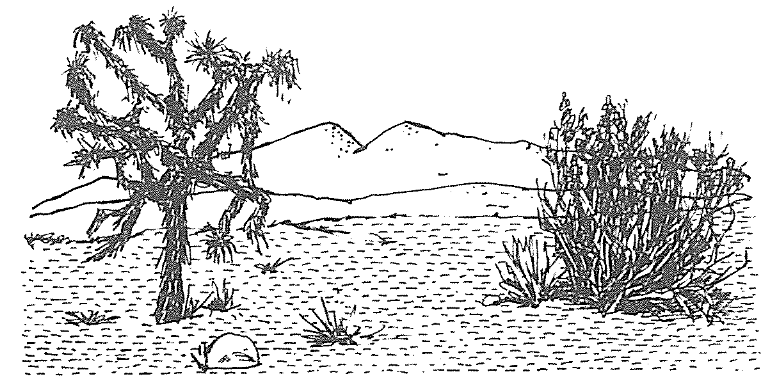
Burgess L. Kay
Department of Agronomy and Range Science
University of California
Davis, CA 95616



Mojave Revegetation Notes

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LONG-TERM STORAGE OF DESERT SHRUB SEED

Burgess L. Kay, Walter L. Graves, and James A. Young 1/

Abstract

Seed of desert plants, needed for sowing following disturbance of desert soils, may not be available for collection when needed due to the erratic seed production by wild desert plants. Therefore native seed banks are desirable to assure seed availability. In this study seed from 115 desert species, mostly native shrubs, were kept in four storage environments. In three treatments, dried seeds were placed in hermetically sealed glass jars and then stored at -15C, 4C, or room temperature. In the fourth treatment seeds were stored in typical warehouse conditions. For most plants, seed life was significantly shorter in warehouse storage. Some seeds were stored for as long as fourteen years under one or more conditions without any loss of viability. Sealed storage of dry seed, rather than storage temperature, appears to be the most important factor for increasing storage life.

1/ Wildland Seeding Specialist, Department of Agronomy and Range Science, University of California, Davis; Farm Advisor, UC Cooperative Extension, San Diego County; and Range Scientist, USDA Agricultural Research Service, Reno, Nevada.

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Introduction

Increased use of the California deserts has resulted in degradation of the plant communities and loss of the soil (10,13,15). Typical disruptive activities are agriculture, subdivisions, mining, overgrazing, roads, and excessive use by off-road-vehicles. Natural recovery to original soil conditions and plant cover in these arid environments is on the order of tens to hundreds of years (12,16). Soil loss could best be reduced by arid land revegetation (7). Native shrubs are the most promising for this purpose (2,7,9,18).

Establishing native plants will require considerable amounts of seed, which must be gathered from local plants. However, wild plants may produce seed only on unusually wet years. Therefore it would be advantageous to maintain a seed bank of seeds collected in these good years.

This study was undertaken to determine the practicality of storing desert shrub seed, and to determine the best long term storage conditions.

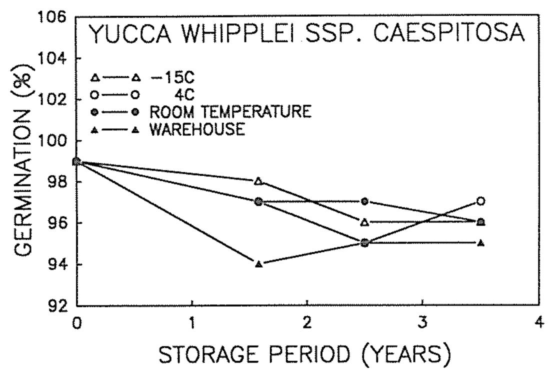
Materials and Methods

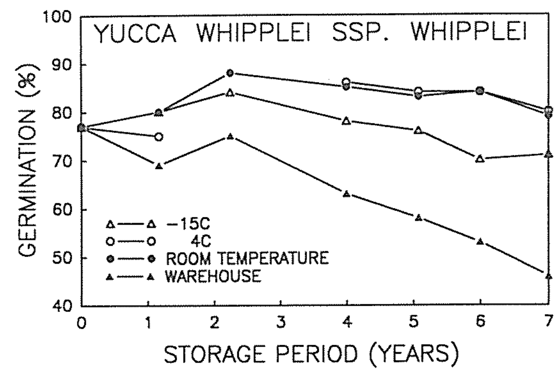
Seeds (fruits) were hand collected from wild plants, mostly in the Mojave and Colorado deserts in the period 1972 through 1982. Because of the different maturity seasons for different species, collection dates ranged from May to December. Collection dates, common and scientific names, and the approximate collection locations for the 115 species appear in Table 1.

Following field collection, seeds were stored temporarily in cloth or paper bags under low relative humidity/high temperature conditions typical of the Central Valley of California during the summer. Samples were cleaned within a few weeks to remove all non-seed material such as twigs, dirt, and miscellaneous flower parts. They were then treated with the insecticide "PHOSTOX" (aluminum phosphide).

Initial germination tests of all species consisted of four replications of 100 seeds. Seeds were placed on damp paper toweling, which was rolled and stored upright in a growth chamber maintained at 15C. Test conditions were maintained for 28 days and germination percentages were recorded every seven days. Seeds with radicles of 5mm or longer were counted as germinated and removed at each weekly inspection.

Seeds to be placed under sealed storage conditions were dried at 35C for 6 days before sealing in the fall of the collection year. Also included in the one-gallon glass jar used for storage was 90 grams of color-indicator silica gel for moisture control and as an indicator of moisture unexpectedly getting into the jar. These jars were then stored at either room temperature





(actually a warehouse where temperatures fluctuated seasonally), refrigerated (4C), or frozen (-15C). In the fourth storage condition, which served as a control, seeds were placed in cloth or paper bags and stored in an open warehouse (California Crop Improvement Association warehouse, U.C.-Davis).

Seeds were sampled for germination at approximately yearly intervals as indicated by the points on the figures appearing later in this paper. Four replications of 50 seeds were used for each measurement. Optimum germination temperatures for many species were concurrently determined by the methods of Young and Evans (17) and used for subsequent tests. The optimum germination temperature for most species was 15C (Table 3). Exceptions are noted under "comments" in Table 2. A statistical analaysis, made after the first 111 months of the initial years' collection, has been reported elsewhere (8).

Not all collections were of sufficient quantity to include in the long-term study, but the information on initial germination and number of seeds per pound of these collections are included in Table 2.

Results and Discussion

The results of seed storage treatments are shown in the attached figures. Individual graphs are arranged alphabetically for each of the 115 species tested. Because these are wild collections, grown under less than optimal conditions, many are of poor initial germination.

Sealed storage of dry seed appears to be the most important factor for maintaining seed viability. This finding agrees with other studies which have shown that low moisture content of stored seed is a critical factor in keeping seed alive (1,3,4,11).

Some seeds stored well under all conditions for at least five years. Species of Atriplex generally stored well even in the warehouse, and special storage conditions would only be required for long terms.

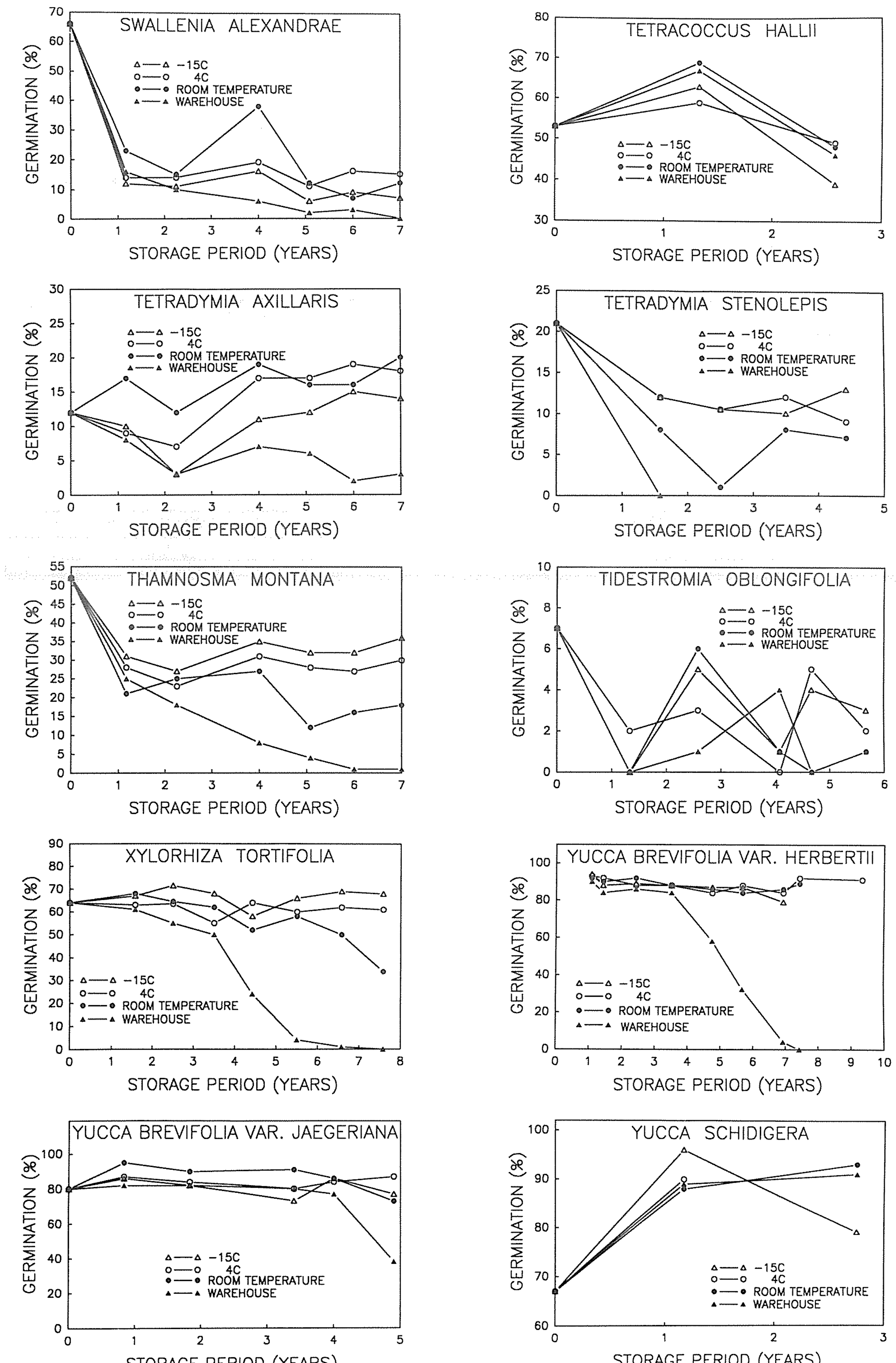
Cold temperatures prolonged the seed storage life of a few species. Among the most notable were Chrysothamnus sp., Haplopappus sp., Lepidospartum, and Thamnosma.

Freezing temperatures seem to benefit Ephedra nevadensis, E. viridis, and Eriophyllum confertifolium.

Seeds of a few species did not store well under any of the storage conditions. These included two shrubs (Acamptopappus sphaerocephalus and Stephanomeria pauciflora), one tree (Olneya tesota), and all three of the grasses (Hilaria rigida, Stipa speciosa, and Swallenia alexandrae).

Table 1. Scientific and common names, and date and site of collection of seeds included in this study.

