



RESEARCH ARTICLE

GENETIC DIVERSITY OF Bt AND non-Bt COTTON VARIETIES IN ANDHRA PRADESH- A STATISTICAL STUDY

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ABSTRACT

This paper focuses on the importance of the genetic diversity and application of statistical tools in the analysis of genetic variation at the interspecific and intra specific level of Bt and non-Bt cotton varieties in Andhra Pradesh. Genetic variation and assessment of distribution of a crop species and its relatives is essential in understanding the pattern of diversity and evolutionary relationship between accessions that help to sample genetic resources in a more systematic fashion for conservation and plant improvement. Currently a number of tools and methods are available for analysis of statistical genetic diversity with qualitative and quantitative traits in between group populations [treated (Bt) and non treated (non-Bt)] and within group individuals (Bt and non-Bt) of Bt and non- Bt elite cotton varieties of Andhra Pradesh.

The present study revealed more significant mean value for characters like Average yield per plant (Nuziveedu Bt, Tulasi Bt, JK Bt), Boll per plant (Tulasi Bt, Nuziveedu Bt), Effective monopodias (Kaveri Bt, Tulasi Bt, Bhaskar Bt) and Number of bolls per plant (Tulasi Bt, JK Bt, Vibha Bt) for Bt than the non-Bt varieties (*G.hirsutum* and *G.arboreum*). Where as non Bt-varieties have shown significance for the characters like Plant height (Narasimha, NDLH-1959, Srinandi, Vibha non-Bt, Bhaskar non-Bt), Maturity days (*G.hirsutum*, Yaganti, Vibha non-Bt) and Days to flower (NDLH-1938, Yaganti, Tulasi, Bhaskar) respectively. A few of non-Bt varieties like Sivanandi (*G.hirsutum*), NDLH-1938 (*G.hirsutum*), and Yaganti (*G.arboreum*) have also shown significance in production of yield per plant. Overall the growth parameters were significant in non-Bt than Bt cotton varieties in contrast to the production and yield per plant.

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INTRODUCTION

Cotton popularly known as 'White Gold' is an important commercial crop in India. It contributes about 30% of the country's export earnings. Cotton belongs to the family *Malvaceae*, genus *Gossypium* and comprises of 50 different species, of these only four species are cultivated in India. India is the only country in the world growing all the four cultivated species of cotton two diploids-*G.arboreum* and *G.herbaceum*; and two tetraploid *G.hirsutum* and *G.barbadense* which are considered as successfully exploiting heterosis through cultivation of intra and interspecific hybrids (Current cotton scenario, 2014).

Andhra Pradesh is playing a key role in national efforts for stepping up of cotton production and its productivity in India. Due to susceptibility of prominent hybrids, the total area under cotton cultivation in the state is around 10 lakh hectares with an annual production of about 26 lakh bales (1 bale=170 kg each). Out of this, about 12 percent is being grown under irrigated dry condition (Current cotton scenario, 2014). In

Andhra Pradesh three different agro climatic regions are existing viz., Coastal region, Telangana region and Rayalaseema region. All the cultivable species of *Gossypium* viz; *G.arboreum*, *G.herbaceum*, *G.hirsutum* and *G.barbadense* are grown in commercial proportions. Andhra Pradesh has unique distinction of cultivating the largest number of cotton varieties in a season which includes certain non-descript types (Current cotton scenario, 2014). Cotton is used to make a number of textile products and cotton seed which remains after the cotton ginned is used to produce cotton seed oil.

Statistics is the study of the collection, organization, presentation, analysis and interpretation of data; it deals with all aspects of data including the planning of data collection in terms of the design of surveys and experiments. Measurable differences can also be found among individuals in a group or population (Mohammadi, 2003). Currently, a number of statistical tools and methods are available for analysis of genetic diversity in germplasm accessions, breeding line, populations and individuals of Bt and non- Bt cotton varieties. These methods mostly depend on morphological

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data, agronomic performance data, pedigree data, biochemical data and more recently DNA-based molecular data. It is therefore important to know how much variation in a particular phenotype (observable trait) might be expected so that it can be determined whether the variation observed experimentally may be viewed as normal for that population. Normal would be defined as the range of potential phenotypes that a population would exhibit in a specified range of environmental conditions (Efron, 1986).

