

# ***Portulaca pilosa* var. *mundala*: Drought resistant succulent thrives in the rockiest of gardens**

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## **EXECUTIVE SUMMARY**

*Portulaca pilosa* var. *mundula*, a succulent adaptable to warm climates around the world, thrives under the driest of conditions. It propagates by cutting or seed, with cuttings preferable to retail markets. While they have yet to find a huge place on the market, there is every reason to buy this plant this spring. For consumers looking for a flower that is easy to take care of and provides numerous health benefits *P. pilosa* is the ideal plant.

## I. INTRODUCTION

### A. Study Species.

[Goal 1] *Portulaca pilosa* var. *mundula* is from the family Portulacaceae and is commonly called pink purslane due to its bright color, shown in Figure 1 (The Institute for Regional Conservation, n.d.). Other common names include kiss-me-quick because their flowers open with light and close in darkness, in addition to hairy pigweed due to its hairy stems (Galdo, 2018). Since 1992, *Portulaca pilosa* has been considered to be a synonym of *Portulaca pilosa* var. *mundula*, consequently this paper will be using the term *Portulaca pilosa* or *P. pilosa* to refer to this succulent (Matthews, Ketron, Zane, 1992).



Figure 1. Image showcasing the distinct pink color of a *P. pilosa* flower (Keith A Bradley, 2013).

### B. Taxonomic Classification and Geographic Distribution in the Wild.

[Goal 2] It is debated as to where *P. pilosa* originated because it spread so quickly, but it appears that it is native to Mexico, Central America and South America, the southern United States and the Caribbean. In the US it is native to 15 states, mainly proliferating in Florida, but also grows as far west as Arizona, as far north as Oklahoma and Tennessee, to the east in North Carolina and Florida, and has found its way to Hawaii (Centre for Agriculture..., 2019; The Institute for Regional

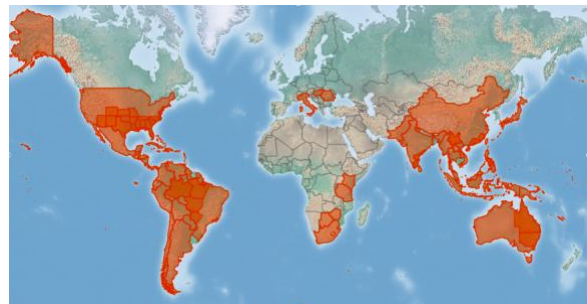


Figure 2. Distribution of *P. pilosa* (Centre for Agriculture..., 2019).

Conservation, n.d.). As shown in Figure 2, it has become invasive across the world, spreading to Asia, Australia, parts of southern Africa and southern Europe. Its latitudinal range is 40 degrees N and 40 degrees S, and it grows from 0 to 2000m altitudes (Centre for Agriculture..., 2019).

The environments that *P. pilosa* grows in shows that it is quite adaptable (see a healthy, spreading *P. pilosa* in figure 3). It prefers the following climates: tropical savanna with dry summer, tropical wet and dry savanna, steppe, desert, warm temperate with dry summer, warm temperate with dry winter. This is probably due to the fact that *P. pilosa* is “drought tolerant and is able to utilize crassulacean acid



Figure 3. Spreading *P. pilosa* (Forest & Kim Starr Images-2003. CC-BY-3.0).

metabolism during drought stress,” allowing for proliferation around the globe (Centre for Agriculture..., 2019). This plant requires well drained soil and can be found where there are “dry soils, beaches and disturbed habitats, as well as roadsides, railroads and limestone, granite and sandstone outcrops” (Centre for Agriculture..., 2019). This suggests that in the greenhouse they should be grown with a large particle substrate and over-watering should be monitored.

*Portulaca pilosa* is frequently associated with mangroves and in Hawaii it has been found growing on lava fields (Centre for Agriculture..., 2019). In addition to water requirements, *P. pilosa* is also particular about sunlight, as its flowers will not open without it (Centre for Agriculture..., 2019).

Flowers are ephemeral, they require full sunlight and will close when the sun goes down at night (see close up of the flower in Figure 4).

Most blooming takes place in the warmer months and high temperatures are also required for seed production. *Portulaca pilosa* is very invasive and has spread far from its native habitat, as mentioned.

