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Germination of pearl millet (*Pennisetum glaucum*) seeds stored under different conditions for six years

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Summary

Storage conditions can affect seed viability Seven pearl millet (*Pennisetum glaucum* (L) R Br) cultivars were kept for six years under three storage conditions ambient [15 40 C 20 90% relative humidity (RH)] short-term (18 20 C 30 40% RH) and medium term (4 C 20% RH) six types of containers were used glass and plastic bottles aluminum foil and paper packets and polyethylene and cloth bags Germination of the seeds was studied at six month intervals for six years Under ambient conditions germination was completely lost within five years in all treatments Under short-term storage conditions germination of seeds was significantly reduced compared to that under medium term conditions where the germination was more than 80% Significant genotypic differences were observed larger and denser seeds survived longer than others Viability of the early maturing cultivars was lower probably due to grain weathering consequent to delayed harvesting Seeds stored in moisture proof containers like glass and plastic bottles aluminum foil and polyethylene bags retained viability longer than in the moisture permeable cloth bags and paper packets

Introduction

Pearl millet [*Pennisetum glaucum* (L) R Br] is an important grain and forage crop in the semi-arid tropics of Asia and Africa The seeds are stored for varying periods depending on the need Low temperature and relative humidity/seed moisture content are known to increase seed longevity (Roberts, 1972) Standards for short, medium and long-term storage of seeds have been recommended to ensure maximum seed longevity under each condition (IBPGR, 1976) However, they are often difficult to achieve due to financial and other constraints in many developing countries and so seeds are often stored under improvised conditions using locally available resources and materials Moore and Roos (1982) studied the viability of pearl millet seeds stored under different temperature and relative humidity conditions, loss of germination was faster in seeds stored at high temperature and high relative humidity Since not much published information is available on pearl millet seed viability during storage, we initiated an experiment in December, 1983 to study the influence of three storage conditions and six containers, commonly used at ICRISAT, on viability of seven diverse

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Table 1. Origin and characteristics of the pearl millet cultivars used in seed germination study.

Cultivar	Origin	Type of material*	Time to flowering (days ± SE)	1000 seed mass (g ± SE)	Endosperm texture**	Initial seed	
						Moisture content (% ± SE)	Germination (% ± SE)
IP 4021	India	LR	33 ± 0.9	6.6 ± 0.3	5	9.2 ± 0.3	91 ± 4.2
IP 5427	Niger	LR	74 ± 2.0	9.6 ± 0.1	4	9.1 ± 0.2	95 ± 1.4
IP 8329	India	LR	74 ± 0.3	3.3 ± 0.2	6	9.8 ± 0.1	89 ± 1.4
IP 9411	Ghana	LR	42 ± 2.1	12.0 ± 0.2	4	8.8 ± 0.1	96 ± 2.8
BJ 104	India	HB	49 ± 3.2	5.5 ± 0.1	6	9.7 ± 0.1	98 ± 0.0
ICMV 1	India	IC	53 ± 2.7	10.3 ± 0.2	3	9.9 ± 0.1	90 ± 0.0
D 24-2	Niger	WD	70 ± 0.6	7.0 ± 0.2	3	8.8 ± 0.1	81 ± 5.8

* LR = landrace, HB = commercial hybrid, IC = improved cultivar, WD = weedy type
** Scored on 1–9 scale; 1, extremely hard, 9, extremely soft (see IBPGR, ICRISAT, 1981)

pearl millet cultivars.

Materials and methods

Seeds of seven diverse pearl millet cultivars; four germplasm accessions, IP 4021, IP 5427, IP 8329, IP 9411; one hybrid, BJ 104; one improved variety, ICMV 1; and one weedy form, D 24-2 were used in the study. These were chosen to provide a range of flowering time (33–74 d), grain size (3–12 mg) and endosperm texture (soft–hard) based on the data obtained from the routine germplasm evaluation (table 1). The seeds of all seven cultivars used in this study were produced under uniform crop growing conditions during June-October, 1983 at ICRISAT center, Patancheru. Before storage, the seeds were treated with a mixture of commercial formulations of Aldrex (10% Aldrin) and Thiram (Tetra methyl thiram disulphide, 50% wettable powder) in 3:1 ratio at the rate of 2 g/kg seeds. Depending on seed size, 50–150 g of seeds were stored for each treatment. Six types of containers were used for the seed storage: (1) glass bottles with screw caps, (2) plastic bottles with inner lids and screw caps, (3) zipper seal polyethylene bags, (4) aluminum foil packets (unsealed but closed with paper clips), (5) metal fold paper packets and (6) cloth bags. All the containers kept in aluminum trays were stored under three conditions; (1) ambient (15–40 C and 20–90% RH), (2) short-term (18–20 C and 30–40% RH) and (3) medium-term (4 C and 20% RH). The containers and storage conditions were not replicated.

