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Evaluation of genetic parameter of yield and related traits and their associations in upland cotton (*Gossypium hirsutum* L.) genotypes

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COTTON is a crucial raw material for textile industry. The study aimed to evaluate variability and character associations of 100 upland cotton genotypes. For this, a field study was conducted from July to December, 2021 in the experimental field of Cotton Research, Training and Seed Multiplication Farm, Sadarpur, Dinajpur, Bangladesh. Here, eleven yield and yield-related traits were measured and the genotypes revealed significant differences for all of these traits. The genotype JA-11/L exhibited the greatest seed cotton yield per plant (128.54 g) followed by BC-0025 (126.25 g) and BC-0033 (126.10 g) along with superior average sympodial branches per plant, bolls per plant, single boll weight with early maturing phenomena. A high heritability (>70.00%) with increased genetic advance as a percentage of the mean (>20%) was revealed in plant height, phenotypic acceptability, bolls per plant and single boll weight. Seed cotton yield per plant exhibited a strong positive correlation with lint fiber yield per plant (0.820** and 0.776**), bolls per plant (0.469** and 0.297**) and phenotypic acceptability (0.442** and 0.326**) at both genotypic and phenotypic levels, respectively. Path analysis showed highest positive direct association between seed cotton yield per plant and lint fiber yield per plant (0.797 and 0.765), bolls per plant (0.216 and 0.063) and single boll weight (0.087 and 0.036) at both genotypic and phenotypic levels, respectively. Based on the overall performances, the genotypes JA-11/L, RA-2, RA-5, CB-8, TC-1903, BC-0025, BC-0033, BC-0042 and BC-0062 could be taken under consideration for future upland cotton breeding in Bangladesh.

Keywords: Heritability; Genetic advance; Correlation co-efficient; Path analysis; Upland cotton.

Introduction

Cotton (*Gossypium hirsutum* L.) is a predominant fiber crop worldwide, supplying more than 95% of the unprocessed natural fibers utilized in the textile industry, and holds significance as an oilseed and bioenergy crop (Farias et al., 2016; Salama et al., 2024). It is the most lucrative non-food crop, supporting the USD 3 trillion global fashion industry, which earned USD 1.3 trillion in global garment exports in 2019 (Kadam et al., 2024). It is belonging to the *Gossypium* genus, has 46 diploid species ($2n = 2x = 26$) with 7 allotetraploids ($2n = 4x = 52$) (; Ulloa et al., 2006; Chen et al., 2007; Kranthi et al., 2017). There is a significant phenotypic variability among the 53 main species (Wendel and Cronn, 2003). *Gossypium hirsutum* L., commonly known as upland cotton or American cotton, is the predominant cotton species cultivated in over 80 nations and regions globally playing a pivotal role in the nation's economy (Shakeel et al., 2015; Kadam et al., 2024).

The upland American cotton is the most important fiber crops in Bangladesh and contributes about 96% of its total domestic production (Tabib, 2023 It is well known globally as a vital fiber crop and is grown as an annual crop in tropical and subtropical regions worldwide. In Bangladesh, it is grown mainly in northern and western regions and introducing in hilly regions of the country. But the yield of seed cotton of Bangladesh is lower than other cotton-producing countries. In 2020-21, the average lint production was 1090 kg ha^{-1}, which was below the world's leading cotton producers such as China (1787 kg ha^{-1}), Australia (1887 kg ha^{-1}) and Brazil (1712 kg ha^{-1}) (The ICAC's 82nd Plenary Meeting). Consequently, it is imperative to improve high-yielding cotton cultivars to increase seed cotton yield (Balci et al., 2020).

The yield and its attributing traits are heritable in nature (Peohlman and Selper, 1995). To differentiate between heritable and non-heritable components of variation in a population, genetic indices such as

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heritability, genetic advance, genotypic coefficient of variation can be utilized to formulate the breeding plan according to specific breeding objectives (Batool et al., 2010; Dhamayanathi et al., 2010; Khan et al., 2010). Consequently, quantitative features can be enhanced by the implementation of suitable breeding programs. Plant breeders consistently promoted genetic variety within breeding populations, viewing it as a fundamental prerequisite for evaluating genetic material against various biotic and abiotic challenges (Govindaraj et al., 2015; Gnanasekaran et al., 2018; Swarup et al. 2021). Several researchers reported significant variability coupled with increased heritability and genetic advance in cotton genotypes for yield and its attributing features exist (Ahsan et al., 2015; Abbas et al., 2015).

The yield is a complex mixture of components (Iqbal et al., 2006; Magadum et al., 2012; Rao et al., 2013; Baloch et al., 2014). Thus, breeding programs aim to understand how morphological parameters are linked together (Raza et al., 2016; Reddy et al., 2016; Khan et al., 2017). A through picture about nature and magnitude of crop performance and its associated traits with yield is imperative selecting a superior parent for hybridization (Teklewold et al., 2000; Abdel-Monaem et al., 2022). This might be achieved by considering positive contribution of these yield traits (Sun et al., 2017; Huang et al., 2017).

Correlation determines the mutual relationships among various plant traits and several characters that can be used for selection to improve yield (Shabbir et al., 2016; Kadam et al., 2024). Understanding the correlation between important characteristics is necessary for selecting genotypes with high yield performance (Abd EL-Mohsen and Amein, 2016). Genotypic correlation values quantify the genetic inter-relationship between traits, explaining the extent interaction between traits genetically and phenotypically (Farias et al., 2016; Chapepa et al., 2020; Kadam et al., 2024) while, both genotypic and environmental factors contribute to phenotypic variation (Ahmad et al., 2008; Desalegn et al., 2009; Ahmad et al., 2016; Gnanasekaran et al., 2018)

Path analysis is a crucial tool for researchers seeking understanding the intricacies of variable relationships in their studies (Manonmani et al., 2019; Sharma et al., 2023; Kadam et al., 2024) Direct and indirect impacts are separated from the correlation coefficients, clarifying whether these traits affect yield directly or indirectly via other traits (Wright, 1921; Dewey and Lu, 1959). It provides more elaborate insights into relationships than correlation coefficients, making it a preferred method for plant breeders evaluating seed cotton yield in relation to other variables (Sainath et al., 2022). Hence, the current study sought to examine mean performances of 100 cotton (*Gossypium hirsutum* L.) genotypes, genetic parameter study and to assess character associations in upland cotton genotypes.

Here, GCV and PCV estimates were grouped as low (0–10%), moderate (10–20%), or high (20% and above) as instructed by Burton and De Vane, 1953. The estimation of heritability in broad sense (h^2_b) was conducted following the formula proposed by Johnson et al., 1955; Allard, 1960; Falconer and Mackay, 1996. Based on description by Robinson et al., 1949; Falconer and Mackay, 1996 heritability estimates were categorized as low (<30%), moderate (30-60%) and high (>60%). The estimation of genetic advance (GA) was performed utilizing the equation supplied by Johnson et al., 1955; Allard, 1960. The calculation of genetic advance as a percentage of the mean (GAM) was performed using the tools developed by Comstock and Robinson, 1952; Robinson et al., 1949. According to Johnson et al., 1955; Falconer and Mackay, 1996 GAM was grouped as low (0–10%), moderate (10–20%), or high (≥ 20%). The correlation coefficients between the genotype and phenotype of yield and its contributing factors was evaluated following the technique developed by Johnson et al., 1955. The path coefficient analysis was determined by the technique suggested by Singh and Chaudhary, 1985. This approach allowed for the separation of direct and indirect impacts on yield. The above-mentioned parameters were computed using the software package "variability" in R of version 4.4.3 (R Core Team, 2025).

Materials and Methods

Plant materials and experimental setup

The plant materials employed in this investigation consisted of the 100 upland cotton genotypes (*Gossypium hirsutum* L.) collected from gene bank of Cotton Development Board (CDB), Cotton Research Centre, Mahiganj, Rangpur, Bangladesh (Table 1). The experiment was conducted from July, 2021 to December 2021 inside the experimental domain located at Cotton Research, Training and Seed Multiplication Farm, Sadarpur, Dinajpur, under Cotton Development Board, Bangladesh.

The study was implemented utilizing a complete randomized block design including three replications. 4 m × 4.5 m unit plot was planted with a spacing of 40 cm between plants and 90 cm between rows, with three seeds put in 10 lines for each genotype. The crops were safe guarded from pest infestations with multiple applications of commercial insecticides, and weeds were managed as needed. Data were collected pertaining to the eleven distinct morphological characteristics at various phases of plant growth displayed in Table 2.

Table 1. Plant genetic materials used in this experiment.

