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Ultra dry seed storage- a cost effective method for conservation of germplasm and commercial seeds of papaya

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ABSTRACT

Studies on ultra dry seed storage were undertaken in papaya to find out its effect on seed longevity under ambient and controlled temperatures. Fresh seeds of cvs. Arka Prabhath and Arka Surya dried to 4.1% and 4.2% moisture content, respectively could maintain initial viability and vigour up to 42 months and 36 months in cv. Arka Prabhath and cv. Arka Surya respectively, under ambient temperature. However, ultra dry seeds of Sunrise Solo with 3.6% m.c. showed reduced germination immediately after drying than seeds with 8% m.c. indicating reduction in m.c. below 4% may be harmful. Whereas seeds with moisture content of 7.5-8.1% showed decline in seed viability and vigour after 18 months of storage under ambient temperature and rapid decline was noticed after 30 months of storage, reaching 50% viability in cv. Arka Prabhath, 17% in cv. Arka Surya and 0% in Sunrise Solo at 42 months. At 15°C seeds with 7-8% moisture content showed no decline in viability and vigour after 42 months of storage in Arka Prabhath and Arka Surya and upto 66 months in Sunrise Solo. Whereas, ultra dry seeds of Arka Prabhath and Arka Surya could maintain more than 85% germination up to 72 months. Similarly, ultra dry seeds of Sunrise Solo maintained its germination and vigour up to 72 months. Similar trend was observed for field emergence.

Key words: *Carica papaya*, seed longerity, germination, vigour.

INTRODUCTION

Seed moisture content or relative humidity of seed storage environment and storage temperature are the two important factors that determine the longevity of seeds in storage. Hitherto, seed scientists have given more importance to storage temperature than to seed moisture content. Some studies have indicated that seed moisture content is more important than temperature in extending viability of seeds especially under tropical conditions (Justice and Bass, 1). For long term storage, the seeds are dried to 5-6% moisture content and stored at sub zero temperatures (FAO/IPGRI, 2). Drying seeds to below 5% was considered as detrimental to seed viability. But studies have shown that seeds can be dried to below 5% and in some species even below 1% without affecting the viability as well as genetic fidelity of the species (Ellis *et al.,* 3). Such ultra dry seeds can be stored for more than 8-10 years under ambient temperature (sub zero condition in temperate region in winter to 50°C in tropical region during summer). The longevity of ultra dry seeds can be further extended by keeping at lower temperature (10-15°C). This method will eliminate or avoid the requirement for low temperature storage. Low temperature storage in tropical developing countries cannot work efficiently and effectively because of frequent power cuts. As a result, risks of losing valuable seed material is very high. Ultra dry seed storage offers a great hope under such situations with minimum cost. However, before committing valuable germplasm to storage at such low seed moisture, the potential benefit and risk of ultra-drying to seeds longevity must be evaluated as some reports have indicated that drying to very low water contents damage seeds. Hence, the study was taken up with papaya, an important seed propagated fruit crop which is assumed to lose viability quickly under ambient conditions.

MATERIALS AND METHODS

Three cultivars of papaya, viz., Arka Surya, Arka Prabhath and Sunrise Solo were selected for this study. Fresh seeds of cv. Arka Surya were obtained from the seed crop raised at KVK, Hirehalli by harvesting fruits at full maturity stage whereas that of Arka Prabhath and Sunrise Solo were obtained from Division of fruit crops, IIHR, Bengaluru. The seeds were cleaned and graded to remove chaffy and undersized seeds using seed blower.

Seed quality parameters such as germination and vigour of fresh seeds with initial moisture content of 8-10%, were assessed before subjecting them for ultra low drying. Seeds were ultra dried using activated blue silica gel in 1:3 ratio (seed: silica gel); partially saturated silica gel was replaced by activated silica gel 2-3 times during drying. Seeds

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of cvs. Arka Prabhath, Arka Surya and Sunrise Solo were dried to 4.1%, 4.2% and 3.6% moisture levels, respectively. Further reduction in moisture content was not possible with silica gel. This drying process took around 30-40 days to achieve ultra low moisture levels. These ultra dry seeds as well as seeds with normal moisture content i.e., 7-8% in papaya, were packed in poly aluminium pouches, heat sealed and stored at ambient room temperatures ranging from (average min. temperature 23°C and average max. temperature of 28°C) and at a constant controlled temperature of 15°C. In order to avoid exposure of seeds to outside humidity at the time of sampling seeds for quality tests at regular intervals, as many packets as the number of observations were made so that each time one packet of seed could be used completely. In case of Arka Prabhath and Arka Surya, the seeds with normal moisture were stored up to 54 months only with an assumption that the seeds may not survive beyond 54 months based on the available literature, whereas ultra dry seeds were stored up to 72 months. In case of Sunrise Solo, both ultra dry and normal moisture seeds were stored up to 72 months as we had extra seeds with normal moisture content.

