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FINAL STUDY REPORT
Lockeford Plant Materials Center
Lockeford, California

Milkweed Establishment in California's Central Valley: I. Showy Milkweed, *Asclepias speciosa* by Seed, Rhizome and Transplants

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ABSTRACT

Milkweed species provide breeding sites essential for the survival of monarch butterflies that overwinter on the California Coast and migrate inland to other Western States. Showy milkweed, *Asclepias speciosa*, is widely distributed throughout Northern California and seed and transplants are commercially available. Showy milkweed populations have declined for a variety of reasons including discontinuation of indigenous stewardship methods, a transition to rangelands dominated by weedy annual grasses, and an increase in intensive agriculture. The objective of this study was to find the most effective way to establish showy milkweed. The establishment of plants grown from seed and rhizomes was evaluated as well as, the success of three planting times for transplants, in fall, early spring and late spring. The study site at the Lockeford Plant Materials Center was solarized in the summer of 2017 prior to planting. Plants were irrigated during the first year of the trial and hand weeded. Evaluations were conducted during 2018 and 2019 for germination and survival, plant height, disease resistance and insect resistance. Showy milkweed rhizomes had the best establishment and survival rates in both the 2018 and 2019 growing seasons and were tallest in height. All fall and spring transplants showed good establishment during both years of the trial, while the seeded plots had poorest establishment across planting types.

INTRODUCTION

Milkweeds are herbaceous perennials in the *Asclepiadaceae* (Milkweed) family that are critically important for survival of monarch butterflies (*Danaus plexippus*) as they are the primary larval host for the caterpillars. The Xerces Society recommends milkweed species in hedgerow and pollinator plantings (Borders and Lee-Mader, 2014). Since 2010, observations by the Xerces Society in pollinator plantings in California and at the Lockeford PMC indicate that milkweed establishment, as part of a pollinator mix, is frequently unsuccessful. Poor establishment occurred when milkweed seed was part of a mix and additionally, milkweed transplants used in plantings were less likely to establish than other pollinator plants. The reason for the lack of success in milkweed establishment is not clear as establishment guidelines used successfully for other species are followed (Borders and Lee-Mader, 2014). This study focused on showy milkweed. A milkweed species that is widely distributed and commercially available.

Showy milkweed has sturdy single or multiple stems, 1 to 5 feet tall, with large opposite leaves that terminate in several umbels near the top of the stem with large pink to purplish flowers (Borders, 2012; Rosatti and Hoffman, 2017; Stevens, 2000) (Figures 8 and 9). The umbels are

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between 1.5 and 3 inches across, with flowers ~0.5 inches across with elongate hoods. The stems have opposite spade-shaped leaves that are fuzzy on both sides with rather woolly hairs below. Pods are upright, 4 to 5 inches long and covered with hairs and some have warty projections. The stems dieback each winter and regenerate each spring from a strong underground rhizome.

The robust growth of showy milkweeds provides other conservation benefits in addition to serving as a host to the larvae of the monarch butterfly. James et al. (2016) found that showy milkweed hosted beneficial insects, including predatory and parasitic insects and native bees, with a greater incidence than European honeybees. Adams et al. (1984) conducted a study in Utah demonstrating the potential of showy milkweed for biomass production and chemicals in a semi-arid environment; extractable chemicals included sucrose and triterpenes

Native American tribes throughout the western United States used all parts of the showy milkweed for food and medicine, while the fibers from the stems were harvested to produced cordage (Goodrich and Lawson, 1980; Stevens and Zelazo, 2010). The fibers were especially important for tribes in California, who used them for cordage, clothing and nets (Stevens, 2000). Historical management of showy milkweed involved fall burning of the residues, which reduced weeds and controlled insect pests and diseases, resulting in straighter stronger stalks the following year (Stevens, 1980). The showy milkweed plantings utilized by Native American tribes were substantial due to the quantities of material required for cordage and clothes (Barrett and Gifford 1933; Stevens, 2010, Stevens and Zelazo, 2010). For example, five stems produced enough fiber for one foot of cordage and a Sierra Miwok feather skirt or cape contains about 100 feet of cordage while a fish net would require several 1000 feet (Stevens, 2010).

Showy milkweed is distributed throughout Northern California including the Coast Ranges and Sierra Foothills of California, primarily north of Merced and the San Francisco Bay (Calflora, 2017). It is adapted to a broad range of moisture conditions and is commonly found in riparian sites and in sub-irrigated or occasionally flooded wetlands with sedges and rushes. Populations can also be found in very dry sites with less than 9 inches of annual precipitation, although these populations are more likely found in depressions with accumulations of moisture.

