2017 Milkweed Production Trials

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Milkweed (*Asclepias syriaca*) is a plant native to North America and has recently become the focus of conservation programs as milkweed is the sole food source for the Monarch butterfly larvae. Milkweed has long been a foe of agricultural operations and as a result, populations have been on the decline throughout the United States. To increase the abundance and scale of conservation plantings of milkweed, the Natural Resource and Conservation Service (NRCS) has developed an incentive program to compensate landowners for establishing perennial monarch habitat including planting milkweed. Landowners in northern Vermont have a unique opportunity to expand milkweed acreage by producing it as a crop. A textile company in Quebec, Canada has recently begun processing the silky fiber (floss) from the milkweed plant for use in a wide variety of oil/chemical absorbent and clothing applications. The floss has insulative properties similar to down due to its unique hollow fiber structure which also makes it incredibly light. Furthermore, the floss is equipped with a natural water-repellant waxy coating that allows it to be waterproof while absorbing hydrophobic liquids such as petroleum products. The Monark Cooperative, who enrolls farmers in production contracts and provides seed, technical assistance, and harvesting equipment to members, is looking to increase milkweed production in Quebec and Vermont. This opportunity will require farms to learn best techniques for cultivating milkweed as a commercial crop versus the techniques they currently know which is to eliminate at first sight!


Figure 1. Milkweed in bloom

Although milkweed (Figure 1) is well adapted to a wide range of soils and growing conditions, economical commercial milkweed production has proven more difficult than initially anticipated. The main obstacle in production is weed pressure during the establishment year. Milkweed can be established during early summer in Vermont, making the slow-growing seedlings vulnerable to weed pressure from fast-growing annuals that are able to take advantage of lower temperatures early in the season. Furthermore, little is known about maintaining a milkweed stand for long-term production once it is established. To support this emerging market, UVM Extension's Northwest Crops and Soils Program installed two trials investigating best management practices for the establishment of milkweed.

Nurse crops are typically used to aid in the establishment of perennial grass or grass-legume stands. These crops are usually annual cereal grains, such as oats or wheat that can grow quickly and out-compete annual weeds while the slower perennials establish. The following season the perennials are in a more competitive position to establish a healthy, dense stand. In 2017, NWCS initiated a trial investigating the use of a variety of nurse crops to establish milkweed in Alburgh, VT.

Winter rye is a widely used cover crop in northern Vermont as it is best adapted to the cold climate, fits into common cropping systems, and has the potential to create a large quantity of biomass that can help build soil and suppress weeds. As winter rye will survive the winter in this region, management in the spring is necessary prior to establishing a cash crop. One method of terminating winter rye is using a roller-crimper. This implement, when used at the proper timing, will crimp the stem of the rye while laying it flat on the ground, causing the plant to lose the ability to move water and nutrients through the plant, killing it.

This creates a dense mat of dead plant material that suppresses weeds as it decomposes for the cash crop that is then planted into the mat. The rye can be rolled and crimped with a variety of tools, and for the purposes of this project, an I&J roller crimper unit, Gordonville, PA (Figure 2) was used to terminate the rye prior to seeding the milkweed.

Figure 2. Roller Crimper (croproller.com)

MATERIALS AND METHODS

Establishing Milkweed with Nurse Crops

To determine the impact of adding a nurse crop to assist with milkweed establishment, a trial was initiated at Borderview Research Farm, Alburgh, VT in 2017. Five nurse crops at two seeding rates (Table 1) were planted with milkweed and compared to establishing milkweed, also at two seeding rates, without an additional nurse crop. Nurse crops were selected based on suitability to our climate and additional crop or pollinator support benefits provided while acting as a nurse crop (i.e. buckwheat seed and ryegrass forage). These additional benefits could help offset the cost of production during the establishment year when milkweed is not harvested.

Table 1. Nurse crop varieties and seeding rates, 2017.

