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Combining Ability for Seed Vigour and Viability Traits in Sorghum (*Sorghum bicolor* (L) Moench)

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ABSTRACT Combining ability analysis was carried out to obtain the information regarding selection of best combiners (parents) for genetic improvement of seed vigour, viability and field emergence potential in sorghum (*Sorghum bicolor* (L) Moench). The general combining ability estimates revealed that among lines, 463 A had positive and significant *gca* effects for all the seed parameters of both unaged and aged seeds indicating its capability to combine all the vigour and viability traits. Sorghum restorer line NR 99117 showed the highest positive and significant *gca* values for all seed parameters excepting shoot length of unaged seeds and root length of aged seeds revealing its wide capability of combining seed vigour and viability. As seed viability alone concerned, tester NR 99105 showed highly positive and significant *gca* values. It also proved as better general combiner for initial vigour and field emergence of fresh seeds. The line x tester analysis brought out the sorghum line MS 463 A and testers NR 99117 and NR 99105 as better general combiners for seed vigour, viability and field emergence potential traits. The crosses 63 A x NR 99015 and 463 A x NR 99014 proved as best cross combinations among others for seed germination, vigour, viability and field emergence potential by recording positive and significant *sca* values for all important seed traits.

Keywords: Sorghum, seed vigour, viability, combining ability.

In India sorghum is the most important cereal for poor people in semi arid zones. Almost one third of total world sorghum is grown as rainfed crop in India. The success of sorghum hybrids in India has necessitated the production of sorghum hybrid seed on large scale. Seed production is a specialized and essential industry today. Most of the seed production innovations are the outcome of the efforts of the producers and R & D, which made sorghum production a viable industry in the country. Time to time seed growers are facing difficulties at on-farm front. Some of the hybrids exhibit problems such as poor seed quality in terms of low germination, vigour and storage potential. Obtaining the good stand establishment is the prerequisite for maximizing the yield potentials of crops. Identification of superior parental lines and their hybrid combinations for enhanced stand establishment and planting value shall pave the way for exploration of commercial yield on per hectare basis. Hence, evaluation of cytoplasmic genic male sterile lines and restorer lines for better hybrid seed vigour, viability potential along with the productivity remains to be streamlined in hybrid seed research.

MATERIALS AND METHODS

The material consisted of three cytoplasmic genic male sterile lines (63 A, 422 A and 463 A) as lines and seven fertility restoring genetic accessions of *Sorghum bicolor* (L) Moench inbreds (NR 99001, NR 99005, NR 99006, NR 99014, NR 99015, NR 99105 and NR 99117) as testers. The parents were crossed in 21 possible combinations in the year 2001-2002 at National Research Centre for Sorghum (NRCS) and the seeds harvested from the parents and their hybrid combinations were evaluated at seed research laboratory, NRCS. The unaged fresh seeds and accelerated aged seeds were evaluated for different seed quality parameters to assess the seed vigour and viability potential of parents and hybrids [1]. The germination test was conducted as per the set

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Table 1. General and specific combining ability effects for seed vigour traits of sorghum.