There are many features of this annual that allow it to be so invasive across the world. First, it can vegetatively propagate or propagate by



Figure 4. Close up of *P. pilosa* flower. ©Keith A Bradley 2013

seed, making “garden escapes” very likely to put down roots (Centre for Agriculture..., 2019). Seeds may also get carried by animals through their feces, however, a study in Australia in 1999 found that dispersal through cattle lead to only low levels of germination. Birds are also not effective carriers, as shown in a 1977 study on the bird *Passer domesticus*, which resulted in only a “15.9% [viability] after being eaten” (Centre for Agriculture..., 2019). The greatest accidental spread of seeds for this species is the movement of hay and garden waste. It can also self-pollinate and is drought tolerant so it will grow in many environments that are typically undesirable to other plants. In addition, there are no commonly reported pest or disease problems, further adding to its resilience. Perhaps the greatest cause for its invasiveness is the fact that it can produce seeds every two months with a total average of 292,000 each season (Centre for Agriculture..., 2019). While growing in greenhouses, one must be careful of where all seeds and cuttings are going because they can be so easily spread.

*P. pilosa* is a herbaceous annual that grows to be around 30 cm tall with fleshy roots, leaves and hairy stems. Its leaves are opposite or alternate, 20 mm long and 3 mm wide. Flowers usually consist of 5 petals that are 5-12 mm wide and are dark pink. As shown in Figure 5, seeds are grown in capsules, are typically black to gray and are less than 1 mm in diameter. Morphology differs based on location where dry habitats produce more hairs and grow more compactly. Moist environments allow them to spread out more before growing upwards (Centre for Agriculture..., 2019).



Figure 5. Seeds of *P. pilosa* (“PORTULACACEAE”, utexas.edu).

There are many uses for *P. pilosa* that differ worldwide. Most commonly, this plant is used as a bedding ornamental or planted on roofs, particularly common in Cuba (Centre for Agriculture..., 2019). Oftentimes, *P. pilosa* is not purposefully planted though, and since it is so highly invasive, it spreads on its own. Some cultures in Melanesia and south India eat the leaves as a vegetable, but while it has not been found to be poisonous, it is not commonly eaten elsewhere. However, this may change with the publishing of a recent 2017 study showing that “the content in polyphenols, short chain organic acids, and saccharides” in *P. pilosa* shows “antioxidant activity, low toxicity on normal cells, and high toxicity on tumor cells,” impressive impacts for such a small plant (Gatea et al., 2017). The same study also showed that it can also prevent liver damage and works as an “antidiarrheal and diuretic and for burns, erysipelas and injuries” (Gatea et al., 2017). In addition to being used as human food and for medicinal purposes, *P. pilosa* has also been known to be used for cattle feed in New Mexico and Australia (Centre for Agriculture..., 2019).

## **II. CROP SPECIES**

### **A. History and Potential Uses.**

[Goal 3] *Portulaca pilosa* has been found across the world within the last century, but the first hitchhiker to have been recorded leaving its native habitat may have been carried to Australia as early as 1870. As for breeding history, there has only been one attempt and that was in 1990 when researchers Kim I and Carr GD “attempted to produce interspecific hybrids” but were unable to do so (Centre for Agriculture..., 2019).

Cuttings and seeds are both viable parts of *P. pilosa* to propagate. Due to lack of research on production, it is unclear which is most desirable for consumers to grow themselves. From the author’s experience, *P. pilosa* seeds are very small and hard to work with so it would be

recommended to be sold as a cutting. However, there is one seller on Ebay, leasgarden11, who is currently selling seeds (Ebay, n.d). There are three other sellers of *P. pilosa* with sites to purchase cuttings online: Naturescapes of Beaufort, EvanlyPlants on Etsy, and the Cactus King (see distribution chain in Figure 6) (Naturescapes, 2020; Etsy, n.d; The Cactus King, n.d.). Buyer beware, there are other sellers claiming to have *P. pilosa* but their naming is not accurate.