The seed viability, vigour, field emergence and seed moisture of ultra dry seed were monitored along with seeds with normal moisture at regular intervals for 74 months. Hot air oven method as described by ISTA (4) was followed for seed moisture estimation. Two replicates of 2 gram each were dried at 103°C for 17 hours as papaya seeds are rich in oil content. Moisture content was expressed on a fresh weight basis. Germination test was conducted using between paper method with 4 replications of 50 seeds each. Before keeping the ultra dry seeds for germination, the seeds were brought to equilibrium moisture with the surrounding air RH of 75-80% by exposing the seeds for 48 h to avoid imbibitional damage. The first count was recorded on 15th day and the final count was made on 20th day after incubation (Yogeesha *et al.*, 5). For seedling vigour estimation, mean seedling length of 10 normal seedlings (cm) obtained randomly at the end of germination test period, was measured and this value was multiplied by germination % (Abdul Baki and Anderson 6). Field emergence test was done with 4 replicates of 50 seeds each in pro trays containing decomposed coco peat. The final count on seedling emergence was recorded on 20th day after sowing and expressed in percentage.

Statistical analyses were performed separately for each cultivar using two way analysis of variance, and means were compared using critical difference at 0.01 level of significance.

RESULTS AND DISCUSSION

Seed quality evaluated at 6 months interval during storage starting from initial evaluation i.e. just before storage, are presented and discussed here.

Ultra-dry seeds of papaya tested for seed quality at 6 months interval during storage along with seeds of higher moisture contents showed no marked reduction in seed quality compared to initial quality in cvs. Arka Prabhath and Arka Surya up to 12 months storage under both controlled and ambient temperatures (Fig. 1-8). In fact, there was a little increase in germination and other seed quality attributes up to 12 months as the fresh seeds exhibit dormancy which breaks down upon storage (Yogeesha *et al.*, 5). The first sign of seed deterioration was observed after 18 months of storage in Arka Surya seeds with higher moisture content which showed slow rate of germination as reflected in first count (57%) but the final germination was at par with ultra dry seed, which showed no sign of deterioration even under ambient storage. But in case of Arka Prabhath, there was no decline in viability and vigour irrespective of moisture content and storage temperatures up to 18 months. However, at 24 months seeds of cv. Arka Prabhath with 8% moisture content and stored at ambient temperature showed slow rate of germination compared to ultra dry seed but the final germination was on par with seeds with ultra low moisture (4%). The ultra dry seeds showed germination of 99% under ambient conditions. In case of cv. Arka Surya seeds with 8.1% moisture content and stored at ambient temperature showed not only slow rate of germination but also significantly lower final germination percentage than seeds with ultra low moisture (4%) after 24 months of storage. The ultra dry seeds showed germination of 92% under ambient conditions. After 30 months of storage, seeds of cv. Arka Prabhath with 8% moisture content and stored at ambient condition showed significantly slow rate of germination and lower final germination compared to ultra dry seed (4%). The ultra dry seeds showed germination of 93% under ambient temperature. The rate of decline in seed germination was faster in seeds with normal moisture after 30 months storage both in Arka Prabhath and Arka Surya reaching 88% and 74% at 30 months, 70% and 66% at 36 months, 50% and 13% at 42 months and finally zero (in both cultivars) after 48 months, respectively whereas the ultra dry seed maintained very high germination (76%) and vigour (first count) even after 54 months of storage under ambient temperature in both varieties. Seed stored at controlled temperature of 15^{o}C, maintained very high seed quality even after 48 months irrespective of seed moisture. At 15^{0}C, ultra dry seeds had

>87% germination in both Arka Prabhath and Arka Surya after 72 months of storage but under ambient temperature it was 19% and 5% in Arka Prabhath and Arka Surya, respectively. Similar trend was observed with respect to field emergence from the beginning of storage till 72 months in both the varieties.

