2018 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 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 three trials investigating best management practices for the establishment of milkweed.

MATERIALS AND METHODS

Milkweed fertility trials-Nitrogen and Potassium

Producing optimal yields of any crop requires having adequate levels of nutrients available in the soil. Typically, farmers will test their soils to determine their nutrient content and will receive recommendations on additional fertility required by the crop that they are growing. For milkweed, these required fertility levels have not yet been established. We hypothesize that, as with most crops, providing additional nitrogen will increase plant productivity. In addition, we hypothesize that, as with many deep tap rooted crops, milkweed productivity will increase with increased availability of potassium. However, with both of these, we do not know if the increase in productivity will translate into increased floss yield specifically, or if the level of supplemental fertilizer needed to attain the increased yield will be economical. To help determine optimal and economical fertility strategies that support a high yielding milkweed crop, two fertility trials, investigating additions of nitrogen and potassium, were established in 2018.

The experimental design in each trial was a complete randomized block with four replications. Plots 8’ x 35’ were imposed into an area of milkweed that was established in 2016. Prior to the addition of fertilizer, the soil in the area was sampled to be analyzed for nutritional content. Plots were also assessed for milkweed populations, height, and flowering status at the time the fertilizer treatments were implemented. Table 1 shows the treatments for each trial. The nitrogen rates were attained through additions of urea (46-0-0) while potassium rates were attained through additions of potassium sulfate (0-0-52). Fertilizer treatments were applied on 31-May in both trials.

Table 1. Nitrogen and potassium treatments, 2018.

Nitrogen lbs N ac^{-1}	Potassium lbs K ac^{-1}
0	0
25	50
50	75
75	125
100	150

Figure 2. Unripe seeds (left) ripe seeds (right)
(photo credit: Brianna Borders, The Xerces Society)

The plots did not receive any further management throughout the season. Determining the timing of milkweed harvest relies on two key factors: seed ripeness and pod opening. Milkweed pods are ready for harvest when the seeds inside ripen turning a brown color (Figure 2). Plots were monitored for ripeness on a weekly basis by collecting a variety of pods from across the trial area and inspecting them for seed ripeness. However, to minimize floss losses during harvest, pods should be harvested when the majority of seeds are ripe but before the pods have broken open. Plots in both trials were harvested on 5-Sep. At harvest, milkweed populations were determined by counting the number of plants within a $0.25m^2$ quadrat. The number of the plants that had pods, and the total number of pods were recorded as well. Plant height and pod length were recorded for 5 randomly selected plants out of the quadrat area. The pods from the 5 plants were then weighed and a subsample dried to determine moisture content. A subset of the pods from each plot was also separated into pod, floss, and seed fractions and weighed.

Impact of herbicide use on milkweed stand productivity

Although weed pressure during establishment is known to be a challenge in successful milkweed production, we have yet to understand the impacts of weeds or weed management strategies over the stands’ lifetime. As the stands fill in, there are little or no opportunities for mechanical cultivation. Chemical control therefore, seems to be the most practical solution. To investigate the impact of chemical weed control on milkweed productivity, an herbicide trial was implemented in 2018.

A milkweed stand that was established in 2016 was used for the trial. Prior to herbicide application, weed composition and ground cover were measured in each plot. This was done by visually identifying the weed species present in each plot and by using the beaded string method (Sloneker and Moldenhauer, 1977). The field was sprayed with Roundup® in strips leaving unsprayed control areas on 8-May. Plots were then imposed into these strips. Sprayed plots were approximately 18' x 50' while control plots were approximately 7' x 50'. Once the milkweed had emerged, plant populations were measured in each plot by counting the number of plants in two 0.25m^2 quadrats. The trial was harvested on 5-Sep. At harvest, milkweed populations were determined by counting the number of plants within a 0.25m^2 quadrat. The number of the plants that had pods, and the total number of pods were recorded as well. Plant height and pod length were recorded for 5 randomly selected plants out of the quadrat area. The pods from the 5 plants were then weighed and a subsample dried to determine moisture content. A subset of the pods from each plot was also separated into pod, floss, and seed fractions and weighed.

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 this 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. Overall, the season was hotter and dryer than normal as temperatures were slightly above normal with a few periods of very hot weather in the middle of the summer and only about 60% of the normal precipitation accumulation. There were only four rain events during this trial's growing season that produced >0.75" of accumulation. These four events constituted approximately 33% of the total rainfall. Therefore, there were extended periods with very little to no rainfall, the longest of which was approximately 25 days with no rainfall >0.25". These dry conditions occurred during pod and seed formation and therefore may have impacted development and productivity. However, these warm conditions did provide optimal Growing Degree Days (GDDs) through the season with a total of 2650 GDDs accumulated May-Sep, 439 above normal.

