Osmoconditioning and Ageing of Pepper Seeds During Storage

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ABSTRACT

The effects of osmoconditioning on the germination at 15 and 25 °C of pepper (*Capsicum annuum* L.) seeds were studied over a 3-year period with respect to temperature of storage. Untreated seeds stored at 5 °C showed high germinability throughout the entire storage period, whereas untreated seeds stored at 25 °C showed a progressive decline in germinability, especially when assayed at 15 °C. Seeds that had been osmoconditioned prior to storage retained a high level of germinability irrespective of either storage or germination temperatures. When seeds that had been stored at 25 °C were osmoconditioned after storage, there was a significantly higher germinability (assayed at 15 °C) in comparison with the corresponding untreated seeds. Seeds that were osmoconditioned twice (prior to and after storage) germinated in a similar way to those that had been osmoconditioned once only.

Key words: *Capsicum annuum*, sweet pepper, seed, germination, osmoconditioning, priming, storage, ageing.

INTRODUCTION

Although osmoconditioning (priming) has been shown to improve the germination of seeds of many plant species (Heydecker, Higgins and Gulliver, 1973; Heydecker, Higgins and Turner, 1975; Heydecker and Coolbear, 1977; Bradford, 1986), its effects in relation to seed storage are still ill-defined. Generally, where storage of osmoconditioned seed has been carried out, the period of storage has been short, and seeds have been reported either to retain their germinability (Heydecker *et al.*, 1975; Atherton and Farooque, 1983) or to deteriorate (Nakamura and Enohara, 1980; Ely and Heydecker, 1981). In the case of peppers (*Capsicum annuum* L.), the promotive effects of osmoconditioning have been reported to be retained for up to 2 months (Perl and Feder, 1981), to be reduced rapidly on drying of the seeds (Sachs, Cantliffe and Watkins, 1980), or to vary according to the conditions of treatment (O'Sullivan and Bouw, 1984; Aljaro and Wyneken, 1985).

If osmoconditioning is to be of practical application, it is important that any promotive effects on germination should be retained throughout drying and storage. Therefore, Georghiou, Thanos and Passam (1987) examined the interactions between osmoconditioning and storage of pepper seeds at high temperature (35 °C) over a 6-month period and showed that osmoconditioning slowed the rate of seed deterioration under these conditions. In the present paper, we present the results of longer-term experiments in which pepper seeds were osmoconditioned before and/or after storage for up to 3 years at 5 and 25 °C.

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MATERIALS AND METHODS

Sweet pepper (*Capsicum annuum*) seeds were donated by Enza Zaden, The Netherlands, in 1984 (trial 1) and 1985 (trial 2). Osmoconditioning was carried out in darkness at 25 °C for 4 d, using 0·4 M mannitol (Ferak, Berlin) solutions (ψs of osmoticum −0·991 MPa) on samples of 100 seeds per Petri dish (10 cm in diameter, containing 5·5 ml mannitol solution and two sheets of filter paper). Osmoconditioned seeds were washed with deionised water and air-dried for 48 h to their original moisture content (9·8 % on wet basis), in a dark room maintained at 25 ± 0·5 °C. Untreated and osmoconditioned seeds were stored in light-

