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Assessment of genetic variability in promising Asiatic cotton (*Gossypium arboreum* L.) genotypes under rainfed conditions

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Abstract

The experiment entitled “Assessment of Genetic variability in promising Asiatic cotton (*Gossypium arboreum* L.) Genotypes under rainfed conditions” was conducted at Research Area of Cotton Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar, (Haryana). The experiment was carried out in randomized block design involving 50 Asiatic cotton genotypes with three replications during *Kharif* 2021-22 under rainfed conditions. The observations were recorded on eight morphological traits (plant height, number of monopods/plant, days to first flower, number of bolls/plant, boll weight, seed cotton yield/plant, number of seeds/boll, ginning out turn), six physiological traits (relative water content, photosynthesis rate, stomatal conductance, transpiration rate, total chlorophyll content, proline content) and three biochemical traits (crude protein content, seed oil content, gossypol content). Based on ANOVA, it was revealed that all genotypes exhibited sufficient genetic variability for all the traits. Data was statistically analyzed to estimate various genetic variability parameters and it was found that GCV of each trait was lower than its corresponding PCV. High heritability coupled with high genetic advance expressed as percent of mean exhibited by plant height, number of monopods/plant, number of bolls/plant, seed cotton yield/plant, relative water content, photosynthesis rate, stomatal conductance, transpiration rate and gossypol content which revealed that additive gene action played a predominant role in governing the traits. It indicated the suitability of selection of these traits for further improvement among genotypes under studied.

Keywords: Asiatic cotton, genetic advance, heritability, rainfed, variability

Introduction

Cotton (*Gossypium* spp.) is the most pertinent leading fibre and cash crop at global level which is grown mainly for its lint, textile raw materials, seeds, seed oil and protein. It is the king of appraisal fibres and popularly known as “White Gold”. Cotton seed contains 23% high quality protein (Lusas and Jividen, 1987) ^[15] and has major contribution in edible oil, protein and other by- products (Harijan *et al.*, 2016) ^[9]. Its oil is used for preparation of alkyl resins for interior paints, special bio-lubricants and soft soaps in industries (Saxena *et al.*, 2011) ^[25]. “Gossypol” is an important biochemical component which provide defense against insect-pests and diseases to cotton crop. Presence of gossypol make it unfit for human consumption. *Gossypium* is a large and diverse genus, which includes 50 species, out of which four are cultivated, 44 are wild diploids and two are wild tetraploids. India is the only country where all the four species of cultivated cotton *i.e.*, *Gossypium arboreum* L. and *G. herbaceum* L. (Asian cotton), *G. barbadense* L. (Egyptian cotton) and *G. hirsutum* L. (American upland cotton) are grown besides hybrid cotton. Among the cultivated diploid species, Asiatic cotton (*Gossypium arboreum*) beholds prime importance due to its desirable attributes like hardiness, earliness, tolerance to drought and insect pests resulting in low cost of production. The fibre is coarse and short along with high plant’s resistance against abiotic and biotic stresses. The year 2021-2022 recorded a production of 340 lakh bales of cotton from an area of 123 lakh hectares with a productivity of 469 kg/ha in India (Cotton Corporation of India, 2022).

Cotton breeders encompass breeding targets like good quality lint fibre, high quality seed production, early maturity and resilience to biotic and abiotic stresses for developing superior varieties. These goals can only be realized through assessment of variability of yield and its component traits available in gene pool followed by development of effective breeding techniques. The creation and quantification of genetic variability is of vital importance (Hussain *et al.*, 2010) ^[10].

For initiating any crop improvement program, the knowledge of genetic variability, heritability and genetic advance is prerequisite. Selection is effective only when variability exists in sufficient magnitude. A wider range of variability helps in selecting elite genotypes. Heritability is another corner stone for crop breeding as total variability might be masked by its non-heritable proportion, posing difficulty in selection. Therefore, it becomes necessary to split total variability into heritable and non-heritable components applying genetic parameters such as genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) without jeopardizing the accuracy of breeding programme. The genetic variability along with heritability of a trait indicates extent of improvement which is possible through phenotypic selection (Magadum *et al.*, 2012) [16]. It has been established that heritability estimate alone does not clearly indicate the breeding value (Mishra *et al.*, 2015) [17]. Therefore, genetic advance over means should also be incorporated to enhance the predictability of traits based on selection (Ramanjinappa *et al.*, 2011; Eswari *et al.*, 2018) [22, 6]. Keeping the above stated facts in mind, efforts have been made in present study to analyze the components of variability among selected Asiatic cotton genotypes with objective to identify suitable genotypes for moisture stress conditions and future breeding programme.