Crop	Variety	Seeding rates (lbs ac^{-1})	
		Low	High
Buckwheat	VNS	12	25
Clover	Freedom Red	4.5	9
Oats	Forage Maker 50	25	50
Phacelia	–	2	4
Ryegrass	Kodiak	5	10
Milkweed	–	3	6

The experimental design was a complete randomized block with four replications. The area was prepared using a moldboard plow, disc harrow, and spike tooth harrow prior to planting. Due to complications in securing the milkweed seed from Monark Cooperative, the trial was planted later than anticipated on 23-Jul using a Great Plains Grain Cone Seeder. The stand was assessed for milkweed populations and biomass, nurse crop biomass, and weed biomass on 29-Sep and were again assessed for milkweed populations 22-May 2018. To do this, the vegetation growing within a $0.25m^2$ area in each plot was harvested to ground level. This sample was sorted into milkweed, nurse crop, and weed fractions. The number of milkweed plants was recorded. The biomass of the milkweed, nurse crop, and weed fractions were also recorded. All fractions were dried to determine dry matter content and calculate dry matter biomass. The $0.25m^2$ areas that were sampled were marked to allow for monitoring of the milkweed population the following spring. However, in the spring the populations were so low that the number of plants was recorded for the entire plot area instead of the individual quadrat areas.

Establishing Milkweed Using Cover Crop Roller-Crimper Planter Technology

To determine the impact of a rolled and crimped stand of winter rye on weed and milkweed establishment, a trial was initiated at Borderview Research Farm in 2017. Treatments were winter rye cover crop terminated with a roller-crimper and no cover crop. Plots with the winter rye treatment were seeded using a Sunflower grain drill (Beloit, KS) in the fall of 2016 at 110 lbs ac^{-1}. The winter rye was terminated using an I&J Roller Crimper (Gordonville, PA) (Figure 2). Plots with no cover crop were lightly disked at this time to incorporate any weed biomass. Due to a delay in securing milkweed seed from Monark Cooperative, the milkweed was planted much later than anticipated on 31-Jul using a Sunflower grain drill (Beloit, KS). Milkweed was planted at 6 lbs ac^{-1}.

The plots were assessed for milkweed populations on 26-Sep 2017. This was done by counting the number of milkweed plants present in two $0.25m^2$ quadrats in each plot. The areas were marked to allow for future data collection in the same location. These quadrat areas were revisited on 3-Oct 2017 to assess weed populations and collect weed biomass, and milkweed populations were assessed again in 22-May 2018. In the spring, due to very low populations, the number of plants in the entire plot area was measured instead of the individual quadrat areas.

Pollinator Sampling in Established Milkweed Stands

In order to develop in-season management recommendations for established milkweed stands, we need to understand what pollinators are utilizing milkweed plants throughout the season. This information will allow us to shift in-season management operations to minimize negative impacts on insect and pollinator populations. Although harvest occurs later in the fall once many of the milkweed leaves have fallen, it has yet to be shown if any insects, especially Monarch caterpillars, utilize milkweed during that period that may be impacted by harvest operations. To begin to investigate this matter, two milkweed fields established in 2015 and 2016, were surveyed for pollinators 3 times between 3-Jul and 11-Jul. At each sampling, the plants at four locations (Figure 3) throughout each field, which had open flowers present, were watched for 10 minutes each. During this time the number of individuals and flower visits for eight morphospecies of pollinators were noted: *Apis*, *Bombus* (queens), *Bombus* (workers), big black bees, slender black bees, tiny black bees, *Lepidoptera*, wasps, flies, and beetles. Prior to moving to another observation area, the number of open flowers was recorded as well as weather conditions including temperature, wind speed, relative humidity, and sky condition. The flowering status of both milkweed and weeds were also noted by rating on a 0-3 scale where 0 indicated no flowers present and 3 indicated full bloom. An approximate 10m transect was then walked in each field for 10 minutes collecting insects with an insect net. If honey bees were collected with the net the timer was stopped to allow for time to remove the honey bees. After 10 minutes, the insects collected in the net were transferred to a glass kill-jar for preservation and later identification. Finally, to understand bee pollination efficacy of milkweed, a 20m transect was walked for 1 hour or until 20 bees visiting milkweed flowers were located. The bees were collected, identified, and placed in a non-kill glass jar for inspection. The number of pollinia, milkweed pollen structures, stuck to each bee was recorded. The bees were released after data was collected. The timer was stopped while bees were transferred and data was collected.

Figure 3. Layout of observation areas within stands.

Variations in yield and quality can occur because of variations in genetics, soil, weather, and other growing conditions. Statistical analysis makes it possible to determine whether a difference among treatments is real or whether it might have occurred due to other variations in the field. All data was analyzed using a mixed model analysis where replicates were considered random effects. At the bottom of each table, a LSD value is presented for each variable (e.g. yield). Least Significant Differences (LSDs) at the 10% level (0.10) of probability are shown. Where the difference between two treatments within a column is equal to or greater than the LSD value at the bottom of the column, you can be sure in 9 out of 10 chances that there is a real difference between the two values. Treatments listed in bold had the top performance in a particular column; treatments that did not perform significantly worse than the top-performer in a particular column are indicated with an asterisk. In the above example, treatment A is significantly different from treatment C, but not from treatment B. The difference between A and B is equal to 400, which is less than the LSD value of 500. This means that these treatments did not differ in yield. The difference between A and C is equal to 650, which is greater than the LSD value of 500. This means that the yields of these treatments were significantly different from one another.

