Wisconsin Emerging Crops Accelerator

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Exploration of Hemp for Fiber Production and Quality in Wisconsin

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Introduction

This project was developed to study industrial hemp (Cannabis sativa L.) production and utilization in Western Wisconsin. Trials were planned and established in three locations: Buffalo County, Chippewa County and Monroe County at Whirling Thunder Farm - Ho-Chunk Nation. The 2021 trials were funded through a UW-Madison Division of Extension Innovative grant, Sustainable Agriculture Research and Education (SARE) mini-grant, and Wisconsin Farmers Union Foundation grant. The Buffalo and Chippewa County sites were grown under conventional management, the Monroe County site was managed using organic approved management and inputs.

Buffalo County Trial Site

Monroe County Trial Site - Whirling Thunder Farm

Chippewa County Trial Site

Table 1: Precipitation and Temperatures at Each Site

Month & Location		Temperature/20 year mean F	Precipitation/20 year mean Inches
June	Buffalo	73.0(69.7)	5.31(5.95)
	Chippewa	73.1(66.4)	5.33(4.51)
	Monroe	72.0(66.9)	5.03(5.31)
July	Buffalo	72.2(73.9)	3.19(3.96)
	Chippewa	72.1(70.5)	3.75(4.14)
	Monroe	71.1(70.8)	5.86(4.07)
August	Buffalo	71.1(71.5)	8.05(4.86)
	Chippewa	70.7(68.1)	9.80(3.98)
	Monroe	69.9(68.5)	8.07(4.30)
September	Buffalo	64.0(64.4)	2.59(4.10)
	Chippewa	63.0(59.7)	1.85(3.32)
	Monroe	61.6(60.2)	1.66(3.73)

Table 2: Location Information

Location	Soil Type	Previous Crop	Soil Preparation
Buffalo	Valton Silt Loam (6-12% slope)	Soybeans (rye cover crop)	Rye killed with herbicide One pass with light disk
Chippewa	Scott Lake Sandy Loam (0-6% slope)	Soybeans	Field cultivator and cultipacker
Monroe	Norden Silt Loam (6-12% slope)	Grass legume sod	Moldboard plow, rotavator

Methods:

The experimental design was a randomized complete block with four replications at three sites. There were eight hemp varieties evaluated in the trial. Seeding rates were adjusted for germination rates provided by companies for each variety. The trial was planted at 40 pounds of viable seed per acre in four feet by twenty feet plots. All variety plots were planted using a Hege cone planter in seven-inch rows (photo 4). Planting dates were June 11 (Chippewa), June 15 (Buffalo), and June 16 (Monroe), 2021.

Varieties were selected based on other trials that have been conducted in the United States with similar environments to Western Wisconsin. All are European varieties since they have been involved in fiber hemp production since the 1990's. The varieties were all certified seed from source countries.

Photo 4: Hemp plot layout and planting in June.

Table 3: Varieties Planted in 2021 Trials

Variety	County of Origin	Reproduction
Futura 75	France	Monecious
Tiborszallasi	Hungary	Dioecious
Secuieni Jubileu	Romania	Monecious
Felina 32	France	Monecious
Henola	Poland	Monecious
Bialobrzeskie	Poland	Monecious
Ferimon	France	Monecious
Fibror 79	France	Monecious

Trials at Buffalo and Chippewa Counties were fertilized with 100 pounds of nitrogen using SuperU® nitrogen fertilizer. Monroe County trial also received 100 pounds of nitrogen using Chilean Nitrate fertilizer. Fifty pounds of potassium, and 18 pounds of sulfur were also applied. Weed control at all sites was through hand weeding. Weed issues were not significant at Buffalo or Chippewa Counties, but the Monroe County site had some areas with significant velvetleaf pressure early in the season likely due to uneven germination caused by dry soil conditions and seedbed preparation challenges.

Scouting for insect and disease issues was conducted throughout the season. No significant problems were observed at any of the sites. There were a number of Japanese Beetles at all sites, but no damage was observed that seemed to hinder crop development or yield.

Harvest was conducted two times: in early August for forage yield and quality, and late August for fiber yields. All trials were harvested within three days. Plant heights were taken and a three foot by four feet section was harvested of each variety on one replication for forage yield and quality (only one replication was harvested due to limited funds for testing). Total plant biomass was collected and weighed for each plot. A subsample, of five random plants, was chopped and sampled for dry matter, wet chemistry analysis was conducted for % CP (crude protein) and % TDN (total digestible nutrients).

