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A Productive Breeding Programme on Identifying the Elite Combiners for Early Vigour and Productivity Related Traits in identified Local Landraces of *rabi* sorghum [*Sorghum bicolor* (L.) Moench]

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ABSTRACT: Early vigor in sorghum [*Sorghum bicolor* (L.) Moench] is important for improving stand establishment of the crop, particularly in rainfed regions. Hence present study emphasis on combining ability analysis for early vigour and productivity related traits of 48 hybrids (8 Lines × 6 Testers) revealed that all the traits under study including early vigour were under non-additive genetic control. Among parents, Kodmurkhi local was the best general combiner for panicle breadth, panicle weight, grain yield per plant and number of leaves per plant along with CSV- 216R as best general combiner for early vigour traits as well as productivity related traits this signified positive response of early vigour to the productive related traits. The crosses CSV-216R × IS-4631 and SPV-2333 × RSLG-23 were good specific combiners for grain yield per plant, panicle weight and 100 seed weight, interestingly, the above-mentioned cross CSV-216R × IS-4631 was also the good specific combiner for early vigour traits *viz.,* root collar diameter, plant height and leaf width. These elite crosses can be advanced further to isolate the transgressive seggregants for nutritional quality traits as crosses bearing the blood from the elite landraces. Further, superior early vigour hybrids will be bone for shoot fly resistance coupled with quality traits.

Keywords: Landraces, early vigour, combining ability.

INTRODUCTION

In the era of climate change, C_4 plants have a role in combating global warming because of their higher optimal temperature and higher photosynthetic efficiency. Sorghum [*Sorghum bicolor* (L.) Moench] being a C_4 plant with higher photosynthetic efficiency and abiotic stress tolerance (Reddy *et al.,* 2009) adapted to a diverse set of environments ranging from arid and semiarid to tropical regions throughout the world. Among the cereals, sorghum is one of the far-reaching crops cultivated globally for food, fodder, feed, and fuel. The total production and productivity of sorghum are 4.77 million tons and around one ton per hectare, respectively from an area of 4.82 m ha (Indiastat, 2019-20).

Landraces are the varieties nurtured and cultivated by the farmers through traditional method of selection over the decades. The Biodiversity Act (2002) describes "landrace" as primitive cultivar that was grown by ancient farmers and their successors. This natural genetic diversity is under threat due to the destruction of habitats, commercial agricultural practices, industrial and infrastructural activities, and large-scale adoption of improved cultivars. Sorghum germplasm collections in Karnataka represents greater genetic diversity as the crops is being grown traditionally under varied agro climatic conditions in centuries. Most of the landraces are new versions of the past collections with natural crossing and selection and utilization of the accessions over the decades by the farming community. These land races with rare and useful alleles could serve as a potential donar for yield enhancement and also for developing varieties to withstand biotic and abiotic stresses in the semi-arid tropical regions.

In arid environments, crop varieties with early seedling vigor and good stand establishment tend to maximize use of available soil water, resistance to shoot fly, resulting in increased dry matter accumulation and improved grain yield (Ludlow and Muchow 1990). Seedling vigor in sorghum has been assessed by direct measurement of seedling dry weight, which was highly correlated to leaf area, leaf number, and plant height (Maiti *et al.,* 1981) and these characters used in the present study. Plant characteristics that are responsible for differences in early seedling vigor among and within plant species have not been fully explored and present study emphasis on this.

Choice of appropriate parents is crucial step in order to exploit hybrid vigour. The factors like *per se* performance of the parents and their combining ability influence on the selection of the parents. Approach of general and specific combining ability (Sprague and Tatum 1942) benefits the breeder in assessing many of the lines to be accompanied as parents in the advancement of hybrids and also in crossing program to architect new varieties. Superior grain quality (bold, white and sweeter taste) is found in few sorghum landraces and even today most of the farmers prefer to cultivate landraces of sorghum during *rabi*. In general sorghum landraces have low yields and needs improvement in this direction. Further recent trends in sorghum improvement indicate, need for the exploitation of combining ability for increased yield coupled with superior grain quality to meet the demands for *rabi* sorghum. Present study involves improvement of identified *rabi* sorghum landraces and to assess genetics of combining ability for these landraces with newly released varieties of *rabi* sorghum.