Historical declines of showy milkweed populations occurred with the substitution of indigenous management methods (Stevens, 2010). Additionally, the introduction of cattle and sheep to historic milkweed habitat resulted in the dominance of European annual grasses (Burcham, 1981). Showy milkweed is toxic to livestock, although less so than other milkweed species, and while the plant is generally avoided, grazing by cattle has been reported and the plant is discouraged by ranchers (DiTomaso and Healy, 2007; Stevens, 2010). Currently, the Central Valley is one of the most intensively farmed areas in the world, resulting in significant loss of native habitat. Extensive use of pesticides ,and cultivation, are linked to a reduction of milkweed in fields and field borders (Pleasants and Oberhauser, 2012).

Western monarch butterfly populations measured by Xerces volunteer-Thanksgiving counts of overwintering populations in groves on the California coast have declined precipitously in recent years (Pelton, 2017; Xerces Society, 2020). The 2018 Xerces Thanksgiving count total was less than 30,000 butterflies, a 99% drop since 1997. This large drop causes concern of a quasi-extinction event for the Western Monarch (Pelton et al. 2019). The environmental drivers for this catastrophe include climatic events, loss of habitat and pesticide exposure. Monarch declines are most severe between late fall and early spring (Espeset et al. 2016). Climatic events include extreme storm events casing damage to overwintering sites, and periods of prolonged droughts that reduce areas of breeding sites. Use of pesticides both in agricultural and urban settings are correlated with monarch butterfly declines, especially the use of neonicotinoid insecticides (Forister et al., 2016; Halsch et al., 2020; Pleasants and Oberhauser, 2012). The continued loss of milkweed plants across the western monarch's breeding range is a major factor contributing to monarch population decline. A year-round population model showed that losses to breeding sites had four times the loss impact as the loss of overwintering sites (Flockhart et al., 2015). Monarch butterflies experience several generations throughout California, into Nevada and Idaho, before they return to overwintering sites on the California Coast. Increasing milkweed populations for the butterflies to lay their eggs on during their annual migration to other Western States is essential for the conservation of the monarch butterfly.

Propagation methods of showy milkweed from seed, transplants and rhizomes are well documented (Skinner, 2008; Stevens, 2000; Tilley, 2016; Tilley and Cruz, 2019). Seed and transplants are commercially available. The objective of this study is to find the most effective way to establish showy milkweed plantings. The study compared establishment of plants grown from seed, rhizomes, and also evaluated three planting times for transplants, in fall, early spring and late spring. The results reported here are part of a larger milkweed establishment study at the California Plant Materials Center (CAPMC). The additional reports are: Milkweed Establishment in California's Central Valley: II. Comparison of *Asclepias eriocarpa, A. fascicularis,* and *A. speciosa* by Seed, and Milkweed Establishment in California's Central Valley: III. Comparison of Milkweed Species *Asclepias eriocarpa, A. fascicularis,* and *A. speciosa* by Transplants.

MATERIALS AND METHODS

The CAPMC is located on the eastern side of the San Joaquin Valley in central California and sits on a historical flood plain on the west bank of the Mokelumne River. The soil series is a Columbia fine sandy loam on 0 to 2 percent slopes. It is a very deep, well-drained soil with pH ranging from moderately acid to slightly alkaline. The mean annual maximum temperature in this area is 73.6°F and minimum temperature is 46°F (WRCC, 2018). The mean annual precipitation is 17.24 inches, mainly occurring between the months of December and March (WRCC, 2018). Precipitation totals were just below average (16.8 inches) between September 1, 2017 and August 1, 2018 and were above average (24 inches) between September 1, 2018 and August 1, 2019 shown in Figure 1 (WWG, 2019).

