03**	-16.07**	-47.76 **
17	31.40**	19.21**	-22.07**	1.75	-0.98	0.99	12.98**	-0.84	-17.54**	67.68**	52.94**	-26.96 **
18	-10.02**	-14.38**	-44.03**	-2.56	-4.39*	-2.49	-3.23	-19.97**	-33.45**	10.3**	5.65*	-49.54 **
19	6.11*	-8.21**	-40.00**	4.83**	3.83	7.96**	-29.24**	-39.24**	-49.47**	18.67**	5.85*	-49.45 **
20	-24.2**	-36.11**	-58.23**	0.51	-3.90	-1.99	-10.57**	-19.69**	-33.22**	-32.6**	-41.33**	-71.98 **
S. E. (gi) (±)	1.81	2.10	2.06	0.03	0.04	0.04	0.47	0.55	0.61	0.98	1.13	1.20

*, ** Significance at P≤ 0.05 and 0.01 %, respectively. For cross name refer Table 5.

Heterosis is closely related to SCA, thus, hybrids with high SCA show high heterosis. The range of heterosis is depicted in **Table 6**. Potential hybrids were identified with desirable direction in all three types of heterosis for different yield and yield related traits. SPV 2424 x IS 9807 exhibited significant for all three heterosis for eight characters *viz*., plant height, stem diameter, days to 50% flowering, number of nodes, number of leaves, leaf area index, panicle length, panicle weight and grain yield per plant. CO(S) 28 x IS 18551, CO 30 x SPV 759 and K 12 x IS 88 recorded significant for all three types of heterosis for seven, five and three traits respectively. For grain yield per plant, eight hybrids were evinced desirable direction significant for both mid parent heterosis and better parent heterosis. Based on *per* se, *sca* effects and heterosis, the hybrid *viz*., CO(S) 28 x IS 18551, SPV 2424 x IS 9807 and CO 30 x SPV 759 exhibited significantly superior. In sorghum, this result was in consonance with Umakanth *et al*. (2012), Kumari *et al.* (2018), Sandeep and Biradar (2020), Mengistu *et al*. (2020), Maiga *et al.* (2021) and Diatta *et al.* (2021).

For all the traits in this study, the analysis of variance showed highly significant. The parents, CO(S) 28 SPV 759 and IS 9807 exhibited desirable *per se* performance and perfect general combining ability for yield and yield contributing traits. These parents can be further exploited in the hybridization programme to develop high heterotic hybrids. The hybrids *viz*., CO(S) 28 x IS 18551, SPV 2424 x IS 9807, CO 30 x SPV 759 recorded higher magnitude for *per se*, specific combining ability and heterosis for all important yield and yield contributing traits and can be commercially exploited for heterosis breeding programme.

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