Qualitative characteristics are those that are expressed in discontinuous states. These states are self-explanatory and independently meaningful. All states are necessary to describe the full range of characteristics, and every form of expression can be described by a single state.

The states do not have any logical order. As a rule, the characteristics are not influenced by environment. The state of expression of certain characteristic is determined in comparison to example varieties and similar varieties. Quantitative varieties are those, which are measurable and those that show continuous variation from one extreme to the other. The range of expression is divided into a number of states of expression for the purpose of description. Number of states of expression is determined. Qualitative characteristics are normally recorded visually, whereas quantitative characteristics can be measured. Quantitative characteristics, especially observation like maturity days to flower and yield can be determined on the basis of recording.

Genetic variation is a prerequisite for any crop improvement program. Distribution of genetic variation and assessment of the extent in a crop species and its relatives is essential in understanding pattern of diversity and evolutionary relationship between accessions that help us to sample genetic resources in a more systematic fashion for conservation and plant improvement. Accurate estimates of genetic diversity, adequate attention to sampling design, utilization of various data sets on the basis of the understanding of their strength and constraints, choice of genetic variation, clustering tools and other multivariate methods can be used in the analysis of data and for objective determination of genetic relationships. Usage of statistical tools and techniques such as bootstrapping is vital for addressing complex issues related to data analysis and illustration of results from different types of data sets, particularly through clustering approaches.

In the present investigation in general the statistical analysis of the data is studied for elite Bt and non-Bt cotton varieties of Andhra Pradesh for the following quantitative traits; such as Average Plant height, Days to flower, Average number of effective monopodia, Number of bolls per plant, Boll weight, Maturity days to flower and Average yield per plant that can be concluded to know their genetic diversity and relationship between genotypes.

MATERIALS AND METHODS

The plant material used in study, twenty three elite Bt and non-Bt [*Gossypium hirsutum* (Narasimha, Sivanandi, NDLH-1906, NDLH-1928, NDLH-2947, NDLH-2948), *Gossypium arboreum* (Aravinda, Srinandi, Yaganti, NDLA-2947, NDLA-2948), non-Bt (Bhaskar non-Bt, Nuziveedu non-Bt, JK non-Bt, Kaveri non-Bt, Tulasi non-Bt, Vibha non-Bt) and Bt (Bhaskar(Tulasi9BGII)), Nuziveedu (NCS112Bt2), JK

(JKCH8905BGII), Kaveri (KCH25K38BGII), Tulasi (SRITULASI 4B GII), Vibha (VBCH 1545 BGII)] cotton varieties of Andhra Pradesh were grown in pots and field. The Germplasms of *Gossypium* (Cotton) were collected from Regional Agricultural Research Station (RARS), Nandyal, Kurnool district, Andhra Pradesh.

Statistical Study

Quantitative Traits

Quantitative genetics is the study of the inheritance of continuously measured traits and their mechanisms. It is an extension of simple Mendelian inheritance in which the combined effects of one or more genes and the environments in which they are expressed give rise to continuous distributions of phenotypic values. In the present investigation, quantitative traits are studied for twenty three elite Bt and non-Bt cotton varieties of Andhra Pradesh such as

1. Average plant height
2. Days to flower
3. Average number of effective monopodia
4. Number of bolls per plant
5. Boll weight
6. Maturity days to flower
7. Average yield per plant

Location and Experimental Site

The present investigation was carried out in the fields located at Regional Agricultural Station, Nandyal, Kurnool District, Andhra Pradesh. The experimental site is located between 15, 4833(1528'59.880" N) latitude and 78, 4833 (7828'59.880"E) longitude and has altitude of 202m above mean sea level. It comes under transition tract of Andhra Pradesh state.

Experimental Material

The experimental material of the study comprised of twenty three cotton genotypes. This material includes 6 (*Gossypium hirsutum*), 5 (*Gossypium arboreum*) genotypes, 6 (Bt-cotton) and 6 non-Bt.

