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Heterosis and Combining Ability Studies in Sweet Sorghum [*Sorghum bicolor* (L.) Moench] for Green Fodder Yield and Its Contributing Traits

T. Soujanya[1*], T. Shashikala[2] and A.V. Umakanth[3]

[1]Department of Genetics and Plant breeding, College of Agriculture, PJTSAU, Telangana, India
[2]AICRP on Forage Crops, ARI, Rajendranagar, Hyderabad, 500030, Telangana, India
[3]ICAR-Indian Institute of Millets Research, Hyderabad 500 030, Telangana, India
*Corresponding author

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A B S T R A C T

An experiment was conducted to exploit heterosis in F_1 hybrids of sweet sorghum (*Sorghum bicolor* L.) and to identify parents with desirable genetic effects with respect to single-cut green fodder yield and its component traits. 48 F_1 hybrids were evaluated to assess general and specific combining ability and gene action governing the green fodder yield and its attributing traits. Analysis of variance revealed the presence of sufficient variation in the experimental material. The SCA variance was greater in magnitude than GCA variance for most of the traits under study indicating predominance of non-additive gene action in the genetic control of those traits. Line 185A and testers RSSV138-1, RSSV466 and RSSV404 emerged as good general combiners for single-cut green fodder yield. Based on *sca* effects, 185A x RSSV466, 185A x RSSV138-1, PMS71A x RSSV138-1 and PMS71A x RSSV404 were identified as good specific combiners for green fodder yield and its attributing traits.185A x RSSV466 recorded maximum single-cut green fodder yield with 12.53 per cent heterosis over the best check CSV30F.

Introduction

Agricultural crops and livestock play a vital role in the national economy since they fulfill the basic needs of life. Agriculture accounts for 54.6% of total employment in India and contributes 15.2% of total GDP. Livestock occupies a crucial position in Indian agriculture and directly contributes 27% of agricultural GDP. India, with 2.29% of the world land area, is maintaining about 10.71% of world's livestock population. The number of milch animals has increased from 62 million in 2000 to 83.15 million in 2012 resulting in 4.04% year-on-year growth rate of milk (Livestock census, 2012).

Thus, to sustain this growth rate and for further expansion to meet the demands of ever growing human population, livestock needs sustainable supply of feed material.

The area under fodder cultivation is estimated to be about 4% of the gross cropped area which remained static for the last four decades. The available fodder production is less than the actual requirement. At present, the country faces a net deficit of 61.1% green fodder, 21.9% dry crop residues and 64% concentrate feeds (Dhananjoy, 2013). Moreover, livestock population survives to a large extent on crop residues, which are nutritionally poor.

In India, Sorghum (*Sorghum bicolor* (L.) Moench) is one of the most important forage crops grown widely in north western states and to a limited scale in central and southern states. Sorghum ranks first among the cereal fodder crops because of its growing ability in poor soil, faster growing habit, high yield potential, suitability to cultivate throughout the year, palatability, nutritious fodder quality, higher digestibility and various forms of its utilization. It gives uniform green fodder throughout the year and produces tonnage of dry matter having digestible nutrients (50%), crude protein (8%), fat (2.5%) and nitrogen free extracts (45%) (Azam *et al.*, 2010). The cultivated area under different forage crops is 4.4 per cent of the total area under cultivation, of which about 2.3 m ha is under forage sorghum (Anon., 2011).

Sweet sorghum, being a well-known crop can supply food, feed, fodder, fiber and fuel. However, it has not been studied much as a fodder crop. Sweet sorghum has high biomass production, high brix percentage, short duration, low water requirement and wider adaptability (Reddy *et al.*, 2005). Sweet sorghum hybrids have been reported to produce higher sugar yield (21%) and higher grain yield (15%) than non-sweet sorghum hybrids in the rainy season indicating that there is no trade-off between grain and sugar. The palatability and quality of forage will increase by increasing the sugar content of sorghum stalk. Therefore, the important goals of sweet sorghum forage breeding programs are to increase sweetness, leafiness and juiciness in sorghum (Poehlman, 2006) which can be achieved by developing fodder varieties/hybrids in sweet sorghum with high green fodder yield per unit area and time combined with superior quality. Therefore, the present study was undertaken to assess the general and specific combining ability for fodder yield and quality and to identify parents and crosses with desirable genetic effects and also to assess the possibility of commercial exploitation of heterosis for single-cut green fodder yield and quality through estimating of heterosis over better parent and standard check.

