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Genotypic Variation in Physiological Quality of Fresh Cotton Seed

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Authors' contributions

This work was carried out in collaboration between all authors. Author MAS designed the study, wrote the protocol, executed the experiment, performed the statistical analysis and wrote the first draft of the manuscript. Author MMH reviewed the design and supervised the study. Authors MOI and MNU contributed during writing up and editing of manuscript. Author MNH reviewed each draft of the manuscript and final proof submission. All authors read and approved the final manuscript.

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ABSTRACT

Quality seed is essential to increase cotton production in Bangladesh. For this, 43 cotton genotypes were evaluated to identify better inherent physiological seed quality. The experiment was set up at the Seed Science and Technology Unit Laboratory of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh in May, 2009. The results showed great variation exists in seed index, seed germination percentage, electrical conductivity and seedling vigour of studied cotton genotypes. Frequency distribution suggested the majority number of the genotypes had higher values of germination percentage and seedling vigour. Electrical conductivity (EC) test of seed leachate provides the status of seed quality. The highest EC of seed leachate found in

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genotypes BC-0434 and BC-0432 ensuing of weak membrane while the lowest EC of seed leachate was recorded in genotype BC-0125. Cluster analysis grouped the genotypes into five distinct groups which categorized into (i) low, (ii) medium low, (iii) medium, (iv) medium high and (v) high vigour. The genotypes BC-051, BC-0197, BC-0432, BC-0438 and BC-0252 in cluster V showed the highest germination percentage (96.20%) with the highest seedling vigour index (5064). Therefore, these genotypes could be used for genetic improvement of cotton considering higher yield with better seed quality.

Keywords: Cluster analysis; electrical conductivity; seed germination percentage; seed index.

1. INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is the most important textile fibre crop and plays a key role in economic and social welfare in the world [1]. Cotton is also important cash as well as fibre crop of Bangladesh which provides raw materials to domestic cotton industries. The total raw cotton production of the country is nearly 0.09 million bales against the requirement of 4.00 million bales. Rest amount of raw cotton is imported each year by expensing huge amount of foreign exchange. Moreover, consumption of raw cotton in Bangladesh is increasing day by day due to increasing demand from spinning sub-sector, cotton textiles and ready-made garments. Therefore, it is essential to increase cotton production in Bangladesh where use of quality seed can play a vital role.

Cotton production may be increased either by horizontally or vertically or by the both ways. But in practice, it is almost impossible to increase cotton production horizontally because of severe crop competition in same growing season. Yield increment of cotton by vertically is possible because the productivity of cotton in Bangladesh is only 1.5 to 2.0 t ha^{-1} against average yield (4.5 to 5.0 t ha^{-1}) in other cotton growing countries like China, Uzbekistan and Turkey. Such yield gap of cotton can be minimised by using quality seed as availability of good quality seed remains one of the major constrains in crop production of many field crops [2]. Higher yield of cotton may be achieved by selecting appropriate variety specifically suited to local ecological condition [3].

For better growth, yield and lint quality, use of quality seed is the prime concern as quality seed itself can increase yield by 5-20% [4]. Seed quality comprises a wide range of interrelated attributes *viz.,* genetical, physical, physiological and pathological. Quality seed is considered to be the basic input for increasing agricultural output. Effectiveness of other inputs such as fertilizer, irrigation, pesticides are largely depending on seed quality. If the seed is not quality one, the use of other inputs become less fruitful or sometimes wasteful. As quality of seed is mostly genetically controlled, search for inherent high quality seed is imperative for obtaining high yielding cotton genotype consistent with better seed quality. Therefore, the objective of this study was to identify cotton genotypes having better inherent physiological seed quality that may be used in further yield improvement of cotton.

