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Influence of Vacuum Packaging and Storage Conditions on the Seed Quality of Cotton (*Gossypium* spp.)

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ABSTRACT

The studies were carried out to find out theInfluence of packaging and storage conditions on seed quality of cotton. Cotton seeds were stored in different packaging materials viz., cloth, aluminium and vacuum packed bags stored at room temperature (25 ± 2º C) and cold storage (4 ± 1º C) for a period of 18 months. The seed quality parameters on germination per cent, root length, shoot length, total seedling length and seedling vigour index decreased with an advancement of storage period, but electrical conductivity increased with an increase in storage period. Among the containers, the seeds stored in vacuum packed bags maintained the seed quality with least deterioration compared to seeds stored in aluminium and cloth bags. The rate of absorbance of moisture content is more in aluminium and cloth bags because these are not air tight container while vacuum packed bags maintained constant moisture content. It was observed that the samples stored in vacuum packed bags maintained the seed quality with least deterioration in all the quality parameters compared to samples stored in aluminum and cloth bags.

Keywords: *Germination, Root and Shoot Length, Seedling Vigour Index, Electrical Conductivity, Vacuum Packaging and Storage.*

INTRODUCTION

Seed is the foundation of agriculture for enhancing crop production. But the availability of quality seed is the main constraint to crop production in developing country like India. The use of quality seed can contribute significantly to increased grain yield as well as to increased availability of every day's food intake. Seed viability is a major factor in crop establishment and subsequent productivity in many parts of the world. Losses in seed quality occur during field weathering, harvesting and storage. Seeds get damaged if they are exposed to high temperature and high humidity. In agriculture; seed is a vehicle to deliver almost all agro-based technological innovations so that the farmers can exploit the genetic potential of new varieties.

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The availability, access and use of seeds of adaptable varieties are, therefore, the major determinants to attain the efficiency and productivity of other packages like irrigation, fertilizers and pesticides. This is one of the vital keys to increase crop production, enhance food security and alleviate rural poverty in the developing countries. In storage, the viability and vigour of the seeds not only vary from genera to genera and variety to variety, but it is also regulated by many physico-chemical factors like moisture content, atmospheric relative humidity, temperature, initial seed quality, physical and chemical composition of seed, gaseous exchange, storage structure, packaging materials *etc*[11]. To combat these factors effectively, storing seeds in vapour proof containers like polythene bag, aluminium foils, tins or any sealed containers is found to be more useful in maintaining the desired quality of seeds for longer period[12], unlike those stored in moisture pervious containers like cloth bag and gunny bag[30].

Indian cotton industry is considered as the centre of finest textiles industry in the world. The total area under this crop in the world is 101.71 m ha and the productivity is 680 kg per ha[3]. India has a pride of place in the global cotton scenario with the highest cotton growing area of 111.42 lakh ha with a total production of 3339.10 lakh bales of (170 kg) and productivity of 599 kg per ha[3]. In Karnataka, the area under cotton cultivation is 5.47 lakh ha with a production of 10.00 lakh bales and an average productivity of 392 kg lint per ha[3]. In spite of larger area under the crop, the yield of cotton per hectare is considerably low both at state and national levels, due to several factors *viz*., use of low quality seeds, larger cotton area under rainfed situation, pest and disease incidence *etc*. Among these non availability of high quality seeds in adequate quantity seems to be the major factor which contributes for enhanced cotton yield in our country.

In cotton, upon storage, many enzymatic changes, oxidation and respiration occur. If the viability and vigor is not maintained properly during storage period, it will be difficult to sell it as a seed material for the next season. Post harvest storage life of onion largely depends on the genotypes, treatment, packaging material and storage conditions. In storage, viability and vigour of the seeds is regulated by many physico-chemical factors as the seed is hygroscopic in nature, seed quality is affected by variation in moisture content, relative humidity and temperature. To combat these factors, it is better to store the seeds in moisture vapour proof containers like polythene bag, aluminium foil, tin or any sealed container to maintain the quality for longer period. Research concerning these aspects is very meagre. Keeping these aspects in the view and considering their importance in maintaining viability for longer period the present investigation was carried out.

