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Multivariate Analysis based Characterization of Cotton Germplasm

A. Manivannan* and B. Dharajothi

ICAR-Central Institute for Cotton Research, Regional Station, Coimbatore 641003, India

**Corresponding author*

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ABSTRACT

A set of 52 leaf hopper resistant cotton accessions were evaluated in during *Kharif* 2017. Multivariate analysis employing Principal Component Analysis (PCA) identified seven principal components were accounted for a cumulative variation of 99%. The first principal component accounted for 70.5%, second for 12.16%, third for 6.6%, fourth for 3.75%,fifth for 2.94%, sixth for 2.39% and seventh for 1% of total variation. First principal component (PC 1) was correlated with boll shape (0.33) and bract size, petal color and boll surface, each of 0.20(Table 3). Second principal component (PC 2) was associated with boll shape (0.65) and bract size, petal color and boll surface, each of 0.24. PC 3 was correlated with leaf lobbing (0.95). Forth PC (PC 4) was associated with boll size (0.61) and leaf size (0.50). Fifth PC (PC 5) was related with leaf shape (0.60) and plant type (0.48). Sixth PC was related with plant type (0.35) and seventh PC correlated with stem hairiness, leaf size, bracts and petal color, each of 0.23. Principal Component Analysis (PCA) based on qualitative traits revealed that traits namely Bract size, petal color, boll shape and boll surface distinguished all genotypes in higher order than other traits. Convex of the hull occupied by the genotypes namely ICB124, H1464, Suvin, ICB 85, CSH3088, LHSusDCH32, and AKH1355 as these genotypes showed the highest point among the factors. All the genotypes were grouped into two distinguished clusters.

Introduction

Multivariate analysis (MVA) is a set of techniques employed for analysis of data sets that contain more than one variable, and the techniques are useful when working with more correlated variables. The techniques provide an empirical method for vital information extraction, regression, or classification. The main purpose of multivariate analysis would be information extraction. The simplest form of information extraction and data reduction is the Principal Component Analysis (PCA) technique (Pearson 1901). PCA is defined as an orthogonal linear transformation that transforms the data to a new coordinate system such that the greatest variance by any projection of the data come into lie on the first coordinate (called the first principal component), the second greatest variance on the second coordinate, and so on. The longest axis inside the volume occupied by the data points in this space will be the first principle component (PC1). The second longest axis orthogonal to Principal Component 1(PC1) will be Principal Component 2(PC2), and so on. In this way, a new coordinate system that emphasizes the greatest variances in the data set is constructed. Certain plots and graphical presentations are frequently used in multivariate analysis and the most frequently used is the bi plot. This is a two-dimensional scatter plot of scores for two specified components (PCs). The plot gives information about patterns in the samples. The score plot for PC1 and PC2 may be especially useful because these two components summarize more variation in the data than any other pair of components. Clustering of data upon the plots forms certain association among them, this helps in grouping of the variables.

In Cotton, sucking pest, *Amrasca biguttula biguttula* (jassids) has become serious in India (Singh and Agarwal, 1988). The pest is prevalent from the vegetative to reproductive phase of the crop growth. Nymphs and adults of this insect cause damage by sucking the cell sap from the leaves which result in yellowing, reddening and drying of leaves characteristic of phyto-toxaemia, called as hopperburn (Uthamasamy, 1985) leading to yield loss. Host plant resistance is an effective tool for controlling insect pest and is the key component of integrated pest management because it enables plants to avoid, tolerate or recover from the effects of insect pest attack (Painter, 1951). Hence, the development of high yielding jassid tolerant genotypes becomes important. In order to breed for host plant resistance, characterization of the available germplasm is a penultimate goal.

PCA technique is now a days widely used for characterization based grouping of large number of genotypes and also helpful in identifying the most discriminating traits for characterization of germplasm. In the era of molecular markers, still morphological characterization using qualitative traits are being reliable and economical for screening and cataloging of germplam and widely being used for characterization across many plant species (Santos *et al.,* 2012). These morphological traits are most useful in description, identification, characterization and evaluation. Few of the important traits are having high discriminating ability when handling volumes of germplasm.

