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Research Article

Assessment of longevity of single cross maize hybrids and parental lines

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Abstract
Maize is the Queen of Cereals and has proven its utility as food, feed, fodder, fuel and raw materials for many industries. In order to meet the ever increasing demand of maize, the hybrid seed production plays an important role. The hybrid performance is based on its parental inbred potential and longevity. Accelerated ageing test is an efficient method to measure the seed vigour and to predict seed longevity. Single cross maize hybrids *viz.*, CoH(M) 6, CoH(M) 8 and their parental lines *viz.*, UMI 1200 (female parent of CoH(M) 6), UMI 1201 (female parent of CoH(M) 8) and UMI 1230 (common male parent of CoH(M) 6 and CoH(M) 8) were subjected to accelerated ageing test at 40 ± 1 C and 100 per cent relative humidity for a period of 10 days. The results of the study revealed that the hybrid seeds of CoH(M) 6 maintained their viability for a longer period up to four days when compared to CoH(M) 8 which maintaining its viability up to third day of accelerated ageing as per Indian Minimum Seed Certification Standard (90 per cent germination). All the inbreds lost their viability after the first day of accelerated ageing and the rate of deterioration was higher in UMI 1230. The other parameters like seedling length (cm), dry matter production (g/10 seedlings) and vigour index decreased upon ageing and electrical conductivity (dsm^{-1}) increased with increase in accelerated ageing periods.

Keywords
Maize hybrids, parental lines, longevity. accelerated ageing test

Introduction

Maize (*Zea mays L.*) is a versatile crop grown over a wide range of agro climatic zones. Next to rice and wheat, maize is an important cereal crop in the world with regard to total cultivated area and production. In India, it is cultivated in an area of 7.4 million hectares with a production of 27.14 million tonnes with an average productivity of 3.6 tonnes per hectare (Directorate of statistics, 2017).In Tamil Nadu, it is cultivated over an area of 3.21 lakh hectares with a production of 26.47 lakh tonnes with an average productivity of 8224 Kg per hectare. CoH (M) 6 is a single cross maize hybrid released during 2012 from Tamil Nadu Agricultural University, Coimbatore. Because of its superiority in performance, it was released for National level cultivation as CMH 08-282. It has high beta carotene (40µg/gm), semi dent orange colour kernel with yield potential of 8.6 t/ha in irrigated and 5 t/ha under rain fed conditions. The demand of maize is ever increasing due to its adaptability and resistance towards pest and diseases. The Gujarat State Seed Corporation, Bihar State Seed Corporation and Karnataka State Seed Corporation are involved in large scale seed production of hybrid maize to meet their demand. In Tamil Nadu also five state seed farms are involved in the production of hybrid seeds of maize.

Similarly, CoH(M) 8 single cross hybrid maize was also released at National level suitable for cultivation in Karnataka, Andhra Pradesh, Tamil Nadu, Gujarat, Bihar, Madhya Pradesh states. Karnataka State Seed Corporation made an agreement with Tamil Nadu Agricultural University for production of hybrids for popularization in Karnataka state. Hybrid maize cultivation is dominating in Tamil Nadu for more than 85 per cent of area. Seed deterioration, a natural process is expressed as the loss of vigour and viability of seeds during ageing or adverse environmental conditions. It is an irreversible degenerative process that occurs during storage in which seed vigour would deteriorate 500 times more rapidly at 40 C and 18 per cent moisture content comparatively at 20 C and 8 per cent moisture content. Accelerated ageing has been developed as an artificial ageing technique used to estimate the deterioration pattern of seed vigour during storage. Hence an investigation was carried to assess the potential relative storability of maize hybrids and their inbreds under accelerated ageing condition which would be useful for designing the hybrid seed production and marketing strategy for maize seeds. Further, the studies on physiological and biochemical changes would be helpful for better understanding of the pattern of seed deterioration of maize seed.