Serial	Genotype	Serial	Genotype	Serial	Genotype	Serial	Genotype
1.	RA-2	26.	CB-17, RA-3	51.	JA-11/L	76.	BC-0038
2.	RA-4	27.	JA-1055, CB-1055	52.	JA-17/2	77.	BC-0039
3.	RA-5	28.	BC-0385	53.	JA-13/X	78.	BC-0040
4.	RA-9.N5	29.	BC-0397	54.	JA-09/G	79.	BC-0041
5.	RA-15	30.	BC-0410	55.	JA-08/4	80.	BC-0042
6.	RA-16	31.	BC-0415	56.	JA-085	81.	BC-0043
7.	SR-17	32.	BC-0419	57.	JA-0510	82.	BC-0044
8.	SR-18	33.	BC-0435	58.	Mutant-1	83.	BC-0045
9.	SR-19	34.	BC-0436	59.	TC-1901	84.	BC-0046
10.	CB-1	35.	BC-0442	60.	TC-1902	85.	BC-0047
11.	CB-2	36.	BC-0462	61.	TC-1903	86.	BC-0048
12.	CB-3	37.	BC-0488	62.	TC-1904	87.	BC-0049
13.	CB-4	38.	BC-0490	63.	BC-0024	88.	BC-0050
14.	CB-5	39.	BC-0491	64.	BC-0025	89.	BC-0051
15.	CB-6	40.	BC-0495	65.	BC-0026	90.	BC-0052
16.	CB-7	41.	BC-0509	66.	BC-0027	91.	BC-0053
17.	CB-8	42.	BC-0510	67.	BC-0028	92.	BC-0054
18.	CB-9	43.	BC-0511	68.	BC-0029	93.	BC-0055
19.	CB-10	44.	BC-0512	69.	BC-0030	94.	BC-0056
20.	CB-11	45.	BC-0513	70.	BC-0031	95.	BC-0057
21.	CB-12	46.	BC-0514	71.	BC-0032	96.	BC-0058
22.	CB-13	47.	BC-0515	72.	BC-0033	97.	BC-0059
23.	CB-14	48.	JA-11/N	73.	BC-0035	98.	BC-0060
24.	CB-15	49.	JA-13/R	74.	BC-0036	99.	BC-0061
25.	CB-16, JA-0819	50.	JA-08/B	75.	BC-0037	100.	BC-0062

Origin: Gene bank of Cotton Development Board (CDB), Cotton Research Centre, Mahiganj, Rangpur, Bangladesh.

Table 2. The morphological traits with abbreviation, unit and measurement method used in the study.

Trait	Abbreviation	Unit	Methods of measurement
Phenotypic acceptability	PA	-	Visual phenotypic (vigorous growth) scoring in the scale of 1 to 10 of the selected plants
Plant height	PH	cm	From the stem's base to its tip using tape ruler
Sympodial branches per plant	SBPP	-	The direct fruiting branches of cotton plants which were counted by tallying the nodes from the base to the first monopodial branch
Days to 50% flowering	DFF	-	Days from planting to fifty percent flowering
Days to first boll formation	DFBF	-	Counting the days from planting to initial boll formation
Bolls per plant	BPP	-	Enumerating all bolls on the entire plant
Single boll weight	SBW	g	Choosing 30 bolls from each selected plant, weighing them to derive an average
Seeds per boll	SPB	-	Counting the seeds in each boll then averaged
Seed cotton yield per plant	SCYPP	g	Averaging the results from ten plants to calculate the yield for each genotype
Lint fiber yield per plant	LFYPP	g	Averaging the results from ten plants to calculate the yield for each genotype deducting the average seed weight
Earliness Index	EI	%	Estimated by percentage of first picking from total picking

Statistical and quantitative analyses

The characters were analyzed using the F variance test. The analysis of variance (ANOVA) was measured by the technique proposed by Panse and Sukhatme, 1978. The magnitude of the variations among the means was assessed using Tukey's test to interpret the data. The estimation of genotypic and phenotypic variances was conducted using the technique given by Burton and De Vane, 1953; Dagnelie, 1975 which considered whether the genotype, location, and environment factors were characterized as random or fixed. The genotypic and phenotypic variances was addressed by the formula proposed by Johnson et al., 1955. The genotypic coefficients of variation (GCV) and phenotypic coefficient of variation (PCV) were estimated using the formula provided by Burton and De Vane, 1953; Singh and Chaudhary, 1985.

Here, GCV and PCV estimates were grouped as low (0–10%), moderate (10–20%), or high (20% and above) as instructed by Burton and De Vane, 1953. The estimation of heritability in broad sense (h^2_b) was conducted following the formula proposed by Johnson et al., 1955; Allard, 1960; Falconer and Mackay, 1996. Based on description by Robinson et al., 1949; Falconer and Mackay, 1996 heritability estimates were categorized as low (<30%), moderate (30-60%) and high (>60%). The estimation of genetic advance (GA) was performed utilizing the equation supplied by Johnson et al., 1955; Allard, 1960. The calculation of genetic advance as a percentage of the mean (GAM) was performed using the tools developed by Comstock and Robinson, 1952; Robinson et al., 1949. According to Johnson et al., 1955; Falconer and Mackay, 1996 GAM was grouped as low (0–10%), moderate (10–20%), or high (≥ 20%). The correlation coefficients between the genotype and phenotype of yield and its contributing factors was evaluated following the technique developed by Johnson et al., 1955. The path coefficient analysis was determined by the technique suggested by Singh and Chaudhary, 1985. This approach allowed for the separation of direct and indirect impacts on yield. The above-mentioned parameters were computed using the software package “variability” in R of version 4.4.3 (R Core Team, 2025).

Results and Discussion

Analysis of variance

Table 3 displayed the information of analysis of variance (ANOVA) for eleven morphological traits of 100 upland cotton genotypes. A significant and notable disparity among genotypes for all the characters examined were disclosed by the analysis of variance. The observed differences in genotypes indicated substantial genetic variation among the studied genotypes. This modification would offer possibilities for choosing and cultivating advantageous genetic characteristics, which can be associated with the diverse genetic makeup of the populations that have undergone evolution. Salahuddin et al., (2010) argued that this demonstrates substantial genetic variability of the attributes among the genotypes, which has further impacted other associated traits. Kumar et al., 2019; Chapepa et al., 2020; Rehman et al., 2020; Sahar et al., 2021; Sarwar et al., 2021; Amer et al., 2022; Amer et al., 2023; Nivedha et al., 2024 also found significant differences among the cotton genotypes. The wide range among cotton genotypes for the different plant characters were also outlined by Jarwar et al., 2018; Bhatti et al., 2020; Sarwar et al., 2020; Amer et al., 2021; Gibely, 2021; Balarabe et al., 2022; Yasar, 2023.

Mean performances

Table 4 displayed the average performances of eleven yield and its attributing traits of 100 upland cotton genotypes. Mean performance revealed, the genotype BC-0062, RA-5, BC-0510, BC-0036 had the highest phenotypic acceptability of 9.2 and 9.0 respectively. In contrast, CB-8, BC-0049 and BC-0042 had the lowest phenotypic acceptability of 3.0 and 3.3.

The mean plant height at the time of initial harvest varied between 86.87 cm and 177.47 cm. The genotype CB-10 had the tallest plant, measuring 177.47 cm followed by CB-8 (175.48 cm) and BC-0025 (175.34 cm) while the genotype BC-0397 had the shortest plant, measuring 86.87 cm followed by BC-0043 (88.29 cm) and BC-0513 (89.98 cm), respectively. Whereas, Mawblei et al., (2022) found plant height ranged from 56 cm-103 cm. Bhatti et al., (2020) opined that the plant height ranged from 98 to 150 cm.

Sympodial branches per plant ranged from 16 to 23.18. The genotype BC-0057 (23.18) had the highest number of sympodial branches per plant whereas, the genotype BC-0036 and BC-0052 had the minimum measuring the value 16. An increased number of sympodial branches per plant impact the effectiveness of flowering and boll formation, which in turn enhances growth and yield. The results were congruent with Mawblei et al., (2022) found that, the genotype D16 (20.3) showed the highest performance for sympodia per plant among 100 different genotypes. Rehman et al., (2020) reported that the genotype VH-367 exhibited the maximum mean value of 23.13 subsequent to A555 (22.66), IUB-222 (20.93) and NIAB-414 (20.93), respectively for sympodial branches per plant.

Days to 50% flowering is an important character to determine earliness in cotton hence an important aspect for cotton breeders to incorporate this trait to develop early fruit setters. In the present study, the genotype BC-0024, BC-0043 and RA-2, BC-0027 are the early flowering genotypes comprised of 44.33 days and 44.67 days to 50% flowering whereas the late flowering genotypes are BC-0061, BC-0062 and CB-4, BC-0495 comprised of 54 days and 52.73 days to 50% flowering, respectively. Bhatti et al., (2020) found that days to 50% flowering varied from 61-70 days, however the lowest and statistically at par value was expressed by the cultivar FH-142 followed by MNH-886. Therefore, our study revealed early flowering. Days to first boll formation varies between 125-140 days. The early boll formation genotypes are CB-7 and BC-0397 comprised of 125 days and 125.67 days while the late boll formation genotypes are BC-0033 and BC-0036, BC-0053 comprised of 140 days and 138 days, respectively. Anjum et al., (2001) Showed that days to first boll formation varied from 82.30-92.30 days after sowing.

Among other yield related attributes bolls per plant is very important feature associated with high yielding cultivars and discussed by many workers. The maximum bolls per plant bearing genotypes were BC-0033, BC-0062 and BC-0055 comprised of 34.33, 34.0 and 33.0 bolls per plant. Mawblei et al., (2022) found among the 100 different genotypes, Stardel (23.67) showed the highest performance for bolls per plant. Bhatti et al., (2020) opined that bolls per plant varied from 13 bolls to 31on the basis of variation among genotypes. Rehman et al., (2020) reported that bolls per plant varied from 16.26 to 32.13.

Single boll weight varied from 3.60-6.44 g. The genotype CB-8, BC-0049, BC-0042, CB-6, BC-0048 had > 6 g of single boll weight. Boll weight is a crucial element that has a direct impact on yield. The increased yield was related to a greater quantity of bolls per plant as well as a greater quantity of single boll weight. Mawblei et al., (2022) reported Acala-1577-D (4.67 g) showed the highest performance for boll weight. Rehman et al., (2020) reported that the genotype VH-367 scored highest mean estimate of 2.46 g whereas, CIM-632 had least mean estimate for boll weight of 1.83g.