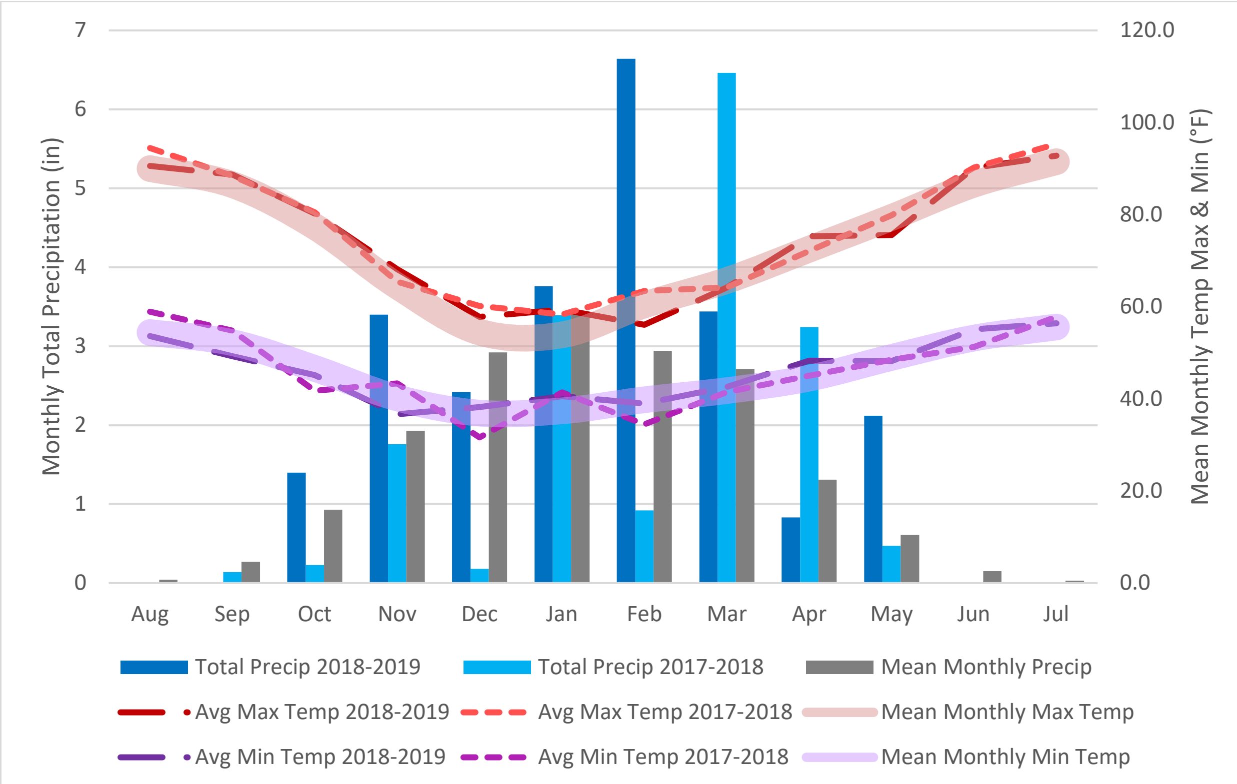

Figure 1. Mean minimum and maximum temperatures in the 2017/2018 and 2018/2019 growing seasons generally followed annual averages. Total precipitation was just below average in 2017/2018 and above average in 2018/2019. Monthly weather data from September through August was provided from Western Weather Group Lockeford Weather Station located directly across the river from the CAPMC. Average weather summaries from 1893-2015 for the Lodi area were provided from Western Regional Climate Center.

Site Preparation

Site preparation began in June 2017. Weeds and the remaining residue from the previous fall planted cover crop were disked. The area was chisel plowed and cultipacked to prepare a firm seed bed and smooth solarization surface. Sprinkler handlines were laid to provide adequate soil moisture. prior to solarization. The UV-treated, 4 mm plastic was installed in June for maximum solar incidence for weed control (Figure 2). The solarization treatment effectiveess was marginal as nutsedge *(Cyperus spp.)* and other weeds grew under the plastic. Nutsedge was dug up and removed prior to planting and additional harrowing and cultipacking was also required prior to planting the milkweed trial.

Planting Materials

Showy milkweed seed, transplants and rhizomes and were provided by Hedgerow Farms (Winters, CA). Transplants (approximately 4-months-old) for early fall, early spring and late spring plantings were propagated by Valley Transplant Nursery (Acampo, CA).

Experimental Design

The experimental design was a randomized complete block with four replications. The blocks were oriented to remove variation due to a slight moisture and soil texture gradient.

Three methods of establishment were compared in this trial; seeding, transplanting, and establishment with rhizomes. Planting dates were also evaluated for transplants.. Planting methods and times are described below:

1. Seeding in fall (November, after rainfall).
2. Rhizome planting in fall (October).
3. Transplanting mid-fall (October, prior to plant dormancy period).
4. Transplanting in early spring (March, while plants are dormant).
5. Transplanting in late spring (May, after plants come out of dormancy).

Seed Planting

Seeding occurred on November 6, 2017. No pre-irrigation of the plots was conducted as soil was moist from previous rainfall. A Great Plains (Salina, KS) no-till drill planted the seed into 5 x 20 feet plots at a seeding rate of 15 live seeds per square foot to $^{1}/_{2}$-inch depth.

Rhizome Planting

Rhizomes were received in the summer of 2017 and stored at 45 °C prior to planting to maintain their viability. They were cut into pieces containing at least one node each(Figure 3). The rhizomes were planted on October 24, 2017. A trench of approximately 4 inches deep was dug and rhizomes laid into the bottom at 12-inch spacing. The trench was filled in and the soil tamped. Rhizomes were planted in a single row in each block (Figure 4).