Hemp for fiber was harvested the end of August, with all three sites being harvested within three days. Plant heights were taken, and males and female plants were counted from a three foot by four foot harvested section of each plot in the trial. Three random plants, from each plot, were kept and sent to the lab for dry matter analysis. Weights were taken on the entire biomass and for the stem alone. Base diameter was recorded on ten random plants within the sample area.

Photo 5: Early season crop

Photo 6: Harvesting Hemp

Photo 7: Cutting hemp plants for forage testing.

Results:

Forage Yield and Quality: Hemp is a popular cattle feed in other parts of the world. Because of the short growing season (planted in mid-June and harvested in early August), it may fit as a planned forage crop or an emergency forage crop in Wisconsin. Hemp is normally harvested and used as livestock feed as female flowers emerge resulting in higher quality forage. The data collected is very preliminary as it was only from one replication at each trial site. There were also issues with lab results from one site, so the quality data was only from two trial sites. **It is important to note that hemp currently cannot be legally fed to livestock in the United States.**

Maturity of the plants appears to be an issue after analyzing sample results. Some plants were harvested after flowering, not as they emerge, due to timing and feasibility of taking the samples.

More research and sampling of industrial hemp is necessary to determine if it is a suitable forage for livestock feed.

Table 4: Forage Testing Results

Variety	Height (inches)	% DM	DM/ acre (tons)	Crude Protein (%)	TDN (%)
Futura 75					
Buffalo	63	24.34	2.6	NA	NA
Chippewa	50	19.47	3.1	17.56	58.00
Monroe	88	20.20	4.9	20.25	58.81
Tiborszallasi					
Buffalo	80	21.25	3.5	NA	NA
Chippewa	65	21.11	3.8	18.45	60.04
Monroe	86	20.98	6.5	14.50	56.41
Secuieni Jubileu					
Buffalo	65	23.18	2.5	NA	NA
Chippewa	43	23.32	2.0	20.36	61.02
Monroe	92	21.68	2.4	15.70	56.85
Felina 32					
Buffalo	58	20.78	2.8	NA	NA
Chippewa	47	20.99	3.5	22.69	62.35
Monroe	72	21.73	4.0	15.80	55.66
Henola					
Buffalo	57	23.50	2.4	NA	NA
Chippewa	40	24.47	2.8	19.04	60.00
Monroe	78	20.49	1.8	15.10	54.64
Bialobrzeskie					
Buffalo	64	22.28	2.2	NA	NA
Chippewa	48	22.01	2.6	17.71	58.90
Monroe	77	22.06	4.1	17.20	56.76
Ferimon					
Buffalo	63	21.72	2.7	NA	NA
Chippewa	49	19.47	2.5	21.10	58.47
Monroe	72	22.67	3.9	12.2	55.23
Fibror 79					
Buffalo	77	19.33	2.1	NA	NA
Chippewa	45	16.58	2.1	19.67	57.43
Monroe	79	17.04	3.3	20.2	55.40

Photo 8: Measuring plant stem diameter.

Photo 9: Bundling and preparing hemp stems for retting.

Fiber Variety Trials: Results of the variety trials were variable in production between sites but did give some clear indications of the best and worst varieties measured by yield of total biomass and stem biomass per acre. Fiber quality based on variety is currently unclear, but is being studied by Dr. Shelby Ellison, UW-Madison College of Agriculture & Life Sciences (CALS) in cooperation with several other departments at UW-Madison and private businesses. Tables 5, 6, and 7 display the individual results at each location. Graph 1, shows trends in the data when location information is combined.

