



Accelerated Ageing Test in Maize: Pattern of Seed Deterioration

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The freshly harvested seeds of maize single cross hybrid TNAU maize hybrid CO 6 were kept under accelerated ageing condition by exposing the seeds to 40°C temperature and 100 per cent relative humidity in order to assess the physical, physiological and biochemical changes taking place during storage. This study revealed that minimum germination of 90 per cent as per the Indian Minimum Seed Certification Standards (IMSCS) was reached on 4th day of accelerated ageing and reached 54 percent on 9th day of accelerated ageing against the initial seed germination of 98 per cent. The moisture content was increased from 10.1 per cent to 15.9 per cent on 9th day of accelerated ageing. The root length, shoot length, dry matter production, vigour index, α-amylase, catalase, peroxidase activity and carbohydrate content were decreased. Whereas electrical conductivity of seed leachate and reducing sugars were increased, while advancing the period of accelerated ageing.

Key words : Maize, Accelerated ageing, Seed storage, Seed deterioration

Maize (*Zea mays*) is the most important cereal crops next to wheat and rice. It is a versatile crop grown over a range of agro climatic zones. The seed is rich in carbohydrate (75 per cent). It is utilized as food, feed, industrial raw material and for biofuel production. In India, it is cultivated in an area of 9.43 million hectares with a production of 24.35 million tonnes and an average productivity is 2.5 t / ha. In Tamil Nadu, the crop is being cultivated in an area of 3.80 lakh hectares with a production of 2.24 million tonnes and an average productivity is 5.9 t / ha. (www.indiastat.com, 2013 - 2014).

To cope with the current and future demand of the increasing population for the food grains, it is emphasized to reduce the loss of seeds during and after harvest. Seeds are stored for varying periods to ensure a proper and balanced public distribution throughout the year. Post harvest losses in India are estimated to be around 10 per cent of which the losses during storage alone are estimated to be 6 per cent (Singh and Satapathy, 2003). The study on physical, physiological and biochemical changes under accelerated ageing conditions will be helpful for better understanding the process of seed deterioration. The relative storability of a particular seed lot could be predicted through accelerated ageing by exposing the seeds to high temperature (40°C) and relative humidity (100 per cent), which will be useful in retention or disposal of a particular variety or seed lot. Accelerated ageing has been developed as a self ageing technique. The accelerated ageing test has been used to estimate seed vigour and deterioration during storage (Delouche and Baskin, 1973). Keeping this in view, the present study was carried out in

the Dept., of Seed Science and Technology, TNAU, Coimbatore.

Material and Methods

Genetically pure and freshly harvested seeds of maize (TNAU Maize Hybrid CO 6) were kept under accelerated ageing condition by exposing the seeds to 40°C temperature and 100 per cent relative humidity. The samples were drawn at daily interval from accelerated ageing condition and analyzed for physical, physiological and biochemical parameters. The following observations viz., seed moisture content, germination per cent, root length, shoot length, dry matter production, vigour index, electrical conductivity, α-amylase, catalase, peroxidase activity, carbohydrate content and reducing sugars were made. The storability period was calculated based on the time taken to reach the germination as per the IMSCS. In order to assess the pattern of deterioration, the accelerated ageing was continued when seed reaches the germination of about 50 per cent.

Results and Discussion

The results indicated that the maize seed had low moisture content initially (10.1 per cent) and it was higher in 9 days (15.9 per cent) of accelerated ageing (Table 1). The possible reason could be due to continuous and slow supply of moisture to the seed which increased the moisture content of the seeds as the seeds are hydrophilic in nature. In the present investigation, deterioration in seed quality was associated with decrease in germination, seedling length, dry matter production and vigour index become evident with advancement of time in storage under accelerated ageing condition (Table 1). Similar

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Table 1. Physical and physiological changes due to accelerated ageing of maize seeds

Accelerated ageing (days)	Moisture content (%)	Germination (%)	Root length (cm)	Shoot length (cm)	Dry matter production (g 10 seedlings ⁻¹)	Vigour Index
0 (control)	10.1	98 (81.87)	27.8	15.4	1.450	4234
1	10.4	97 (80.02)	26.9	15.2	1.398	4084
2	10.7	95 (77.08)	25.4	14.5	1.245	3790
3	10.9	93 (74.66)	24.3	13.2	1.174	3487
4	11.3	90 (71.56)	23.9	12.4	1.114	3267
5	11.8	85 (67.21)	21.4	11.8	0.949	2822
6	12.5	79 (62.72)	20.8	11.4	0.849	2544
7	13.6	70 (56.79)	18.8	10.8	0.795	2072
8	14.7	57 (49.02)	16.9	10.3	0.697	1550
9	15.9	54 (47.29)	15.2	9.2	0.657	1318
Mean	12.2	82 (64.89)	22.1	12.4	1.033	2917
SEd	0.17	1.48	0.32	0.19	0.019	43.15
CD (P=0.05)	0.36	3.03	0.67	0.39	0.039	88.12

(Figures in parenthesis indicate arcsine values)

reduction in physiological parameters during ageing was also reported by Kapoor *et al.*, (2011) in rice, Vijay *et al.*, (2010) in soybean and Godakahriz *et al.*, (2012) in safflower. The germination of control seeds was 98 per cent and showed declining trend with period of

accelerated ageing. The germination reached IMSCS of 90 per cent on 4th day of accelerated ageing and it was reduced further to 54 per cent on 9th day of accelerated ageing.