Transplant Establishment

Planting dates were October 25, 2017, March 26, 2018, and May 15, 2018. The replicated treatments in each block consisted of 12 well rooted, 1-inch x 1-inch x 2.5-inch plug transplants, planted at a 12-inch spacing (Figure 5).

Irrigation

Drip irrigation was applied for milkweed establishment during the first year of the study. Each transplant and rhizome row had a drip line, with a milkweed at each emitter. The seeded plots had 4 lines of drip tape spaced evenly in the plot. Irrigation sets were run at the time of planting the rhizomes and transplants (October, March and May), as well as once in June and once in July for all three planting methods.

Weed Control

Weed control during the first year was primarily hand hoeing. This technique was extremely time consuming, especially within the seeded milkweed plots, where emerging seedlings were small and fragile in early spring. To more efficiently control weeds, a broad-spectrum herbicide was applied in the winter while the fall planted milkweeds were dormant, and in the spring of 2018 (prior to planting the transplants). A pre-emergent herbicide was applied in the winter of 2019.

Evaluations

Several evaluations were collected during the 2018 and 2019 growing seasons following national Plant Materials Program protocol, including: germination/survival, plant height, disease resistance and insect resistance.

Germination/survival was defined as germination percentage and survival percentage. Evaluations were conducted every 7 days during the initial emergence/transplant period and then every 14 days over the summer. Germination/survival was rated on a 0 - 4 scale, where 0 = poor (<25% germination/survival), 1 = fair (30 – 45% germination/survival), 2 = moderate (50 - 65% germination/survival), 3 = good (70 - 80% germination/survival), and 4 = excellent (90 - 100% germination/survival). Plant height was defined as the average height of lush canopy growth. Plant height was collected in inches from the base of the plant to the top of the inflorescence every 30 days from three randomly selected plants within each plot. Disease and insect resistance were visual estimates of foliar diseases and insect damage. Plots were rated every 14 days on a 0 - 5 scale, where 0 = no damage and 5 = severe damage.

Statistical Analysis

Statistical analysis was run on the evaluations collected from the 2018 and 2019 growing seasons using Statistix 10 (Analytical Software, Tallahassee, FL). Ordinal data (germination/survival and disease and insect resistance) was analyzed using Kruskal-Wallis one-way analysis of variance (AOV) and Dunn's All-Pairwise Comparisons Test to separate means at the 5% level. Analysis was done on quantitative plant measurements (plant height) using the analysis of variance (AOV) procedure for a randomized complete block design (RCBD) along with Tukey's 1 Degree of Freedom test for non-additivity. Significant means were separated with Tukey's Honestly Significant Difference (HSD) All-Pairwise Comparisons Test at the 5% level.

Figure 2. Xerces and NRCS staff laying out plastic sheets for solarization prior to planting in June 2017.

Figure 3. Kathryn Prince, Xerces Pollinator Conservation Planner/NRCS Partner Biologist, cutting *A. speciosa* rhizomes into pieces prior to planting.

Figure 4. Kathryn Prince and Matthew Bronson, CAPMC Farm Manager, plant milkweed rhizomes in October 2017.

Figure 5. *A. speciosa* transplant plugs in October 2017.

RESULTS AND DISCUSSION

Five different planting methods of showy milkweed were evaluated in the 2018 and 2019 growing seasons for germination and survival, height, and disease and insect resistance.

The fall planted showy milkweed rhizomes were the first to germinate in the early spring of 2018. By mid-March, the rhizomes had fair to moderate germination while the other fall seeded and fall transplants had no germination. Fall planted rhizomes had significantly higher germination and survival rates in 2018 compared to the fall seeded plots according to the Kruskal-Wallis one-way AOV and Dunn's All-Pairwise Comparisons Tests at the 5% level (Table 1). After transplanting plugs in May, both rhizomes and May transplants had significantly higher survival rate (good to excellent survival) than all seeded plots (fair survival) and numerically higher survival rate than the other planting types throughout the remaining 2018 growing season. In the early spring of 2019, rhizomes again had the highest germination rates (moderate to good germination), with fall and both early and late spring transplants at fair to moderate and poor to fair germination, respectively. The seeded plots did not start to germinate until mid to late April and remained in the fair category throughout the 2019 growing season. Rhizomes had significantly higher survival rates (good to excellent survival) than the fall seed plots (fair survival) and were numerically higher than all other fall and spring planting types (moderate to good survival), with the exception of the late spring transplant evaluations in May (Table 2).