Materials and Methods

The present investigation involving four lines, namely 185A, ICS38A, 24A, PMS71A twelve testers PMS130, KR135, SSV74, SSVV84, NSSV14, RSSV138-1, RSSV404, RSSV466, IS18542, 6NRL, BNM16, UK81 and forty eight F_1 hybrids along with the standard check CSV30F were sown in randomized block design with three replications at the research farm of AICRP on Forage Crops, Agricultural Research Institute, Rajendranagar, Hyderabad, Telangana during kharif, 2016. Each entry was raised in two rows of 4 m length with a spacing of 30 cm between the rows and 10 cm between the plants with in the row. All the recommended agronomical practices under AICRP on sorghum were followed and plant protection measures were applied as and when required to ensure good crop. The observations were recorded on five randomly selected plants per each entry in each replication for days to 50 per cent flowering, plant height, number of leaves per plant, leaf length, leaf breadth, number of nodes per plant, internodal length, stem girth, leaf to stem ratio, green fodder yield. Mean of five plants for each entry for each character was calculated and the data was analyzed statistically using the software WINDOSTAT version 8.1.

Results and Discussion

Analysis of variance for combining ability revealed that parents and crosses differed significantly for all the characters studied (Table 1). The mean squares due to lines and testers were significant for most of the characters. Estimates of mean squares for lines and testers revealed the presence of great deal of diversity among the parents with respect to fodder yield and yield contributing traits. The mean squares due to Lines vs Testers were significant for all the characters. This revealed that lines and testers interacted and pronounced different heterotic effects. This could be due to the fact that parents used in this investigation had considerable genetic variability. Analysis of variance for combining ability for yield and yield components indicated that general combining ability (GCA) and specific combining ability (SCA) mean squares were highly significant for all the characters.

The magnitude of *sca* variance is higher than that of *gca* variance for all the traits under study except days to 50 per cent flowering (Mohammed, 2009), (Table 2) and revealed that non additive gene action was predominant in the inheritance of green fodder yield and its component traits. Similar observations were also reported by Bhatt and Bhasketi (2011), Kamdi *et al.,* (2011), Akbari *et al.,* (2013) and Tariq *et al.,* (2014).

The range of standard heterosis of different characters along with number of significant crosses are presented in the Table 3. In the present study, magnitude of heterosis varied from cross to cross for all the characters studied. Standard heterosis is the most effective parameter amongst the three parameters of heterosis. In the present investigation, well known variety CSV30F is used as standard check to get the information on superiority of the crosses. Considerable amount of heterosis was observed for green fodder yield and its component traits. The results revealed presence of heterosis for majority of the traits under study. The hybrid, 185A x RSSV466 exhibited high estimates of standard heterosis for green fodder yield and also showed heterosis in desirable direction for characters like for days to 50 per cent flowering and leaf breadth. Hybrid 27A x RSSV138-1 showed heterosis in desirable direction for characters like, plant height, leaf breadth, internodal length and stem girth. 185A x RSSV138-1 showed heterosis in desirable direction for number of leaves per plant and leaf breadth, 27A x RSSV466 showed heterosis in desirable direction for days to 50 per cent flowering, number of leaves per plant and leaf breadth. ICS38A x IS18542 showed heterosis in desirable direction for leaf length, leaf breadth and internodal length.

In the present study, hybrid 185A x RSSV466 exhibited highest significant positive heterosis of 12.53 per cent over the best check with highest green fodder yield of 62.47 t ha^{-1}. In addition, the hybrid also exhibited significant heterosis in desirable direction for days to 50 per cent flowering and leaf breadth.