Experiment Layout

The experiment was laid out in Simple lattice Design with three replications. Each genotype in each replication was grown in a plot of 3 rows of 2 meter length each with a spacing of 23 cm between rows. The crop was provided with protective irrigations.

Recording of Observations

Observations on yield and yield attributing characters were recorded. In each plot, five random plants were tagged to record these observations. The mean value for the treatment was computed and given in tables.

Average Plant Height (cm)

The plant height on the average was measured from bottom of the plant *i.e.*, from soil level to the tip of the plant in centimeters.

Days to Flower

The number of days are taken on the average from the date of sowing the seed till the day on which 50 per cent of the flowers bloomed.

Days to Maturity

Numbers of maturity days taken from the date of sowing the seed to the time when more than 75 percent of the bolls got maturity on the plant was recorded.

Average Number of Effective Monopodia

Average numbers of effective monopodias are measured from the average number of branches that produced the bolls.

Number of Bolls per Plant

Numbers of bolls are measured by the total number bolls per plant.

Boll Weight (g)

Boll weight is measured by the weight of each boll on each plant in grams.

Average Yield per Plant (g)

Average yield per plant is measured by total flowering cotton produced to the grams of cotton produced from each plant.

Statistical Analysis

The statistical analysis of the data on individual character was carried out on the mean values of two replications.

The statistical methods adopted were as follows:

i. General mean (X) = $\frac{\text{Sum of observations of all the plants for each genotype}}{\text{Number of plants}}$

ii. Range = The minimum and maximum values for each trait within population σ_p .

iii. Coefficient of variation (CV%) = $\frac{\sigma_p}{\bar{X}} \times 100$

Where, σ_p = Phenotypic standard deviation

Estimation of Genetic Parameters

In order to assess and quantify the genetic variability among the genotypes for the characters under study, the following parameters were estimated. Components of Phenotypic and genotypic variances were estimated using the following formul:

Genotypic variance (σ_g^2) = $\frac{\text{MSS (genotypes)} - \text{MSS (error)}}{\text{Number of replications}} = \frac{M2 - M3}{r}$

Phenotypic variance (σ_p^2) = $\sigma_g^2 + \text{MSS error} = \frac{M2 - M3}{r} + M3$

Where, MSS (genotype) is the mean sum of squares of genotypes and MSS (errors) is the mean sum of squares of genotype.

Student t-Test

Student's t-test is used to compare the means of Bt and non Bt cotton variety samples when they are independent and when they are dependent (paired t-test). It can be used to compare a sample mean to a theoretical mean (Rohatgi, 2014).

In the present investigation, Student's t-test is applied to compare the mean values of the measurement variable. The measurement variables of elite Bt and non-Bt cotton varieties in Andhra Pradesh are Average Plant height, Days to flower, Average number of effective monopodia, Number of bolls per plant, Boll weight, Maturity days to flower and Average yield per plant.

Paired t-test applied to compare the mean values of the measurement variables between treated (Bt) [(Bhaskar (Tulasi9BGII), Nuziveedu (NCS112Bt2), JK (JKCH

Table 1 Descriptive statistics for all the varieties studied.

Quantitative character	Sample Number	Minimum	Maximum	Mean	Std. Error	Std. Deviation	Variance
Average plant height	23	88.20	156.40	120.69	3.60326	17.28065	298.621
Days to flower	23	37.60	57.00	50.3696	1.24924	5.99116	35.894
Average number of effective monopodia	23	1.00	2.80	1.9217	.11228	.53848	.290
Number of bolls per plant	23	22.40	34.00	26.8783	.65345	3.13383	9.821
Boll weight	23	2.26	4.76	3.7654	.17271	.82828	.686
Maturity days to flower	23	150.00	171.40	164.65	1.15610	5.54448	30.741
Average yield per plant	23	52.00	89.40	65.8087	2.08850	10.01607	100.322

Table 2 Analysis of variance

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	514408.300	6	85734.717	1.260E3	.000
Within Groups	10480.244	154	68.054	1.279E3	.002
Total	524888.543	160			

8905BGII), Kaveri (KCH25K38BGII), Tulasi (SRITULASI 4B GII), Vibha (VBCH 1545 BGII)], and nontreated (non-Bt) [(Bhaskar non-Bt, Nuziveedu non-Bt, JK non-Bt, Kaveri non-Bt, Tulasi non-Bt, Vibha non-Bt)] cotton varieties.

