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Effect of accelerated ageing on seed quality parameters in onion

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ABSTRACT A laboratory experiment was carried out to study the effect of accelerated ageing on seed quality parameters in onion with completely randomized design (factorial). Seeds of ten onion genotypes were subjected to accelerated ageing at higher temperature and humidity (45°C and 100% RH) for various time intervals (0, 3, 5, and 7 days) and observation recorded. In this experiment parameters to be recorded was first count of germination, germination percentage, speed of germination, shoot, root and seedling length, seedling dry weight, vigour index-I and II, electrical conductivity of seed and enzyme activity of catalase, peroxidise and superoxide dismutase. Among all this characters the decreasing trend was found as ageing duration was increased except electrical conductivity, which was increasing with advanced ageing period. Among the ten onion genotypes, N-2-4-1 proved to be a promising cultivar, which retained seed vigour, viability and high enzymatic activity under prolonged artificial ageing conditions and could be stored for longer time and which can be employed for further breeding programmes.

Key words: Onion, accelerated ageing enzyme, activity and seed quality

Onion (*Allium cepa L.*) is a bulbous vegetable crop of family *Amarilidaceae*. Globally, India is the second largest producer of onion, next to China. It is being grown both in *kharif* and *Rabi* in India. It occupies a 10.4 per cent share of major vegetable crops in India. Onion is grown an area of 10.51 lakh hectare with production of 168.13 lakh tons and productivity of 1.6 metric tons per hectare. Gujarat is having the highest productivity of 24.4 metric tons per hectare [1].

Cultivation of vegetables like onion are carried out in intensive production systems and the success of this activity depends on the use of high quality seeds with superior seed vigour which germinates quickly and uniformly. Onion seeds also have a high commercial value and hence, the availability of satisfactory vigour tests for onion seeds is desirable [2]. Further, onion seed loses its viability rapidly under storage. Therefore, it is imperative that proper storage conditions are maintained to ensure good germinability, seed vigour and quality. Hence, this study aims to investigate the effect of accelerated ageing on seed germinability, vigour and quality parameters in different genotypes of onion.

MATERIALS AND METHODS

The experiment was conducted in a completely randomized design (factorial) with three replications. Accelerated ageing treatment was given to 10 onion genotypes. They were Bhimashakti, Bhimakiran, Bhima raj, Bhima red, Bhima super and N-2-4-1 (Directorate of Onion and Garlic Research, Pune), Pusa red (Indian Agricultural Research Institute, New Delhi) and Gujarat white onion-1, Agrifound dark red and Pillipatti (Junagadh Agricultural University, Junagadh).

Accelerated Ageing

400 seeds of each genotype in three replications were tied in a fine muslin cloth bag and placed in desiccators on a wire mesh. The lower part of the desiccators was filled with water, in such a way that there was not any direct contact between water and seed. The jar was covered with the lid and sealed with parafin wax to make it air tight. The jar was placed in the accelerated ageing chamber maintained at 45°C temperature and 100% relative humidity for 0 (control) 3, 5 and 7 days. The jar was removed after this period and the seeds were cooled in a dessicator. The seeds were then tested for germination [3].

Germination test

Germination percentages, using three replicates of 50 seeds were determined by top of paper method at 20°C [3]. First count was taken on 6th day and final count on 12th day. The germination percentage was calculated on the basis of normal seedlings, counted on the final day.

Speed of germination

Speed of germination was recorded, daily germination counts taken and the seedlings having minimum of two

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centimetres in length were considered as germinated seedlings. The speed of germination was calculated by using the formula [4]

$$GRI = \frac{G_1}{T_1} + \frac{G_2}{T_2} + \cdots \frac{G_n}{T_n}$$

Where, GRI is Germination Rate Index and G_1, G_2 .... G_n are the number of seeds germinated at T_1, T_2......T_n, time intervals respectively.

Seedling length (cm)

Mean of total seedling length of each genotype was determined by addition of seedling root and shoot length, measured using scale.

Seedling dry weight (mg)

Fresh seedlings were placed at 80°C in an oven for 24 h for drying. Samples were cooled in an air-tight closed glass desiccator containing silica gel for 15 - 30 min and then weighed to record seedling dry weight. Seedling dry weight was estimated following the standard method [5] and expressed as mg/10 seedlings.

Vigour indices

The vigour indices were calculated using the procedure suggested by [6] and expressed in whole number.

