RESEARCH ARTICLE

Assessment Of Frequency Distribution In F_3 generation of Sorghum (*Sorghum bicolor* L. Moench.) For Grain Yield And Its Attributed Traits

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ABSTRACT

The present study was conducted to assess the gene interaction for grain yield and its attributing traits towards the increase of grain yield in sorghum. In F_3 generation, symmetrical distribution, positive skewness and negative skewness were observed for 14 traits in various crosses. Symmetrical distribution indicates the presence of segregating genes that gives wider variation in F_3 populations. Significant and positive skewness indicates the complementary type of gene action hence the expected genetic gain is slower with mild selection and faster with intensive selection for that particular trait. Significant and negative skewness denotes the presence of duplicate epistatic gene action therefore the gain is faster with mild selection and less rapid with intense selection. In kurtosis, leptokurtic and mesokurtic nature was observed which indicate that the traits are under the control of few segregating genes and the next indicates the non-significant of kurtosis respectively. The intensive selection of these characters in F_3 generation paved the way to achieve the gain faster.

Keywords: *Sorghum; Frequency distribution; Skewness; Kurtosis*

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Monech) is a predominantly inbreeding, diploid (2n=20) species, which is originated in West Africa and spread throughout Africa and South Asia (Haussmann *et al.,* 2002; Ayanar and Bekele, 2000 and Aba *et al*., 2001). It is highly adapted to drought prone areas and can tolerate even high temperature of above 38˚C (Nimbalkar *et al.,* 1988; Sharma *et al.,* 2006 and Berthaud, 1997). Drought stress occurs at the post flowering stage needs serious consideration because it drastically reduces the yield. Many studies indicated that the introgression of stay green trait in sorghum improves the drought tolerant nature (Borrell *et al.,* 2000). In the present study, the frequency distribution of F_3 populations of five crosses was identified through the estimation of skewness and kurtosis. Skewness describes the degree of departure of a distribution from symmetry and kurtosis characterizes the peakedness of a curve. In a frequency distribution of a segregating generation, skewness could result when certain combinations of genes are lethal, presence of incomplete linkage of certain genes, presence of epistasis and one gene having a much larger effect than others (Snape and Riggs, 1975). Kurtosis results if either a few genes are contributing to the phenotypic distribution or there are inequalities in the additive genetic effects at different loci.

MATRIALS AND METHODS

The experimental materials used in this study consisted of five parents *viz*., IS18551, CO30, CO26, K8 and B35 and five F_3 populations *viz*., K8 × IS18551 (Cross 1), CO26 × IS18551 (Cross 2), CO26 × B35 (Cross 3), CO30 × IS18551 (Cross 4) and CO30 × B35 (Cross 5). The present study involved in the field evaluation of five F_3 populations for grain yield and its component traits, screening for stay green trait, and statistical analysis of recorded data for skewness and kurtosis. The parents and 50 families of each cross have been raised in a single row of 2-meter length. The plant-to-plant spacing of 15cm and row-to-row spacing of 45 cm has been adapted. Agronomic practices were carried out as per the recommendations. During the initiation of

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anthesis, each plant was selfed by covering with brown paper cover to protect it from foreign pollen. 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 and single plant yield were recorded in each F_3 populations and ten randomly selected plants in parents. **Plant height (cm):** The height of each plant was measured from the ground level to the tip of ear head of the plant in centimeters at the time of harvest. **Number of leaves per plant:** The total numbers of leaves per plant were counted and recorded at the time of maturity. **Leaf chlorophyll index:** Leaf chlorophyll index was recorded in third leaf from the top using Minolta chlorophyll meter SPAD-502, at the time of flowering. In each leaf, reading was taken at three places (Base, middle and tip of the leaf). **Flag leaf length (cm):** The length of the flag leaf from base to tip was measured. **Flag leaf width (cm):** The width of the flag leaf at the middle of the leaf was measured. **Stem girth (cm):** It is a measurement of the distance around the stem of a plant above the first node from the ground and expressed in centimeter. **Panicle length (cm):** The length of the panicle was measured from the basal whorl of the rachis branches to the tip of the panicle at maturity. **Panicle weight (g):** The dry weight panicle at the time of harvest was measured in grams. **Biological yield (g/plant):** The whole plant dry weight at the time of harvest was measured in grams. **Test weight (g):** A random sample of 100 grains per panicle was weighed and recorded. **Harvest index (%):** Harvest index was calculated from the dry weight of the seeds and dry weight of the whole plant at harvest by using the following formula and expressed in fraction.

$$\text{Harvest index} = \frac{\text{Single Plant Yield}}{\text{Biological Yield per Plant}} \times 100$$

Stay green trait: The stay green nature was estimated using a scale of 1 to 5 based on the degree of leaf and plant death at physiological maturity in the field. Wanous *et al*. (1991) reported the visual ratings of stay-green trait in sorghum. The stay green trait score of F_3 crosses were furnished in.