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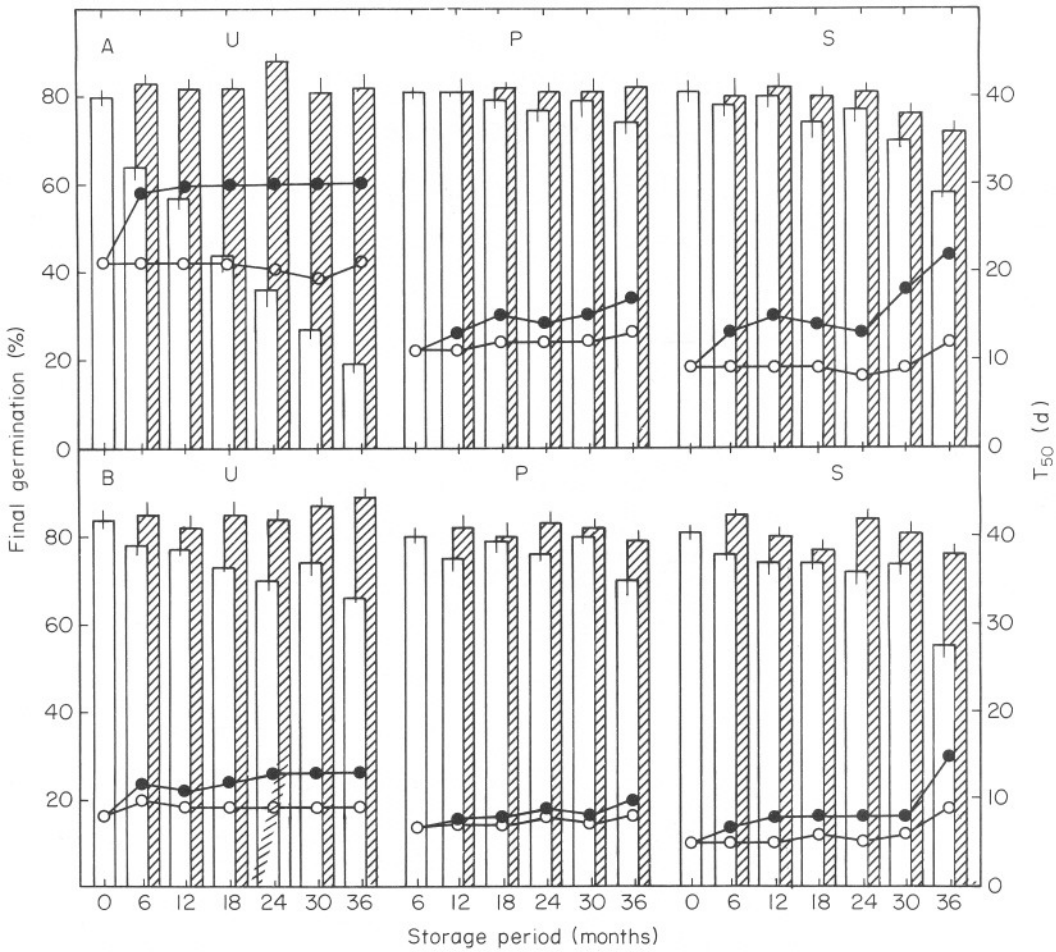

FIG. 1. Final germination (vertical bars), at 15, A, and 25 °C, B, of pepper seeds as a function of storage period. The seeds were tested untreated (U) or osmoconditioned prior (P) and subsequent (S) to storage. Storage temperatures were either 5 (hatched bars) or 25 °C (white bars). The points represent values of T_{50}, the time needed for 50% of final germination (○, ●: seeds stored at 5 and 25 °C, respectively).

and moisture-proof plastic boxes for up to either 3 (trial 1) or 2 years (trial 2). The seed containing boxes were stored in a refrigerator (5±2 °C, for trials 1 and 2), in the dark room (25±0·5 °C, trial 1) and in room temperature conditions (25±3 °C, trial 2). Germination tests were performed in darkness at 15 and 25 °C, as described previously (Georghiou *et al.*, 1987). Germination values are means of six replicates and vertical lines (in figures) represent s.e. T_{50}, the time needed for 50% of final germination was estimated from the median values of the germination time courses.

RESULTS

The rate of germination (T_{50}) and final germination percentage of pepper seeds throughout a 3-year storage period (trial 1, 1984–1987) are shown in Fig. 1. Storage was carried out at 5 and 25 °C and germination was assayed at 15 °C (Fig. 1A) or 25 °C (Fig. 1B). Untreated seed stored at 5 °C retained a high level of germinability throughout the entire storage period, total germination being consistently between 80 and 90% irrespective of assay temperature) and the time to 50% germination (T_{50}) being 8–10 d (assayed at 25 °C) and 18–21 days (assayed at 15 °C). By contrast, untreated seed that was stored at 25 °C showed a decline in germinability during storage which was particularly marked when germination was assayed at 15 °C (Fig. 1A). Thus, the total germination fell from 79·7±2·3 to 19·3±2·3% (15 °C) and from 84·3±1·7 to 66·0±0·7% (25 °C), and the T_{50} increased from 21 to 30 d (15 °C) and from 8 to