Vigour index-I = Germination (%) X Seedling length (cm)

Vigour index-II = Germination (%) X Seedling dry weight (mg)

Electrical conductivity

Electrical conductivity was measured following the standard procedure [2]. One gram of seed in two replications was imbibed in 25 ml of deionised water at 20±1°C for 24 h., the electrical conductance of the leachate measured at room temperature by using EC meter and calculated as µSi/cm/g.

Enzyme activity

The enzyme analysis was done as per standard procedure [7] for catalase (CAT), [8] for peroxidase (POX) and [9] for superoxide dismutase (SOD). CAT and POX activities were expressed as Mmol min^{-1} g^{-1} while one unit of SOD was defined as that being present in the volume of extract that caused inhibition of the photo-reduction of nitrobluetetrazolium (NBT) by 50%. The protein content of each extract was determined using the "Bio-Rad Laboratories Method 1994" and the enzyme activity was expressed based on the protein amount. Measurements were performed three times with each extract.

Statistical methods

The observed data were statistically analyzed by appropriate statistical procedures as suggested for Completely Randomized Design (Factorial) [10]

RESULTS AND DISCUSSION

Effect of accelerated ageing on germination and its attributes

The results of germination % are presented in Fig.1. Accelerated ageing showed significant results for varieties as well as for ageing treatments. The interaction between varieties and ageing treatments in both the years and pooled was significant. Among the genotypes, N-2-4-1 recorded the highest germination percentage *i.e.*, 65.25% when the artificial ageing treatment was imposed on onion genotypes. The same genotype *i.e.*, N-2-4-1 retained the highest germination percentage at P_4 (7 days of ageing) *i.e.*, 24.00 percentage. However, there was pronounced reduction in germination when the days for accelerated ageing was increased. The lowest reduction in germination percentage was observed for the genotype AGFD, which was 54.33 per cent, whereas the highest reduction in germination percentage was observed in the variety N-2-4-1 (74.33 %). The same trend was observed for first count of germination percentage also [Fig 1]. It could be concluded that ageing considerably hamper the ability of onion seeds to germinate. The results are in accordance with earlier studies [11-14], who reported the same response for carrot, onion, and chickpea seeds, when subjected to accelerated ageing treatments respectively. It could be concluded that rapid ageing had damaging effect on seed membrane and as a result lipid peroxidation products increased.

Regarding the germination speed, among the genotypes, N-2-4-1 had the highest germination speed (15.33) under the artificial ageing treatments. The same genotype *i.e.*, N-2-4-1 retained the highest germination speed at P_4 (7 days of ageing) *i.e.*, 4.61. However, for this character also, reduction in germination speed was observed, when the days for accelerated ageing were increased. The lowest reduction in germination speed was observed for the genotype AGFD, which was 13.48; whereas, the highest reduction in germination speed was observed in the variety N-2-4-1 (19.87).