In 2018, rhizomes were significantly taller (30.4 inches in September) than the other planting types across all showy milkweed plots using Tukey's HSD at the 5% level (Table 3 and Figure 6). May transplants were significantly shorter (10.7 inches in September) during 2018, because they were planted late in the growing season. In 2019, the rhizomes were initially the tallest planting type, but the fall seeded plots caught up in late June (rhizomes were 45.3 inches and seeded plots were 44.8 inches in late June) (Table 4 and Figure 7). The spring transplants were both significantly shorter (March transplants were 32.4 inches and May transplants were 34.5 inches in late August) than all other planting types throughout the 2019 season.

Very little disease and insect damage were observed on the plants until late in the 2018 season (August and September) (Table 7). Insect damage from oleander aphid infestations resulted in chewed leaves. Disease in the form of black sooty mold appeared as dark spots on leaves due to the large amounts of sticky honeydew produced by the aphids. Fall seeded plots had the highest disease and insect resistance with only slight disease damage and slight to moderate insect damage in August and September (Table 5). Fall, early and late spring transplants had low disease and insect resistance, with moderate to severe disease and insect damage. The fall seeded plots had significantly higher disease and insect resistance than the fall and spring transplants according to the Kruskal-Wallis one-way AOV and Dunn's All-Pairwise Comparisons Tests at the 5% level. Disease and insect pressure increased during the 2019 growing season and no differences were seen across planting types (Table 6). Disease was detected in late July 2019 and all planting types had slightly moderate damage. By September, all panting types had moderately severe damage. Insects appeared in early July 2019, causing all

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plants to have slight damage, then later in the season, insect damage increased to moderately severe on all planting types.

The results from two years of evaluations indicate that the showy milkweed rhizomes had very successful establishment and survival rates throughout both growing seasons. Shoots from rhizomes emerged earlier and faster than plants established from seed and transplants. Rhizomes were also taller in height, which indicates the ability to compete with weeds early in the growing season. Unfortunately, rhizomes are not typically commercially available and may be difficult to purchase. All fall and spring transplants also had good establishment during both years of the trial, while the seeded plots had the poorest performance across planting types. Transplants are more expensive than seed but appear to be worth the extra expense due to the higher survival rates. Timing of planting transplants does not appear to be as important as initial site preparation and management. Showy milkweed transplant survival rate can be improved with supplemental irrigation and intensive weed management during the first year of establishment. Insect and disease susceptibility may be more dependent on weather patterns, time of year and surrounding vegetation rather than *A. speciosa* planting type. The use of pesticides on a monarch habitat site for weed control should be weighed carefully, as it may have unintended effects on non-target species.

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Table 1. *Asclepious speciosa* germination and survival evaluations collected at the Lockeford Plant Materials Center, CA 2018.

Asclepias speciosa - 2018 Evaluations

Planting Type	Planting Date	Germination/ Survival[¥]									
		5/24/2018	6/6/2018	6/11/2018	6/18/2017	7/5/2018	7/16/2018	8/1/2018	8/15/2018	8/30/2018	9/12/2018
Fall Seeding	11/6/2017	0.0 b	0.3 b	0.3 b	1.0 b	1.0 b	1.0 b	1.0 b	1.0 b	1.0 b	1.0 b
Fall Rhizomes	10/24/2017	3.8 a	3.8 a	3.8 ab	3.8 ab	4.0 a	3.5 ab	3.5 ab	3.5 ab	3.8 a	3.8 a
Fall Transplant	10/25/2017	2.8 ab	3.0 ab	3.3 ab	3.5 ab	3.5 ab	3.3 ab	3.5 ab	3.3 ab	3.3 ab	3.3 ab
Early Spring Transplant	3/26/2018	3.5 ab	3.5 ab	3.5 ab	3.5 ab	3.5 ab	3.5 ab	3.5 ab	3.3 ab	3.3 ab	3.0 ab
Late Spring Transplant	5/15/2018	4.0 a	4.0 a	4.0 a	4.0 a	4.0 a	4.0 a	4.0 a	4.0 a	4.0 a	4.0 a
Mean		2.8	2.9	3.0	3.2	3.2	3.1	3.1	3.0	3.1	3.0
SD[#]		1.6	1.5	1.5	1.2	1.2	1.1	1.2	1.1	1.1	1.1

[#]Standard deviation

*Means in columns followed by the same letters are not significantly different at $P<0.05$.

[¥]Germination/Survival rated on the following scale: 0=poor (<25% germination), 1=fair (30-45%), 2=moderate (50-65%), 3=good (70-85%), 4=excellent (90-100%).

Table 2. *Asclepious speciosa* germination and survival evaluations collected at the Lockeford Plant Materials Center, CA 2019.