13 d (25 °C). Seed that had been osmoconditioned prior to storage retained a high level of germinability throughout the storage period irrespective of storage temperature. Thus, seed stored at 5 °C (Fig. 1A) showed a total germination of about 80% (assayed at both 15 and 25 °C) and the T_{50} values remained constant (7–8 d at 25 °C and 11–13 d at 15 °C). Osmoconditioned seed stored at 25 °C also germinated to a final total of between 70 and 80%, although the T_{50} increased gradually: from 7 to 10 d assayed at 25 °C, and from 11 to 17 d assayed at 15 °C. It may be noted that the T_{50} of seeds conditioned prior to storage (both at 5 and 25 °C) was consistently lower than that of the untreated seeds at both assay temperatures. This indicates that osmoconditioning (*a*) reduced the rate of seed deterioration during storage, principally at 25 °C, and (*b*) brought about a promotion of the original rate of germination which was retained too, although only clearly seen at the lower assay temperature. When osmoconditioning was carried out after storage, the final percentage of germination throughout storage at 5 °C was similar to that of the untreated seed (about 80% irrespective of assay temperature) although the T_{50} was significantly decreased. When storage was carried out at 25 °C and the seed subsequently conditioned the final percentage of germination was higher than for the corresponding untreated seed, although by 36 months of storage total germination had fallen to $57{\cdot}7 \pm 1{\cdot}7$% (15 °C) and $54{\cdot}7 \pm 3{\cdot}2$% (25 °C), and the T_{50} had correspondingly risen to 23 and 15 d, respectively. This indicates that although osmoconditioning after storage at 25 °C reversed to a large extent the deterioration in germinability, the efficacy of reversal became less as storage time increased.

The results of the second storage trial, this time of 2 years duration (1985–1987), are given in Fig. 2. As in the first trial, seed stored at 5 °C retained a high percentage of total germination irrespective of treatment and temperature of assay. Untreated seed stored at 25 °C showed a decline in total germination during storage, particularly when assayed at 15 °C, and an increase in T_{50}. Similar to the results of the first trial, seed that had been osmoconditioned prior to or following storage at 25 °C showed total percentage germination values similar to that of the original seed prior to storage, and the rate of germination, especially at 15 °C, was increased, as shown by the lower T_{50} values.

It may be noted that the seed batch used in the second trial had a lower total germination at the start of the experiment than that used for trial 1 (cf. Figs 1 and 2); at 15 °C total germination was $66{\cdot}7 \pm 1{\cdot}9$% (trial 2) in comparison with $79{\cdot}7 \pm 2{\cdot}3$% (trial 1). This indicated that the seed of the second trial was physiologically inferior to that used for the first. In trial 2 (Fig. 2), osmoconditioning of the seed, either before or after storage, not only prevented or reversed the decline in germinability during storage at 25 °C (and observed particularly when assayed at 15 °C), but in the case of pre-storage osmoconditioning even raised the percentage of total germination above that of the untreated seed prior to storage, thus bringing about an improvement in germinability over that of the original seed which was retained throughout storage.

In a further experiment (Fig. 2), seeds were osmoconditioned twice: first before storage at 5 or 25 °C, and secondly immediately following storage and prior to assay. The total percentage of germination and the T_{50} in each case were similar to those of seeds conditioned once after storage.

DISCUSSION

The present results clearly show that although pepper seeds may be satisfactorily stored under refrigerated conditions (5 °C) for up to at least 3 years, at ambient temperatures (25 °C) there is a progressive loss of germinability which is reflected in a lower total germination and an increased T_{50}. Loss of germinability is particularly evident at sub-optimal germination temperatures (15 °C) and in the field is a cause of erratic seedling emergence and poor stand establishment (Gerson and Honma, 1978; Sachs *et al.*, 1980; O'Sullivan and Bouw, 1984).

Osmoconditioning of pepper seeds prior to storage has two principal effects: (*a*) it increases the rate of germination (lower T_{50}). This effect, most clearly seen when seed is germinated at 15 °C, is retained throughout storage; (*b*) it reduces the rate of seed deterioration at 25 °C, shown by a higher total germination and lower T_{50}.

These findings are in agreement with previous reports on the promotion of seed germination by osmoconditioning (Heydecker *et al.*, 1973, 1975; Heydecker and Coolbear, 1977; Bradford, 1986) and on the effects of osmoconditioning on short-term seed storage (Perl and Feder, 1981; Georghiou *et al.*, 1987). The demonstration here that these beneficial effects of osmoconditioning may be retained for as long as 3 years is unique and may indicate a practical use for this process in seed storage.