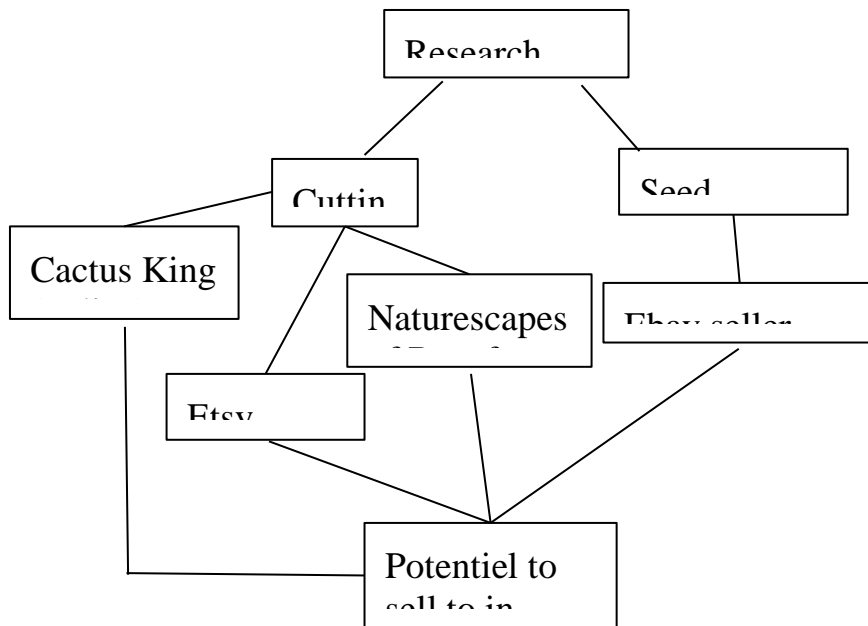


Figure 6. Horticultural distribution chain.

No known in-store retailers currently sell *P. pilosa* seeds or cuttings. However, there is potential for a new market to open up where a larger online seller, like the one on Ebay with seeds or Cactus King, can distribute to a local retail store and consumers can purchase there. Different treatments are needed for growing this succulent from cuttings versus seeds so that is something that each retailer and consumer needs to consider.

### III. PRODUCTION INFORMATION

#### A. Anticipated Cultural Requirements.

[Goal 4] The life cycle of *Portulaca* in general is that it grows relatively quickly, germinating in 2-3 days. From sowing the seeds to a retail transplant takes 4-5 weeks and from then it takes 5-6 weeks to mature (Ball Horticultural Company, 2021). This cultivar would be best positioned as an annual in the retail horticultural industry. While it is a short-lived annual, the high level of invasiveness will likely lead to continued growth of the plant in the area it grows, leaving the consumer with beautiful greens and pinks in their garden for years to come (Centre for Agriculture..., 2019). It would be helpful to provide customers with guidance on trimming it back and making them aware of its invasive, self-seeding tendencies.

The most important traits that *P. pilosa* possess which can be useful to the market are its bright flowers, the fact that it will be around for a long time and that it is edible. The market would be for an annual bedding plant or a potted plant. It is to be noted that planting this as a bedding ornamental can very easily lead to it spreading to other parts of the yard, especially in the warmer climates in which it has already become invasive. It is recommended that there are no grasses nearby in which it could take over. If there is, it might be best to grow this indoors. The spread can be controlled somewhat by herbicides like glyphosate, but this is not advised due to being unsustainable and harmful for the environment. Growing *P. pilosa* indoors is ideal because

it can easily be harvested as a snack or for medicine or just to have beautiful flowers in your living space (Centre for Agriculture..., 2019).

*Portulaca pilosa* grows in USDA defined hardiness Zones 6-13 (see figure 7) which include the warmest parts of Oklahoma, Tennessee and down to Puerto Rico (USDA, 2012). It inhabits heat zones 8-11 (see Figure 8), showing that this product has a wide range of potential homes (American Horticultural Society, 1997). This product could be sold in any of these areas where it can survive winters above 32F with minimum precipitation, however, temperatures of 65-76F are ideal during growth (Ball Horticultural Company, 2020). It should be noted too that *P. pilosa* does not have a high saltwater tolerance, so growing in areas at risk for ocean flooding would not be advised (The Institute for Regional

Conservation, n.d.). Instead, this crop should be advertised to those living in dryer climates who do not want to waste water on their garden. As of March 2nd, 2021 most of AZ, NM and parts of TX are in extreme drought so many consumers will want to conserve their water and might be

unwilling to use it on their gardens (Skipwith, 2021). A succulent like *P. pilosa* is a perfect fit for consumers in these types of situations. It could also be marketed to people living in houses only part time as they could find the ease of care desirable.