Materials and Methods

The present experiment was conducted in the Research Area of Cotton Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar (Haryana) during *Kharif* 2021-22 to analyze genetic variability in promising Asiatic cotton genotypes under restricted irrigation condition. Fifty genotypes of Asiatic cotton, each with single row of 6.0 m length were sown in randomized block design along with three replications. The spacing of 67.5 cm between rows and 30 cm between plants was maintained. In the experimental field, only pre-sowing irrigation was applied. After that no irrigation was applied during the entire crop season. The observations were recorded from five randomly selected plants of each genotype in each replication and then the mean observations were used for statistical analysis on different morphological (plant height, number of monopods/plant, days to first flower, number of bolls/plant, boll weight, seed cotton yield/plant, number of seeds/boll, ginning out turn), physiological (relative water content, photosynthesis rate, stomatal conductance, transpiration rate, total chlorophyll content, proline content) and biochemical (crude protein content, seed oil content, gossypol content) traits.

Statistical analysis

To test the difference among the genotypes, the analysis of variance was worked out separately for each trait as per method suggested by Fisher (1925) [18]. Genotypic coefficient of variation (GCV) and Phenotypic coefficient of variation (PCV) were calculated as per the standard formula suggested by Burton and Devane (1953) [3]. Heritability (h^2) in broad sense, genetic advance percent mean was calculated by using formula given by Johnson *et al.*, (1955) [12].

Results and Discussion

Analysis of variance (ANOVA): Analysis of variance for all

the morpho-physiological and biochemical traits exhibited significant mean sum of squares due to genotypes for all the characters studied reflecting that sufficient genetic variability was present among the genotypes for all the traits (Table 1) that can be further exploited for cotton improvement program. Similar results for analysis of variance were observed by Ahmad *et al.* (2008) [11], Nikhil *et al.* (2018a) [18], Eldessousky *et al.* (2021) [5] and Jogender *et al.* (2023) [11], for one or more traits. The mean values of different traits observed in 50 Asiatic cotton genotypes along with their range are presented in the Table 2.

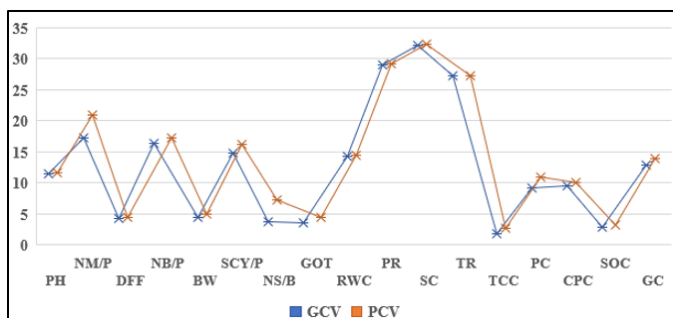
Table 1: Analysis of variance of 50 Asiatic cotton genotypes for various morpho-physiological and biochemical traits

Sr. No.	Traits	Source of Variation		
		Replications [2]	Treatments [4, 8]	Error [9, 8]
1	Plant height (cm)	77.69	73023.85**	488.85
2	Number of monopods/plant	0.06	9.68**	2.68
3	Days to first flower	3.77	946.73**	54.89
4	Number of bolls/plant	52.20	4204.30**	274.75
5	Boll weight (g)	0.02	1.69**	0.30
6	Seed cotton yield/plant (g)	533.04	19652.02**	2405.68
7	Number of seeds/boll	5.44	242.44**	237.58
8	Ginning out turn (%)	2.85	371.18**	112.50
9	Relative water content (%)	10.28	4851.37**	87.11
10	Photosynthesis rate ($\mu\text{mol CO}_2 \text{ m}^{-2}\text{s}^{-1}$)	0.04	342.76**	1.40
11	Stomatal conductance ($\text{mmol H}_2\text{O m}^{-2}\text{s}^{-1}$)	0.00	0.11**	0.00
12	Transpiration rate ($\text{mmol H}_2\text{O m}^{-2}\text{s}^{-1}$)	0.08	85.53**	0.62
13	Total chlorophyll content (SPAD value)	22.17	469.67**	416.59
14	Proline content ($\mu\text{moles/g}$)	0.00	0.06**	0.02
15	Crude protein content (%)	0.44	518.352**	30.64
16	Seed oil content (%)	0.14	28.18**	5.72
17	Gossypol content (%)	0.00	0.27**	0.03