The general combining ability effects of lines and testers are presented in the Table 4. Among the parents, 185A showed significant *gca* effects in desirable direction for days to 50 per cent flowering, green fodder yield leaf breadth and stem girth. RSSV138-1 was found good general combiner for green fodder yield, plant height, number of leaves per plant, leaf length, leaf breadth and number of nodes per plant. RSSV466 showed high significant desirable *gca* effects for days to 50 per cent flowering, green fodder yield, plant height, leaf breadth and number of nodes per plant. RSSV404 showed high significant desirable *gca* effects for green fodder yield, plant height, number of leaves per plant, number of nodes per plant and leaf to stem ratio. High GCA values of parents RSSV138-1, RSSV466, RSSV404 and 185A for green fodder yield and its contributing traits indicated that these parents had favourable genes, therefore could be better choices for improvement of forage yield and component traits through hybridization.

Table.1 Analysis of variance for green fodder yield and yield components in sweet sorghum

Source of variation	d.f.	Days to 50% flowering	Plant height	No of leaves /plant	Leaf length	Leaf breadth	No of nodes / plant	Internodal length	Stem girth	Leaf to stem ratio	Green fodder yield
Replications	2	1.764	1.515	0.226	47.738	0.016	0.004	0.231	0.003	0.094	4.876
Crosses	47	186.541**	2410.438**	5.038**	172.985**	1.022**	2.529**	18.689**	0.692**	15.002**	262.145**
Lines	3	1316.206	11776.320**	4.326	796.594**	3.998**	7.325**	40.188**	3.275**	80.357**	733.290**
Testers	11	216.647	3870.859**	14.313**	143.020	0.654	4.742**	43.525**	1.067**	12.968	456.227**
Line*Tester	33	73.809**	1072.188**	2.011**	126.281**	0.889**	1.356**	8.456**	0.333**	9.739**	154.619**
Error	94	16.255	1.218	0.135	46.732	0.010	0.015	0.129	0.011	0.274	7.155
Total	143	51.911	793.064	1.748	88.242	0.343	0.841	6.230	0.235	5.112	90.931

***significant at 5% level, **significant at 1% level

Table.2 Estimation of general and specific combining ability variances for green fodder yield and its components in sweet sorghum

Source of variation	Days to 50% flowering	Plant height	No of leaves /plant	Leaf length	Leaf breadth	No of nodes /plant	Internodal length	Stem girth	Leaf to stem ratio	Green fodder yield
σ^2gca	**31.302**	**325.591**	**0.383**	**18.115**	**0.0961**	**0.251**	**1.737**	**0.090**	**1.931**	**24.478**
σ^2sca	**19.544**	**354.258**	**0.625**	**30.408**	**0.289**	**0.447**	**2.765**	**0.105**	**3.141**	**49.114**
σ^2gca / σ^2sca	**1.60**	**0.919**	**0.612**	**0.602**	**0.331**	**0.561**	**0.628**	**0.857**	**0.614**	**0.498**

Table.3 The range of standard heterosis and number of crosses showing significant heterosis for various traits in sweet sorghum

Characters	Range of heterosis	Noumber of hybrids having significant heterotic effect	
		+ve	**-ve**
Days to 50% flowering	-14.23 to 15.81 (185A x RSSV466)	16	14
Plant height (cm)	-38.41 to 6.22 (27A x RSSV138-1)	2	44
No of leaves /plant	-35.83 to 11.53 (185A x RSSV138-1)	3	43
Leaf length (cm)	-45.80 to 11.15 (ICS38A x IS18542)	8	16
Leaf breadth (cm)	-12.18 to 23.69 (185A x RSSV466)	31	2
No of nodes /plant	-34.33 to 0.89 (PMS71A x RSSV404)	1	47
Internodal length	-29.84 to 11.55 (PMS71A XPMS130)	2	41
Stem girth	-26.54 to 7.02 (27A x BNM16)	3	31
Leaf to stem ratio	-36.32 to 0.82 (ICS38A x KR135)	1	45
Green fodder yield (t/ha)	-67.53 to 12.53 (185A x RSSV466	1	47