In the present study, seeds per boll varied from 22-37. The genotype BC-0028 had the highest number of seeds per boll of 37. Rehman et al., (2020) reported that for 100-seed weight, the accessions NIAB-414 and A555 demonstrated the lowest and highest mean estimations of 5.07 and 5.64 g, respectively.

Among the 100 upland cotton genotypes, JA-11/L exhibited the greatest seed cotton yield per plant, measuring 128.54g, followed by BC-0025 and BC-0033 which achieved seed cotton yield per plant of 126.25g and 126.10g, respectively. Consequently, these may serve as prospective donors for future breeding programs. The genotype BC-0042 had the lowest number of seed cotton yield per plant of 112.58g followed by BC-0049 and BC-0045 of 116.23 and 117.35g per plant. Rehman et al., (2020) opined that IUB-222 scored highest mean value of 74.81g for seed cotton yield. Mawblei et al., (2022) reported that 16 genotypes exhibited elevated yield based on the mean performance among 100 upland cotton germplasms. Mahdy et al., (2022) showed that mean seed cotton yield/plant of the parents Giza90 and Giza86 was 104.67 and 94.06g under normal soil.

Lint fiber yield per plant varies between 101.58-120 g per plant. The genotype JA-11/L had the highest lint fiber yield per plant of 120g whereas the genotype BC-0042 showed lowest lint fiber yield per plant of 101.58 g. Hence, these can serve as a crucial donor for forthcoming breeding programs in cotton. Mahdy et al., (2018) showed that the reduction in lint yield was more than that in seed cotton yield.

Earliness index varied between 76.21 % - 94 %. The genotype BC-0024, RA-2, BC-0027, BC-0053 are the early maturing genotypes ad the showed maximum values for earliness index of 93 %, and 91.65 %. The genotype BC-0061, BC-0062, CB-2, CB-5 are the late maturing genotypes exhibited earliness index of < 80 %. Mahdy et al., (2018) opined that G. 90 flowered normal and showed the highest earliness index, indicating that G. 90 flowered normal and gave most of its yield in few weeks. Amer et al., (2023) examined that earliness index varied from 58.41% for Giza 87, which indicate more lateness to 82.39% for promising line no.3, the more earliness of this genotype may be attributed to the foreign genotype involved in it. Abubakar et al., (2024) showed that the greater earliness index was recorded in PB-130 (67.06) and the lowest earliness index was recorded in PB-94 (42.73) when analyzed 14 genotypes of cotton.

Variability study

The ability to improve economic characteristics via crop selection is primarily contingent upon the degree of genetic variability. The genotypic and phenotypic coefficients of variation reflect the degree of genetic variability within a population, but heritability facilitates the prediction of the impact of transmission factors on phenotype expression, thereby informing the process of selecting better genotypes through natural selection. Heritability with genetic advance, guarantees the stability of genetic parameters for certain characteristics. The outcomes of several genetic parameters for eleven traits were presented in Table 5. The findings indicated that the observed variations in phenotypic (σ^2p) traits were greater than the variations in genetic (σ^2g) makeup for all the characteristics.

Table 3. Mean squares (MS) derived on eleven morphological characters in 100 upland cotton genotypes.

Character	Mean Sum of Squares			
	Genotype	**Replication**	**Error**	**CV (%)**
Phenotypic acceptability	4.89***	0.21	0.29	8.64
Plant height (cm)	1901.85***	77.11*	17.16	3.12
Sympodial branches per plant	5.09***	0.08	1.22	5.77
Days to 50% flowering	14.09***	3.69*	0.96	2.02
Days to first boll formation	26.07***	1.68	2.29	1.16
Bolls per plant	41.04***	0.91	3.92	7.72
Single boll weight (g)	0.99***	0.06	0.09	6.41
Seeds per boll	14.86***	7.02	3.41	6.02
Seed cotton yield per plant (g)	11.53***	4.73	1.64	1.05
Lint fiber yield per plant (g)	15.94***	4.15	1.57	1.10
Earliness index (%)	22.97***	12.04	5.42	2.72

Here, * and *** indicated significant at 5% and 0.1% levels of probability, respectively and CV = coefficient of variation

Table 4. Mean values based on phenotypic expressions for 11 morphological characteristics in 100 upland cotton genotypes.