2. MATERIALS AND METHODS

2.1 Experimental Materials

Physiological quality of freshly harvested cotton seed was assessed at the Seed Science and Technology Unit Laboratory of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh in May, 2009. A total of 43 cotton genotypes formed the treatment variables. The genotypes were CB-1, CB-2, CB-3, CB-4, CB-5, CB-6, CB-7, CB-8, CB-9, CB-10, CB-11, SR-01,SR-08, SR-12, JA-541, BC-027, BC-037, BC-044, BC-047, BC-051, BC-063, BC-088, BC-098, BC-0114, BC-0125, BC-0165, BC-0175, BC-0188, BC-0197, BC-0236, BC-0252, BC-0303, BC-0342, BC-0345, BC-0405, BC-0406, BC-0414, BC-0430, BC-0431, BC-0432, BC-0433, BC-0434, and BC-0438. Fresh seeds were collected from Cotton Research Centre, Cotton Development Board, Bangladesh. Seeds were dried in the sun until moisture percentage reached to about 9.0% and packed in air tight polythene bag for seed quality assessment.

2.2 Seed Quality Assessment

Seed quality was assessed in the laboratory of seed science and technology unit, Banghabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh. Quality of freshly harvested cotton seeds were assessed by seed index, germination test, coefficient of germination, seedling vigour index, mean days to germination and electrical conductivity test. Seed index of cotton genotypes were determined from 100 seeds randomly counted from pure seeds by multi auto counter and weighed in an electrical balance (Model FX-300m). For germination test, one hundred seeds from each genotype were used and replicated three times. Seeds were placed in 21 cm × 15.5 cm plastic trays containing filter paper soaked with distilled water. The plastic trays with seeds were placed in an incubator at 25℃ for 7 days and water was added if necessary. Seedlings were counted every day up to completion of germination. A seed was considered to be germinated as the seed coat ruptured and radical came out up to 2 mm length. Germination percentage was calculated according to Krishnasamy and Seshu [5].

For electrical conductivity test, four sub-samples of 50 seeds were weighed, soaked into plastic beakers with 75 ml de-ionized water and were incubated for 24 hours at 25℃ [6]. Then the seeds were removed from the beakers and the electrical conductivity of the water containing seed leachate was measured with a conductivity meter (Model-CM-30ET).

For seedling growth, ten plants from each Petri dish were sampled on the day 7 of the germination test. Root and shoot length of individual seedling was measured and then dried at 70℃ for 72 hours for dry matter yield. Seedling vigour index was calculated according to the following formula [7].

2.3 Statistical Analysis

As large number of genotypes included in the study, analysis of variance (ANOVA) was not performed to evaluate the genotypic variation in physiological quality of cotton seed. Instead, frequency distribution, relationship, cluster and Discriminant Function Analysis (DFA) were employed for classification of cotton genotypes into a number of groups. The statistical package SPSS version 11.5 was used in conducting these analyses.

3. RESULTS AND DISCUSSION

3.1 Seed Index (g)

Cotton genotypes varied greatly in seed index which ranged from 7.38 to 10.17 g (Fig. 1). Based on seed index, 4 genotypes had small (7.38-8.07 g), 34 had medium (8.07-9.47 g), 4 had large (9.47-9.82 g) and one genotype (SR-12) had very large seed (10.17 g). Among them, one genotype showed highest seed index (9.82-10.17) and two genotypes showed lowest (7.38-7.72). Such variability in seed index of cotton genotypes has great influence on physiological seed quality as there is positive relationship between seed mass and germination in cotton seed [8]. Tupper and Kunze [9] also reported that seed size is the physical characteristics that had great impact on the germination of cotton.

3.2 Germination (%)

Germination test is an integral component of seed quality assessment which varied from 88.50 to 97.64% in different cotton genotypes (Fig. 2). Lower germination percentage (<90%) was found only in 3 genotypes and most of the genotypes showed 90 to 95% germination while seeds of 13 genotypes maintained more than 95% germination. Among them, eight genotypes showed highest germination (96.50-97.64%) and three genotypes showed lowest (88.50-89.64%). Frequency distribution of germination percentage indicated that most of the genotypes showed high germination percentage and slightly skewed towards right. This indicates that the majority of cotton genotypes had germination percentage more than median. These results also are in conformity with Akhtar et al. [10] in chickpea genotypes.

