Chapter 41

Effect of Ultra-Drying on *Ex Situ* Seed Conservation

Neeta Singh, Anurudh K. Singh and
Baldev S. Dhillon
National Bureau of Plant Genetic Resources
IARI Campus, New Delhi – 110012, India

Summary

Currently seed germplasm is dried to 3–7% moisture content (mc) before storage at sub-zero temperatures. In the present study, seeds were dried to different low moisture contents and stored under various conditions, to identify any increase in seed longevity. Seeds were dried to 1.7% in safflower (*Carthamus tinctorius* L.) and 2–3.4% in chickpea (*Cicer arietinum* L.), castor (*Ricinus communis* L.), sesame (*Sesamum indicum* L.), niger (*Guizotia abyssinica* L.F. Cass.) groundnut (*Arachis hypogaea* L.) and cotton (*Gossypium hirsutum* L.). Seed conditioned to various mc's were stored hermetically at temperatures of -20°C, 5°C and ambient. Seed germination and vigour was assessed at 3, 4 or 6 months intervals in each crop during storage in these environments. In chickpea and cotton, drying from 5 to 3% had little or no beneficial effect on seed germination after 60 months of storage at ambient temperature. In sesame, drying from 4.5% to 2% mc improved germination after 60 months of storage. In castor, drying below 6% to 5% and 3.2% was progressively beneficial to germination at 43 months of storage both at ambient and 4°C. In niger and safflower, drying below 6% to 4% and 3.8%, respectively, improved germination after 43 and 38 months of storage at ambient temperature, respectively. However, further drying to 2% and 1.7% mc, respectively, had no effect on germination. In groundnut, varieties SB 11 and Girnar-1 had better germination on drying from 6% to 2%, after 36 months at ambient temperature. No detrimental effects of ultra-drying were observed in any of the crops. At -20°C, no significant changes in germination were observed in any of the crops. The results show that the optimum moisture content for storability of the crops at ambient temperature is less than 6% in all of the crops studied.

Introduction

Moisture content and storage temperature are the two key factors affecting the longevity of seeds. The internationally recommended standards are that seeds be dried to 5±2% moisture content prior to sub-zero storage (FAO/IPGRI, 1994). However, experiments using a number of different species have shown that longevity may be improved if seeds are dried to less than the recommended value (Ellis *et al.*, 1988, 1989, 1990, 1995). Experiments have also shown that there are limits to the beneficial effects of drying, such that drying below an optimum or critical moisture content will not improve longevity and may have detrimental effects on seed longevity during storage (Nutile, 1964; Nakamura, 1975; Woodstock *et al.*, 1976; Vertucci *et al.*, 1994). The idea of ultra-drying seeds (i.e., drying to moisture contents less than 5%) was introduced as a means to reduce or eliminate the need for refrigeration (IBPGR, 1992; Ellis *et al.*, 1989, 1990; FAO/IPGRI, 1994). However, before committing valuable germplasm to storage at such low seed moisture, the potential benefit and risk of ultra-drying to seed longevity must be further evaluated. In the present investigations, the effect of ultra-drying of seeds to various low moisture levels on longevity was studied.