MATERIALS AND METHODS

A storage experiment was carried out for a period of 18 months under laboratory condition at Department of Crop Physiology, University of Agricultural Sciences, Dharwad. Freshly harvested cotton seeds (Sahana) were dried under sun and stored under different storage conditions and containers. The temperature maintained in the cold storage was around (4 °C ± 1°C) and relative humidity was 65 to 75 per cent. For ambient storage, bags were stored in the laboratory at room temperature (25 ± 2 °C). Cotton seeds were packed in 10.0 g vacuum packed bags (The machine used for vacuum packaging of different seeds was OLPACK 501/V manufactured by INTERPRISE–BRUSSELS S.A., BRUXTAINER DIVISION, Belgium) and aluminium bags while 500 g cotton was packed in cloth bags. After packaging of all the seeds in different containers, 50 % bags were stored properly in the iron racks without stacking so that all the bags were uniformly exposed to the particular treatment condition; while 50 % bags were stored under cold storage. The treatment consisting of different containers viz., cloth, aluminium and vacuum packed bags were replicated four times in both cold and ambient storage conditions in completely randomised design. The observation on germination test was conducted as per the ISTA procedure[2] using between paper method, vigour index values were computed using the formula of following[1] and the mean values were expressed in whole number and the electrical conductivity of the seed leachate was measured by a digital conductivity meter and expressed as dS m^{-1}[22] at bimonthly interval upto18 months. After that data collected on various seed quality parameters and mean data of germination per cent, shoot length, root length, total seedling length, vigour index, and electrical conductivity were recorded and Fisher's method of analysis of variance was applied for the analysis and interpretation of the experimental data as suggested by Panse and Sukhatme[21] and level of significance used in 'F' and 't' test was $P = 0.01$.

RESULTS AND DISCUSSION

There was a gradual decline in all the seed quality parameters such as germination per cent, root and shoot length, total seedling length, seedling vigour index and marked increase in electrical conductivity of seed leachates from initial to 18 months of storage.

Effect on germination per cent

Germination per cent of cotton seed was influenced by various packaging material and storage conditions and there was completely significant difference between all the treatments. The data on germination per cent revealed significant differences between treatments from 6 months of storage and up to 18 months of storage (Table 1). At 18 months of storage, vacuum packed bags recorded significantly higher germination per cent over all other containers under both ambient and cold storage. It was further observed that, cold storage recorded significantly higher germination per cent in aluminium and, cloth bags compared to ambient storage. The higher germination per cent indicates good quality of seeds as well as more viability. In the present investigation, the onion seeds stored in cold storage recorded higher germination percent compared to ambient storage throughout out the storage period of 18 months. The seeds preserved in the cold storage maintained higher seed viability vigour and quality because of lower respiration rate and metabolic activity as it is evidenced by higher germination (88.4%) at the end of 18 months of storage period. Also at low temperature degradation rate of stored food is lower as compared to higher temperature that helped to increase the germinability, root and shoot length and vigour of the seeds for longer time in bush bean[18]. Among the containers vacuum packed seeds of onion irrespective of storage conditions were found better over aluminium and cloth bags. In the aluminium bags germination values were higher than cloth while, it was lower than vacuum packed bags. Similar result also reported by Selvaraj and Ramaswamy[29] in cotton and Bhattacharya and Mandi[5] in wheat seeds.