Parents and Crosses	Seed vigour traits of imaged seeds						
	100-seed weight (g)	Germination (%)	Root length (cm)	Shoot length (cm)	Seedling dry matter (mg)	Seedling vigour index	Field emergence (%)
63 A	-0.106**	-0.989	-0.081	-3.076**	-3.367**	-339.2**	-1.568
422 A	-0.291**	-2.399	-0.952**	0.045	0.380	-13.7	-0.518
463 A	0.397**	3.388*	1.033**	3.031**	2.987**	352.8**	2.086*
NR 99001	-0.049	-7.383**	-1.157*	-0.792	-0.154	-174.3*	-5.450**
NR 99005	-0.033	-0.152	0.926*	-2.225**	-3.004**	-239.5*	1.049
NR 99006	-0.054	-0.829	-0.499	-0.917	1.027	118.9	1.293
NR 99014	-0.041	-2.182	-1.799**	-1.000	1.245	79.2	-1.485
NR 99015	0.188**	-2.163	1.868**	5.067**	0.897	23.1	-2.310
NR 99105	-0.109**	6.696**	0.193	0.583	-2.133**	-102.3	3.029*
NR 99117	0.098*	6.013**	0.468	-0.717	2.123**	294.9**	3.875**
63A x NR 99001	0.351**	-10.500**	-3.211**	-0.040	0.615	-180.3	-8.094**
63 A x NR 99005	0.529**	-4.727	1.181	1.318	-1.075	-171.4	-2.758
63 A x NR 99006	0.353**	-2.022	2.131**	5.285**	-1.765	-185.8	-0.629
63 Ax NR 99014	-0.337**	-2.084	3.331**	-3.407**	-1.839	-169.4	-1.247
63A x NR 99015	0.571**	6.630*	0.589	-1.899	3.332*	466.0**	4.699*
63A x NR 99105	-0.867**	7.783*	-0.836	0.785	0.984	186.3	4.100
63A x NR 99117	-0.601**	4.921	-3.186**	-2.040	-0.252	54.7	3.929
422 A x NR 99001	-0.357**	12.734**	1.136	0.188	-3.804**	-56.1	8.976**
422 A x NR 99005	-0.496**	6.163*	-0.723	-1.579	0.269	134.8	4.134
422 A x NR 99006	-0.797**	4.765	-0.573	-4.562**	-4.017**	-279.1*	1.635
422 A x NR 99014	0.242**	-5.282	-1.823*	2.846**	-0.396	-192.9	-2.835
422 A x NR 99015	-0.337**	-8.911**	0.336	0.905	-0.795	-311.5*	-7.059**
422 A x NR 99 105	1.081**	-8.305**	0.261	0.688	0.207	-75.2	-3.636
422A x NR 99117	0.664**	-1.165	1.386	1.513	8.536**	779.9**	-1.216
463 A x NR 99001	0.006	-2.234	2.075*	-0.148	3.189*	236.4	-0.883
463 A x NR 99005	-0.033	-1.436	-0.458	0.261	0.806	36.6	-1.377
463 A x NR 99006	0.443**	-2.743	-1.558	-0.723	5.783**	464.9**	-1.006
463 A x NR 99014	0.095	7.367*	-1.508	0.561	2.234	362.3**	4.082
463 A x NR 99015	-0.234**	2.281	-0.925	0.994	-2.537*	-154.5	2.360
463 A x NR 99105	-0.214**	0.522	0.575	-1.473	-1.191	-111.2	-0.464
463 A x NR 99117	-0.063	-3.756	1.800*	0.527	-8.284**	-834.6	-2.713
SE (gi) Lines	0.024	1.145	0.298	0.402	0.476	51.163	0.793
SE (gi) Testers	0.037	1.749	0.455	0.615	0.728	78.152	1.211
SE (gij) Hybrids	0.064	3.029	9.788	1.065	1.260	135.364	2.097

* ** : Significant at 5% and 1% respectively.

Table 2. General and specific combining ability effects for seed viability traits of sorghum.

