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Genotypic Variation in Physiological Quality of Stored 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

Seeds of five cotton genotypes *viz.,* CB-8, BC-0236, SR-08, BC-0125 and BC-0252 were assessed to observe the effect of packing materials on physiological quality of cotton seed stored under ambient condition. The packaging materials were hermetically sealed polythene bag (thickness 8 μ) and cloth bag. Physiological quality of cotton seeds was assessed in the laboratory of Seed Science and Technology Unit of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during May, 2009 to July, 2010. Results revealed that better physiological

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quality of cotton seeds was achieved by storing in hermetically sealed polythene bag instead of cloth bag. Moisture content of cotton seed increased rapidly in cloth bag upto 4 months. Afterwards, it decreased up to 10 months and then again increased slightly depending upon relative humidity of ambient condition. Contrary, moisture in seed of polythene bag remained more or less stable throughout the storage period. Excellent germinability (>80%) was observed in seeds of polythene bag as compare to cloth bag even after 14 months of storage. Considering genotypes, significant genotypic variation was found in all physiological traits of stored cotton seed. The genotype BC-0252 maintained the highest storability as it showed highest germination (83%) and vigour index (3167) with the lowest (6.47%) loss of seed weight at the end of storage. The genotype BC-0252 therefore, could be useful in future breeding program for cotton improvement consistent with better seed quality.

Keywords: Cloth bag; genotype; polythene bag; seed index; seed moisture.

1. INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is the most important textile fibre crop in the world [1]. It is also important cash as well as fibre crop of Bangladesh which provides raw materials to domestic cotton industries. In Bangladesh the total production of raw cotton is nearly 0.09 million bales against the requirement of 4.00 million bales [2]. Rest amount of raw cotton is imported each year by expensing huge amount of foreign exchange. In addition, 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. Cotton production in Bangladesh may be increased as yield of cotton in country is only 1.5 to 2.0 t ha^{-1} against the average yield (4.5-5.0 t ha^{-1}) of other leading cotton growing countries like China, Uzbekistan and Turkey. Such yield gap can be minimized by using high yielding genotypes having higher germinabilty (> 80%) in storage, which in turn increase the survivability of established seedlings per unit area at farmer's field.

Cotton seed however needs to be stored for several months before sowing in next season. In storage, seed deterioration is a serious problem if proper control of humidity and temperature are not done. Temperature and seed moisture content are the main factors influencing seed deterioration and viability loss in storage [3]. Kushwaha [4] reported that 96% relative humidity and 30°C temperature would be better for the storage of cotton seeds. Low temperature and humidity results in delayed seed deterioration process and aging thereby leads to extended viability period. Seed ageing is generally marked by reduction in vigor [5], capacity of germination [6], increased solute leakage [7,8] and susceptibility to stresses which reduced tolerance under adverse storage conditions [9].

It is known that reduction of quality of seed in storage is related to biochemical alterations such as changes in respiration and enzymatic activities, synthesis process, cell membranes and chromosomes integrity [10]. However, information regarding physiological attributes associated with cotton seed deterioration in storage still to be determined. Therefore, the present study was planned with the objectives (i) to determine effect of packing materials on physiological quality of stored cotton seed, (ii) to observe changes in viability and vigour of stored cotton seed of different genotypes and (iii) to assess genotypic variation in inherent physiological quality of stored cotton seed under ambient condition.

2. MATERIALS AND METHODS

2.1 Experimental Materials

Seeds of five cotton genotypes *viz.,* CB-8, BC-0236, SR-08, BC-0125 and BC-0252 were used for this study. The fresh seeds were collected from Cotton Research Centre, Cotton Development Board, Rangpur, Bangladesh. Seeds were dried in the sun until moisture percentage reached to about 9.0% and packed for physiological seed quality assessment. 100 seeds per packet and 3 packets per genotype were used in this experiment. Seeds were packed using two packaging materials (i) hermetically sealed polythene bag (thickness 8 μ) and (ii) cloth bag and stored at ambient environment for a period of 14 months. The polythene bags were sealed by sealing machine and cloth bags were tightened with cotton threat. The temperature and relative humidity of the store experienced by the seeds in ambient conditions are illustrated in Fig. 1 which indicated that both temperature and relative humidity changed markedly over the whole storing period.