Effect on root, shoot and total seedling length (cm) and seedling vigor index

Seed quality is judged by seedling vigour parameters like root, shoot and total seedling length (Table 2, 3 & 4) and seedling vigour index (Table 5) showed significant differences between the storage containers, storage conditions up to 4 months of storage. At 8 months of storage, significant lower root, shoot and total seedling length, and seedling vigour index values (16.80 and 13.95 cm, 32.63 & 2388), respectively were recorded in cloth bag seeds kept under room temperature. While the significant higher root and shoot length, and seedling vigour values (17.87 and 14.83 cm, 32.70 & 2921) was recorded in vacuum packed seeds stored under cold storage followed by aluminum packed seeds (17.63 and 14.55 cm, 32.18 & 2713), respectively. The vacuum packed seeds of cotton, irrespective of storage conditions were found to better over aluminium and cloth bags. The reason can be attributed to the vacuum that was created while packing. In the cloth bags, the seed quality parameters (germination per cent, root length, shoot length, and vigour index) were very less and variable according to environmental conditions; while in the aluminium bags, germination (seed quality) values were higher than cloth bags and lower than vacuum packed seeds. These are again due to, vacuum packed bags are less permeable to air moisture and humidity. Seeds preserved in cold storage recorded higher root length and shoot length compared to ambient condition which may be due to lower respiration rate and metabolic activity at lower temperature, Similar results were reported by Das *et al*[8]., in Rajmah . Higher seedling length is an indication of maintenance of vigour in the seeds preserved in cold storage. These results are in good agreement with the study of Doijode[11] in chilli and Khalequzzaman *et al*[14]., in frenchbean. Similar findings were also reported by other researcher in sorghum[31] and soybean[10]. The decrease in seed germination with increasing length of storage period has been reported by many other workers like Jayaraj *et al*[13]., in tomato and brinjal, Biradar Patil *et al*[6]., in rice, Selvaraj[29] in delinted cotton seeds (cv. MCU-7).

Effect on moisture content (%)

The moisture content (%) of cotton seeds presented in Table 6 indicated significant differences between the treatments at all the stages of storage upto 18 months except at the initial stages (i.e., 0 months). In general, these was no change in the moisture content of vacuum packed as well as aluminium packed seeds during storage for 18 months however there was a slight decline in the moisture content with progress in the storage time. More fluctuations were seen in the moisture content of cotton seeds stored in cloth bags, irrespective of storage at room temperature or cold storage throughout the storage period. All through the 18 months of storage, the maximum moisture content (12.00 %) was observed in cloth bags at cold storage followed by cloth bags at room temperature (9.91 %). Lower moisture content (8.26 and 8.25 %) was observed in aluminium packed seeds followed by vacuum packed seeds (8.24 and 8.23 %) at cold storage and room temperature, respectively. Cloth bags containers at cold storage recorded higher values of moisture content at all the stages of storage even upto 18 months as compared to containers stored at room temperature. These results are in agreement with the findings of Davidson *et al*[9]., in shelled peanuts, Malekar *et al*[16]., in wheat, Rajendra prasad *et al*[24]., in groundnut kernels, Dadlani and Veena[7], Gurmit singh and Hari Singh[12], Remya[26] in chilli powder, Roshany[27] in whole chilli and Monira *et al*[17]., in soybean storability for longer period.

Effect on electrical conductivity

The electrical conductivity (dSm^{-1}) of cotton seeds differed significantly between the treatments at all the stages of storage period (Table 7). The increase in electrical conductivity was observed exactly from 4 months onwards during storage in cloth bag seeds at room temperature. The increase in electrical conductivity of vacuum packed seeds was much lesser and slower than in aluminium packed seeds at all the stages of storage. At 18 months of storage, seeds stored in vacuum packed bags recorded significantly lower values of electrical conductivity (0.545 and 0.548 d Sm^{-1}) at cold storage and room temperature as compared to aluminium bags (0.635 and 0.665 d Sm^{-1}) while, maximum values of electrical conductivity (0.692 and 0.728 d Sm^{-1}) was recorded in cloth bags, respectively. It is clear from the results that the vacuum packed seeds could maintain lower electrical conductivity as compared to aluminium bags followed by cloth bags during the storage period. The result of the present study corroborates with the study of previous researchers. According to Biradarpatil, N. K. and Kulkarni[6] in sorghum, Lin[15] in mungbean, Raiker *et al*[23]., in rice, Lin[15] in cucumbers, Narayanaswamy *et al*[19]., in groundnut, Nataraj *et al*[20]., in sunflower, Ravi Hunje *et al*[25]., in chilli and Asha[4] in maize seeds. The lower electrical conductivity of seed leachate was mainly governed by lower cell wall permeability which indicates lower respiration rate and metabolic activity and responsible for the maintenance of vigour during storage. The electrical conductivity was significantly lower in seeds stored in vacuum sealed containers followed by aluminum bags and was higher in cloth bags and cloth bags throughout the storage period. Higher electrical conductivity values recorded in seeds stored in aluminum bags and cloth may be due to higher level of seed deterioration on account of age induced membrane damage of various cell and cell organelles or degradation or disruption of cell membranes leading to subsequent loss of membrane integrity[32] in groundnut seeds and Sastry *et al*[28] ., in bitter gourd seeds.