Parents and Crosses	Seed viability traits of aged seeds					
	Germination (%)	Root length (cm)	Shoot length (cm)	Seedling dry matter (mg)	Seedling vigour index	Field emergence (%)
63 A	0.999	-0.007	-2.012**	-1.894**	-84.9**	0.376
422 A	-2.373*	1.148*	-0.646*	-0.553	-91.5**	-2.649**
463 A	1.374	-1.142*	2.658**	2.447**	176.4**	2.273**
NR 99001	-2.685*	0.604	-0.177	1.558**	29.7	-2.770*
NR 99005	-0.112	-0.119	-1.398**	-2.698**	-217.3**	-0.089
NR 99006	-2.658*	-0.115	-1.502**	1.261*	-31.8	-3.079**
NR 99014	-5.519**	-1.911**	-0.435	-3.450**	-212.5**	-5.504**
NR 99015	-0.453	0.047	0.698	0.923	62.8	0.543
NR 99105	7.401**	1.530*	2.390**	1.350*	266.3**	6.758**
NR 99117	4.027**	-0.036	0.423	1.055*	102.9*	4.140**
63 A x NR 99001	-22.842**	-1.967	-0.571	-0.169	-587.1**	-21.888**
63 A x NR 99005	1.603	1.133	-0.163	-1.329	1.4	3.274
63 A x NR 99006	-14.331**	0.915	2.079**	-0.638	-341.4**	-14.718**
63A x NR 99014	13.193**	0.523	0.162	2.048*	298.8**	12.739**
63A x NR 99015	12.759**	0.415	0.054	2.836**	531.3**	11.929**
63 Ax NR 99105	4.022	-1.218	0.162	-1.759	-32.05	3.527
63 Ax NR 99117	5.596**	0.198	-1.721*	-0.989	129.1	5.137**
422 A x NR 99001	21.290**	-0.822	2.238**	-2.455**	351.0**	19.325**
422 A x NR 99005	18.942**	0.976	2.658**	-0.299	419.8**	16.084**
422 A x NR 99006	19.229**	-0.027	-1.287	-4.756**	158.0*	19.084**
422 A x NR 99014	-22.488**	-1.907	-2.979**	-4.163**	-569.6**	-21.451**
422 A x NR 99015	-15.766**	-2.165	-2.138**	0.285	-440.3**	-14.911**
422 A x NR 99105	-7.743**	1.227	1.596*	4.856**	101.3	-5.346**
422A x NR 99117	-13.465**	2.718*	-0.087	6.532**	-20.2	-12.783**
463 A x NR 99001	1.551	2.788*	-1.666*	2.625**	236.1**	2.563
463 A x NR 99005	-20.545**	-2.109	-2.495**	1.628	-421.1**	-19.358**
463 A x NR 99006	-4.898*	-0.887	-0.791	5.394**	183.4*	-4.365*
463 A x NR 99014	9.295**	1.383	2.817**	2.115*	270.8**	8.712**
463 A x NR 99015	3.007	1.750	2.084**	-3.120**	-90.9	2.982
463 A x NR 99105	3.720	-0.008	-1.758*	-3.097**	-69.3	1.820
463 A x NR 99117	7.869**	-2.917*	1.809**	-5.543**	-108.9	7.646**
SE (gi) Lines	0.783	0.419	0.257	0.33 t hefd 92	6.486	0. 713
SE (gj) Testers	1.196	0.641	0.392	0.519	40.458	1.089
SE (gij) Hybrids	2.071	1.109	0.679	0.898	70.076	1.886

*, ** : Significant at 5% and 1% respectively.

Table 3. Ranking of better parents based on positive and significant *gca* effects for important seed vigour and viability traits.

S.No.	Parents	Unaged seeds			Aged seeds		
		Germination	Seedling vigour index	Field emergence	Germination	Seedling vigour index	Field emergence
1	463 A	+*	+**	+**	+	+**	+**
2	NR 99117	+**	+**	+**	+**	+*	+**
3	NR 99105	+**	-	+*	+**	+**	+**
4	NR 99015	-	+	-	-	+	+

(+): Positive, (-): Negative and (* **) : Significant at 5% and 1% respectively.

Table 4. Ranking of better crosses based on positive and significant sca effects for important seed vigour and viability traits.

