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Research Article

Genetic variability studies for stay green and different yield attributing traits in Sorghum

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Abstract
The present study was carried to identify the nature and extend of variability present for stay green and other twelve grain yield attributing traits in the F_3 populations of five sorghum crosses *viz.,* K8 × IS18551, CO26 × IS18551, CO26 × B35, CO30 × IS18551 and CO30 × B35. The high mean value coupled with moderate variability was observed for stay green trait in cross CO26 × IS18551 and leaf chlorophyll index, flag leaf length, panicle length, panicle weight and single plant yield in cross CO26 × B35. In cross CO 30 × IS18551, high mean value along with high variability was observed for biological yield and moderate variability for stem girth and number of leaves per plant. High heritability with high genetic advance as per cent of mean indicates that the heritability is due to additive gene effects and selection may be effective. This was observed for grain yield and maximum number of yield contributing traits *viz.,* plant height, number of leaves per plant, panicle length, leaf chlorophyll index, stem girth, stay green trait and biological yield in cross CO26 × B35. Hence among the five crosses, CO26 × B35 considered as a best cross for further evaluation.

Key words
Stay green trait, Heritability, Genetic advance, Additive gene effects

Introduction

In worldwide, Sorghum is the fifth important cereal and third important in India after rice and wheat. Often it referred as poor man's crop since being staple food for millions of poor in semi arid tropics of Africa and Asia. The major problem in sorghum cultivation is post flowering drought which drastically reduces its yield. This problem can be circumvent by the introgression of gene responsible for stay green trait which directly associates with post flowering adaptation (Tuinstra *et al.,* 1997; Kebede *et al.,* 2001). For crop improvement, creating variability is the prime objective by effecting crosses between diverse parents fallowed by selection. Biometric parameters include estimation of genetic variability fallowed by heritability helps to predict the expected advance from selection. Genetic advance is yet another parameter for knowing the quantum of desired genes transferred to the progenies. Hence, the present investigation was taken to select the promising segregants which are having drought tolerant ability along with high yield from the F_3 populations of sorghum.

Materials and Methods

The present investigation was carried out at the Department of Millets, Tamil Nadu Agricultural University, Coimbatore during *Kharif* season of 2014-2015. The experimental materials used in this study consisted of three female parents *viz.,* CO30, CO26 and K8 and two male parents *viz.,* IS18551 and B35. Five crosses *viz.,* K8 × IS18551, CO26 × IS18551, CO26 × B35, CO30 × IS18551 and CO30 × B35 were made for this study. The parents and 50 families of each cross were raised in a field with a spacing of 45 × 15 cm and agronomic practices were carried out as per the recommendations. Observations on 14 traits *viz.,* days to flowering, plant height, number of leaves per plant, leaf chlorophyll index, flag leaf length, flag leaf width, stem girth, panicle length, panicle weight, biological yield, test weight, harvest index, stay green trait, single plant yield were recorded and plants were selected based on phenotypic superiority in each cross of F_3 and ten randomly selected plants in parents. Wanous *et al.* (1991) reported the visual ratings of stay-green trait in sorghum. The mean and variability of both parents and F_3 populations were worked out. The variation was analyzed in terms of variance, standard deviation, standard error and coefficient of variation by using standard methods. The PCV and GCV are classified as suggested by Sivasubramanian and Menon (1973): above 20% - high coefficient of variation, 10-20% - Medium coefficient of variation and below 10% - low coefficient of variation. Heritability (h^2) estimate in broad sense and expected genetic advance (GA) were estimated by the methods devised by Lush (1940), illustrated by Allard (1960) and expressed in percentage. The heritability per cent was categorized by Robinson *et al.* in 1949: less than 30% - low heritability, 31-60 – medium heritability and more than 60% - high heritability. Similarly, Johnson *et al.* (1955) classified genetic advance as per cent of mean (GAM) as different category: less than 10% – low GAM, 10-20 % – moderate GAM and more than 20% – high GAM.

Results and Discussion

The results of mean performance and variability parameters for five F_3 populations and their parents are discussed here.