Table 1: Influence of packaging and storage conditions on germination (%) at different time intervals of storage in cotton seeds

Treatments	Storage period (months)									
	0	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**
T_1 – Cloth bag (CS)	90.9 (72.63)	87.4 (69.24)	85.4 (67.54)	83.7 (66.31)	81.8 (64.69)	78.7 (62.51)	75.8 (60.52)	71.1 (57.43)	64.5 (53.40)	57.8 (49.44)
T_2 – Cloth bag (RT)	90.9 (72.63)	86.1 (68.09)	83.9 (66.08)	80.2 (63.61)	77.7 (61.78)	75.4 (60.26)	68.0 (55.53)	65.6 (54.04)	53.8 (47.18)	47.2 (43.39)
T_3 – Aluminium bag (CS)	90.9 (72.63)	89.2 (70.89)	88.6 (70.32)	86.8 (68.79)	84.3 (66.66)	82.4 (64.95)	80.1 (63.50)	76.7 (60.66)	71.8 (57.87)	68.3 (55.53)
T_4 – Aluminium bag (RT)	90.9 (72.63)	88.3 (70.02)	87.3 (69.33)	85.4 (67.62)	82.6 (65.38)	79.7 (63.18)	75.9 (60.59)	70.5 (57.08)	66.5 (54.60)	62.1 (51.98)
T_5 – Vacuum packed (CS)	90.9 (72.63)	90.8 (72.49)	90.4 (72.17)	89.9 (71.47)	89.4 (70.92)	89.3 (70.86)	89.1 (70.67)	88.9 (70.47)	88.8 (70.33)	88.4 (70.04)
T_6 – Vacuum packed (RT)	90.9 (72.63)	90.5 (72.14)	89.8 (71.22)	89.6 (71.38)	89.1 (70.72)	89.0 (70.56)	88.8 (70.44)	88.7 (70.31)	88.5 (70.15)	88.2 (69.90)
S.Em (±)	1.71	1.28	1.64	1.84	0.36	0.28	0.17	0.34	0.72	0.60
C. D. (1%)	NS	NS	NS	4.65	1.08	0.83	0.52	1.01	2.13	1.78

NS = Non significant CS = Cold storage RT = Room temperature Figures in parenthesis are Arcsine values

(Minimum seed certification standards as per Central Seed Certification Board (CSCB), GOI Norms = 75%)

Table 2: Influence of packaging and storage conditions on root length (cm) at different time intervals of storage in cotton seeds

Treatments	**Storage period (months)**									
	0	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**
T_1 – Cloth bag (CS)	18.10	17.63	17.45	17.33	16.83	16.50	16.18	15.98	15.73	15.33
T_2 – Cloth bag (RT)	18.10	17.55	17.26	17.18	16.80	16.41	15.93	15.68	15.08	14.90
T_3 – Aluminium bag (CS)	18.10	17.93	17.84	17.65	17.63	17.70	17.62	17.28	16.68	16.23
T_4 – Aluminium bag (RT)	18.10	17.88	17.78	17.60	17.52	17.65	17.54	17.05	16.50	16.08
T_5 – Vacuum packed (CS)	18.10	18.05	18.00	17.91	17.87	17.85	17.81	17.88	17.78	17.58
T_6 – Vacuum packed (RT)	18.10	18.01	17.98	17.90	17.86	17.83	17.77	17.80	17.70	17.47
S.Em (±)	**0.10**	**0.17**	**0.20**	**0.05**	**0.04**	**0.04**	**0.06**	**0.07**	**0.05**	**0.06**
C. D. (1%)	**NS**	**NS**	**NS**	**0.15**	**0.12**	**0.10**	**0.19**	**0.21**	**0.15**	**0.18**