** Significant at 1% level of significance, []: Degree of freedom

Table 2: Mean, maximum and minimum values for various morpho-physiological and biochemical traits of 50 asiatic cotton

Sr. No.	Traits	Mean	Range	
			Max.	Min.
1	Plant height (cm)	193.43	239.04	151.72
2	Number of monopods/plant	1.39	2.00	1.00
3	Days to first flower	59.47	63.67	52.67
4	Number of bolls/plant	31.99	43.22	22.78
5	Boll weight (g)	2.36	2.70	2.10
6	Seed cotton yield/plant (g)	75.45	102.54	52.97
7	Number of seeds/boll	25.10	28.43	22.12
8	Ginning out turn (%)	34.00	39.07	31.53
9	Relative water content (%)	40.20	49.43	24.59
10	Photosynthesis rate ($\mu\text{mol CO}_2 \text{ m}^{-2}\text{s}^{-1}$)	5.23	8.06	3.00
11	Stomatal conductance ($\text{mmol H}_2\text{O m}^{-2}\text{s}^{-1}$)	0.08	0.13	0.02
12	Transpiration rate ($\text{mmol H}_2\text{O m}^{-2}\text{s}^{-1}$)	2.80	4.02	1.94
13	Total chlorophyll content (SPAD value)	47.63	51.60	43.33
14	Proline content ($\mu\text{moles/g}$)	0.22	0.26	0.18
15	Crude protein content (%)	19.28	24.49	15.23
16	Seed oil content (%)	14.87	15.60	14.20
17	Gossypol content (%)	0.32	0.40	0.25



PH: Plant height (cm), NM/P: Number of monopods/plant, DFF: Days to first flower, NB/P: Number of bolls/plant, BW: Boll weight (g), SCY/P: Seed cotton yield/plant (g), NS/B: Number of seeds/boll, GOT: Ginning out turn (%), RWC: Relative water content (%), PR: Photosynthesis rate ($\mu\text{mol CO}_2 \text{ m}^{-2}\text{s}^{-1}$), SC: Stomatal conductance ($\text{mmol H}_2\text{O m}^{-2}\text{s}^{-1}$), TR: Transpiration rate ($\text{mmol H}_2\text{O m}^{-2}\text{s}^{-1}$), TCC: Total chlorophyll content (SPAD value), PC: Proline content ($\mu\text{moles/g}$), CPC: Crude protein content (%), SOC: Seed oil content (%), GC: Gossypol content (%)

Graph 1: Comparison of Genotypic and Phenotypic coefficient of variation possessed by various traits

Coefficient of variation

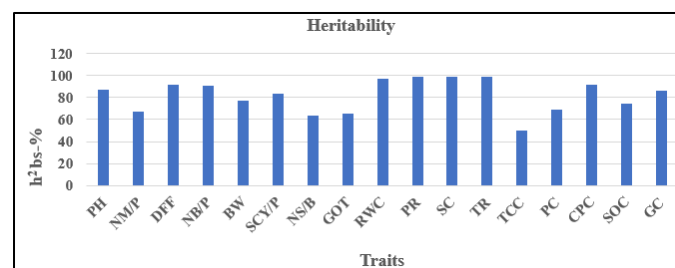
The estimation of GCV and PCV indicate the interference of environment with the expression of different traits under study. Genotypic and phenotypic coefficients of variation were estimated for all the traits among 50 genotypes and it was found that genotypic coefficient of variation (GCV) of each trait was lower than its corresponding phenotypic coefficient of variation (PCV). The difference between GCV and PCV of each trait was found narrow and therefore, it revealed that expressions of these traits were little affected by the environmental factors.

