

## **Freesia is a risky option for early high tunnel production in the US Mountain West**

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High tunnels have tremendous potential for cut flower farms, from improving crop yield and quality, to advancing and extending the production window, such that double-cropping is possible in cool regions. In the US West, drought can heighten the need for early-season production, as maximum water availability typically occurs in late-winter through spring snowmelt, while the potential for water shortages and restrictions increase by mid- to late-summer (NIDIS, 2023; UDNR, 2023). Crop irrigation needs can also be lower during cooler, more humid conditions. Therefore, in drought years, farmers may decrease financial risk by shifting reliance to spring crops and reducing summer to fall production. The suitability of several cool-season cut flowers for earlier production in high tunnels is well-documented, as they are readily advanced, have greater yields, and have a strong profit potential (e.g., Lewis et al., 2021; Lewis et al., 2022; Lewis et al., 2023). Even USDA Hardiness Zone 7 crops, such as ranunculus and anemone, can be successfully overwintered at Zone 5 for earlier production in high tunnels (Rauter et al., 2022a; Rauter et al., 2022b). In effort to expand and diversify early-season production in high tunnels, we are continually trialing additional crops identified by stakeholders to serve the ever-increasing floral market needs.

*Freesia (Freesia x hybridia)* has small space requirements and potential for early harvest before the main season or irrigation restrictions begin, as well as unique fragrance. Conditions for flowering include 41 to 68°F, and are optimal at 54-60 °F, while soil should be cooler and remain moist (Anderson, 2007; Armitage and Laushman; de Hertogh, 1996). Spring plantings after the danger of frost are recommended for Zones 8 and cooler, but result in bloom during high summer temperatures that reduce stem quantity and quality and force dormancy. Though rated for USDA Hardiness Zone 9, freesia planted in Maryland (Zone 7) high tunnels in Feb. successfully bloomed 3 to 4 months later (Dowling, No Date). Growers in Idaho and Utah (Zones 5-6) may pre-sprout and then plant heated high tunnels by Feb. for harvest in Apr. to mid-May (personal communications, Florage Farms & Flourish Flower Farm, 1 Jul 2021). Evaluating protected cultivation of freesia in Utah (Zones 5 to 8) through high tunnels with cold protection will help determine the practicality of this crop as an early-season option.

### **Project goals**

- 1) Trial winter plantings of freesia as an early, cool-season crop in a high tunnel.
  - Use succession plantings to determine ideal timing (years 1 and 2)
  - Test additional protection for winter (years 1 and 2)
- 2) Monitor air and soil temperatures to understand crop behavior in local environmental conditions (years 1 and 2).
- 3) Work with growers in Utah across USDA Hardiness Zone 5 to 8 to test crop performance around the state (year 1).

### **Procedures**

The main study was established at Utah State University's (USU's) Agricultural Research Farm in North Logan, UT (USDA Hardiness Zone 5b) and tested from December 2021 – August 2022, and December 2022 – August 2023. In 2021-2022, we trialed freesia in an unheated high tunnel by direct-planting the corms of two cultivars: 'Riga' (double-blooming white) and 'Anouk' (single-blooming white). Planting occurred on 10 Dec 2021, 25 Jan 2022, and 21 Mar 2022. Within the high tunnel, the plantings were either covered with a low tunnel for additional cold protection, or left bare as a control to test natural high tunnel conditions. Five Utah growers also received corms of these cultivars to plant across two winter planting dates of their choice. Their USDA Hardiness Zones ranged from 5a to 8a.

In 2022-2023, 'Riga' and 'Corvette' (a single-blooming white to replace 'Anouk' that was not available) were evaluated solely at USU's Research Farm. Because soil temperatures drive emergence and can be cooler than optimal in Zone 5 winters, half of the corms were pre-sprouted and half were direct-planted in a high tunnel. Pre-sprouting was initiated approximately one month prior to planting and planting dates were on 12 Jan and 10 Feb 2022. For greater cold protection, all plantings were covered with low tunnels within the high tunnel this year. Half of the low tunnels also received soil heating via infrared heat mats placed near the exterior edge of the high tunnel and set to 55°F. In early 2023, Northern Utah began experiencing record cold temperatures that were 20 to 30 degrees below normal minimums (Table 1), and a space heater was installed that activated to keep the tunnel above freezing.