Independent t-test is employed between two groups to compare the mean values of the measurement variables of Bt [(Bhaskar (Tulasi9BGII), Nuziveedu (NCS112Bt2),

Table 3 Paired t-test

Qualitative trait	Between Sample	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
					Average plant height	Bt and non-Bt			
Days to flower	Bt and non-Bt	-9.08333	6.05720	2.4784	-15.43997	-2.72669	-3.673	5	.014
Average Number of Effective Monopodia	Bt and non-Bt	.30000	.78740	.32146	-.52633	1.12633	.933	5	.394
Number of Bolls per Plant	Bt and non-Bt	3.39274	1.38508	1.38508	.40621	7.52713	2.864	5	.035
Boll Weight (g)	Bt and non-Bt	.48233	.39798	.16247	.06468	.89998	2.969	5	.031
Maturity Days	Bt and non-Bt	9.00000	3.51682	1.43573	5.30933	12.69067	6.269	5	.002
Average Yield per Plant (g)	Bt and non-Bt	-3.13333	7.47761	3.05272	-10.98060	4.71394	-1.026	5	.352

JK (JKCH 8905BGII), Kaveri (KCH25K38BGII), Tulasi SRITULASI 4B GII), Vibha (VBCH 1545 BGII) and non-Bt [*Gossypium arboreum* (Aravinda, Srinandi, Yaganti, NDLA-2947, NDLA-2948), *Gossypium hirsutum* (Narasimha, Sivanandi, NDLH-1906, NDLH-1928, NDLH-2947, NDLH-2948, non-Bt (Bhaskar non-Bt, Nuziveedu non-Bt, JK non-Bt, Kaveri non-Bt, Tulasi non-Bt, Vibha non-Bt)] elite cotton varieties of Andhra Pradesh.

Analysis Of Variance (ANOVA)

Student's t-test is mathematically identical to ANOVA done on data with two categories. The t-test is easier to do and is familiar to more people, but it is limited to just two categories of data. The ANOVA can be done on two or more categories. Comparisons of more than two means can be done by using one-way ANOVA. The analysis of variance (ANOVA) for all characters was carried out separately.

For elite Bt and non-Bt cotton varieties in Andhra Pradesh the statistical measures such as Mean, Standard deviation and Variance are recorded and presented in table (1) for Average Plant height (Mean=120.069, Std. Deviation=17.28065 and variance=298.621), Days to flower (Mean=50.36, Std. Deviation=5.99 and variance=35.89). Average number of effective monopodia (Mean=1.92, Std. Deviation=0.53 and variance=0.29) Number of bolls per plant (Mean=26.87, Std. Deviation=3.13 and variance=9.82), Boll weight (Mean=3.76, Std. Deviation=0.82 and variance=0.68), Maturity days to flower (Mean=1.646, Std. Deviation=5.54 and variance=30.74) and Average yield per plant (Mean=65.80, Std. Deviation=10.01 and variance=100.32) respectively.

From the Analysis of variance (ANOVA) results (table 2) calculated “p” value is significant (2-tailed) between the groups [(0.00), (Bt (treated) and non-Bt (non treated))] and