2.2 Seed Quality Assessment

Seed quality was assessed in the laboratory of the Seed Science and Technology Unit of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh.One packet seed of each genotype was taken from the store at every 2 months interval up to 14 months for assessment of different physiological quality of seed. Moisture content was determined by constant oven dry method following ISTA [10] rules. Seed index of cotton genotypes were determined from 100 seeds randomly counted from stored seeds by multi auto counter and weighed in an electrical balance (Model FX-300m). Seed index was determined once at beginning and another at end of the study.

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°C 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 radicle came out up to 2 mm length as per ISTA [11] rule.

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°C [12]. 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°C for 72 hours for dry matter yield. Seedling vigour index was calculated according to the formula devised earlier [13].

2.3 Statistical Analysis

The data obtained from different parameters were analyzed statistically by analysis of variance (ANOVA) technique with the help of MSTAT-C computer package program [14]. Least significant difference (LSD) test was used for comparison of means at 5% level of probability.

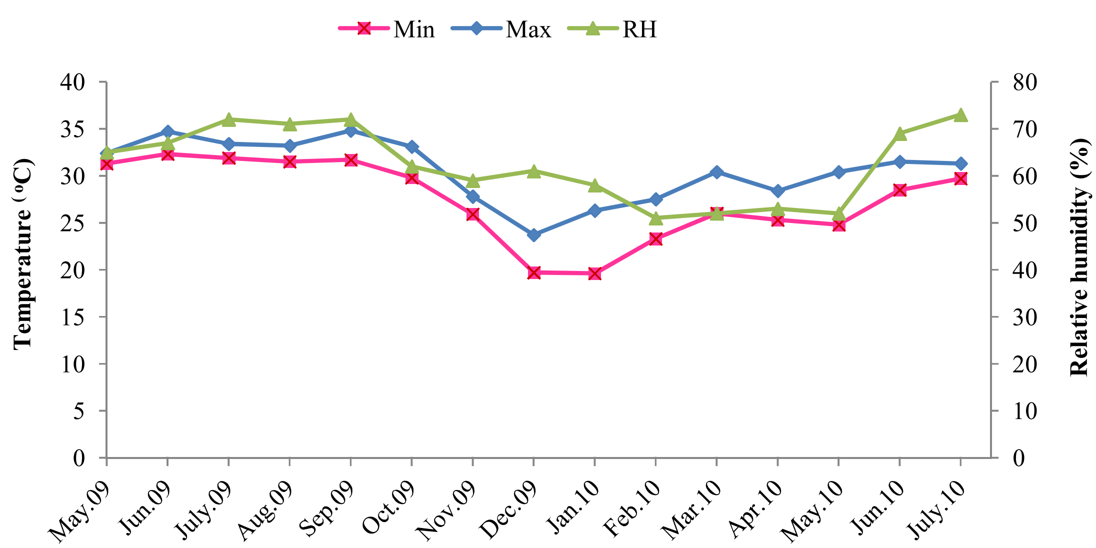

Fig. 1. Monthly maximum and minimum temperature and relative humidity of the store at ambient conditions

3. RESULTS AND DISCUSSION

3.1 Seed Moisture

Seed moisture content is the most important factor that regulates the longevity of seed in storage. Higher moisture content in the seed enhances seed deterioration, which reduces the quality of seed [15]. Cotton seed containing 9.03 to 9.20% moisture were stored in cloth and polythene bag for a period of 14 months at ambient condition. Moisture content of cotton seed varied widely in between cloth and polythene bag (Fig. 2). In cloth bags, seed moisture contents increased rapidly up to 4 months of storage and afterwards decrease up to 10 months and then again increased slightly. This was happened because of changes in relative humidity of ambient storage condition (Fig. 1). Rapid increase in seed moisture content in cloth bag at earlier storage period was ascribed to the increase in relative humidity of the atmosphere. As seed is highly hygroscopic living material and it absorbs moisture from air to maintain equilibrium to relative humidity of atmosphere [16], seed moisture content increased with the increase of relative humidity (65 to 72%) of the atmosphere. Further decrease or increase in seed moisture content was resembled to that of decrease or increase in relative humidity of storage environment. In contrast, moisture content of cotton seeds within polythene bags remained more or less stable throughout the storage period because of no moisture absorbed or released under hermetically sealed condition. These results are agreement with the findings of Vadivellu et al. [17] in chickpea; Baskin et al. [18] in soybean; Usha et al. [19] in cowpea and Hemashree et al. [20] in cotton seeds. Considering genotypic variation in seed moisture content, the genotype CB-8 contained the lowest and SR-08 contained the highest amount of moisture throughout the storing period. Such variation in seed moisture content in different genotypes may be ascribed to differences in oil content in cotton seed [21].