The physiological effects of osmoconditioning would appear to depend on the time of treatment. The retention of a high level of total germination and a low T_{50} (at 15 °C) in seeds that had been osmoconditioned prior to storage indicates that here, osmoconditioning may have caused a delay in the ageing processes of the seeds, which obviously would be higher at 25 than 5 °C

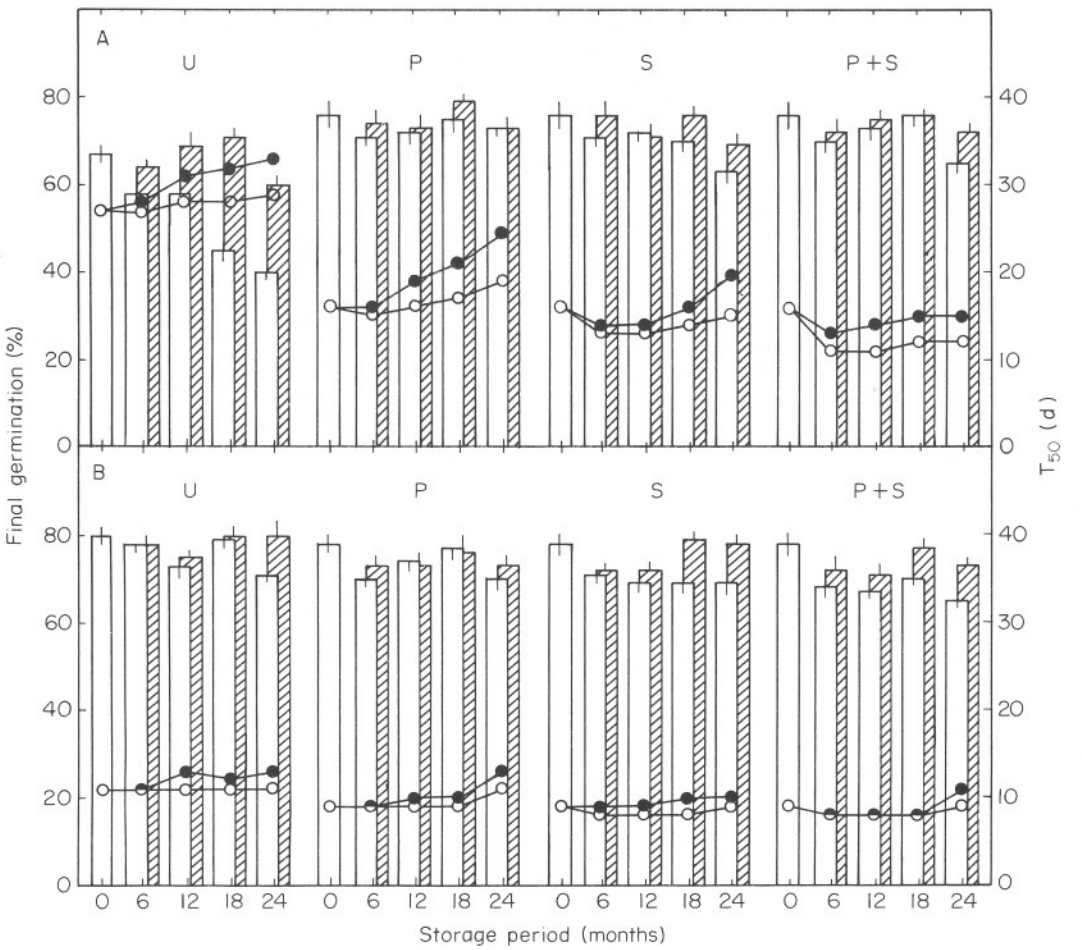

FIG. 2. Final germination (vertical bars), at 15, A, and 25 °C, B, of pepper seeds as a function of storage period. Seeds were tested untreated (U) or osmoconditioned prior (P), subsequent (S) and both prior and subsequent (P + S) to storage. Storage temperatures were either 5 (hatched bars) or 25 °C (white bars). The points represent values of T_{50}, the time needed for 50% of final germination (○, ●: seeds stored at 5 and 25 °C, respectively).

(Roberts, 1979, 1981). Maintenance of such so-called seed vigour has been previously shown by the consistently higher rates of germination (lower T_{50}) of seeds that had been conditioned prior to storage, in comparison with those of untreated seed (Woodstock, 1973; Savino, Haigh and Leo, 1979). However, the increase in total germination and reduction in T_{50} caused by osmoconditioning after storage at 25 °C indicates that osmoconditioning may also be linked to repair processes of the type reported for other species (Sanchez and Miguel, 1983; Ward and Powell, 1983; Burgass and Powell, 1984). Since the ability of post-storage osmoconditioning to reverse deterioration decreases with increasing storage time (especially apparent when germination is assayed at 15 °C), for storage purposes a pre-storage osmoconditioning treatment is preferable to a post-storage one.

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