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Analysis of skewness and kurtosis in F_2 generation of four crosses in American cotton (*Gossypium hirsutum* L.)

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Abstract

The current study was conducted to assess the mean, range, skewness, and kurtosis of four crosses in the F_2 generation of upland cotton. The study consists of eight parents hybridized in a diallel method to obtain fifty-six hybrids. From these hybrids, four elite hybrids were forwarded to the F_2 generation based on high boll weight, high yield of cotton per plant and high fiber quality. Based on the mean performance in the F_2 population, Cross I (CO 14 x IC 359538) documented a high mean value for the locules number per boll and uniformity index. Cross II (GISV 328 x IC 359538) recorded the highest mean value for the number of monopodial branches per plant, boll number per plant, yield of cotton per plant and lint index. Cross III (IC 292130 x GISV 328) recorded a high mean for plant height, number of sympodial branches per plant, seed index and fiber fineness. Cross IV (MCU 5 x IC 359464) registered a high mean value for boll weight, number of seeds per boll, upper half mean length, fiber strength, elongation percentage and ginning outturn. All four crosses showed positive skewness for monopodial branches per plant, sympodial branches per plant, boll number per plant, locules number per boll, yield of cotton per plant, seed index, fiber strength and elongation percentage. Positive skewness is associated with complementary gene interactions, while negative skewness is associated with duplicate gene interactions. The platykurtic curve was observed for sympodial branches per plant, boll weight, seed index, fiber fineness and ginning outturn in all four crosses, whereas the leptokurtic peak was noted for yield of cotton per plant and boll number per plant in all four crosses.

Keywords kurtosis, mean performance, skewness, upland cotton

Introduction

The most valuable cash crop and major contributor to the Indian textile industry's economy is cotton, sometimes known as the "king of fibers." It employs both rural and urban sectors and enriches the livelihood of around 6 million farmers [1]. Besides its dominant role in providing fiber, cotton also provides other materials such as edible oils, cattle feed and materials for food and cosmetics. Cotton, the world's leading textile crop, belongs to the family Malvaceae and genus *Gossypium* which includes 50 species that were distributed over various continents. It includes four cultivated species *viz*., two diploid old-world cotton and two tetraploid new world cotton. All four cultivated species were commercially exploited in India [2] of which, upland cotton (*G. hirsutum* L.) alone contributes around 90% of cotton production globally. The demand for cotton yield and quality is increasing at a rapid pace among farmers due to the modernization of textile industries. The polygenic nature of quantitative traits is the primary target of plant breeders as it includes important traits such as seed cotton yield and its component traits [3]. Because of the complex nature of yield in cotton production, it is mandated to break the yield into its components such as boll weight, number of bolls, boll size, lint index and seed index. Of these, the number of bolls and boll weight will inflate 90% and 10% of the yield, respectively [4]. It is essential to effectively harness the existing genetic variability to improve the yield potential. In order to improve the effectiveness of our selection and breeding, more research on the degree of gene interaction is required. Flatness, surfaces, and frequency curve fitting all made use of higher order statistics, such as skewness and kurtosis. When the frequency distribution curve is asymmetrical, it is said to be skew. When skewness is negative, most scores fall on the high end of the distribution; conversely, when skewness is positive, most scores fall on the low end. If a trait is high- or low-tailed with a normal distribution, kurtosis can determine it. The study on skewness and kurtosis is required to assess the extent to which F_2 values influence the mean of the F_3 generation and determine whether this parameter can be used for selection or not. This helps in the selection of superior progenies in the further segregating generations. Skewness aids in our understanding of the gene action in a given trait. Positive skewness is indicative of complementary epistatic gene action for the trait. Under mild selection, gain is slower, while under intense selection, gain is faster. The presence of duplicate epistasis indicates the negative skewness and the gain is faster under mild selection and rapid under intense selection. Similarly, the platykurtic and leptokurtic nature of kurtosis signify the populations' wider and narrow variability, respectively. Thus, the platykurtic nature will help in the selection process because of wider variability in the population for particular traits.

Therefore, efforts are required to increase seed yields of cotton by persistent selection of high-yielding cultivars with a wide range of climatic and edaphic adaptations as well as site-specific varietal selection [5]. Thus, the present study aimed to examine the yield and fiber quality potential of different crosses to assess plant parameters, yield and its constituent traits, and fiber quality attributes in the specific location. This will allow up possibilities for the creation of superior varieties with potentially heterotic traits.