3.3 Electrical Conductivity (mS cm^{-1} g^{-1})

Electrical conductivity (EC) test of seed leachate also provides the status of seed quality. This test is related to degradation of cell membranes and intensity of leakage out of cells [11]. The level of leachate conductivity depends on the amount of electrolytes leached into an imbibing medium [12]. In present study, EC of cotton seed of 43 genotypes differed from 0.281 to 0.969 $mScm^{-1}g^{-1}$ (Fig. 3) which indicates that there is great variability in degree of membrane integrity in cotton seeds. The highest EC of seed leachate found in BC-0434 and BC-0432 were the resultant of weak membrane. Conversely, the lowest EC of seed leachate was recorded in one genotype (BC-0125). This may be the consequence of some genetically controlled traits of this genotype. The genotype BC-0125 might present higher membrane integrity with higher lignin content in seed coat. These characteristics of seed coat can have a direct effect on EC as water absorption by seed coat is controlled by seed coat pores and by the amount of wax material present in the epidermic cells [13].

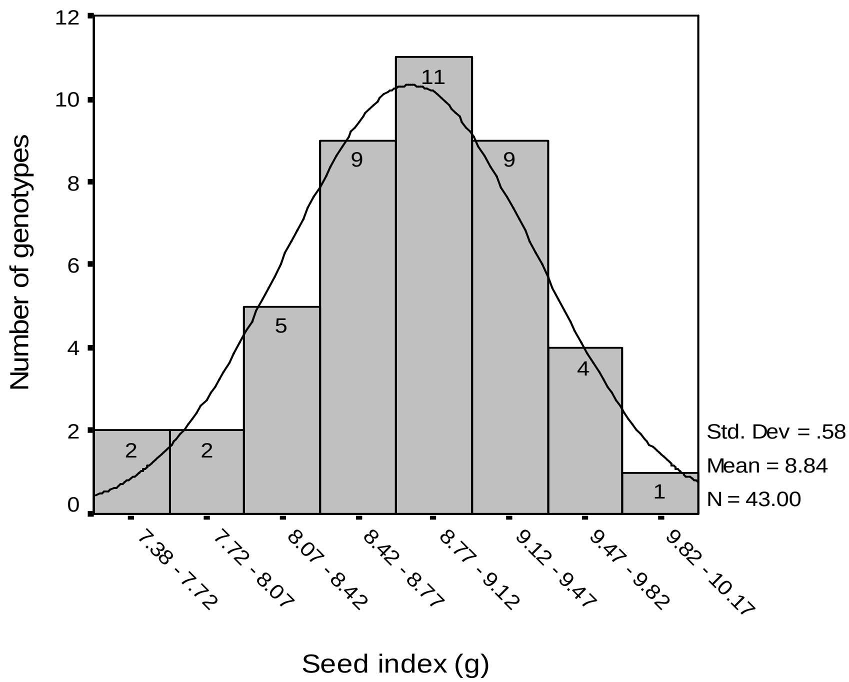

Fig. 1. Frequency distribution of 43 cotton genotypes based on seed index

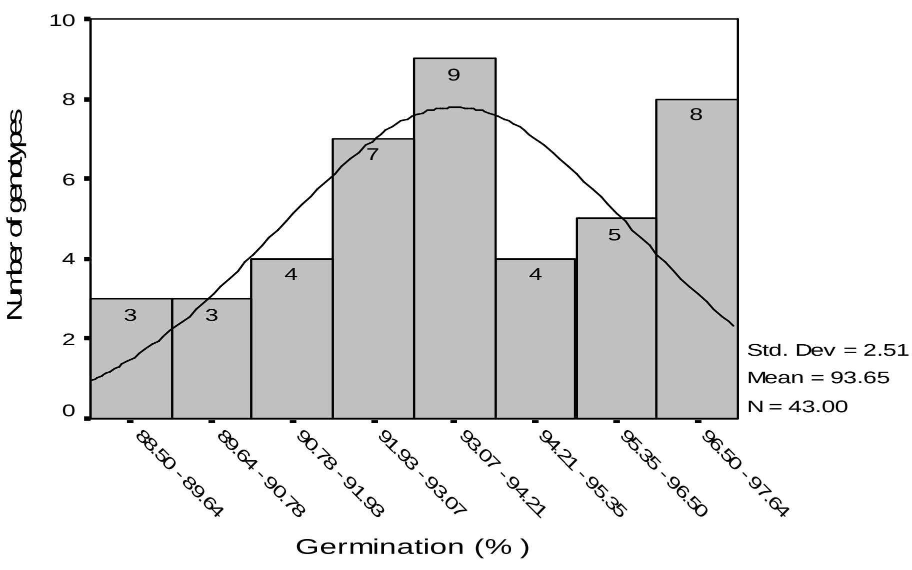

Fig. 2. Frequency distribution of 43 cotton genotypes based on germination capacity

3.4 Seedling Vigour Index