Materials and Methods

A set of 52 leaf hopper resistant cotton accessions were raised at ICAR- Central Institute for Cotton Research, Regional Station, Coimbatore, India during *kharif* crop season 2017. Each entry occupied a three-meter row with spacing of 60 × 30 cm. All agronomical practices were followed as prescribed by the agronomists. Qualitative characters were taken under consideration for evaluating the substantial variation and relationship among cotton genotypes. Traits namely leaf size, leaf lobbing, leaf shape, petal color, bract size, boll shape, boll size, boll surface, locules, stem hairiness and plant type were used to describe genetic diversity. Scores were assigned for each trait as per the guide lines by DUS (Distinct, Uniformity, and Stability) guide line formulated by PPV& FRA, 2001. Multivariate based Principal component analyses (PCA) using eleven qualitative traits was performed to find out the relative importance of different traits in capturing the genetic variation in cotton. The factors of these traits were used to determine the contribution of each factor towards variation. The standardized values were used to perform PCA using PAST 3 (Hammer *et al.,* 2001). A scree plot was drawn from the Eigen values associated with a component or factor in descending order versus the number of the component or factor. Scree plot used for visually assess which components or factors explain most of the variability in the data. Dissimilarity matrix based on EUCLIDEAN distance was calculated using these traits by DARwin 5. Most dissimilar and least dissimilar accessions were identified in genotypes based on dissimilarity matrix. A hierarchical cluster analysis for pooled data was performed using scores of dissimilarity matrix (Ward, 1963).

Results and Discussion

Morphological characters grouped into different nature viz., qualitative and quantitative in nature. Qualitative characters are very much helpful in characterization of the germplasm because they are least affected by the environmental conditions. Qualitative traits form distinct phenotypic classes and therefore are useful tools in classifying germplasm and can be predominantly assessed visually, because of these attributes large number of DUS (distinctiveness, uniformity and stability) characters for plant cultivar registration are defined using qualitative traits. Very few such qualitative traits are available in practical terms (Kruskal, 1978).

Observations on eleven qualitative traits were recorded for all the 52 genotypes and the scores were analyzed (Table 1). Majority of the genotypes were (85%) medium bracts and seven accessions were large (ICB-124, ICB-85, ICB-67, ICB-264, Suvin, ICB-105 and LH SusDCH32). Higher frequency of yellow color spotless petal was observed except these accessions ICB-124, ICB-85, ICB-67, ICB-264, Suvin, ICB-105 and LH SusDCH32. The trait boll size showed two categories namely big and small. Higher proportion (94%) of medium size was observed when compare with small boll size (CSH 3088, F 2383 and AKH 1355). Higher frequency of medium leaf size was observed (94.2%) when compared with 3.8% of small and 2% of large leaf size respectively. Two distinct groups were observed for the leaf lobbing trait, 61.5% were three lob and 38.5% were 3-5 lobs. Three category of leaf shape was observed *viz.*, 90% were normal. Six classes of boll locules were observed among the accessions. In boll shape class, 43 of ovate, 3 of round (ANGC-1451, GISV-267 and GISV-216) and six conical shape (ICB-85, ICB-67, ICB-264, Suvin, ICB-105 and LH SusDCH32) was observed. When boll surfaces observed for pittedness, it was found that 6 genotypes (ICB-85, ICB-67, ICB-264, Suvin, ICB-105 and LH SusDCH32) were possessing pittedness compared to others. Six genotypes were spreading types (ICB-85, ICB-67, ICB-264, Suvin, ICB-105 and LH SusDCH32) while rest of them were compact in nature.

Seven genotypes were glabrous for stem hairness (ICB-85, ICB-67, ICB-124, ICB-264, Suvin, ICB-105 and LH SusDCH32). Leaf lobbing, stem color and petal color has been used for grouping of cotton germplasms (Sangwan *et al.,* 2008).

PCA (Table 2) identified seven principal components were accounted for a cumulative variation of 99.4%. The first principal component accounted for 70.5%, second for 12.16%, third for 6.6%, fourth for 3.75%,fifth for 2.94%, sixth for 2.39% and seventh for 1% of total variation. First principal component (PC 1) was correlated with boll shape (0.33) and bract size, petal color and boll surface, each of 0.20 (Table 3). Second principal component (PC 2) was associated with boll shape (0.65) and bract size, petal color and boll surface, each of 0.24. PC 3 was correlated with leaf lobbing (0.95). Forth PC (PC 4) was associated with boll size (0.61) and leaf size (0.50). Fifth PC (PC 5) was related with leaf shape (0.60) and plant type (0.48). Sixth PC was related with plant type (0.35) and seventh PC correlated with stem hairiness, leaf size, bracts and petal color, each of 0.23.