Mean performance is the basic criteria for selection and presented in Table 1. Based on the *per se* performance of parents, the parent genotype B35 was the highest grain yielder followed by CO26 when compared to all other genotypes. The parent B35 performed better for stay green trait, harvest index, biological yield, panicle weight, stem girth, flag leaf width and number of leaves per plant while CO26 registered highest value for plant height, number of leaves per plant, panicle length and test weight. Hence these two parents were adjudged as the best parent for further breeding programme.

Considering the mean performance of F_3 populations, high mean value for plant height, Number of leaves per plant, stem girth and biological yield was recorded in cross CO30 × IS18551 and also it exhibited low mean value for days to flowering. The cross CO26 × B35 showed high mean value for leaf chlorophyll index, flag leaf length, flag leaf width, panicle length, panicle weight, harvest index and single plant yield and the cross CO26 × IS18551 registered high mean value for test weight and stay green trait. The results have clearly indicated that the cross CO26 × B35 followed by the cross CO30 × IS18551 would be the best crosses for the improvement of grain yield because these crosses showed high mean value for most of the grain yield contributing traits. For the improvement of stay green trait and test weight, cross CO26 × IS18551 is considered as suitable.

Allard (1960) reported that the potentiality of the crosses generated by breeding is not only measured by mean performance but also by the extent of the variability created for different quantitative traits. The variability analysis of five F_3 populations *viz.*, K8 × IS18551, CO26 × IS18551, CO26 × B35, CO30 × IS18551 and CO30 × B35 are presented in Table 2 and Table 3 along with their mean values. These were subjected to different degrees of heritable and non-heritable variability. The magnitude of heritable variability was the most important aspect, which showed close bearing on the response to selection (Panse, 1957). High PCV and GCV were recorded for number of leaves per plant in crosses K8 × IS18551 and CO26 × IS18551, panicle length in all crosses except cross CO26 × B35, flag leaf length in crosses CO26 × IS18551 and CO30 × B35, single plant yield in crosses CO30 × IS18551 and CO30 × B35, panicle weight and biological yield in cross CO30 × IS18551 and stay green trait in crosses CO30 × IS18551 and CO30 × B35. Similar results were obtained for panicle length by several researchers (Bello *et al.*, 2007; William *et al.*, 1987; Basu, 1981 and Eckebil *et al.*, 1977), number of leaves per plant and flag leaf length (Bello *et al.*, 2007) and biological yield (Arunkumar, 2013; Jain and Patel, 2013).

High heritability and moderate GCV were registered for plant height in crosses K8 × IS18551 and CO30 × B35, flag leaf length in crosses K8 × IS18551 and CO30 × IS18551, stem girth in crosses K8 × IS18551 and CO26 × IS18551, stay green trait in crosses K8 × IS18551, CO26 × B35 and CO30 × B35, single plant yield in cross K8 × IS18551 and biological yield and panicle weight in cross CO30 × B35. The similar result of PCV for single plant yield was reported by number of researchers (Chavan *et al.*, 2010; Sandeep *et al.*, 2009; Sharma *et al.*, 2006; Tiwari *et al.*, 2003; Chaudhary *et al.*, 2001 and Sankarapandian *et al.*, 1996); for flag leaf length, flag leaf weight were reported by Bello *et al.*, 2007 and stay green trait was reported by Tomar *et al.* (2012). Similar result of GCV were reported for plant height (Kamatar *et al.*, 2011; Jain and Patel, 2013; Susmitha and Selvi, 2014 and Tomar *et al.*, 2012) and stem girth was reported by Tomar *et al.* (2012). Moderate PCV and GCV were observed for leaf chlorophyll index in all crosses except cross K8 × IS18551, panicle weight in crosses K8 × IS18551 and CO26 × B35, biological yield in crosses K8 × IS18551 and CO26 × B35, harvest index in crosses K8 × IS18551, CO30 × IS18551 and CO30 × B35, plant height in crosses CO26 × IS18551, CO26 × B35 and CO30 × IS18551, stay green trait in cross CO26 × IS18551, number of leaves per plant in crosses CO26 × B35, CO30 × IS18551 and CO30 × B35, stem girth in crosses CO26 × B35 and CO30 × IS18551, flag leaf length, panicle length and single plant yield in crosses CO26 × B35. Similar results were reported for panicle weight (Susmitha and Selvi, 2014). The same findings of PCV were obtained for plant height (Tomar *et al.*, 2012; Jain and Patel, 2013; Arunkumar, 2013; Susmitha and Selvi, 2014 and Kamatar *et al.*, 2011).

