SHORT COMMUNICATION

Survival of watermelon (*Citrullus lanatus* (Thunb.) Matsum. and Nakai) seeds at 40°C prolonged by prior storage at 30°C

I. Demir* and H.A. van de Venter

Department of Botany, University of Pretoria, Pretoria 0002, South Africa

Abstract

Seeds of watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai var. Congo) were subjected to mild accelerated ageing treatments of 30 and 60 d at 30°C at a moisture content of 7.2%. In comparison to a cold-stored control, normal germination and viability were slightly (but not significantly) decreased by these treatments. Subsequent construction of survival curves during storage at 40°C, at seed moisture contents ranging from 10–18%, revealed that the prior 30°C ageing treatments prolonged survival under these conditions.

Keywords: accelerated ageing, *Citrullus lanatus*, longevity, storage, survival, watermelon

Introduction

Seeds are usually stored at elevated temperatures in the range 30–50°C, to accelerate ageing in seeds for research purposes, in some cases after raising their moisture content (Georghiou *et al*., 1987; Argerich *et al*., 1989; Argerich and Bradford, 1989; Hampton *et al*., 1992). In many areas where watermelon seeds (*Citrullus lanatus*) are produced, they may suffer a similar mild ageing experience before being put into storage. The main aim of this work was to investigate the extent to which a previous ageing treatment might affect the longevity of seeds during subsequent storage.

Materials and methods

Seeds of a single harvest of watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai var. Congo), harvested in May 1997 from fully mature fruits, were obtained from MayFord Quality Seeds (Pretoria, South Africa) in July 1997 and placed in sealed glass jars in a cold room at 2°C. During December 1997 and January 1998, samples which had the same moisture content of 7.2%, fresh mass basis, were randomly separated from the main bulk and placed in sealed glass jars at 30°C for 30 and 60 d after which they were returned to cold storage.

A standard germination test (ISTA, 1996) was conducted on samples of each treatment using four replicates of 100 seeds each on seed lots stored at 30°C. The results for normal seedling counts were as follows: control: 95%; 30 d at 30°C: 94%; 60 d at 30°C: 91%. The results for viability counts in the same test were as follows: control: 98%; 30 d at 30°C: 95%; 60 d at 30°C: 94%. In both cases the differences between treatments were not statistically significant.

Steep-water conductivity of the control, 30 d and 60 d treatments was determined following the procedure of Hampton and TeKrony (1995).

In March 1998 moisture contents of samples of the 30°C and control treatments were adjusted to 10%, 12%, 14%, 16% and 18% (fresh mass basis), respectively, by placing them above water in closed containers at 15°C until predetermined weights were attained. The samples were then hermetically sealed in aluminium foil-polyethylene pouches and placed at 2°C for 7 d. Subsequent seed moisture determinations revealed that moisture contents were within 0.2% of the required levels. Seed moisture content was determined according to the high temperature oven method (130°C, 1 h) of ISTA (1996).

The hermetically sealed individual samples of 100 seeds were placed in a germination cabinet at 40°C. Four replicates of 25 seeds of each treatment at each sampling time were removed at regular intervals and viability determined in rolled paper towels at 25°C. Radicle protrusion of 2 mm, after 14 d, was used as germination criterion. Survival curves were constructed and linearized by plotting probit of

*Correspondence. Present address: Department of Horticulture, Faculty of Agriculture, University of Ankara, 06110, Ankara, Turkey.
Fax: 0990-312-3179119
Email: demir@agri.ankara.edu.tr

https://doi.org/10.1017/S0960258599000264 Published online by Cambridge University Press

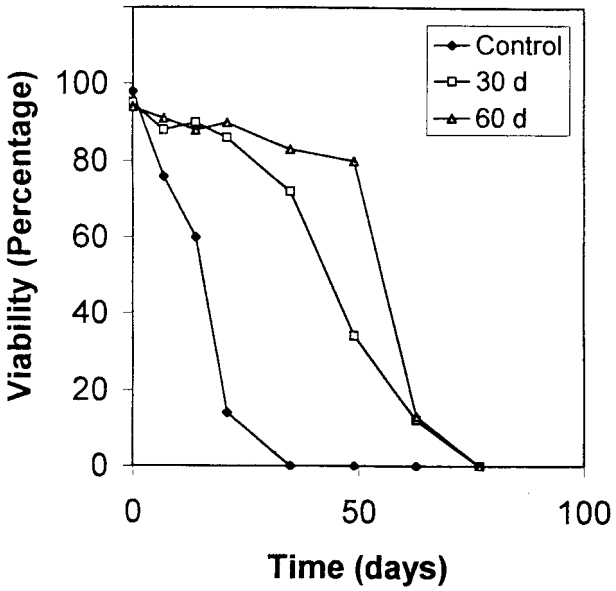

Figure 1. Survival curves for watermelon seeds at 10% moisture content and 40°C preceded by ageing treatments of 30 and 60 d at 30°C at a moisture content of 7.2%. Control seeds were not subjected to prior accelerated ageing.