High GCV (> 20%) was indicated by traits *viz.* photosynthesis rate (29.03%), stomatal conductance (32.22%) and transpiration rate (27.19%). Traits showing moderate GCV value (10-20%) were plant height (11.50%), number of monopods/plant (17.16%), number of bolls/plant (16.44%), seed cotton yield/plant (14.85%), relative water content (14.23%) and gossypol content (12.88%). While, days to first flower (4.21%), boll weight (4.35%), number of seed/boll (3.66%), ginning out turn (3.57%), total chlorophyll content (1.80%), proline content (9.16%), crude protein content (9.60%) and seed oil content (2.79%) exhibited low GCV (<10%).

On the other hand, high PCV (> 20%) was exhibited by number of monopods/plant (20.89%), photosynthesis rate (29.12%), stomatal conductance (32.35%) and transpiration rate (27.33%). Moderate PCV values (10-20%) were indicated by plant height (11.56%), number of bolls/plant (17.26%), seed cotton yield/plant (16.24%), relative water content (14.42%), proline content (11.01%), crude protein content (10.02%) and gossypol content (13.87%). Low PCV (< 10%) exhibited by days to first flower (4.39%), boll weight (4.95%), number of seeds/boll (7.20%), ginning out turn (4.43%), total chlorophyll content (2.61%) and seed oil content (3.23%).

Similar results were confirmed by Baloch *et al.* (2004) [2],

Ranganatha *et al.* (2013) [23], Pujer *et al.* (2014a) [20], Raza *et al.* (2016) [24] and Kumar *et al.* (2023).



PH: Plant height (cm), NM/P: Number of monopods/plant, DFF: Days to first flower, NB/P: Number of bolls/plant, BW: Boll weight (g), SCY/P: Seed cotton yield/plant (g), NS/B: Number of seeds/boll, GOT: Ginning out turn (%), RWC: Relative water content (%), PR: Photosynthesis rate ($\mu\text{mol CO}_2 \text{ m}^{-2}\text{s}^{-1}$), SC: Stomatal conductance ($\text{mmol H}_2\text{O m}^{-2}\text{s}^{-1}$), TR: Transpiration rate ($\text{mmol H}_2\text{O m}^{-2}\text{s}^{-1}$), TCC: Total chlorophyll content (SPAD value), PC: Proline content ($\mu\text{moles/g}$), CPC: Crude protein content (%), SOC: Seed oil content (%), GC: Gossypol content (%)

Graph 2: Broad sense heritability possessed by various traits

Heritability (%)

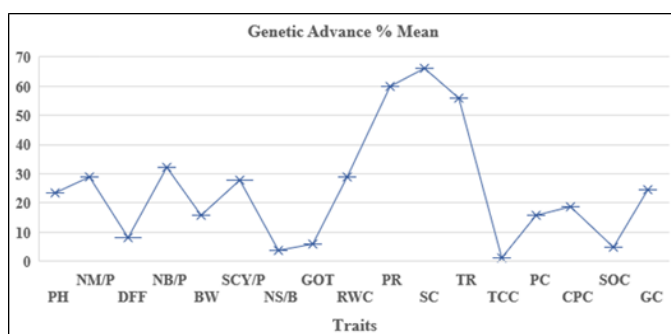
The estimates of broad sense heritability ranged from 50.26 to 99.39%. High value of broad sense heritability (> 60%) exhibited by plant height (87.01%), number of monopods/plant (67.45%), days to first flower (91.78%), number of bolls/plant (90.98%), boll weight (77.28%), seed cotton yield/plant (83.64%), number of seeds/boll (63.77%), ginning out turn (65.08%), relative water content (97.36%), photosynthesis rate (99.39%), stomatal conductance (99.19%), transpiration rate (98.93%), proline content (69.32%), crude protein content (91.64%), seed oil content (74.73%) and gossypol content (86.13%) whereas moderate broad sense heritability (30-60%) exhibited by total chlorophyll content (50.26%). Similar results were also confirmed earlier by Khan *et al.* (2009) [13], Ranganatha *et al.* (2013) [23], Farooq *et al.* (2014) [7] and Nikhil *et al.* (2018a) [18].