In both years, freesia corms were planted at a two-inch depth and spaced four inches apart (Figure 1). Horizontal trellis was installed to encourage straight stems. The soil was a silt loam, and irrigation was applied as needed, which was approximately once per week in December through February, and two- to three-times per week from March onward. Soil tests were conducted prior to planting to determine phosphorus and potassium levels, which were sufficient. Nitrogen (N) was split across three monthly applications for a total of 1.5 lbs N per 1000 ft<sup>2</sup>. Hourly soil and air temperatures were monitored with environmental sensors. Soil temperature was measured at a 2-inch depth, to represent the conditions the corms experienced, while air temperature was measured at a 6-inch height aboveground to monitor near the surface temperatures that the plants primarily experienced. A weather station at the farm recorded hourly air temperature and other conditions at reference height (UCC, 2023).

## Results

### *Emergence and growth*

Of all the years to trial freesia, 2021-22 and 2022-23 were perhaps the most challenging, and for different reasons. In 2021, the corms were delayed at sea because of supply chain lags from COVID-19. Prolonged time in a shipping container strongly reduced their quality upon arrival, particularly that of 'Riga'. This was especially problematic for freesia, as the corms should be planted as soon as possible, or stored for a limited time at 55°F (Faust and Dole, 2021). As a result, the emergence rates were greatest with the December planting, with 93% of the 'Anouk' corms emerging, and only 39% of the 'Riga' (Figure 2). Emergence declined with subsequent plantings. Overall, the winter season was colder than normal, with the outdoor lows frequently below 10°F into March (Table 1). The average near-surface air temperature in the high tunnel remained 15°F above outside lows (Table 1), but was not warm enough for the crop. Soil temperature gradually increased from 40 or cooler in December to the mid-50s by April, with the low tunnel raising the average soil temperature by 1 to 3 degrees (Table 2). Interestingly, a number of the plants developed lesions and streaks and were tested by the USU Plant Pathology Laboratory (Figure 3). Freesia Sneak Virus was confirmed and became the *first* documented case of the virus in Utah (Nischwitz and Stock, 2022). Per additional soil testing, the virus is believed to have come from the plant stock.

In 2022-23, three separate shipments arrived on time and corms were pre-sprouted or planted within one week of arrival, though quality was still a challenge, with nearly half of the corms culled because of visual signs of rot. Pre-sprouting helped cull weak corms (Figure 2). However, Northern Utah experienced record cold (but thankfully also snow) in 2022-23, with temperatures often 30-degrees below normal. Minimum temperatures reached -18°F in January, when the average outdoor low is typically 14°F, and cold persisted into April (Table 1). Soil temperature was maintained above freezing, but because high tunnels are passively heated by the sun, overcoming overnight lows like this, even with heaters and low tunnels, can be a challenge, and proved to be when growing this Zone 9 crop.

## Harvest

After plants emerged, soil temperatures were optimal for flowering in April, but harvest was minimal across both years. Because of the semi-arid climate in the north and arid climate in the south, Utah has strong daily temperature fluctuations that can be 30 to 40 degrees apart, often making nights too cold and days too hot, with high-elevation sun that can be too intense. High tunnels can help moderate these temperatures with management (frequent venting, frequent layering and removing of insulative materials), but the conditions in Utah were too extreme for freesia during these two years. We averaged fewer than two stems per emerged plant in 2022, and fewer than one stem per plant in 2023. The optimal harvest stage for local markets was “2+”, when two flowers were open and a third was enlarged (personal communication, Florage Farms, 18 Apr 2022). Harvest lasted from 18 April to 1 July 2022, and 24 Mar to 18 April 2023. After this, the temperature conditions triggered dormancy. Collaborating farms experienced similar low yields across zones. Vegetative regrowth was observed in fall 2022 by three farms, and in August 2023, the corms at USU were excavated to assess their quality. Indeed, they appeared healthy, but dormant.

## Take-home Message

Freesia requires strong management and tailored conditions for production because it has specific temperature ranges that trigger dormancy, growth, and flowering. In Utah, unheated or minimally-heated high tunnels were tested in years with record-cold winters and could not moderate temperatures enough for early production. Planting early, pre-sprouting, and adding additional protection like low tunnels and heating helped. There may be potential for those who have heated greenhouses, live in more moderate climates (less day/night temperature variation) or have mild winters, or use crates that can be moved to warmer/cooler locations when needed. However, the cost of every warming technique: high tunnels, low tunnels, soil heating, space heaters – and the labor that comes with this management – must also be balanced when deciding on this crop. Freesia may create a niche, and some experienced farms have done this. For most high-elevation growers, however, we have other cut flower recommendations that are promising for early-season production in high tunnels, and unfortunately from these trials years, cannot add freesia to the list.