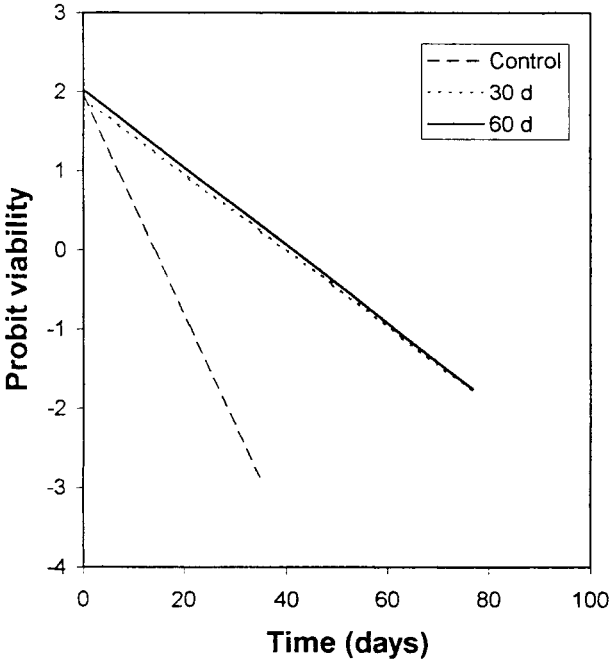

Figure 2. Survival as probit viability for watermelon seeds at 10% moisture content and 40°C preceded by ageing treatments of 30 and 60 d 30°C at a moisture content of 7.2%. Control seeds were not subjected to prior accelerated ageing.

percentage germination against time (Ellis and Roberts, 1980), using SAS/STAT (SAS Institute Inc. Cary, NC, USA 1989 Copyright). Values for K_i (intercept on the *y*-axis), (standard deviation of the individual life spans) and P_{50} (time to 50% viability) were determined (Ellis and Roberts, 1980).

Results

As indicated above, the 30°C ageing treatments had a slight, but statistically non-significant effect on viability and normal germination. The K_i values in Table 1 indicate that they were, generally, similar for the control, 30 d and 60 d treatments within each moisture level. Differences in theoretical initial germination were, therefore, negligible.

The survival curves for the 40°C/10% moisture content treatment (Fig. 1) and the probit plots for the same treatment (Fig. 2) show that both the prior 30 d and 60 d storage treatments at 30°C had similar effects in prolonging subsequent storage at 40°C substantially. Both σ and P_{50} values were increased almost three-fold (Table 1). The same trend was observed at all moisture contents (Table 1), though the differences between the control and 30°C treatments tended to decrease as moisture content increased. Conductivity measurements showed that values were similar for all initial treatments, viz. 12.19 μS cm^{-1} g^{-1} for the control, 11.75 μS cm^{-1} g^{-1} for the 30d/30°C treatment and 11.92 μS cm^{-1} g^{-1} for the 60d/30°C treatment.

Discussion

Ageing watermelon seeds at 7.2% moisture content at 30°C for 30 and 60 d was, obviously, a mild treatment which resulted in small and non-significant decreases in viability. It was nevertheless expected that subsequent survival of the aged seeds at 40°C would be inferior to that of the control. The fact that the 30°C treatments resulted in prolonged survival was an unexpected and surprising result.

No explanation can be offered for the phenomenon. It is inconceivable that heat-shock protein synthesis and thermotolerance induction can proceed in dry seeds. It was postulated that the 30°C treatment may have had a physical effect on membrane structure, but conductivity measurements did not support this hypothesis. The other likely occurrence can be that heat treatment might change water relations, and in turn, repair mechanisms can work; however, we did not compare the control lot to treated ones with respect to the moisture contents they reached at similar relative humidity.

https://doi.org/10.1017/S0960258599000264 Published online by Cambridge University Press

Table 1. Values of K_i, and P_{50} for watermelon seeds stored at 40°C at different moisture contents after ageing treatments of 30 and 60 d at 30°C at a moisture content of 7.2%. Control seeds were not subjected to prior accelerated ageing.