## B. Market Niche.

[Goal 5] Looking at market niche starts with the target sales date. In more northern climates, this product would be sold in the spring so that by the time it got warm in the summer it would be

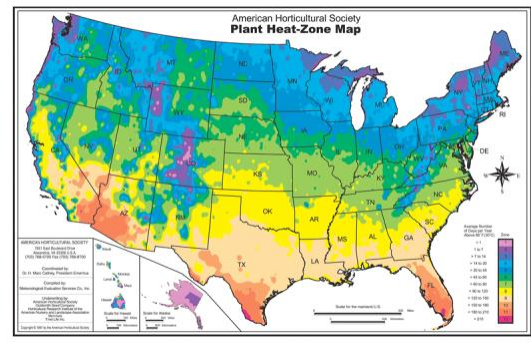


Figure 8. Plant Heat-Zone map (American Horticultural Society, 1997).  
Figure 7. Plant Hardiness Zone map (USDA, 2012).



able to flower. In southern climates, this could be sold year-round because it could flower anytime outdoors. It would be perfect as a Mother's Day gift because the flowers are pink and in many climates the temperatures and light in May would be the perfect time to plant it.

This product has the potential to be programmably forced year-round in greenhouses. While it could be perfect for Mother's Day, the ease of care of this plant would make it ideal for keeping up with year-round. However, flowering season is typically spring to fall so some consumers may find it desirable to purchase it then (The Institute for Regional Conservation, n.d.).

There are a few main potential issues that this species might have, including its sensitivity to light, temperature, and water. A grower needs to be careful to expose *P. pilosa* to enough light or they will be disappointed by the lack of flowering. Sunlight is important as soon as the seeds are sown, however, it is not necessary during germination but can be helpful and will set up the grower for good habits. Next, the temperature should be relatively consistent. A grower could prevent flowering altogether if temperatures are too low. Water is another factor that can be tricky when growing *P. pilosa* as too much water can kill the plant. The bright side though is that too little water will not be an issue as they are very tolerant of drought. Using the proper substrate that allows for frequency drying is essential. Something else to be wary of is transplanting seedlings fast enough when they germinate in the same pot as the mother plant. Because *P. pilosa* spreads so quickly, it is important to not let too many grow in one pot or they will all compete for water and nutrients.

One competitor to *P. pilosa* could potentially be *Calandrinia spectabilis*, also known as Rock Purslane (shown in Figure 9). It is also a drought tolerant succulent, which is a very desirable trait for many growers who want low maintenance plants, and it has very similar pink flowers to

*P. pilosa*. One major upside to this plant is that it is not invasive as the seeds take a long time to grow and when they are produced it is not in large quantities. They propagate best vegetatively, meaning that a grower has much more control over it and one plant also lasts for 2-3 years (*Rock Purslane Care*, 2020).



Figure 9. *Calandrinia spectabilis* or rock purslane (w

Another competitor is *Portulaca grandiflora* (as shown in Figure 10) which has many similar characteristics but is less invasive, a trait that may be more desirable if a grower wants more control over their garden. One downside to this species is that a single plant does spread farther than *P. pilosa*, extending up to 2 ft. versus 11 in., so it would not be ideal for indoor growing (Cornell University, 2006).



Figure 10. Note the bright pink flowers of *Portulaca grandiflora* (Cornell University, 2006).

The main trait that will capture the horticulture world's attention is the story of drought tolerance and its use as a potential treatment for gastrointestinal disorders. In general, *Portulaca* can survive through periods of drought and can recover in less than 24 hours, making this an ideal plant for growers who need a more hands-off approach to gardening (Jin, R., Wang, Y., Liu, R., Gou, J., & Chan, Z. 2016). This would also be ideal for a grower who has gastrointestinal health issues, not only for the ease of care, but also for the proven antioxidants that *P. pilosa* provides. Not only are its flowers beautiful, it also can help with a consumer's own beauty as its leaves can be used as a hair gel that keeps on growing. Overall, *P. pilosa* is highly desirable due to its ease of care and treatment for health conditions (Centre for Agriculture..., 2019).