Decimal score	Stay-green nature
1.	Leaves have natural green colour
2.	1/3rd of leaves yellowing
3.	Intermediate
4.	1/3rd of leaves green
5.	All leaves yellow or dead

Single plant yield (g): The weight of the dried and cleaned grains from a single plant was weighed and expressed in grams.

Frequency Distribution

The Skewness (β_1) and Kurtosis (β_2) is calculated based on the standard classifications given by Kapur, 1981.

β_1 = Skewness is categorized as follows

$\beta_1 > 0$ = positively skewed

$\beta_1 < 0$ = negatively skewed

$\beta_1 = 0$ = symmetric distribution

β_2 = Kurtosis is categorized as follows

$\beta_2 > 1$ = leptokurtic

$\beta_2 < 1$ = platykurtic

$\beta_2 = 0$ = mesokurtic

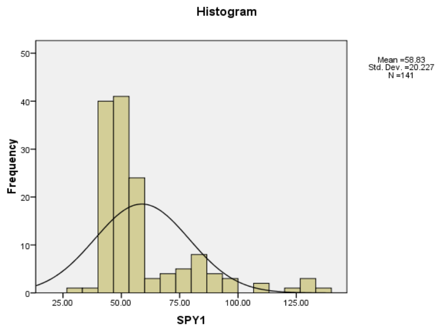
To test the significance of skewness (β_1) and kurtosis (β_2) in F_3 populations, the t value is calculated by divide the skewness (β_1) and kurtosis (β_2) using their respective standard errors then the calculated t value is compared with t table with (n-1) degrees of freedom.

$$\text{SE of skewness } (\beta_1) = \sqrt{\frac{6}{N}}$$

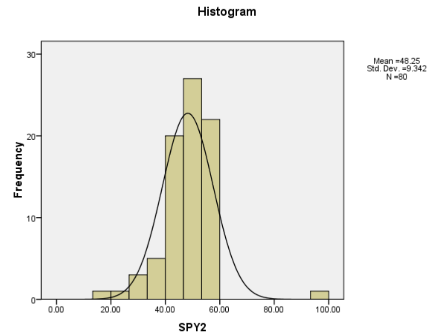
$$\text{SE of kurtosis } (\beta_2) = \sqrt{\frac{24}{N}}.$$