Variety	Yield
A	**1600***
B	1200*
C	950
LSD (0.10)	500

RESULTS

Weather data was recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT (Table 2). Growing Degree Days (GDDs) were summarized using the base and maximum temperatures for corn as they are not known for milkweed specifically. Temperatures around planting were above average but generally during July and August, temperatures were slightly below the long term average. Conversely, rainfall was about 1-2 inches above normal with much of the total precipitation for these months being delivered in a few large rainstorms. The weather became warmer and drier in the fall months with above average temperatures and below average rainfall. These favorable weather conditions allowed the milkweed, despite late planting, to have time to germinate and grow.

Table 2. 2017 weather data for Alburgh, VT.

	July	August	September	October
Average temperature (°F)	68.7	67.7	64.4	57.4
Departure from normal	-1.90	-1.07	3.76	9.20
Precipitation (inches)	4.88	5.54	1.84	3.3
Departure from normal	0.73	1.63	-1.80	-0.31
Growing Degree Days (base 50°F)	580	553	447	287
Departure from normal	-60	-28	129	175

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger.
Historical averages are for 30 years of NOAA data (1981-2010) from Burlington, VT.

Establishing Milkweed with Nurse Crops

On 29-Sep, 68 days after planting, biomass and populations of nurse crops, weeds, and milkweed (Table 3) were evaluated. The highest biomass producing nurse crop was buckwheat which produced 2.61 tons ac^{-1}. This treatment also produced the lowest weed biomass which was also statistically similar to the oats in terms of weeds. However, no milkweed was found growing with the buckwheat, likely due to competition for sunlight as the buckwheat grew very quickly and to a height of approximately 24 inches. Interestingly, the clover treatment produced the lowest biomass and milkweed was found growing in both low and high seeding rate treatments (Table 4). In plots with a higher clover seeding rate, higher milkweed populations were found. Overall milkweed establishment was poor, likely due to the delay in planting and maybe also related to seed quality. Also of interest was the performance of the two milkweed-only seeding rate treatments. The low seeding rate (3 lbs ac^{-1}) is the rate that has been recommended by producers in Quebec, Canada. When seeded alone at this rate, fall milkweed populations of 0.0929 plants ft^{-2} were observed whereas when the higher seeding rate of 6 lbs ac^{-1} was used, fall milkweed populations of 0.557 plants ft^{-2} were observed. Target stand densities for establishment, according to early milkweed research conducted by Dr. Phippen of Western Illinois University, are 24,000 plants ac^{-1} or 0.550 plants ft^{-2}. The only treatment that achieved this target density was the milkweed seeded alone at the high seeding rate. The nurse crop treatment that came the closest to this target was the clover seeded at the high rate which produced 0.279 plants ft^{-2}, approximately half the target. In performing germination tests on milkweed seed, it has become apparent that the seed germinates at highly variable rates, some germinating within a couple of days and others taking more than 2 weeks. Therefore, plots were revisited in May 2018 to reassess the milkweed establishment. Unfortunately, the stands were even poorer in the spring with an average of 0.00333 plants ft^{-2} observed across the trial. The highest population in the spring was still observed in the milkweed-only high seeding rate treatment. However, the survival of the milkweed in the annual ryegrass and clover plots may also have been compromised by the mild winter conditions which led to the unintended survival of these nurse crops.

Table 3. Nurse crop trial fall biomass and milkweed populations by nurse crop, 2017.

Nurse crop	DM biomass		Milkweed populations	
	Nurse crop	Weeds	Fall	Spring
	tons ac^{-1}		plants ft^{-2}	
Annual ryegrass	1.30	0.79	0.047	0.001
Buckwheat	**2.61**	**0.22**	0.000	0.003
Clover	0.55	1.15	0.186*	0.004
Oat	1.31	0.64*	0.047	0.000
Phacelia	1.37	0.91	0.0465	0.004
No nurse crop	0.00	1.58	**0.325**	**0.009**
LSD (p = 0.10)	0.532	0.427	0.195	NS
Trial mean	1.19	0.88	0.1080	0.00333

Treatments with an asterisk* performed similarly to the top performer in **bold**.
NS-No significant difference.