Not only is *P. pilosa* ideal for homeowners, it also has the potential to be marketed to cattle farmers as the perfect new feed. If left wild, this plant spreads quickly so a farmer will not have to keep spending money on buying feedstock. As mentioned above, it also requires minimal water, so it is unlikely to die in extreme conditions, a cost saving aspect for farmers looking for sustainable feed sources (Centre for Agriculture..., 2019).

*Portulaca pilosa* seeds and cuttings will be available on the market by June 1st, ready to be planted for the summer. Buying new plants can be intimidating so that's why there are free samples for growers, retailers, and consumers so they can test this new product and see for themselves what a great addition to a garden *P. pilosa* will be.

#### **IV. PRODUCT INFORMATION GUIDE (PIG) & CROP SCHEDULE**

More experiments need to be done on *P. pilosa* in professional settings to be able to put together a more accurate product information guide. However, from the existing research done as well as with the insight from similar crops that are being commercially produced, one can put together a roughly accurate guide to growing *P. pilosa*. From the author's own research, the germination of *P. pilosa* from seed was 0% successful when seeded in 3 different media: Berger BM2 germination mix, vermiculite, a 50% mixture of germination mix and vermiculite. The germination mix had a pH of 5.2 - 6.0, contained 70-80% peat moss with the remainder made up of perlite, vermiculite, dolomitic and calcitic limestone. Additionally, seed depth was found to have no effect on germination when seeds were planted at ¼" depth versus uncovered. For future research, it is recommended to try stratifying or scarifying the seeds as a possible way to induce germination. There is also the possibility that the seeds in the author's experiment were too old to germinate so future research should ensure that seeds are new when planting.

Below is a proposal on all factors of plant growth needed for production. As there is no information on commercially growing *P. pilosa*, information on growing *Portulaca grandiflora* which has similar morphology (fleshy leaves), reaction to the sun (ephemeral flowers), is also drought tolerant and likes rocky soils will be used in this section (North Carolina State Extension, n.d.). The first table is based on information from Ball Seed Company on propagating *P. grandiflora* by seed. The second table is based on information from Sakota Ornamentals on propagation of *P. grandiflora* by cutting.

### Propagation of *P. grandiflora* from seed

Stage	Soil Temperature	Light	Moisture	Fertilizer
<b>Stage 1</b> (2-3 days)	71-79°F (22-26°C)	Not required but beneficial	Level 4 Keep moist	None
<b>Stage 2</b>	71-73°F (22-23°C)	2,500 foot candles (f.c.) (26,900 Lux)	Level 3 Slightly reduce soil moisture; dry out before rewatering	Rate 1  (less than 100 ppm N/less than 0.7 mS/cm EC); low levels of phosphorus, ammonium
<b>Stage 3</b>	68 to 73°F (20 to 23°C)	2,500 f.c. (26,900 Lux)	Level 2-4 Wet-dry cycle Irrigate early in the day	Rate 2 (100 to 175 ppmN/0.7 to 1.2 mS/cm EC)
<b>Stage 4</b>	65-67°F (18-19°C)	Up to 5,000 f.c. (53,800 Lux)	Level 2-4 Wet-dry cycle Irrigate early in the day	Rate 2 (100 to 175 ppmN/0.7 to 1.2 mS/cm EC)
<b>Finishing</b>	Nights: 65- 67°F	As high as	Be careful to not	Every other

	(18-19°C)  Days: 68-76°F (20-25°C)	possible	overwater. Dry media dry thoroughly between waterings.	irrigation alternating 15-0-15 with 20-10-20, 150 to 200 ppm N.
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Table 1. Recommended soil temperature, light, moisture, fertilizer for stages1 to finishing for *P. grandiflora* (Ball Horticultural Company, 2021).