Materials and Methods

Freshly harvested seeds of chickpea *(Cicer arietinum* L. cv. Pusa 372), cotton (*Gossypium hirsutum* L. cv. Pusa 8–6) and sesame (*Sesamum indicum* L.) were obtained in 1995 and those of safflower (*Carthamus tinctorius* L. cv. Annigeri-1), niger (*Guizotia abyssinica (*L.f.) Cass. cv. IGP-76), castor (*Ricinus communis* L. cv. GCH-4), and groundnut (*Arachis hypogaea* L. cv., SB-11, and Girnar-1) were obtained in 1997. The experiment was started for different crops in their respective year of harvest. Seeds were adjusted to different moisture levels by drying over regularly regenerated silica gel in a desiccator or humidifying at 25°C for varying periods of time. Different moisture contents were achieved by removing seeds from the dessicator after intervals varying from 7–40 d, and then sealing them in laminated aluminium foil packets. Moisture contents were determined by the high (chickpea) and low (safflower, sesame, niger, groundnut, castor and cotton) constant temperature oven methods prescribed by the International Seed Testing Association (ISTA, 1993) and are expressed on a dry weight basis. The hermetically sealed packets were kept at -20°C, 5°C, 60°C and ambient conditions of our laboratory in New Delhi (25–45° C). To determine the effect of moisture content and temperature on seed longevity, percentage germination was evaluated at intervals of three, four or six months, depending on the crop species and storage temperature. The 60°C sub samples were drawn at regular intervals during ageing. Prior to germination, seeds were humidified slowly in a germinator for two days. Germination tests were conducted following ISTA rules (ISTA, 1985). Three replicates, each of 100 seeds were used in each germination test, though the results were not subjected to any statistical analysis.

Results and Discussion

The initial moisture contents ranged from 8.4% in chickpea to 4.1% in sesame seeds. The seeds could be dried to 1.7% moisture content in safflower, to 2% in castor, groundnut, sesame and chickpea, 2.3% in niger and 3% in cotton. The potential of ultra-dry technology (drying below 5% moisture content) was studied by evaluating the short- and long-term effects of drying to low moisture content on seed survival in seven crop species. The effect of ultra-drying was evaluated over the short term by storing seeds at different moisture contents (mc) at 60°C, and over the long term by storing the seeds at both the recommended storage temperatures of -20°C and 4°C (FAO/IPGRI, 1994) and at ambient temperatures. Results for 60°C storage are presented here for

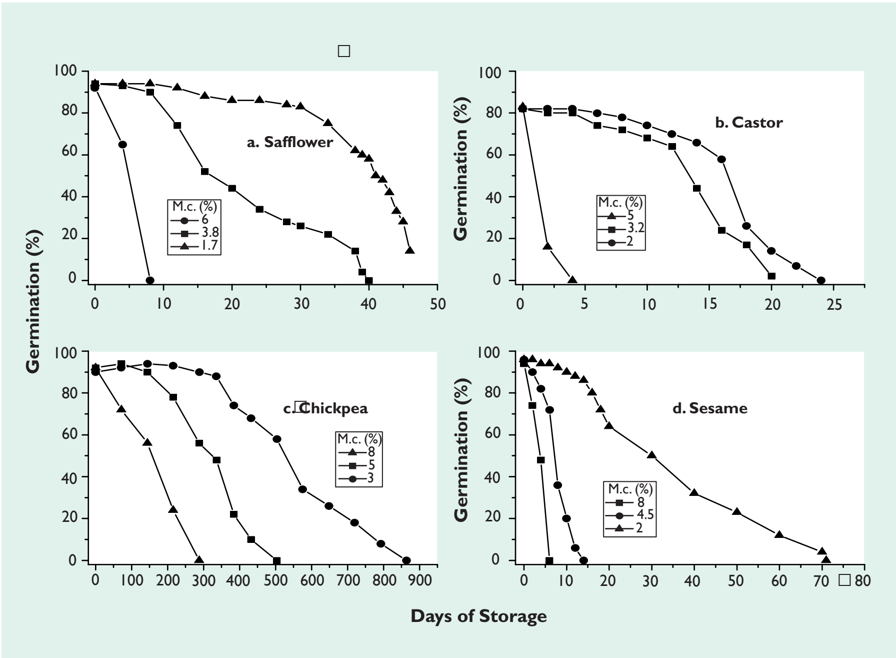

Figure 41.1 Seed storability of various crops at 60°C and different moisture contents.