Table 2. Biochemical changes due to accelerated ageing of maize seeds

Accelerated ageing (days)	Electrical conductivity ($\mu\text{S cm}^{-1}$)	α -amylase (mg maltose min^{-1})	Catalase (m mol H_2O_2 reduced min^{-1} g^{-1} seed)	Peroxidase (m mol tetraguaiacol formed min^{-1} g^{-1} seed)	Carbohydrate (%)	Reducing sugar (mg g^{-1})
0 (control)	24.7	25.45	0.494	0.246	71	0.12
1	26.8	24.32	0.484	0.221	70	0.12
2	31.7	22.39	0.474	0.207	67	0.13
3	34.6	21.35	0.365	0.195	65	0.15
4	39.4	20.09	0.355	0.173	62	0.16
5	43.9	18.10	0.351	0.157	58	0.19
6	47.1	16.91	0.243	0.142	55	0.23
7	50.9	15.65	0.239	0.135	53	0.27
8	68.8	10.14	0.118	0.127	49	0.39
9	73.0	9.78	0.116	0.120	46	0.44
Mean	44.1	18.42	0.324	0.172	60	0.22
SEd	0.48	0.19	0.001	0.002	0.82	0.008
CD (P=0.05)	0.98	0.39	0.003	0.005	1.68	0.018

The decline in germinability during storage could be attributed to the irreversible ageing characteristics of all living biological organism causing deteriorative changes in the physical, physiological and biochemical characters of seeds (Abdul-Baki and Anderson, 1973) and Ghassemi *et al.* (2010) also reported that decrease in germination per cent and other indices can be related to physiological and biochemical changes during seed ageing. The accelerated ageing resulted significant reduction of root and shoot length in maize. The longest root of 27.8 cm and shoot of 15.4 cm was recorded by control

seeds of maize. The root and shoot length were decreased when subjected to accelerated ageing and found to be 15.2 cm and 9.2 cm, respectively on 9th day of accelerated ageing.

In the present investigation, dry matter production and vigour index exhibited the similar trend of result as revealed in the germination and seedling length (Table 1). The maize seeds recorded dry matter production of 1.114 g 10 seedlings⁻¹ and vigour index of 3267 on 4th day of accelerated ageing. Thereafter, the dry matter production and vigour index were still reduced and recorded 0.657 g 10 seedlings⁻¹ and

1318, respectively on 9th day of accelerated ageing. The control seeds recorded higher dry matter production of 1.450 g 10 seedlings⁻¹ and vigour index of 4234. The vigour index was decreased as the quality of seed became poor in course of time during ageing in maize (Basu *et al.*, 2004).

and recorded as 0.116 m mol H₂O₂ reduced min⁻¹ g⁻¹ seed at the end of 9th day of accelerated ageing where control seeds recorded more catalase activity of 0.494 m mol H₂O₂ reduced min⁻¹ g⁻¹ seed. (Fig. 1).

The peroxidase activity followed the similar trend of results as that of catalase activity under