Table.4 General combining ability effects of parents for green fodder yield and yield components in sweet sorghum

Genotype	Days to 50% flowering	Plant height (cm)	No. of leaves /plant	Leaf length (cm)	Leaf breadth (cm)	No. of nodes /plant	Internodal length (cm)	Stem girth (cm)	Leaf to stem ratio	Green fodder yield (t/ha)
185A	-8.425**	-22.586**	-0.182**	-6.944**	0.440**	-0.605**	-0.570**	0.311**	-0.071	6.120**
ICS38A	3.025	-1.753**	0.123*	3.361**	-0.030	0.151**	-0.711**	-0.023	2.133**	-4.604**
27A	-0.036	21.443**	0.423**	2.270*	-0.049*	0.470**	1.562**	0.114**	-0.939**	0.052
PMS71A	5.436**	2.896**	-0.365**	1.313	-0.362**	-0.016	-0.282**	-0.403**	-1.123**	-1.568**
SE (lines)	0.9182	0.7232	0.0873	1.3956	0.0328	0.0960	0.0942	0.0328	0.1325	0.6358 0266+
PMS130	-4.525	-31.218**	-1.265**	-2.940	-0.034	-1.170**	-1.983**	0.116**	1.260**	-1.313
KR135	-2.025	-25.385**	-0.487**	-0.374	-0.044	-0.672**	-1.854**	0.326**	1.312**	-3.921**
SSV74	1.933	2.345**	-0.078	0.598	-0.118**	0.066	-1.518**	-0.242**	-1.005**	-5.134**
SSV84	4.158**	-20.195**	-0.556**	-2.549	-0.224**	0.068*	-1.498**	-0.655**	-0.273	-7.210**
NSSV14	1.775	5.460**	-0.739**	-4.365*	-.284**	0.053	-1.333**	-0.174**	-1.238**	-2.694*
RSSV138-1	7.317**	29.555**	2.550**	8.048**	0.147**	1.146**	0.936**	-0.074	-1.441**	4.586**
RSSV404	0.075	17.375**	0.736**	1.516	0.047	0.793**	2.045**	0.005	0.562**	8.023**
RSSV466	-6.425**	6.689**	-0.002	-3.959*	0.474**	0.121**	3.350**	0.076	-0.039	11.874**
IS18542	4.658**	5.872**	1.545**	2.771	0.233**	0.507**	-0.374**	0.377**	0.690**	-5.053**
6NRL	-4.842**	14.251**	-0.557**	1.706	0.171**	-0.161**	2.826**	0.336**	-0.458**	-4.614**
BNM16	-3.008	-5.307**	-0.470**	0.991	-0.049	-0.518**	0.602**	0.142**	1.473**	6.430**
UK81	0.908	0.560	-0.677**	-1.444	0.316**	-0.097**	-1.197**	-0.231**	-0.844**	-0.973
SE (testers)	1.5903	1.2526	0.1512	2.4172	0.0568	0.0480	0.1632	0.0569	0.2296	1.1012

*significant at 5% level, **significant at 1% level

Table.5 Specific combining ability effects for for green fodder yield and yield components in sweet sorghum