Prior ageing	Moisture content at 40°C (%)	$K_i \pm$ se	σ	P_{50} (d)
Control	10	1.95 ± 0.17	7.25	14.1
30 d	10	1.91 ± 0.20	20.88	40.0
60 d	10	2.02 ± 0.29	20.47	41.2
Control	12	2.30 ± 0.24	3.77	8.0
30 d	12	2.18 ± 0.24	8.78	19.1
60 d	12	2.11 ± 0.29	9.00	18.7
Control	14	2.09 ± 0.22	3.88	8.0
30 d	14	1.99 ± 0.34	9.39	18.6
60 d	14	2.02 ± 0.32	9.50	19.0
Control	16	2.78 ± 0.35	4.05	11.0
30 d	16	2.14 ± 0.34	7.15	15.4
60 d	16	2.02 ± 0.31	6.57	15.63
Control	18	2.59 ± 0.35	3.37	8.5
30 d	18	2.25 ± 0.64	6.51	14.5
60 d	18	2.16 ± 0.35	5.47	11.83

The difference in longevity is unlikely to depend on the maturation level as the seed lot was harvested at full maturity. If it were not so, this might have been revealed by the initial germination percentages. In fact, the germination percentages of seed batches were not significantly different before storage started at 40°C.

The underlying mechanism of the heat-induced longevity described here for watermelon seeds needs to be resolved. Other important questions raised are whether the phenomenon is restricted to watermelon seeds and whether it would be evident at subsequent storage temperatures below 40°C and lower seed moisture contents. Investigations on these aspects are continuing.

References

Argerich, C.A. and Bradford, K.J. (1989) The effects of priming and ageing on seed vigour in tomato. *Journal of Experimental Botany* **40**, 599–607.

Argerich, C.A., Bradford, K.J. and Tarquis, A.M. (1989) The effects of priming and ageing on resistance to deterioration of tomato seeds. *Journal of Experimental Botany* **40**, 593–598.

Ellis, R.H. and Roberts, E.H. (1980) Improved equations for the prediction of seed longevity. *Annals of Botany* **45**, 13–30.

Georghiou, K., Thanos, C.A. and Passam, H.C. (1987) Osmoconditioning as a means of counteracting the ageing of pepper seeds during high-temperature storage. *Annals of Botany* **60**, 279–285.

Hampton, J.G., Johnstone, K.A. and Eua-Umpon, V. (1992) Ageing vigour tests for mungbean and French bean seed lots. *Seed Science and Technology* **20**, 643–653.

Hampton, J.G. and TeKrony, D.M. (1995) *Handbook of vigour test methods* (Third edition) Zurich, International Seed Testing Association.

International Seed Testing Association (1996) International rules for seed testing. Rules 1996. *Seed Science and Technology* **24**, Supplement.

Received 19 August 1998,
accepted after revision 10 February 1999

https://doi.org/10.1017/S0960258599000264 Published online by Cambridge University Press

Electronic Article Submission

To facilitate the publishing process CAB *International* welcomes all accepted articles to be submitted in electronic form.

Please follow the guidelines as detailed below.

Text:

- After acceptance of the article in its final form, submission of the final version on disk should be accompanied by three hard copy printouts. The hard copy printout **must** be identical to the material on the disk. Any small errors spotted on the printed version may be indicated in ink on all 3 copies of the printout.
- CABI will accept Disks in PC or MAC format.
- Disks must be labelled clearly with the author's name, title of the journal and the short title of the article.
- Authors are asked to specify the software package used, including the version, e.g. Word 7.
- The use of formatting codes should be as minimal as possible, however bold, italic, subscript and superscript should be indicated using the facilities of the word processing software.
- Whenever possible tables and equations should also be included in the electronic version. Tables should be supplied as separate pages on the printout.

Illustrations:

- Line artwork should be supplied in electronic form whenever possible.
- All artwork **must** be accompanied by three hard copy printouts, these must match the electronic files.
- Preferred software packages are Adobe Illustrator, Adobe Photoshop, Aldus Freehand, Chemdraw or CorelDraw.
- Preferred formats are TIFF or JPEG, if a TIFF file is not possible save as an EPS or a windows metafile.
- Halftone photographs should be supplied as outlined in the Directions to Contributors at the back of this issue.

In the event that the disk is unusable for any reason The Publisher retains the rights to use the hard copy as supplied by the author to prepare the article for publication. Where there is a difference between the disk and the hard copy, the hard copy will always be the definitive version.