Scientific name	Common name	Date	Location
Abronia villosa var. aurita	Sand verbena	May 2 79	T16S, R20E, SBM
Acacia gregii	Catclaw acacia	Aug 14 80	T16N, R12E, SBM
Acamptopappus shockleyi	Goldenhead	May 21 79	T12S, R37E, MDM
Acamptopappus sphaerocephalus var. hirtellus	Goldenhead	Aug 17 73	T26S, R37E, MDM
Agave deserti	Desert agave	Jun 17 82	T12S, R 7E, SBM
Ambrosia dumosa	Burrow bush	Jun 23 73	T27N, R37E, MDM
Ambrosia eriocentra	Bur bush	Jul 1 80	T20N, R10E, SBM
Amphipappus fremontii	Chaff-bush	May 18 79	T14S, R39E, MDM
Asclepias subulata	Milkweed	Jun 16 81	T5S, R21E, SBM
Astragalus lentiginosus var. micans	Shining locoweed	Jun 28 80	T10S, R39E, MDM
Atriplex canescens	4-wing saltbush	Dec 15 73	T26S, R37E, MDM
Atriplex confertifolia	Shadscale		T18S, R39E, MDM
Atriplex hymenelytra	Desert Holly	May 5 80	T18S, R42E, MDM
Atriplex lentiformis	Quailbush	May 3 82	T15S, R 8E, SBM
Atriplex polycarpa	Desert saltbush	Dec 15 73	T29S, R37E, MDM
Atriplex spinifera	Spiney saltbush	Jun 12 81	T7N, R 7W, SBM
Atriplex torreyi	Torrey's saltbush	Nov 25 81	T15S, R36E, MDM
Bebbia juncea var. aspera	Sweetbush	May 21 79	T14S, R38E, MDM
Brickellia incana	Brickell bush	Jul 2 80	T12N, R13E, SBM
Brickellia multiflora	Gum-leaved brickellia	Nov 25 81	T16S, R40E, MDM
Brickellia oblongifolia var. linifolia	Narrow-leaved Brickellia	Jun 28 80	T10S, R40E, MDM
Camissonia cardiophylla ssp. robusta	Heart-leaved primrose	Jun 16 77	T21S, R45E, MDM
Cassia armata	Desert senna	Aug 17 73	T30S, R37E, MDM
Castilleja sp.	Indian paintbrush	Aug 12 80	T16S, R39E, MDM
Ceratoides lanata	Winterfat	Aug 16 73	T27S, R37E, MDM
Cercidium floridum	Palo verde	Jun 15 81	T7S, R10E, SBM
Chilopsis linearis	Desert willow	Jul 31 81	T7N, R12E, SBM
Chrysothamnus nauseosus ssp. hololeucus	Rubber rabbitbrush	Dec 18 73	T32S, R36E, MDM
Chrysothamnus nauseosus ssp. mohavensis	Mojave rubber rabbitbrush	Nov 20 79	T32S, R36E, MDM
Chrysothamnus paniculatus	Desert rabbitbrush	Nov 20 79	T32S, R35E, MDM
Chrysothamnus teretifolius	Needleleaved rabbitbrush	Nov 21 79	T21S, R37E, MDM
Chrysothamnus vicidiflorus	Sticky-leaved rabbitbrush	Nov 21 79	T16S, R40E, MDM
Coleogyne ramosissima	Black Brush	Jul 2 80	T9N, R10E, SBM
Cowania mexicana var. stansburiana	Cliff rose	Jul 2 80	T20N, R10E, SBM
Croton wigginsii	Wiggins' croton	Nov 79	T13S, R18E, SBM
Cucurbita foetidissima	Wild gourd	Jul 31 81	T7N, R12E, SBM
Datura discolor	Jimsonweed	Aug 13 80	T31S, R11W, MDM
Dedeckera eurekensis	July gold	Aug 10 80	T10S, R40E, MDM
Dyssodia cooperi	Cooper's Dyssodia	Jun 3 80	T10N, R18E, SBM
Eastwoodia elegans	Eastwoodia	Aug 18 80	T31S, R21E, MDM
Encelia farinosa	Brittlebush	Jun 4 80	T6S, R11E, SBM
Encelia frutescens	Green brittlebush	Jun 16 82	T9N, R 8E, SBM
Encelia virginensis ssp. actoni	Virgin River Encelia	Jun 24 73	T26S, R37E, MDM
Enceliopsis covillei	Panamint daisey	Jun 13 77	T21S, R44E, MDM
Ephedra californica	California ephedra	Aug 18 80	T31S, R21E, MDM
Ephedra fasciculata var. clokeyi	Clokey Joint Fir	Jun 4 80	T5N, R18E, SBM
Ephedra funerea	Death Valley joint fir	Jun 16 82	T22N, R 4E, MDM
Ephedra nevadensis	Gray Ephedra	Jun 24 73	T26S, R37E, MDM
Ephedra trifurca	Long-leaved joint fir	Jun 17 82	T8S, R14E, SBM
Ephedra viridis	Green Ephedra	Jun 25 73	T22N, R20E, MDM
Eriogonum fasciculatum	Buckwheat	Jun 22 73	T31S, R36E, MDM
Eriogonum heermanii ssp. humilius	Rough heermann buckwheat	Aug 9 80	T9S, R35E, MDM
Eriogonum inflatum	Desert Trumpet	Aug 24 79	T27S, R37E, MDM
Eriogonum umbellatum	Sulfur flower buckwheat	Jul 29 81	T4S, R31E, MDM
Eriophyllum confertifolium	Golden yarrow	Jun 11 81	T29S, R20E, MDM
Fouquieria splendens	Ocotillo	Jun 16 81	T6S, R14E, SBM
Grayia spinosa	Spiny hopsage	Jun 25 73	T26S, R37E, MDM
Gutierrezia microcephala	Desert snakeweed	Oct 20 79	T27S, R38E, MDM
Haplopappus cooperi	Goldenbush	May 18 79	T15S, R40E, MDM
Haplopappus linearifolius	Goldenbush	May 16 79	T32S, R35E, MDM
Hilaria rigida	Big galleta	May 2 82	T17S, R11E, SBM
Hofmeisteria pluriseta	Arrowleaf	Apr 11 82	T16S, R 9E, SBM
Hymenoclea salsola	Cheesebush	Jun 24 73	T26S, R37E, MDM



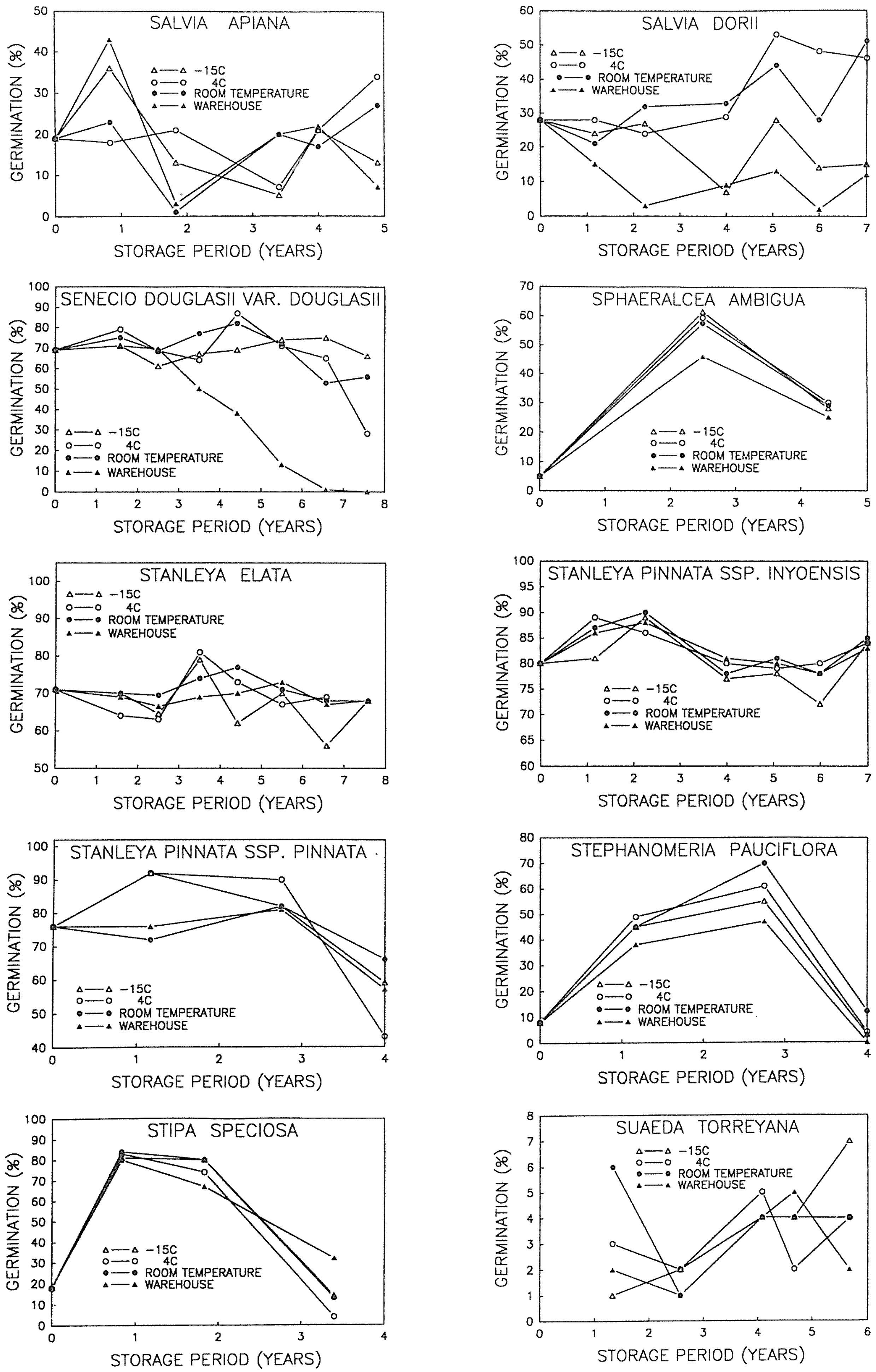
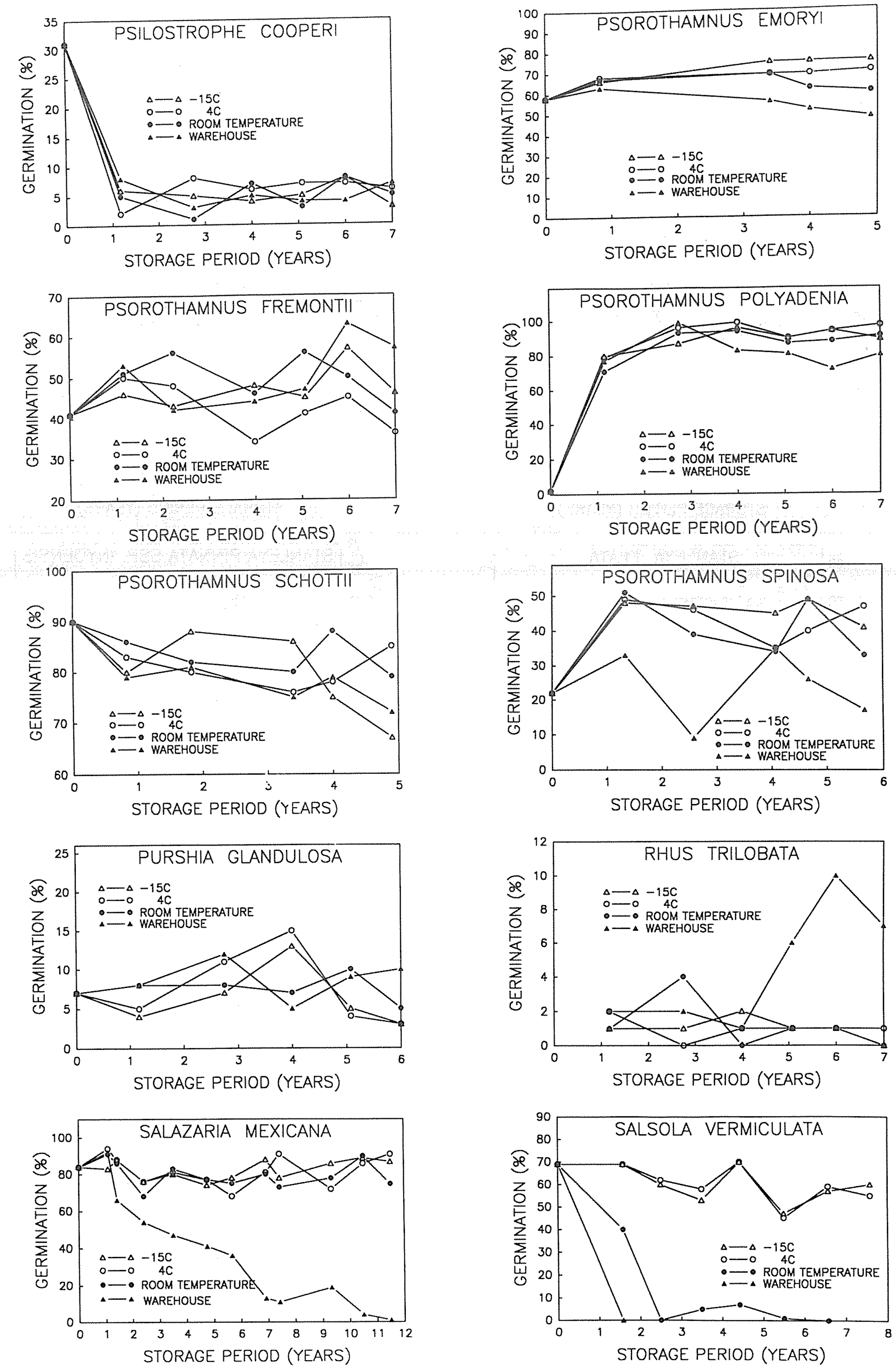


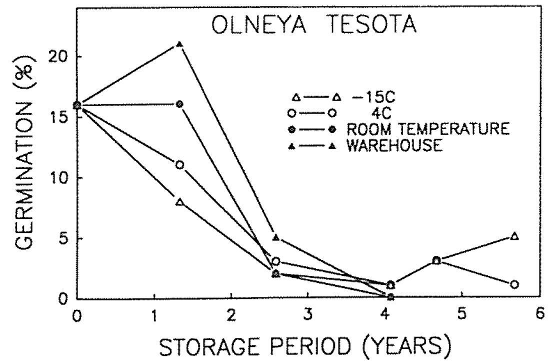
Table 1. continued.