Contrarily, in case of cv. Sunrise Solo ultra dry seeds (m.c. 3.6%) showed significant reduction in

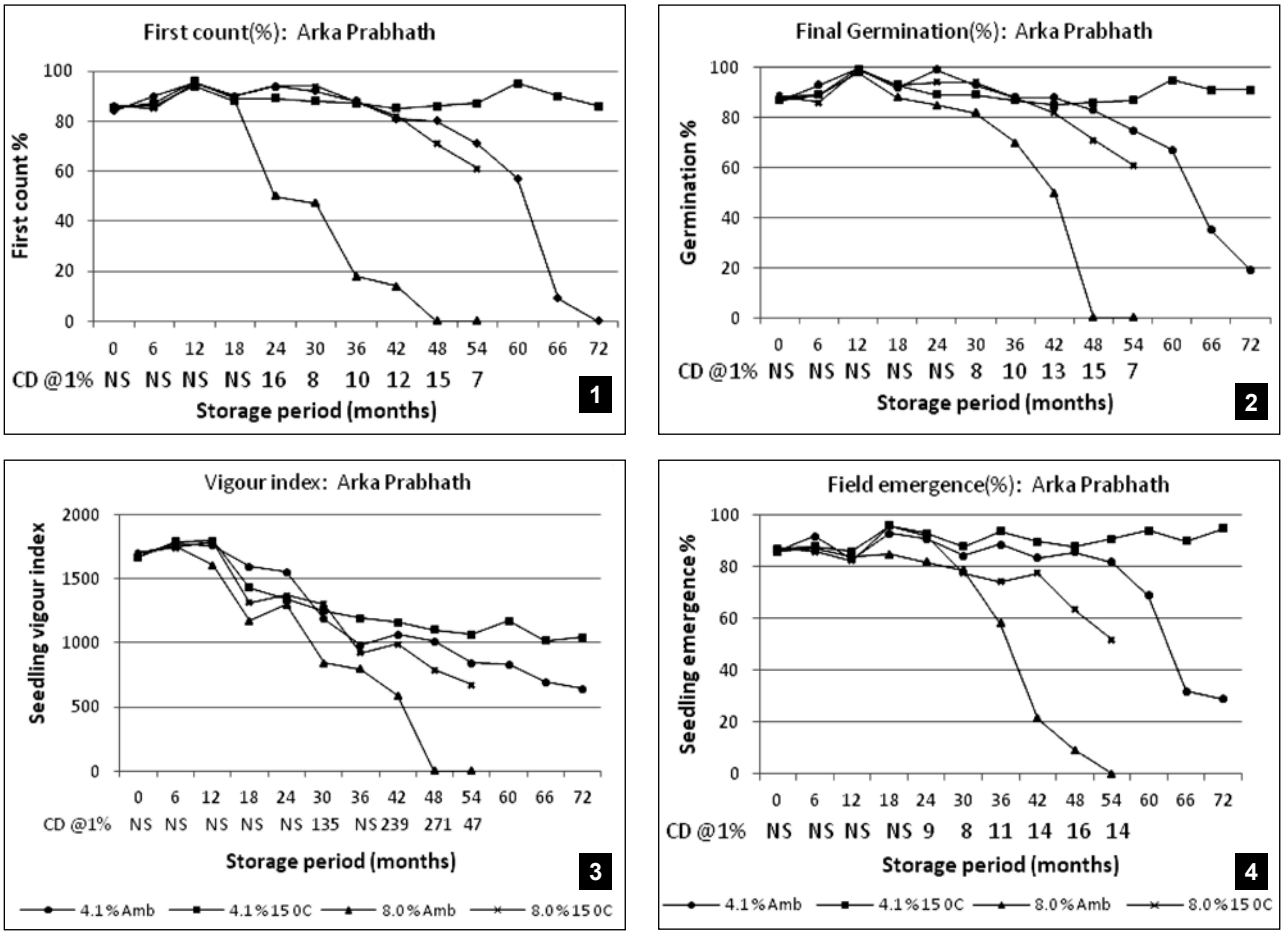
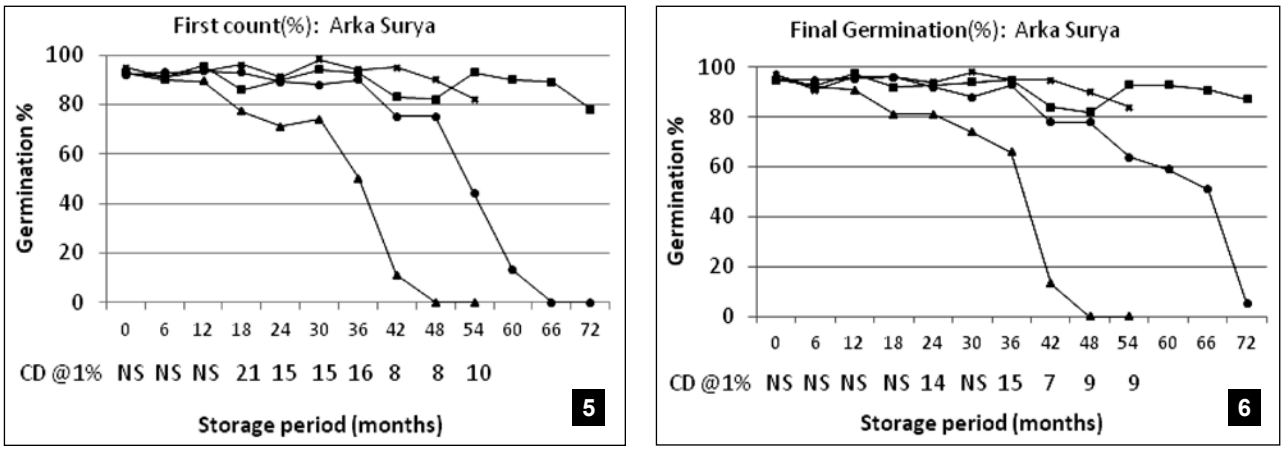