Photo 10: Retting hemp in field

Photo 11: Weighing samples at harvest

Table 5 : Buffalo County 2021 Fiber Hemp Variety Trial Results

Variety	Height (cm)	Stem Diameter (mm)	Biomass weight per acre (tons)	Main stem weight per acre (tons)	Plant population
Bialobrzeskie	164.33	4.88	5.069	2.633	648148
Felina 32	178.65	4.50	5.545	3.302	561002
Ferimon	170.50	4.78	4.567	2.903	621822
Fibror 79	195.80	6.06	6.679	3.978	596405
Futura 75	192.70	5.94	5.873	3.441	562817
Henola	141.90	4.69	3.815	2.262	508351
Secuieni Jubileu	160.15	6.74	3.571	1.936	279593
Tiborszallasi	181.48	6.59	5.241	3.544	556463

Table 6 : Chippewa County 2021 Fiber Hemp Variety Trial Results

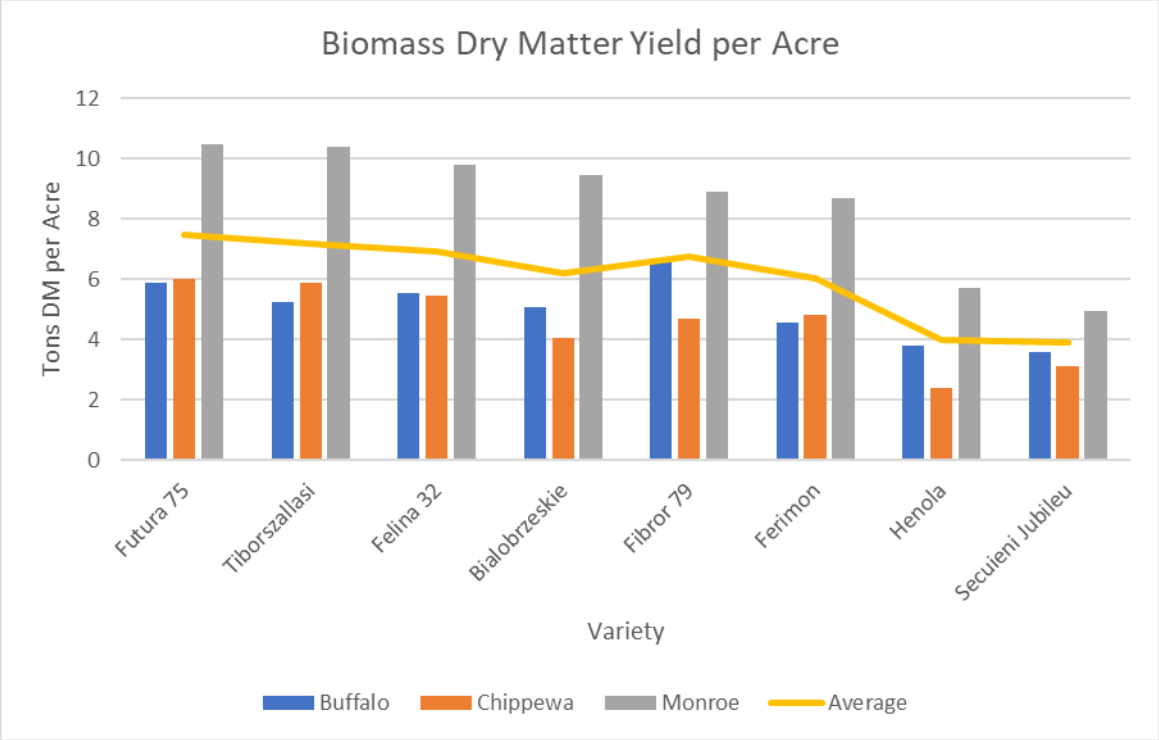
Variety	Height (cm)	Stem Diameter (mm)	Biomass weight per acre (tons)	Main stem weight per acre (tons)	Plant population
Bialobrzeskie	118.60	3.80	4.060	1.639	915940
Felina 32	126.80	3.80	5.472	2.071	1077524
Ferimon	129.80	4.20	4.821	2.095	935004
Fibror 79	148.70	5.20	4.695	1.994	668119
Futura 75	147.00	4.50	6.021	2.437	986747
Henola	77.78	2.89	2.410	0.514	104028
Secuieni Jubileu	106.78	3.86	3.137	0.841	436638
Tiborszallasi	176.10	6.5125	5.890	2.242	593077

The varieties Henola and Secuieni Jubileu did not yield as well as the other varieties at any location. This is only one year data and the varieties will be tested again in 2022 with the addition of one or two new recommended varieties.

