**Influence of artificial ageing on seed quality of Fenugreek (*Trigonella foenum- graecum* L.) germplasm**

**ABSTRACT**

Seed quality plays an important role in the crop establishment and overall performance of the crop. Keeping in view, the importance of quality seed, the present research entitled “Influence of artificial ageing on seed quality of Fenugreek (Trigonella foenum- graecum L.) germplasm” was carried out in the Department of Seed Science and Technology, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (U.P.) during, the year 2024-2025. The experimental material for present research comprised of four genotypes of fenugreek viz. RMT-361, RMT-303, GM-1 and AFG-4, with four seed lots of each genotype including 24 hr. aged seed, 48 hr. aged seed, 72 hr. aged seed and 96 hr. aged seed lot. In the experiment, all the four seed lots of each four genotypes were tested for various physiological basis for loss in viability. It was observed that, test weight (g), seed density (g/cc), standard germination (%), seedling length (cm), dry weight per seedling (mg), vigour index-I & II, viability (%), speed of emergence, seedling establishment (%) decreased whereas, mean emergence time (days) increased with ageing period. The seed of each genotype sustain their germination up to 48 hr. aged seed thereafter, the germination fall below IMSCS (70 %). After ageing maximum germination was retained by genotype RMT-361 followed by, GM-1 and maximum loss of germination was observed in genotype AFG-4, hence the genotype RMT-361 was good storer whereas genotype AFG-4 was poor storer under ambient condition.

**Keywords:** fenugreek, germplasm, artificial ageing, germination, vigour

**INTRODUCTION**

Fenugreek (Trigonella foenum-graecum L.) belongs to the sub-family papilionaceae of Leguminosae is an important multiuse seed spice crop cultivated in India, Argentina, Egypt, Morocco, Southern France, Spain, Turkey, China, Algeria and Ethiopia. In India, it is mainly grown in the states of Rajasthan, Gujarat, Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Maharashtra, Tamil Nadu and Andhra Pradesh. The nutritional significance of fenugreek is well recognized all over the world as a vital source of essential minerals, vitamins and dietary fibers. Seeds are rich in protein (Chandramani et al., 1975), minerals, especially iron and calcium (Rao and Sharma, 1987), vitamins, particularly vitamin A, C and B2 (Aykroyed, 1963) and contain substances like volatile oil, cellulose, starch, sugars, alkaloids and enzymes. Fenugreek seeds are rich in essential amino acids and trigonelline (150 mg/100 g) for which it is valued for medicinal uses.

Seed is an important component and the quality seed plays a crucial role in agricultural production as well as in national economy. Availability of viable and vigorous seed at the planting time is important for achieving targets of agricultural production because good quality seed acts as a catalyst for realizing the potential of other inputs. Seed possesses maximum viability and vigour at physiological maturity (Meena et al., 1994) thereafter, seeds gradually ages and decline in viability and vigour. Seed deterioration leads to reduction in seed quality, performance and stand establishment which is major problem in agriculture production (Christiansen and Rowland, 1981). Seed ageing cause gradual decline in all vital cellular components causing thereby progressive loss of viability. Lipid auto-oxidation has also been suggested to be one of the causes of seed ageing (Willson and McDonald, 1986) which involve the production of free radicals. Such problems impart serious threat to agriculture, hence require management to maintain viability and vigour of seed.

**MATERIALS AND METHODS**

 The present investigation was carried out in the Department of Seed Science and Technology, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (U.P.) during 2024-2025. Seed material comprised of four genotypes viz. RMT-361, RMT-303, GM-1 and AFG-4 of fenugreek crop were taken. Seeds were subjected to accelerated aging in water jacketed accelerated aging (AA) chamber by procedure described by the Tekrony (2005). For accelerated aging the fenugreek seeds were placed on a screen tray in uniform layer, which was inserted into a small plastic box containing 40 ml of water. The plastic box was placed into a water-jacketed AA chamber and the seeds were aged at a temperature 45°C and relative humidity 95±5 % for 24, 48, 72 and 96 h. During the aging period, the seeds absorbed moisture from the humid environment (95% RH) within the plastic box and were stressed by high temperature as seed moisture increased to a uniform level. Uniform temperature was maintained in the aging chamber throughout the aging period. After completion of specified aging period the seeds on screen trays were taken out of aging chamber and air dried in shade. After accelerated aging, the seeds were tested for seed quality parameters such as test weight, seed density, standard germination, seedling length, dry weight per seedling, seedling vigour index, field emergence, seedling establishment and mean emergence time.