Asclepias speciosa - 2019 Evaluations

Planting Type	Planting Date	Germination/ Survival[¥]									
		4/5/2019	4/12/2019	4/25/2019	5/10/2019	5/17/2019	7/16/2019	7/30/2019	8/16/2019	8/29/2019	9/19/2019
Fall Seeding	11/6/2017	0.0 b	0.3 b	0.8 b	0.8 b	1.0 b	1.0 b	1.0 b	1.0 b	1.0 b	1.0 b
Fall Rhizomes	10/24/2017	2.8 a	2.8 a	3.8 a	3.8 a	3.8 a	3.8 a	3.8 a	3.8 a	3.8 a	3.8 a
Fall Transplant	10/25/2017	1.8 ab	2.5 ab	3.3 ab	3.5 ab	3.3 ab	3.5 ab	3.0 ab	2.5 ab	2.5 ab	2.5 ab
Early Spring Transplant	3/26/2018	0.8 ab	1.0 ab	2.3 ab	2.5 ab	2.8 ab	3.3 ab	2.8 ab	2.5 ab	2.5 ab	2.5 ab
Late Spring Transplant	5/15/2018	0.8 ab	1.8 ab	3.0 ab	3.8 a	3.8 a	3.5 ab	2.8 ab	2.5 ab	2.5 ab	2.5 ab
Mean		1.2	1.7	2.6	2.9	2.9	3.0	2.7	2.5	2.5	2.5
SD[#]		1.2	1.2	1.2	1.3	1.2	1.1	1.0	1.1	1.1	1.1

[#]Standard deviation

*Means in columns followed by the same letters are not significantly different at $P<0.05$.

[¥]Germination/Survival rated on the following scale: 0=poor (<25% germination), 1=fair (30-45%), 2=moderate (50-65%), 3=good (70-85%), 4=excellent (90-100%).

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Table 3. *Asclepious speciosa* height measurements collected at the Lockeford Plant Materials Center, CA 2018.

Asclepias speciosa - 2018 Height Evaluations									
Planting Type	Planting Date	Height (inches)							
		3/26/2018	4/26/2018	5/24/2018	6/18/2017	7/5/2018	7/16/2018	8/15/2018	9/12/2018
Fall Seeding	11/6/2017	N/A	N/A	3.3	4.4	7.3	12.5	16.1 bc*	15.7 bc
Fall Rhizomes	10/24/2017	1.5	5.7	12.6	18.3	21.6	25.0	27.3 a	30.4 a
Fall Transplant	10/25/2017	0.3	2.1	4.0	6.1	10.5	12.7	18.0 b	19.0 b
Early Spring Transplant	3/26/2018	N/A	1.3	3.5	5.6	9.0	10.3	13.1 bc	13.3 bc
Late Spring Transplant	5/15/2018	N/A	N/A	4.3	4.8	6.3	8.0	8.9 c	10.7 c
Mean		1.1	3.0	5.5	7.8	10.9	13.7	16.7	17.8
SD[#]		0.9	2.1	3.7	5.5	6.0	6.7	7.4	7.8

[#]Standard deviation

*Means in columns followed by the same letters are not significantly different at P <0.05.