Methodology

During 2021-2022, the trial was carried out in the Department of Cotton, Tamil Nadu Agricultural University, Coimbatore. The experimental material of this study consists of eight genotypes. These genotypes were crossed using a diallel mating design including direct and reciprocal crosses to generate 56 hybrids. Cross-breeding was carried out by Doak's method [6]. In Kharif 2021, the fifty-six hybrids and their eight parents were raised in a randomized complete block design with two replications with a spacing of 90 cm x 60 cm. Phenotypic observations were taken in the F_1 generation to identify the best hybrids in order to forward to the next generation. The four crosses (CO 14 x IC 359538, GISV 328 x IC 359538, IC 292130 x GISV 328 and MCU 5 x IC 359464) out of fifty-six hybrids were selected and forwarded to F2 generation for phenotypic evaluation based on high boll weight, yield of cotton per plant and fiber quality. All suggested agronomic practice packages were adhered to until harvest.

Observation taken

Phenotypic data was taken for each segregant in each cross for the following yield component and fiber quality traits include plant height (cm), monopodial branches per plant, sympodial branches per plant, boll number per plant, locules number per boll, boll weight (g), number of seeds per boll, the yield of cotton per plant (g), seed index (g), lint index (g), ginning out turn (%), upper half mean length (mm), fiber strength (g/tex), fiber fineness or micronaire (µg/ inch), uniformity index and elongation percentage (%). Skewness and kurtosis were analysed using the formula derived by Kapur [7] in R studio version 1.4.1717 © 2009-21 package.

Results and Discussion

The mean was evaluated for sixteen economic traits in all four crosses (cross I- CO 14 x IC 359538, cross II- GISV 328 x IC 359538, cross III- IC 292130 x GISV 328, and cross IV- MCU 5 x IC 359464) and the results were presented in Figure 1.

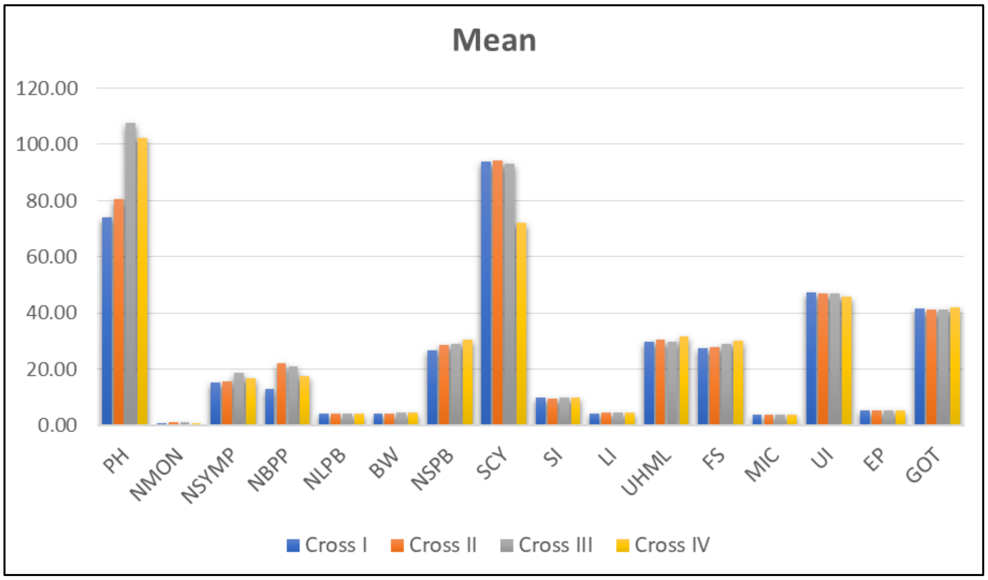

Figure 1. The mean value of four crosses for sixteen traits

[PH-plant height (cm), NMON-monopodial branches per plant, NSYMP-sympodial branches per plant, NBPP-boll number per plant, NLPB-locules number per boll, BW-boll weight (g), NSPB- number of seeds per boll, SCY-yield of cotton per plant (g), SI-seed index (g), LI-lint index (g), GOT-ginning out turn (%), UHML-upper half mean length (mm), FS-fiber strength (g/tex), MIC-fiber fineness (µg/inch), UI-uniformity index, and EP-elongation percentage (%)]

Mean: Among the four crosses, cross III (IC 292130 x GISV 328) recorded a high mean for plant height, sympodial branches per plant, seed index and fiber fineness. Cross II (GISV 328 x IC 359538) recorded the highest mean value for monopodial branches per plant, boll number per plant, yield of cotton per plant and lint index. Cross IV (MCU 5 x IC 359464) registered a high mean value for boll weight, number of seeds per boll, upper half mean length, fiber strength, elongation percentage and ginning outturn. Cross I (CO 14 x IC 359538) documented a high mean value for locules number per boll and uniformity index. These findings were in accordance with several other researchers [8-13].