four crop species *viz.*, chickpea, safflower, sesame and castor. Seeds deteriorated quickly when stored at 60°C (Figure 41.1). The decline in germination percentage was fastest for seeds stored with higher moisture content (8% for chickpea and sesame, 6% for safflower, and 5% for castor). At the lowest moisture content studied, seed germination dropped to 0 within 864, 71, 46, and 24 days in chickpea, sesame, safflower, and castor respectively (Figure 41.1). The long-term effects of ultra-drying seeds were evaluated by a comparison of the germination of seed dried to different moisture levels and stored at -20°C, 4°C and ambient temperature. Here, preliminary data are presented, based on a storage duration of a maximum of 3–5 years in various crops. Percentage germination of seeds at moisture content above 5% and stored at ambient temperature declined as storage duration increased (Figure 41.2). As has been shown previously (Ellis *et al.*, 1989, 1990; Nutile, 1964; Nakamura, 1975; Woodstock *et al.*, 1976, 1983; Zheng, 1994; Zheng, *et al.*, 1998), the moisture content at which seeds were stored had a major effect on the final germination percentage (Table 41.1). In chickpea and cotton, drying from 5% to 3% mc had little or no beneficial effect on seed survival after 60 months of storage at ambient temperature. In castor, drying below 6% to 5% and 3.2%, was progressively beneficial to survival at 43 months of storage both at ambient and at 4°C. In niger and safflower, drying below 6% to 4% and

Table 41.1 **Germination percentage of various crops after storage at 4°C or ambient temperatures and at various moisture contents**

Crop	Storage Period (Months)	Initial Viability %	Moisture Content % (d.wt)	% Germ. at Storage Temperature	
				Ambient	+4°C
Chickpea	60	99	8	0	94
			5	90	100
			3	94	100
Safflower	38	100	6	1	84
			3.8	98	100
			1.7	100	100
Niger	43	97	8	0	94
			6	0	96
			4	100	100
			2.3	100	98
Groundnut cv. Girnar-1	36	98	6.2	0	100
			4.8	98	100
			2	98	100
Groundnut cv. SB-11	36	100	6	0	96
			4.3	76	100
			2.4	94	100
Sesame	53	96	10	0	72
			4.5	80	90
			2	88	90
Castor	43	84	6	0	52
			5	36	60
			3.2	64	64
Cotton	60	88	10	0	60
			5	69	83
			3	70	84
			2	70	84

3.8%, respectively, improved survival after 43 and 38 months of storage at ambient temperature, respectively. However, further drying to 2.3% and 1.7% mc, respectively, had no effect on germination. In groundnut, cultivar SB-11 and Girnar-1 had better germination on drying from 6% and 6.2% to 2.4% and 2%, respectively, after 36 months at ambient temperature. In sesame, drying from 4.5% to 2% improved germination from 80 to 88% after 53 months of storage. There was no consistent evidence for deterioration in seeds at low (less then 6%) moisture and 4°C. Deterioration was observed in castor up to the moisture level of 3.2%. However, the benefits of ultra-drying were more marked at ambient than at 4°C, while at -20°C (data not presented), it was nil or negligible during the period of investigation. Longer storage periods are required to obtain more reliable information regarding the interaction of moisture content, temperature and seed longevity and the true potential of ultra-dry technology. How long ultra-dry seeds survive at ambient temperature compared to the refrigerated conditions cannot be evaluated