Fig. 1-4. Seed quality as affected by seed moisture and storage temperature over 72 months of storage in cv. Arka Prabhath (CD values at 1% level of significance are given below X-axis; each value corresponds to storage period on X axis)



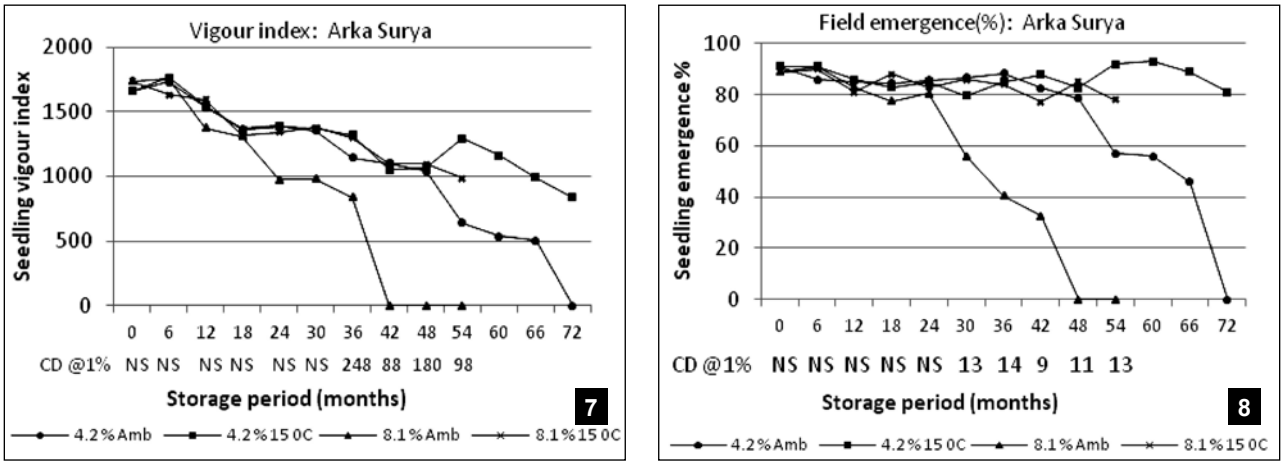


Fig. 5-8. Seed quality as affected by seed moisture and storage temperature over 72 months of storage in cv. Arka Surya (CD values at 1% level of significance are given below X-axis; each value corresponds to storage period on X axis).

germination and vigour compared to that of seeds with normal moisture content even before storage (Fig. 9-12). The initial first count, germination % and seedling vigour index in ultra dry Sunrise Solo seeds was 60%, 60% and 820, respectively, which were much lower than that of seeds with normal moisture content; first count and germination of 88% and seedling vigour index of 1100. This difference persisted till 18 months of storage. After 24 months of storage, seeds with normal moisture content stored at ambient temperature showed decline in original seed quality, but it was still better than ultra dry seed. Ultra dry seed maintained the seed quality which they exhibited immediately after drying till 42 months under ambient temperature and up to 72 months at 15°C. But seeds with normal moisture stored under ambient temperature showed rapid decline after 30 months with a germination of 62% at 30 months to 0% at 42 months of storage whereas, at 15°C these seeds maintained germination above 80% up to 66 months but declined to below 80% at 72 months. Similar trend was noticed for other quality parameters, such as first count %, seedling vigour index and field emergence %. The seed vigour expressed as first count % was lower in normal seeds at 72 months of storage than that of ultra dry seeds at 15°C. During initial period of storage a little increase in germination and other quality parameters was observed similar to Arka Prabhath and Arka Surya that could be attributed to seed dormancy.