Skewness and kurtosis: The skewness and kurtosis were assessed for sixteen economic traits in all four crosses (cross I- CO 14 x IC 359538, cross II- GISV 328 x IC 359538, cross III- IC 292130 x GISV 328, and cross IV- MCU 5 x IC 359464) and the results were displayed in Table 1.

Skewness: Plant height was positively skewed in cross I (0.80), cross II (0.26), cross III (0.35) and negatively skewed in cross IV (-0.43). Monopodial branches per plant were positively skewed in all four crosses (0.88, 0.55, 0.25 and 0.09 respectively). Cross I (0.75) shows a leptokurtic curve and crosses II (-0.30), III (-0.97) and IV (-1.00) show a platykurtic curve. The trait, sympodial branches per plant showed positive skewness for all four crosses (0.47, 0.28, 0.16 and 0.13 respectively). Positive skewness was exhibited by all four crosses (0.97, 0.91, 0.80 and 0.98 respectively) for the boll number per plant. Locules number per boll was positively skewed in all crosses I (0.45),

Table 1. Analysis of skewness and kurtosis for four crosses

Traits	Cross I		Cross II		Cross III		Cross IV	
	SKEW	KURT	SKEW	KURT	SKEW	KURT	SKEW	KURT
PH	0.80	0.11	0.26	-0.59	0.35	-0.26	-0.43	0.45
NMON	0.88	0.75	0.55	-0.30	0.25	-0.97	0.09	-1.00
NSYMP	0.47	-0.70	0.28	-0.54	0.16	-0.41	0.13	-0.41
NBPP	0.97	0.64	0.91	0.45	0.80	0.33	0.98	1.09
NLPB	0.45	-1.81	2.24	3.02	2.79	7.79	4.36	17.37
BW	0.30	-0.50	0.49	-0.30	0.18	-0.34	-0.07	-0.60
NSPB	-0.20	-0.05	0.06	0.49	-0.31	-0.04	-0.43	-0.17
SCY	1.03	1.22	1.09	1.01	1.01	1.00	1.02	1.66
SI	0.20	-0.37	0.60	-0.21	0.44	-0.42	0.10	-0.53
LI	0.00	-0.57	-0.05	-0.73	0.06	-0.37	-0.14	-0.12
UHML	0.48	0.04	0.17	-0.60	0.38	-0.39	-0.54	0.70
FS	0.54	-0.11	0.48	-0.48	0.12	-0.97	0.61	0.13
MIC	-0.31	-0.38	0.05	-0.79	-0.02	-1.11	-0.19	-0.24
UI	0.33	1.20	-0.05	-1.00	-0.04	-0.29	1.12	1.95
EP	0.35	-0.45	0.20	-0.44	0.12	-0.92	0.73	1.01
GOT	-0.25	-0.98	-0.26	-1.07	-0.22	-0.99	-0.34	-0.73

[PH-plant height (cm), NMON-monopodial branches per plant, NSYMP-sympodial branches per plant, NBPP-boll number per plant, NLPB-locules number per boll, BW-boll weight (g), NSPB- number of seeds per boll, SCY-yield of cotton per plant (g), SI-seed index (g), LI-lint index (g), GOT-ginning out turn (%), UHML-upper half mean length (mm), FS-fiber strength (g/tex), MIC-fiber fineness (µg/inch), UI-uniformity index, and EP-elongation percentage (%)]

II (2.24), III (2.79) and IV (4.36). The trait, boll weight was positively skewed in cross I (0.30), II (0.49) and III (0.18), while it was negatively skewed in cross IV (-0.07). Number of seeds per boll was positively skewed for cross II (0.06), while it was negatively skewed for cross I (-0.20), III (-0.31) and IV (-0.43). Positive skewness was observed in all four crosses (1.03, 1.09, 1.01 and 1.02 respectively) for the yield of cotton per plant. The trait, seed index has shown positive skewness in all crosses (0.20, 0.60, 0.44 and 0.10 respectively). In terms of lint index, Cross I (0.00) showed symmetric distribution, cross III (0.06) was positively skewed, while it was negatively skewed in crosses II (-0.05) and IV (-0.14).