Materials and Methods

The experiment was carried out during 2018-2019 at the Department of Seed Science and Technology, Agricultural College and Research Institute, Tamil

Nadu Agricultural University, Madurai. The freshly harvested seeds of maize hybrids and their parental lines viz., (CoH(M) 6, CoH(M) 8, UMI 1200 (female), UMI 1201(female), UMI 1230 (male)) constituted the materials for the study. The seeds of above five lots were exposed to a temperature of 40 ± 1°C and 100 per cent RH for accelerated ageing as per the procedure adopted by Delouche and Baskin (1973) over a period of 10 days. The seeds which are not exposed to accelerated ageing are referred to as 0 (zero) day. The seed samples were drawn at daily interval and evaluated for physiological and biochemical characteristics along with the control seeds.

The germination test was conducted in four replications of 100 seeds from each sample in roll towel method with four replication as described by ISTA (2010). At the end of 7^{th} day the final count was taken. The germination was expressed in per cent. Ten normal seedlings were selected at random from each replication and the length of root and shoot was measured and the mean was expressed in centimetre (cm). After measuring the root and shoot length, the ten normal seedlings in each replication was shade dried for 24 hrs and kept in hot air oven maintained at 85 ± 1 C for 1 hour and then, they were cooled for 30 min. The mean weight was expressed as dry matter production per 10 seedlings in gram (Gupta, 1993).The vigour index was calculated as per the formula given by Abdul Baki and Anderson (1973). The biochemical characteristics like Electrical Conductivity (Presely,1958), Dehydrogenase activity (Kittock and Law,1968), α-amylase activity (Paul *et al*., 1970), Peroxidase activity (Malik and Singh, 1980), Catalase activity (Luck, 1974) were also estimated.

The data were subjected to statistical analysis by following the standard ANOVA method for Complete Randomized Design (Panse and Sukhatme, 1985). Wherever necessary, the per cent values were transformed to angular (Arc-sine) values before analysis. The critical differences (CD) were calculated at 5 per cent probability level.

Results and Discussion

Accelerated ageing test is a widely used tool to estimate the seed deterioration. Seed technologists generally use this technique to predict the storability of seeds as it stimulates conditions conducive for seed deterioration. The process of deterioration by accelerated ageing condition is the same as that of natural ageing but only the rate of deterioration is enormous. In the present study, seed lots of maize hybrids and their inbreds were artificially aged at 100 per cent RH and 40 ± 1 C temperature over a period of 10 days. In present study, the data revealed that the fresh seeds of UMI 1200, UMI 1201, UMI 1230, CoH(M) 6 and CoH(M) 8 recorded the 92,94,96,98 and 96 per cent of germination, respectively. Upon ageing, the seeds of all the parental inbreds *viz.*, UMI 1200, UMI 1201, UMI 1230 deteriorated at a faster rate and reached Indian Minimum Seed Certification Standard of 90 per cent germination at first day of accelerated ageing thereafter the germination started to decrease below 90 per cent. The rate of deterioration was more pronounced in inbred UMI 1230. The seeds of CoH(M) 6 reached 90 per cent germination on fourth day of accelerated ageing whereas CoH(M) 8 reached 91 per cent germination on third day of accelerated ageing (Table 2). Decrease in germination percentage is related to reduction in root length, shoot length, dry matter production and vigour index (Fig 1) with increase in accelerated ageing periods (Table 2,3 and 4) . Similar results were reported in peanut (Sung & Jeng, 1994), chickpea (Kapoor *et al*., 2010) and rice (Kapoor *et al*., 2011). This reduction might be due to the lowering of the biochemical activities in seeds. The reduction in germination might be due to degradation of mitochondrial membrane leading to reduction in energy supply necessary for germination (Gidrol *et al*., 1998) .The decline in shoot length, root length and seedling vigour index might be attributed to DNA degradation with ageing which leads to impaired transcription causing incomplete or faulty enzyme synthesis essential for earlier stages of germination (plate 1).