Rank No.	Crosses	Unaged seeds			Aged seeds		
		Germination	Seedling vigour index	Field emergence	Germination	Seedling vigour index	Field emergence
1	63 A x NR 99015	+*	+*	+*	+**	+*	+**
2	463 A x NR 99014	+*	+**	+	+**	+**	+**
3	422 A x NR 99001	+**	_	+**	+**	+**	+**
4	422 A x NR 99005	+*	+	+	+**	+**	+**
5	422 A x NR 99006	+	_	+	+**	+*	+**
6	63 A x NR 99117	+	+	+	+**	+	+*
7	463 A xNR 99001	-	+	-	+	+**	+
8	63 A x NR 99014	-	-	-	+**	+**	+**

(+): Positive, (-): Negative and (*, **) : Significant at 5% and 1% respectively.

procedures of international seed testing rules using between papers (BP) method [2]. Seedling vigour index was computed as per [3]. The combining ability analysis was carried out with line x tester method of [4].

RESULTS AND DISCUSSION

The analysis of variance for lines, testers and lines x testers was highly significant for most of the characters revealing the wide variability existing among the genotypes for different seed vigour, viability and field emergence traits. The general combining ability estimates revealed that among lines, 463 A had positive and significant *gca* effects for all the seed parameters of both unaged and aged seeds indicating its capability to combine all the vigour, viability and field emergence traits (Tables 1 & 2). These observations indicated that the sorghum CMS line 463 A carries large number of favorable genes for seed vigour and viability potential.

Sorghum restorer line NR 99117 showed the highest positive and significant *gca* values for all seed parameters excepting shoot length of unaged seeds and root length of aged seeds (Tables 1, 2 and 3) revealing its wide capability of combining seed vigour, viability and field emergence. As the seed viability concerned, tester NR 99105 is the best general combiner that showed highly positive and significant *gca* values. It also proved as better general combiner for initial vigour and stand establishment of fresh seeds (Table 3 and 4). Next to NR 99117 and NR 99105, the tester NR 99015 could combine 10 out of 13 seed traits but failed for important characters like germination and field emergence potential. The line x tester analysis brought out the sorghum line MS 463 A and testers NR 99117 & NR 99105 as better general combiners for seed vigour and viability traits (Table 1, 2 and 3). Similar evaluations of parental lines and crosses for seed quality traits were also reported in different crops [5-9].

The planting quality of seeds can be characterized by their viability and vigour. These two characteristics determine the value and utility of seeds [5]. Among the characters studied, germination, vigour index and field emergence potential of both unaged and aged seeds were considered as most desirable traits to judge the ultimate seed quality and storage potential. Eight better crosses combining these important characters with positive and significant or positive and non-significant *sca* effects were identified and ranked. The crosses 63 A x NR 99015 and 463 A x NR 99014 proved as best cross combinations among others for seed germination, vigour, viability and field emergence by recording positive and significant *sca* values for all important seed traits (Table 2, 3 and 5). The hybrid 422 A x NR 99001 showed significantly positive *sca* values for all important seed vigour, viability and stand establishment traits excepting seedling vigour index of unaged seeds. Similarly, the crosses 422 A x NR 99006, 63 A x NR 99117, 463 A x NR 99001 and 63 A x NR 99014 had positive *sca* effects for all the important seed quality traits (Table 1, 2 and 4). Similar studies were reported in different crops for identification of superior hybrids [5-9].

The parents 463A, NR 99105, NR 99117 and NR 99015 proved well in cross combination also by expressing significantly positive *sca* effects for most of the characters. The performance of cross combination is therefore understandable that the high *gca* effects of parents had partly contributed to the high *sca* of the cross combination. It was also pointed out that the other better hybrids combining most of the important desirable seed quality traits have both the parents with low *gca* effects or high *gca* effects or either of them with low *gca* effect. It is also clear that many of the hybrids exhibiting highest *sca* values failed to possess the parents of superior general combining ability.

The incorporation of the features of seed quality and storability along with the productivity in breeding program of sorghum hybrids shall facilitate to overcome the problems with poor field stand under unfavourable stress conditions. From the present study it can be inferred that among ten sorghum parents and twenty one crosses, the line MS 463 A, testers NR 99117 and NR 99105 proved as better general combiners and the combinations of 63 A x NR 99015 and 463 A x NR 99014 as better crosses for seed vigour, viability and stand establishment traits.

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