Serial	Genotype	PA	PH	SBPP	DFF	DFBF	BPP	SBW	SPB	SCYPP	LFYPP	EI
1	RA-2	7.00^{g-l}	155.47^{e-i}	19.00^{f-p}	44.67^{c}	136.00^{b-d}	28.00^{e-j}	4.37^{u-h}	36.00^{ab}	122.24^{n-a}	114.36^{n-f}	91.65^{ab}
2	RA-4	6.67^{h-o}	143.65^{l-p}	17.87^{n-s}	50.53^{d-k}	127.67^{u-a}	32.00^{a-d}	5.83^{b-d}	32.47^{c-l}	121.58^{r-d}	113.32^{v-i}	84.55^{g-s}
3	RA-5	9.00^{ab}	157.21^{d-h}	17.80^{o-s}	47.33^{r-x}	132.00^{g-m}	32.00^{a-d}	3.83^{i-l}	31.00^{f-s}	122.51^{k-y}	115.13^{g-x}	86.45^{c-n}
4	RA-9.N5	7.00^{g-l}	150.82^{h-k}	19.00^{f-p}	51.33^{b-f}	128.00^{s-a}	28.00^{e-j}	4.46^{r-f}	30.00^{j-t}	124.87^{a-f}	114.20^{o-f}	81.61^{r-u}
5	RA-15	6.67^{h-o}	151.56^{f-k}	19.20^{e-p}	47.33^{r-x}	129.33^{o-x}	32.53^{a-c}	5.64^{c-e}	32.67^{c-k}	121.50^{t-d}	113.23^{x-j}	87.28^{c-l}
6	RA-16	5.87^{o-v}	171.51^{ab}	20.40^{c-h}	44.80^{bc}	133.73^{d-h}	20.00^{b-e}	4.63^{l-b}	33.73^{b-f}	122.89^{f-x}	112.69^{c-j}	87.98^{b-i}
7	SR-17	7.00^{g-l}	158.12^{d-f}	18.53^{i-r}	47.00^{t-z}	128.00^{s-a}	25.87^{h-r}	5.46^{d-g}	32.40^{c-l}	123.44^{c-u}	108.71^{l}	83.45^{m-t}
8	SR-18	4.75^{yz}	148.01^{j-n}	17.93^{m-s}	48.13^{n-u}	130.33^{k-s}	26.80^{g-n}	4.91^{i-s}	31.80^{d-p}	122.68^{h-y}	113.15^{x-j}	88.56^{b-d}
9	SR-19	7.40^{e-h}	116.93^{z-d}	17.87^{n-s}	51.00^{c-g}	129.20^{o-x}	30.13^{c-f}	4.49^{r-e}	31.87^{d-o}	123.68^{c-q}	115.49^{d-u}	87.48^{c-k}
10	CB-1	4.53^{z}	127.72^{uv}	19.73^{d-l}	47.67^{p-w}	128.93^{p-y}	27.07^{fm}	4.46^{r-f}	31.53^{d-r}	123.92^{c-o}	115.76^{b-p}	85.99^{c-p}
11	CB-2	5.00^{w-z}	162.71^{cd}	20.00^{d-j}	50.33^{d-k}	130.67^{j-r}	23.00^{p-b}	5.38^{d-i}	30.00^{j-t}	123.65^{c-q}	115.34^{f-u}	78.23^{uv}
12	CB-3	5.93^{o-u}	167.41^{bc}	20.73^{b-f}	51.60^{b-e}	130.33^{k-s}	24.73^{k-w}	4.99^{g-p}	29.20^{n-u}	123.5^{c-t}	114.88^{i-a}	86.41^{c-n}
13	CB-4	6.20^{l-s}	154.68^{e-j}	19.27^{d-o}	52.73^{ab}	132.20^{g-l}	25.27^{j-u}	4.86^{j-t}	33.53^{b-g}	122.10^{n-b}	114.98^{i-z}	85.85^{c-p}
14	CB-5	6.27^{k-s}	173.34^{ab}	19.27^{d-o}	52.13^{bc}	130.47^{k-r}	28.80^{e-i}	4.43^{s-g}	30.27^{i-t}	121.64^{q-d}	111.89^{h-k}	79.72^{t-v}
15	CB-6	5.00^{w-z}	160.17^{de}	19.00^{f-p}	47.67^{p-w}	127.00^{x-b}	20.73^{a-d}	6.14^{ab}	34.00^{b-e}	122.81^{f-x}	114.67^{j-d}	86.45^{c-n}
16	CB-7	5.00^{w-z}	173.63^{ab}	20.00^{d-j}	47.33^{r-x}	125.00^{b}	23.00^{p-b}	5.35^{d-i}	34.27^{a-d}	123.16^{d-w}	115.35^{f-u}	84.88^{d-s}
17	CB-8	3.00^{a}	175.48^{a}	20.00^{d-j}	50.33^{d-k}	130.00^{l-u}	19.67^{c-e}	6.44^{a}	35.00^{a-c}	120.32^{z-d}	112.37^{f-k}	84.88^{d-s}
18	CB-9	4.80^{yz}	153.28^{f-j}	19.73^{d-l}	50.67^{c-j}	131.40^{h-o}	24.13^{m-y}	5.06^{f-m}	28.13^{s-v}	122.55^{j-y}	114.83^{i-b}	86.53^{c-n}
19	CB-10	7.00^{g-l}	177.47^{a}	20.00^{d-j}	49.33^{i-o}	127.00^{x-b}	28.00^{e-j}	4.33^{w-h}	32.00^{d-n}	121.26^{v-d}	114.43^{m-e}	85.78^{c-p}
20	CB-11	6.20^{l-s}	172.90^{ab}	18.47^{i-r}	47.27^{r-y}	130.93^{i-q}	23.00^{p-b}	4.76^{k-y}	29.00^{o-u}	121.89^{o-d}	111.24^{jk}	88.28^{b-g}
21	CB-12	6.93^{g-m}	148.03^{j-n}	19.93^{d-k}	45.13^{a-c}	131.33^{h-p}	25.47^{j-t}	4.50^{q-d}	32.40^{c-l}	122.37^{l-z}	115.36^{f-u}	85.77^{c-p}
22	CB-13	6.40^{j-r}	157.95^{d-g}	20.80^{b-e}	45.73^{y-c}	129.13^{o-x}	28.80^{e-i}	4.68^{l-z}	32.47^{c-l}	121.98^{o-c}	112.49^{e-k}	83.00^{n-t}
23	CB-14	7.00^{g-l}	139.76^{o-r}	23.00^{a}	48.00^{o-v}	126.67^{y-b}	27.00^{f-m}	4.53^{p-c}	29.00^{o-u}	122.37^{l-z}	111.74^{i-k}	86.45^{c-n}
24	CB-15	6.13^{m-t}	121.02^{w-a}	19.47^{d-o}	48.73^{l-r}	130.93^{i-q}	25.27^{j-u}	4.08^{c-l}	31.13^{e-r}	122.29^{m-a}	113.95^{p-g}	85.60^{c-q}
25	CB-16, JA-0819	6.07^{n-t}	99.16^{l-o}	19.07^{e-p}	45.13^{a-c}	130.53^{k-r}	23.93^{m-z}	4.46^{r-f}	30.73^{g-t}	122.78^{g-x}	113.53^{s-i}	82.91^{n-t}
26	CB-17, RA-3	5.73^{p-w}	135.58^{q-s}	17.80^{o-s}	45.27^{a-c}	129.13^{o-x}	23.27^{o-a}	4.43^{s-g}	31.53^{d-r}	123.95^{c-o}	114.99^{i-z}	84.31^{i-s}
27	JA-1055, CB-1055	5.87^{o-v}	102.34^{k-n}	19.33^{d-o}	45.87^{x-c}	127.60^{u-a}	22.20^{u-c}	4.22^{z-j}	32.40^{c-l}	121.66^{q-d}	113.27^{w-i}	87.37^{c-k}
28	BC-0385	5.07^{v-z}	90.01^{q-s}	17.47^{p-t}	49.20^{j-p}	129.53^{n-w}	22.53^{s-c}	4.55^{p-c}	32.80^{c-j}	121.78^{p-d}	113.48^{u-i}	87.99^{b-i}
29	BC-0397	6.00^{o-u}	86.87^{s}	18.53^{i-r}	45.60^{z-c}	125.67^{ab}	22.07^{v-c}	5.04^{f-o}	29.07^{n-u}	124.35^{a-m}	114.71^{j-c}	86.32^{c-o}
30	BC-0410	6.97^{g-n}	95.64^{o-q}	19.67^{d-m}	50.13^{e-l}	129.07^{o-y}	25.53^{j-s}	5.07^{f-m}	30.33^{h-t}	123.40^{c-u}	117.26^{a-f}	87.59^{c-k}
31	BC-0415	6.40^{j-r}	108.75^{g-k}	18.47^{i-r}	50.20^{e-l}	133.20^{e-i}	25.40^{j-t}	4.21^{z-j}	31.73^{d-p}	124.45^{a-k}	118.45^{a}	87.59^{c-k}
32	BC-0419	5.93^{o-u}	111.12^{d-j}	18.40^{i-r}	49.13^{j-p}	132.13^{g-l}	27.47^{f-l}	4.31^{x-i}	32.27^{c-m}	122.79^{g-x}	115.28^{f-w}	84.75^{e-s}
33	BC-0435	6.53^{i-p}	108.84^{f-k}	18.93^{g-p}	49.00^{k-q}	128.33^{r-z}	25.40^{j-t}	4.42^{t-g}	29.07^{n-u}	124.70^{a-h}	117.13^{a-g}	84.28^{i-s}
34	BC-0436	5.33^{t-z}	109.64^{e-j}	18.87^{h-q}	49.93^{f-l}	130.93^{i-q}	25.47^{j-t}	4.69^{l-z}	31.27^{e-r}	122.20^{n-a}	113.03^{z-j}	87.11^{c-m}
35	BC-0442	5.47^{s-y}	107.94^{h-k}	18.80^{h-q}	51.67^{b-e}	132.00^{g-m}	24.33^{l-x}	4.33^{v-h}	28.60^{r-v}	123.65^{c-q}	115.41^{e-u}	84.79^{e-s}
36	BC-0462	5.67^{q-x}	105.82^{j-l}	18.60^{i-r}	51.67^{b-e}	130.13^{l-t}	27.73^{f-k}	4.38^{t-h}	29.27^{n-u}	122.16^{n-b}	113.61^{r-i}	82.61^{o-t}
37	BC-0488	5.87^{o-v}	91.23^{p-s}	19.13^{e-p}	50.87^{c-i}	127.47^{v-a}	26.27^{g-o}	4.37^{u-h}	29.40^{m-u}	121.21^{v-d}	113.09^{y-j}	84.52^{h-s}
38	BC-0490	5.47^{s-y}	113.00^{b-i}	18.80^{h-q}	47.20^{r-y}	130.27^{k-t}	26.73^{g-n}	4.02^{d-l}	31.93^{d-o}	121.95^{o-c}	112.72^{c-j}	85.23^{c-r}
39	BC-0491	7.00^{g-l}	115.00^{a-g}	17.13^{q-t}	50.00^{f-l}	126.00^{z-b}	26.00^{h-q}	4.63^{l-b}	34.00^{b-e}	120.29^{a-d}	111.73^{i-k}	86.86^{c-m}
40	BC-0495	6.93^{g-m}	107.84^{h-k}	19.80^{d-k}	52.73^{ab}	130.93^{i-q}	25.13^{j-v}	5.23^{e-k}	31.13^{e-r}	121.43^{u-d}	112.69^{d-j}	88.44^{b-e}
41	BC-0509	6.07^{n-t}	124.83^{v-x}	19.93^{d-k}	49.53^{g-o}	129.00^{o-y}	23.67^{n-a}	4.64^{l-b}	31.67^{d-q}	122.78^{g-x}	114.06^{p-g}	85.82^{c-p}
42	BC-0510	9.00^{ab}	95.34^{o-q}	19.33^{d-o}	48.67^{l-s}	128.00^{s-a}	28.00^{e-j}	3.97^{g-l}	30.00^{j-t}	122.92^{e-x}	115.51^{c-s}	84.88^{d-s}
43	BC-0511	5.93^{o-u}	113.53^{b-i}	17.93^{m-s}	48.97^{k-q}	127.47^{v-a}	26.60^{g-n}	4.85^{j-u}	29.27^{n-u}	122.07^{n-b}	114.75^{j-b}	84.68^{f-s}