In the present study, the electrical conductivity of fresh (unaged) seeds recorded 0.19, 0.17, 0.20, 0.07, 0.15 dSm^{-1}, respectively by UMI 1200, UMI 1201, UMI 1230, CoH(M)6 and CoH(M)8. Electrical Conductivity increases with an increase in ageing period and reached the mean value of 0.487, 0.434,0.490,0.378,0.388 dsm^{-1} for UMI 1200, UMI 1201, UMI 1230, CoH(M)6 and CoH(M)8, respectively (Table 5). 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. Likewise, the activities of dehydrogenase, α-amylase, peroxidase, and catalase were higher in control seeds whereas after 10days of accelerated ageing, the enzyme activity gets decreased (Table 6 and 7). Chauhan *et al*., (2011) noticed declined dehydrogenase enzyme activity due to enzymes undergoing compositional changes by losing or gaining certain functional groups, by oxidation of sulf-hydral groups or by conversion of amino acids within the protein structure. The enzymes may undergo configurational changes such as partial folding or unfolding of ultrastructure and condensation to form polymers and degradation to sub units i.e., absorbance of dehydrogenase enzyme was decreased as the period of storage increased in sunflower. Verma *et al*., (2003) observed that the dehydrogenase activity was reduced as the ageing progressed and was found lowest after four year of storage in Brassica spp. Mustafa *et al*., (2010) found that a high level of correlation was found between the loss of seed viability and the decreased that occurred in dehydrogenase activity in onion.

Similar results of decrease in amylase activity was also reported by Norastehnia *et al.* (2007) who also noticed that as deterioration advances, there is accumulation of aldehyde compounds especially methyl jasmonte (MeJA) which is a potential inhibitor of amylase . The ageing period had significant effect on peroxidase activity. The decline in scavenging enzymes particularly peroxidase could be due to lipid peroxidation and sugar hydrolysis (formation of reducing sugars) was coupled to the Maillard reactions during seed ageing. Cakmak *et al*. (2010) also studied the decrease in germination ability of aged legume seed and found that it was correlated with decrease in activity of enzymatic antioxidant studies. Ageing coincides with protein denaturation and degradation, inactivation of enzymes, breakdown of phospholipids and depository lipids, lipid peroxidation and alteration of membrane permeability. CAT activity in onion seeds were observed to decrease upon ageing. These results support the hypothesis that a decrease in antioxidant enzymes is linked to an increased lipid peroxidation and accelerated ageing. Subsequently, Bailly *et al*. (2000 and 2002) proposed a positive relationship between antioxidant enzyme capacity and the vigour of the seed. It could be concluded that hybrids are better storer when compared to inbreds. Among the inbreds the rate of deterioration was very fast in UMI 1230.

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Table 1. Analysis of variance (ANOVA) for accelerated ageing of maize inbreds and hybrids

