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Preliminary Survey of Cold Hardiness Levels of Several Bulbous Ornamental Plant Species[1]

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Abstract. **Cold hardiness levels determined for 23 species of plants with bulbs or other specialized underground structures showed great differences in hardiness; *Ixia* sp., *Ranunculus* sp., and *Sparaxis tricolor* were killed at −2°C, while *Ixiolirion montanum* was first injured at −18°C. In most species of bulbs, the basal plant and roots were the least hardy tissues. Results of this study do not agree with hardiness zone ratings found in the literature for many of the plants tested.**

Little information is available on the hardiness of bulbs, corms, tubers and tuberous-rooted plants (collectively referred to as "bulbs"). "Hardy bulbs" refer to those plant species with underground storage structures which are successfully fall planted. "Tender bulbs" such as dahlias, and others must be dug every fall, stored and replanted in the spring (3, 4, 8).

Abramova and Zakalyabina (1) observed cold injury to many bulbous plants during two unusually severe winters in which the air temp went as low as −29°C. Of 13 genera represented in their study, only Darwin Hybrid tulips, *Muscari, Scilla* and *Hyacinthus romanus* survived uninjured.

Sakai (5) reported that bulbs that are able to cold acclimate develop some cold hardiness as they mature and then acclimate further in response to cold temperature. The hardiest bulbs that he tested under winter conditions were able to tolerate 24 hr of freezing at −15 to −18°C. However, dried tubers of *Anemone* and *Ranunculus* survived exposure of 24 hr at −196°.

Van der Valk (6) reported marked differences in cold hardiness between various tissues within the bulbs. The bulb scales were the most hardy and the basal plate was quite sensitive to cold injury. He also reported that duration of freezing temp influenced amount of injury.

Crockett (2) gives hardiness zones for many of the "bulbs." Minimum air temp, which is used to define the USDA hardiness zones, only partly relates to the soil temp which actually affects the underground structure. The soil temp is also affected by snow cover and mulches which act as insulation. Thus, hardiness zones based on minimum air temp may not be a good criteria for rating hardiness of bulbous plants.

Cold hardiness was determined for 23 bulbous plant species ranging from those expected to be hardy to those considered tender (Table 1). Plant species were randomly divided into 3 groups for the freezing treatment. Within each group, one "bulb" of each of the cultivars included was planted in a commercial peat-vermiculite mix in each of 20 15 cm clay pots on Oct. 23, 1974. The bulbs were planted within a week after receiving them from commercial distributors. They were planted with the top of the bulb 1 cm beneath the surface of the media. The pots were held in a greenhouse at approx 5°C and kept moist until Jan. 7, 1975 (76 days). At this time shoots of many of the plants (*Allium neapolitanum, Crocus, Galanthis, Hyacinthus, Leucojum, Lycoris, Puschkinia, Ranunculus, Scilla tubergeniana* and 'Red Emperor' and 'Apeldoorn' tulips) were beginning to break the soil surface and the pots were moved to a −2°C cooler for 10–23 days until exposed to the test temp.

Each pot was put in a polyethylene bag to maintain soil moisture at approx field capacity and then placed in a freezer controlled by a Partlow temp recording programmer for treatment. The freezer temp was dropped to the first

Table 1. Cold hardiness levels of plants with specialized plant structure.

Species	Temp of severe injury (°C)	Field survival[z]		Hardiness zone rating[y]
		mulched	non-mulched	
Allium moly L.	−6.5	+	+	4
Allium neapolitanum Cir.	−9	+	+	6
Anemone blanda Schott & Kotschy	−9	+	+	6
Camassia quamash (Pursh) Greene	−15.5	+	+	3
Crocus speciosus Bieb.	−9	−	−	3
Endymion hispanicus (Mill.) Chouard	−9	+	+	4
Eranthis hyemalis (L.) Salisb.	−11	+	+	4
Galanthus nivalis L.	−9	+	+	3
Hyacinthus orientalis L. cv. King of the Blues	−9	+	+	4
Ixia sp.	−2[x]	+	−	8
Ixiolirion montanum (Lab.) Herb.	−18	+	+	7
Leucojum aestivum L.	−6.5	Not eval.		4
Lycoris radiata (l'Her.) Herb.	−9	+	+	8
Muscari armeniacum Leichtl. ex Bak. cv. Blue Spike	−9	+	+	−
Puschkinia scilloides Adams	−11	+	+	3
Ranunculus sp.	−2	+	−	8
Scilla sibirica Andr.	−11	+	+	1
Scilla tubergeniana Hoog	−9	+	+	1
Sparaxis tricolor Ker.	−2[x]	−	−	9
Sternbergia lutea Ker. ex Spreng	−6.5	+	+	6
Tulipa fosteriana Hort. cv. Red Emperor	−13.5	+	+	3
Tulipa gesneriana L. cv. Apeldoorn	−13.5	Not eval.		3
Tulipa kaufmanniana Regel	−9	+	+	3

[z]+ = survived, − = dead.
[y]USDA Zones. See Crockett (2).
[x]Injured during the pretreatment period at −2°C.