Table 2. 2018 weather data for Alburgh, VT.

Alburgh, VT	May	June	July	August	September
Average temperature (°F)	59.5	64.4	74.1	72.8	63.4
Departure from normal	3.10	-1.38	3.51	3.96	2.76
Precipitation (inches)	1.94	3.74	2.43	2.96	3.48
Departure from normal	-1.51	0.05	-1.72	-0.95	-0.16
Growing Degree Days (50-86°F)	352	447	728	696	427
Departure from normal	154	-27	88	115	109

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.

Milkweed fertility trials-Nitrogen and Potassium

Fertility treatments did not significantly vary in terms of yield and many harvest characteristics in either trial (Tables 3 and 4). The number of pods per plant averaged 3.60 and 3.81 with 74.1% and 74.2% of plants having formed pods in the nitrogen and potassium trials respectively. Pods averaged 9.05 and 9.25cm in length and 63.6% and 57.8% moisture content at the time of harvest for the nitrogen and potassium trials respectively. The total pod yields, expressed on a dry matter basis, were 1.05 and 1.30 tons ac^{-1} for the nitrogen and potassium trials respectively. None of these characteristics varied statistically across nutrient application rates. The one characteristic that did vary statistically, however, was plant height. Plant height, measured at harvest, averaged 42.9 and 40.7 inches in the nitrogen and potassium trials respectively. In the nitrogen trial, heights ranged from 39.2 to 45.8 in and were not statistically different. This result was surprising as we would assume that additional nitrogen would be utilized by the plant in its biomass. However, the extremely dry conditions throughout the season likely influenced the availability of nitrogen to the plants. For the potassium trial, heights ranged from 38.0 to 44.5 inches and was statistically different across potassium rates. Interestingly, the tallest plants were observed in the 50 lb K ac^{-1} treatment which was not statistically similar to any other treatment.

Table 3. Milkweed harvest characteristics, Nitrogen trial, 2018.

Nitrogen rate	Pod production		Pod length	Plant height	Pod moisture	Pod yield
lbs N ac^{-1}	pods plant^{-1}	% of plants	cm	in	%	DM tons ac^{-1}
0	**4.33**	72.1	9.34	39.2	**61.9**	**1.33**
25	3.92	75.9	8.73	43.6	64.6	1.13
50	3.23	**80.5**	**9.45**	45.1	64.1	0.98
75	3.78	68.6	8.99	40.7	64.9	0.99
100	2.74	73.3	8.75	45.8	62.4	0.81
LSD (p = 0.10)	NS	NS	NS	NS	NS	NS
Trial mean	3.60	74.1	9.05	42.9	63.6	1.05

Treatments that are top performers are indicated in **bold**.
NS – No significant differences.

Table 4. Milkweed harvest characteristics, Potassium trial, 2018.

Potassium Rate	Pod production		Pod length	Plant height	Pod moisture	Pod yield
lbs K ac^{-1}	pods $plant^{-1}$	% of plants	cm	in	%	DM tons ac^{-1}
0	3.66	65.9	9.09	38.0	57.7	1.33
50	3.88	**83.7**	9.61	**44.5**	60.6	1.34
75	**4.19**	68.4	8.93	39.6	**54.9**	1.31
125	3.35	77.7	8.82	40.9	59.0	1.13
150	3.96	75.4	**9.82**	40.4	56.8	**1.38**
LSD (p = 0.10)	NS	NS	NS	3.50	NS	NS
Trial mean	3.81	74.2	9.25	40.7	57.8	1.30

Treatments that are top performers are indicated in **bold**.
NS – No significant differences.

Treatments also did not differ significantly in terms of pod composition across either trial (Tables 5 and 6). The majority of the total pod weight is composed of pod material as this was found to be 60.0% and 57.5% for the nitrogen and potassium trials respectively. The floss, as to be expected, accounted for the smallest fraction at only 16.3% and 17.3% of the total pod weight for the nitrogen and potassium trials respectively. Based on the pod yields observed in the trial, and the current value estimate for pods at 30% moisture being \$0.40 per pound, the value of the crop would be between \$1200 and \$1500 per acre. However, the actual value that can be realized will be lower as these estimates assume that all of the pods can be harvested from the field without loss.