Characteristics	Hybrids and inbreds	Source of variance	Df	Sum of square	Mean sum of square	F test
Germination %	UMI 1200	Treatment	10	18778.909	1877.890	
		Error	22	57.100	2.595	723.520**
	UMI 1201	Treatment	10	18283.636	1828.363	
		Error	22	32.608	1.482	1233.551**
	UMI 1230	Treatment	10	12163.636	1216.363	
		Error	22	96.720	4.396	276.672**
	CoH(M)6	Treatment	10	14386.909	1438.690	
		Error	22	37.082	1.685	853.542**
	CoH(M)8	Treatment	10	16969.636	1696.963	
		Error	22	110.359	5.016	338.286**
Shoot length (cm)	UMI 1200	Treatment	10	172.560	17.256	68.907**
		Error	22	5.509	0.250	
	UMI 1201	Treatment	10	370.081	37.008	142.323**
		Error	22	5.720	0.260	
	UMI 1230	Treatment	10	240.723	24.072	167.434**
		Error	22	3.162	0.143	
	CoH(M)6	Treatment	10	242.428	24.242	104.418**
		Error	22	5.107	0.232	
	CoH(M)8	Treatment	10	109.711	10.971	36.262**
		Error	22	6.656	0.302	
Root length (cm)	UMI 1200	Treatment	10	239.841	23.984	94.830**
		Error	22	5.564	0.252	
	UMI 1201	Treatment	10	433.454	43.345	163.728**
		Error	22	5.824	0.264	
	UMI 1230	Treatment	10	358.857	35.885	136.378**
		Error	22	358.857	35.885	
	CoH(M)6	Treatment	10	695.963	69.596	163.519**
		Error	22	9.363	0.425	
	CoH(M)8	Treatment	10	225.084	22.508	58.635**
		Error	22	8.445	0.383	
Vigour index I	UMI 1200	Treatment	10	36875422.746	3687542.274	1524.533**
		Error	22	53213.618	2418.800	
	UMI 1201	Treatment	10	43848055.636	4384805.563	1932.713**
		Error	22	49912.058	2268.729	
	UMI 1230	Treatment	10	34037010.314	3403701.031	315.578**
		Error	22	237282.886	10785.585	
	CoH(M)6	Treatment	10	57405063.188	5740506.318	937.458**
		Error	22	134716.581	6123.480	
	CoH(M)8	Treatment	10	52092703.304	5209270.330	582.204**
		Error	22	196844.827	8947.492138	
Vigour index II	UMI 1200	Treatment	10	129510.020	12951.002	1212.988**
		Error	22	234.892	10.676	
	UMI 1201	Treatment	10	151264.909	15126.490	1187.064**
		Error	22	280.340	12.742	
	UMI 1230	Treatment	10	101263.636	10126.363	593.756**
		Error	22	375.204	17.054	
	CoH(M)6	Treatment	10	205082.727	20508.272	876.477**
		Error	22	514.767	23.398	
	CoH(M)8	Treatment	10	108367.638	10836.763	754.367**
		Error	22	316.037	14.365	
Dry Matter Production (g/10 seedling)	UMI 1200	Treatment	10	5.481	0.548	187.523**
		Error	22	0.064	0.002	
	UMI 1201	Treatment	10	5.964	0.596	439.823**
		Error	22	0.029	0.001	
	UMI 1230	Treatment	10	4.812	0.481	263.692**
		Error	22	0.040	0.001	
	CoH(M)6	Treatment	10	9.308	0.930	194.037**
		Error	22	0.105	0.004	
	CoH(M)8	Treatment	10	7.621	0.762	252.179**
		Error	22	0.066	0.003	

** indicates significance of value at P=0.01 Df-Degree of Freedom

Table 1. Contd…

Characteristics	Hybrids and inbreds	Source of variance	Df	Sum of square	Mean sum of square	F test
Electrical Conductivity (dSm^{-1})	UMI 1200	Treatment	10	1.763	0.176	946.125**
		Error	22	0.004	0.001	
	UMI 1201	Treatment	10	1.618	0.161	815.278**
		Error	22	0.004	0.001	
	UMI 1230	Treatment	10	1.909	0.190	2815.525**
		Error	22	0.001	0.006	
	CoH(M)6	Treatment	10	1.589	0.158	1196.264**
		Error	22	0.002	0.001	
	CoH(M)8	Treatment	10	0.977	0.097	800.316**
		Error	22	0.002	0.001	
Alpha Amylase (mg maltose min^{-1})	UMI 1200	Treatment	10	237.397	23.739	406.854**
		Error	22	1.283	0.058	
	UMI 1201	Treatment	10	260.561	26.056	2184.951**
		Error	22	0.262	0.011	
	UMI 1230	Treatment	10	185.812	18.581	726.761**
		Error	22	0.562	0.025	
	CoH(M)6	Treatment	10	239.797	23.979	920.924**
		Error	22	0.572	0.026	
	CoH(M)8	Treatment	10	260.261	26.026	497.829**
		Error	22	1.150	0.025	
Dehydrogenase (OD value)	UMI 1200	Treatment	10	0.439	0.043	536.094**
		Error	22	0.001	0.008	
	UMI 1201	Treatment	10	0.312	0.031	846.303**
		Error	22	0.008	0.003	
	UMI 1230	Treatment	10	0.183	0.018	855.570**
		Error	22	0.004	0.002	
	CoH(M)6	Treatment	10	0.099	0.009	645.745**
		Error	22	0.003	0.001	
	CoH(M)8	Treatment	10	0.193	0.019	512.875**
		Error	22	0.008	0.003	
Peroxidase (maltose min^{-1})	UMI 1200	Treatment	10	3.778	0.377	851.158**
		Error	22	0.009	0.004	
	UMI 1201	Treatment	10	3.240	0.324	1442.994**
		Error	22	0.004	0.002	
	UMI 1230	Treatment	10	4.318	0.431	635.561**
		Error	22	0.014	0.006	
	CoH(M)6	Treatment	10	8.068	0.806	482.994**
		Error	22	0.036	0.001	
	CoH(M)8	Treatment	10	4.729	0.472	1458.618**
		Error	22	0.007	0.003	
Catalase ($\mu g\ g^{-1}$)	UMI 1200	Treatment	10	13.639	1.363	160.749**
		Error	22	0.186	0.008	
	UMI 1201	Treatment	10	14.758	1.475	175.969**
		Error	22	0.184	0.008	
	UMI 1230	Treatment	10	12.964	1.296	252.400**
		Error	22	0.113	0.005	
	CoH(M)6	Treatment	10	15.730	1.573	151.092**
		Error	22	0.229	0.010	
	CoH(M)8	Treatment	10	21.360	2.136	230.119**
		Error	22	0.204	0.009	