Seedling vigour testing is important as it gives better prediction of field performance of seed [14]. Results of vigour test of cotton seed revealed the variability in vigour index in different genotypes which varied from 2900 to 5300 (Fig. 4). Two genotypes (CB-1 and CB-8) showed low seedling vigour index while high vigour index were recorded in 3 genotypes (BC-0432, BC-051 and BC-0438). Further, frequency distribution of vigour index positively skewed which indicated that majority number of the genotypes showed higher values of seedling vigour index. Thus, seeds of these genotypes are assumed to have high vigour and this possibly can be caused by a genotype effect [15].

3.5 Grouping of Genotypes

In many experiments like present study (43 genotypes) which compare a large number of genotypes require to decide which sub-sets of genotypes do not differ significantly from each other. Such homogenous groups of genotypes are formed for further detailed study as it is very difficult to explain a large number of variables for each genotype. In order to doing so, a dendrogram can be used through cluster analysis [16]. A dendrogram was prepared using cluster analysis based on 11 variables of 43 cotton genotypes (Fig. 5). This dendrogram makes statistically homogenous groups on the basis of variables which is simple in presentation and interpretation of results. This is constructed in the scale of 5 divided into five groups and genotypes with the same group considered as homogenous in nature [17].

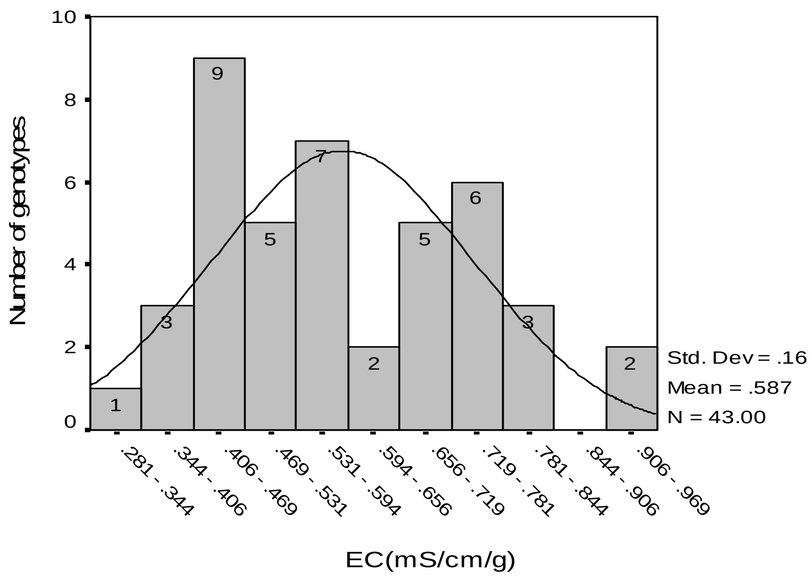

Fig. 3. Frequency distribution of 43 cotton genotypes based on EC presented in normal distribution curve