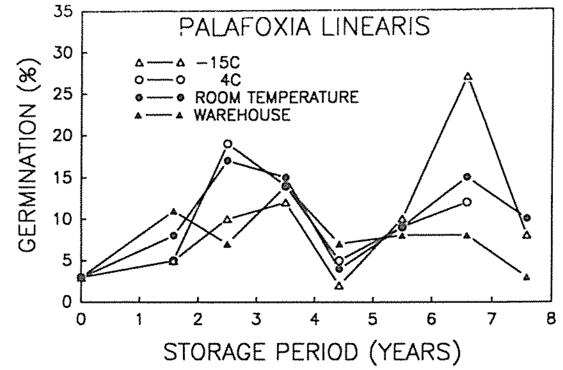
Scientific name	Common name	Date	Location
Hymenoclea salsola var. pentalepis	Cheesebush	May 2 79	T16S, R19E, SBM
Hyptis emoryi	Desert lavender	Jun 18 82	T15S, R 7E, SBM
Isomeris arborea	Bladderpod	Jun 27 73	T31S, R36E, MDM
Larrea tridentata	Creosote bush	Aug 15 73	T31S, R37E, MDM
Lepidium fremontii	Bush peppergrass	May 7 80	T6N, R17E, SBM
Lepidospartum squamatum	Scale broom	Dec 13 73	T32S, R36E, MDM
Lotus rigidus	Desert rock pea	Jun 3 80	T20N, R10E, SBM
Lupinus excubitus var. excubitus	Interior bush lupine	Jul 4 80	T16S, R41E, MDM
Lycium andersonii	Anderson desert thorn	Aug 16 73	T26S, R37E, MDM
Lycium cooperi	Cooper's desert thorn	Aug 16 73	T12N, R13W, SBM
Machaeranthera orcuttii	Orcutt aster	May 3 82	T11S, R 9E, SBM
Maytenus phyllanthoides	Mangle dulce	Apr 27 82	Isla Partita BAJA
Menodora spinescens	Twinfruit	Jun 27 80	T4S, R31E, MDM
Nolina bigelovii	Bigelow's nolina	Jul 31 81	T13N, R19E, SBM
Nolina wolfii	Wolf's Nolina	Jul 2 80	T9N, R10E, SBM
Oenothera ovita ssp. eurekensis	Eureka evening primrose	Aug 79	T10S, R39E, MDM
Olneya tesota	Desert ironwood	Jun 16 81	T5S, R21E, SBM
Palafoxia linearis var. gigantea	Giant Spanish Needle	79	T13S, R18E, SBM
Penstemon fruticiformis	Desert mtn. penstemon	Aug 24 79	T16S, R40E, MDM
Penstemon incertus	Mojave penstemon	Aug 24 79	T27S, R37E, MDM
Penstemon palmeri	Beard tongue	Jul 1 80	T20N, R10E, SBM
Petalonyx thurberi	Sandpaper plant	Aug 10 80	T10S, R40E, MDM
Peucephyllum schottii	Spruce bush	May 5 82	T26N, R 2E, MDM
Porophyllum gracile	Odora	May 6 80	T9N, R17E, SBM
Prosopis glandulosa var. torreyana	Mesquite	Aug 15 80	T20S, R 7E, SBM
Prosopis pubescens	Screw-bean mesquite	Aug 15 80	T20S, R 7E, SBM
Prunus andersonii	Desert peach	Jun 25 73	T22N, R18E, MDM
Psilostrophe cooperi	Paper flower	Jul 3 80	T6N, R17E, SBM
Psorothamnus emoryi	Dyeweed	Jun 18 82	T17S, P 8E, SBM
Psorothamnus fremontii var. fremontii	Indigo bush	Jul 5 80	T5S, R31E, MDM
Psorothamnus polyadenia	Dotted dalea	Aug 9 80	T4S, R31E, MDM
Psorothamnus schottii	Schott's indigobush	Jun 18 82	T17S, R 8E, SBM
Psorothamnus spinosa	Smoke tree	Jul 31 81	T7N, R12E, SBM
Purshia glandulosa	Antelope bitterbrush	Jul 2 80	T20N, R10E, SBM
Rhus trilobata var. anisophylla	Squaw bush	Jul 2 80	T20N, R10E, SBM
Salazaria mexicana	Bladder sage	Jun 24 73	T26S, R37E, MDM
Salsola vermiculata var. villosa	Wormleaf Salsola	79	T31S, R21E, MDM
Salvia apiana	White sage	Jun 18 82	T17S, R 8E, SBM
Salvia dorrii	Purple sage	Jul 2 80	T9N, R10E, SBM
Salvia greatae	Orocopia sage	Jun 15 81	T7S, R13E, SBM
Senecio douglasii var. douglasii	Groundsel	Nov 20 79	T27S, R36E, MDM
Sphaeralcea ambigua	Desert Mallow	Jul 3 79	T6S, R37E, MDM
Stanleya elata	Panamint prince's plume	Aug 24 79	T18S, R39E, MDM
Stanleya pinnata ssp. inyoensis	Eureka Valley Prince's Plume	Jun 28 80	T10S, R39E, MDM
Stanleya pinnata ssp. pinnata	Prince's plume	Aug 18 80	T31S, R21E, MDM
Stephanomeria pauciflora	Wire lettuce	Jun 28 80	T10S, R40E, MDM
Stipa speciosa	Desert needlegrass	May 3 82	T17S, R 8E, SBM
Suaeda torreyana	Sea blight	Nov 27 81	T26S, R43E, MDM
Swallenia alexandrae	Eureka dunegrasss	Jun 28 80	T10S, R39E, MDM
Tetracoccus hallii	Purple bush	Jun 17 81	T3N, R21E, SBM
Tetradymia axillaris	Cottonthorn	Jun 1 80	T15S, R40E, MDM
Tetradymia stenolepis	Mojave horsebrush	Sep 17 79	T4N, R 6W, SBM
Thamnosma montana	Turpentine broom	May 7 80	T6N, R17E, SBM
Tidestromia oblongifolia	Honeysweet	Nov 25 81	T16S, R37E, MDM
Xylorhiza tortifolia	Mojave aster	Jun 1 79	T29S, R38E, MDM
Yucca brevifolia var. herbertii	Joshua tree	Jul 74	T30S, R12W, MDM
Yucca brevifolia var. jaegeriana	Jaeger's yucca	Jun 16 82	T16N, R12E, SBM
Yucca schidigera	Mojave Yucca	Aug 15 80	T20N, R10E, SBM
Yucca whipplei ssp. caespitosa	Our Lord's Candle	Sep 17 79	T4N, R 6W, SBM
Yucca whipplei ssp. whipplei	Spanish bayonet	Aug 18 80	T31S, R21E, MDM

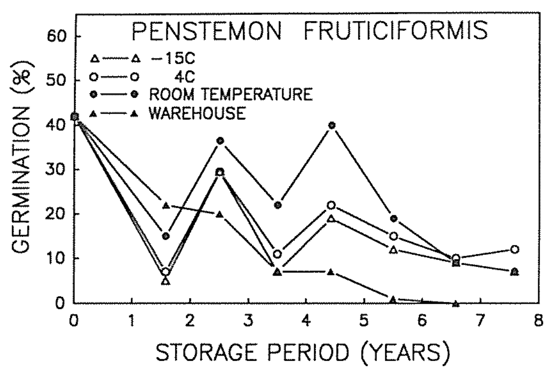
Table 2. Seeds per pound (thousands), initial and best germination, and storability 1/ of seeds included in this study.

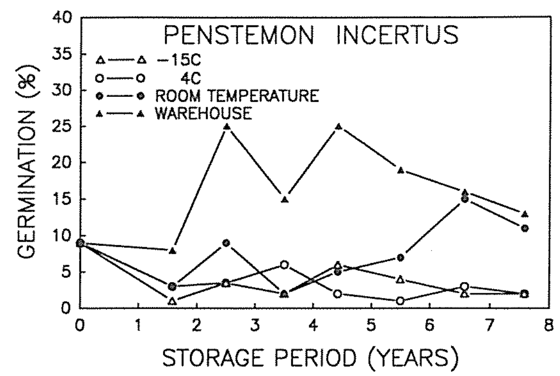
Scientific Name	Sds /lb	Init Germ	Best Germ	Stora-bility	Comments
Abronia villosa var. aurita	84		4	G	4% at 30 mo., available commercially.
Acacia gregii	6	79	79	F	25C for initial germ only.
Acamptopappus shockleyi	502	7	10	F	4C and sealed storage desirable.
Acamptopappus sphaerocephalus var. hirt.	472	11	11	P	Does not store well.
Agave deserti	58	47	89	E	After-ripening requirement.
Ambrosia dumosa	170	5	9	E	Sealed storage desirable.
Ambrosia eriocentra	41	18	30	G	Sealed storage required.
Amphipappus fremontii	249	61	61	F	Sealed storage required.
Asclepias subulata	71	17	27	G	
Astragalus lentiginosus var. micans	68	24	53	E	37-53% hard seed at 7 yrs.
Atriplex canescens	20	23	39	E	Collected at 4,000 ft., bracts not removed.
Atriplex confertifolia	35		1		Never solved germination requirements.
Atriplex hymenelytra	81	26	67	E	No special storage required.
Atriplex lentiformis	446	41	47	E	No special storage required.
Atriplex polycarpa	550	23	28	E	Sealed storage required.
Atriplex spinifera	46		1	?	Never solved germ. requirements.
Atriplex torreyi	796	51	77	E	No special storage required.
Bebbia juncea var. aspera	597	1	15	F	
Brickellia incana	99	40	76	E	Sealed storage required.
Brickellia multiflora	2945	68	76	G	Sealed storage preferred.
Brickellia oblongifolia var. linifolia	694	5	15	G	Short test period.
Camissonia cardiophylla ssp. robusta	12600	76			Alternate 20/30, no storage test.
Cassia armata	18	75	92	E	Sealed storage desirable.
Castilleja sp.	1643	3	8	P	Poor sample
Ceratoides lanata	162	22	20	E	Sealed storage required, germ. at 10C..
Cercidium floridum	2	97	97	g	90-95% hard seed.
Chilopsis linearis	108	64	67	G	Sealed storage desirable.
Chrysothamnus nauseosus ssp. hololeucus	2270	22	24	G	4C and sealed storage necessary, germ. at 10C.
Chrysothamnus nauseosus ssp. mohavensis	944	73	83	G	4C and sealed storage necessary.
Chrysothamnus paniculatus	1090	19	35	G	4C and sealed storage necessary.
Chrysothamnus teretifolius	1119	13	19	G	4C and sealed storage necessary.
Chrysothamnus vicidiflorus	1314	3	23	E	Cold and sealed storage necessary.
Coleogyne ramosissima	22	10	10	P	Difficult to find seed.
Cowania mexicana var. stansburiana	59	11	42	G	Germination doubled if measured 14 weeks.
Croton wigginsii	25	14	18	G	Increased at Davis from 1977 col. by H, Johnson.
Cucurbita foetidissima	7	1	68	F	Requires high germination temp. (25C)
Datura discolor	42	3	5	P	
Dedeckera eurekensis	898	8	50	P	After ripening requirement.
Dyssodia cooperi	278		23	G	After-ripening requirement.
Eastwoodia elegans	401	35	68	E	Sealed storage recommended.
Encelia farinosa	410	1	1		Retained orig. germ. of 1-2% for 7 yrs.
Encelia frutescens	101	73	91	G	No special storage required.
Encelia virginensis ssp. actoni	217	77	67	E	Sealed storage desirable.
Enceliopsis covillei	28	94			34% after 3yrs in warehouse.
Ephedra californica	8	89	92	G	Sealed storage recommended.
Ephedra fasciculata var. clokeyi	16				Germination requirements not determined.
Ephedra funerea	28		6	F	Poor sample.
Ephedra nevadensis	19	68	40	F	Freezing may help.
Ephedra trifurca	8	27	45	E	No special storage required.
Ephedra viridis	25	38	74	E	-15C best storage, germ. at 5/15C (8hr/16hr alt).
Eriogonum fasciculatum	537	4	22	G	Sealed storage desirable.
Eriogonum heermanii ssp. humilius	606	1	3		Retained the original 1% germ. for 7 yrs.
Eriogonum inflatum	661	2	5	G	Poor initial germ., but stored well.
Eriogonum umbellatum	202	23	27	G	Sealed storage preferred.
Eriophyllum confertifolium	1113	8	25	F	Freezing appears best.
Fouquieria splendens	59	89	93	G	Small sample.
Grayia spinosa	230	42	70	E	Sealed storage required.
Gutierrezia microcephala	740	5	10	F	Sealed, cold storage indicated.
Haplopappus cooperi	848	47	64	G	Sealed, cold storage indicated.
Haplopappus linearifolius	129	36	52	G	Sealed cold storage indicated.
Hilaria rigida	262	16	18	P	Did not store well.
Hofmeisteria pluriseta	1008	2	11	G	Sack storage best.
Hymenoclea salsola	38	68	74	E	Sealed storage required, germ. at 20C.