NS = Non significant CS = Cold storage RT = Room temperature

Table 3: Influence of packaging and storage conditions on shoot length (cm) at different time intervals of storage in cotton seeds

Treatments	Storage period (months)									
	0	2	4	6	8	10	12	14	16	18
T_1 – Cloth bag (CS)	15.05	14.60	14.55	14.48	14.30	13.83	13.53	13.03	12.55	12.00
T_2 – Cloth bag (RT)	15.05	14.53	14.48	14.29	13.95	13.67	13.08	12.85	12.46	11.88
T_3 – Aluminium bag (CS)	15.05	14.78	14.77	14.63	14.55	14.45	14.23	14.18	13.68	13.05
T_4 – Aluminium bag (RT)	15.05	14.73	14.68	14.60	14.50	14.30	14.10	14.00	13.28	12.95
T_5 – Vacuum packed (CS)	15.05	14.98	14.94	14.86	14.83	14.80	14.75	14.71	14.70	14.53
T_6 – Vacuum packed (RT)	15.05	14.93	14.88	14.81	14.78	14.76	14.73	14.69	14.65	14.45
S.Em (±)	**0.10**	**0.16**	**0.18**	**0.09**	**0.12**	**0.07**	**0.08**	**0.12**	**0.7**	**0.6**
C. D. (1%)	**NS**	**NS**	**NS**	**0.26**	**0.36**	**0.21**	**0.24**	**0.35**	**0.20**	**0.18**

NS = Non significant CS = Cold storage RT = Room temperature

Table 4: Influence of packaging and storage conditions on total seedling length (cm) at different time intervals of storage in cotton seeds

Treatments	Storage period (months)									
	0	2	4	6	8	10	12	14	16	18
T_1 – Cloth bag (CS)	33.15	32.23	32.00	31.80	31.10	30.33	29.70	29.01	28.28	27.33
T_2 – Cloth bag (RT)	33.15	32.08	31.68	31.45	30.75	30.07	29.00	28.53	27.53	26.78
T_3 – Aluminium bag (CS)	33.15	32.70	32.61	32.28	32.18	32.15	31.83	31.45	30.35	29.28
T_4 – Aluminium bag (RT)	33.15	32.60	32.45	32.20	32.00	31.95	31.64	31.05	29.78	29.03
T_5 – Vacuum packed (CS)	33.15	33.03	32.93	32.77	32.70	32.65	32.56	32.59	32.48	32.10
T_6 – Vacuum packed (RT)	33.15	32.94	32.85	32.71	32.63	32.59	32.50	32.49	32.35	31.93
S.Em (±)	**0.17**	**0.30**	**0.36**	**0.12**	**0.13**	**0.08**	**0.13**	**0.15**	**0.07**	**0.09**
C. D. (1%)	**NS**	**NS**	**NS**	**0.36**	**0.40**	**0.24**	**0.39**	**0.45**	**0.22**	**0.28**

NS = Non significant CS = Cold storage RT = Room temperature

Table 5. Influence of packaging and storage conditions on seedling vigor index (SVI) at different time intervals of storage in cotton seeds

Treatments	Storage period (months)									
	0	2	4	6	8	10	12	14	16	18
T_1 – Cloth bag (CS)	3014	2816	2734	2666	2542	2387	2252	2061	1823	1578
T_2 – Cloth bag (RT)	3014	2762	2646	2521	2388	2268	1972	1870	1481	1264
T_3 – Aluminium bag (CS)	3014	2917	2889	2800	2713	2640	2550	2391	2178	1991
T_4 – Aluminium bag (RT)	3014	2878	2832	2749	2646	2546	2402	2187	1979	1803
T_5 – Vacuum packed (CS)	3014	3000	2974	2933	2921	2914	2900	2895	2889	2837
T_6 – Vacuum packed (RT)	3014	2982	2944	2930	2908	2899	2886	2881	2863	2817
S.Em (±)	**57.14**	**57.78**	**65.31**	**63.06**	**13.01**	**10.19**	**11.36**	**11.56**	**19.77**	**20.15**
C. D. (1%)	**NS**	**NS**	**NS**	**187.37**	**38.64**	**30.27**	**33.74**	**34.33**	**58.78**	**59.87**