Studies carried out so far on ultra dry seed storage in various crops have thrown contradicting results. Drying seed beyond critical moisture content provided no additional benefit to longevity (Ellis *et al*. 7) and may even accelerate seed aging rate (Ellis *et al*. 7, Chai *et al*. 8). In our study with papaya, it may partly be correct in cv. Sun rise Solo as the ultra dry seeds with 3.6% moisture showed reduced germination and vigour than seeds with normal moisture initially under ambient temperature but as the storage duration advanced, the seeds with higher moisture content lost germination and vigour rapidly than ultra dry seeds. This shows that the critical moisture level lies somewhere between 3.5 to 4%, as other two cultivars Arka Surya and Arka Prabhath with 4.1 and 4.2 % m.c maintained germination and vigour up to 60 months. Seed moisture of 2.5–4.5% at ambient temperature was recommended for long term storage of leak, Chinese cabbage, tomato, radish, eggplant and cucumber (Zheng *et al*. 9). Similarly, our study clearly shows that ultra dry storage offers potential benefits in extending longevity of papaya seed under ambient temperatures. Ultra dry seeds maintained high viability and vigour even after 60 and 54 months, respectively in Arka Prabhath and Arka Surya. Seeds with normal moisture content showed decline in viability and vigour after 18 months storage under ambient temperatures, although little varietal variations to this effect was observed. Lettuce seed stored at room temperature with 6-7% moisture content gave 91% germination after 9 years, but only 2.5% germination after 15 years; whereas seed with 2.5% moisture content gave 40% germination after 20 years (Nakamura, 10). Onion and China aster seeds stored at room temperature with 3.5-4.0% moisture content maintained original germination even after 60 months (Yogeesha *et al*. 11).

Seed vigour expressed as seedling vigour index showed steady decline in germination in all categories of seeds and storage temperatures both in Arka