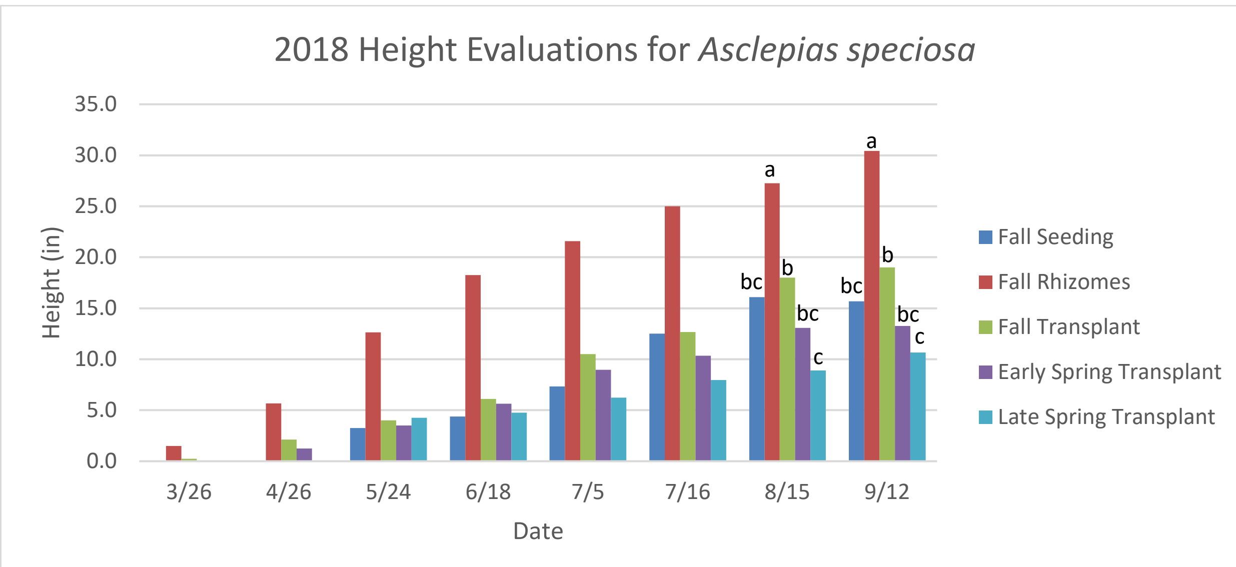

Figure 6. Differences in height of showy milkweed in the 2018 growing season. The rhizomes were significantly the tallest and late spring transplants were significantly the shortest across all planting types using Tukey's HSD at the 5% level. Columns with the same letters are not significantly different at P <0.05.

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Table 4. *Asclepious speciosa* height measurements collected at the Lockeford Plant Materials Center, CA 2019.

Asclepias speciosa - 2019 Height Evaluations

Planting Type	Planting Date	Height (inches)				
		4/25/2019	5/23/2019	6/27/2019	7/23/2019	8/23/2019
Fall Seeding	11/6/2017	11.9 b*	20.4 ab	44.8 a	49.7 a	51.2 a
Fall Rhizomes	10/24/2017	16.6 a	28.1 a	45.3 a	50.9 a	52.0 a
Fall Transplant	10/25/2017	9.4 bc	22.1 ab	36.9 ab	42.2 ab	45.3 ab
Early Spring Transplant	3/26/2018	8.3 cd	17.1 b	29.8 b	31.8 bc	32.4 b
Late Spring Transplant	5/15/2018	6.7 d	15.9 b	29.5 b	28.2 c	34.5 b
Mean		10.6	20.7	37.3	40.6	43.1
SD[#]		3.8	5.8	8.7	11.0	10.9

[#]Standard deviation

*Means in columns followed by the same letters are not significantly different at $P<0.05$.

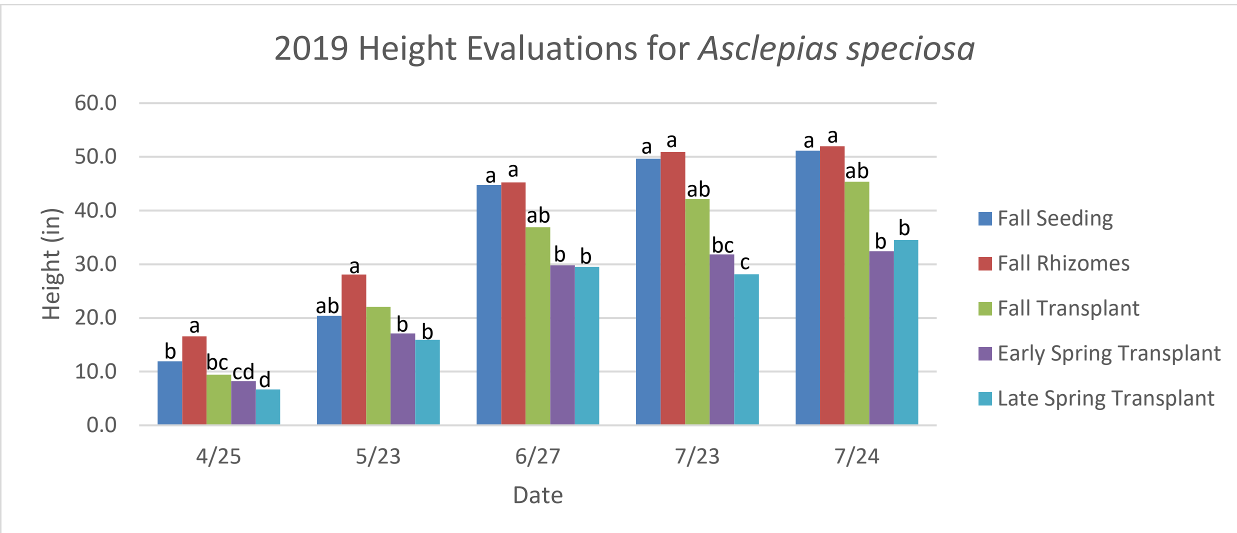

Figure 7. Differences in height of showy milkweed in the 2019 growing season. The rhizomes were significantly the tallest with the fall seeding catching up in June. The late spring transplants were significantly the shortest across all planting types during the growing season using Tukey's HSD at the 5% level. Columns with the same letters are not significantly different at $P<0.05$.

Table 5. *Asclepious speciosa* disease and insect resistance evaluations collected at the Lockeford Plant Materials Center, CA 2018.