Table.1 Morphological description of cotton germplasm

Traits	Description	Genotypes	Frequency (%)	Traits	Description	Genotypes	Frequency (%)
Bracts	Medium	45	86.5	Leaf shape	Normal	50	96.0
	Large	7	13.5		Semi Okra	1	2.0
					Okra	1	2.0
Petal Color	Creamy yellow Spotless	45	86.5				
	Yellow Spotted	7	13.5	Lobbing	3	32	61.5
					3-5	20	38.5
Boll Size	Medium	49	94.2				
	Small	3	5.8	Locule	3	6	11.5
					3-4	8	15.4
Boll Shape	Ovate	43	82.7		3-5	2	3.8
	Round	3	5.8		4	32	61.5
	Conical	6	11.5		4-5	3	5.8
					5	1	2.0
Boll surface	Smooth	46	89.5				
	Pitted	6	11.5	Plant type	Compact	46	89.5
					Spreading	6	11.5
Leaf Size	Small	2	3.8	Stem Hairiness	Hairiness	45	86.5
	Medium	49	94.2		Glabrous	7	13.5
	Large	1	2.0				

Table.2 Principal component analysis of different traits

Principal component	Eigen value	Proportion of variation (%)	Cumulative (%)
1	7.81	70.50	70.50
2	1.35	12.16	82.65
3	0.74	6.66	89.31
4	0.42	3.75	93.06
5	0.33	2.94	96.01
6	0.27	2.39	98.40
7	0.12	1.04	99.44

Table.3 Principal components of various traits

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7
BR	0.20	0.24	-0.01	0.03	0.07	0.30	0.23
PC	0.20	0.24	-0.01	0.03	0.07	0.30	0.23
BSZ	0.00	0.08	0.00	0.61	0.24	-0.18	-0.11
BSH	0.33	0.65	-0.25	-0.04	-0.36	-0.44	-0.27
BSF	0.20	0.24	-0.01	0.03	0.07	0.30	0.23
PT	0.15	0.06	-0.05	-0.03	0.48	0.35	-0.77
SH	0.20	0.24	-0.01	0.03	0.07	0.30	0.23
LSZ	-0.01	0.09	0.07	0.50	0.43	-0.34	0.23
LSH	0.07	0.13	0.09	-0.60	0.60	-0.40	0.19
LOB	0.18	0.11	0.95	0.02	-0.16	-0.04	-0.13
LOC	-0.82	0.54	0.10	-0.04	0.03	0.14	-0.04

BR Bract size, PC Petal color, BSZ Boll size, BSH Boll shape, BSF Boll surface, PT Plant type, SH Stem hairiness, LSZ Leaf size, LSP Leaf shape, LOB Leaf lobbing, LOC Locule

Table.4 Qualitative traits towards variability

Traits	Variability contribution (%)
Bract size	75.50
Petal color	13.20
Boll size	4.19
Boll shape	3.15
Boll surface	1.40
Plant type	0.50
Stem hairiness	0.50
Leaf size	0.45
Leaf shape	0.45
Leaf lobbing	0.45
Locule	0.21