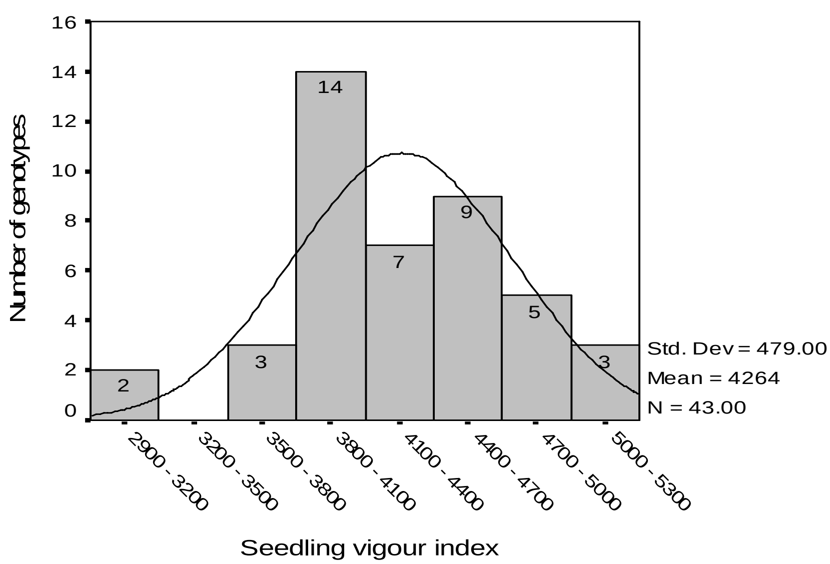

Fig. 4. Frequency distribution of 43 cotton genotypes based on seedling vigour index

Dendrogram using Average Linkage (Between Groups)
Rescaled Distance Cluster Combine

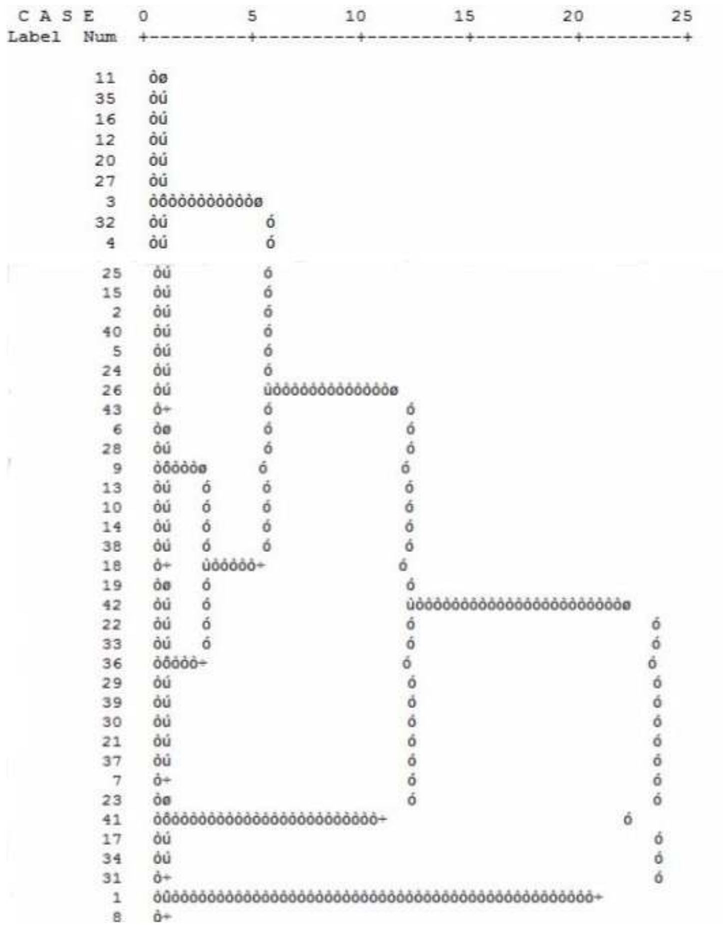

Fig. 5. Dendrogram of 43 genotypes on the basis of studied parameters

Table 1. Pair-wise Mahalanobis distances (D^2) between 5 clusters of 43 cotton genotypes