 The factorial experiment in completely randomized design (CRD) as well as in randomized block design (RBD) will be conducted for laboratory and field parameters, respectively. The data obtained from experiment conducted in CRD and RBD will be analysed as per standard method suggested by Panse and Sukhatme (1985).

**RESULTS AND DISCUSSION**

In present study, test weight (gm) decreased as period of artificial ageing increases in all four genotypes (Table-1). Highest test weight (11.644) observed in genotypes which were 24 hr. aged seed, while lowest (10.660) was observed which were 96 hr. aged seed. The results indicated that the genotype RMT-361 recorded highest test weight (12.331) where as GM-1 recorded lowest (10.293). Similar finding was reported in coriander (Corandrum sativum L.) by Kumar, 2007 and in Salvia L. by Afshari et al., 2011. It is concluded that as the times passes seed losses its weight.

The seed density of each seed lot decreased with ageing (Table-2). The highest seed density (1.236) was observed in the seed which was 24 hr. aged seed and lowest (1.163) in the seed which was harvested in 96 hr. aged seed. Among genotypes, the genotype RMT-361 recorded highest seed density (1.332) whereas AFG-4 recorded lowest (1.110). When seed losss its weight due to artificial ageing, seed density will be automatically less.

Standard germination percentage decreases as period of ageing increases in all the four genotypes (Table 3). Maximum standard germination (95.50) was observed in genotypes which were 24 hr. aged seed while minimum (66.83) was observed in genotypes which were 96 hr. aged seed. Maximum (86.33) standard germination was observed in RMT-361 while minimum (82.17) was observed in AFG-214. Similar results were observed in onion by Kumari, 1994; in Indian mustard seeds by Verma et al., 2003; in onion by Kumar, 2004; in coriander by Desraj (2002), Kumar (2007, 2010); in Entada pursaetha by Priya et al., 2008; in tomato by Perez-Camacho et al., 2008 and in four vegetables seeds (carrot, cucumber, onion and tomato) by Alhamdan et al., 2011. It is concluded that natural ageing has adverse effect on germination.

Seedling length (cm) in all the four genotypes decreased significantly with the advancement of ageing period (Table 4). Longest seedling length (28.903) was observed in genotypes which were 24 hr. aged seed while; shortest (24.188) was observed in genotypes which were 96 hr. aged seed. The longest seedling length (26.809) was recorded in genotype RMT-361 and shortest (25.847) seedling length was recorded in GM-1. Similar finding was reported in urd bean and mung bean by Singh et al., 2003, in Indian mustard seeds by Verma et al., 2003; in onion by Kumar, 2004; in coriander by Desraj, 2002; Kumar, 2007; Kumar, 2010.

Seedling dry weight (mg) decreased as period of artificial ageing increases in all four genotypes (Table 5). The highest (6.947) seedling dry weight was recorded in RMT-361 and lowest (6.478) seedling weight was recorded in AFG-4. The seedling dry weight of fresh seed was recorded highest ,(7.592). But in advancement of storage period, a significant reduction in dry weight was observed in 48 hr. aged seed (7.150 mg), 72 hr. aged seed (6.333) and 96 hr. aged seed lot (5.775) as compared to 24 hr. aged seed lot (7.592). Similar conclusion also drawn in mustard by Verma et al., 2003; in onion by Kumar, 2004; in okra by Nagarajan et al., 2004.

Vigour index - I decreased as period of artificial ageing increases in all four genotypes. The vigour index-I was recorded highest (2763.13) in 24 hr. aged seed lot and then gradually decrease as the seed aged and minimum (1631.61) vigour index-I reported in three year aged seed lot. The vigour index-I of fenugreek seed was maximum (2,336.97) in genotype RMT-361 and minimum (2,147.47) in genotype AFG-4. Vigour index-II was decreased with ageing in all the four genotypes of fenugreek. The vigour index-II was recorded highest (725.54) in 24 hr. aged seed lot and then gradually decrease as the seed aged and minimum (386.36) vigour index-II reported in 96 hr. aged seed lot. The maximum (606.34) value of Vigour index-II was recorded in RMT-361 and minimum (541.63) vigour index-II was recorded in AFG-4. Similar conclusion also drawn in mustard by Verma et al., 2003; in onion by Kumar, 2004; in okra by Nagarajan et al., 2004.