Serial	Genotype	PA	PH	SBPP	DFF	DFBF	BPP	SBW	SPB	SCYPP	LFYPP	EI
44	BC-0512	5.67^{q-x}	97.87^{m-p}	20.00^{d-j}	48.33^{m-t}	133.33^{e-i}	25.00^{j-v}	4.93^{h-r}	26.00^{vw}	123.16^{d-w}	113.54^{s-i}	87.30^{c-l}
45	BC-0513	4.80^{yz}	89.98^{q-s}	18.93^{g-p}	49.33^{ij-o}	129.40^{o-x}	24.33^{l-x}	4.75^{k-y}	29.73^{k-u}	123.57^{c-s}	116.56^{a-k}	84.84^{d-s}
46	BC-0514	6.53^{i-p}	107.55^{i-k}	19.07^{e-p}	46.60^{u-a}	127.47^{v-a}	26.53^{g-n}	4.40^{t-h}	31.93^{d-o}	123.77^{c-p}	115.30^{f-v}	83.37^{m-t}
47	BC-0515	5.87^{o-v}	94.86^{o-r}	19.53^{d-o}	46.53^{v-a}	130.47^{k-r}	22.87^{q-b}	4.56^{o-c}	30.20^{i-t}	122.21^{n-a}	112.10^{g-k}	84.02^{k-s}
48	JA-11/N	4.87^{x-z}	108.63^{g-k}	19.20^{e-p}	49.73^{g-m}	127.67^{u-a}	22.53^{s-c}	4.57^{n-b}	31.33^{d-r}	123.04^{d-w}	114.29^{o-f}	88.14^{b-h}
49	JA-13/R	6.93^{g-m}	94.14^{o-r}	19.27^{d-o}	51.87^{b-d}	130.93^{i-q}	22.33^{t-c}	4.43^{s-g}	30.53^{h-t}	122.08^{n-b}	113.96^{p-g}	81.38^{s-u}
50	JA-08/B	5.07^{v-z}	94.13^{o-r}	19.63^{d-n}	51.00^{c-g}	130.60^{j-r}	25.87^{h-r}	4.68^{l-z}	30.60^{g-t}	122.22^{n-a}	114.34^{o-f}	85.34^{c-r}
51	JA-11/L	7.00^{g-l}	167.79^{bc}	17.00^{r-t}	46.67^{u-a}	127.00^{x-b}	27.33^{f-l}	4.76^{k-y}	29.67^{l-u}	128.54^{a}	120.50^{a}	87.78^{c-j}
52	JA-17/2	7.00^{g-l}	148.79^{j-m}	20.00^{d-j}	46.67^{u-a}	134.67^{c-f}	27.33^{f-l}	4.29^{y-i}	31.00^{f-s}	124.59^{a-j}	117.46^{a-d}	87.78^{c-j}
53	JA-13/X	7.00^{g-l}	151.35^{g-k}	19.73^{d-l}	50.00^{f-l}	126.00^{z-b}	27.00^{f-m}	4.46^{r-f}	30.00^{j-t}	124.97^{a-e}	116.62^{a-j}	81.62^{r-u}
54	JA-09/G	4.53^{z}	150.20^{i-l}	17.87^{n-s}	50.20^{e-l}	128.67^{q-y}	28.00^{e-j}	4.60^{l-b}	29.67^{l-u}	120.94^{x-d}	112.84^{b-j}	81.33^{s-u}
55	JA-08/4	5.07^{v-z}	153.30^{f-j}	18.53^{i-r}	49.60^{g-n}	130.47^{k-r}	25.73^{i-r}	4.82^{k-v}	30.40^{h-t}	122.54^{j-y}	114.67^{j-d}	88.45^{b-e}
56	JA-085	6.60^{h-o}	157.77^{d-g}	19.40^{d-o}	50.20^{e-l}	130.93^{i-q}	24.80^{k-w}	4.37^{u-h}	29.00^{o-u}	122.17^{n-b}	114.21^{o-f}	87.94^{b-i}
57	JA-0510	7.07^{g-k}	157.76^{d-g}	20.07^{d-i}	47.13^{s-z}	131.93^{g-n}	25.47^{j-t}	4.98^{h-q}	31.73^{d-p}	121.13^{w-d}	113.89^{p-h}	85.34^{c-r}
58	Mutant-1	8.13^{c-e}	136.08^{q-s}	20.13^{d-i}	47.00^{t-z}	127.33^{w-b}	27.00^{f-m}	4.42^{t-g}	28.00^{t-v}	121.11^{w-d}	112.11^{g-k}	86.45^{c-n}
59	TC-1901	5.20^{u-z}	135.50^{q-s}	19.60^{d-n}	45.40^{a-c}	129.80^{l-v}	24.47^{l-x}	4.45^{r-g}	31.73^{d-p}	123.37^{d-u}	114.56^{k-d}	87.37^{c-k}
60	TC-1902	5.20^{u-z}	141.63^{n-q}	19.07^{e-p}	49.33^{i-o}	129.80^{l-v}	27.00^{f-m}	4.36^{v-h}	32.73^{c-j}	121.25^{v-d}	114.20^{o-f}	83.55^{l-s}
61	TC-1903	8.33^{b-d}	146.03^{k-o}	21.00^{b-d}	48.33^{m-t}	135.00^{c-f}	31.00^{b-e}	4.01^{e-l}	31.00^{f-s}	124.78^{a-g}	115.77^{b-p}	84.88^{d-s}
62	TC-1904	5.00^{w-z}	158.08^{d-f}	18.00^{l-s}	47.33^{r-x}	133.00^{e-j}	25.00^{j-v}	5.30^{e-j}	32.00^{d-n}	124.45^{a-k}	115.50^{d-t}	86.45^{c-n}
63	BC-0024	7.20^{f-j}	158.22^{d-f}	19.00^{f-p}	44.33^{c}	128.00^{s-a}	25.67^{i-s}	4.16^{b-k}	31.00^{f-s}	120.68^{y-d}	113.17^{x-j}	93.00^{a}
64	BC-0025	7.00^{g-l}	175.34^{a}	21.00^{b-d}	49.67^{g-n}	130.00^{l-u}	29.00^{d-h}	4.35^{v-h}	30.00^{j-t}	126.25^{a}	116.81^{a-i}	84.88^{d-s}
65	BC-0026	5.00^{w-z}	152.71^{f-j}	19.00^{f-p}	46.33^{w-b}	132.00^{g-m}	24.33^{l-x}	5.41^{d-h}	28.00^{t-v}	124.36^{a-l}	114.48^{l-e}	87.78^{c-j}
66	BC-0027	8.67^{a-c}	137.07^{p-s}	20.00^{d-j}	44.67^{c}	136.00^{b-d}	32.00^{a-d}	3.79^{j-l}	33.00^{c-i}	121.22^{v-d}	113.50^{s-i}	91.65^{ab}
67	BC-0028	7.67^{d-g}	123.92^{v-x}	16.33st	49.33^{i-o}	127.00^{x-b}	27.00^{f-m}	4.52^{p-c}	37.00^{a}	123.64^{c-r}	116.56^{a-k}	86.45^{c-n}
68	BC-0029	6.47^{j-q}	158.04^{d-f}	20.00^{d-j}	48.33^{m-t}	129.00^{o-y}	29.00^{d-h}	4.30^{y-i}	30.00^{j-t}	124.76^{a-g}	117.11^{a-h}	86.45^{c-n}
69	BC-0030	6.40^{j-r}	143.01^{m-p}	18.27^{j-r}	47.47^{q-w}	128.73^{q-y}	29.27^{d-g}	3.92^{h-l}	31.80^{d-p}	121.57^{s-d}	113.50^{s-i}	85.78^{c-p}
70	BC-0031	5.73^{p-w}	134.17^{r-u}	17.87^{n-s}	50.93^{c-h}	132.60^{f-k}	21.40^{x-c}	4.66^{l-a}	29.87^{j-u}	122.60^{j-y}	115.40^{e-u}	81.87^{q-u}
71	BC-0032	5.60^{r-y}	123.98^{v-x}	20.67^{b-g}	46.33^{w-b}	129.67^{m-w}	28.93^{d-h}	4.93^{h-r}	33.27^{b-h}	123.21^{d-v}	114.37^{n-f}	87.41^{c-k}
72	BC-0033	8.67^{a-c}	117.07^{y-d}	18.00^{l-s}	47.00^{t-z}	140.00^{a}	34.33^{a}	4.28^{y-i}	31.00^{f-s}	126.10^{ab}	116.36^{b-n}	88.33^{b-f}
73	BC-0035	6.13^{m-t}	102.66^{k-m}	19.87^{d-k}	45.80^{x-c}	131.33^{h-p}	26.13^{g-p}	3.60^{l}	32.00^{d-n}	122.96^{d-x}	115.33^{f-v}	84.64^{f-s}
74	BC-0036	9.00^{ab}	123.54^{v-z}	16.00^{t}	47.00^{t-z}	138.00^{ab}	31.13^{b-e}	4.16^{b-k}	29.00^{o-u}	123.90^{c-o}	114.92^{i-a}	87.78^{c-j}
75	BC-0037	8.00^{c-f}	114.45^{a-h}	17.00^{r-t}	47.00^{t-z}	134.00^{d-g}	29.00^{d-h}	4.24^{z-j}	31.00^{f-s}	125.43^{a-c}	117.53^{a-c}	87.78^{c-j}
76	BC-0038	6.50^{i-q}	115.46^{a-f}	16.33st	47.00^{t-z}	128.00^{s-a}	24.00^{m-z}	5.31^{e-j}	22.00^{x}	124.69^{a-h}	116.50^{a-l}	87.78^{c-j}
77	BC-0039	5.07^{v-z}	116.26^{a-e}	18.93^{g-p}	45.27^{a-c}	129.33^{o-x}	27.47^{f-l}	4.99^{g-p}	32.00^{d-n}	122.57^{j-y}	113.74^{q-i}	82.52^{p-t}
78	BC-0040	6.20^{l-s}	102.77^{k-m}	20.67^{b-g}	47.73^{p-w}	131.00^{i-q}	15.80^{fg}	4.62^{l-b}	31.87^{d-o}	122.89^{f-x}	115.60^{b-r}	85.06^{c-s}
79	BC-0041	4.60^{z}	95.94^{n-q}	18.20^{k-r}	47.20^{r-y}	131.07^{i-q}	16.87^{ef}	4.81^{k-w}	30.00^{j-t}	122.21^{n-a}	115.10^{h-y}	86.32^{c-o}
80	BC-0042	3.33^{a}	135.77^{q-s}	18.00^{l-s}	47.33^{r-x}	130.67^{j-r}	13.00^{g}	6.25^{ab}	25.00^{w}	112.58^{f}	101.58^{m}	86.45^{c-n}
81	BC-0043	4.87^{x-z}	88.29^{rs}	19.13^{e-p}	44.33^{c}	127.87^{t-a}	20.87^{z-d}	4.66^{l-a}	32.27^{c-m}	121.47^{t-d}	113.49^{t-i}	84.17^{j-s}
82	BC-0044	5.60^{r-y}	123.70^{v-y}	19.07^{e-p}	49.40^{h-o}	133.00^{e-j}	22.73^{r-c}	4.49^{r-e}	28.73^{q-v}	122.62^{i-y}	116.12^{b-o}	84.51^{h-s}
83	BC-0045	5.00^{w-z}	131.52^{s-u}	20.00^{d-j}	47.33^{r-x}	135.33^{c-e}	22.00^{v-c}	5.33^{e-j}	29.00^{o-u}	117.35^{e}	110.50^{kl}	86.45^{c-n}
84	BC-0046	5.00^{w-z}	133.08^{s-u}	19.00^{f-p}	47.00^{t-z}	128.67^{q-y}	24.00^{m-z}	4.50^{g-p}	29.00^{o-u}	120.00^{cd}	112.96^{a-j}	87.78^{c-j}
85	BC-0047	5.00^{w-z}	127.54^{u-w}	19.00^{f-p}	49.33^{i-o}	126.00^{z-b}	25.00^{j-v}	4.79^{k-x}	31.00^{f-s}	119.85^{d}	111.73^{i-k}	86.45^{c-n}
86	BC-0048	5.00^{w-z}	128.20^{t-v}	19.67^{d-m}	49.33^{i-o}	133.33^{e-i}	21.00^{y-d}	6.12^{a-c}	27.00^{u-w}	122.33^{l-a}	115.09^{i-y}	81.62^{r-u}
87	BC-0049	3.00^{a}	112.39^{c-j}	18.00^{l-s}	49.33^{i-o}	135.33^{c-e}	18.00^{d-f}	6.44^{a}	32.00^{d-n}	116.23^{e}	108.54^{l}	86.45^{c-n}
88	BC-0050	7.00^{g-l}	134.73^{r-t}	17.00^{r-t}	49.00^{k-q}	130.00^{l-u}	26.00^{h-q}	4.76^{k-y}	28.00^{t-v}	123.64^{c-r}	114.86^{i-b}	84.88^{d-s}
89	BC-0051	4.80^{yz}	142.07^{n-q}	19.53^{d-o}	50.53^{d-k}	133.73^{d-h}	25.53^{j-s}	5.08^{f-l}	30.80^{f-t}	122.81^{g-x}	116.21^{b-o}	85.37^{c-q}
90	BC-0052	8.67^{a-c}	131.70^{s-u}	16.00^{t}	50.00^{f-l}	130.00^{lu}	31.00^{b-e}	3.98^{f-l}	28.00^{t-v}	123.24^{d-v}	117.13^{a-g}	81.62^{r-u}
91	BC-0053	5.00^{w-z}	149.59^{i-m}	20.00^{d-j}	47.33^{r-x}	138.00^{ab}	24.00^{m-z}	5.17^{e-k}	27.00^{u-w}	124.07^{b-n}	115.74^{b-q}	91.65^{ab}
92	BC-0054	7.33^{e-i}	135.53^{q-s}	22.20^{ab}	51.33^{b-f}	136.67^{bc}	27.00^{f-m}	4.59^{m-b}	33.00^{c-i}	124.67^{a-i}	117.61^{ab}	81.62^{r-u}
93	BC-0055	8.33^{b-d}	134.45^{r-t}	18.00^{l-s}	49.00^{k-q}	129.00^{o-y}	33.00^{a-c}	3.71^{kl}	27.00^{u-w}	122.34^{l-a}	114.61^{j-d}	84.88^{d-s}
94	BC-0056	5.67^{q-x}	153.53^{e-j}	20.07^{d-i}	49.33^{i-o}	134.80^{c-f}	21.80^{w-c}	4.29^{y-i}	30.80^{f-t}	122.74^{g-x}	116.21^{b-o}	88.65^{bc}
95	BC-0057	5.67^{q-x}	156.90^{d-h}	23.18^{a}	49.00^{k-q}	128.00^{s-a}	22.00^{v-c}	5.51^{d-f}	28.00^{t-v}	121.23^{v-d}	113.08^{y-j}	86.45^{c-n}
96	BC-0058	7.00^{g-l}	172.89^{ab}	19.67^{d-m}	49.00^{k-q}	126.00^{z-b}	26.00^{h-q}	4.62^{l-b}	31.00^{f-s}	120.13^{b-d}	116.19^{b-o}	84.88^{d-s}
97	BC-0059	5.00^{w-z}	143.31^{m-p}	21.00^{b-d}	49.00^{k-q}	134.00^{d-g}	24.00^{m-z}	5.05^{f-n}	34.00^{b-e}	121.21^{v-d}	117.41^{a-e}	84.88^{d-s}
98	BC-0060	7.00^{g-l}	119.31^{x-b}	20.00^{d-j}	48.67^{l-s}	130.00^{l-u}	29.00^{d-h}	4.31^{x-i}	29.00^{o-u}	125.00^{a-d}	116.09^{b-o}	84.88^{d-s}
99	BC-0061	6.33^{k-r}	118.96^{x-c}	20.00^{d-j}	54.00^{a}	128.00^{s-a}	29.00^{d-h}	4.19^{a-k}	30.00^{j-t}	121.43^{u-d}	114.37^{n-f}	76.21^{v}
100	BC-0062	9.20^{a}	168.48^{bc}	22.00^{a-c}	54.00^{a}	132.00^{g-m}	34.00^{ab}	3.63^{l}	28.87^{p-v}	123.33^{d-u}	116.41^{b-m}	77.09^{v}
SD		1.27	25.18	1.30	2.17	2.95	3.70	0.57	2.23	1.96	2.31	2.77
LSD (5%)		0.86	6.67	1.78	1.58	2.44	3.19	0.48	2.98	2.06	2.02	3.75