MATERIAL AND METHODS

The 64 entries were sown in the randomized block design with two replications; where each entry was sown in single row of 3 m length with inter row spacing of 45 cm and intra row spacing of 15 cm, in vertisol (medium deep black soil) under rain-fed condition at AICRP on Sorghum, University of Agricultural Sciences, Dharwad during *rabi* 2017-18. The recommended Fertilizer dose of 50:25:0 kg/ha of N, P_2O_5, K_2O was applied and agronomic practices were followed to raise crop. From each entry five competitive plants were tagged randomly and numbered for recording observations on early vigour and quantitative characters. Mean of the five plants for each entry was used for analysing line × tester method suggested by Kempthorne (1957). Seeds for the physical grain quality parameters were classified based on the scale given by Elongovan *et al.* (2004).

RESULTS AND DISCUSSION

The combining ability analysis of variance for the productivity and early vigour characters revealed presence of significant genotypic differences justifying further analysis. The entries differed significantly for the traits *viz.,* plant height, and number of leaves per plant, leaf length, grain yield and yield attributing traits. Crosses exhibited significant effects of variation for all the productive and early vigour characters at 5 per cent level of probability. The estimation of both *gca* and *sca* effects of parents and hybrids helps in identifying superior parents and crosses to be utilized for creation of variability in subsequent generations for exploitation of heterosis in desired direction through hybrid breeding.

In case of *rabi* sorghum fodder yield has equal importance along with grain yield, as most of the cultivars of *rabi* sorghum are grown for dual purpose. Among parents, Barsi Jowar was better *per se* performance with significant *gca* effects for fodder yield as well as for grain yield per plant indicating choice of the parents for hybridization to obtain useful segregants in early generations and utilization of these parents in developing dual purpose genotypes in *rabi* sorghum (Jain and Patel 2014). Similarly, the line, Kodmurki Local was good combiner for panicle breadth, panicle weight, grain yield per plant and number of leaves per plant. In case of early vigour at 60 days CSV- 216R was shown significant *gca* effects for the traits *viz.,* root collar diameter, plant height, number of leaves, leaf width, plant height and panicle length (Table 1 and 2). Since ear head weight, early vigour traits and grain yield per plant are significantly associated with each other in positive direction, improvement in these traits by exercising simple selection at early stage also results in simultaneous improvement of grain yield trait apart from other traits (Umakanth *et al.,* 2003; Deepalakshmi and Ganesamurthy 2007).

The genetic worth of the parents is decided on the basis of their combining ability and to produce better effects in F_1 hybrids. The *sca* effects of hybrids have been attributed to the combination of positive favourable genes from different parents. Out of 48 hybrids, CSV-216R × IS-4631 was shown apex significant positive *sca* effect for root collar diameter (0.23), plant height (34.20), leaf width (0.50) along with grain yield per plant (27.32) and 100 seed wt, (0.39) which signifies the positive association between the early vigour traits and grain yield and yield atrrubuting traits (Table 3 and 4). Out of the ten potential hybrids, exhibiting highest *sca* effects, Kodmurkhi Local × RSLG-23, Kodmurkhi Local × EC-8, Lakmapur Local × EC-8 and SPV-2333 × RSLG-23, interestingly these cross combinations had at least one of the parents with good general combining ability revealed advancement of crosses to isolate transgressive segregants. Several workers, Girma *et al.* (2010); Prabhakar *et al.* (2013); Murumkar *et al.* (2005); Prabhakar and Raut (2010); Jadhav and Deshmukh (2017); Dehinwal *et al.* (2017); Thakare *et al.* (2014) also reported positive significant *gca* and *sca* effects for grain yield and its components from their studies in *rabi* sorghum.

Grain quality plays a vital role in consumer preference *viz.*, grain colour, shape, hardiness and lusture are useful criteria for consumer preference and they show high heritability and stable expression. Further, association of any grain characters with yield components serve as phenotypic marker in selection process. The most important trait that consumer prefer and determines the market price is grain lusture and interestingly most of the hybrid genotypes obtained in the present study were lusturous. As many as 54.17 % of the genotypes had seeds with lustrous appearance followed by 37.5 % had intermediate and 8.33 % had non-lustrous appearance. When seed shape was considered as physical grain quality parameter most of hybrid genotypes having round (54.14 %) succeeded by oval (33.33 %), elliptical (6.28 %) and Sub-lenticular round but flat from other side (6.25 %). This result revealed that round grain shape was predominant among all the hybrids than the other shapes. The frequency of destitution is in accordance with Chaudhary *et al*. (2004). Human selection was reported as another important factor influencing the domination of certain landraces with particular grain colour (Ayana and Bekele 1999). Predominant proportion of study material with Light yellow and creamy straw colored grains in the present study indicates the role of human selection.

Table 1: Estimates of general combining ability (*gca*) effects of lines and testers for productive related traits in *rabi* sorghum.