Fig.1 Scatter plot based on PC1 and PC2 of qualitative characters

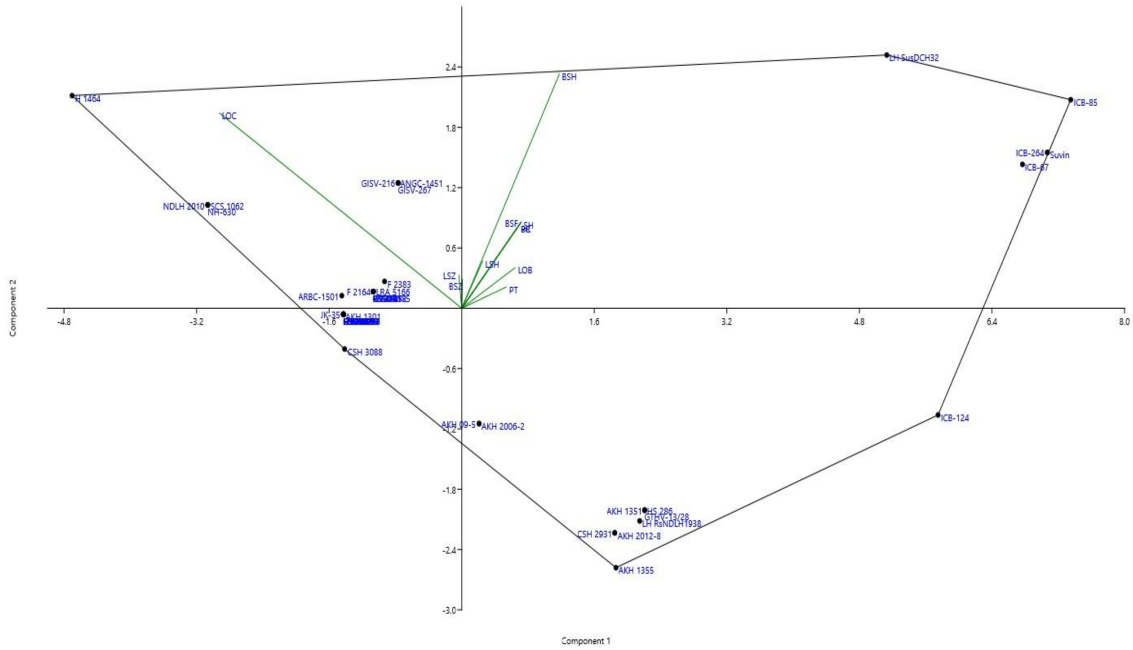
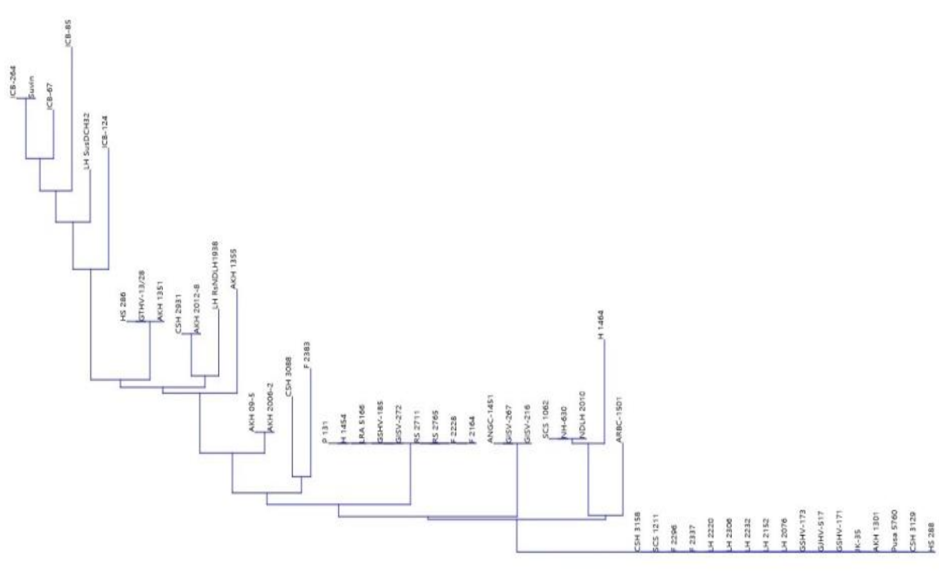


Fig.2 Clustering pattern of cotton accessions



Based on all the principal components, maximum variation was recorded for bract size (75.5%), moderate variability was recorded for petal color (13.2%), boll size (4.19%), boll shape (3.15%) and boll surface (1.40%). Low amount of variability observed for the rest of the traits (Table 4). Based on the four PCs, scatter and scree plots depicted the variability.

A scatter plot (Fig. 1) drawn using PC1 and PC2 factor scores and clear pattern of grouping between the genotypes was observed in the factor plane. Biplot depicts that following genotypes were ICB124, H1464, Suvin, ICB 85, CSH3088, LHSusDCH32, and AKH1355 were highly diverse as they occupied the convex of the hull. These genotypes can be used a diverse parents for further breeding programmes. PCA was used to characterize 26 *G.arboreum* genotypes based on different qualitative traits (Iqbal *et al.*, 2015). Grouping was done based on standardized Euclidean distance and un-weighted paired group method using arithmetic average (UPGMA) clustering method showed two distinct clusters (Fig. 2).

This study is conducted for comparing the morphological characteristics of leaf hopper resistance accessions. The data obtained showed that germplasm resources present a wide range of diversity for morphological traits. The investigations were also very useful in choosing the most precious accessions for further breeding programmes. Principal Component Analysis (PCA) revealed that the traits viz., bract size, petal color, boll shape and boll surface contributed more than 90% of the variability. These traits have the highest discriminating ability among all other traits.

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