For propagating by seed, there are multiple factors to consider. The amount of daily sunlight is vital to *Portulaca* growth. If exposed to short days they can rosette and cannot recover, so it is necessary to provide at least 12-13 hours of daylength during production. It needs soilless media with medium nutrient levels and a pH of 5.5-6.2. Sow seeds uncovered in a 288 cell plug tray. If seedlings are transplanted in 606 flats, they will take 5 weeks to mature; if transplanted into 4” pots it will take 5-6 weeks to mature. Relative humidity of 95% is ideal for germination. To control height PGR is generally not used, instead it is more effective to reduce the soil moisture, phosphorus and ammonium-form nitrogen (Ball Horticultural Company, 2021).

### Propagation of *P. grandiflora* from cutting

Stage	Soil Temperature	Light	Moisture	Fertilizer
<b>Stage 1</b> (1-6 days)	70-75°F (21-24°C)	2,000 foot candles (f.c.) (22,000 lux)	Pre-moistened media  If high heat: minimal misting for 3-4 days	None
<b>Stage 2</b> (7-13 days)	68°F (20°C)	3,000-3,500 f.c. (32,000-38,000 lux)	Reduce air humidity to 70-80%	75 ppm nitrogen  Balanced calcium nitrate-

				based formulation
<b>Stage 3</b> (14-20 days)	68°F (20°C)	3,000-3,500 f.c. (32,000-38,000 lux)	Partially dry down between irrigations	100-150 ppm N EC of 1.0 mmhos
<b>Stage 4</b> (21-25 days)		Minimum of 5,000 f.c. (53,000 lux)	Dry between waterings	

Table 2. Recommendations for soil temperature, light, moisture and fertilizer for stages 1-4 for *P. grandiflora* (Sakata Ornamentals, 2011).

To successfully propagate *P. grandiflora* it is essential to select media with good aeration and keep the pH between 5.5 and 6.5 and the EC at less than 0.75 mmhos. Before planting the cuttings make sure that they are not exposed to 50°F (10°C). No rooting chemical is needed. If branching is desired, pinch 1 week before transplanting (Sakata Ornamentals, 2011).

Container Size	Rooting time	From Transplant	Total Crop Time
4 inch / 10 cm.	3-4 weeks	5-6 weeks	10-12 weeks
6 inch / 15 cm.	3-4 weeks	6-7 weeks	11-12 weeks
10 inch / 25 cm.	3-4 weeks	7-8 weeks	12-13 weeks
12 inch / 30 cm.	3-4 weeks	8-9 weeks	13-14 weeks

Table 3. Table comparing container size to rooting time and time to transplant (Sakata Ornamentals, 2011).

Once again, temperature and light are very important to *Portulaca* species, as cold temperatures will slow down growth and low light will not allow flowers to open (Ball Horticultural Company, 2021). Below is a table showing the effects of day length, temperature and light level on the time it takes *P. grandiflora* to grow from seed (Table 4).

Factor	Effect
Day length < 12 hours	Increases crop time
Day length > 14 hours	Decreases crop time
Temperature < 70°F/21°C	Increases crop time
Temperature > 70°F/21°C	Decreases crop time
Light Level < 5,000 f.c./ 54,000 lux	Increases crop time
Light Level > 5,000 f.c./ 54,000 lux	Decreases crop time

Table 4. Effects of different factors on *P. grandiflora* growth (Sakata Ornamentals, 2011).

Other factors to consider when growing include Plant Growth Regulators (PGRs), vernalization and pinching. For *P. pilosa*, growth regulators are unnecessary if watering is controlled to allow proper drying. If it is grown under very wet conditions where the substrate cannot dry out, then a PGR might be necessary. If height control is desired, one should reduce the amount of fertilizer used, focusing on reducing phosphorus and ammonium-form nitrogen. Cooling or vernalization is not recommended as it could be harmful to growth (Ball Horticultural Company, 2021).

Pinching has been shown to be beneficial for *P. grandiflora* to promote outward growth but is not necessary (Sakata Ornamentals, 2011).