Here, same letter indicated no significant difference, $p < 0.05$.

PA= phenotypic acceptability, PH= plant height (cm), SBPP= sympodial branches per plant, DFF= days to 50% flowering, DFBF= days to first boll formation, BPP= bolls per plant, SBW= single boll weight (g), SPB= seeds per boll, SCYPP= seed cotton yield per plant (g), LFYPP= lint fiber yield per plant (g), EI= earliness Index (%), SD= standard deviation and LSD (5%)= least significance difference at 5% level of probability.

High σ^2g and σ^2p were recorded with plant height (628.23 and 645.39) followed by bolls per plant (12.37 and 16.30), days to 50% flowering (7.93 and 10.22) and the low values were ranged from (>1 to 2) observed with the character single boll weight (0.30 and 0.39) followed by sympodial branches per plant (1.29 and 2.51) and phenotypic acceptability (1.53 and 1.82), respectively.

The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all the traits. Based on Burton and De Vane (1953) classification of PCV and GCV, the current study revealed elevated values of GCV and PCV for phenotypic acceptability (20.06 % and 21.84 %), attributed to significant heterogeneity among the genotypes examined for the attributes. The similarity between the two values indicated very little environmental influence on these traits, highlighting a significant potential for enhancement through selection. The results aligned with Aarthi et al., 2018; Pandiyan et al., 2019; Praveen et al., 2019; Reddy et al., 2019).

Average GCV and PCV were assessed for plant height (18.89 % and 19.15 %), bolls per plant (13.70 % and 15.73 %) and single boll weight (11.66 % and 13.31 %) indicating the existence of a moderate degree of magnitude that can be utilized through selection for an effective breeding effort. The results validated the outcomes of Dhivya et al., 2014; Aarthi et al., 2018; Pandiyan et al., 2019; Shruti et al., 2019.

Low GCV and PCV were accounted for the traits like seeds per boll (6.36 % and 8.76 %), sympodial branches per plant (5.92 % and 8.27 %), days to 50 % flowering (4.31 % and 4.76 %), earliness index (2.83 % and 9.92 %), days to first boll formation (2.016 % and 2.45 %), lint fiber yield per plant (1.91 % and 2.20 %) and seed cotton yield per plant (1.48 % and 1.81 %) demonstrating reduced variability among the examined genotypes. Comparable outcomes were also suggested by Aarthi et al., 2018; Pandiyan et al., 2019; Reddy et al., 2019; Shruti et al., 2019.

In this study, the heritability (h^2b) estimation ranged from 51.31 % to 97.34 %. Plant height (97.34 %), phenotypic acceptability (84.35 %), days to 50 % flowering (82.07 %), days to first boll formation (77.56 %), single boll weight (76.79 %), bolls per plant (75.92 %), lint fiber yield per plant (75.26 %) and seed cotton per plant (66.76 %) demonstrated high h^2b values as per the categories described by Robinson et al., 1949Falconer and Mackay, 1996. This recommended that additive gene action primarily influences above traits and, consequently, can be effectively targeted for selection and improvement in future breeding programs. It was aligned to prior findings of Deshmukh et al., 2019; Manonmani et al., 2019; Pandiyan et al., 2019; Praveen et al., 2019;; Reddy et al., 2019; Shruti at el., 2019; Patel et al., 2023.

Heritability estimates alone are less helpful than heritability coupled with genetic advances in projecting yield under phenotypic selection, according to earlier research of Johnson et al., 1955; Swarup and Chaugale, 1962. When heritability is highly influenced by non-additive gene effects, the genetic advance tends to be low. Conversely, if a significant additive gene effect is present, a higher genetic advance is anticipated (Panse, 1957).

The most accurate measure of the expected progress resulting from the selection can be derived from the integration of heritability, genotypic coefficient of variation, and genetic advance (Johnson et al., 1995). The genetic advance as percentage of mean (GAM) varied from 2.49 % for seed cotton yield per plant to 38.39% for plant height. Out of eleven traits, four traits such as plant height (38.39 %), phenotypic acceptability (37.95 %), bolls per plant (24.59 %) and single boll weight (21.06 %) exhibited elevated levels of GAM (>20 %) coupled with high heritability in accordance with Johnson et al., 1955; Falconer and Mackay, 1996. This suggested that heritability was predominantly responsible to additive genetic effects, thus, selection may be advantageous by exploiting the heritable genes for enhancement. Meena et al., (2023) indicated that monopodia per plant (39.26 %), sympodia per plant (22.50 %), plant height (21.39 %), bolls per plant (58.58 %), seed cotton yield per plant (52.97 %) and lint yield per plant (56.39 %) exhibited high h2b along with high GAM. Comparable outcomes were also shown by Aarthi et al., 2018; Monisha et al., 2018; Pandiyan et al., 2019; Praveen et al., 2019.