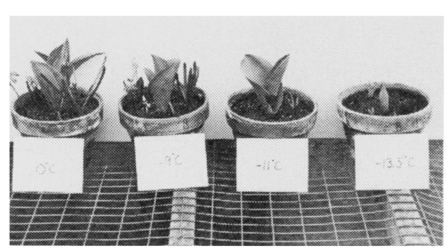

Fig. 1. One group of bulbs in the freezing test. In the center of the pot is *Tulipa fosteriana.* Starting from the left side where *Eranthis* is blooming and progressing clock wise around the pot are *Scilla sibirica* and *Muscari.* In the −9°C pot counterclockwise from the *Eranthis, Scilla tubergeniana* is blooming.

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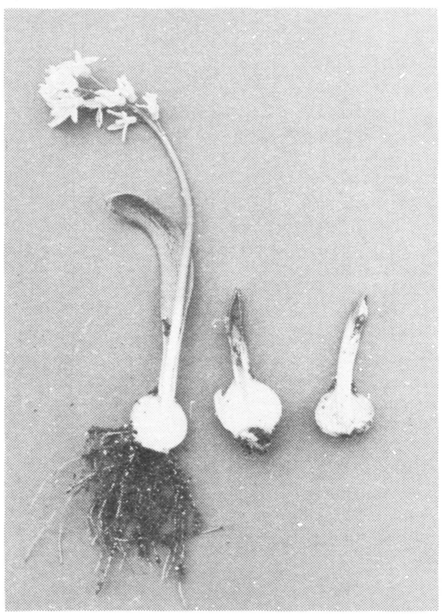
temp and held until potentiometer readings of thermocouples inserted in the center of the pot prior to the freezing test indicated that the soil had stabilized at the desired temp (a minimum of 4 hr was required each time). Two pots were removed at each temp before dropping to the next lower test temp. The test temps were: nonfrozen (check), −4.5, −6.5, −9, −11, −13.5, −15.5, −18, −20, and −22°C. After removal from the freezer, the pots were put in a 1°C cooler to thaw gradually. When thawed, they were moved to a warm greenhouse (approx 20°) for forcing. Visual observations were made of growth and flowering. Plants showing abnormal growth were dug and dissected to determine the location and degree of injury.

To compare laboratory results to natural conditions, additional bulbs were planted outdoors in late Oct. at 2 locations, one at the University of Minnesota Landscape Arboretum in Chanhassen, Carver County, Minnesota, and the other about 48 km (30 miles) west in Hale Township, McLeod County, Minnesota. Tulips and hyacinths were planted 12–15 cm deep and other species at 8–10 cm. Five bulbs of each species at each location were mulched with approx 10 cm of marsh grass hay and 5 were not. Soil temps were periodically recorded. Visual observation of winter injury of these plants was made in the spring of 1975.

The freezing tests showed a great variation in the hardiness of the plants tested (Table 1, Fig. 1). There were also differences in the hardiness of different tissues within the bulbs. In *Allium neapolitanum*, *Camassia quamash*, and *Sternbergia lutea* all tissues were killed at about the same temp. In *Tulip fosteriana*, the basal plate and roots were killed at −13.5°C, the outer scales were injured at −15.5°, the inner scales were killed at −18° and the stem and flower buds were killed at −20°. At any temp above −20°C the shoot developed as much as 12 cm above the bulb. This pattern was also exhibited by *Allium moly, Galanthus nivalis, Ixiolirion montanum, Lycoris radiata, Muscari armeniacum, Puschkinia scilloides, Endymion hispanicus, Scilla sibirica* and *Scilla tubergeniana* (Fig. 2). With *Hyacinthus orientalis* and *Leucojum aestivum*, the stem and flower stalk was injured at the same temp as the basal plate, while some of the scales remained alive.