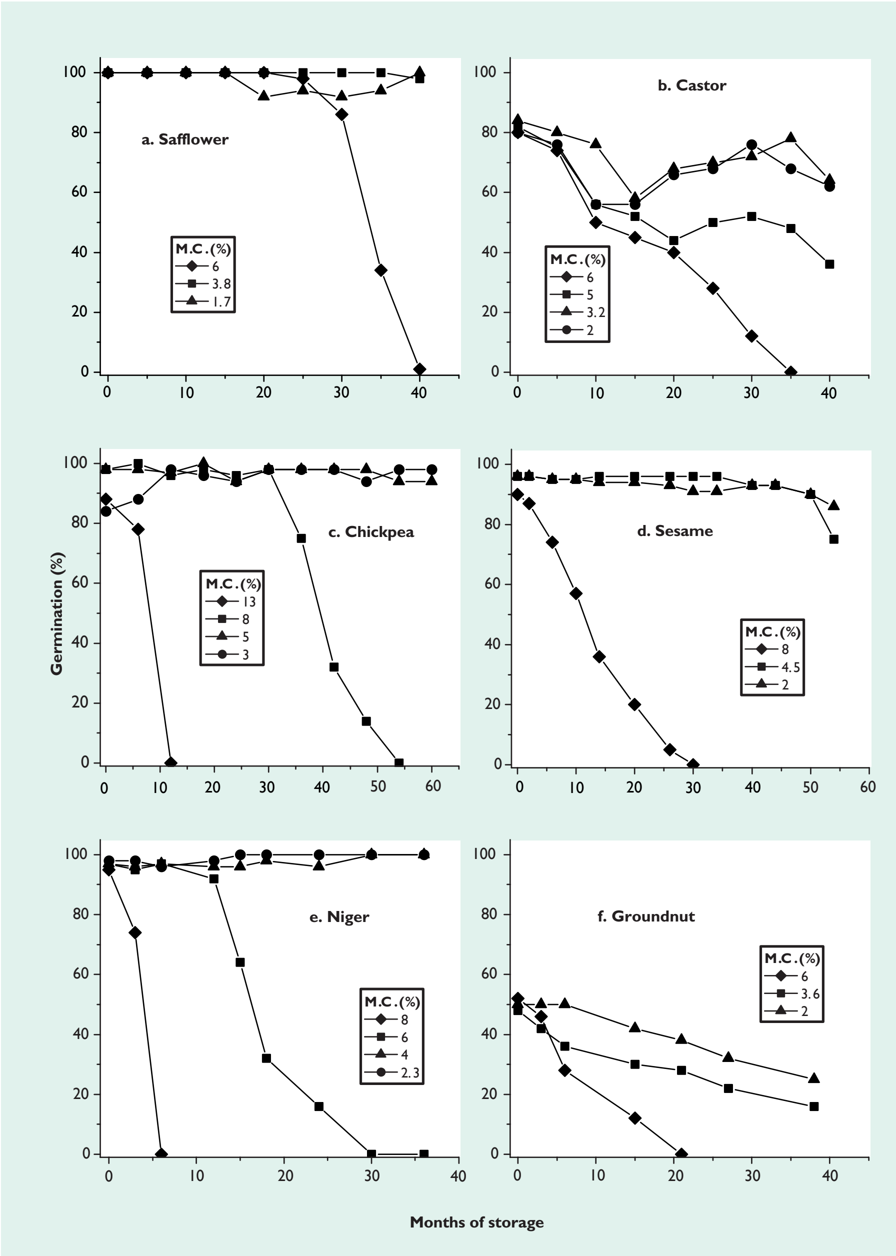

Figure 41.2 Seed storability of various crops at ambient temperature and different moisture contents.

until deterioration at ambient temperature, 4°C and -20° C is detected at all the moisture levels. Nevertheless, results obtained in this study confirm earlier reports of a clear benefit of drying to low moisture content when seeds are stored at ambient temperature. However, the extent of improvement in longevity appears to be species specific. Contrary to earlier reports (Kosar and Thompson, 1957; Ellis *et al.*, 1989, 1990; Vertucci and Roos, 1990; Carpenter and Boucher, 1992; Vertucci *et al.*, 1994; Dickie and Smith, 1995; Chai *et al.*, 1998), no detrimental effects of ultra-drying were observed in any of the crops. At ambient storage, most species showed maximum germination when seeds were stored at moistures less than 4% (Table 41.1), with the corresponding moisture level dependent on the crop species. This value (at which germination is maximum) is within the range of the FAO/IPGRI recommendation of 5–3% moisture (FAO/IPGRI, 1994) for some species (castor and cotton), but for others (safflower and sesame) is below the 3% level recommended in the current standard. Based on this data, we conclude that drying below the currently recommended seed moisture level prolongs the life spans of seeds in some crops studied in this experiment, at least under ambient storage.