** indicates significance of value at P=0.01 Df- Degree of Freedom

Table 2. Effect of accelerated ageing on germination per cent of maize inbreds and hybrids

Ageing period (Days)	GERMINATION (%)				
	UMI 1200 (Female)	**UMI 1201 (Female)**	**UMI 1230 (male)**	**CoH(M)6**	**CoH(M)8**
0	92(73.57)	94(75.82)	96(78.46)	98(81.87)	96(78.46)
1	90(71.56)	90(71.56)	92(73.57)	96(78.46)	94(75.82)
2	88(69.73)	88(69.73)	85(67.21)	94(75.82)	92(73.57)
3	86(68.02)	82(64.89)	80(63.43)	92(73.57)	91(72.54)
4	84(66.42)	80(63.43)	75(60.00)	90(71.56)	80(63.43)
5	82(64.89)	76(60.66)	68(55.55)	84(66.42)	78(65.02)
6	74(54.23)	66(54.33)	62(51.94)	78(65.02)	74(59.34)
7	64(53.13)	58(49.60)	57(49.02)	62(51.94)	64(53.13)
8	54(47.29)	40(39.23)	50(45.00)	58(49.60)	52(41.55)
9	42(40.39)	34(35.66)	32(34.45)	48(42.66)	38(35.66)
10	20(25.26)	22(29.33)	13(21.13)	34(34.45)	26(30.65)
Mean	**69.818**	**66.363**	**64.540**	**75.818**	**71.363**
SEd	1.315	0.994	1.712	1.060	1.828
CD (0.05)	2.728	2.061	3.550	1.828	3.792

Figures in parenthesis are arcsine-transformed values.

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Table 3. Effect of accelerated ageing on shoot length (cm) and root length (cm) maize inbreds and hybrids

Ageing period (Days)	Shoot length (cm)					Root length (cm)				
	UMI 1200 (Female)	UMI 1201 (Female)	UMI 1230 (male)	CoH(M) 6	CoH(M) 8	UMI 1200 (Female)	UMI 1201 (Female)	UMI 1230 (male)	CoH(M) 6	CoH(M)8
0	18.16	21.21	20.20	23.64	21.43	23.41	26.62	24.61	29.69	25.59
1	18.05	20.71	18.50	21.76	20.62	22.34	24.51	23.12	27.55	23.48
2	17.65	19.50	17.12	20.28	19.19	21.38	23.20	22.81	26.11	22.41
3	17.30	19.21	16.16	19.72	19.12	20.76	22.15	20.25	23.90	21.19
4	16.87	18.30	15.72	19.15	18.57	20.07	20.81	19.65	22.51	20.84
5	14.85	14.90	14.54	18.25	18.35	19.16	19.05	18.95	19.36	19.76
6	14.57	14.51	13.85	17.45	17.94	18.29	18.37	17.54	18.51	19.23
7	14.03	13.64	12.89	16.63	17.71	17.68	17.52	16.37	17.89	18.84
8	14.46	13.15	12.35	16.19	16.23	17.18	16.84	15.72	17.45	18.23
9	13.17	12.41	11.91	15.42	15.85	16.05	15.47	15.20	16.38	17.36
10	10.57	11.85	11.53	14.11	10.27	13.97	15.04	14.48	15.91	12.44
Mean	**15.425**	**16.308**	**14.979**	**18.418**	**18.207**	**19.117**	**19.961**	**18.972**	**21.387**	**20.306**
SEd	0.408	0.416	0.309	0.393	0.449	0.418	0.420	0.410	0.532	0.505
CD (0.05)	0.847	0.863	0.642	0.815	0.931	0.851	0.871	0.868	1.104	1.049