3.2 Seed Index

Irrespective of genotypes and containers, seed index decreased with the increase of storage period (Table 1). However, reduction of seed index was lower in polythene bag than that of cloth bag. The reduction of lower seed index in polythene bag was probably ascribed to its impervious nature of pores which had offered better protection to seeds in changing seed moisture content at variable relative humidity during 14 months of storage. In fact, lower seed moisture in polythene bag decreased the rate of respiration and consequently reduction was lower in seed index. Conversely, the higher rate of respiration in cloth bag might have lost the reserved nutrient of seed which in turn reduced the seed index more in comparison with polythene bag [5]. Among the genotypes, loss of seed weight was the lowest (6.47%) in BC-0252 genotype stored in polythene bag and it was the highest (16.44%) in seeds of the genotype CB-8 stored in cloth bag after 14 month of storage.

Table 1. Storage time and containers effects on the seed index of cotton seed of different genotypes

Name of genotypes	Seed index at the time of storage (g)	Seed index after 14 months of storage (g)	
		Cloth bag	Polythene bag
CB-8	7.48	6.61	6.89
SR-08	8.85	7.98	8.11
BC-0125	8.85	8.11	8.21
BC-0236	8.74	7.81	7.97
BC-0252	8.96	8.31	8.38
$LSD_{(0.05)}$	0.40	0.24	0.18
CV (%)	2.56	1.67	1.25

3.3 Seed Germination

The seed viability during storage depends upon the initial quality of seed and the manner in which it is stored [22]. Fresh cotton seed of different genotypes having 91.67 to 97.00% germination were stored in cloth and polythene bag. It is revealed from the Fig. 3 that cotton seed may be stored safely up to 4 months either in cloth bag or polythene bag under ambient condition as seeds maintained more than 85% germination at the end of 4 months of storage. Afterwards, seeds started deterioration and it was faster in cloth bag which is demonstrated by faster decrease in germination. Decline in germination percentage of seeds stored in cloth bag at faster rate during storage period might be due to increase in moisture content. Increase in seed moisture content in cloth bag led to higher respiration rate which in turn declined the germination potential of stored seeds [23]. Seeds in polythene bag showed germination percentage more than 85% up to 8 months of storage and more than 80% up to 10 months of storage which indicated that cotton seed in polythene bag is much safer than that of cloth bag. These results are in agreement with the findings of Nahar et al. [24] in bean seeds and Hemashree et al. [20] in cotton seeds.