Asclepias speciosa - 2018 Disease and Insect Evaluations

Planting Type	Planting Date	Disease Resistance[£]		Insect Resistance[£]			
		8/30/2018	9/12/2018	8/1/2018	8/15/2018	8/30/2018	9/12/2018
Fall Seeding	11/6/2017	1.5 a	1.3 b	0.0 b	1.5 a	2.4 a	2.3 b
Fall Rhizomes	10/24/2017	2.8 a	2.5 ab	0.0 b	1.3 a	3.3 a	3.0 ab
Fall Transplant	10/25/2017	3.0 a	4.0 a	1.0 ab	2.0 a	3.3 a	4.5 a
Early Spring Transplant	3/26/2018	2.8 a	4.0 a	0.8 ab	2.3 a	3.5 a	4.5 a
Late Spring Transplant	5/15/2018	2.3 a	3.5 ab	1.5 a	2.5 a	3.5 a	4.5 a
Mean		2.5	3.1	0.7	1.9	3.2	3.8
SD[#]		1.0	1.3	0.7	0.6	0.6	1.1

[#]Standard deviation

*Means in columns followed by the same letters are not significantly different at P <0.05.

[£]Disease/Insect Resistance rated on the following scale: 0=no damage, 1=slight damage, 3=moderate damage, 5=severe damage.

Table 6. *Asclepious speciosa* disease and insect resistance evaluations collected at the Lockeford Plant Materials Center, CA 2018.

Asclepias speciosa - 2019 Disease and Insect Evaluations

Planting Type	Planting Date	Disease Resistance[£]						Insect Resistance[£]					
		7/8/2019	7/16/2019	7/30/2019	8/16/2019	8/29/2019	9/19/2019	7/8/2019	7/16/2019	7/30/2019	8/16/2019	8/29/2019	9/19/2019
Fall Seeding	11/6/2017	0.0 a	0.0 a	1.3 a	2.8 a	2.8 a	3.0 a	0.5 ab	1.0 ab	3.0 a	3.0 a	3.0 a	3.0 a
Fall Rhizomes	10/24/2017	0.3 a	0.5 a	1.3 a	2.5 a	3.5 a	3.8 a	0.0 b	0.5 b	2.8 a	2.3 a	3.0 a	3.0 a
Fall Transplant	10/25/2017	0.0 a	0.5 a	1.5 a	2.8 a	2.8 a	3.5 a	0.8 ab	1.5 ab	2.8 a	3.0 a	3.0 a	3.0 a
Early Spring Transplant	3/26/2018	0.0 a	1.0 a	2.0 a	3.3 a	3.3 a	3.8 a	1.5 a	2.0 a	3.0 a	3.3 a	3.8 a	3.8 a
Late Spring Transplant	5/15/2018	0.3 a	0.3 a	1.5 a	2.8 a	2.8 a	4.0 a	1.0 ab	1.3 ab	2.3 a	3.0 a	3.0 a	3.5 a
Mean		0.1	0.5	1.5	2.8	3.0	3.6	0.8	1.3	2.8	2.9	3.2	3.3
SD[#]		0.3	0.6	0.6	0.5	0.6	0.6	0.6	0.7	0.4	0.6	0.5	0.6

[#]Standard deviation

*Means in columns followed by the same letters are not significantly different at P <0.05.

[£]Disease/Insect Resistance rated on the following scale: 0=no damage, 1=slight damage, 3=moderate damage, 5=severe damage.

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Figure 8. Several different establishment methods for *A. speciosa* in May 2019. Seeded plots are in the foreground with rhizomes in the next row, and three rows of transplants in the background.

Figure 9. A monarch butterfly lands on an *A. speciosa* flower in June of 2018.

CONCLUSION

Evaluation of five planting types across two years of study indicate that showy milkweed rhizomes had the most successful establishment and survival rates in both the 2018 and 2019 growing seasons. Rhizomes were taller, indicating an ability to compete with early summer weeds. Unfortunately, rhizomes are not readily commercially available and may be difficult to purchase for pollinator and monarch habitat plantings. All fall and spring transplants showed good establishment during both years of the trial and are commercially available. The seeded plots had poorest establishment across planting types. Transplants are initially more expensive than seed but appear to be worth the extra expense due to higher survival rates seen in this study. Timing of planting transplants in fall, early or late spring does not appear to be as important as initial preparation and management of the planting site. Showy milkweed transplant establishment and survival rates can be greatly improved with supplemental irrigation and intensive weed management during the first year of establishment. Insect, disease and weed management techniques will need to be considered carefully, as the use of pesticides may affect non-target species, including small monarch caterpillars, as well as other beneficial insects living in monarch habitat.

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