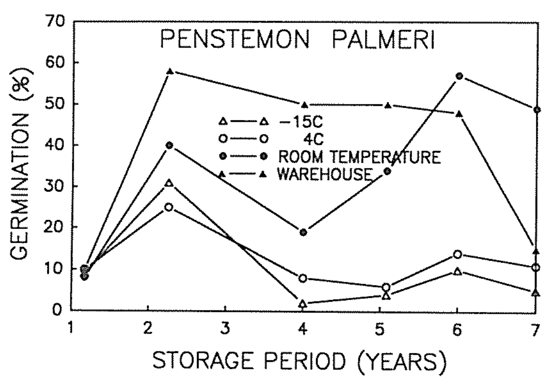


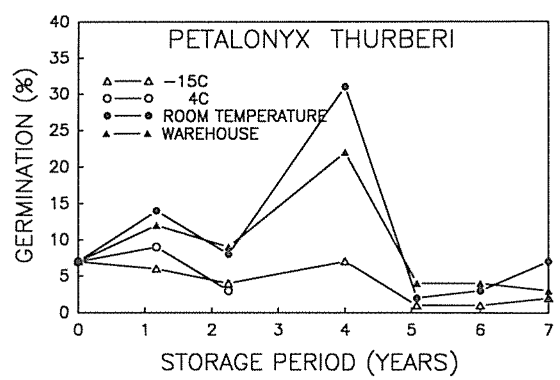


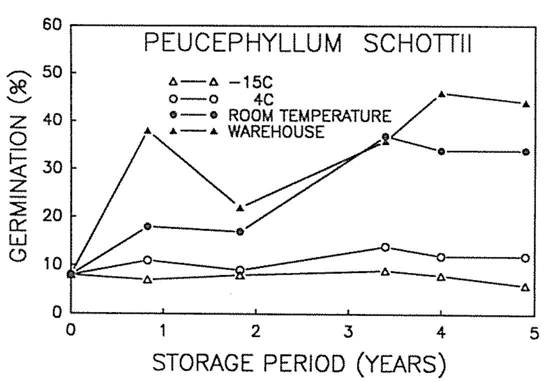


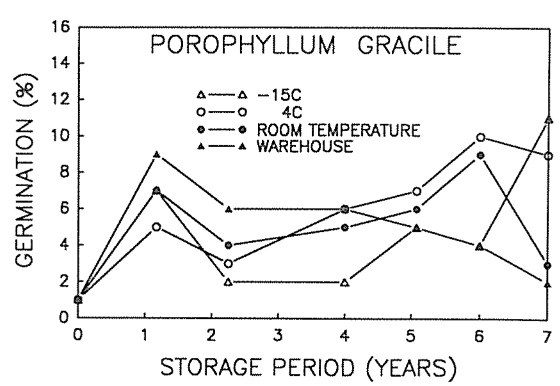


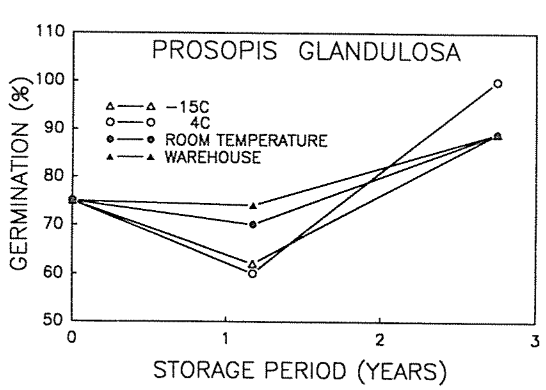












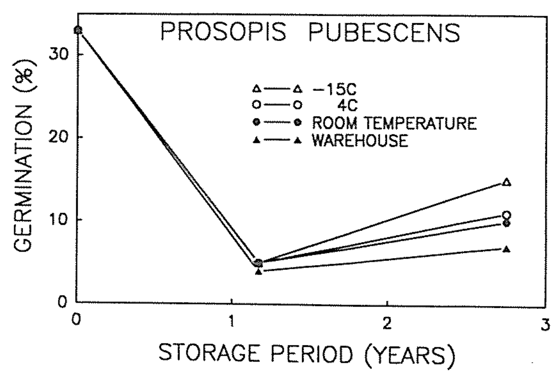


Table 2. continued.

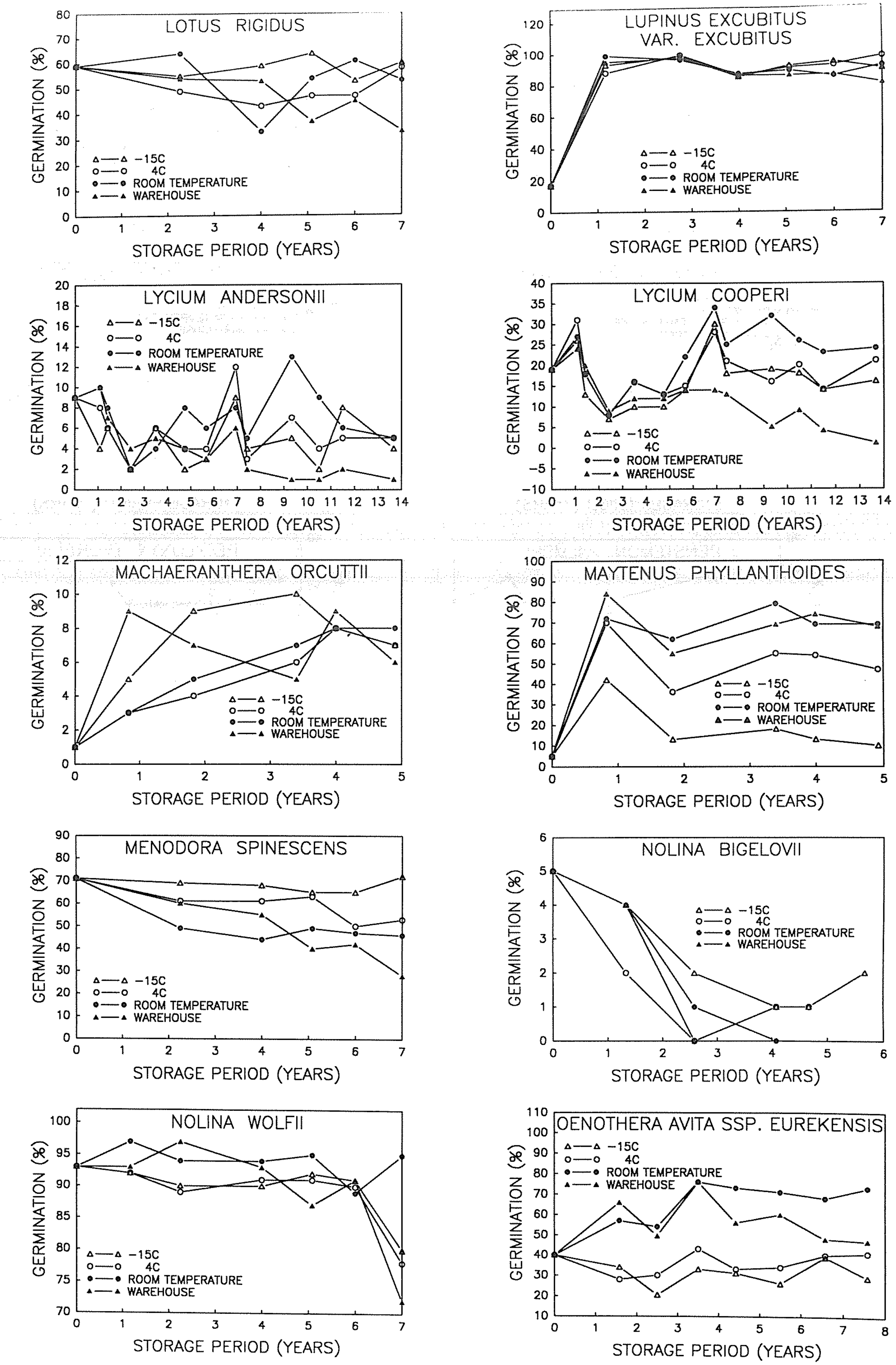
Scientific Name	Sds /lb	Init Germ	Best Germ	Storability	Comments
Hymenoclea salsola var. pentalepis	97	17	33	G	Sealed storage is best.
Hyptis emoryi		1	46	G	Small sample, short test.
Isomeris arborea	7	38	81	E	Sealed storage required.
Larrea tridentata	82	6	3	P	Requires high temp. germ. (25C).
Lepidium fremontii	227	18	18	P	Exceptional germ. for this species.
Lepidospartum squamatum	310	58	33	F	Sealed cold storage necessary, germ. at 5C.
Lotus rigidus	146	59	64	E	33-60% hard seed.
Lupinus excubitus var. excubitus	14	17	99	E	85-94% hard seed.
Lycium andersonii	194	9	8	F	Sealed storage desirable, germ. at 20C.
Lycium cooperi	213	19	23	E	Sealed storage desirable, germ at 20C.
Machaeranthera orcuttii	89	1	10	E	After ripening requirement.
Maytenus phyllanthoides	54	5	84	G	No special storage required.
Menodora spinescens	21	71	72	E	Sealed storage desirable.
Nolina bigelovii	105	5	5	P	Seed may have been immature.
Nolina wolfii	23	93	97	E	Germ declines rapidly after 6 years.
Oenothera ovita ssp. eurekensis	782	40	76	E	Seed increased at Davis
Olneya tesota	3	16	16	P	Does not store well.
Palafoxia linearis var. gigantea	238	3	27	G	25-30C would give better germ (Romspert, 1979) Seed increased at Davis from 1977 col. by H. Johnso Orig seed 66, 88, and 58% at 8, 13, and 25 months (
Penstemon fruticiformis	350	42	42	F	
Penstemon incertus	234	9	25	G	Giberellic acid increased germ.
Penstemon palmeri	468		58	G	Cold may induce dormancy.
Petalonyx thurberi	311	7	31	P	Difficult to find good seed.
Peucephyllum schottii	289	8	44	E	Cold may extend after ripening requirement.
Porophyllum gracile	605	1	10	G	After-ripening requirement.
Prosopis glandulosa var. torreyana	13	75	##	E	25C initial germ. only.
Prosopis pubescens	62	33	33	P	25C initial germ only.
Prunus andersonii			7		Treat seed with activated carbon.
Psilostrophe cooperi	12	31	31	P	Germ. declined by 14 mo.
Psorothamnus emoryi	275	58	75	E	Stores well.
Psorothamnus fremontii var. fremontii	16	41	97	E	50% hard seed, stores well.
Psorothamnus polyadenia	210	2	99	E	90% hard seed, stores well.
Psorothamnus schottii	10	90	88	G	
Psorothamnus spinosa	23	22	58	E	17-47% hard seed.
Purshia glandulosa	15	7	15	G	Low initial germ., but stores well.
Rhus trilobata var. anisophylla	10		10	P	After-ripening requirement?
Salazaria mexicana	96	84	90	E	Sealed storage required.
Salsola vermiculata var. villosa	57	69	70	E	Introduced from Syria.
Salvia apiana	233	19	43	F	Inconsistent between years.
Salvia dorrii	189	28	53	G	Freezing may induce dormancy.
Salvia greatae	719		1		Germination requirements not determined.
Senecio douglasii var. douglasii	457	69	87	G	Sealed storage desirable.
Sphaeralcea ambigua	376	5	62	G	25-30% hard seed.
Stanleya elata	239	71	81	E	No special storage required.
Stanleya pinnata ssp. inyoensis	192	80	90	E	No special storage required.
Stanleya pinnata ssp. pinnata	154	76	92	F	20C initial germ. only.
Stephanomeria pauciflora	2062	8	70	P	Stores well to three years only.
Stipa speciosa		18	84	P	Stores for two years only.
Suaeda torreyana	1701		7	F	Poor quality sample, eratic germ.
Swallenia alexandrae	89	66	66	P	Init. germ. alt. 20/30 (8hr/16hr), others 15C.
Tetracoccus hallii	15	53	69	F	Short test period.
Tetradymia axillaris	103	12	20	G	Germinated at 5C.
Tetradymia stenolepis	84	21	21	F	Sealed storage desirable.
Thamnosma montana	45	52	52	F	Sealed, 4C storage desirable.
Tidestromia oblongifolia	199	7	7	P	Eratic germination.
Xylorhiza tortifolia	296	64	72	E	Sealed, 4C storage desirable.
Yucca brevifolia var. herbertii	5		89	E	Sealed storage necessary.
Yucca brevifolia var. jaegeriana	8	80	95	E	Sealed storage recommended.
Yucca schidigera	5	67	96	G	No special storage required.
Yucca whipplei ssp. caespitosa	25	99	99	E	No special storage required.
Yucca whipplei ssp. whipplei	30	77	88	G	Sealed storage desirable.

