



2023 Industrial Grain Hemp Variety Trial



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2023 INDUSTRIAL GRAIN HEMP VARIETY TRIAL

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Hemp is a non-psychoactive variety of *Cannabis sativa L.* The crop is one of historical importance in the U.S. and reemerging in worldwide importance as manufacturers seek hemp as a renewable and sustainable resource for a wide variety of consumer and industrial products. The crop produces a valuable oilseed, rich in Omega-3, and other essential fatty acids that are often absent in western diets. When the oil is extracted from the seed, what remains is a marketable meal co-product, which is used for human and animal consumption. The fiber has high tensile strength and can be used to create cloth, rope, building materials, and even a form of plastic. For twenty years, U.S. entrepreneurs have been importing hemp from China, Eastern Europe, and Canada. Today, industrial hemp is re-emerging as a locally grown product in the U.S. To help farmers succeed, agronomic research on hemp is needed, as much of the historical production knowledge for the region has been lost. In this trial, hemp grain varieties were evaluated to determine best suited cultivars for the region.

MATERIALS AND METHODS

The trial was initiated at Borderview Research Farm in Alburgh, Vermont (Table 1) to evaluate yield potential of hemp grain varieties in the Northeast. The experimental design was a randomized complete block with four replications. The seed bed was prepared with a Pottinger TerraDisc. Seventeen grain and dual-purpose hemp varieties (Table 2) were planted into 5 x 20' plots at a target rate of 38 lbs ac⁻¹ or 250 seeds m⁻² on 25-May with a Great Plains NT60 Cone Seeder. The soil type was Benson rocky silt loam with 8-15% slopes, and the previous crop was summer forage annuals.

Table 1. Agronomic information for the industrial hemp grain variety trial, Alburgh, VT, 2023.

Location	Borderview Research Farm Alburgh, VT
Soil type	Benson rocky silt loam, 8-15% slopes
Previous crop	Summer annuals
Plot size (ft)	5 x 20
Planting date	25-May
Row spacing	7"
Replicates	4
Planting equipment	Great Plains NT60 Cone Seeder
Seeding rate (seeds m⁻²)	250
Harvest date	6-Sep, 15-Sep, 13-Oct

Seed was sourced from the seed companies displayed below in Tables 2 and 3. On 6-Jun, emergence populations were counted in three one-foot sections per plot. Prior to harvest, populations were taken at random from each plot and heights were recorded. On 6-Sep, 15-Sep, and 13-Oct, the plots were harvested with an Almaco (Nevada, IA) SPC50 small plot combine based on relative maturity. Grain yield and moisture were determined at harvest. Thousand kernel weights of the harvested seed were determined for each variety.

Table 2. Hemp grain varieties evaluated in the hemp trial, Alburgh, VT, 2023.

Variety	Seed source	Days to maturity	Thousand kernel weights	Seeds
			g	seeds lb ⁻¹
Anka	Uniseeds	105-110	14.9	30443
Bialobrzeskie	International Hemp	115-120	15.7	28892
Carmenecta	International Hemp	130-150	20.0	22680
Earlina 08FC	Hemp Seed Warehouse		13.7	33109
Fedora 17	Hemp Seed Warehouse	110-115	18.7	24257
Felina 32	Hemp Seed Warehouse	110-115	16.3	27828
Ferimon 12	Hemp Seed Warehouse	110-115	17.7	25627
Futura 83	Hemp Seed Warehouse	115-120	19.7	23025
Henola	International Hemp	110-115	15.7	28892
NWG 2463	New West Genetics	100-120	15.6	29077
NWG 2730	New West Genetics	100-120	12.7	35717
NWG 4000	New West Genetics	100-120	17.2	26372
NWG 4113	New West Genetics	100-120	15.6	29077
Orion 33	Hemp Seed Warehouse	115-120	18.0	25200
Silesia	Uniseeds	110-115	17.2	26372
Vega	Uniseeds	100-105	21.0	21600
X59	IND Hemp	110-115	17.3	26220

Table 3. Participating seed companies and contact information.

Company	Contact Information
Hemp Seed Warehouse	Corbett Miteff mcmiteff@gmail.com
IND Hemp	Ben Brimlow ben@indhemp.com
International Hemp	Terry Moran terry@international-hemp.com
New West Genetics	Rich Fletcher rfletcher@newwestgenetics.com https://newwestgenetics.com/contact/
UniSeeds/Seedway	Pierre Lanoie pierre@uniseeds.ca

Data were analyzed using a general linear model procedure of SAS (SAS Institute, 2008). Replications were treated as random effects, and treatments were treated as fixed. Mean comparisons were made using the Least Significant Difference (LSD) procedure where the F-test was considered significant, at $p < 0.10$.