Cluster number	1	2	3	4	5
1	-	107.241**	193.918**	346.325**	487.626**
2			58.086**	287.763**	445.160**
3				50.329**	171.525**
4					59.770**
5					-

***Distance differing from zero at 0.01 level of significance*

3.6 Mahalanobis Distance (D^2) Analysis

Pair-wise Mahalanobis distance (D^2) analysis among 5 clusters was statistically different from each other (Table 1). Among 5 clusters, Cluster 1 indicated the highest distant unit (487.625) with cluster 5 which was followed by the distance (445.160) between cluster 2 and cluster 5 and the distance (346.325) between cluster 1 and 4. Several workers also did similar Mahalanobis distance (D^2) analysis to select the distinct clusters in different studies [17,18].

3.7 Descriptive Statistics

Descriptive statistics (mean) of four major seed qualitative attributes of 43 cotton genotypes made from results obtained through cluster

Table 2. Descriptive statistics (mean) of major seed qualitative attributes of cotton seeds made from results obtained through cluster analysis

Cluster number	Germination (%)	Mean days To germination (days)	Seedling Vigour Index	Seedling dry weight (mg)	Vigour group	Genotypes under the group	Genotypes may be selected for next study
1	90.84	3.00	3108	34.24	Low	CB-1 , CB-8	CB-8
2	92.65	2.99	3927	42.40	Medium low	CB-2, CB-3, CB-4, CB-5, CB-11, JA-541, BC-0405, BC-037, BC-0236, BC-0303, BC-0406, BC-0433, SR-01, BC-0430, BC-027, BC-0175, BC-0345	BC-236
3	92.79	2.98	4273	46.06	Medium	CB-6 , CB-9, CB-10, BC-0434, BC-044, BC-063, SR-08, BC-0114	SR-08
4	95.18	2.96	4622	48.56	Medium high	CB-7 , BC-0188, SR-12, BC-0165, BC-0342, BC-088, BC-0431, BC-047, BC-098, BC-0125, BC-0414	BC-125
5	96.20	2.95	5064	52.66	High	BC-051, BC-0197, BC-0432, BC-0438, BC-0252	BC-252

Table 3. Correlation coefficient among different seed quality characters of 43 cotton genotypes

Characters	Seedling vigour index	Electrical conductivity (mS cm^{-1} g^{-1})	Seed index (g)
Germination (%)	0.629**	-0.066	0.252
Seedling vigour index		-0.016	0.520**
Electrical conductivity (mS cm^{-1} g^{-1})			-0.083

***Significant at 1% level of significance*

analysis is shown in Table 2. The results showed that the highest germination percentage (96.20%) was found from cluster 5 with the lowest mean days to germination (2.95 days), the highest seedling vigour index (5064) and the highest seedling dry weight (52.66 mg) which represented the highest vigour of the seeds of cotton genotypes.

3.8 Correlation Coefficient Studies

Among the Pearson's correlation coefficient studies germination percentage and seedling vigour index showed positive and significant relation with seedling vigour index and seed index, respectively (Table 3).

4. CONCLUSION

In this research we concluded that there was a great variation among the studied cotton genotypes in seed index, germination percentage, electrical conductivity and seedling vigour. Frequency distribution of seedling vigour index positively skewed which depicted that majority number of the genotypes showed higher values of seedling vigour. Cluster analysis categorized into low, medium low, medium, medium high and high vigour seed. In this study, the genotypes BC-051, BC-0197, BC-0432, BC-0438, BC-0252 showed better inherent physiological seed quality of Cotton.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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