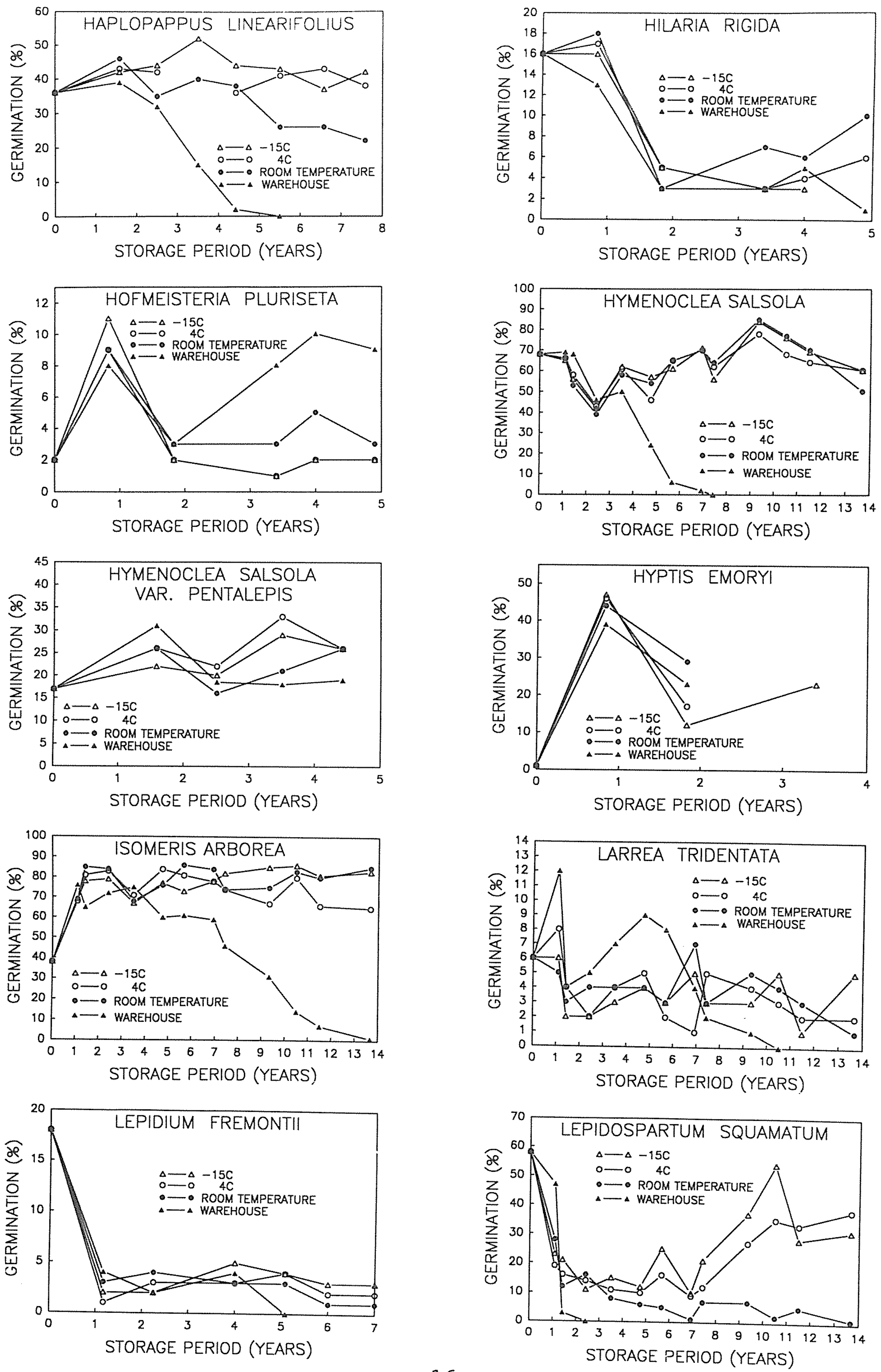
1/ E = excellent, G = good, F = fair, and P = poor.

Table 3. Effect of temperature on the germination of some of the seeds included in this study. 1/

Scientific name	2C	5C	10C	15C	20C	25C	30C	40C	Comments
Acamptopappus shockleyi		3	5	2	9	8	0		
Acamptopappus sphaerocephalus var. hirt.	2b	9a	3b	0b	0b	2b	0b	0b	
Ambrosia dumosa	0b	0b	4ab	26a	21ab	18ab	10ab		
Ambrosia eriocentra		0	10	26	14	24	12		Alternate 5/30=27%, 15/25=28%
Amphipappus fremontii		35	29	23	31	6	0		
Astragalus lentiginosus var. micans		20		17	14	18			
Atriplex canescens	19	15	17	20	13	8	14	16	
Atriplex confertifolia		0	0	0	0	0	0		
Atriplex hymenelytra	0	17	8	0	4	0	0	0	
Atriplex polycarpa	23abc	27a	24ab	20a-e	22a-d	14a-f	5e-f	0f	
Bebbia juncea var. aspera		0	1	6	9	13	15		
Brickellia incana		0	17	71	54	41	26		
Cassia armata	0d	0d	19cd	41ab	46a	20cd	28ab	0d	
Ceratoides lanata	14a	15a	21a	16a	15a	15a	10ab	0b	
Chrysothamnus nauseosus ssp. hololeucus	15bc	22ab	35a	22ab	3cd	0d	1d	0d	
Chrysothamnus nauseosus ssp. mohavensis		56	59	87	76	59	30		
Chrysothamnus paniculatus		15	9	27	19	22	12		
Chrysothamnus teretifolius		6	17	13	12	10	3		
Chrysothamnus vicidiflorus		3	4	14	10	4	4		
Croton wiginsii				20	40	40	0	0	Data from Romsport (1979)
Datura discolor		0	2	0	3	1	2		Alternate 20/25= 15%
Dyssodia cooperi		38	1	40	41	52	39	24	
Eastwoodia elegans		26	45	38	33	21	1		
Encelia farinosa		0	2	2	2	1	0	14	
Encelia virginensis ssp. actoni	0d	1d	47a-c	65a	55ab	5d	7d	0d	
Enceliopsis covillei		34		76	94	43			27,705 seed/lb
Ephedra nevadensis	2n	73a	63ab	69a	78a	51bc	4n	0n	
Ephedra viridis	33e-h	64a-c	48de	49cd	19h-m	5 l-n	5 l-n	1n	Alternate 16 hr @5C/8hr @15C= 71%
Eriogonum fasciculatum	2c-e	14a-d	15a-c	19a	18ab	8a-e	0e	0e	
Eriogonum inflatum		2	2	1	2	0	0		
Grayia spinosa	6gh	4h	74ab	70ab	46c	30d	36d	20e	
Gutierrezia microcephala		3	9	6	9	4	1		
Haplopappus cooperi		67	59	66	54	37	2		
Haplopappus linearifolius		36	32	35	32	31	9		
Hymenoclea salsola var. pentalepis	2	0	4	59	75	66	40		
Isomeris arborea	15de	48a-c	59ab	69a	25d	6de	1de	0e	
Larrea tridentata	0	0	0	5	3	4	1	0	Requires high temp. germ. (25C).
Lepidospartum squamatum	52ab	64a	57a	31bc	22cd	5d	4d		
Lotus rigidus		7	10	13	10	6	3	0	
Lycium andersonii	0b	0b	0b	0b	3a	0b	0b	0b	
Lycium cooperi	0b	0b	2b	7ab	8a	5ab	4ab	0b	
Menodora spinescens			9	5	11				Alternate 10/25=43%
Nolina wolfii		94	89	90	89	1	0		
Oenothera ovita ssp. eurekensis		10	21	49	46	33	5		
Palafoxia linearis		0	3	8	4	11	9		
Penstemon fruticiformis		51	62	62	57	3	0		
Penstemon incertus		6	13	7	3	0	0		GA3 (200ppm @ 15C) =52%
Penstemon palmeri		8	61	34	50	2	0		
Salazaria mexicana	0c	0c	17ab	24a	15a-c	11a-c	2bc	0c	
Salsola vermiculata var. villosa		53	54	27	27	1	0		
Senecio douglasii var. douglasii		61	73	72	70	35	0		
Sphaeralcea ambigua		8	10	8	10	12	14		
Stanleya elata		45	66	80	79	79	72		
Stanleya pinnata		50	92	88	100	84	70		
Stephanomeria paciflora		88	94	90	95	80	1	15	
Suaeda torreyana		1	0	1	0	0	0		Alternate 20/30=5%
Swallenia alexandrae		0		4	7	31			Alternate 20/30=66%
Tetradymia axillaris		12	7	2	4	0	0	0	
Tetradymia glabrata		2	3	3	0	0	0	0	
Tetradymia stenolepis		18	22	10	10	6	0		
Thamnosma montana		53	64	63	55	41	13		Alternate 5/20=78%
Xylorhiza tortifolia		55	59	60	56	39	11		
Yucca whipplei ssp. whipplei		30	77	88	88	65	6		
Yucca whipplei ssp. caespitosa		83	97	95	96	88	7		

1/ Values followed by the same letter are not significantly different at the .01 level.





Hard seed (seed which will not imbibe moisture due to an impermeable seed coat) is common to many legumes when stored under low moisture conditions (5). The percent hard seed was high in a number of legume species studied here, such as Cassia armata, Lotus rigidus, Lupinus excubitus, Psorothamnus fremontii and P. polyadenia.

Some important desert species are particularly difficult to find with collectable seed. Among these are Artemisia spinescens, Atriplex spinifera, Coleogyne ramosissima, Krameria species, and Pluchea sericea. It would be unfortunate to include these species in reseeding recommendations, because it would be virtually impossible to obtain good seed. Similarly, if the collector were presented with the rare opportunity of finding collectable seed of good quality, it might be desirable to place some in proper storage and advertise it as being available..

Other species produced seed on a regular basis, but either the fill and/or germination was consistently very low. Numerous examples may be noted from the figures. Creosote bush (Larrea) regularly produces large quantities of seed, sometimes over an extended period, but the quality is consistently low. Burrowbush (Ambrosia dumosa) and sweetbush (Bebbia juncea) were also collected numerous times, but the germination never exceeded 10 percent. For this reason, seeding recommendations should specify seeding rates in pounds per acre pure live seed (PLS), so extra seed will be planted to compensate for the low quality.

Germination tests may not fairly indicate the quality or usability of seed as shown by the important saline soil species shadscale (Atriplex confertifolia). Numerous collections were made, but we were never able to obtain significant germination. The problem was studied, but no workable solution to improving laboratory germination was found (14). However this is not a decisive reason for not using it in field plantings, as nature can be expected to provide a solution if the seed is of good quality and is planted in the fall.