References

Carpenter, W.J. and Boucher, J.F. (1992). Temperature requirements for the storage and germination of *Delphinium* × *cultorum* seed. *Hortscience* **27**(**9**): 989–992.

Chai, J., Ma, R., Li, L. and Du, Y. (1998). Optimum moisture content of seeds stored at ambient temperatures. *Seed Science Research* **8**: Suppl. 1, 23–28.

Dickie, J.B. and Smith, R.S. (1995). Observations on the survival of seeds of *Agathis* spp. stored at low moisture contents and temperatures. *Seed Science Research* **5**: 5–14.

Ellis, R.H., Hong, T.D. and Roberts, E.H. (1988). A low moisture content limit to logarithmic relations between seed moisture content and longevity. *Annals of Botany* **61**: 405–408.

Ellis, R.H., Hong, T.D. and Roberts, E.H. (1989). A comparison of low moisture content limit to the logarithmic relation between seed moisture and longevity in 12 species. *Annals of Botany* **63**: 601–611.

Ellis, R.H., Hong, T.D. and Roberts, E.H. (1995). Survival and vigour of lettuce and sunflower seeds stored at low and very low moisture contents. *Annals of Botany* **76**: 521–534.

Ellis, R.H., Hong, T.D. Roberts, E.H. and Tao, K.L. (1990). Low moisture content limits to relations between seed longevity and moisture. *Annals of Botany* **65**: 493–504.

FAO/IPGRI (1994). Genebank Standards. FAO/IPGRI, Rome, Italy. 13 pp.

IBPGR (1992). Annual Report 1991. International Board for Plant Genetic Resources, Rome, Italy.

ISTA (1985). International Seed Testing Association. International rules for seed testing. Rules 1985. *Seed Science and Technology* **13**: 299–513.

ISTA (1993). International Seed Testing Association. International rules for seed testing, 1993. *Seed Science and Technology* **21**: Supplement, 296 pp.

Kosar, W.F. and Thompson, R.C. (1957). Influence of storage humidity on dormancy and longevity of lettuce seed. *Proceedings of the American Society of Horticultural Science* **70**: 273–276.

Nakamura, S. (1975). The most appropriate moisture content of seeds for their long life span. *Seed Science and Technology* **3**: 747–759.

Nutile G.E. (1964). Effect of desiccation on viability of seeds. *Crop Science* **4**: 325–328.

Vertucci, C.W. and Roos, E.E. (1990). Theoretical basis of protocols for seed storage. *Plant Physiology* **94**: 1019–1023.

Vertucci, C.W., Roos, E.E and Crane, J. (1994). Theoretical basis of protocols for seed storage. III. Optimum moisture content for pea seeds stored at different temperatures. *Annals of Botany* **74**: 531–540.

Woodstock, L.W., Simkin, J. and Schroeder, E. (1976). Freeze drying to improve seed storability. *Seed Science and Technology* **4**: 301–311.

Woodstock, L.W., Maxon, S., Faul, K. and Bass, L. (1983) Use of freeze drying and acetone impregnation with natural and synthetic antioxidants to improve storability of onion, pepper and parsley seeds. *Journal of American Society for Horticultural Science* **108**: 692–696.

Zheng, G.H. (1994) Ultra dry seed storage: possible improved strategies and technology for germplasm conservation. *Chinese Biodiversity* **2**: 61–65.

Zheng, G.H., Jing, X.M. and Tao, K.L. (1998). Ultra dry seed storage cuts cost of gene bank. *Nature* **393**: 223–224.