Speed of emergence decreased as period of natural ageing increases in all four genotypes (Table 5). Highest (8.528) speed of emergence was observed in genotypes which were 24 hr. aged seed while lowest (3.613) was observed in genotypes which were 96 hr. aged seed. Among genotypes highest (6.918) speed of emergence was observed in genotype RMT-303 while lowest (6.445) was observed in AFG-4. Similar finding was reported by Verma et al., 2003 in Brassica campestris; Desraj, 2002 in coriander; Kumar, 2004 in onion; Kumar, 2007 in coriander; Singh, 2009 in wheat and Kumar, 2010 in coriander.

Mean emergence time (days) increased as period of artificial ageing increases in all four genotypes of fenugreek (Table 6). Highest (7.413) Mean emergence time was observed in RMT-303 while lowest (7.133) was observed in GM-1. Highest (8.842) Mean emergence time was observed in genotypes which were 96 hr. aged seed while lowest (4.548) observed in genotypes which were 24 hr. aged seed. Similar finding was reported by Verma et al., 2003 in Brassica campestris; Desraj, 2002 in coriander; Kumar, 2004 in onion; Kumar, 2007 in coriander; Singh, 2009 in wheat and Kumar, 2010 in coriander

Seedling establishment percentage decrease as period of artificial ageing increases in all four genotypes (Table 7). Maximum (58.92) Seedling establishment percentage was observed in RMT-303 while minimum (53.17) observed in AFG-4. Maximum (70.83) seedling establishment percentage was observed in genotypes which were 24 hr. aged seed while minimum (31.17) was observed in genotypes which were 96 hr. aged seed. Similar finding was reported by Verma et al., 2003 in Brassica campestris; Desraj, 2002 in coriander; Kumar, 2004 in onion; Kumar, 2007 in coriander; Singh, 2009 in wheat and Kumar, 2010 in coriander. All aged seed lots showed better germination in the laboratory as compared to field observation because; standard germination is conducted in ideal conditions (temperature, moisture and substrates).

Table 1: Effect of artificial ageing on test weight of fenugreek

|  |  |
| --- | --- |
| Genotypes | Ageing |
| 24 hr. | 48 hr. | 72 hr. | 96 hr. | Mean A |
| RMT-361 | 12.610 | 12.452 | 12.262 | 11.998 | 12.331 |
| RMT-303 | 12.070 | 11.903 | 10.953 | 10.436 | 11.341 |
| GM-1 | 10.743 | 10.439 | 10.032 | 9.959 | 10.293 |
| AFG-4 | 11.153 | 11.047 | 10.787 | 10.248 | 10.809 |
| Mean B | 11.644 | 11.460 | 11.009 | 10.660 |  |
| Factors | C.D. | SE(d) | SE(m) |
| Factor(A) | 0.152 | 0.074 | 0.052 |
| Factor(B) | 0.152 | 0.074 | 0.052 |
| Factor(A X B) | 0.304 | 0.148 | 0.105 |

Table 2: Effect of artificial ageing on seed density of fenugreek

|  |  |
| --- | --- |
| Genotypes | Ageing |
| 24 hr. | 48 hr. | 72 hr. | 96 hr. | Mean A |
| RMT-361 | 1.404 | 1.340 | 1.302 | 1.280 | 1.332 |
| RMT-303 | 1.228 | 1.215 | 1.181 | 1.161 | 1.196 |
| GM-1 | 1.184 | 1.163 | 1.145 | 1.122 | 1.153 |
| AFG-4 | 1.130 | 1.120 | 1.101 | 1.087 | 1.110 |
| Mean B | 1.236 | 1.209 | 1.183 | 1.163 |  |
| Factors | C.D. | SE(d) | SE(m) |
| Factor(A) | 0.024 | 0.012 | 0.008 |
| Factor(B) | 0.024 | 0.012 | 0.008 |
| Factor(A X B) | NS | 0.024 | 0.017 |