The upper half mean length was positively skewed in crosses I (0.48), II (0.17) and III (0.38), whereas it was negatively skewed in cross IV (-0.54). Positive skewness was exhibited by all four crosses (0.54, 0.48, 0.12 and 0.61 respectively) for fiber strength. Cross II (0.05) was positively skewed whereas crosses I (-0.31), III (-0.02) and IV (-0.19) were negatively skewed for fiber fineness.

Uniformity index was positively skewed in crosses I (0.33) and IV (1.12), while it was negatively skewed in crosses II (-0.05) and III (-0.04). Positive skewness was observed for elongation percentage in all four crosses viz., I (0.35), II (0.20), III (0.12) and IV (0.73). Ginning outturn exerted negative skewness in all four crosses (-0.25, -0.26, -0.22 and -0.34). These findings coincide with other researchers [14-16].

Kurtosis: Cross I (0.11) and cross IV (0.45) observed a leptokurtic curve while cross II (-0.59) and cross III (-0.26) observed a platykurtic curve for plant height. In monopodial branches per plant, cross I (0.75) shows a leptokurtic curve and crosses II (-0.30), III (-0.97) and IV (-1.00) shown platykurtic curve. In terms of sympodial branches per plant, the platykurtic curve was observed for all four crosses (-0.70, -0.54, -0.41 and -0.41 respectively). The curve was leptokurtic for all the crosses I (0.64), II (0.45), III (0.33) and IV (1.09) for boll number per plant.

Cross I (-1.81) showed a platykurtic curve whereas crosses II (3.02), III (7.79) and IV (17.37) showed a leptokurtic curve for locules number per boll. In the case of boll weight, all four crosses (-0.50, -0.30, -0.34 and -0.60) shown a platykurtic curve. In the number of seeds per boll, Cross II (0.49) displayed leptokurtic curve whereas platykurtic curve was recorded in cross I (-0.05), III (-0.04) and IV (-0.17).

The curve was leptokurtic in all four crosses *viz*., I (1.22), II (1.01), III (1.00) and IV (1.66) for yield of cotton per plant. The seed index displayed a platykurtic curve for all crosses (-0.37, -0.21, -0.42 and -0.53). The platykurtic curve was observed for all the crosses (-0.57, -0.73, -0.37 and -0.12 respectively) in terms of lint index.

The curve was leptokurtic in cross I (0.04) and IV (0.70), while it was platykurtic in cross II (-0.60) and III (-0.39) for the upper half mean length. Fiber strength showed platykurtic curve for crosses I (-0.11), II (-0.48) and III (-0.97), while a leptokurtic peak was observed for cross IV (0.13). In the case of fiber fineness, all four crosses (-0.38, - 0.79, -1.11 and -0.24) showed a platykurtic curve.

The curve was leptokurtic in crosses I (1.20), IV (1.95) and platykurtic in crosses II (-1.00), III (-0.29) for uniformity index. For elongation percentage, the Platykurtic curve was shown by crosses I (-0.45), II (-0.44), III (-0.92) and leptokurtic peak was observed in cross IV (1.01). In terms of ginning percentage, all crosses viz., I (-0.98), II (-1.07), III (-0.99) and IV (-0.73) showed a platykurtic curve. A similar trend was reported by various scientists [14-16].

Conclusion

Crosses II and IV were found to have high mean values for the yield of cotton per plant, boll number per plant, boll weight and fiber quality. Segregants from these two crosses can be forwarded to further generation to improve yield as well as quality. A trait's skewed distribution suggests that non-additive gene activity controls the trait and is impacted by environmental factors. The traits with negative skewness refer to duplicate gene action, whereas positive skewness indicates complementary gene action. Nevertheless, of whether the genes influencing the trait have an increasing or decreasing effect on the trait, they tend to be predominately dominant. Leptokurtic curve indicates the existence of gene activity which was controlled by a smaller number of genes while platykurtic curve indicates the gene activity is governed by polygenes. Selection intensity will be higher under complementary gene interaction as the performance of the population will be greater than duplicate gene interaction. Genetic gain in traits showing negative skewness will be rapid under mild selection from the existing variability. Hence, from the analysis of skewness and kurtosis, a breeder can know the selection intensity of a population and the gene action, thereby utilizing it effectively for future crop improvement programmes.

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