Table 4 Independent Samples Test

Qualitative trait	Individual sample	Levene's Test for Equality of Variances				t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Average plant height	Equal variances assumed	.066	.800	.460	21	.650	3.845	8.356	-13.534	21.224
	Equal variances not assumed			.461	8.847	.656	3.845	8.337	-15.064	22.754
Days to flower	Equal variances assumed	.307	.585	-2.055	21	.052	-5.460	2.656	-10.986	.06456
	Equal variances not assumed			-1.841	7.404	.106	-5.460	2.966	-12.398	1.477
Number of Bolls per Plant	Equal variances assumed	.653	.428	2.268	21	.034	3.09608	1.36510	.25720	5.93496
	Equal variances not assumed			2.853	14.761	.012	3.09608	1.08517	.77982	5.41233
Average Number of Effective Monopodia	Equal variances assumed	.245	.626	.759	21	.456	.19608	.25820	-.34087	.73303
	Equal variances not assumed			.720	8.049	.492	.19608	.27245	-.43153	.82369
Boll Weight (g)	Equal variances assumed	6.427	.019	3.157	21	.005	1.04665	.33151	.35724	1.73606
	Equal variances not assumed			4.707	20.892	.000	1.04665	.22237	.58407	1.50923
Maturity Days	Equal variances assumed	2.849	.106	2.485	21	.021	5.88588	2.36902	.95924	10.81252
	Equal variances not assumed			3.037	13.704	.009	5.88588	1.93793	1.72100	10.05077
Average Yield per Plant (g)	Equal variances assumed	3.181	.089	1.630	21	.118	7.47451	4.58676	-2.06419	17.01320
	Equal variances not assumed			2.174	17.183	.044	7.47451	3.43761	.22766	14.72136

RESULTS AND DISCUSSION

Statistical tools were applied to study the analysis of genetic variation at the interspecific and intra specific level in Bt and non-Bt cotton varieties of Andhra Pradesh. Descriptive statistics is carried out by SPSS (Statistical Package for the Social Sciences) 20.0 version software. In the present study, results reveal the variation among individuals in a group and population of elite Bt and non-Bt [*Gossypium hirsutum* (Narasimha, Sivanandi, NDLH-1906, NDLH-1928, NDLH-2947, NDLH-2948), *Gossypium arboreum* (Aravinda, Srinandi, Yaganti, NDLA-2947, NDLA-2948), non-Bt (Bhaskar non-Bt, Nuziveedu non-Bt, JK non-Bt, Kaveri non-Bt, Tulasi non-Bt, Vibha non-Bt) and Bt (Bhaskar (Tulasi9BGII), Nuziveedu (NCS112Bt2), JK (JKCH8905BGII), Kaveri (KCH25K38BGII), Tulasi (SRITULASI 4B GII), Vibha (VBCH 1545 BGII)] cotton varieties in Andhra Pradesh with seven quantitative characters such as; Average Plant height, Days to flower, Average number of effective monopodia, Number of bolls per plant, Boll weight, Maturity days to flower and Average yield per plant.

within groups [(0.002), (Bt and non-Bt)] which is less than 0.05 (= 5%). Hence null hypothesis is rejected at 5% level of significance with 6 degrees of freedom. So there is a significant difference between and within groups of individuals of Bt and non-Bt cotton varieties for the characters under study i.e., Average Plant height, Days to flower, Average number of effective monopodia, Number of bolls per plant, Boll weight, Maturity days to flower and Average yield per plant.

From the paired t-test table (3), Average plant height character of studied Bt and non-Bt cotton varieties, p-value is 0.008 which is less than 0.05. Hence null hypothesis is rejected at 5% level of significance (=5%, 2-tailed) so, there is a significant difference between mean scores of Average plant height between treated (Bt) and non-treated (non-Bt) cotton varieties. Days to flower character of studied Bt and non-Bt cotton varieties p-value is 0.014 which is less than 0.05. Hence null hypothesis is rejected at 5% level of significance (=5%, 2-tailed) so, there is a significant difference between mean scores of Days to flower between treated (Bt) and non-treated (non-Bt) cotton varieties. Average number of effective

monopodia character of studied Bt and non-Bt cotton varieties p-value is 0.397 which is greater than 0.05; null hypothesis is accepted at 5% level of significance (=5%,2-tailed); So that there is no significant difference between mean scores of Average number of effective monopodia between treated (Bt) and non-treated (non-Bt) cotton varieties.