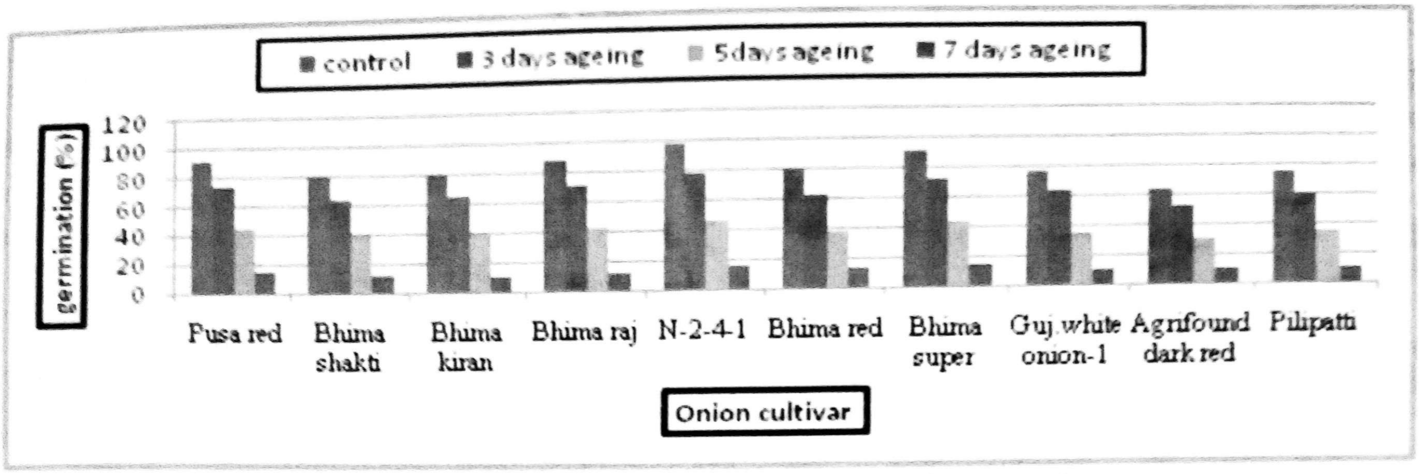

Fig. 1. Effect of accelerated ageing on first count of germination

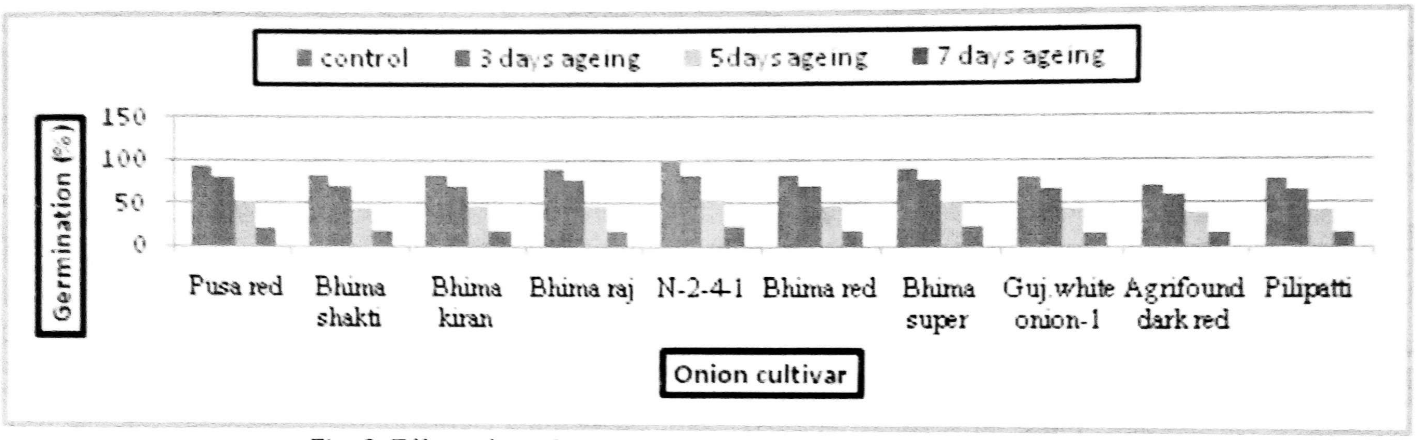

Fig. 2. Effect of accelerated ageing on germination percentage