Shoots of *Crocus speciosus* were injured first and the rest of the stem tissue survived to a slightly lower temp. With *Eranthis hyemalis* and *Anemone blanda*, all tissues were killed at the same temp. The temp of severe injury reported in Table 1 is the highest temp resulting in severe injury to any tissue within the bulb.

Results of the field trial usually confirmed the laboratory test. *Crocus speciosus* and *Lycoris radiata* are exceptions and should be retested. The winter of 1974-75 was a mild winter for underground plant structures in Minnesota and this may account for the survival of *Ranunculus* and *Ixia* under mulch. In Dec., the low air temp was −18°C which occurred on Dec. 25. Shortly after that date thermocouples at the soil surface registered 4° under 15 cm of mulch and −4° on top of unmulched soil (both covered with 3–5 cm of snow). This was the largest difference between mulched and unmulched soil temps all winter though, because on Jan. 10 and 11, 60 to 90 cm of snow accumulated over the planting areas and after that the soil surface temp rose to 0° and remained there the rest of the season. The temp 15 cm below the surface, the usual planting depth for many bulbs, was 1.5 to 2° higher than that at the surface.



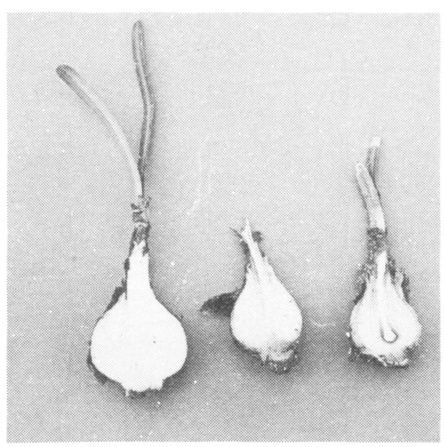


Fig. 2. Top. *Puschkinia scilloides* frozen to −9, −11, −13.5°C.
Bottom. *Lycoris radiata* frozen to −6.5, −9, −11°C.
Note the injury to the basal plate in Puschkinia at −11°C and *Lycoris* at −9°C, and to the scales at −13.5°C and −11°C, respectively.

Wildung et al. (7) measured soil temp during 7 winters in a location near this study and found temp as low as −12°C at a 15 cm depth under 15 cm of mulch plus the natural snow cover, and a temp of −18° at 15 cm under unmulched soil plus the snow. These temp were recorded in a winter with 44 cm total snowfall. In winters with more snow cover (up to 199 cm) the temp 15 cm under mulch rarely went below −7° while that under unmulched soil plus snow was usually no lower than −13°. Based on our freezing test it seems that a soil mulch could make a difference in how many species could be grown. Only *Ixiolirion montanum* and *Camassia quamash* in this test were hardy to −13° or below, but 17 were hardy to at least −7°, and several more might survive a mild winter with the aid of a heavy mulch.

It is interesting to note the differences between our data and the hardiness zone ratings given by Crockett (2). *Ixiolirion montanum* is an extreme example. It was rated at zone 7 (which ranges from Texas through Tennessee to Virginia) yet withstood temps to −15.5°C without injury in our tests and flowered profusely in the field trials without mulch. With knowledge of local winter soil temp conditions, data of "bulb" hardiness capabilities should be helpful to gardeners in predicting success. Additional studies are needed to determine relationship of cold acclimation of bulbs to their stage of development and to environmental conditions. Further studies are also needed to verify results of these preliminary studies and to determine hardiness capabilities of additional species.

Literature Cited

1. Abramova, S. N. and L. G. Zakalyabina. 1973. Overwintering of bulbous and cormous plants in Ashkhabad in 1968-1972. *Glavnyi Bot. Sad.* 88:27-29.
2. Crockett, J. U. 1971. Bulbs. Time-Life Books, New York.
3. Genders, R. 1973. Bulbs, a complete handbook. Robert Hale and Co. London.
4. Jefferson-Brown, M. 1966. Daffodils, tulips and other hardy bulbs. John Gifford Limited, London.
5. Sakai, A. 1960. The frost hardiness of bulbs and tubers. *J. Hort. Assoc. (Japan)* 29:233-238.
6. Van de Valk, G. G. M. 1970. Frost injury to flowerbulb crops. *Acta Hort.* 23:345-349.
7. Wildung, D. K., C. J. Weiser, and H. M. Pellett. 1973. Cold hardiness of malling clonal apple rootstocks under different conditions of winter soil cover. *Can. J. Plant Sci.* 53:323-329.
8. Wister, G. 1964. Hardy garden bulbs. E. P. Dutton and Co., Inc.