RESULTS AND DISCUSSION

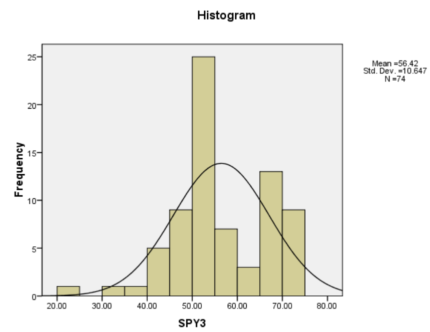
The value of skewness and kurtosis for 14 characters of five crosses are presented in Table 1 and frequency distribution for single plant yield is graphically represented in figure 1. **Plant height:** Significant and positive skewness was observed for four crosses *viz.,* Cross 4(0.72), Cross 5 (1.22), Cross 2 (1.53) and Cross 1 (1.60). No skewness was observed for Cross 3 (0.02). Leptokurtic significant kurtosis was observed for Cross 2 (4.00) and Cross 1 (4.18) and other crosses exhibited mesokurtic nature. **Number of leaves per plant:** Positive skewness was observed in Cross 3 (0.73), Cross 2 (0.81), Cross 5 (1.22) while Cross 4 (-1.19) exhibited negative skewness. In case of kurtosis, mesokurtic nature was observed in all the crosses. **Leaf chlorophyll index**: Significant and negative skewness was observed for all crosses except Cross 1. With regard to kurtosis, leptokurtic was observed for Cross 1 (2.14) and Cross 2 (4.06) and other crosses exhibit mesokurtic nature. **Flag leaf length**: Significant and positive skewness was recorded in Cross 2 (0.84) and Cross 1 (0.85). Significant and negative skewness was observed for Cross 3 (-0.34). In case of kurtosis, mesokurtic nature was observed in all the crosses. **Flag leaf width:** Significant and positive skewness was recorded in Cross 1 (1.38) and symmetrical distribution for skewness was observed in other crosses. However, leptokurtic kurtosis was observed in Cross 1 (1.59) and Cross 3 (2.01) while the remaining crosses exhibited mesokurtic nature. **Stem girth:** Normal distribution for skewness was observed in all the crosses. With regard to kurtosis, leptokurtic was observed for Cross 3 (1.27) and Cross 5 (2.60) and mesokurtic was observed in all other crosses. **Panicle length:** Significant and positive skewness was observed in cross 1 (1.13) and negative skewness was recorded in Cross 3 (-0.83). In case of kurtosis, leptokurtic was observed in Cross 3 (1.45) and Cross 4 (2.95). All other crosses showed mesokurtic nature. Jayaramachandran et al. (2010) recorded a similar result for panicle length. **Panicle weight:** Significant and positive skewness was observed in Cross 1 (1.76) and symmetrical distribution was observed in all other crosses. However, leptokurtic nature was observed in Cross 1 (2.45), Cross 4 (2.55) and Cross 2 (8.51) and other crosses showed mesokurtic nature. **Biological yield:** Significant and positive skewness was recorded in three crosses *viz.,* Cross 5 (0.66), Cross 1 (1.00) and Cross 2 (3.88). The remaining cross showed normal distribution for skewness. In case of kurtosis, leptokurtic was observed in Cross 4 (1.78) and Cross 2 (30.05) while remaining crosses showed mesokurtic nature. **Test weight:** Significant and positive skewness was observed in Cross 1 (0.71) and Cross 4 (1.96) and symmetrical distribution for skewness was observed for the remaining crosses. With regard to kurtosis, all the crosses showed leptokurtic nature except Cross 5 (-0.67) and it showed mesokurtic nature. **Harvest index:** Significant and negative skewness was observed for all the crosses except Cross 3 (0.33) and it recorded normal distribution for skewness. In case of kurtosis, all the crosses exhibited leptokurtic nature. **Stay green trait:** Significant and positive skewness was observed for Cross 3 (0.66), Cross 4 (0.85) and Cross 5 (0.86) and noskewness was observed in Cross 2 (-0.26). However, leptokurtic kurtosis was observed in Cross 1 (1.88) and mesokurtic nature was observed in other crosses. **Single plant yield:** Significant and positive skewness was observed in Cross 1 (1.69) and other crosses showed symmetrical distribution for skewness. In case of kurtosis, leptokurtic nature was observed in Cross 1 (2.36), Cross 4 (2.52) and Cross 2 (8.65) and mesokurtic in other crosses.



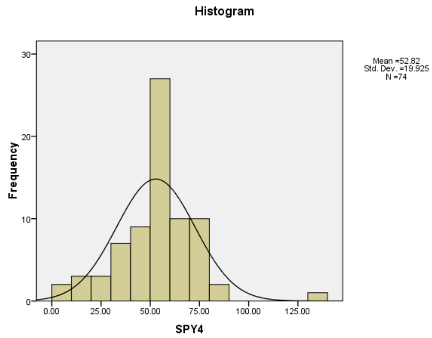
Cross 1



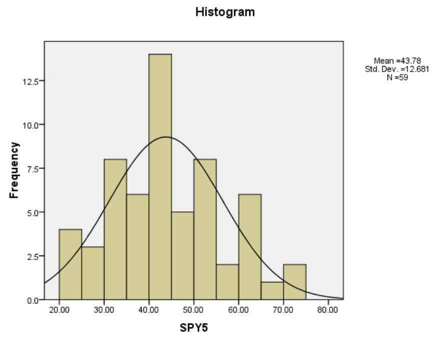
Cross 2



Cross 3



Cross 4



Cross 5

Figure 1. Frequency distribution of single plant yield in five crosses of F_3 populations