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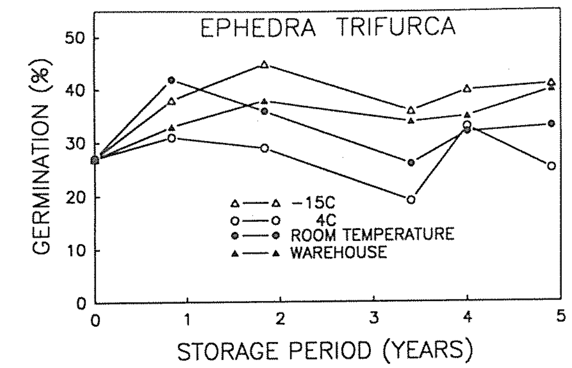
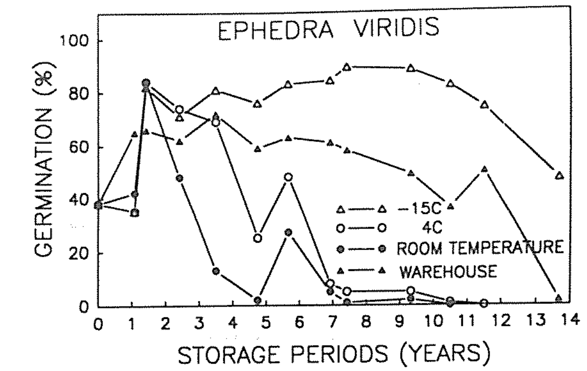
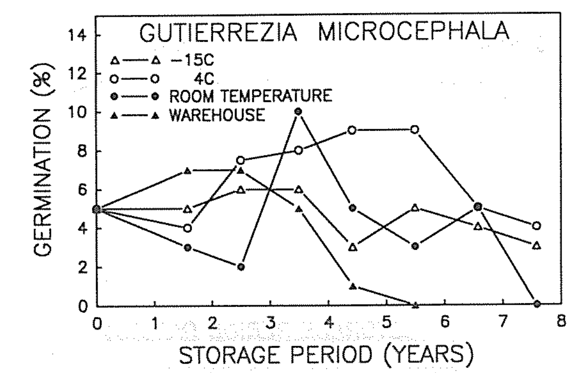
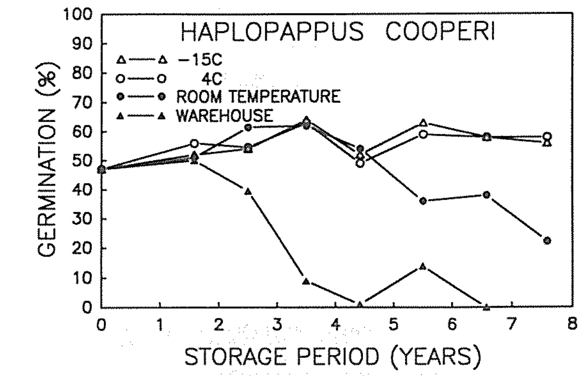
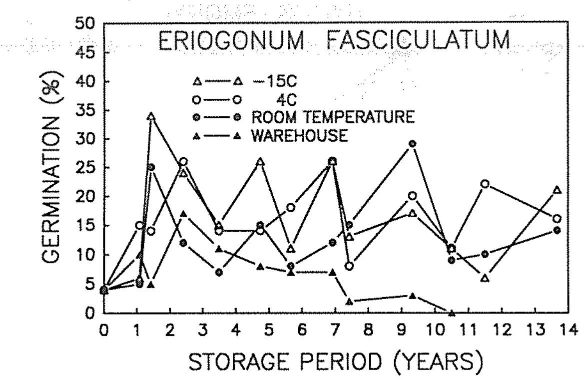
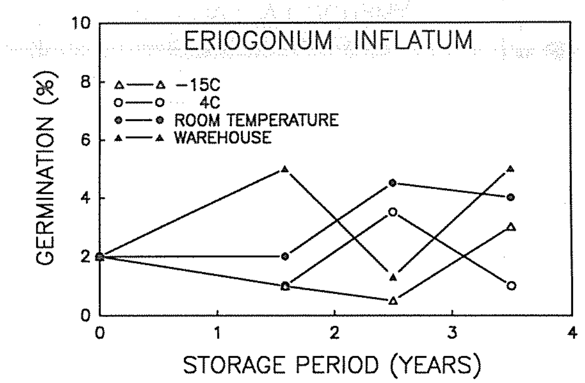


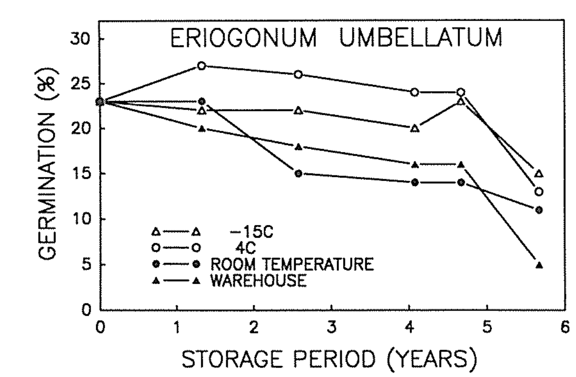


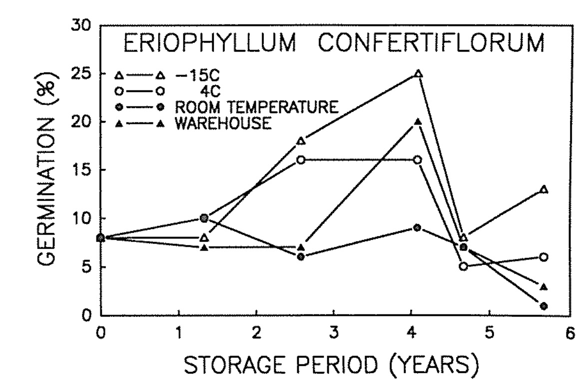


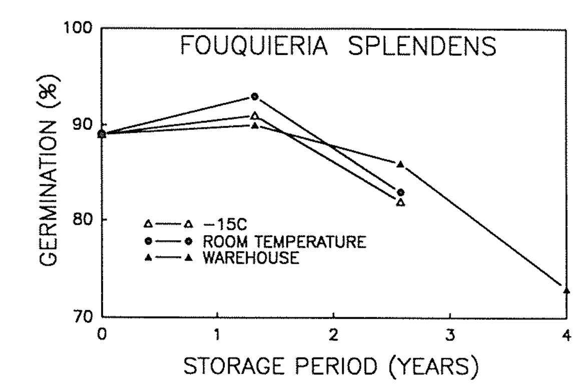


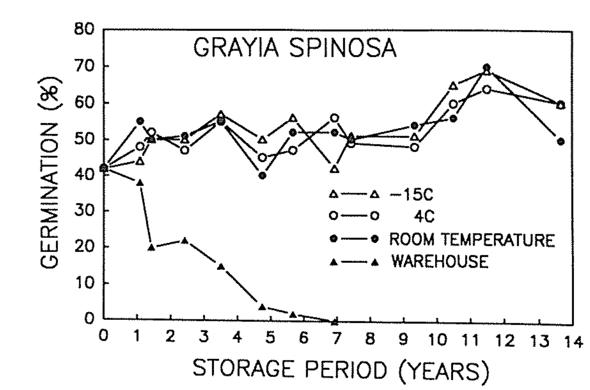


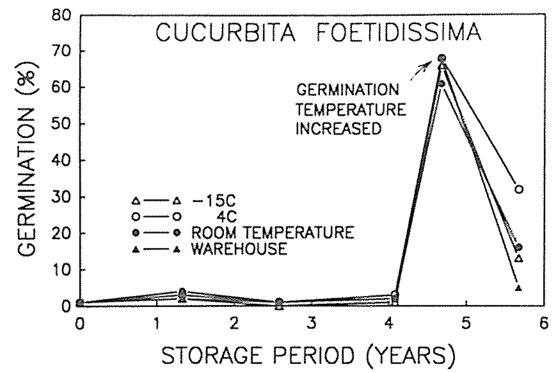


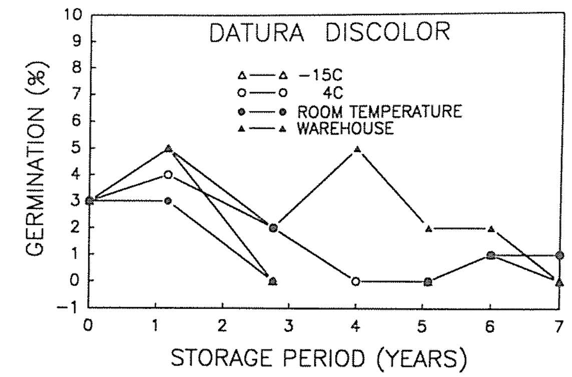


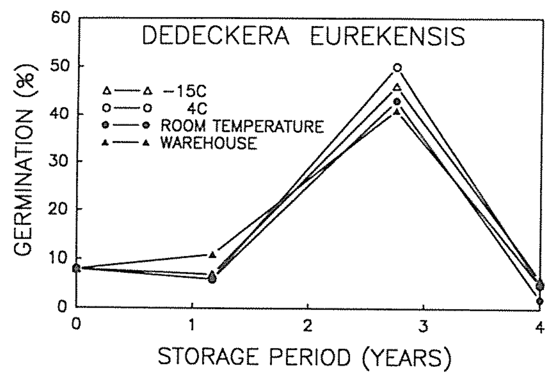


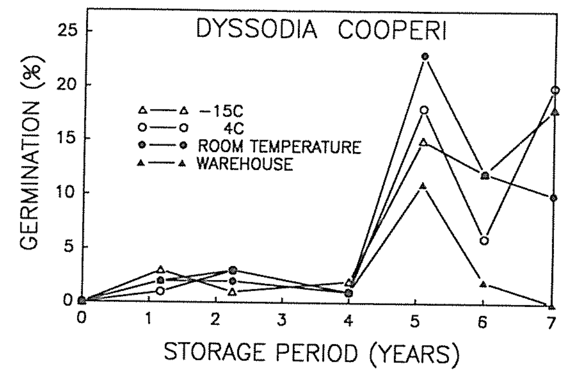


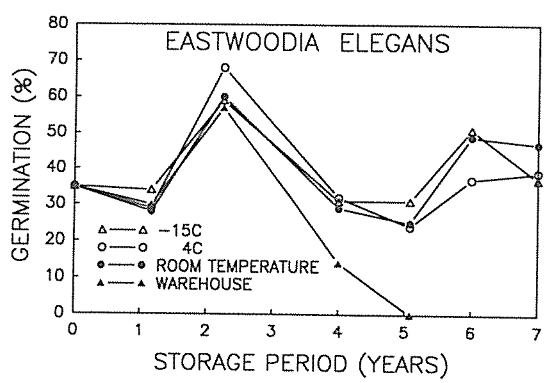


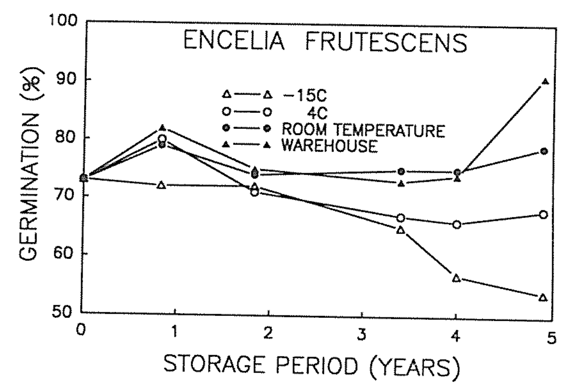

CUCURBITA FOETIDISSIMA
GERMINATION TEMPERATURE INCREASED
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)

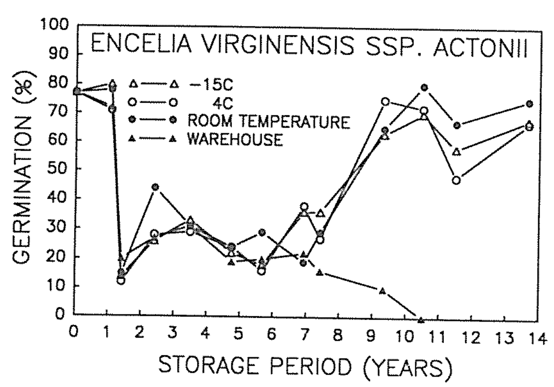

DATURA DISCOLOR
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)

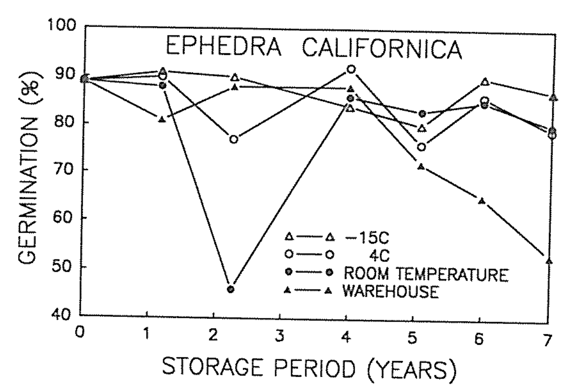

DEDECKERA EUREKENSIS
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)


DYSSODIA COOPERI
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)


EASTWOODIA ELEGANS
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)