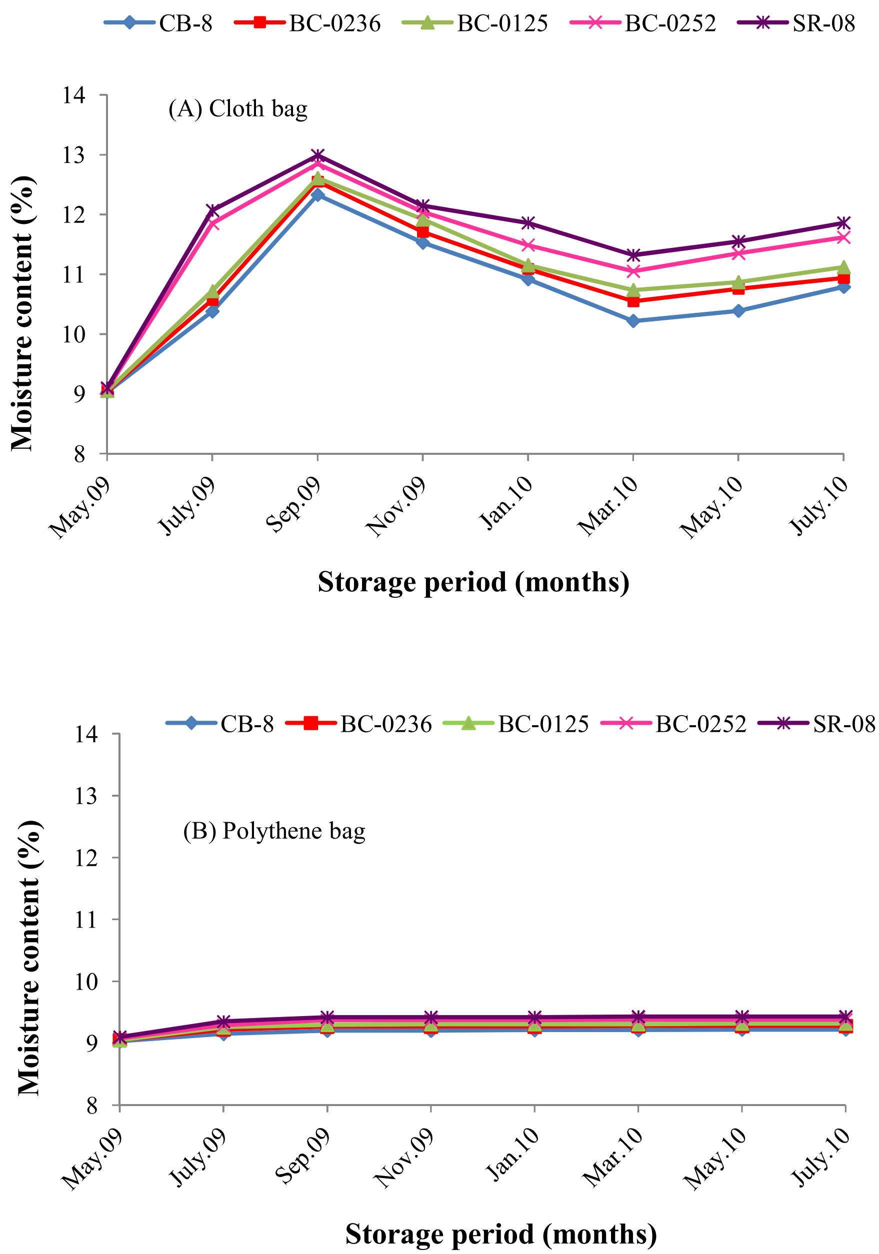

Fig. 2. Moisture content of cotton seed genotypes in (A) cloth and (B) polythene bag over times

The genotypes differed markedly in germination ability under ambient condition. After 14 months of storage, germination of cotton seed obtained from the genotype CB-8 stored in cloth and polythene bag were 29.67 and 74.33%, respectively. In contrast, germination of cotton seed of the genotype BC-0252 stored in cloth and polythene bag were 37.67 and 83%, respectively. This indicated that genotypes might have differences in genetic makeup which determined the variability in germination of cotton seeds stored in different containers under ambient condition [25].

3.4 Electrical Conductivity

There was significant variation of electrical conductivity of the solution that contained cotton seed of different age stored in two packaging materials. In general, electrical conductivity was higher with the advancement of storage period and this is an indication of seed deterioration over time (Fig. 4). Again, deterioration of seeds stored in cloth bag was faster as compared to that of the seeds stored in polythene bag as indicated by its higher values of electrical conductivity. In contrary, seeds of polythene bag showed lower electrical conductivity which is an indication of higher seed vigour. Because the electrical conductivity is related with the amount of ions leached into the solution, which in turn is directly associated with the integrity of the cellular membranes, badly structured membranes and damaged cells are usually associated with the process of seed deterioration and reduced seed vigour [26]. The decrease in