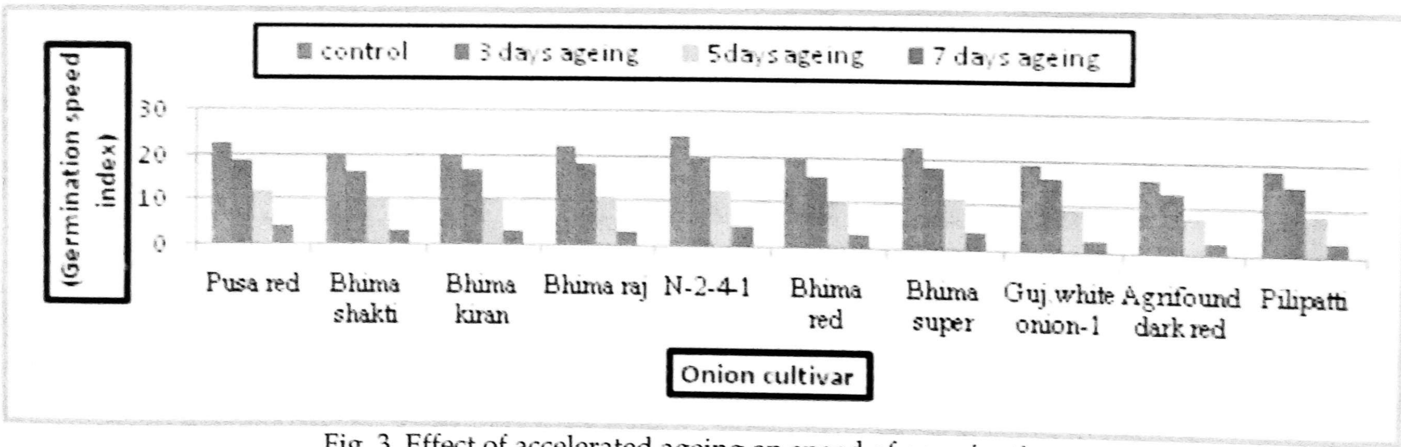

Fig. 3. Effect of accelerated ageing on speed of germination

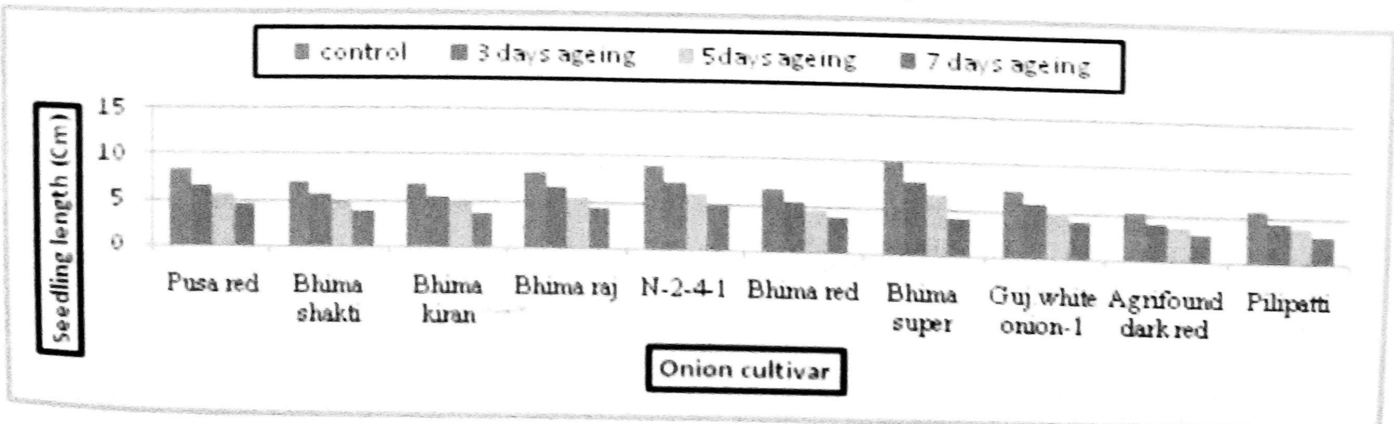

Fig. 4. Effect of accelerated ageing on seedling length (cm)