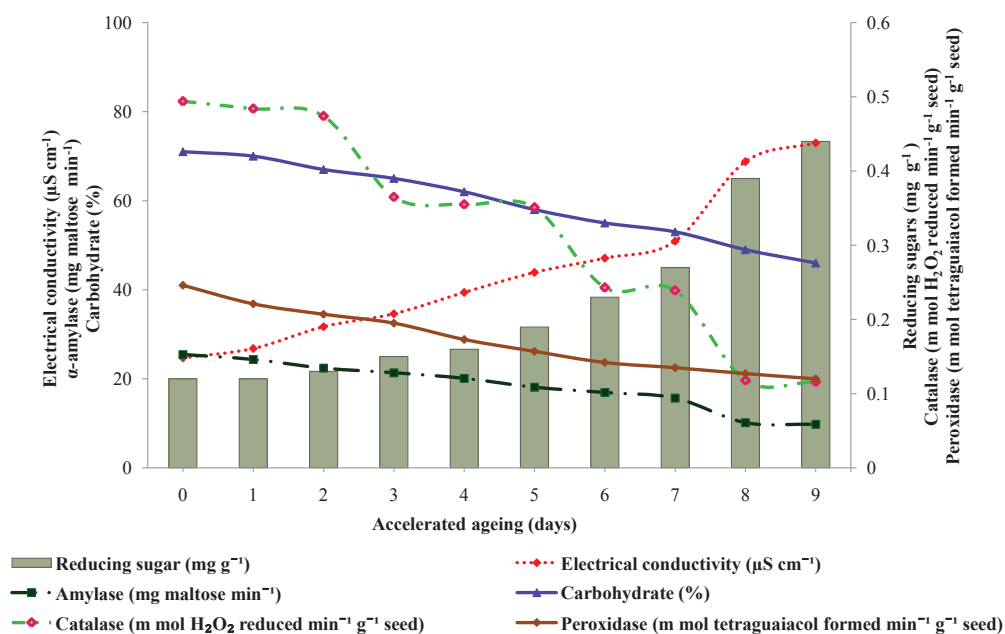


Fig. 1. Biochemical changes due to accelerated ageing of maize seeds

Electrical conductivity of seed leachate is a good index of seed deterioration. Intensity of membrane damage during storage was measured by electrical conductivity of the seed leachate (Matthews and Bradnock, 1968). In the present research, the electrical conductivity of seed leachate increased with increase in period of accelerated ageing (Table 2). In maize, the electrical conductivity was less in control seeds (24.7 $\mu\text{S cm}^{-1}$). In accelerated ageing, it showed an increasing trend and reached 39.4 $\mu\text{S cm}^{-1}$ on 4th day of accelerated ageing where the germination reached IMSCS of 90 per cent. Thereafter, the electrical conductivity was drastically increased and measured as 73.0 $\mu\text{S cm}^{-1}$ on 9th day of accelerated ageing (Fig. 1). Gupta *et al.* (2005) reported that electrical conductivity increased after the seeds were subjected to accelerated ageing because of membrane deterioration and metabolic changes in the seed. Loss of seed vigour and viability is associated with deterioration of membrane properties (Priestley, 1986).

The α -amylase activity was decreased with increasing period of storage under accelerated ageing. The α -amylase activity was decreased from 25.45 mg maltose min⁻¹ at initial to 9.78 mg maltose min⁻¹ after 9 days of accelerated ageing (Table 2). The catalase activity in maize seed was reduced to 0.355 m mol H₂O₂ reduced min⁻¹ g⁻¹ seed on 4th day of accelerated ageing and it was reduced further

accelerated ageing (Fig. 1). The peroxidase activity in control seeds of maize was measured as 0.246 m mol tetraguaiacol formed min⁻¹ g⁻¹ seed. After undergoing accelerated ageing, seeds lost the activity upto 0.173 m mol tetraguaiacol formed min⁻¹ g⁻¹ seed and 0.120 m mol tetraguaiacol formed min⁻¹ g⁻¹ seed on 4th and 9th day of accelerated ageing, respectively (Table 2). Gidrol *et al.*, (1989) reported that the decreased activity of catalase and peroxidase was due to accumulation of H₂O₂ and this accumulation of hydrogen peroxide itself was detrimental to seeds. Similar result was reported by Bhanuprakash *et al.*, (2010) in bell pepper, Demirkaya *et al.*, (2010) in onion seeds. The loss of activity of enzymes in accelerated ageing might be due to the rapid oxidative stress caused by high temperature and relative humidity.

In the present study, though the carbohydrate decreased with increase in storage period, the reducing sugars increased with increase in period of storage (Table 2). In maize, 4 days accelerated aged seeds recorded 62 per cent of carbohydrate whereas control seeds recorded 71 per cent of carbohydrate content. Reducing sugars was increased to 0.16 mg g⁻¹ on 4th day of accelerated ageing from 0.12 mg g⁻¹ in control seeds and reached 0.44 mg g⁻¹ on 9th day of accelerated ageing (Fig. 2). Bailly (2004) reported that reduction of carbohydrate and α -amylase activity cause loss of viability in aged seeds. Bedi *et al.*, (2006) also reported a significant increase in the

level of reducing sugars while decrease of protein content in Brassica seeds during storage. Decrease in carbohydrate content may be due to the hydrolytic breakdown of carbohydrate into simple sugars or due to exudation by loss of cell membrane integrity (Short and Lacy, 1976).

From this study it could be concluded that while subjecting the seeds of maize single cross hybrid TNAU Maize Hybrid CO 6 to accelerated ageing, it attained minimum germination as per the IMSCS of 90 per cent on 4th day of accelerated ageing. The root length, shoot length, dry matter production, vigour index, α -amylase, catalase, peroxidase activity and carbohydrate content were decreased. Whereas moisture content, electrical conductivity of seed leachate and reducing sugars were increased while advancing the period of accelerated ageing.

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