It is concluded that, high mean value for stay green trait was exhibited by cross CO26 × IS18551 coupled with moderate variability and cross CO26 × B35 had high mean value with moderate variability for leaf chlorophyll index, flag leaf length, panicle length, panicle weight and single plant yield. Cross CO30 × IS18551 had high mean value along with high variability for biological yield and high mean value with moderate variability for stem girth and number of leaves per plant. Cross CO30 × B35 had high mean value with moderate variability for plant height. These crosses can be exploited for selecting traits for which they are performing better.

The genetic variation along with the heritability estimates would give better idea about the expected efficiency of selection (Burton, 1952). The information on heritability solely may not help in pin pointing the characters for enforcing selection. However, the heritability estimates in conjunction with predicted genetic advance as per cent of mean would be more reliable (Johnson *et al.,* 1955).

In the present investigation, the high heritability and high genetic advance as per cent of mean was reported for plant height, number of leaves per plant and panicle length in all crosses but panicle weight and single plant yield was high in all crosses except in cross CO26 × IS18551, harvest index in crosses K8 × IS18551, CO30 × IS18551 and CO30 × B35, leaf chlorophyll index in crosses CO26 × IS18551, CO26 × B35 and CO30 × B35, stem girth and stay green trait in CO26 × B35 and biological yield in crosses CO26 × B35, CO30 × IS18551 and CO30 × B35. This indicates that these traits would respond to selection and are found to be predominantly governed by additive gene action and therefore selection would be effective for improving the traits. Similar results were obtained for plant height by Arunkumar, (2013); Chavan *et al.* (2010); Arunkumar *et al.* (2004); Kamatar *et al.* (2011) and Jain and Patel (2013), for panicle length (Chavan *et al.,* 2010 and Arunkumar *et al.*, 2004) and for number of leaves per plant by Arunkumar *et al.* (2004). Similar results were reported for panicle weight (Susmitha and Selvi, 2014) and for single plant yield by Susmitha and Selvi (2014), Kamatar *et al.* (2011), Arunkumar *et al.* (2004), Kalpande *et al.* (2014) and Chavan *et al.* (2010). Similar observations for harvest index were made by Chavan *et al.* (2010).

High heritability and moderate genetic advance as per cent of mean were observed in days to flowering in all crosses, flag leaf length in crosses CO26 × IS18551, CO26 × B35 and CO30 × B35 and harvest index in crosses CO26 × IS18551 and CO26 × B35 indicates that these characters may be governed by additive gene action partially. High heritability for days to flowering were reported by many scientists (Bello *et al.,* 2007; Aba *et al.,* 2001; Totok, 1997; William *et al.*, 1987; Basu, 1981 and Eckebil *et al.,* 1977) while moderate genetic advance as per cent of mean for days to flowering was reported by Tomar *et al.* (2012), Susmitha and Selvi (2014), Kamatar *et al.* (2011) and Kalpande *et al.* (2014). Moderate heritability and high genetic advance as per cent of mean was observed for stay green trait in all crosses except in CO26 × B35. Hence the selection based on this trait would be effective. Moderate heritability and moderate genetic advance as per cent of mean was observed for biological yield in K8 × IS18551, stem girth in K8 × IS18551 and CO30 × IS18551, flag leaf length in K8 × IS18551 and CO30 × IS18551, flag leaf width in CO26 × B35 and leaf chlorophyll index in CO30 × IS18551. Similar results for stem girth were obtained by Jain and Patel (2013). The present study revealed that the magnitude of heritability and genetic advance as per cent of mean estimate varied in the five F_3 populations for fourteen different traits. This indicated that selection criteria might be specific to a particular cross and could not be generalized.