Genotype	Days to 50% flowering	Plant height (cm)	No of leaves /plant	Leaf length (cm)	Leaf breadth (cm)	No of nodes/plant	Internodal length (cm)	Stem girth (cm)	Leaf to stem ratio	Green fodder yield (t/ha)
185A x PMS130	1.125	16.305**	0.767**	1.283	0.061	0.681**	0.678**	-0.107	-3.349**	-9.080**
185A x KR135	3.292	-9.954**	-1.007**	-2.374	-0.982**	-0.327**	-1.038**	-0.371**	-1.494**	-2.915
185A x SSV74	0.067	-42.158**	-1.479**	1.561	-0.438**	-1.031**	-1.290**	-0.200*	-0.177	0.645
185A x SSV84	-2.158	-20.241**	-0.968**	-3.205	-1.262**	-1.201**	-1.555**	-0.170*	-0.566	0.987
185A x NSSV14	-3.308	-18.806**	0.182	-20.292**	0.848**	0.435**	-1.259**	0.616**	1.989**	6.198**
185A x RSSV138-1	12.017**	22.756**	1.576**	10.698**	0.314**	0.379**	3.759**	0.349**	-0.181	-10.809**
185A x RSSV404	-3.742	-10.888**	0.140	2.926	0.300**	-0.011	-1.404**	0.070	1.530**	-0.480
185A x RSSV466	0.758	31.882**	1.078**	7.315*	0.170*	0.730**	1.925**	-0.211*	0.231	12.473**
185A x IS18542	-7.992**	-2.752	-1.303**	-4.089	-0.086	-0.175*	0.692**	-0.112	1.235**	-3.640*
185A x6NRL	2.842	27.236**	0.367	6.774	0.470**	1.392**	0.322	-0.061	1.186**	3.958*
185A x BNM16	0.008	7.894**	0.296	-2.849	0.266**	-0.131	-1.488**	-0.121	-1.105**	-5.986**
185A x UK81	-2.908	-1.273	0.352	2.253	0.340**	0.131	0.658**	0.316**	0.702*	8.650**
ICS38A x PMS130	-1.258	16.672**	-0.080	-2.121	-0.262**	-0.372**	1.029**	0.203*	0.328	15.547**
ICS38A x KR135	-2.425	-7.360**	-0.275	-2.288	-0.049	-0.427**	-0.067	0.100	0.622	-4.605**
ICS38A x SSV74	-5.617*	17.875**	0.963**	-8.110*	0.212**	0.505**	-0.666**	0.308**	0.180	3.308*
ICS38A x SSV84	0.725	-5.950**	0.960**	4.571	0.531**	1.409**	-1.787**	0.067	-0.483	-2.163
ICS38A x NSSV14	4.108	4.761**	-0.066	9.537**	-0.149	-0.592**	2.476**	0.190*	-1.881**	-2.505
ICS38A x RSSV138-1	-6.133**	-32.944**	-1.005**	-6.056	0.107	0.025	-1.620**	-0.117	0.909**	-2.855
ICS38A x RSSV404	-2.192	-6.527**	-1.221**	-4.178	-0.030	-0.428**	-0.529*	-0.323**	-0.247	0.651
ICS38A x RSSV466	3.975	-15.068**	-0.333	-3.269	-0.450**	-0.496**	-2.994**	0.089	-0.263	-7.387**
ICS38A x IS18542	3.558	-1.518	1.490**	9.964**	0.560**	0.115	0.850**	0.148	-1.282**	2.623
ICS38A x x6NRL	4.058	14.103**	0.015	2.999	-0.107	-0.178*	1.890*	-0.133	-1.394**	0.102
ICS38A x BNM16	2.558	1.428	-0.092	-1.893	-0.314**	-0.125	0.613**	-0.180*	3.308**	0.837