Sr. No.	Lines/ Testers	Name of the genotypes	Plant height (cm)	Panicle Length (cm)	Panicle Breadth (cm)	Panicle Weight (g)	Grain yield per plant (g)	Fodder yield per plant (g)	100 seed wt. (g)
1.	L1	Barsi Jowar	14.12**	0.30	-0.04	-7.38*	5.81**	13.92*	-0.09
2.	L4	Kodmurki Local	-8.01	0.31	0.84**	13.38**	13.22**	0.93	-0.05
		C.D.@ 5%	8.08	0.615	0.26	6.58	3.61	11.84	0.10
3.	T1	EC-8	-2.10	1.51**	0.47**	2.31	7.33**	-0.09	-0.01
4.	T6	EC-15	3.41	-0.91**	0.02	5.90*	3.70*	4.03	-0.33**
		C.D.@ 5%	6.99	0.532	0.23	5.70	3.13	10.25	0.09

Table 2: Estimates of general combining ability (*gca*) effects of lines and testers for early vigour at 60 days in *rabi* sorghum.

Sr. No.	Parents	Root collar Diameter (cm)	Plant height (cm)	Number of leaves	Leaf length (cm)	Leaf width (cm)	SPAD value
1.	Kodmurki Local	0.06	-1.01	0.40*	-1.35	-0.15	-0.57
2.	CSV-216R	0.18**	13.95**	1.05**	-3.26**	0.23*	1.19
3.	SPV-2333	0.14**	-7.50	0.26	2.12*	0.83**	-3.54**
	C.D.@ 5%	0.08	7.72	0.38	2.07	0.18	2.09
4.	EP-83	0.06	-4.57	0.10	-1.76	0.31**	-0.20
5.	EC-15	0.07*	2.04	0.13	1.72	-0.41**	-0.26
	C.D.@ 5%	0.07	6.69	0.33	1.79	0.16	1.81

*- significant at 5 % level of probability; **- significant at 1 % level of probability

Table 3: Estimates of specific combining ability (*sca*) effects of crosses for productive related traits in *rabi* sorghum.

Sr. No.	Hybrids	Plant Height (cm)	Panicle Length (cm)	Panicle breadth (cm)	Panicle weight (g)	Grain yield per plant (g)	Fodder yield per plant (g)	100 seed wt. (g)
1.	Barsi Jowar × RSLG-23	-8.22	1.41	0.47	8.50	18.19**	10.14	0.37**
2.	Barsi Jowar × EP-83	4.20	1.56*	0.67*	10.13	9.96*	17.64	0.34**
3.	Madbhavi Local × IS- 3971	7.28	-1.18	0.60	25.80**	19.61**	23.14	-0.05
4.	Kodmurkhi Local × RSLG-23	7.23	1.36	-0.26	8.25	16.01**	23.14	-0.12
5.	Lakmapur Local × EC-8	5.55	1.03	1.22**	29.97**	19.59**	6.01	0.25
6.	SPV-2217 × EC-8	0.13	0.38	-0.70*	-32.21**	10.81*	-6.32	0.33**
7.	SPV-2217 × RSLG-23	9.56	0.43	0.88**	42.80**	17.17**	-10.20	0.11
8.	CSV-216R × IS-4631	12.38	1.03	0.32	41.94**	27.32**	19.78	0.39**
9.	CSV-216R × EP-83	-2.70	0.44	0.51	16.16*	17.00**	1.97	-0.03
10.	SPV-2333 × RSLG-23	9.09	1.25	1.09**	42.80**	21.16**	29.80*	0.32*
	C.D.@ 5%	19.79	1.51	0.64	16.12	8.85	29.00	0.24

Table 4: Estimates of specific combining ability (*sca*) effects related to early plant vigour at 60 days in *rabi* sorghum.

Sr. No.	Hybrids	Root collar Diameter (cm)	Plant height (cm)	Number of leaves	Leaf length (cm)	Leaf width (cm)	SPAD value
1.	Barsi Jowar × RSLG-23	0.09	1.45	0.28	1.41	0.86**	-0.37
2.	Barsi Jowar × EC-15	0.19	35.40**	0.82	1.56	0.55*	2.03
3.	Billigunda × IS-4631	-0.04	-0.89	-0.39	1.56	0.64**	4.25
4.	Madbhavi Local × IS-3971	0.26*	3.40	1.03*	-1.79	0.52*	-3.54
5.	Kodmurkhi Local × EC-8	0.11	18.17	1.09*	1.79	0.58*	-0.10
6.	Lakmapur Local × IS-4631	0.01	-7.69	-0.34	1.96	0.83**	-2.18
7.	Lakmapur Local × EP-83	0.23*	12.48	1.22*	-4.36	0.57*	-0.26
8.	SPV-2217 × IS- 3971	-0.03	14.98	-0.38	0.64	0.74**	2.34
9.	CSV-216R × IS-4631	0.23*	34.20**	0.54	2.02	0.50*	3.40
10.	CSV-216R × RSLG-23	0.08	-15.54	0.57	-0.48	0.62**	1.11
	C.D.@ 5%	0.20	18.92	0.92	5.08	0.44	5.12