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Table 1. Mean performance of parents for different traits

SI. NO.	Characters/Parents	IS18551	B35	CO26	CO30	K8
1.	**Days to flowering (Days)**	71.1	70.0	68.2	68.2	70.4
2.	**Plant height (cm)**	170.5	156.8	176.3	173.5	172.6
3.	**Number of leaves per plant**	8.7	9.3	9.3	8.6	9.0
4.	**Leaf chlorophyll index**	47.8	47.2	46.5	54.0	48.2
5.	**Flag leaf length (cm)**	29.8	29.3	27.5	29.3	33.9
6.	**Flag leaf width (cm)**	5.8	6.8	6.3	6.8	5.6
7.	**Stem girth (cm)**	5.8	7.3	6.0	7.0	6.7
8.	**Panicle length (cm)**	26.0	28.0	28.9	25.4	22.2
9.	**Panicle weight(g)**	69.3	80.8	77.5	73.4	74.4
10.	**Biological yield (g/plant)**	155.5	164.8	158.2	149.5	164.6
11.	**Test weight (g)**	2.23	2.8	3.1	2.0	2.1
12.	**Harvest index (%)**	37.4	42.3	41.0	41.7	37.4
13.	**Stay green trait**	2.9	4.2	2.9	2.6	1.9
14	**Single plant yield (g)**	57.8	69.7	65.0	62.4	62.2

Table 2. Variability analysis for days to flowering, plant height, number of leaves, leaf chlorophyll index, flag leaf length, flag leaf width and stem girth in F_3 populations in Sorghum (C1- K8 × IS18551, C2- CO26 × IS18551, C3-CO26 × B35, C4- CO30 × IS18551 and C5- CO30 × B35)

Traits	Cross	Range	Mean	SE(d)	PCV (%)	GCV (%)	h2 (%)	GA	GAM (%)
Days to flowering	C1	60-89	74.7	0.9	9.8	8.3	71.1	11	14.3
	C2	60-84	72.9	1.1	9.3	8.1	75.2	11	14.4
	C3	54-88	72.6	1.1	8.9	8.3	88.0	12	16.0
	C4	54-83	70.1	1.5	11.4	9.9	75.6	12	17.7
	C5	60-80	72.0	1.1	8.4	7.3	75.0	9.3	13.0
Plant height	C1	118.5-301.0	163.3	4.0	20.7	19.8	91.7	64	39.1
	C2	126.0-301.0	174.3	5.1	18.6	18.1	93.8	63	36.0
	C3	110.0-229.5	174.4	4.0	14.0	13.3	90.0	45	26.0
	C4	123.4-255.0	176.9	5.0	14.8	13.9	87.4	47	26.6
	C5	110.2-255.0	154.1	6.5	22.9	19.2	70.3	51	33.2
Number of leaves	C1	6-18	11.7	0.4	31.9	25.8	65.7	5.1	43.1
	C2	6-18	10.6	0.6	33.3	29.2	76.6	5.6	52.5
	C3	6-14	9.3	0.3	19.1	16.1	71.2	2.6	28.0
	C4	8-14	12.4	0.3	14.6	12.5	72.9	2.7	22.0
	C5	6-14	8.9	0.3	19.8	15.7	63.2	2.3	25.7
Leaf chlorophyll index	C1	20.9-65.5	46.5	0.9	15.2	7.7	25.5	3.7	8.0
	C2	14.6-63.3	48.8	1.2	15.6	12.4	63.4	9.9	20.3
	C3	32.0-64.9	53.5	1.2	14.1	12.9	83.2	13	24.2
	C4	30.0-59.9	50.1	1.5	15.4	11.7	57.9	9.2	18.3
	C5	22.9-59.5	46.6	1.6	18.8	17.1	82.6	15	32.0
Flag leaf length	C1	20.4-69.0	40.3	1.3	27.7	17.0	37.6	8.6	21.4
	C2	22.0-68.0	38.7	1.7	28.1	22.5	63.8	14	37.0
	C3	23.0-70.3	51.6	1.6	19.4	18.8	94.3	19	37.7
	C4	22.0-58.0	40.7	1.8	22.8	16.6	53.1	10	24.9
	C5	20.0-57.0	38.3	1.9	26.8	26.5	97.2	21	53.7
Flag leaf width	C1	2.0-7.8	4.2	0.2	31.7	6.2	3.8	0.1	2.5
	C2	2.0-8.0	4.7	0.2	25.8	8.5	10.9	0.3	5.8
	C3	3.2-7.0	5.4	0.1	13.0	9.1	49.1	0.7	13.2
	C4	2.0-7.6	4.9	0.2	25.2	9.2	13.2	0.3	6.9
	C5	3.2-5.6	4.3	0.1	12.6	5.5	19.3	0.2	5.0
Stem girth	C1	2.4-10.0	7.0	0.9	22.3	13.2	35.3	1.1	16.2
	C2	2.0-10.0	6.3	0.3	31.7	16.8	26.0	1.1	17.0
	C3	4.0-8.8	7.0	0.2	13.7	12.2	80.0	1.6	22.5
	C4	4.6-10.2	7.0	0.3	19.2	11.7	37.0	1	14.7
	C5	3.2-8.-0	5.4	0.2	16.0	8.7	29.3	0.5	9.7