Table 1. Frequency distribution in F_3 populations of sorghum

Traits	K8 × IS18551 (Cross 1)		CO26 × IS18551 (Cross 2)		CO26 × B35 (Cross 3)		CO30 × IS18551 (Cross 4)		CO30 × B35 (Cross 5)	
	Skew	Kur	Skew	Kur	Skew	Kur	Skew	Kur	Skew	Kur
Days to flowering	0.02	-0.56	-0.17	-0.95	-0.40	0.06	-0.17	-0.88	-0.21	-0.78
Plant height (cm)	1.60**	4.18**	1.53**	4.00**	0.02	-0.05	0.72*	1.22	1.22**	0.95
Number of leaves per plant	0.21	-1.11	0.81**	-0.49	0.73*	0.92	-1.19**	0.39	1.22**	0.60
Leaf chlorophyll index	-0.22	2.14**	-1.11**	4.06**	-0.61*	0.09	-1.09**	0.64	-1.06**	0.44
Flag leaf length (cm)	0.85**	0.39	0.84**	0.02	-0.34*	0.26	0.05	-0.63	0.18	-1.02
Flag leaf width (cm)	1.38**	1.59**	0.64	0.17	-0.50	2.10**	0.20	-0.14	0.34	0.26
Stem girth (cm)	-0.24	-0.04	-0.10	-0.42	-0.12	1.27**	0.55	-0.20	0.44	2.60**
Panicle length (cm)	1.13**	0.18	0.49	-0.92	-0.83**	1.45*	0.11	2.95**	0.36	-0.93
Panicle weight (g)	1.76**	2.45**	0.15	8.51**	-0.30	0.03	0.42	2.55**	0.40	-0.17
Biological yield (g/plant)	1.00**	-0.21	3.88**	30.05**	-0.18	-0.25	0.24	1.78**	0.66*	-0.34
Test weight (g)	0.71**	1.50**	-0.25	1.81**	0.40	2.57**	1.96**	6.69**	-0.16	-0.67
Harvest index (%)	-1.55**	1.60**	-1.37**	1.73**	0.33	7.05**	-3.00**	12.96**	-2.06**	4.78**
Stay green trait	0.24	1.88**	-0.26	-0.63	0.66*	0.83	0.85*	-0.09	0.86**	-0.02
Single plant yield (g)	1.69**	2.36**	0.29	8.65**	-0.22	0.04	0.47	2.52**	0.28	-0.39

Conclusion

The symmetrical distribution observed for days to flowering, stem girth and panicle weight in all crosses, flag leaf width in all crosses except Cross 1, panicle length in Cross 2, Cross 4 and Cross 5, biological yield in Cross 3 and Cross 4, test weight in Cross 2, Cross 3 and Cross 5, stay green trait in Cross 1 and Cross 2, single plant yield in all crosses except Cross 1, number of leaves per plant and leaf chlorophyll index in Cross 1, flag leaf length in Cross 4, plant height and harvest index in Cross 3. The symmetrical distribution indicates the presence of segregating genes which gives wider variation in F_3 populations. Significant and positive skewness observed for plant height in all crosses except Cross 3, number of leaves per plant in Cross 2, Cross 3 and Cross 5, flag leaf length in Cross 1 and Cross 2, biological yield in Cross 1, Cross 2 and Cross 5, test weight in Cross 1 and Cross 4, stay green trait in Cross 3, Cross 4 and Cross 5 and flag leaf width, panicle weight, single plant yield in Cross 1. It indicates that the complementary type of gene action exists in these populations hence the expected genetic gain is slower with mild selection and faster with intensive selection for that particular trait. The remaining traits in all crosses showed significant negative skewness. It denotes the presence of duplicate epistatic gene action therefore the gain is faster with mild selection and less rapid with intense selection.

In kurtosis, leptokurtic nature (significant and positive) was observed for plant height, leaf chlorophyll index, single plant yield, panicle weight, test weight in Cross 1 and Cross 2, stem girth in Cross 3 and Cross 5, panicle length, test weight in Cross 3, flag leaf width and stay green trait in Cross 1 and panicle length, panicle weight, biological yield and single plant yield in Cross 4. It indicates that these traits are under the control of few segregating genes. Other traits in all crosses exhibited meso kurtic nature (non significant) of kurtosis. Thus, the estimated frequency distribution paved the way for selection of superior plants in F_3 generations.

Ethics statement

No specific permits were required for the described field studies because no human or animal subjects were involved in this research.

Originality and plagiarism

We are ensure that we have written and submit only entirely original works, and if we have used the work and/or words of others, that has been appropriately cited.

Consent for publication

We (Shamini K and Selvi B) are agreed to publish the content.

Competing interests

There were no conflict of interest in the publication of this content

Data availability

All the data of this manuscript are included in the MS.

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