Number of bolls per plant character of studied Bt and non-Bt cotton varieties p-value is 0.035 which is less than 0.05. Hence null hypothesis is rejected at 5% level of significance (=5%,2-tailed) so, there is a significant difference between mean scores of Number of bolls per plant between treated (Bt) and non-treated (non-Bt) cotton varieties. Boll weight character of studied Bt and non-Bt cotton varieties p-value is 0.031 which is less than 0.05. Hence null hypothesis is rejected at 5% level of significance (=5%,2-tailed) so, there is a significant difference between mean scores of Boll weight between treated (Bt) and non-treated (non-Bt) cotton varieties. Maturity days character of studied Bt and non-Bt cotton varieties p-value is 0.002 which is less than 0.05. Hence null hypothesis is rejected at 5% level of significance (=5%,2-tailed) so, there is a significant difference between mean scores of Maturity days between treated (Bt) and non-treated (non-Bt) cotton varieties. Average yield per plant character of studied Bt and non-Bt cotton varieties p-value is 0.352 which is greater than 0.05. Hence null hypothesis is accepted at 5% level of significance (=5%,2-tailed) so, there is no significant difference between mean scores of Average yield per plant between treated (Bt) and non-treated (non-Bt) cotton varieties.)

From the independent t-test table (4) Average plant height character of studied Bt and non-Bt cotton varieties p-value is 0.650 which is greater than 0.05. Hence null hypothesis is accepted at 5% level of significance (=5%,2-tailed) so there is no significant difference between mean scores of Average plant height between Bt and non-Bt groups of cotton varieties. Days to flower character of studied Bt and non-Bt cotton varieties p-value is 0.05 which is equal to 0.05. Hence null hypothesis is rejected at 5% level of significance (=5%,2-tailed) so, there is a significant difference between mean scores of Days to flower between Bt and non-Bt groups of cotton varieties.

Average number of effective monopodia character of studied Bt and non-Bt cotton varieties p-value is 0.456 which is greater than 0.05. Hence null hypothesis is accepted at 5% level of significance (=5%,2-tailed) so, there is no significant difference between mean scores of Average number of effective monopodia between Bt and non-Bt groups of cotton varieties. Number of bolls per plant character of studied Bt and non-Bt cotton varieties p-value is 0.034 which is less than 0.05. Hence null hypothesis is rejected at 5% level of significance (=5%,2-tailed) so, there is a significant difference between mean scores of Number of bolls per plant between Bt and non-Bt groups of cotton varieties. Boll weight character of studied Bt and non-Bt cotton varieties p-value is

0.005 which is less than 0.05. Hence null hypothesis is rejected at 5% level of significance (=5%,2-tailed) so, there is a significant difference between mean scores of Boll weight between Bt and non-Bt groups of cotton varieties. Maturity days character of studied Bt and non-Bt cotton varieties p-value is 0.021 which is less than 0.05. Hence null hypothesis is rejected at 5% level of significance (=5%,2-tailed) so, there is a significant difference between mean scores of Maturity days between Bt and non-Bt groups of cotton varieties. Average yield per plant character of studied Bt and non-Bt cotton varieties p-value is 0.118 which is greater than 0.05. Hence null hypothesis is accepted at 5% level of significance (=5%,2-tailed) so, there is no significant difference between mean scores of Average yield per plant between Bt and non-Bt groups of cotton varieties.

CONCLUSION

From the above analysis we infer that Bt varieties have shown more significant mean value for characters like Average yield per plant (Nuzivvedu Bt, Tulasi Bt, JK Bt), Boll per plant (Tulasi Bt, Nuzivvedu Bt), Effective monopodias (Kaveri Bt, Tulasi Bt, Bhaskar Bt) and Number of bolls per plant (Tulasi Bt, JK Bt, Vibha Bt) than the non-Bt varieties (G.hirsutum and G.arboreum) respectively.

Whereas non-Bt-varieties have shown significance in the characters like Plant height (Narasimha non-Bt, NDLH-1959 non-Bt, Srinandi ,Vibha non-Bt, Bhasakar non-Bt, Bhaskar non-Bt), Maturity days (G.hirsutum , Yaganti, Vibha non-Bt) and Days to flower (NDLH-1938 non-Bt, Yaganti non-Bt, Tulasi non-Bt, Bhasakar non-Bt) respectively. However, a few of non-Bt varieties like Sivanandi (G.hirsutum), NDLH-1938 (G.hirsutum), and Yaganti (G.arboreum) have also shown significance for production of yield per plant. Overall the growth parameters were significant in non-Bt than Bt cotton varieties in contrast to the production and yield per plant.

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