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**Table 1.** The minimum monthly air temperatures from Dec to Jun of 2021-2022 and 2022-2023. The outdoor and high tunnel air temperatures are given in °F.

Month	Outdoor air temperature (°F) <sup>1</sup>		High tunnel air temperature (°F)	
	2021-22	2022-23	2021-22	2022-23
Dec	8	-6	23	ND <sup>2</sup>
Jan	-1	-18	18	ND <sup>2</sup>
Feb	4	-1	18	29
Mar	7	8	24	31
Apr	23	13	31	33
May	30	37	28	38
Jun	37	42	35	39

<sup>1</sup>Data courtesy of the Utah Climate Center (2023).

<sup>2</sup>No data (ND) due to sensors.

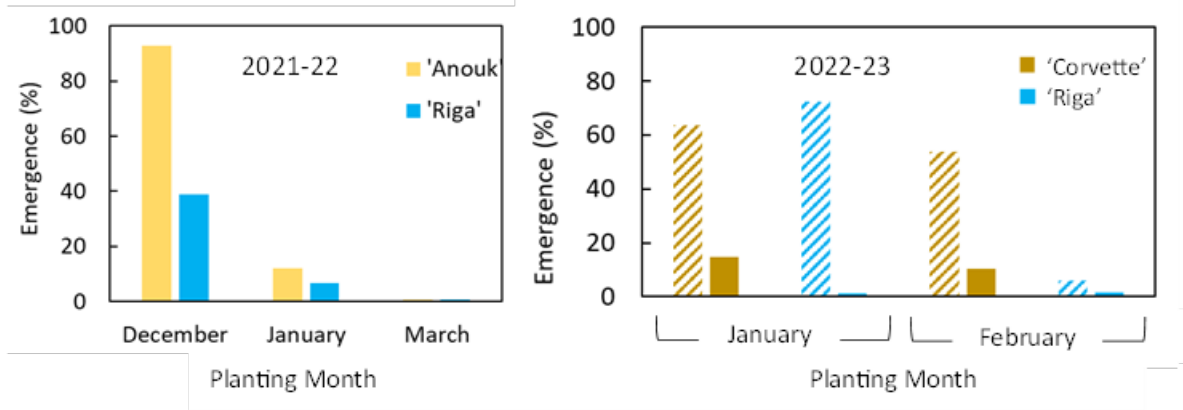
**Table 2.** The average monthly soil temperatures from Dec to Jun of 2021-2022 and 2022-2023. Temperatures were recorded at a 2-inch depth and are given in °F. In 2021-2022, bare soil and low tunnels were tested within the high tunnel. In 2022-2023, there was no bare soil. Instead, low tunnels and low tunnels with soil heating were used, as well as a space heater.

Month	2021-2022		2022-2023	
	Bare soil (°F)	Soil with low tunnel (°F)	Soil with low tunnel (°F)	Soil with low tunnel and heating (°F)
Dec	39	41	ND <sup>1</sup>	ND <sup>1</sup>
Jan	36	39	ND <sup>1</sup>	ND <sup>1</sup>
Feb	42	44	44	47
Mar	51	51	50	52
Apr	55	53	56	56
May	58	56	66	66
Jun	64	63	69	70

<sup>1</sup>No data (ND) due to sensors.



**Figure 1.** High tunnels (*left*) in North Logan, Utah, with corms ready to plant (*right*).



**Figure 2.** The emergence rate of freesia when planted in a USDA Hardiness Zone 5b high tunnel. In 2021-22 (*left chart*), 'Anouk' (yellow bars) and 'Riga' (blue bars) were planted without pre-sprouting in December, January, and March. In 2022-23 (*right chart*), 'Corvette' (brown bars) and 'Riga' (blue bars) were planted in January and February with pre-sprouting (patterned bars) and without pre-sprouting (solid bars).



**Figure 3.** Visible symptoms of Freesia Sneak Virus that were later confirmed by the USU Plant Pathology Laboratory.