NS = Non significant CS = Cold storage RT = Room temperature

Table 6: Influence of packaging and storage conditions on moisture content (MC, %) at different time intervals of storage in cotton seeds

Treatments	Storage period (months)									
	0	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**
T_1 – Cloth bag (CS)	8.30	12.03	12.08	12.05	12.10	12.09	12.07	12.03	12.01	12.00
T_2 – Cloth bag (RT)	8.30	10.24	10.22	10.09	10.07	10.92	10.88	10.68	9.95	9.91
T_3 – Aluminium bag (CS)	8.30	8.73	8.71	8.63	8.59	8.51	8.50	8.40	8.27	8.26
T_4 – Aluminium bag (RT)	8.30	8.56	8.69	8.59	8.46	8.40	8.31	8.28	8.26	8.25
T_5 – Vacuum packed (CS)	8.30	8.35	8.36	8.37	8.35	8.34	8.32	8.27	8.26	8.24
T_6 – Vacuum packed (RT)	8.30	8.32	8.34	8.31	8.30	8.29	8.28	8.26	8.25	8.23
S.Em (±)	**0.15**	**0.11**	**0.08**	**0.03**	**0.04**	**0.03**	**0.02**	**0.03**	**0.01**	**0.04**
C. D. (1%)	**NS**	**0.33**	**0.23**	**0.08**	**0.12**	**0.08**	**0.06**	**0.09**	**0.03**	**0.11**

NS = Non significant CS = Cold storage RT = Room temperature

Table 7: Influence of packaging and storage conditions on electrical conductivity (EC, dSm^{-1}) at different time intervals of storage in cotton seeds

Treatments	Storage period (months)									
	0	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**
T_1 – Cloth bag (CS)	0.519	0.522	0.529	0.538	0.550	0.568	0.584	0.614	0.649	0.692
T_2 – Cloth bag (RT)	0.518	0.524	0.534	0.553	0.561	0.589	0.616	0.635	0.695	0.728
T_3 – Aluminium bag (CS)	0.518	0.516	0.527	0.530	0.539	0.553	0.572	0.586	0.608	0.635
T_4 – Aluminium bag (RT)	0.518	0.526	0.532	0.538	0.548	0.565	0.584	0.598	0.625	0.665
T_5 – Vacuum packed (CS)	0.518	0.519	0.522	0.524	0.528	0.531	0.534	0.537	0.540	0.545
T_6 – Vacuum packed (RT)	0.518	0.520	0.523	0.526	0.530	0.533	0.536	0.539	0.543	0.548
S.Em (±)	**0.001**	**0.002**	**0.001**	**0.001**	**0.001**	**0.001**	**0.0016**	**0.001**	**0.002**	**0.001**
C. D. (1%)	**NS**	**NS**	**0.002**	**0.003**	**0.002**	**0.003**	**0.0048**	**0.003**	**0.005**	**0.003**

NS = Non significant CS = Cold storage RT = Room temperature

CONCLUSIONS

Seed quality deterioration is an inexorable and an irreversible process. The quality and viability of onion seeds are subjected to variations during storage conditions and it has been found that the life span of seeds depends on moisture content of the seeds, relative humidity, temperature, light and oxygen content under which the seeds are stored. It has been found in the present study that it is possible to extend the shelf life of onion seeds up to 18 months without deterioration in quality parameters *viz.,* germination per cent, root and shoot length, total seedling length, and seedling vigour index, moisture content and electrical conductivity by storing them under vacuum package. Since seed is an important input in agriculture which determines not only the production but also the productivity, it is essential to maintain the quality as well as seed vigor.

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