Table 7: Monroe County 2021 Fiber Hemp Variety Trial Results

Variety	Height (cm)	Stem Diameter (mm)	Biomass weight per acre (tons)	Main stem weight per acre (tons)	Plant population
Bialobrzeskie	227.21	10.56	9.465	4.547	264161
Felina 32	224.31	10.12	9.780	4.883	315904
Ferimon	203.30	9.17	8.669	4.302	384895
Fibror 79	240.35	12.59	8.882	4.633	210603
Futura 75	251.13	12.89	10.490	5.141	182462
Henola	172.86	8.02	5.702	2.691	286855
Secuieni Jubileu	187.87	9.72	4.947	2.558	163399
Tiborszallasi	264.27	13.10	10.405	5.724	199710

Graph 1: Biomass Dry Matter Yield Across Locations



Plant Population: Plant population differences were observed between trial sites. All plots were planted using the same equipment, timing, and seeding rate yet the population differences were large. It appeared that all populations were similar at germination, but early population counts were not taken. In 2022, population counts will be conducted at six inches, at three feet and at harvest to see what changes may occur throughout the growing season.

Nitrogen Fertilizer Trial: A nitrogen fertilization trial was conducted at all three locations. Plots received 0, 40, 80, or 120 pounds of nitrogen at planting (or just as plants emerged). Yield response was highly variable but does indicate a trend in nitrogen needed by the crop. Choosing varieties that are higher yielding may show more differentiation in nitrogen response.

Photo 12: Fertilizer broadcast applied on emerging hemp plants.

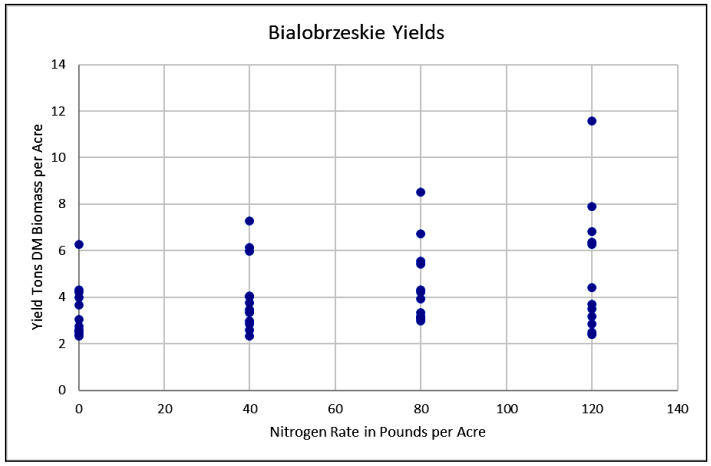
Graph 2 and 3: Yield Response to Nitrogen Fertilizer Rates by Variety

Graphs 2 & 3 display individual plot yields from the three locations. Nitrogen is definitely important for fiber hemp production, but more research will be needed to verify what rates are required.

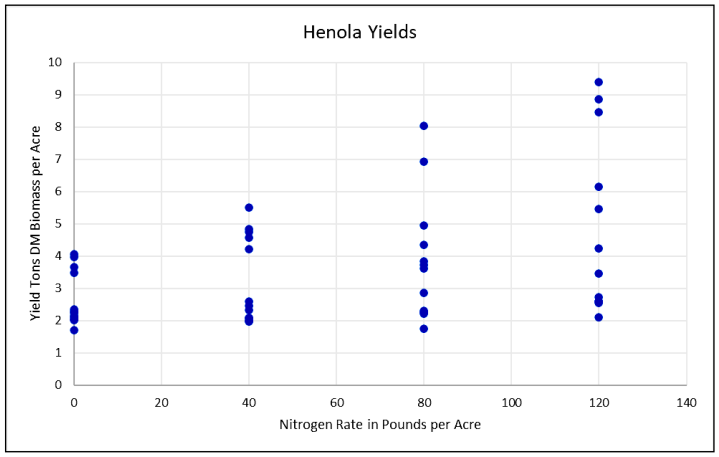
Graph 4: Fiber and Grain Yields at the Chippewa County Plot Site

Grain yields were only taken at the Chippewa County location in 2021 (graph 4). The two highest grain yielding varieties were Futura 74 and Henola. Both of these varieties are considered dual purpose varieties (fiber and grain) so their performance would be consistent with how they were bred and sold in Europe. Yields between 600 – 700 pounds per acre are similar to hemp grain yields of dual-purpose varieties in Canada and Europe. Higher grain yields are typical with varieties that are bred specifically for grain. Grain oil content was not tested in the plots in 2021.