Table 4. Effect of accelerated ageing on vigour index I and vigour index II of maize inbreds and hybrids

Ageing period (Days)	Vigour index I					Vigour index II				
	UMI 1200 (Female)	UMI 1201 (Female)	UMI 1230 (male)	CoH(M) 6	CoH(M) 8	UMI 1200 (Female)	UMI 1201 (Female)	UMI 1230 (male)	CoH(M) 6	CoH(M)8
0	3824	4212	4513	5226	4591	207	262	201	281	248
1	3635	3745	4058	4733	4250	188	197	185	266	182
2	3434	3512	3561	4360	3930	180	172	148	243	170
3	3273	2985	3149	4013	3763	155	158	144	232	148
4	3102	2829	2866	3749	3128	148	134	129	206	137
5	2788	2545	2536	3159	2648	125	121	122	179	124
6	2431	2071	2199	2804	2433	86	106	103	158	116
7	2029	1697	1942	2140	1994	72	87	85	113	89
8	1708	1122	1597	1951	1559	47	57	67	97	73
9	1227	921	993	1526	1059	35	41	46	68	61
10	394	578	321	1020	699	22	27	9	39	42
Mean	**2622**	**2683**	**2521**	**3152**	**2732**	**115**	**123**	**112**	**171**	**126**
SEd	40.156	38.890	84.796	63.893	77.233	2.667	2.914	3.371	3.949	3.094
CD (0.05)	83.279	80.654	75.857	84.506	82.173	5.533	6.044	6.993	8.190	6.418

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Table 5. Effect of accelerated ageing on dry matter production and electrical conductivity of maize inbreds and hybrids

Ageing period (Days)	Dry matter production					Electrical conductivity (dSm^{-1})				
	UMI 1200 (Female)	UMI 1201 (Female)	UMI 1230 (male)	CoH(M) 6	CoH(M)8	UMI 1200 (Female)	UMI 1201 (Female)	UMI 1230 (male)	CoH(M) 6	CoH(M)8
0	2.590	2.210	2.185	2.870	2.735	0.19	0.17	0.20	0.07	0.15
1	1.941	2.091	2.056	2.780	2.105	0.25	0.19	0.21	0.16	0.18
2	1.850	2.055	1.685	2.595	1.875	0.31	0.20	0.23	0.19	0.22
3	1.655	1.901	1.675	2.532	1.740	0.35	0.22	0.32	0.20	0.28
4	1.525	1.860	1.545	2.295	1.680	0.40	0.31	0.38	0.23	0.31
5	1.415	1.655	1.495	2.140	1.560	0.45	0.44	0.41	0.36	0.33
6	1.350	1.310	1.402	2.035	1.435	0.52	0.49	0.57	0.40	0.39
7	1.285	1.245	1.340	1.835	1.360	0.61	0.58	0.61	0.52	0.41
8	1.230	1.189	1.251	1.685	1.115	0.69	0.65	0.74	0.61	0.48
9	1.190	1.054	1.112	1.432	1.085	0.75	0.72	0.83	0.67	0.52
10	1.185	1.026	0.785	1.157	1.043	0.93	0.81	0.89	0.75	0.61
Mean	**1.565**	**1.599**	**1.502**	**2.123**	**1.612**	**0.487**	**0.434**	**0.490**	**0.378**	**0.388**
SEd	0.044	0.030	0.034	0.056	0.045	0.011	0.011	0.013	0.009	0.009
CD (0.05)	0.091	0.062	0.072	0.117	0.093	0.023	0.023	0.019	0.019	0.018

Table 6. Effect of accelerated ageing on α-amylase(mg maltose min^{-1}) and dehydrogenase of maize inbreds and hybrids

