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COMBINING ABILITY FOR BIOLOGICAL YIELD AND HARVEST INDEX IN SORGHUM

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ABSTRACT

Six newly developed ms lines alongwith a standard ms line were crossed with five restorers. The resulting 35 crosses were evaluated for grain yield, dry fodder yield, biological yield and harvest index (HI) on plot basis. Heterosis over ms lines varied from 109 to 147% for yield characters and 9.2% for HI. Over restorers, heterosis was 84% for grain yield, 32% for biological yield, and 44% for HI. These characters were governed by both additive and nonadditive gene action but the proportion of additive genetic variance was higher for HI. Heritability was 32% for grain yield, 50% for fodder and biological yields, and 61% for HI. Estimates of σ^2gca of new ms lines were higher than testers for grain yield and HI. New ms lines will, therefore, be more useful to exploit additive genetic variance for developing future hybrids. MS 340A and SPV 603 were good general combiners for grain and biological yields, while ms 340A, 450A and SPV 467 were good combiners for HI. Hybrids with high HI can be bred by using lines already improved for this trait.

Key words: New ms lines, biological yield, harvest index, heterosis, combining ability, heritability.

The exploitation of dwarfing genes in sorghum has transformed tropical tall cultivars in India into more productive forms. The first commercial hybrid (CSH 1) released in India is dwarf and does not meet the fodder requirement. The high yielding hybrids developed subsequently are better than CSH 1 in per day production [1]. Productivity can be further improved by enhancing the biomass production without losing the harvest index [2]. Thus, studies on the inheritance of biological yield and harvest index (HI) are conducted to reorient the breeding programme for developing high yielding and dual purpose hybrids.

MATERIALS AND METHODS

Six male sterile (ms) lines recently developed were used in this study. The ms 151A, 159A, 340A and 450A lines were dwarf, while 162A and 230A were medium tall. These lines along with a standard ms line 2077A were crossed with five restorer lines of different height. The restorer parents RS 1 and SPV 467 are dwarf, SPV 351 was recently released as CSV 11, and SPV 475 is a high yielding experimental

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variety. SPV 603 is a dual purpose medium tall variety. The resulting 35 F_1 hybrids and their 12 parents were planted in RCBD with three replications, but the parents and hybrids were grouped separately. The crop was grown as rainfed during 1985 rainy season. The seasonal rainfall was 422 mm which is below normal. One irrigation was given after a long spell of drought at grain maturity stage. The fertilizer dose was uniformly applied @ 100 kg N + 50 kg P_2O_5/ha. Two rows of 3 m length constituting 3.6 m^2 plot size were harvested to estimate plot yield and HI. Spacings within and between rows were 14 and 60 cm, respectively, resulting in about 42 plants per plot. Samples taken from air-dried stalks were further dried for 6 h at 60°C in oven to record dry fodder weight. Biological yield was estimated as total dry weight of fodder and panicles.

Combining ability analysis was done according to [3]. Correlation coefficients among different characters were also estimated.

RESULTS

Significant variation among parental lines as well as hybrids was observed for yield characters and HI (Table 1). The range and mean of ms lines for grain, fodder, and total biological yields were comparatively smaller than that of restorer parents and hybrids. Their HI was better than the restorer parents. The highest HI (37.4%) was recorded in ms 450A. All the new ms lines were better than the standard ms 2077A for grain yield and HI. However, ms 151A, 340A and 450A produced less biological yield. Among male parents, SPV 351 and SPV 475 were significantly higher in grain yield and harvest index as compared to others. SPV 603 produced more biological yield. Among hybrids, 340A×SPV 603 gave the highest grain yield of 53.85 q/ha. Other promising hybrids with the range of 47–50 q grain/ha were 450A×SPV 475, 340A×RS 1, 159A×SPV 603, and 340A×SPV 351.

Table 1. Variation in parental lines and hybrids for yield and harvest index

Entry	Parameter	Yield (q/ha)			Harvest
		grain	dry fodder	biological	index (%)
ms lines	Range	7.3–21.6	23.4–54.0	37.0–80.2	26.0–37.4
	Mean	15.7	35.8	57.1	30.2
Restorers	Range	14.5–30.9	46.5–101.1	66.5–122.2	16.2–33.0
	Mean	21.0	69.1	90.6	22.6
Hybrids	Range	28.8–53.8	46.5–110.5	84.0–176.1	23.0–40.6
	Mean	38.7	72.3	119.3	33.0
	Heterosis over ms lines (%)	147.0	101.8	108.9	9.2
	Heterosis over restorers (%)	84.1	4.7	31.7	45.9
	SE	3.5	6.4	10.1	1.8

Hybrids were superior to either parents for all the characters. Average heterosis over ms lines ranged from 9.2% for HI to 147% for grain yield. It was 101.8 and

108.9% for fodder and total biological yields, respectively. Average heterosis over the restorer parents ranged from 4.7% for fodder yield to 84% for grain yield.