Table 5. Milkweed pod composition by weight, Nitrogen trial, 2018.

Nitrogen rate	Floss	Pod	Seed
lbs N ac^{-1}	% by weight		
0	16.2	60.5	23.3
25	16.3	59.6	24.1
50	**17.6**	**59.4**	23.0
75	16.1	60.5	23.4
100	15.5	60.2	**24.3**
LSD (p = 0.10)	NS	NS	NS
Trial mean	16.3	60.0	23.6

Treatments that are top performers are indicated in **bold**.
NS – No significant differences.

Table 6. Milkweed pod composition by weight, Potassium trial, 2018.

Potassium rate	Floss	Pod	Seed
lbs K ac^{-1}	% by weight		
0	17.1	58.1	24.8
25	16.4	59.0	24.7
50	**17.8**	**56.0**	**26.2**
75	17.8	57.0	25.2
100	17.5	57.4	25.0
LSD (p = 0.10)	NS	NS	NS
Trial mean	17.3	57.5	25.2

Treatments that are top performers are indicated in **bold**.
NS – No significant differences.

As with any crop, some level of loss at harvest is to be expected, however, it is exceptionally difficult with milkweed given the extremely low weight of the floss. Harvesting techniques to minimize floss losses and improve purity and cleanliness are currently being developed. Although the floss is the main component of interest in a milkweed crop, the seed may also present opportunities to recoup value, especially as interest in growing milkweed commercially increases. Therefore, the highest seed and floss yielding and lowest pod yielding treatments are represented as the top performing treatments in the tables above.

Impact of herbicide use on milkweed stand productivity

Weed control treatments did not significantly vary in terms of yield and many harvest characteristics (Table 7). The number of pods per plant averaged 3.73 with 68.4% of plants on average having pods. Pods averaged 8.64cm in length and plants averaged 40.2 inches in height at the time of harvest. The total pod yield, expressed on a dry matter basis, was 1.12 tons ac^{-1}. None of these characteristics varied statistically across weed control methods. This may be due to the fact that the weed pressure was similar across the treatments as the percent of ground cover from weedy vegetation at the time of harvest was not statistically different between weed control treatments with the control having 44.5% and the herbicide treatment with 39.0%. The one characteristic that did vary statistically, however, was pod moisture with the control producing pods with 3.9% higher moisture than the herbicide treated plants. This suggest that the early herbicide application may have allowed the plants to mature faster than the plants that did not receive weed control. However, no additional yield was gained from the herbicide application and therefore, is likely not cost effective.

Table 7. Milkweed harvest characteristics, weed control trial, 2018.

Weed control	Ground cover	Pod production		Pod length	Plant height	Pod moisture	Pod yield
	%	pods plant^{-1}	% of plants	cm	in	%	DM tons ac^{-1}
Herbicide	39.0	3.60	63.6	8.83	40.4	58.7	1.19
Control	44.5	3.87	**73.1**	8.45	**40.0**	62.6	1.05
LSD (p = 0.10)	NS	NS	NS	NS	NS	3.73	NS
Trial mean	41.8	3.73	68.4	8.64	40.2	60.7	1.12

Treatments that are top performers are indicated in **bold**.
NS – No significant differences.

DISCUSSION

These preliminary data suggest that additional nitrogen or potassium fertilizer at rates between 0-100 and 0-150 lbs ac^{-1} respectively does not increase milkweed floss yield. The additional nutrients appear to have been used by the plant for vegetative growth as, at least for potassium, plant height differed at harvest across the rates. Perhaps larger differences would have been observed given more favorable weather to encourage nutrient transport into the soil profile. Furthermore, larger differences may be seen on more marginal fields. Prior to fertilizer application, a soil test was taken. The test indicated optimum levels of potassium in the soil. For most crops this would indicate that it would be unlikely to see a yield response if additional potassium was added. In terms of nitrogen, lack of moisture throughout the season likely contributed to lower nitrogen availability in the soil. Furthermore, the few rain events that were experienced throughout the season were >.75” and could have caused leaching or runoff of these nutrients as they are not held by the soil well. These data also suggest that one singular spring application of herbicide did not increase milkweed floss yield. At the time of harvest, the treatments were similar in the amount of ground cover provided by weeds indicating that, although the application may have increased the milkweed’s ability to establish faster, that potential effect did not carry through to the end of the season or impact yield. These data are representative of only one location and year. Further investigation is needed to determine optimal and economical fertility rates and weed control methods for milkweed.

REFERENCES

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