Table 3: Effect of artificial ageing on germination of fenugreek

|  |  |
| --- | --- |
| Genotypes | Ageing |
| 24 hr. | 48 hr. | 72 hr. | 96 hr. | Mean A |
| RMT- 361 | 97.00 (80.09) | 95.00 (77.09) | 83.33(65.89) | 70.00 (56.77) | 86.33 (69.96) |
| RMT-303 | 96.00 (78.49) | 93.67 (75.46) | 81.67 (64.65) | 66.67 (54.71) | 84.50 (68.33) |
| GM-1 | 95.00 (77.09) | 92.67 (74.27) | 81.67 (64.63) | 67.67 (55.33) | 84.25 (67.83) |
| AFG-4 | 94.00 (75.82) | 92.00 (73.56) | 79.67 (63.17) | 63.00 (52.52) | 82.17 (66.27) |
| Mean B | 95.50 (77.87) | 93.33 (75.09) | 81.58 (64.59) | 66.83 (54.83) |  |
| Factors | C.D. | SE(d) | SE(m) |
| Factor(A) | 1.118 | 0.546 | 0.386 |
| Factor(B) | 1.118 | 0.546 | 0.386 |
| Factor(A X B) | 2.237 | 1.093 | 0.773 |

Table 4: Effect of artificial ageing on seedling length of fenugreek

|  |  |
| --- | --- |
| Genotypes | Ageing |
| 24 hr. | 48 hr. | 72 hr. | 96 hr. | Mean A |
| RMT-361 | 29.650 | 27.203 | 25.780 | 24.603 | 26.809 |
| RMT-303 | 29.187 | 26.570 | 25.720 | 24.503 | 26.495 |
| GM-1 | 28.320 | 26.100 | 25.073 | 23.893 | 25.847 |
| AFG-4 | 28.457 | 26.040 | 25.280 | 23.753 | 25.883 |
| Mean B | 28.903 | 26.478 | 25.463 | 24.188 |  |
| Factors | C.D. | SE(d) | SE(m) |
| Factor(A) | 0.219 | 0.107 | 0.076 |
| Factor(B) | 0.219 | 0.107 | 0.076 |
| Factor(A X B) | 0.437 | 0.214 | 0.152 |

Table 5: Effect of artificial ageing on seedling dry weight of fenugreek

|  |  |
| --- | --- |
| Genotypes | Ageing |
| 24 hr. | 48 hr. | 72 hr. | 96 hr. | Mean A |
|  RMT-361 | 7.763 | 7.363 | 6.597 | 6.063 | 6.947 |
|  RMT-303 | 7.543 | 7.143 | 6.277 | 5.677 | 6.660 |
| GM-1 | 7.640 | 7.173 | 6.373 | 5.873 | 6.765 |
| AFG-4 | 7.420 | 6.920 | 6.087 | 5.487 | 6.478 |
| Mean B | 7.592 | 7.150 | 6.333 | 5.775 |  |
| Factors | C.D. | SE(d) | SE(m) |
| Factor(A) | 0.139 | 0.068 | 0.048 |
| Factor(B) | 0.139 | 0.068 | 0.048 |
| Factor(A X B) | N/A | 0.136 | 0.096 |

Table 6: Effect of artificial ageing on vigour index-I of fenugreek

|  |  |
| --- | --- |
| Genotypes | Ageing |
| 24 hr. | 48 hr. | 72 hr. | 96 hr. | Mean A |
| RMT-361 | 2,875.88 | 2,584.19 | 2,165.46 | 1,722.33 | 2,336.97 |
| RMT-303 | 2,811.42 | 2,506.54 | 2,126.13 | 1,690.80 | 2,283.72 |
| GM-1 | 2,690.20 | 2,427.41 | 2,056.24 | 1,616.72 | 2,197.64 |
| AFG-4 | 2,675.04 | 2,404.29 | 2,013.99 | 1,496.58 | 2,147.47 |
| Mean B | 2,763.13 | 2,480.61 | 2,090.46 | 1,631.61 |  |
| Factors | C.D. | SE(d) | SE(m) |
| Factor(A) | 31.400 | 15.346 | 10.851 |
| Factor(B) | 31.400 | 15.346 | 10.851 |
| Factor(A X B) | 62.794 | 30.691 | 21.702 |