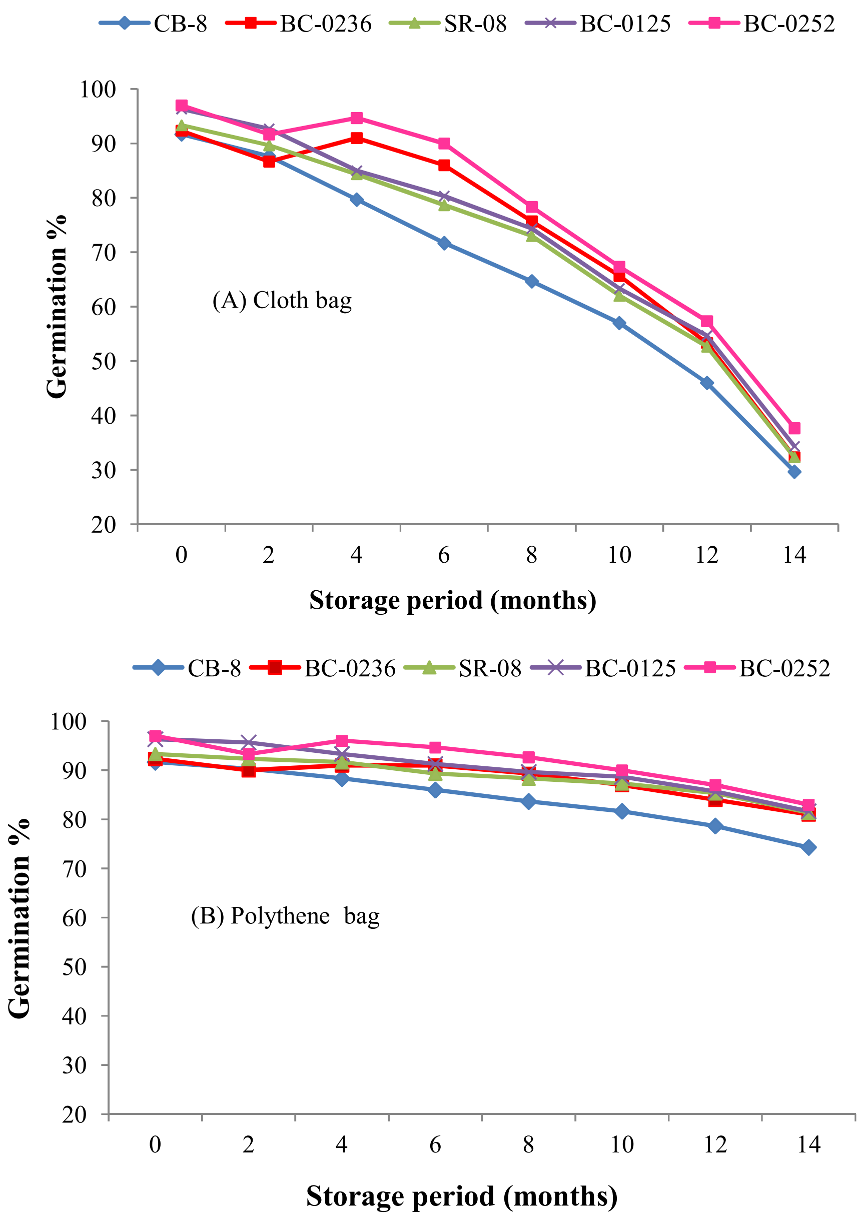

Fig. 3. Pattern of germination capacity of cotton seed genotypes stored with (A) cloth and (B) polythene bag