Elevated heritability alongside minimal GAM was estimated for days to 50% flowering (8.05 %), days to first boll formation (3.92 %), lint fiber yield per plant (3.42 %), and seed cotton yield per plant (2.49 %), suggesting the existence of non-additive gene action that restricts potential for enhancement. Meena et al., (2023) observed significant heritability alongside minimal GAM for days to flowering (8.45 %) and oil content (5.88 %). Erande et al., 2014; Eswari et al., 2017; Manonmani et al., 2019 obtained analogous results.

Moderate heritability with a low GAM, was seen for seeds per boll (9.52), sympodial branches per plant (8.74), and earliness index (4.20 %), signifying the prevalence of non-additive genetic influence. Heritability was shown as a result of environmental factors rather than genotype, suggesting that this trait may be enhanced by heterosis breeding instead of mere selection. Meena et al., (2023) indicated that days to boll bursting (4.70 %), micronaire (7.06 %) and 2.5% span length (3.46 %) exhibited average heritability with poor GAM. Erande et al., 2014; Monisha et al., 2018; Praveen et al., 2019 reported analogous findings.

Table 5. Genotypic and phenotypic parameters for eleven morphological characteristics in 100 upland cotton genotypes.

Character	$\sigma^2 g$	$\sigma^2 p$	GCV	PCV	h^2_b	GA	GAM
PA	1.53	1.82	20.06	21.84	84.35	2.34	37.95
PH	628.23	645.39	18.89	19.15	97.34	50.94	38.39
SBPP	1.29	2.51	5.92	8.27	51.31	1.68	8.74
DFF	4.38	4.38	4.31	4.76	82.07	3.91	8.05
DFBF	7.93	10.22	2.16	2.45	77.56	5.11	3.92
BPP	12.37	16.30	13.70	15.73	75.92	6.31	24.59
SBW	0.30	0.39	11.66	13.31	76.79	0.99	21.06
SPB	3.82	7.23	6.36	8.76	52.78	2.92	9.52
SCYPP	3.30	4.94	1.48	1.81	66.76	3.06	2.49
LFYPP	4.79	6.36	1.91	2.20	75.26	3.91	3.42
EI	5.85	11.27	2.83	3.92	51.90	3.59	4.20

Here, PA= phenotypic acceptability, PH= plant height (cm), SBPP= sympodial branches per plant, DFF= days to 50% flowering, DFBF= days to first boll formation, BPP= bolls per plant, SBW= single boll weight (g), SPB= seeds per boll, SCYPP= seed cotton yield per plant (g), LFYPP= lint fiber yield per plant (g), EI= earliness Index (%), $\sigma^2 g$: genotypic variance, $\sigma^2 p$= phenotypic variance, GCV= genotypic coefficient of variance, PCV= phenotypic coefficient of variance, h^2_b= heritability in broad sense (%), GA= genetic advance, and GAM= genetic advance as percentage of mean.

Correlation coefficient

The correlation coefficient, denoted as "r", provides information regarding the extent and order of the linear relation between the independent variables (Al-Jibouri et al., 1958). The present study examined the relationships in both phenotypic and genotypic levels among eleven variables. The genotypic correlation demonstrates an intrinsic connection between genes that control two distinct traits, hence facilitating the implementation of an effective selection strategy. The phenotypic correlation is an unreliable indicator of the association between two qualities since it is influenced by environmental influences. The genotypic and phenotypic correlation coefficients of eleven morphological characteristics in 100 upland cotton genotypes are evidenced in Table 6. The parameter seed cotton yield per plant revealed a strong positive genotypic and phenotypic correlation with lint fiber yield per plant (0.820** and 0.776**), bolls per plant (0.469** and 0.297**) and phenotypic acceptability (0.442** and 0.326**). The strong correlation between these characteristics suggests that they had a substantial impact on successful selection for increased productivity. Similar attributes were also observed by Gnanasekaran et al., 2018; Nawaz et al., 2019; Chapepa et al., 2020; Patel et al., 2023. Mahdy et al., (2022) examined that the correlations of lint yield per plant behaved the same as seed cotton yield per plant. Plant height (0.031 and 0.017) and days to first boll formation (0.068 and 0.051) showed positive genotypic and phenotypic correlation to seed cotton yield per plant. Patel et al., (2023) reported that traits such as boll weight, seed index, lint index, seed oil content, fiber fineness and fiber strength, exhibited non-significant associations with seed cotton yield. Relatable outcomes were also attained by Nikhil et al., 2018; Nawaz et al., 2019; Rai and Sangwan, 2020.

On the other hand, the parameter sympodial branches per plant (-0.026 and -0.043), days to 50% flowering (-0.022 and -0.243), single boll weight (-0.406** and -0.278**), seeds per boll (-0.019 and -0.003) and earliness index (-0.048 and -0.007) displayed strong negative genotypic and phenotypic correlation with seed cotton yield per plant. The strong association between seed cotton yield and these traits can be advantageously utilized in the selection program to cultivate high-yielding genotypes. Patel et al., (2023) showed that there were strong negative associations between seed cotton yield and plant height, the number of monopodial branches per plant, the days to 50% boll bursting, and ginning outturn.

Table 6. Genotypic and phenotypic correlation coefficients of eleven morphological characteristics in 100 upland cotton genotypes.

Character	Correlation	PH	SBPP	DFF	DFBF	BPP	SBW	SPB	SCYPP	LFYPP	EI
PA	r_g	0.073	-0.066	0.001	0.083	0.752**	-0.668**	-0.015	0.442**	0.384**	-0.029
	r_p	0.065	-0.045	0.001	0.064	0.609**	-0.533**	-0.033	0.326**	0.302**	0.001
PH	r_g		0.271**	0.011	0.035	0.180	0.172	0.130	0.031	-0.000	0.023
	r_p		0.205**	0.015	0.023	0.149**	0.148*	0.087	0.017	-0.002	0.017
SBPP	r_g			0.103	0.067	-0.107	-0.002	0.086	-0.026	-0.010	-0.145
	r_p			0.068	0.049	-0.023	0.031	0.047	-0.043	0.014	-0.130*
DFF	r_g				-0.056	0.131	0.029	-0.163	-0.022	0.129	-0.565**
	r_p				-0.035	0.090	0.013	-0.099	-0.243	0.101	-0.024
DFBF	r_g					0.063	-0.067	-0.026	0.068	0.118	0.245*
	r_p					0.034	-0.019	-0.015	0.051	0.094	0.175**
BPP	r_g						-0.576**	0.100	0.469**	0.398**	-0.131
	r_p						-0.464**	0.044	0.297**	0.282**	-0.048
SBW	r_g							-0.058	-0.406**	-0.427**	0.085
	r_p							-0.020	-0.278**	-0.321**	0.040
SPB	r_g								-0.019	0.073	0.106
	r_p								-0.003	0.050	0.075
SCYPP	r_g									0.820**	-0.048
	r_p									0.776**	-0.007
LFYPP	r_g										-0.057
	r_p										-0.038

Here, * and ** indicated significant at 5 % and 1 % and levels of probability, respectively.
PA= phenotypic acceptability, PH= plant height (cm), SBPP= sympodial branches per plant, DFF= days to 50% flowering, DFBF= days to first boll formation, BPP= bolls per plant, SBW= single boll weight (g), SPB= seeds per boll, SCYPP= seed cotton yield per plant (g), LFYPP= lint fiber yield per plant (g), EI= earliness Index (%), r_g= correlation coefficient at genotypic level and r_p= correlation coefficient at phenotypic level

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Phenotypic acceptability demonstrated strong positive genotypic and phenotypic correlation with bolls per plant (0.752** and 0.609**), seed cotton yield per plant (0.442** and 0.326**) and lint fiber yield per plant (0.384** and 0.302**) but strong negative correlation with single boll weight (-0.668** and -0.533**). Plant height showed notable and meaningful positive genotypic and phenotypic correlations with sympodial branches per plant (0.271** and 0.205**), but significant positive phenotypic correlation with bolls per plant (0.180 and 0.149**) and single boll weight (0.172 and 0.148*). This correlation is logical and increasing number of sympodial branches per plant with plant height might produce higher seed cotton yield. This result conforms to the investigation carried out by Patel et al., 2023.

Therefore, selecting based on phenotypic acceptability, bolls per plant, sympodial branches per plant, in conjunction with boll weight and lint yield per plant, could lead to a significant breakthrough in enhancing seed cotton yields. Similar results were reported in studies carried out by Kalpande et al., 2008; Rao and Gopinath, 2013.

Path analysis

Path coefficient analysis is an important biometrical analysis which measures direct and indirect contribution of various attributes on yield per plant (Dewey and Lu, 1959). In agriculture, the analysis of path coefficients allows breeders focusing on traits that exhibit a significant direct effect on production, thereby aiding in the identification of features that serve as effective selection criteria for enhancing crop yield. Here, the path coefficient analysis was executed using correlation co-efficient to evaluate the direct and indirect influences of the eleven traits on seed cotton yield per plant both at genotypic and phenotypic level (Table 7).

The genotypic path analysis disclosed that lint fiber yield per plant imposed highest direct positive effect (0.797) on seed cotton yield followed by bolls per plant (0.216), single boll weight (0.087), sympodial branches per plant (0.036) and phenotypic acceptability (0.033). Whereas, plant height (-0.013), days to first boll formation (-0.034), earliness index (-0.083), seeds per boll (-0.124) and days to 50% flowering (-0.228) imposed negative direct effect on seed cotton yield per plant.