To monitor viability during storage, 50 seeds from each treatment were sampled for germination tests at six-month intervals for six years until December 1989, when the experiment was concluded due to complete loss of seed germination in some treatments. For the final germination tests, 200 seeds as four replicates each of 50 seeds were used. All the germination tests were conducted on moist filter papers (Whatman 181) in Petri dishes at 25 C and germination counts taken after 7 days, following

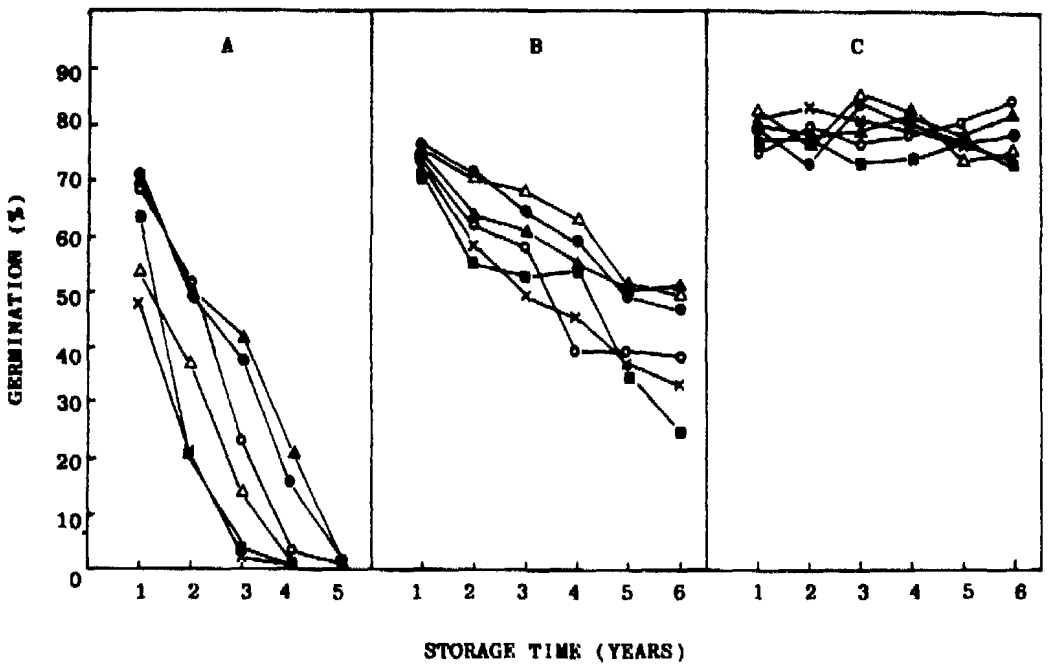

Figure 1. Effect of storage conditions and containers on viability of pearl millet seeds stored for six years. Storage conditions, A. ambient (15–40 °C, 20–90% RH), B. short-term (18–20 °C, 30–40% RH), C. medium-term (4 °C, 20% RH). Containers, (○) glass bottle, (▲) plastic bottle, (●) polyethylene bag, (△) aluminum foil packet, (■) paper packet, (×) cloth bag.

the recommendations of the International Seed Testing Association (ISTA, 1985). Since storage conditions and containers were not replicated, the cultivars in each storage condition and containers were analysed as a completely randomized design for the final evaluation.

Results

Seeds of all cultivars stored under ambient conditions lost germination completely within five years, irrespective of the container in which they were stored. The decline in germination was faster in seeds stored in paper packets and cloth bags, compared to other containers (figure 1).

Under the short-term conditions, the mean percentage germination at the end of the sixth year was highest in IP 9411 (54%) followed by ICMV 1 (49%) and IP 5427 (48%). Seeds of BJ 104 and IP 4021 deteriorated more than any other cultivar and the mean percentage germination was 26% and 32%, respectively (table 2).

The mean germination of the seeds stored under medium-term conditions was significantly higher (78%) than that under short-term conditions (40%) after six years storage. As in short-term storage, IP 9411, IP 5427 and ICMV 1 retained maximum germinability (87%, 86% and 83%, respectively), whereas germination was lowest in IP 4021 (64%) and BJ 104 (69%).

Table 2. Effect of storage conditions and containers on seed germination of seven pearl millet cultivars after 6 years of storage.