*- significant at 5 % level of probability; **- significant at 1 % level of probability

Table 5: List of promising parents and hybrids identified for productive related traits in sorghum.

Sr. No.	Characters	Best general combiner in desired direction	Best specific combiner in desired direction
1.	Plant height (cm)	CSV-216R Lakmapur Local	Barsi Jowar × EC-15 Kodmurkhi Local × IS- 3971 Lakmapur Local × RSLG-23
2.	Panicle length (cm)	CSV-216R EC-8 SPV-2217	Billigunda × EC-15 SPV-2217 × IS- 3971 Madbhavi Local × RSLG-23
3.	Panicle breadth (cm)	Kodmurki Local EC-8	Kodmurkhi Local × EC-8 Lakmapur Local × EC-8 SPV-2333 × RSLG-23
4.	Panicle weight (g)	Kodmurki Local Madbhavi Local EC-15	SPV-2333 × RSLG-23 SPV-2217 × RSLG-23 CSV-216R × IS-4631
5.	Grain yield per plant (g)	Kodmurki Local EC-8	CSV-216R × IS-4631 SPV-2333 × RSLG-23 Madbhavi Local × IS- 3971
6.	Fodder yield per plant (g)	Barsi Jowar CSV-216R	Billigunda × IS- 3971 SPV-2333 × RSLG-23 SPV-2217 × IS-4631
7.	Hundred seed weight (g)	EP-83 Lakmapur Local RSLG-23	Billigunda × IS-4631 CSV-216R × IS-4631 SPV-2333 × EC-15

Table 6: List of promising parents and hybrids identified for early vigour traits at 60 days in sorghum.

Sr. No.	Characters	Best general combiner in desired direction	Best specific combiner in desired direction
1.	Root collar diameter(cm)	CSV-216R SPV-2333	Billigunda × EC-15 Madbhavi Local × IS- 3971 CSV-216R × IS-4631
2.	Plant height(cm)	Billigunda CSV-216R	Barsi Jowar × EC-15 CSV-216R × IS-4631 Barsi Jowar × EP-83
3.	Number of leaves	Kodmurkhi Local CSV-216R	Billigunda × EC-15 SPV-2217 × RSLG-23 SPV-2333 × EC-8
4.	Leaf length(cm)	Lakmapur Local SPV-2333	Lakmapur Local × IS- 3971 SPV-2333 × EC-15 CSV-216R × EC-8
5.	Leaf width(cm)	SPV-2333 EP-83	Barsi Jowar × RSLG-23 Lakmapur Local × IS-4631 SPV-2217 × IS- 3971
6.	SPAD values	Billigunda IS- 3971	Madbhavi Local × EC-8 Kodmurkhi Local × EP-83 Lakmapur Local × EC-8

CONCLUSIONS

The current study revealed that the Kodmurkhi local was the best general combiner for panicle breadth, panicle weight, and grain yield per plant along with number of leaves per plant. Similarly, CSV-216R was the best general combiners for plant height, panicle length, root collar diameter, plant height at 60 days, number of leaves and leaf width this signified positive correlation between early vigour traits and productivity related traits. Further these lines can be used as parent in hybridisation programme and to predict the hybrid performance at early stage of the crop (Table 5 and 6). Among the crosses, Kodmurkhi Local × RSLG-23, CSV-216R × IS-4631, Kodmurkhi Local × EC-8, Lakmapur Local × EC-8, SPV-2333 × RSLG-23, and SPV-2217 × RSLG-23 exhibiting significant *sca* effects, preferred grain shape (Round), grain color (yellow) and *per se* performance for the grain yield per plant can be advanced further to isolate transgressive segregants for grain yield and quality traits with advance of early vigour.

Authors' contribution. Conceptualization of research work and designing of experiments (STK, PK); Execution of field/lab experiments and data collection (PK, STK); Analysis of data and interpretation (STK, PK): Preparation of manuscript (PK).

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Conflict of Interest. None.

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