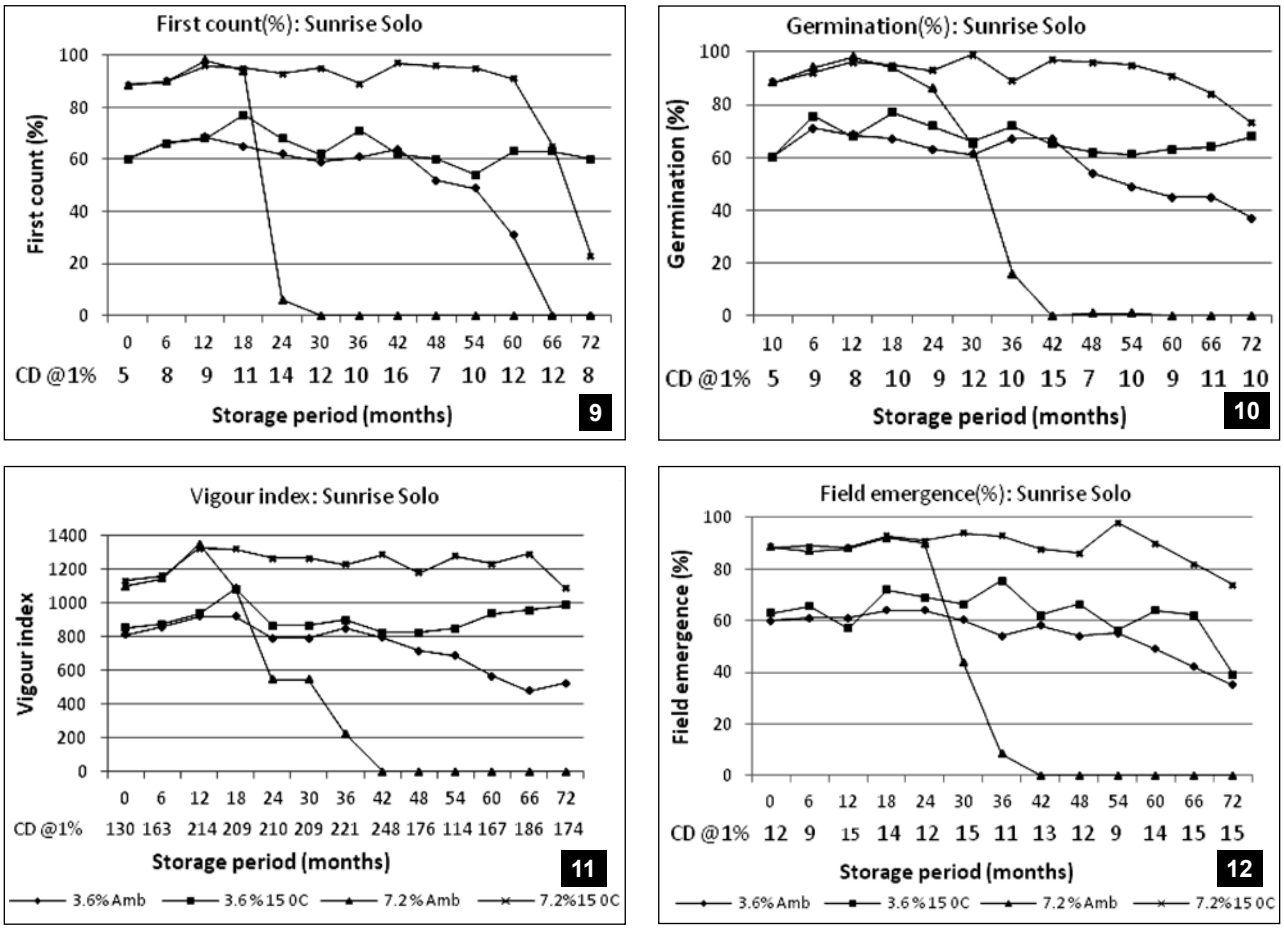


Fig. 9-12. Seed quality as affected by seed moisture and storage temperature over 72 months of storage in cv. Sunrise Solo (CD values at 1% level of significance are given below X-axis; each value corresponds to storage period on X axis).

Prabhath and Arka Surya, but decline was faster in seeds with higher moisture than in ultra dry seeds, Similarly, the decline was more in seeds stored at ambient temperature than seeds stored at 15°C. In case of Sunrise Solo, seedling vigour index declined faster in seeds with higher moisture whereas ultra dry seeds showed little decline. The vigour index expressed in terms of first count and field emergence % followed similar trend as germination percentage in all the three varieties during entire storage period. Vigour level and antioxidant activities in ultra dry seeds of *Ammopiptanthus mongolica* were higher than control seeds, indicating the beneficial effect of ultra dry storage (Yi *et al*. 12). Seed moisture content of the ultra dry and control seeds did not change during storage with a variation of + 0.5 % indicating moisture vapour proof characteristic of aluminium foil used in this study as a packaging material.

Then the next question is whether critical moisture level exists for papaya seed or not. The results revealed that moisture content below 4% may be detrimental to seed viability as it reduced the germination in cv. Sunrise Solo with 3.6% m.c. In case of Arka Prabhath and Arka Surya seeds, moisture content >4.0% was found ideal as it did not affect seed quality. In another study initiated with several other horticultural crops and the preliminary results of which indicated that extreme desiccation lead to no effect on viability in many species, whereas it had had detrimental effect in few species (data not published). Critical moisture contents for some species were reported previously by Ellis *et al.* (7), Shen and Qi (13), Mira *et al.* (14). But in some other species, ultra low moisture was neither detrimental nor beneficial to seed longevity (Hong *et al.* 15, Yi *et al.* 16 and Mira *et al.* 14). Several other studies have reported that some species have no critical water content as they were dried to even below 1% moisture level with beneficial effect on longevity under varied temperatures (Yogeesha *et. al.* 10, Ellis

et al. 17, Zheng *et al.* 8; Yi *et al*. 18, Tong and Han, 19, Sastry *et al.* 20). These studies have clearly shown that some species can withstand extreme desiccation with or without beneficial effect on longevity, whereas some species show sensitivity to extreme desiccation with detrimental effects below a critical moisture level. Hence, it can be said that the seed moisture content of 4-5% is ideal for medium to long term storage of papaya seeds under ambient temperature.

The results clearly established the fact that seeds of papaya can be dried to as low as 4.1% moisture level using silica gel without affecting seed quality and stored under ambient conditions for 60 months without affecting seed viability and vigour. This technique will completely avoid use of cold storage facility in short to medium term seed storage. Further, the viability of ultra dry seed of papaya can be extended beyond 6 years if stored at 15°C.

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