Table 3. Variability analysis for panicle length, panicle weight, biological yield, test weight, harvest index, stay green trait and single plant yield in F_3 populations in Sorghum (C1- K8 × IS18551, C2- CO26 × IS18551, C3-CO26 × B35, C4- CO30 × IS18551 and C5- CO30 × B35)

Traits	Cross	Range	Mean	SE(d)	PCV (%)	GCV (%)	h2 (%)	GA	GAM (%)
Panicle length	C1	7.0-44.5	23.4	1.0	37.3	29.3	61.5	11	47.3
	C2	14.4-44.0	27.3	1.4	32.6	29.2	80.5	15	54.0
	C3	16.5-46.3	36.1	0.9	14.8	14.0	89.8	9.9	27.3
	C4	5.8-73.2	34.0	2.1	32.0	29.5	85.2	19	56.1
	C5	14.3-54.3	32.1	2.0	33.7	33.0	95.8	21	66.5
Panicle weight	C1	50.0-99.0	63.5	1.3	17.2	15.4	80.2	18	28.5
	C2	24.6-104.0	60.0	1.5	15.5	5.0	10.3	2	3.3
	C3	34.9-85.0	68.0	1.8	15.6	14.0	79.8	17	25.7
	C4	12.0-149.0	64.6	4.3	35.3	33.0	87.5	41	63.6
	C5	31.9-87.6	57.2	2.2	21.0	16.5	61.8	15	26.7
Biological yield	C1	100.1-200.3	138.5	3.2	19.5	13.1	45.3	25	18.2
	C2	54.8-300.3	127.7	3.9	19.5	9.5	23.6	12	9.5
	C3	74.0-183.4	141.9	3.8	16.5	1	82.9	40	28.1
	C4	40.0-312.0	145.5	9.0	32.7	31.1	90.9	89	61.2
	C5	80.2-187.2	125.8	5.0	21.6	17.2	63.0	35	28.0
Test weight	C1	1.24-3.9	2.5	0.1	20.4	4.0	3.7	0	1.6
	C2	2.0-4.4	3.4	0.1	12.1	4.9	16.7	0.1	4.2
	C3	1.9-4.0	2.8	0.1	12.6	4.5	12.9	0.1	3.4
	C4	2.3-8.0	2.5	0.1	12.2	3.9	10.0	0.1	2.5
	C5	2.1-3.8	3.1	0.1	14.1	5.5	15.0	0.1	4.4
Harvest index	C1	22.3-44.7	38.2	0.6	14.1	13.2	87.3	9.7	25.4
	C2	25.5-43.4	37.7	0.6	9.6	7.3	57.3	4.3	11.4
	C3	25.9-56.5	39.8	0.7	10.0	9.3	86.5	7.1	17.7
	C4	0.8-44.0	35.0	1.3	19.0	17.8	88.6	12	34.6
	C5	12.8-40.8	34.6	1.0	15.8	15.7	99.5	11	32.3
Stay green trait	C1	1-5	3.2	0.1	23.6	16.5	48.7	0.8	23.6
	C2	2-5	4.0	0.1	20	14.1	49.4	0.8	20.4
	C3	1-5	3.4	0.1	23.3	18.1	60.3	1	28.9
	C4	1-5	2.6	0.2	42.4	24.9	34.4	0.8	30.0
	C5	1-5	2.4	0.1	29.5	19.1	42	0.6	25.5
Single plant yield	C1	32.9-88.0	52.3	1.3	21.4	19.8	85.1	20	37.6
	C2	14.0-93.5	48.3	1.5	19.4	9.0	21.6	4.2	8.6
	C3	1.1-136.2	56.4	1.8	18.9	16.6	77.0	17	30.0
	C4	1.1-136.2	52.9	4.3	43.1	40.3	87.4	41	77.6
	C5	20.3-74.3	43.8	2.3	29.0	24.0	68.8	18	41.0