The correlation coefficients of grain yield with fodder yield (X_1) and total biological yield (X_2) in hybrids were found to be 0.53** and 0.69**, respectively. These correlations were also positive but slightly higher in parents. Fodder yield and total biological yield were highly correlated in parents (r=0.96**) and hybrids (r=0.70**), but these traits were negatively correlated with HI (X_3). The multiple regression equations were estimated as: in hybrids $Y=-1.439+0.209^{**}$; $X_1+0.185^{**}$; $X_2+0.045^{**}$ X_3, and in parents $Y=-1.007+0.042$, $X_1+0.261^{*}$; $X_2+0.033^{**}$ X_3. These equations indicated that high HI is coupled with high biological yield in parents, and along with high fodder and biological yields contribute to high grain yield in hybrids.

Table 2. ANOVA for combining ability for yield and harvest index

Source	d.f.	M. S			
		grain yield	dry fodder yield	biological yield	harvest index
Hybrid	34	0.18**	1.09**	1.88**	59.11**
Line effect (L)	6	0.32**	1.12**	1.64**	128.19**
Tester effect (T)	4	0.29**	3.84**	5.89**	157.81**
L×T interaction	24	0.13**	0.62**	1.22**	25.38**
Error	68	0.06	0.19	0.40	9.80
Heritability	—	31.8	50.1	50.0	60.7

**Significant at 1% level.

There were significant differences among hybrids as well as the lines and tester for all the characters (Table 2). Thus, combining ability effects of ms lines (ms) as well as testers (restorers) were significantly different. The specific combining ability effects of crosses were also significantly different.

The general combining ability (gca) effects revealed that 340A among ms lines and SPV 603 among restorers were the best general combiners for grain yield (Table 3). RS 1 and 151A were poorest combiners, while other parental lines were average combiners for grain yield. The gca effects of ms 162A, 230A, 2077A and SPV 603 for fodder yield were positive and significant. However, gca effects of 340A and SPV 603 for biological yield were only significant and positive. The good general combiners for harvest index were ms 340A, 450A, SPV 467 and SPV 475. MS 159A and SPV 351 were average combiners for HI.

DISCUSSION

The tropical tall varieties have great potential for dry matter production as compared to the temperature dwarf cultivars but their productivity is fairly low [2]. Higher biomass production in these local varieties could not be of much consequence for increasing grain production. The use of temperate germplasm enabled us to increase HI of the derivatives of temperate×tropical crosses [2, 4]. This has been mainly due to reduction in vegetative growth and biological yield per se. The earlier released improved varieties and hybrids represented such changes. It was, however, observed that further increase in total biomass production without changing HI would help in developing high yielding hybrids.

Table 3. Combining ability effects

Parents	Plot yield			Harvest index (%)
	grain	dry fodder	biological	
ms line (L)				
151A	−0.189**	−0.382**	−0.616**	0.03
159A	0.001	−0.080	−0.093	0.39
162A	−0.031	0.244*	0.195	−2.30**
230A	−0.016	0.291*	0.227	−1.70*
340A	0.272**	−0.083	0.366*	4.48**
450A	0.077	−0.266*	−0.184	2.90**
2077A	−0.114	0.275*	0.105	−3.81**
Restorer (T)				
RS 1	−0.158**	−0.088	−0.191	−2.18**
SPV 351	−0.068	−0.299**	−0.400**	1.31
SPV 467	0.002	−0.267**	−0.288*	1.18**
SPV 475	0.088	−0.091	−0.039	2.24**
SPV 603	0.136**	0.745**	0.918**	−3.66**
SE (L)	0.063	0.112	0.163	0.808
SE (T)	0.053	0.095	0.138	0.683

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

Constant efforts have been made to improve the parental lines for grain yield and HI. The restorer line showed higher yield potential as compared to the new ms lines but the latter had higher HI. The ms lines 340A and 450A are better than 2077A in per se performance as well as gca. These ms lines can be used to develop high yielding hybrids with high HI. SPV 603, a medium tall restorer, combined well for grain, fodder and biological yields. It would be useful for developing dual purpose hybrids.

Heterosis for yield in crosses between new ms lines and restorer parents was governed by both additive and nonadditive genes, but the proportion of additive genetic variance was less than nonadditive genetic variance. Grain yield has low heritability (h^2=32%) as compared to fodder (h^2=50%) and biological (h^2=61%) yields. Earlier studies on the inheritance of grain and fodder yield per plant revealed that these characters are mainly governed by nonadditive genes [5–7]. However, constant improvement of parental lines for grain yield and plant type has increased the proportion of additive genes, as was also observed by [8].

The information on the inheritance of biological yield and HI in sorghum is not available. The present study suggests that both additive and nonadditive genes govern these characters with 50% and 61% heritability, respectively. Higher proportion of additive genetic variance as compared to nonadditive variance for HI is a desirable feature. The hybrids with high HI can be bred by using the lines already improved for this trait.

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