ICS38A x UK81	-1.358	14.528**	-0.355	0.845	-0.050	0.565**	0.806**	-0.353**	0.202	-3.553*
27A x PMS130	-4.864*	-7.877**	-0.598**	4.213	1.058**	0.093	0.093	0.187*	0.670*	1.157
27A x KR135	-4.031	12.651**	0.625**	0.903	0.65**	0.481**	0.430	0.387**	0.598	11.432**
27A x SSV74	3.344	10.990**	0.139	5.868	-0.155	0.733**	0.785**	-0.402**	1.192**	-2.222
27A x SSV84	1.119	27.254**	0.527*	1.879	0.478**	0.323**	1.114**	0.094	-0.517	-1.972
27A x NSSV14	2.169	0.066	0.020	6.621	0.892**	0.683**	-1.804**	-0.687**	0.138	-1.618
27A x RSSV138-1	1.294	7.537**	0.187	-3.879	-0.130	-0.557**	-1.760**	-0.037	-0.272	-1.942
27A x RSSV404	8.869**	11.751**	1.002**	-3.221	-0.120	-0.550**	0.491*	-0.239**	-1.942**	-8.879**
27A x RSSV466	-2.297	-6.763**	-0.237	-3.758	0.139	0.062	1.893**	0.303**	2.216**	-3.703*
27A x IS18542	5.953**	-0.247	-0.474*	-2.124	-0.610**	0.073	-0.650**	-0.235**	-3.537**	1.427
27A x 6NRL	-6.881**	-31.693**	-0.472*	-9.253**	-0.044	-0.703**	-1.640**	0.173*	1.961**	3.058
27A x BNM16	-5.381*	-7.334**	-0.526*	-4.081	0.049	0.193**	1.774**	0.653**	-0.453	7.318**
27A x UK81	0.703	-16.334**	-0.103	-1.041	-0.424**	-0.831**	-0.727**	-0.197*	-0.052	-4.056*
PMS71A x PMS130	4.997*	-25.100**	-0.089	-3.374	-0.857**	-0.402**	-1.800**	-0.283**	2.350**	-7.623**
PMS71A x KR135	3.164	4.664**	0.657**	3.759	0.380**	0.273**	0.674**	-0.116	0.275	-3.911*
PMS71A x SSV74	2.206	13.293**	0.377	0.681	0.381**	-0.207**	1.172**	0.295**	-1.195**	-1.731
PMS71A x SSV84	0.314	-1.063	-0.518*	-3.245	0.253**	-0.531**	2.228**	0.008	1.566**	3.148*
PMS71A x NSSV14	-2.969	13.979**	-0.135	4.134	0.193*	0.345**	0.587*	-0.119	-0.245	-2.075
PMS71A x RSSV138-1	-7.178**	2.651	-0.758**	-0.762	-0.291**	0.153*	-0.379	-0.196*	-0.455	15.605**
PMS71A x RSSV404	-2.936	5.664**	0.080	4.473	-0.151	0.989**	1.442**	0.491**	0.659*	8.708**
PMS71A x RSSV466	-2.436	-10.050**	-0.418	-0.288	0.142	-0.296**	-0.823**	-0.180*	-2.184**	-1.383
PMS71A x IS18542	-1.519	4.517*	0.287	-3.462	0.136	-0.012	-0.892**	0.199*	3.584**	-0.410
PMS71A x x6NRL	-0.019	-9.646**	0.090	-0.520	-0.318**	-0.511**	-0.572*	0.021	-1.752**	-7.118**
PMS71A x BNM16	2.814	-1.988	0.322	0.661	-0.002	0.063	-0.899**	-0.353**	-1.750**	-2.169
PMS71A x UK81	3.564	3.079	0.106	-2.057	0.135	0.135*	-0.737**	0.234**	-0.852*	-1.042
SE (crosses)	3.1806	2.5051	0.3024	4.8344	0.1137	0.0960	0.3264	0.1137	0.4591	2.2024