Table 4. Nurse crop fall biomass and milkweed populations by nurse crop and seeding rate, 2017.

Nurse crop	Seeding rate	DM yield		Milkweed populations	
		Nurse crop	Weeds	Fall	Spring
		tons ac^{-1}		plants ft^{-2}	
Annual ryegrass	Low	1.11	0.92	0.093	0.000
	High	1.48	0.66	0.000	0.003
Buckwheat	Low	1.9	0.28	0.000	0.000
	High	3.31	0.16	0.000	0.005
Clover	Low	0.65	1.26	0.093	0.000
	High	0.45	1.04	0.279	0.008
Oat	Low	1.65	0.71	0.093	0.000
	High	0.97	0.56	0.000	0.000
Phacelia	Low	1.34	1.08	0.000	0.003
	High	1.40	0.74	0.093	0.005
No nurse crop	Low	N/A	1.9	0.093	0.000
	High	N/A	1.26	0.557	0.018

Although the higher seeding rate led to higher nurse crop biomass, lower weed biomass, and higher fall and spring milkweed populations, only the weed biomass was statistically different (Table 5).

Table 5. Nurse crop fall biomass and milkweed populations by seeding rate, 2017.

Seeding rate	DM biomass		Milkweed populations	
	Nurse crop	Weeds	Fall	Spring
	tons ac^{-1}		plants ft^{-2}	
Low	1.11	1.03	0.062	0.0004
High	**1.27**	**0.74**	**0.155**	**0.0062**
LSD (p = 0.10)	NS	0.247	NS	NS
Trial mean	1.19	0.880	0.108	0.0033

Treatments with an asterisk* performed similarly to the top performer in **bold**.
NS-No significant difference.

The nurse crop treatments used in this trial were chosen because of their potential to provide the farm with additional benefits during the milkweed establishment year. Table 6 attempts to summarize these benefits as produced through this experiment. However, it is important to remember that these were intended to be benefits in addition to the successful establishment of a milkweed crop. The only treatment which supported milkweed in a reasonable density in the fall was the red clover at a high seeding rate. Unfortunately, this treatment only yielded 0.45 tons ac^{-1} of forage. The nurse crop did reduce overall weed populations especially compared to the treatment with no nurse crop. However, despite these trends the milkweed did not establish well in any of the treatments as demonstrated by the exceptionally low spring populations. Finding the proper balance between the nurse crop and milkweed establishment will be focus of future experiments.

Table 6. Nurse crop additional benefits, 2017.

Treatment	Additional benefit	Quantity	Units
Annual ryegrass	Forage	1.30	tons ac^{-1}
Buckwheat	Grain	341	lbs ac^{-1}
Clover	Forage	0.55	tons ac^{-1}
Oat	Forage	1.31	tons ac^{-1}
Phacelia	Pollinators	25.5	plants m^{2}
No nurse crop	N/A	N/A	N/A

Establishing Milkweed Using Cover Crop Roller-Crimper Planter Technology

Milkweed plant populations were assessed in the fall 57 days after planting. At that time, the no cover crop treatment averaged 0.289 plants ft^{-2} compared to 0.083 plants ft^{-2} in the rye treatment (Table 7). However, this difference was not statistically significant. Despite the control treatment having approximately 3.5 times as much milkweed as the rye treatment, the populations were considerably lower than optimal in either treatment as our target population was 0.557 plants ft^{-2}. Unfortunately, when plots were revisited in the spring, populations had been significantly reduced with approximately 0.0133 plants ft^{-2} in the rye plots and 0.025 plants ft^{-2} in the controls. These treatments were significantly different in terms of fall weed biomass. The rolled rye treatment significantly reduced weed pressure with only 0.574 tons ac^{-1} dry matter present by the end of the season compared to almost double that in the no cover treatment. Furthermore, as demonstrated in Figure 4, most of the material that was present in the rolled rye treatment plots was winter rye that reseeded due to the late timing of using the roller crimper. At the time of rolling, the rye had formed seed heads. Given all of the available moisture and favorable fall temperatures, these seeds germinated creating competition for additional weeds.

Table 7. Roller crimper trial milkweed populations and weed biomass, 2017.