ENCELIA FRUTESCENS
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)


ENCELIA VIRGINENSIS SSP. ACTONII
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)


EPHEDRA CALIFORNICA
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4C
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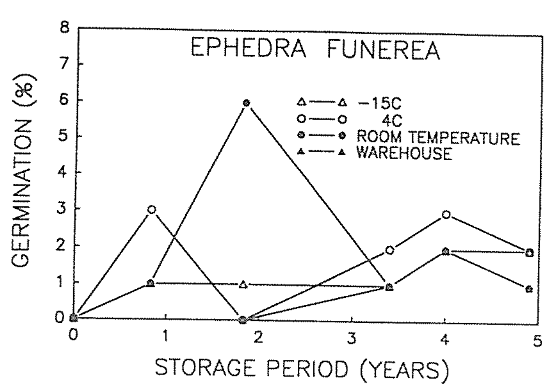
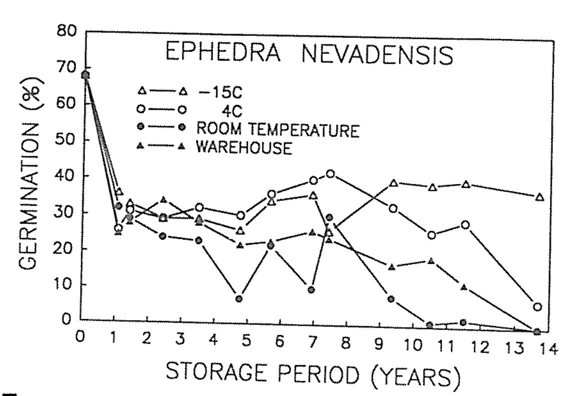
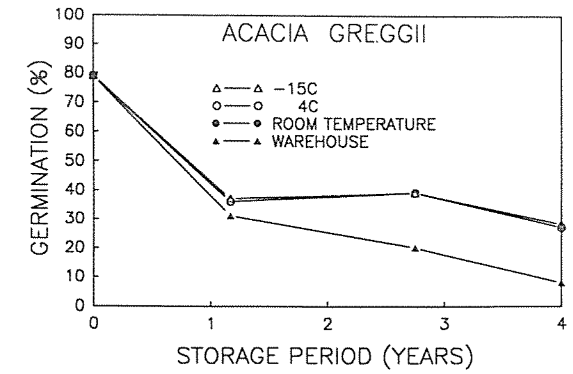
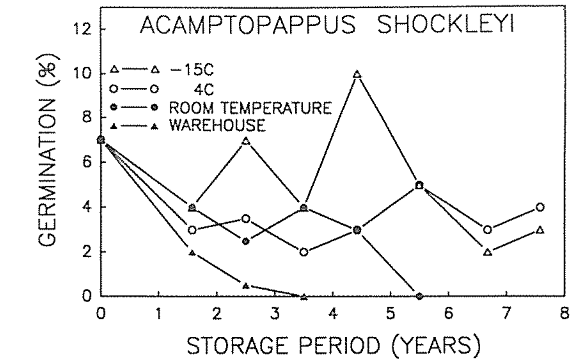
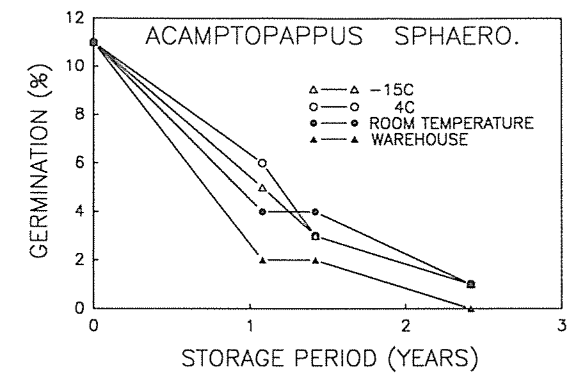
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)

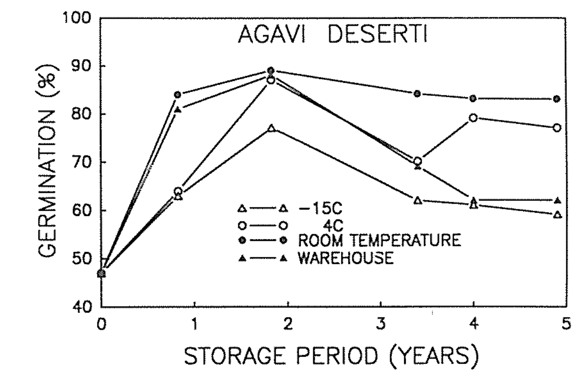

EPHEDRA FUNEREA
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)

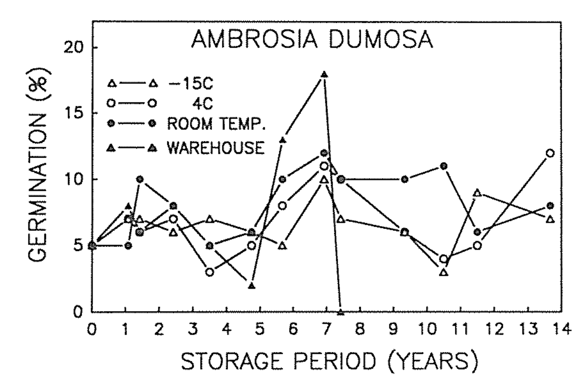

EPHEDRA NEVADENSIS
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)

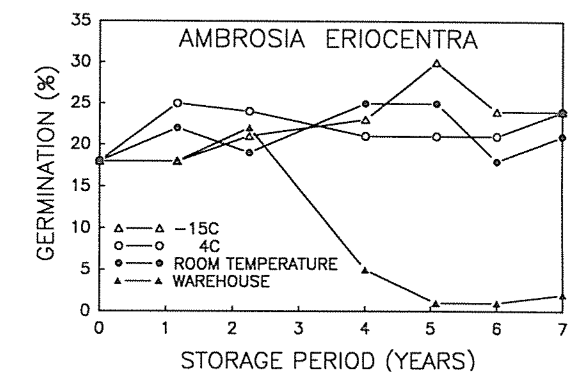

ACACIA GREGGII
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)

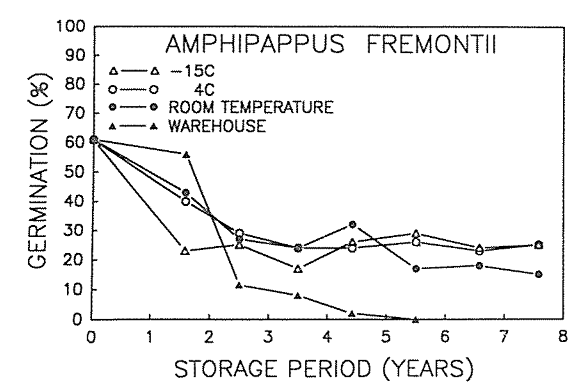

ACAMPTOPAPPUS SHOCKLEYI
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)

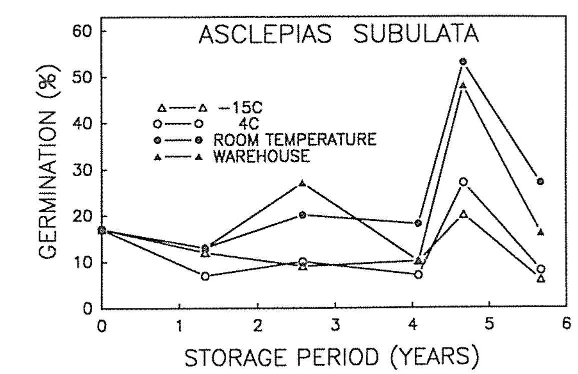

ACAMPTOPAPPUS SPHAERO.
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)

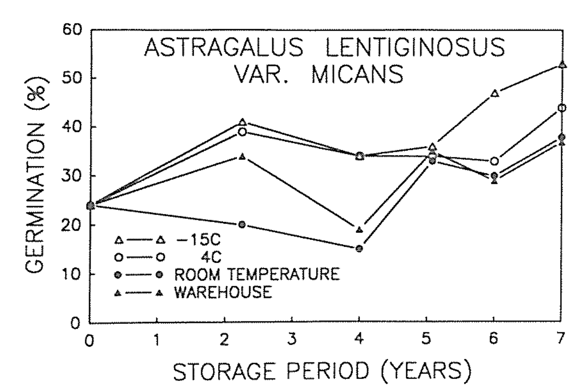

AGAVI DESERTI
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)

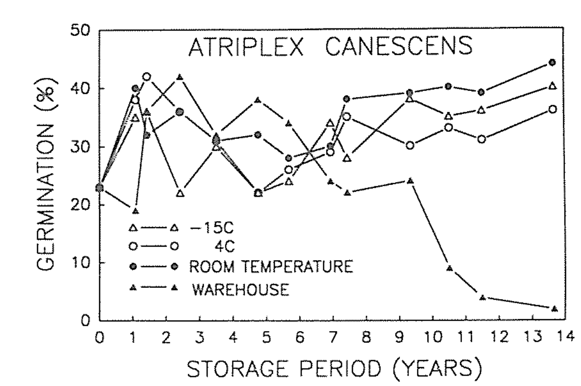

AMBROSIA DUMOSA
−15C
4C
ROOM TEMP.
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)

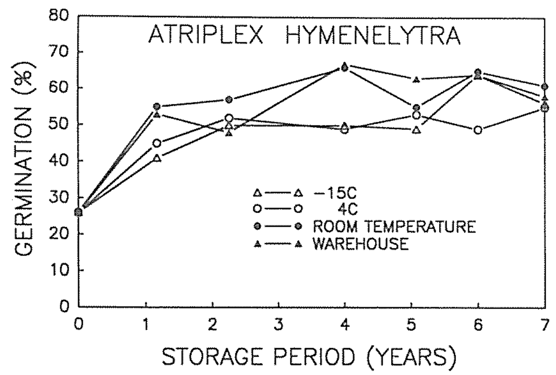

AMBROSIA ERIOCENTRA
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)

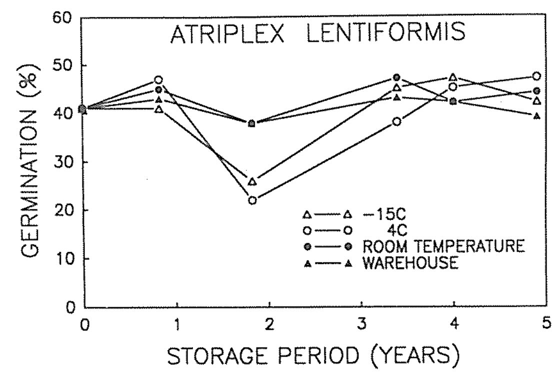

AMPHIPAPPUS FREMONTII
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)

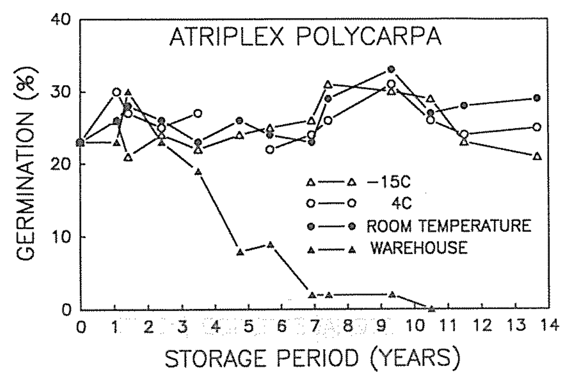

ASCLEPIAS SUBULATA
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)

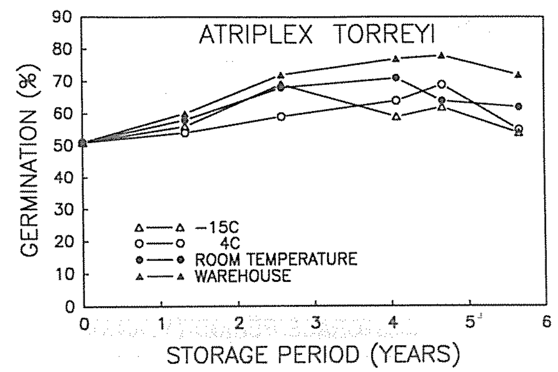

ASTRAGALUS LENTIGINOSUS
VAR. MICANS
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)