*****significant at 5% level, **significant at 1% level

Table.6 Top ranking desirable crosses for *sca* effects with their *per se* performance

Character and Cross	Predominant gene action	Values of *sca* effects	*gca* status of parents	Values of *gca* effects of parents		*Per se* performance
				P -1	P - 2	
Days to 50 % flowering	Additive					
185A x IS18542		-7.992	H x L	-8.425	4.658	74.67
PMS71A x RSSV138-1		-7.178	L x L	5.436,	7.317	92
27A x 6NRL		-6.881	L x H	-0.036	-4.84	74.67
ICS38A x RSSV138-1		-6.133	L x L	3.025	7.317	90.67
Plant height (cm)	Non additive					
185A x RSSV466		31.882	L x H	-22.586	6.689	246.78
27A x SSV84		27.254	H x L	21.443	-20.195	259.30
185A x 6NRL		27.236	L x H	-22.586	14.251	249.70
185A x RSSV138-1		22.756	L x H	-22.586	29.55	260.52
Number of leaves /plant	Non additive					
185A x RSSV138-1		1.576	L x H	-0.182	2.550	13.38
ICS38A x IS18542		1.490	H x H	0.123	1.545	12.60
185A x RSSV466		1.078	L x L	-0.182	-0.002	10.33
Leaf length (cm)	Non additive					
185A x RSSV138-1		10.698	L x H	-6.994	8.048	88.80
ICS38A x IS18542		9.964	H x L	3.361	2.771	93.10
ICS38A x NSSV14		9.537	H x L	3.361	-4.365	85.53
185A x RSSV466		7.315	L x L	-6.994	-3.959	73.41
Leaf breadth (cm)	Non additive					
27A x PMS130		1.058	L x L	-0.049	-0.034	7.95
27A x NSSV14		0.892	L x L	-0.049	-0.284	5.75
185A x NSSV14		0.848	H x L	0.440	-0.284	7.98
Number of nodes/plant	Non additive					
ICS38A x SSV84		1.409	H x H	0.151	0.068	10.51
185A x 6NRL		1.392	L x L	-0.605	-0.161	9.65
PMS71A x RSSV404		0.989	L x H	-0.016	0.793	10.79
Internodal length (cm)	Non additive					
ICS38A x RSSV466		-2.994	H x L	-0.711	3.350	22.14
27A x NSSV14		-1.804	L x H	1.562	-1.333	20.92
PMS71A x PMS130		-1.800	H x H	-0.282	-1.983	18.43
27A x RSSV138-1		-1.760	L x L	1.562	0.936	23.23
Leaf to stem ratio	Non additive					
PMS71A x IS18542		3.584	L x H	-1.123	0.690	0.204
ICS38A x BNM16		0.653	H x H	2.133	1.473	0.241
PMS71A x PMS130		2.350	L x H	-1.123	1.260	0.197
27A x RSSV466		2.216	L x L	-0.939	-0.039	0.184
Stem girth (cm)	Non additive					
27A x BNM16		0.653	H x H	0.114	0.142	2.50
185A x NSSV14		0.616	H x L	0.311	-0.174	2.44
Green fodder yield	Non additive					
PMS71A x RSSV138-1		15.605	L x H	-1.568	4.586	50.63
ICS38A x PMS130		15.547	L x L	-4.604	-1.313	41.63
185A x RSSV466		12.473	H x H	6.120	11.874	62.47

P-1: Parent-1; P-2: Parent-2

Based on the sca effects (Table 5), the hybrid 185A x RSSV466 exhibited significant SCA effects in desirable direction for green fodder yield, plant height, number of leaves per plant, leaf length, leaf breadth and number of nodes per plant. 185A x RSSV138-1 exhibited significant SCA effects in desirable direction for plant height, number of leaves per plant, leaf length, leaf breadth, number of nodes per plant and stem girth. 185A x RSSV404 exhibited significant SCA effects in desirable direction for leaf breadth, intermodal length and leaf to stem ratio. PMS71A x RSSV138-1 exhibited significant SCA effects in desirable direction for green fodder yield, days to 50 per cent flowering, number of nodes per plant. PMS71A x RSSV404 showed significant SCA effects in desirable direction for green fodder yield, plant height, number of nodes per plant, stem girth and leaf to stem ratio. 27A x KR135 showed significant SCA effects in desirable direction for green fodder yield, plant height, number of leaves per plant, leaf breadth, number of nodes per plant and stem girth.

Overall, the cross combinations 185A x RSSV466, 185A x RSSV138-1, PMS71A x RSSV138-1 and PMS71A x RSSV404 exhibited highly significant SCA effects in desirable direction coupled with high *per se* performance for green fodder yield, and other yield contributing characters *viz*., days to 50 per cent flowering, plant height, number of leaves per plant, leaf length and leaf breadth (Table 6). These combinations were derived from High x High and Low x High combiners indicating the presence of complementary or dominance gene action in the direction of additive effects of good performer. So, these cross combinations could be used in forage sorghum improvement programme.

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