Ageing period (Days)	Alpha amylase (mg maltose min^{-1})					Dehydrogenase (OD Value)				
	UMI 1200 (Female)	UMI 1201 (Female)	UMI 1230 (male)	CoH(M)6	CoH(M)8	UMI 1200 (Female)	UMI 1201 (Female)	UMI 1230 (male)	CoH(M)6	CoH(M)8
0	9.975	9.123	9.917	9.908	9.219	0.420	0.310	0.351	0.253	0.340
1	9.897	9.820	9.857	8.754	9.840	0.414	0.289	0.328	0.241	0.319
2	8.888	8.791	8.816	8.123	8.819	0.404	0.230	0.315	0.234	0.304
3	7.756	7.720	7.806	6.457	7.650	0.358	0.189	0.285	0.222	0.265
4	7.645	7.001	7.789	6.211	7.553	0.315	0.150	0.234	0.219	0.245
5	5.432	6.311	6.765	5.315	6.485	0.254	0.120	0.139	0.196	0.225
6	5.389	6.564	5.728	5.001	5.342	0.239	0.115	0.125	0.174	0.241
7	4.35	4.510	5.695	4.679	4.381	0.195	0.109	0.117	0.169	0.189
8	3.192	2.489	4.146	3.318	3.301	0.148	0.105	0.107	0.140	0.150
9	3.009	2.450	3.628	2.233	2.111	0.110	0.101	0.105	0.108	0.112
10	2.251	1.184	2.589	0.478	1.218	0.102	0.098	0.103	0.075	0.105
Mean	**6.162**	**5.996**	**6.612**	**5.497**	**5.992**	**0.269**	**0.165**	**0.200**	**0.184**	**0.226**
SEd	0.197	0.089	0.130	0.131	0.186	0.007	0.003	0.005	0.003	0.005
CD (0.05)	0.409	0.184	0.270	0.273	0.387	0.015	0.007	0.010	0.006	0.010

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Table 7. Effect of accelerated ageing on peroxidase and catalase of maize inbreds and hybrids

Ageing period (Days)	Peroxidase (maltose min^{-1})					Catalase (µg g^{-1})				
	UMI 1200 (Female)	**UMI 1201 (Female)**	**UMI 1230 (male)**	**CoH(M) 6**	**CoH(M)8**	**UMI 1200 (Female)**	**UMI 1201 (Female)**	**UMI 1230 (male)**	**CoH(M) 6**	**CoH(M)8**
0	1.338	0.993	1.983	1.254	1.470	4.266	4.302	4.594	4.184	4.164
1	1.247	0.966	0.956	1.147	1.328	4.040	4.140	4.249	4.062	4.093
2	1.167	0.941	1.925	1.120	1.231	3.794	3.734	4.176	3.712	3.697
3	0.965	0.897	1.916	0.970	0.107	3.584	3.695	3.976	3.689	3.569
4	0.914	0.852	1.829	0.891	0.983	3.344	3.276	3.778	3.155	3.289
5	0.839	0.797	1.581	0.759	0.868	3.278	3.157	3.534	2.978	3.144
6	0.784	0.662	1.359	0.595	0.811	3.125	2.951	3.499	2.726	3.084
7	0.647	0.410	1.256	0.416	0.702	2.909	2.858	3.369	2.607	2.829
8	0.441	0.329	0.937	0.314	0.521	2.851	2.688	3.210	2.472	2.736
9	0.369	0.210	0.773	0.276	0.310	2.279	2.389	2.904	2.360	2.259
10	0.291	0.102	0.519	0.221	0.262	2.136	2.111	2.295	2.061	1.236
Mean	**0.818**	**0.650**	**1.366**	**0.723**	**0.690**	**3.236**	**3.209**	**3.598**	**3.091**	**3.100**
SEd	0.017	0.012	0.033	0.021	0.014	0.075	0.074	0.058	0.083	0.078
CD (0.05)	0.035	0.025	0.069	0.044	0.030	0.156	0.155	0.121	0.172	0.163