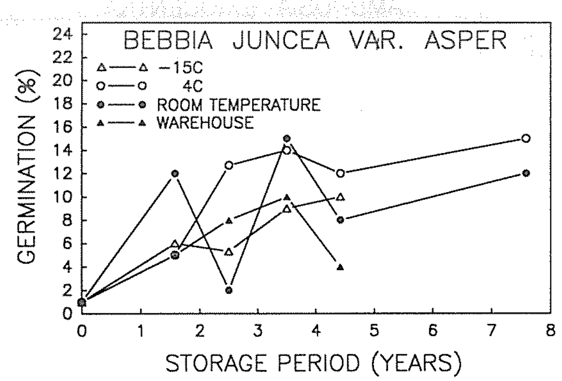

ATRIPLEX CANESCENS
−15C
4C
ROOM TEMPERATURE
WAREHOUSE
GERMINATION (%)
STORAGE PERIOD (YEARS)

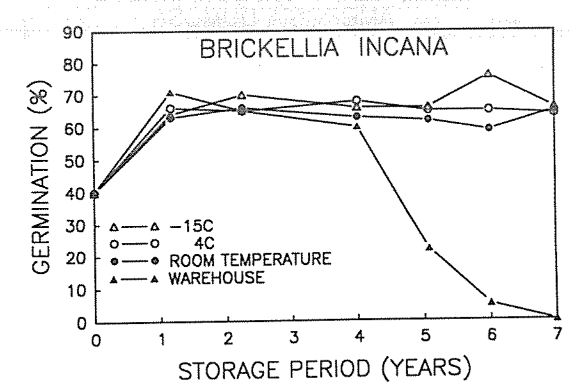

ATRIPLEX HYMENELYTRA
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE

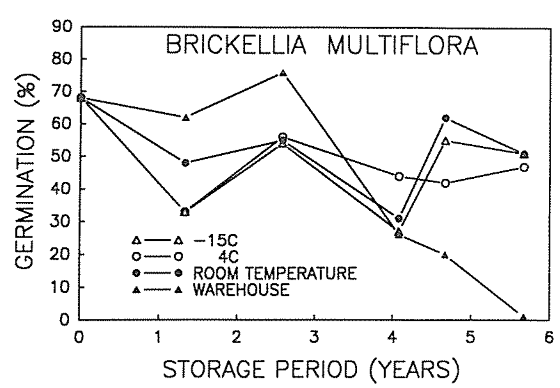

ATRIPLEX LENTIFORMIS
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE

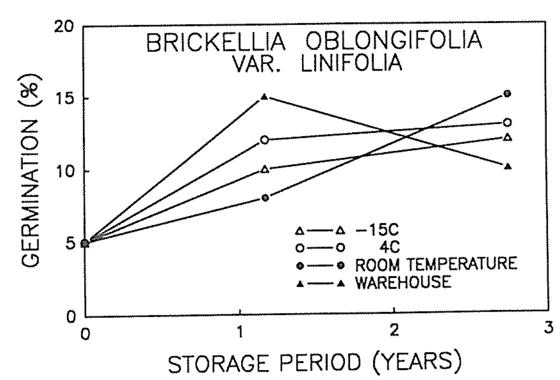

ATRIPLEX POLYCARPA
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE

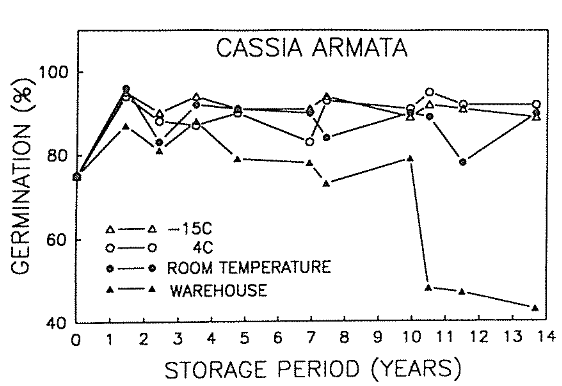

ATRIPLEX TORREYI
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE

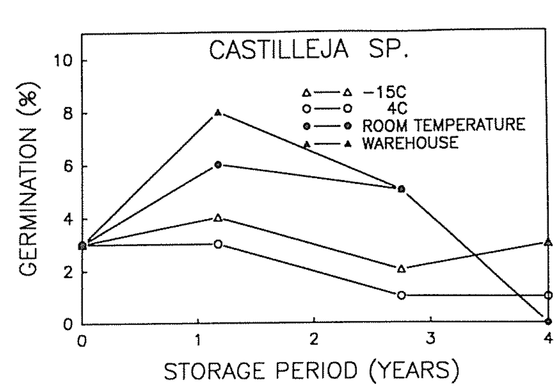

BEBBIA JUNCEA VAR. ASPER
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE

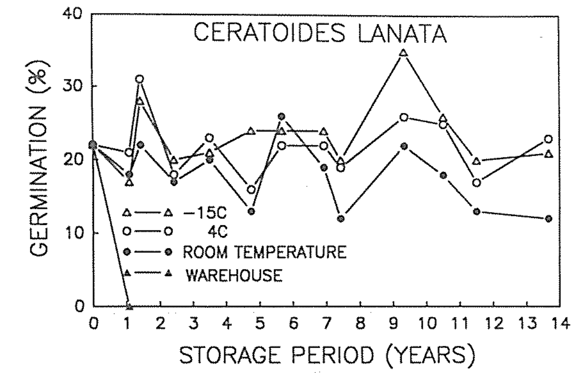

BRICKELLIA INCANA
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE

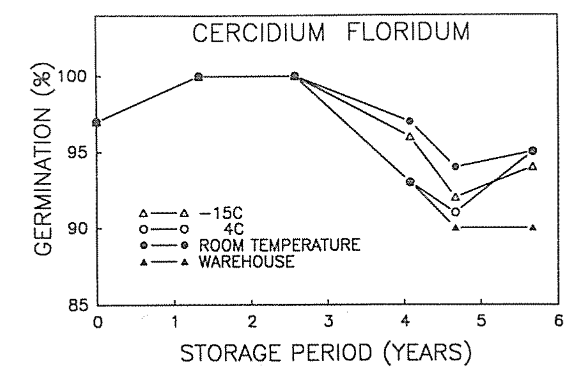

BRICKELLIA MULTIFLORA
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE

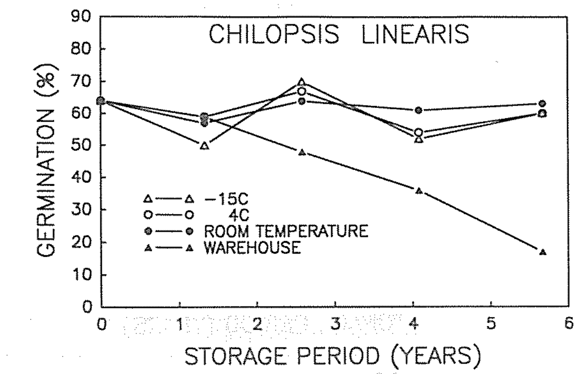

BRICKELLIA OBLONGIFOLIA
VAR. LINIFOLIA
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE

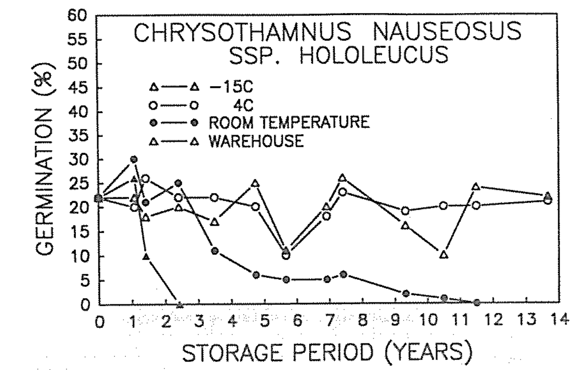

CASSIA ARMATA
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE

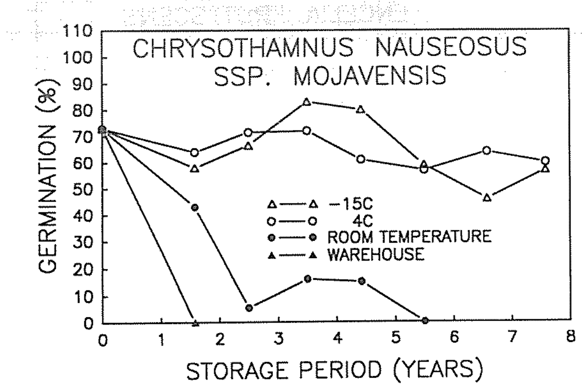

CASTILLEJA SP.
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE

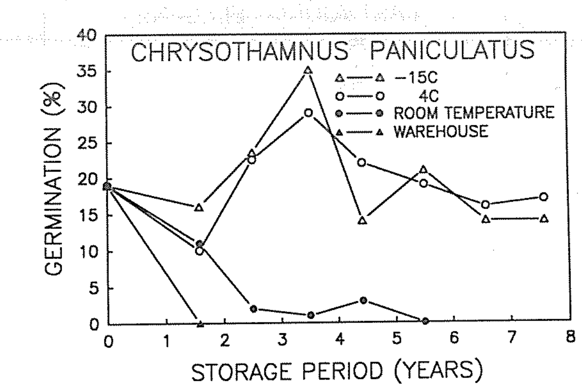

CERATOIDES LANATA
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE

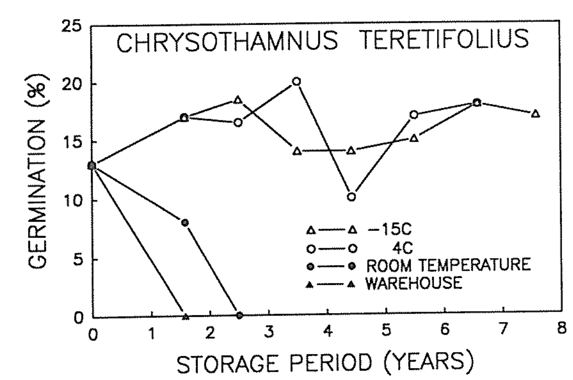

CERCIDIUM FLORIDUM
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE

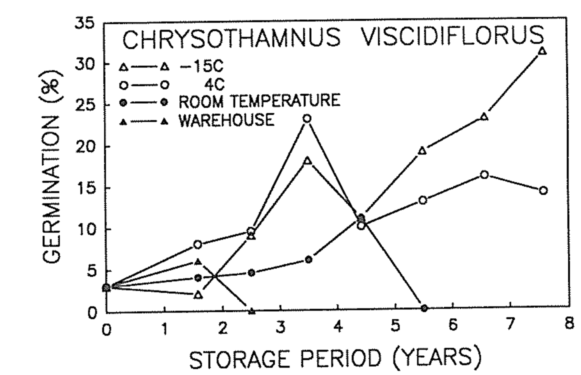

CHILOPSIS LINEARIS
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE

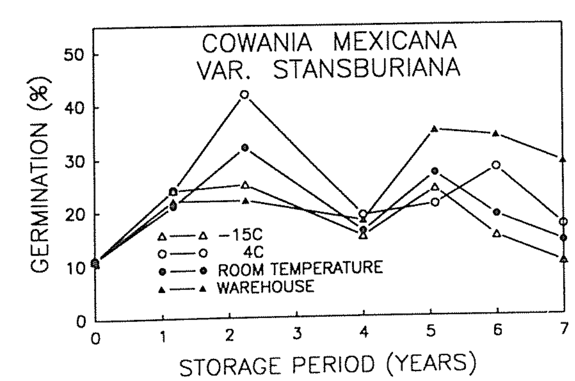

CHRYSOTHAMNUS NAUSEOSUS
SSP. HOLOLEUCUS
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE

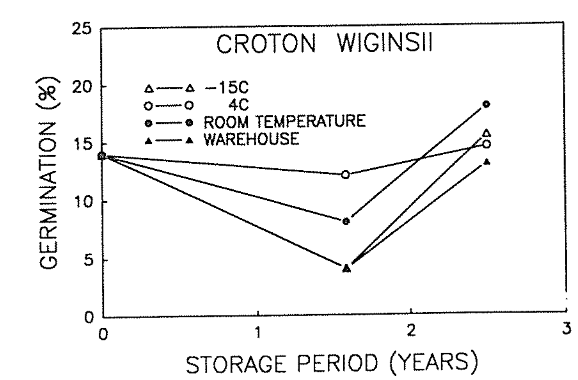

CHRYSOTHAMNUS NAUSEOSUS
SSP. MOJAVENSIS
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE


CHRYSOTHAMNUS PANICULATUS
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE


CHRYSOTHAMNUS TERETIFOLIUS
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE


CHRYSOTHAMNUS VISCIDIFLORUS
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE


COWANIA MEXICANA
VAR. STANSBURIANA
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE


CROTON WIGINSII
GERMINATION (%)
STORAGE PERIOD (YEARS)
-15C
4C
ROOM TEMPERATURE
WAREHOUSE