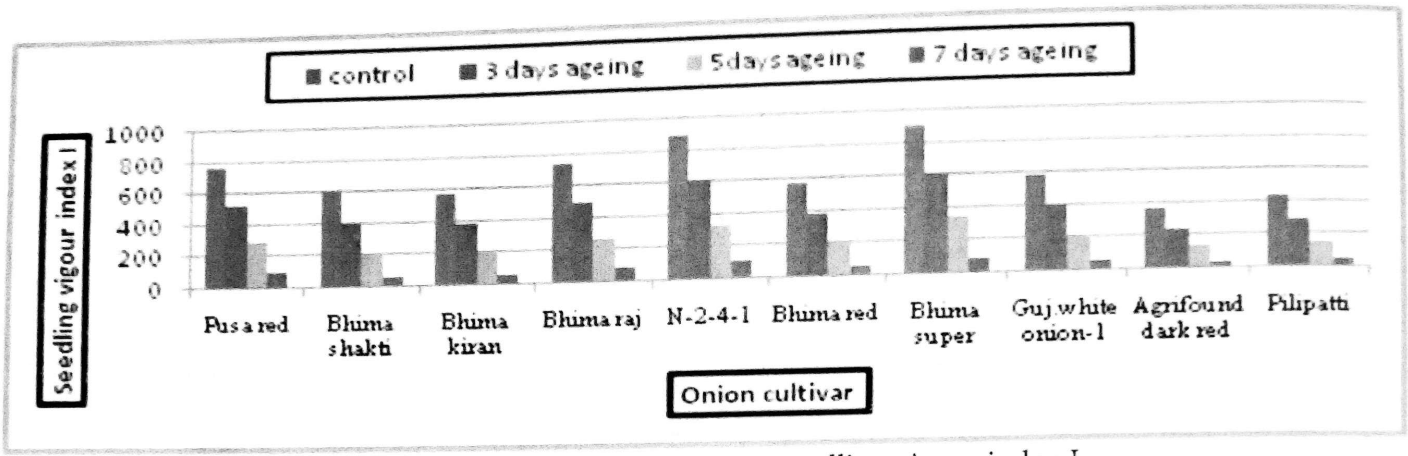

Fig. 5. Effect of accelerated ageing on seedling vigour index-I

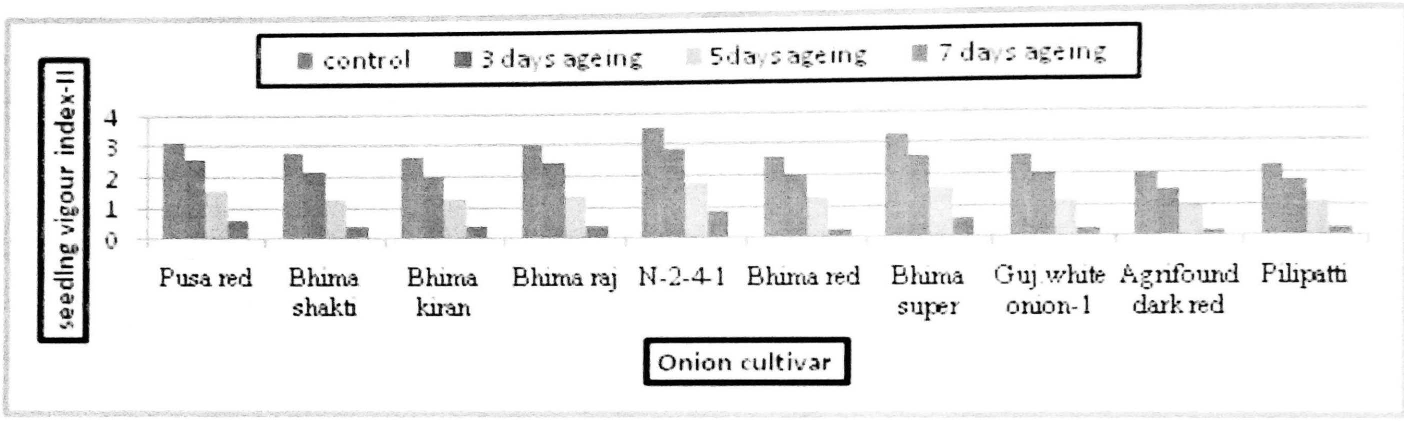

Fig. 6. Effect of accelerated ageing on seedling vigour index-II

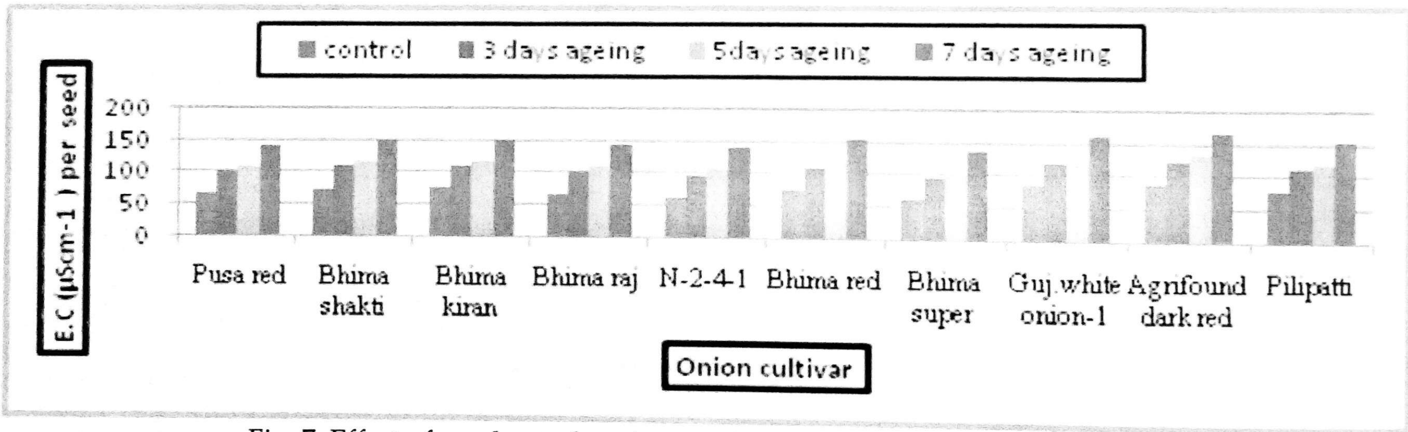

Fig. 7. Effect of accelerated ageing on electrical conductivity (µs cm^{-1} g^{-1})