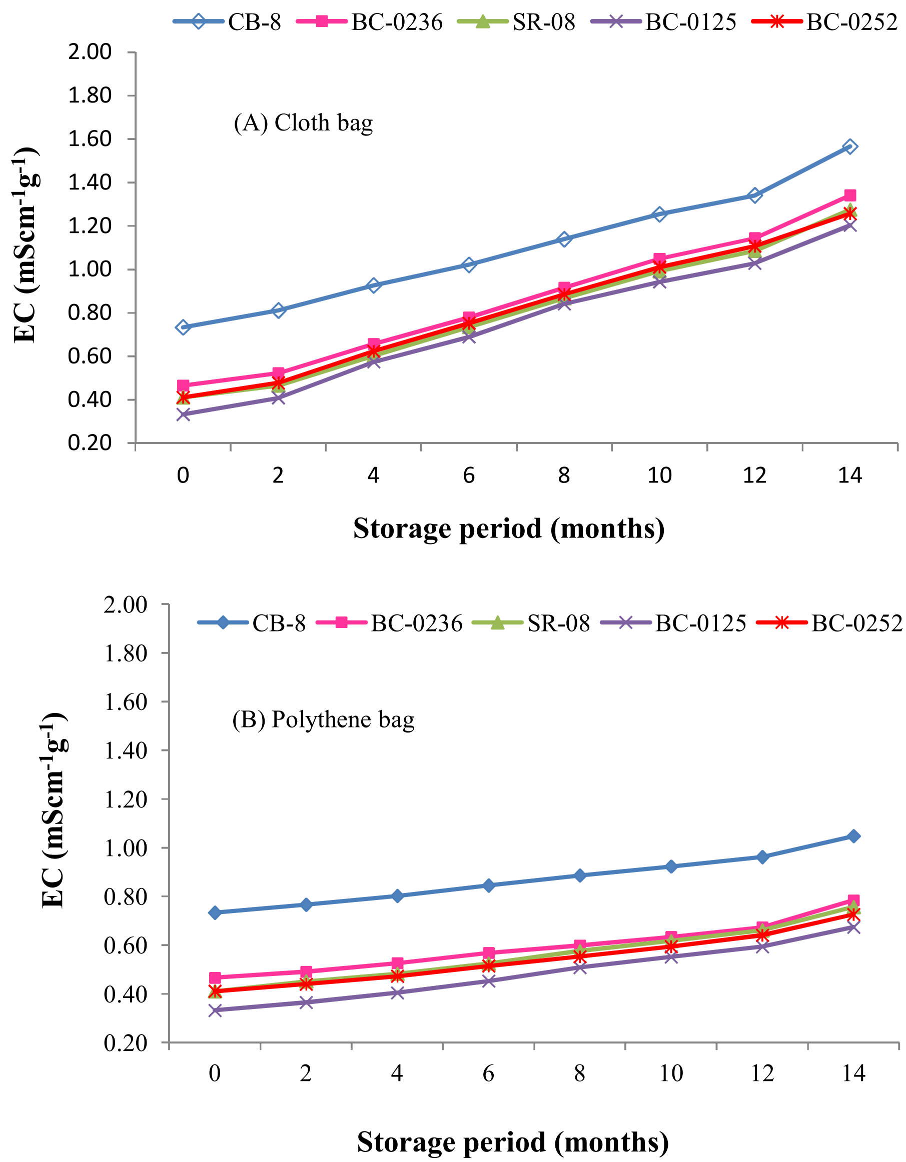

Fig. 4. Electrical conductivity (EC) of cotton seed leachates stored in (A) cloth and (B) polythene bag at ambient condition

germination or vigour is negatively correlated with the electrolytic leaching which increases with the decrease of the phospholipids content of the membrane [27]. Contrarily, the smallest values, corresponding to the smallest exudates liberation, indicate high physiological potential, which indicates smaller disorder intensity in the cell membrane systems [28]. Seeds of the genotypes CB-08 showed higher value of electrical conductivity throughout the storage period and thus seeds of these genotypes are inherently low vigoured.

3.5 Seedling Growth

There was variation in biomass production of cotton seedling obtained from different genotypes. The genotype BC-0252 produced the highest seedling dry weight (50.88 mg plant^{-1}) at the time of storing and maintained the highest dry matter (38.15 mg plant^{-1}) at the end of storing (Table 2). The results indicated that decline in seedling dry weight is common phenomena during storing and this reduction was 25.02% in polythene and 29.62% in cloth bag in case of

BC-0252 genotype. Similar pattern of reduction in seedling dry weight in storage also observed in the other genotypes of cotton. The lower seedling dry weight recorded in cloth bag which was associated with the increase of seed moisture in accordance with increase of relative humidity of ambient atmosphere.

Table 2. Effect of different containers on the seedling dry weight of cotton seed over time

Name of genotypes	Initial seedling dry weight (mg plant^{-1})	Seedling dry weight after 14 months of storage (mg plant^{-1})	
		Cloth bag	Polythene bag
CB-8	33.81	21.77	25.58
SR-08	46.59	31.33	35.19
BC-0125	49.05	33.17	36.37
BC-0236	40.77	27.25	31.17
BC-0252	50.88	35.81	38.15
$LSD_{(0.05)}$	4.36	1.19	1.00
CV (%)	5.42	2.19	1.65

Table 3. Effect of different storage containers on the vigour index of seed of different cotton genotypes

Name of genotypes	Initial vigour index	Vigour index after 14 months of storage	
		Cloth bag	Polythene bag
CB-8	3097	647	1901
SR-08	4349	1012	2862
BC-125	4729	1138	2970
BC-236	3765	882	2524
BC-252	4934	1348	3167
$LSD_{(0.05)}$	468.20	141.20	128.10
CV (%)	6.17	7.72	2.62

3.6 Vigour Index

Storage containers and cotton genotypes interacted significantly on seedling vigour index (Table 3). The results revealed that as the storage period advanced, the vigour index showed the declining trend. Decrease in vigour index corresponded well to that of the seedling dry weight. Like seedling dry weight, seeds of different genotypes packed in polythene bag recorded significantly higher vigour index compared to cloth bag after the 14 months of storage. Similar observations were also made by Vadivellu et al. [17] in chickpea and Usha et al. [19] in cowpea. Among the genotypes, BC-0252 showed the highest vigour index (3167) in polythene bag at the end of the 14 months of storage. In same condition, genotype CB-8 produced the lowest vigour index (1901) which was 39.97% lower than that of BC-0252 genotype.

4. CONCLUSION

Results indicated that the physiological quality of stored cotton seed was better in hermetically sealed polythene bag than cloth bag. Among the genotypes, BC-0252 showed the highest germination with higher vigour index and loss of seed weight was the lowest when stored in polythene bag. Therefore, this cotton genotype is supposed to be potential one and can be utilized in future breeding program for cotton improvement targeted to better seed weight and survivability.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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