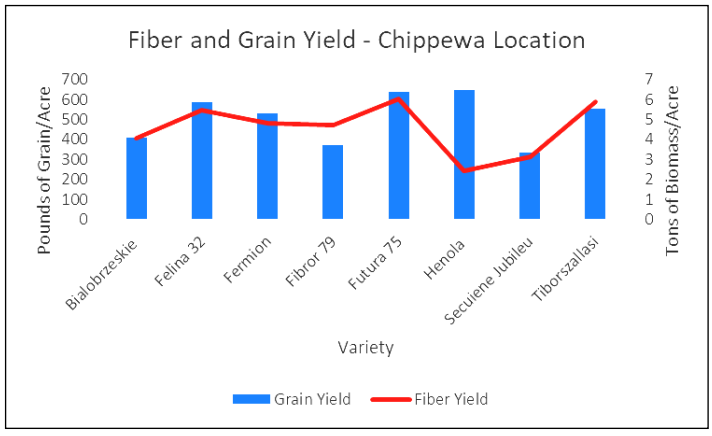
Graph 2



Graph 3



Graph 4



Additional observations regarding the 2021 trials

- Plots in Monroe County were affected by severe storms three times throughout the growing season. High winds were the most damaging result of these storms. Many of the trial plots were almost completely flattened by winds but recovered partially or totally. Many plants were effectively broken off during the third storm but plants that were not, continued to grow (photo 13). Researchers do not have data to show the extent that this damage affected yields.
- Weed pressure varied between the locations but was the worst at the Monroe County trial. Hand weeding was conducted as needed, currently no herbicides are approved at this time. It is extremely important to start with a clean field before planting. At harvest, there were very few weeds at any of the trial locations. Hemp is very competitive under good growing conditions. This is one reason that trials were not planted until mid-June. Hemp likes hot temperatures and seems to out compete most weeds once established.
- Gemination at the Monroe County site was uneven. This is presumed to be a combination of seedbed preparation problems and dry soil conditions at planting. Most of the trial plots seemed to recover from this issue as the growing season progressed.
- Each trial location had a few plants that displayed yellow plants. This was not identified as a pest or disease issue. The most likely cause was the early stages of hybrid development and seed that may not be as pure as we see in other hybrid crops.
- Field days were held at each location. This will continue in 2022 (photo 15).

Photo 13: Storm damaged hemp plant shows continued growth at Whirling Thunder Farm—Monroe County.

Photo 14: Few yellow leaves likely the cause of early stages of hybrid development.

Photo 15: 2021 Field Day

Photo 16: Chippewa County hemp harvest.

Early Economic Review: Because of the very limited market opportunities for fiber hemp, revenue was not included in the 2021 partial budget. A breakeven price was included as a target for future market considerations. The 2021 study included both conventional and organic production systems, therefore expenses for both were included in this budget. Yield will be a large factor in the breakeven cost. In this sample budget, an average yield of five ton per acre was used. Grain yield and income were not considered in this budget. A more complete budget discussion can be found on the UW-Madison Extension Hemp webpage https://fyi.extension.wisc.edu/hemp/

Table 8: Enterprise Budget Estimates for Fiber Hemp

Expenses	Conventional	Organic
Fertilizer	$101.90	$339.25
Seed	$220.00	$220.00
Pesticides	$6.00	$0.00
Other (land rent, soil testing, permit, etc.)	$159.45	$159.45
Total Production Costs	**$437.35**	**$718.70**
Field Preparation and Planting	$45.00	$78.00
Harvest	$162.25	$162.25
Storage and Hauling	$32.50	$32.50
Total Costs (no return to management)	**$677.10**	**$991.45**
Breakeven Cost Per Ton (based on 5 ton per acre yield)	**$135.42**	**$198.29**

Future Plans: Trials will continue at all three locations in 2022. Researchers will continue to look at recommended fiber varieties, forage quality, and add a trial on seeding rate. Additional data will be collected including stand counts throughout the growing season. Forage quality data measures will be added in 2022 that will allow researchers to measure the digestibility of hemp forage.

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