Treatment	Milkweed populations		Weed biomass
	Fall	Spring	
	plants ft^{-2}		DM tons ac^{-1}
Rolled rye	0.0826	0.0133	**0.574**
No cover crop	**0.289**	**0.025**	1.1
LSD (0.10)	NS	NS	0.156
Trial mean	0.186	0.0192	0.839

DM- dry matter.
NS- No significant difference.

Figure 4. Winter rye plot (left) and control plot (right) in the fall, 2017.

Insect Sampling in Established Milkweed Stands

Two established milkweed stands were surveyed three times between 3-Jul and 11-Jul. During these visits, bees belonging to six different genera were collected through net collections. Of these, honeybees, *Apis mellifera* were the most abundant, accounting for >95% of witnessed flower visits. This was not surprising given the proximity of these milkweed stands to managed honeybee hives. Additional insects, including butterflies, beetles, flies, and lacewings, visited milkweed flowers but in significantly lower abundance than honeybees. Furthermore, honeybees were the dominant bee species found to be carrying milkweed pollinia. On average, honeybees were carrying 2.25 pollinia. These pollinia were most often found to be attached to the front legs of the bees. Across the sampling timespan the number of milkweed flowers in bloom were recorded. The number of open flowers averaged 21.4 flowers per m^2 during the first 2 samplings in early July. By the last sampling date in mid-July, the average number of flowers decreased to 8.68 flowers per m^2. The number of honeybees and flower visits in early July peaked at 28.1 individual bees and 112 flower visits. With the decreased number of flowers available in mid-July, the number of honey bees decreased to 2.43 and flower visits to 12.5. These data are summarized in Figure 5. This information helps us understand when peak milkweed bloom and therefore, higher insect activity is occurring in this region. This will be used to inform best management practices that support productive milkweed stands while mitigating negative impacts on critical pollinator species.

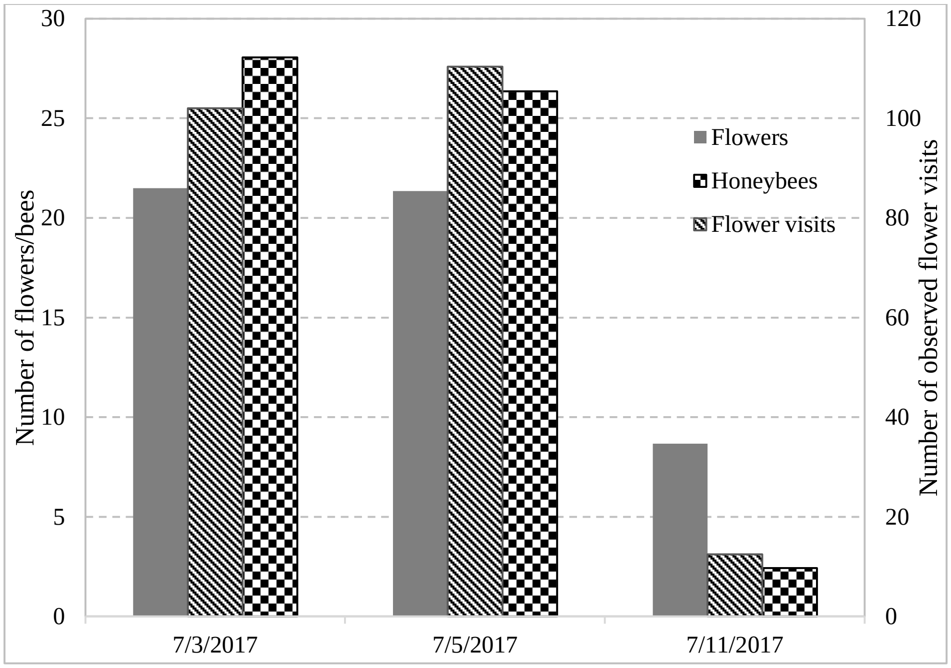

Figure 5. Milkweed flowers, honeybee individuals, and number of flower visits observed, 2017.

DISCUSSION

The weather conditions and delay in acquiring seed greatly impacted these milkweed trials. The lack of milkweed establishment may also be a result of poor seed quality. The nurse crop was successful at reducing weed populations and potentially providing complimentary benefits during the year of milkweed establishment. However, it was unclear if milkweed establishment was hindered by the nurse crop or if low populations were the result of poor seed quality or late seeding. Similar results and conclusions were made with the roll and crimp study. Additional research needs to be conducted to further refine these practices to properly establish milkweed stands.

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