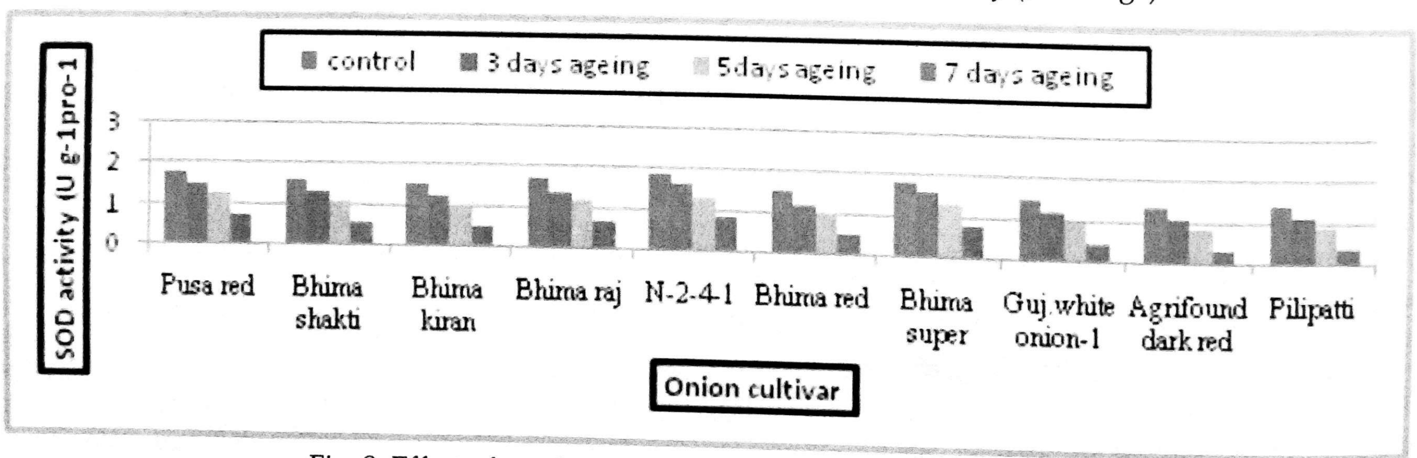

Fig. 8. Effect of accelerated ageing on SOD activity (U g^{-1} pro^{-1})

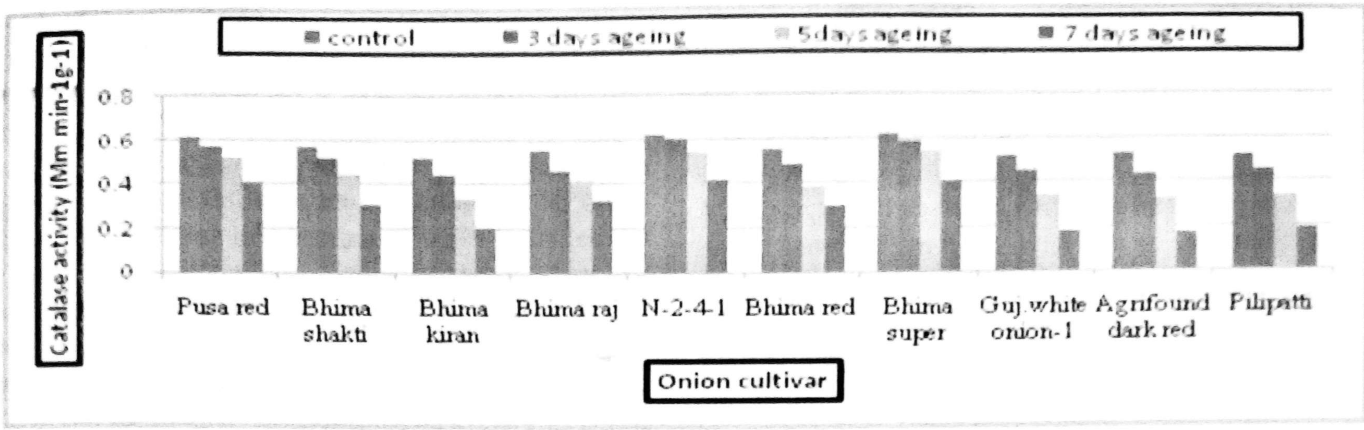

Fig. 9. Effect of accelerated ageing on catalase (CAT) activity (Mm min^{-1} g^{-1})