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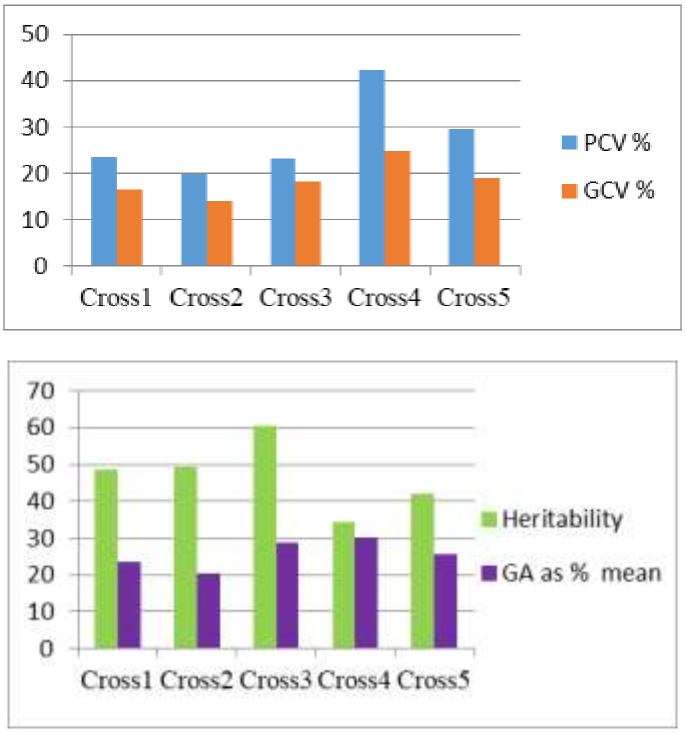

Fig.1. PCV, GCV, heritability and genetic advance as per cent of mean for stay green trait in five crosses of F_3 generation in sorghum

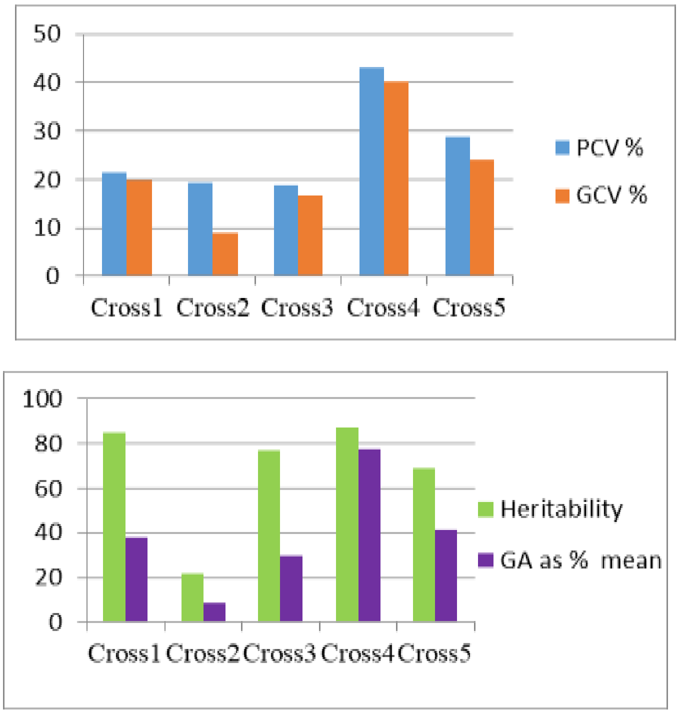

Fig.2. PCV, GCV, heritability and genetic advance as per cent of mean for single plant yield in five crosses of F_3 generation in sorghum

(Cross1- K8 × IS18551, Cross2- CO26 × IS18551, Cross3-CO26 × B35, Cross4- CO30 × IS18551 and Cross5-CO30 × B35)