Genetic advance (% mean)

The magnitude of genetic advance % of mean varied from 1.19 to 66.10%. Traits expressing high value of genetic advance% of mean (> 20%) were plant height (23.58%), number of monopods/plant (29.03%), number of bolls/plant (32.27%), seed cotton yield/plant (27.97%), relative water content (28.91%), photosynthesis rate (59.62%), stomatal conductance (66.10%), transpiration rate (55.70%) and gossypol content (24.61%). Moderate value of genetic advance% of mean (10-20%) expressed by traits like proline content (15.72%), boll weight (15.87%) and crude protein content (18.92%). Low genetic advance% of mean (< 10%) expressing traits were days to first flower (8.30%), number of seeds/boll (3.82%), ginning out turn (5.94%), total chlorophyll content (1.19%) and seed oil content (4.97%). Similar conclusions were also made by Khan *et al.* (2009) [13], Pujer *et al.* (2014b) [21], Nikhil *et al.* (2018b) [19] and Kumar *et al.* (2023).

Table 3: Heritability, Genotypic coefficient of variance (GCV), Phenotypic coefficient of variance (PCV) and Genetic advance% mean for various morpho-physiological and biochemical traits

Sr. No.	Traits	Heritability (bs %)	Coefficient of Variation		Genetic Advance % mean
			GCV (%)	PCV (%)	
1	Plant height (cm)	87.01	11.50	11.56	23.58
2	Number of monopods/plant	67.45	17.16	20.89	29.03
3	Days to first flower	91.78	4.21	4.39	8.30
4	Number of bolls/plant	90.98	16.44	17.26	32.27
5	Boll weight (g)	77.28	4.35	4.95	15.87
6	Seed cotton yield/plant (g)	83.64	14.85	16.24	27.97
7	Number of seeds/boll	63.77	3.66	7.20	3.82
8	Ginning out turn (%)	65.08	3.57	4.43	5.94
9	Relative water content (%)	97.36	14.23	14.42	28.91
10	Photosynthesis rate ($\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$)	99.39	29.03	29.12	59.92
11	Stomatal conductance ($\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$)	99.19	32.22	32.35	66.10
12	Transpiration rate ($\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$)	98.93	27.19	27.33	55.70
13	Total chlorophyll content (SPAD value)	50.26	1.80	2.61	1.19
14	Proline content ($\mu\text{moles/g}$)	69.32	9.16	11.01	15.72
15	Crude protein content (%)	91.64	9.60	10.02	18.72
16	Seed oil content (%)	74.73	2.79	3.23	4.97
17	Gossypol content (%)	86.13	12.88	13.87	24.61



PH: Plant height (cm), NM/P: Number of monopods/plant, DFF: Days to first flower, NB/P: Number of bolls/plant, BW: Boll weight (g), SCY/P: Seed cotton yield/plant (g), NS/B: Number of seeds/boll, GOT: Ginning out turn (%), RWC: Relative water content (%), PR: Photosynthesis rate ($\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$), SC: Stomatal conductance ($\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$), TR: Transpiration rate ($\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$), TCC: Total chlorophyll content (SPAD value), PC: Proline content ($\mu\text{moles/g}$), CPC: Crude protein content (%), SOC: Seed oil content (%), GC: Gossypol content (%)

Graph 3: Genetic advance % mean possessed by various traits

High heritability coupled with high genetic advance% mean (%)

High heritability coupled with high genetic advance expressed as percent of mean revealed that additive gene action played a predominant role in governing the traits and it also indicated the suitability of selected traits for further improvement among genotypes under study. High heritability coupled with high genetic advance expressed as percent of mean exhibited by plant height (87.01 and 23.58), number of monopods/plant (67.45 and 29.03), number of bolls/plant (90.98 and 32.27), seed cotton yield/plant (83.64 and 27.97), relative water content (97.36 and 28.91), photosynthesis rate (99.39 and 59.92), stomatal conductance (99.19 and 66.10), transpiration rate (98.93 and 55.70) and gossypol content (86.13 and 24.61), respectively. Similar results were also reported by Baloch (2004) [2], Ahmad *et al.* (2008) [1], Khan *et al.* (2009) [13], Nikhil *et al.* (2018a) [18] and Jogender *et al.* (2023) [11].

Conclusion

Based upon the results of present investigation, it is suggested that plant height, number of monopods/plant, number of

bolls/plant, seed cotton yield/plant, relative water content, photosynthesis rate, stomatal conductance, transpiration rate and gossypol content showing high heritability along with high genetic advance as per cent of mean should be utilized for direct selection for future genetic enhancement of asiatic cotton.

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Conflict of Interest: The authors declare no conflict of interest.

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