While *Portulaca* does not tend to be greatly affected by pests due to its fleshy leaves, a grower does have to be vigilant of numerous pests when growing *P. grandiflora*, which can be assumed extends to *P. pilosa* as well. Common insect infestations on *P. grandiflora* crops include spider mites, aphids, thrips, whiteflies and fungus gnats. The most important step for proper pest control is to closely monitor a crop, searching for unwanted organisms. While spider mites, aphids and thrips infestations respond well to insecticidal soap sprays, be careful when using these on *P.*

*grandiflora* as soaps have been recorded to cause damage (Ubl, J. D., Munnerlyn, C., & Williamson, J, 2019). If it is desired to use soap spray, test it with a small patch at first.

Each pest has similar, but specific effects, on *Portulaca* so there are different treatments for each. Sakata Ornamentals recommends checking on the underside of leaves for aphids, whose presence can also be noticed due to wilting or yellowing. This greenhouse suggested using “systemic chemicals, such as Marathon, (Imidacloprid,1-)” to reduce aphid presence. Western Flower Thrips are also a possible pest that could affect *Portulaca* growth. Insecticide is very effective but if an organic method is desired for biological control, recommended methods include releasing predatory mites (*Neoseiulus* or *Amblyseius* spp), minute pirate bugs (*Orius* spp.), and entomopathogenic fungi (*Beauveria bassiana*) before a full-blown infestation starts. White flies can also be treated with insecticide and “biological control agents (=natural enemies) commercially available include the parasitoids, *Encarsia formosa*, *Eretmocerus eremicus*, and *Eretmocerus Mundus*; the predatory ladybird beetle, *Delphastus catalinae*; and the beneficial fungus, *Beauveria bassiana*” (Sakata Ornamentals, 2011). For fungus gnats, check for wounds on the plants and if found, it is useful to release “nematodes, *Steinernema feltiae*, the soil-predatory mite, *Hypoaspis miles*, and the rove beetle, *Atheta coriaria*” (Sakata Ornamentals, 2011).

In addition to insects, *Portulaca* is also susceptible to attracting slugs if the plants are too low to the ground. If even one slug is spotted, immediately put out baits containing iron phosphate, or alternatively, inorganic metaldehyde. Consistently monitoring the growing of weeds and cleaning any other debris around this succulent will help prevent slugs from finding their way to the *Portulaca* (Sakata Ornamentals, 2011).



Unfortunately, disease is more common in *Portulaca* compared to pests, but fortunately, preventative measures can help keep a garden disease free. Always ensure a proper amount of water and keep areas around the plants free from debris. Common diseases include *Botrytis cinerea* (gray mold), Crown rot and root rot. *Botrytis cinerea* can develop very quickly: “only five hours of a water film (such as that caused by condensation) are needed for infection to take place if temperatures are between 64-77°F/18 -25°C,” according to Sakata Ornamentals (2011). For this reason, make sure that plants are also not underneath any hanging plants that would be dripping. Keeping proper moisture is also essential to ensure minimum fungus and bacteria growths, like Fusarium and Phytophthora. Root rots caused by Rhizoctonia and Pythium can also be caused by overwatering. As mentioned above, allow the substrate to dry out nightly to prevent these root rots and use a media that has good aeration with no fine particles but instead coarse blends (Sakata Ornamentals, 2011).

If starting portulaca by cutting, it is imperative to handle them gently and plant them as soon as possible. If needed, store them between 50-60 °F.

It is recommended to grow *P. pilosa* in a greenhouse mainly because the temperature and moisture levels can be better controlled than in other structures. As shown in Figure 10 on the right, *P. grandiflora* very successfully grew from seed in a well-controlled greenhouse on the University of Minnesota campus this spring. Over time, genetics of this plant could be altered to make it less susceptible to diseases caused by overwatering, allowing *P. pilosa* to be grown in other structures such as shade houses, low tunnels or high tunnels. Not having to be so particular and cautious about watering would lead a production operation to be more efficient and sustainable. Being able to move away from greenhouse production and move outside to less expensive structures (e.g. low tunnels) would also be desired for a more sustainable operation. While there is much left to research and explore with *Portulaca pilosa*, what horticulturists know so far is enough to show the world the astounding potential that this plant can have on growers.



Figure 11. *Portulaca grandiflora* growing in the University of Minnesota greenhouses. Grown by Elizabeth Goodman.

## V. ACKNOWLEDGEMENTS

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