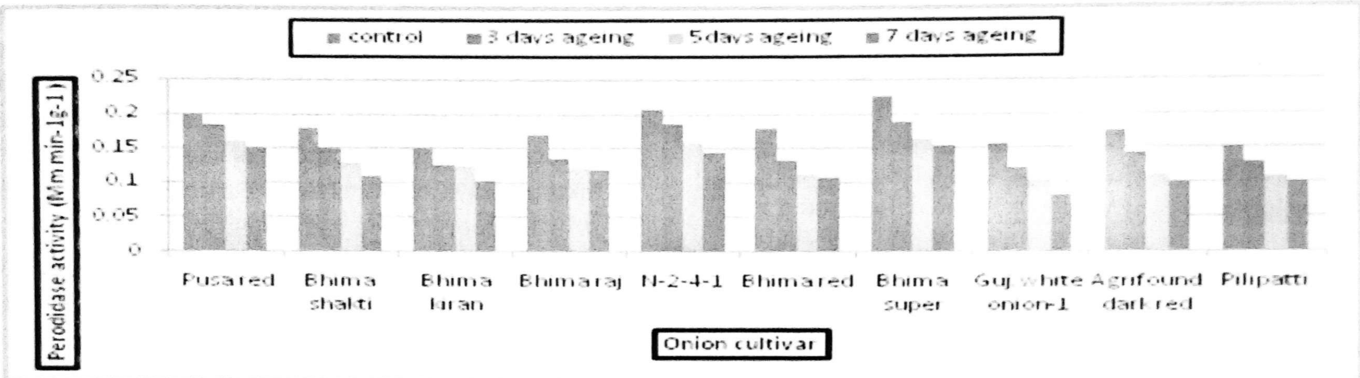

Fig. 10. Effect of accelerated ageing on peroxidase activity (Mm min^{-1} g^{-1})

The results obtained from this study were similar to earlier studies [12, 13, 15 and 16] who reported the same response for onion, pea, and watermelon seeds respectively when subjected to accelerated ageing treatment. Speed of germination was decreased due to decline in seed germinability.

The findings on seedling root length in all onion genotypes revealed that treatment differences were significant for varieties as well as for ageing treatments. For this character also, genotype N-2-4-1 recorded the highest seedling root length *i.e.,* 2.94 cm, when the artificial ageing treatment was imposed. The said genotype, N-2-4-1 retained the highest seedling root length at P_4 (7 days of ageing) *i.e.,* 2.13 cm. The root length was reduced as ageing progressed, the lowest reduction observed for the genotype AGFD (1.00 cm); whereas, the highest reduction was observed in the variety Bhima super (2.08 cm). Similar results were also observed by 4, 13, 17, 18. They reported the same response for onion, beet root, radish and sunflower seeds respectively, when subjected to accelerated ageing treatment. Variation in seedling root length could be attributed to varietal differences. It can also be assumed that the negative impact of seed ageing on root length could be due to increase in lipid peroxidation product.

When seedling shoot length was studied under artificial ageing, the genotype Bhima super produced the highest seedling shoot length 4.39 cm. The genotype Pusa red retained the highest seedling root length at P_4 (7 days of ageing) *i.e.,* 2.73 cm. The shoot length reduced under ageing, the lowest reduction was observed with genotype AGFD, which was 1.40 cm, and the highest reduction was found for variety Bhima super (3.95 cm).

Among the genotypes, Bhima super had the highest seedling length *i.e.,* 7.15 cm under the artificial ageing treatment. The genotype N-2-4-1 retained the highest seedling length at P_4 (7 days of ageing) *i.e.,* 5.00 cm. The lowest reduction in seedling length was observed for the genotype AGFD, which was 2.40 cm; whereas, the highest reduction in seedling length was observed in the variety Bhima super (6.00 cm). Similar results were also observed by other researchers [4, 13, 17, 18] who reported the same response for onion, beet root, radish and sunflower seeds respectively, when subjected to accelerated ageing treatment. Variation in seedling root length could be attributed to varietal differences. It can also be assumed that the negative impact of seed ageing on root length could be due to increase in lipid peroxidation product.

The highest seedling dry weight of 33.10 mg was observed with the genotype N-2-4-1, when the artificial ageing treatment was imposed on onion genotypes; the same genotype retained the highest seedling dry weight at P_4 (7 days of ageing) *i.e.*, 28.10 mg. However, there was pronounced reduction in seedling dry weight when the days for accelerated ageing increased. The lowest reduction in seedling dry weight was observed for the genotype Pilipatti, which was 8.40 mg; whereas, the highest reduction was observed for the variety Bhima red (9.30 mg). Seedling dry weight in onion was observed to decrease with the increased days of accelerated ageing treatments. Varietal difference and reduction in seedling dry weight was due to the loss of seedling length and vigour during accelerated ageing and increase in seed solute leakage. The findings are in accordance with earlier reports [4, 17, 19] in pea, beetroot and sunflower respectively when subjected to accelerated ageing treatment.