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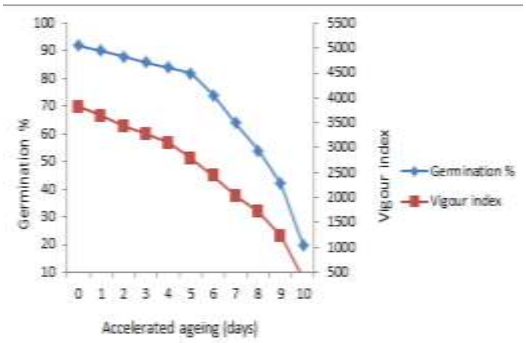

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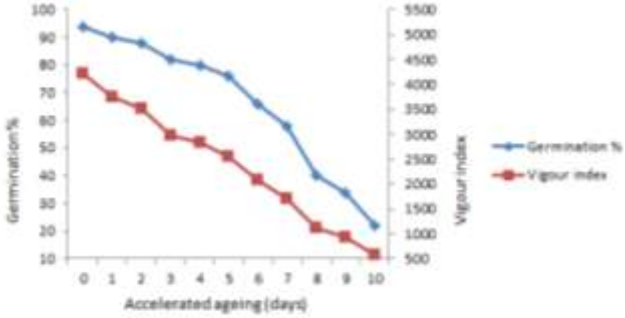

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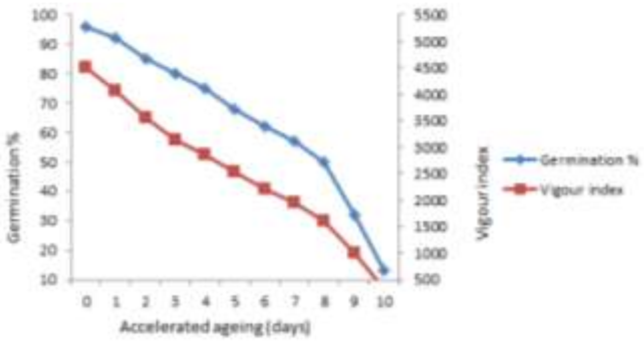

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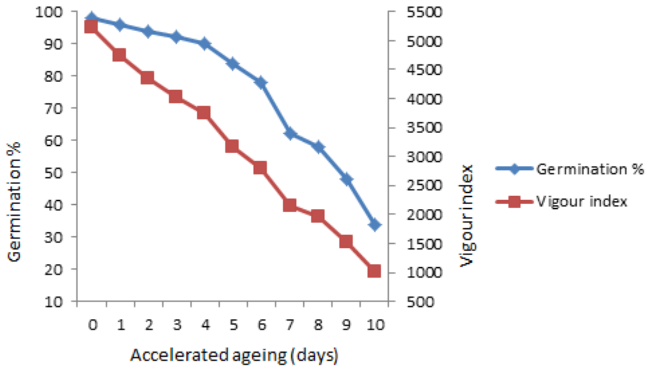
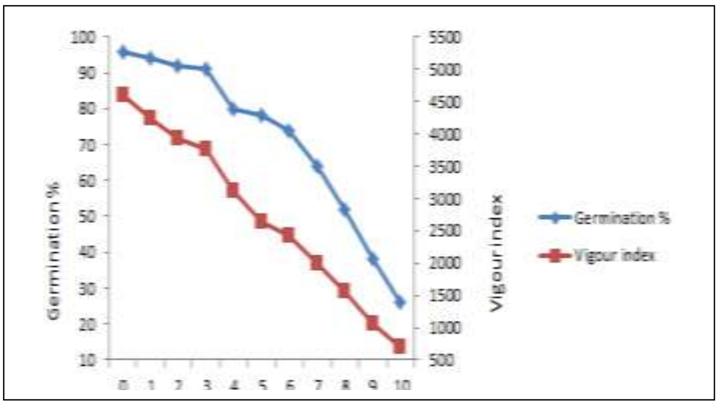


CoH (M) 6



CoH (M) 8

Fig. 1. Germination % and vigour index of maize inbreds and hybrids

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Control

10 Days accelerated ageing

Plate 1. Physiological quality of control seeds and accelerated aged seeds of maize UMI 1230 (male line)

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