Table 7: Effect of natural ageing on vigour index-II of fenugreek

|  |  |
| --- | --- |
| Genotypes | Ageing |
| 2010-11 | 2009-10 | 2008-09 | 2007-08 | Mean A |
| HM-202 | 752.69 | 699.16 | 549.56 | 423.94 | 606.34 |
| HM-204 | 726.56 | 673.74 | 512.66 | 378.40 | 572.84 |
| HM-205 | 725.52 | 666.88 | 522.40 | 397.40 | 578.05 |
| HM-214 | 697.39 | 638.74 | 484.70 | 345.69 | 541.63 |
| Mean B | 725.54 | 669.63 | 517.33 | 386.36 |  |
| Factors | C.D. | SE(d) | SE(m) |
| Factor(A) | 14.720 | 7.194 | 5.087 |
| Factor(B) | 14.720 | 7.194 | 5.087 |
| Factor(A X B) | 29.439 | 14.388 | 10.174 |

Table 8: Effect of artificial ageing on speed of emergence of fenugreek

|  |  |
| --- | --- |
| Genotypes | Ageing |
| 24 hr. | 48 hr. | 72 hr. | 96 hr. | Mean A |
| RMT-361 | 8.543 | 8.143 | 6.650 | 3.583 | 6.730 |
| RMT-303 | 8.640 | 8.443 | 6.610 | 3.977 | 6.918 |
| GM-1 | 8.650 | 8.223 | 6.470 | 3.590 | 6.733 |
| AFG-4 | 8.277 | 8.087 | 6.117 | 3.300 | 6.445 |
| Mean B | 8.528 | 8.224 | 6.462 | 3.613 |  |
| Factors | C.D. | SE(d) | SE(m) |
| Factor(A) | 0.133 | 0.065 | 0.046 |
| Factor(B) | 0.133 | 0.065 | 0.046 |
| Factor(A X B) | N/A | 0.130 | 0.092 |

Table 9: Effect of artificial ageing on mean emergence time of fenugreek

|  |  |
| --- | --- |
| Genotypes | Ageing |
| 24 hr. | 48 hr. | 72 hr. | 96 hr. | Mean A |
| RMT-361 | 4.903 | 7.007 | 8.553 | 9.103 | 7.392 |
| RMT-303 | 4.770 | 7.177 | 8.840 | 8.863 | 7.413 |
| GM-1 | 4.430 | 7.073 | 8.537 | 8.490 | 7.133 |
| AFG-4 | 4.090 | 6.947 | 8.697 | 8.910 | 7.161 |
| Mean B | 4.548 | 7.051 | 8.657 | 8.842 |  |
| Factors | C.D. | SE(d) | SE(m) |
| Factor(A) | 0.329 | 0.160 | 0.113 |
| Factor(B) | 0.329 | 0.160 | 0.113 |
| Factor(A X B) | N/A | 0.321 | 0.227 |

Table 10: Effect of artificial ageing on seedling establishment percentage of fenugreek

|  |  |
| --- | --- |
| Genotypes | Ageing |
| 24 hr. | 48 hr. | 72 hr. | 96 hr. | Mean A |
| RMT-361 | 72.00 (58.04) | 69.00 (56.15) | 55.33 (48.04) | 32.00 (34.43) | 57.08 (49.16) |
| RMT-303 | 73.33 (58.90) | 71.00 (57.40) | 57.00 (49.01) | 34.33 (35.85) | 58.92 (50.29) |
| GM-1 | 70.00 (56.77) | 67.33 (55.12) | 55.00 (47.85) | 30.33 (33.40) | 55.67 (48.29) |
| AFG-4 | 68.00 (55.53) | 65.67 (54.12) | 51.00 (45.55) | 28.00 (31.93) | 53.17 (46.78) |
| Mean B | 70.83 (57.31) | 68.25 (55.70) | 54.58 (47.61) | 31.17 (33.90) |  |
| Factors | C.D. | SE(d) | SE(m) |
| Factor(A) | 1.559 | 0.760 | 0.537 |
| Factor(B) | 1.559 | 0.760 | 0.537 |
| Factor(A X B) | 3.117 | 1.519 | 1.074 |

**CONCLUSION**

In artificial aged seed lots, all fenugreek genotypes sustained their germination up to 48 hr. aged seed showed that fenugreek seed can be stored at ambient conditions up to 72 hr. aged seed without losing its viability and after that the germination falls below 70% (Indian Minimum Seed Certification Standards). RMT-361 was found superior genotype based on majority of the viability and vigour parameters results whereas AFG-4 was found inferior. During artificial ageing, standard germination, seed density, test weight, seedling length, vigour Indices, viability, speed of emergence index and seedling establishment decreased significantly and progressively with the ageing period.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author (s) hereby declare that No generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

**REFERENCES**

Afshari, H., Eftekhari, M., Faraji, M., Ghaffar Ebadi, A. and Ghanbarimalidareh, A. 2011. Studying the effect of 1000 grain weight on the sprouting of different species of Salvia L. grown in Iran. J. Med. Plant. Res. 5(16): 3991-3993.