The results on seedling vigour index-I of onion genotypes revealed that treatment differences were significant for varieties as well as for ageing treatments. The interaction between varieties and ageing treatments in both the years and pooled was significant. Among the genotypes, N-2-4-1 recorded the highest vigour index-I *i.e.*, 493.70, under the artificial ageing treatment. The same genotype *i.e.*, N-2-4-1 retained the highest seedling vigour index-I at P_4 (7 days of ageing) *i.e.*, 119.60. The lowest reduction in seedling vigour index-I was observed for the genotype AGFD, which was 327.5; whereas, the highest reduction in seedling vigour index-I was observed in the variety Bhima super (822.9). Reduction in vigour index-I could be due to the lower germination per cent and decreasing seedling length (cm) with the artificial ageing. Results obtained from this study are in conformation with the results observed by other workers [16, 19, 20] who reported the same results for watermelon, pea, beet root, and radish seeds respectively, when subjected to accelerated ageing treatment.

The same trend was also observed for vigour index-II. The lowest reduction in seedling vigour index-II was observed for the genotype AGFD, which was 1.73; whereas, the highest reduction in seedling vigour index-II was observed in the variety N-2-4-1 (2.91). Decreasing trend in vigour index-II may be due to the lower germination per cent and decreasing seedling dry weight (mg) with the artificial ageing.

Electrical conductivity was measured under artificial ageing, among the genotypes, Bhima Super had the lowest electrical conductivity *i.e.*, 99.46 $\mu S\ cm^{-1} g^{-1}$, which was true for the treatment P_4 (7 days of ageing) *i.e.*, 137.83 $\mu S\ cm^{-1} g^{-1}$. Considerable increase in electrical conductivity was observed under ageing treatments. The lowest increase in electrical conductivity was observed for the genotype AGFD, which was 74.83 $\mu S\ cm^{-1}\ g^{-1}$; whereas, the highest increase in electrical conductivity was observed for variety Bhimashakti (80.00$\mu S\ cm^{-1}\ g^{-1}$). The increasing trend of electrical conductivity was observed with increasing period of accelerated ageing treatments. Seed ageing period greatly affected the electrolyte leakage in onion seeds. It could be due to loss of seed membrane integrity. Results demonstrated that the electrical conductivity of onion seed was related to its membrane disintegration and final loss of viability. The findings are in accordance with earlier studies [13, 16, 18] which reported the same result for watermelon, onion and radish seeds respectively when subjected to accelerated ageing treatment.

Effect of accelerated ageing on enzyme activity

Accelerated ageing reduced the enzymatic activity also. The three enzymes *viz.*, superoxide dismutase, catalase and peroxidase showed reduction in the activity as ageing progressed. For superoxide dismutase and catalase, the genotype N-2-4-1 had the highest activity among the all genotypes *i.e.*, 1.44 U g^{-1} $pro^{-1}$and 0.547 Mm min^{-1} g^{-1}, respectively. At 7day - ageing treatment also, the said genotype recorded the highest activity for superoxide dismutase (0.87 U g^{-1} pro^{-1}) and catalase (0.418 Mm $min^{-1}g^{-1}$). The lowest reduction in superoxide dismutase activity was observed for the genotype AGFD, which was 0.98 Ug^{-1} pro^{-1}; whereas, the highest reduction in superoxide dismutase activity was observed with the variety Pusa red, Bhima raj, and N-2-4-1 (1.04 U $g^{-1}pro^{-1}$). Similarly, the lowest reduction in catalase activity was observed for the genotype Pusa red, which was 0.204 Mm min^{-1} g^{-1}; whereas, the highest reduction in catalase activity was observed in the variety AGFD (0.364 Mm min^{-1} g^{-1}). The decrease in antioxidant enzymes could be linked to an increased lipid peroxidation and accelerated ageing. Results of the present study showed similarity with those of [21] onion, when seeds were subjected to accelerated ageing treatment.

Regarding the peroxidase enzyme, among the genotypes, Bhima Super recorded the highest peroxidase activity *i.e.*, 0.184 Mm min^{-1} g^{-1}, as well as for P_4(7 days of ageing) *i.e.*, 0.152 Mm min^{-1} g^{-1}. The lowest reduction in peroxidase activity was observed for the genotype N-2-4-1, which was 0.046 Mm min^{-1} g^{-1}; whereas, the highest reduction in peroxidase activity was observed in the variety AGFD and Gujarat white onion-1 (0.076 Mm min^{-1} g^{-1}). It could be due to breakage of cell membrane and subsequent loss of membrane integrity. Results obtained from this study are in accordance with those reported earlier [11, 21, 23 and 24] in carrot, onion, radish and sunflower crops respectively.

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