Similar trend of direct associations revealed at phenotypic path. This implied that the direct selection of genotypes exhibiting these characteristics can successfully result in high-yielding genotypes. Kadam et al., (2024) reported that plant height (0.510), bolls per plant (0.404), uniformity ratio (0.339), ginning outturn (0.323), fiber strength (0.080) and lint index (0.029) enforced direct positive effect on seed cotton yield per plant at genotypic level while, days to 50 percent flowering, number of sympodia per plant, seed index, upper half mean length and micronnaire value enforced negative direct effect on seed cotton yield per plant. These results validated with the results of Dahiphale et al., 2015; Latif et al., 2015; Chaudhari et al., 2017; Farias et al., 2016; Shruti et al., 2020).

Here, the phenotypic path coefficient showed that lint fiber yield per plant (0.765) had highest positive direct impact on seed cotton yield per plant followed by phenotypic acceptability (0.073), bolls per plant (0.063), single boll weight (0.036) and plant height (0.014). Therefore, direct selection for these traits are advised to increase yield in cotton. Mawblei et al., (2022) reported that the number of bolls per plant (0.649), boll weight (0.299), plant height (0.058), and monopodia per plant (0.027) had elevated positive direct effects on the seed cotton yield, while, days to 50% flowering (0.004) showed slightly positive direct effect on seed cotton yield. Nawaz et al., (2019) showed positive direct effects of bolls per plant, boll weight and plant height, but a negative direct effect on seed cotton yield by monopodia per plant.

In the present study, each attribute exhibited both positive and negative indirect impacts on the yield per plant at both levels. At genotypic level, the traits phenotypic acceptability exerted maximum positive indirect effect on seed cotton yield per plant via lint fiber yield per plant (0.306) and bolls per plant (0.163) but negative indirect effect through single boll weight (-0.058). The trait days to 50% flowering exerted positive indirect effect on seed cotton yield per plant via lint fiber yield per plant, earliness index, bolls per plant and seeds per boll. Kadam et al., (2024) opined that positive indirect effect on yield was exerted through boll weight (0.054), bolls per plant (0.038), seed index (0.036), sympodia per plant (0.025) and ginning outturn (0.013). These results were in agreement with Gulhane and Wadikar, 2017; Sainath et al., 2022; Shruti et al., 2020. At phenotypic level, the traits bolls per plant displayed a positive indirect effect on seed cotton yield through lint fiber yield per plant (0.215), phenotypic acceptability (0.045) but a negative indirect effect through single boll weight (-0.017) and days to 50% flowering (-0.011). Again, the trait days to 50% flowering had positive indirect effect on seed cotton yield per plant through lint fiber yield per plant (0.077) at phenotypic level. However, it was conflicting with the results of Kadam et al., (2024) who found that days to 50% flowering had negative direct effect (-0.215) on yield. Sympodial branches per plant forecasted positive indirect effect on seed cotton yield per plant via lint fiber yield per plant (0.011) which was in conflict with Rauf et al., 2004; Mawblei et al., 2022. Seeds per boll exhibited positive indirect effect on seed cotton yield per plant via lint fiber yield per plant (0.038), days to 50% flowering (0.012). Patel et al., (2023) reported that seed index imposed a positive and indirect effect on seed cotton yield via lint yield per plant and uniformity index. The trait earliness index exerted positive indirect effect on seed cotton yield per plant via days to 50% flowering (0.129) but negative indirect effect via lint fiber yield per plant (-0.046), bolls per plant (-0.028) and seeds per boll (-0.013) at genotypic level. Earliness index showed similar directions of positive indirect effect on seed cotton yield per plant via days to 50% flowering (0.042) but negative indirect effect through lint fiber yield per plant (-0.029) at phenotypic level. Therefore, earliness index phenomenon tends to negative correlation with seed cotton yield per plant due other attributing factors at both levels. These findings underscored the intricate interaction of characteristics and their influence on seed cotton yield, offering significant insights for breeding programs focused on improving cotton yield.

Table 7. Genotypic and phenotypic path coefficients of 11 morphological characteristics in 100 upland cotton genotypes.

Character	Path coefficients	PA	PH	SBPP	DFF	DFBF	BPP	SBW	SPB	LFYPP	EI	Correlation coefficient with SCYPP
PA	G	**0.033**	-0.001	-0.002	0.000	-0.003	0.163	-0.058	0.002	0.306	0.002	0.442
	P	**0.073**	0.001	0.002	0.000	-0.002	0.038	-0.019	0.002	0.231	0.000	0.326
PH	G	0.002	**-0.013**	0.010	-0.003	-0.001	0.039	0.015	-0.016	0.000	-0.002	0.031
	P	0.005	**0.014**	-0.009	-0.002	-0.001	0.009	0.005	-0.004	-0.001	0.000	0.017
SBPP	G	-0.002	-0.004	**0.036**	-0.023	-0.002	-0.023	0.000	-0.011	-0.008	0.012	-0.025
	P	-0.003	0.003	**-0.043**	-0.008	-0.001	-0.001	0.001	-0.002	0.011	0.002	-0.043
DFF	G	0.000	0.000	0.004	**-0.228**	0.002	0.028	0.003	0.020	0.103	0.047	-0.022
	P	0.000	0.000	-0.003	**-0.116**	0.001	0.006	0.000	0.005	0.077	0.005	-0.024
DFBF	G	0.003	0.000	0.002	0.013	**-0.034**	0.014	-0.006	0.003	0.094	-0.020	0.068
	P	0.005	0.000	-0.002	0.004	**-0.028**	0.002	-0.001	0.001	0.072	-0.003	0.051
BPP	G	0.025	-0.002	-0.004	-0.030	-0.002	**0.216**	-0.050	-0.012	0.317	0.011	0.469
	P	0.045	0.002	0.001	-0.011	-0.001	**0.063**	-0.017	-0.002	0.215	0.001	0.297
SBW	G	-0.022	-0.002	0.000	-0.007	0.002	-0.125	**0.087**	0.007	-0.340	-0.007	-0.406
	P	-0.039	0.002	-0.001	-0.002	0.001	-0.029	**0.036**	0.001	-0.245	-0.001	-0.278
SPB	G	0.000	-0.002	0.003	0.037	0.001	0.022	-0.005	**-0.124**	0.058	-0.009	-0.019
	P	-0.002	0.001	-0.002	0.012	0.000	0.003	-0.001	**-0.051**	0.038	-0.001	-0.003
LFYPP	G	0.013	0.000	0.000	-0.029	-0.004	0.086	-0.037	-0.009	**0.797**	0.005	0.820
	P	0.022	0.000	-0.001	-0.012	-0.003	0.018	-0.011	-0.003	**0.765**	0.001	0.776
EI	G	-0.001	0.000	-0.005	0.129	-0.008	-0.028	0.007	-0.013	-0.046	**-0.083**	-0.048
	P	0.000	0.000	0.006	0.042	-0.005	-0.003	0.001	-0.004	-0.029	**-0.015**	-0.007
Residual effect at genotypic level = 0.258												
Residual effect at phenotypic level = 0.370												

The values on the diagonal (bold) indicated direct effects and the values on the off diagonal indicated indirect effects.
Here, PA= phenotypic acceptability, PH= plant height (cm), SBPP= sympodial branches per plant, DFF= days to 50% flowering, DFBF= days to first boll formation, BPP= bolls per plant, SBW= single boll weight (g), SPB= seeds per boll, SCYPP= seed cotton yield per plant (g), LFYPP= lint fiber yield per plant (g), EI= earliness Index (%), G= genotypic coefficient of variation and P= phenotypic coefficient of variation.

In the present study, the element of residual effect in path analysis in yield contributing traits was 0.258 and 0.370 at genotypic level and phenotypic level, respectively. The reduced residual effect suggested that the selected characters for path analysis were suitable and fitting. Kadam et al., (2024) observed residual effect of 0.500 at genotypic level and 0.340 at phenotypic level in seed cotton yield per plant contributed by eleven characters of 55 elite cotton genotypes through path analysis. Reddy et al., (2015) estimated residual effect of path analysis in yield and fiber quality traits was 0.045 at genotypic level and 0.313 at phenotypic level.

Conclusions

There was a broad spectrum of variances across the genotypes for all the attributes analyzed. Among the 100 upland cotton genotypes, JA-11/L exhibited the greatest yield per plant, (128.54 g) followed by BC-0025 (126.25 g) and BC0033 (126.10 g), respectively. These genotypes also revealed superior performances for average sympodial branches per plant, bolls per plant, single boll weight with early maturing phenomena. For genetic parameters, plant height, phenotypic acceptability, bolls per plant, single boll weight exhibited very high levels of heritability and genetic advance in percentage of mean. Correlation analysis disclosed that seed cotton yield per plant showed significant positive genotypic and phenotypic correlation with lint fiber yield per plant, phenotypic acceptability and bolls per plant at both genotypic and phenotypic levels. The path analysis of the results demonstrated that the trait lint fiber yield per plant, bolls per plant and single boll weight had the higher positive direct impact on seed cotton yield per plant at both levels. Based on the overall performances, the genotypes RA-2, RA-5, CB-8, JA-11/L, TC-1903, BC-0025, BC-0033, BC-0042 and BC-0062 could be taken under consideration for future upland cotton breeding in Bangladesh.

Consent for publication:

All authors declare their consent for publication.

Author contribution:

The manuscript was edited and revised by all authors.

Conflicts of Interest:

The author declares no conflict of interest.

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