	IP 4021	IP 5427	IP 8329	IP 9411	BJ 104	ICMV 1	D 24 :	
AMBIENT (15–40 C, 20–90% RH)								
Germination was lost completely in all the treatments								
SHORT-TERM (18–20 C, 30–40% RH)								
Glass bottle	25	45	35	60	28	44	29	38	2.3
Plastic bottle	42	65	41	58	31	87	33	51	6.1
Polyethylene bag	62	46	48	58	42	39	37	47	6.3
Aluminum foil pkt.	29	60	49	67	29	72	44	50	5.4
Paper packet	15	26	23	34	17	25	23	23	3.3
Cloth bag	21	47	47	46	13	27	30	33	5.5
Cultivar mean	32	48	41	54	26	49	32		
MEDIUM-TERM (4 C, 20% RH)								
Glass bottle	78	89	86	94	75	76	88	84	3.6
Plastic bottle	60	94	82	89	79	90	79	82	3.2
Polyethylene bag	69	90	75	84	66	75	80	77	5.3
Aluminum foil pkt.	53	76	78	86	63	87	80	75	3.0
Paper packet	69	81	75	88	68	83	61	75	4.8
Cloth bag	57	84	76	78	67	87	77	75	3.4
Cultivar mean	64	86	79	87	69	83	77		

Among the containers used under short-term conditions, averaged over the cultivars, germination was lowest in seeds stored in paper packets (23%) and cloth bags (33%), while relatively good germination was seen in plastic bottles (51%), aluminum foil packets (50%) and polyethylene bags (47%). Under medium-term conditions, seed germination averaged over the cultivars was 84% in glass bottles and 82% in plastic bottles. Seeds stored in aluminum foil packets however, lost germination relatively faster.

Discussion

Seed germination was completely lost under ambient conditions in all the cultivars after five years storage, while it was still high after six years under medium-term storage. Germination however, was significantly reduced under short-term conditions after six years storage. Lopes, Giaretta, Silva and Fagundes (1983) also reported a reduction in germination of pearl millet seeds stored for 2 years under ambient conditions compared to storage under controlled conditions (9–15 C and 48–50% RH), and Moore and Roos (1982) found the half-viability period (p_{50}) of pearl millet seeds to be about 128 weeks when stored at 32.2 C and 50% RH, 25.5 weeks at 21.1 C

and 70% RH, and 2.6 weeks at 32.2 C and 90% RH. Roos, Sowa and Burton (1978) studied seed deterioration in four pearl millet lines stored under accelerated aging conditions for up to 44 weeks. Seeds stored at 32 C and 90% RH and 21 C and 90% RH rapidly lost germination capacity (in 3 to 12 weeks), while seeds stored at 32 C and 70% RH and 21 C and 70% RH lost germination more slowly.

Maintaining seeds at low moisture content, after they are dried and prepared for storage depends on the nature and properties of the containers used (Mumford and Freire, 1984). Differences in performance of the various containers observed in this experiment depends on the ability of the material to prevent or resist moisture entering the container and therefore the seeds. The relative humidity at Patancheru varied enormously between 20% and 90%. Cloth and paper bags are porous and less resistant to the passage of moisture, therefore the seeds stored in them adjusted to the changes in relative humidity of the surrounding environment (Bass, 1973) and lost germination at a faster rate. Plastic bottles, laminated aluminum foil and polyethylene bags are moisture-proof and hence retain the initial low seed moisture content and thus seed germination is lost more slowly. Although glass bottles are impervious to moisture, seeds stored in them under short-term conditions lost germination quickly probably because the lids were not air-tight.

Under similar storage conditions, the cultivars IP 9411, IP 5427 and ICMV 1 showed maximum germination, IP 8329 was intermediate, while BJ 104 and IP 4021 deteriorated at a faster rate. It appears that days to flowering, which is related to attaining physiological maturity of seeds (Fussell and Pearson, 1980), and seed size influenced viability during storage. The cultivars BJ 104 and IP 4021 were among the earliest to flower, while IP 9411, IP 5427 and ICMV 1 had larger seeds compared to other cultivars used in this study (table 1).

Seeds attain maximum vigor and full germination capacity at physiological maturity (Harrington, 1972), which is widely considered as the optimum time to harvest the crop to obtain high quality seeds. After physiological maturity, seeds begin to age on the mother plant and any delay in harvesting would result in weathering and loss of much of the initial seed quality. Late-harvested barley (*Hordeum vulgare* L.) seeds lost germination faster compared to others (Shands, Janish and Dickson, 1967). In our experiment, although all cultivars were grown under similar conditions, since they were harvested at the same time (approximately 120 days after sowing), seeds of the early flowering and early maturing cultivars would have been subjected to natural weathering for a longer time in the prevailing warm and humid conditions. This could have resulted in reduced longevity during subsequent storage. The slow deterioration noticed in cultivars with larger and denser seeds in this study is consistent with findings of Gorecki and Jagielski (1982) in pea (*Pisum sativum* L.), yellow lupin (*Lupinus luteus* L.) and broad bean (*Vicia faba* L.).

The results indicate that active/working collections of pearl millet germplasm or breeding stocks which need a carryover of up to 5 years can be safely stored under medium-term conditions. As seen here, viability in all the cultivars was still good even after 6 years of storage at 4 C and 20% RH. When relative humidity of the storage

environment is controlled, the use of moisture-proof containers seems unwarrented. Seed stocks which need a carryover of 2 to 3 years can be stored under short-term conditions in plastic bottles, polyethylene bags or aluminum foil packets.

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