Alhamdan, A.M., Alsadon, A.A., Khalil, S.O., Wahb-Allah, M.A., Nagar, M. El. and Ibrahim, A.A. 2011. Influence of Storage Conditions on Seed Quality and Longevity of Four Vegetable Crops. Am-Euras. J. Agric. & Environ. Sci. 11(3): 353-359.

Aykroyed, W.R., 1963. The Nutritive Value of Indian Foods and Planning for Satisfactory Diets. Indian Council of Medical Research, Special Report, Series No. 42.

Chandramani, R., Krishnamoorthy, K.K., Balasunderam, S.C. and Balakrishnan, T. 1975. Optimum time of cutting for obtaining maximum yield of extractable protein from fenugreek (Trigonella foenum-graecum L.). Madaras Agric. J. 62(4): 230-231.

Chiristiansen, H.R. and Rowland, R. 1981. Cotton physiology seed and germination. In: Proceedings of Beltwide cotton production research conferences, Brown, J.M. (Ed.), 4-8 Jan, 1981, New Orleans, L.A. Publ. Natl. Cotton counc., Memphis, T.N.

Desraj 2002. Studies on viability and vigour in coriander (Coriandrum sativum L.). M. Sc. Thesis, submitted to CCS HAU, Hisar.

Kumari, P. 1994. Seed deterioration studies in onion (Allium cepa L.). Ph.D. thesis submitted to CCS Haryana Agricultural University, Hisar.

Kumar, A. (2004) Seed quality assessment in naturally aged seeds of onion (Allium cepa). M. Sc. Thesis, submitted to CCS HAU, Hisar.

Kumar, A. (2007) Seed quality assessment in naturally aged seeds of coriander (Coriandrum sativum L.). M. Sc. Thesis, submitted to CCS HAU, Hisar.

Kumar, V. 2010 Studies on seed viability and vigour in naturally aged seeds of coriander (Coriandrum sativum L.). M. Sc. Thesis, submitted to CCS HAU, Hisar.

Meena, R.A., Rathinavel, K. and Singh, P. 1994. Seed development and maturation in cotton. Ind. J. Agric. Sci. 64: 111-113.

Nagarajan, S., Sinha, J.P. and Pandita, V.K. 2004. Accelerated ageing behaviour of okra seed lots conditioned to different moisture levels and its relation to seed water characteristics. Seed Res. 32(2): 113-117.

Perez-Camacho, I., Ayala-Garay, O.J., Gonzalez-Hemandez, V.A., Carrillo-Salazar, J.A., Pena-Lomeli, A. and Garcia-de-los-Santos, G. 2008. Morphological and physiological markers of seed deterioration in husk tomato. Agrociencia 42(8): 891-901.

Priya, S.V. and Rao, J.V.S. 2008. Effect of storage period in seed and seedling vigour of Entada pursaetha an endangered gigantic medicinal liana. Seed Sci. &Technol. 36(2): 475-480

Rao, P.U. and Sharma, R.D. 1987. An evaluation of protein quality of fenugreek seeds (Trigonella foenum-graecum L.) and their supplementary effects. Food Chemistry, 24(1): 1-9.

Singh, D. 2009. Seed quality assessment in artificial and natural aged seed of wheat (Triticum aestivum (L.). Ph.D. thesis submitted to CCS Haryana Agricultural University, Hisar.

TeKrony, D.M. Accelerated aging test: Principles and procedures. Seed technology. 2005; 27 (1): 135-146.

Verma, S.S., Verma, U. and Tomer, R.P.S. 2003. Studies on seed quality parameters in deteriorating seeds in brassica (Brassica campestris). Seed Sci. & Technol. 31: 389-396.

Willson, D.O. and McDonald, M.B. 1986. The lipid peroxidation model of seed deterioration. Seed Sci. & Technol. 14: 269-300.