Variations in genetics, soil, weather, and other growing conditions can result in variations in yield and quality. Statistical analysis makes it possible to determine whether a difference between treatments is significant or whether it is due to natural variations in the plant or field. At the bottom of each table, a LSD value is presented for each variable (i.e. yield). Least Significant Differences (LSDs) at the 0.10 level of significance are shown. This means that when the difference between two treatments within a column is equal to or greater to the LSD value for the column, there is a real difference between the treatments 90% of the time. In the example to the right, treatment C was significantly different from treatment A, but not from treatment B. The difference between C and B is 1.5, which is less than the LSD value of 2.0 and so these treatments were not significantly different in yield. The difference between C and A is equal to 3.0, which is greater than the LSD value of 2.0. This means that the yields of these treatments were significantly different from one another. Treatment B was not significantly lower than the top yielding treatment, indicated in bold. A lack of significant difference is indicated by an asterisk.

Treatment	Yield
A	6.0
B	7.5*
C	9.0
LSD	2.0

RESULTS

Seasonal precipitation and temperature were recorded with a Davis Instrument Vantage Pro2 weather station, equipped with a WeatherLink data logger at Borderview Research Farm in Alburgh, VT (Table 4). Much of the growing season in 2023 was defined by heavy rains and below average temperatures during the peak of the season. For the given portion of the season, temperatures were on average 1.87° below the 30-year average for Alburgh, VT. Additionally, precipitation was significantly higher, 8.06” above average, as a result of major storms and flooding that occurred throughout the region with greatest storm events observed in July and August. As a result of these conditions, we saw significantly less cumulative growing degree days (GDDs) during critical maturation periods in August for grain hemp, 101 GDDs below average and a total cumulative GDDs of 2712 for the season.

Table 4. Seasonal weather data collected in Alburgh, VT, 2023.

Alburgh, VT	May	June	July	August	Sept	Oct
Average temperature (°F)	57.1	65.7	72.2	67.0	63.7	54.4
Departure from normal	-1.28	-1.76	-0.24	-3.73	1.03	4.11
Precipitation (inches)	1.98	4.40	10.8	6.27	2.4	5.38
Departure from normal	-1.78	0.14	6.69	2.73	-1.27	1.55
Growing Degree Days (32-95°F)	766	1027	1274	1098	980	711
Departure from normal	-53	-37	22	-101	58	143

Based on weather data from a Davis Instruments Vantage Pro2 with WeatherLink data logger. Alburgh precipitation data from August-October was provided by the NOAA data for Highgate, VT. Historical averages are for 30 years of NOAA data (1991-2020) from Burlington, VT.

Harvest measurements and yields data are displayed below in Tables 5 and 6. NWG 4000 had the highest population at 15.2 plants ft⁻² or 662,112 plants ac⁻¹, and was statistically similar to NWG 2463 and X-59. Carmenecta had the highest average plant height at 268 cm alongside Futura 83 at 250 cm. Like past years, Carmenecta continued to have the tallest plants on average in addition to the greatest thousand kernel weight at 23.0 g. The heavier the TKW, the more robust the grain produced, and the lower the number of seeds per pound. Carmenecta was also the latest maturing variety harvested approximately one month later than the earlier maturing varieties.

Table 5. Harvest metrics by variety for industrial grain hemp, Alburgh, VT, 2023.

Variety	Population plants ft ⁻²	Population plants ac ⁻¹	Average height cm	Average stem diameter mm	Male plants %	Female plants %	Monoecious plants %
Anka	11.4	496584	187	9.20	15.1	46.1	38.8*
Bialobrzieskie	9.70	422532	227	8.80	8.20	55.7	36.1*
Carmenecta	9.10	396396	268	11.6	35.4	64.6*	0.00
Earlina 08FC	10.6	461736	187	7.40	19.3	59.6	21.1
Fedora 17	11.2	487872	202	8.20	2.40	68.1*	29.5*
Felina 32	10.5	457380	206	7.70	3.00	77.7*	19.3
Ferimon 12	9.90	431244	223	9.10	8.20	84.3	7.50
Futura 83	11.7	509652	250*	10.7*	0.00	73.0*	27.0*
Henola	9.70	422532	186	7.40	8.20	60.1	31.7*
NWG 2463	13.6* †	592416*	173	7.00	40.6*	59.4	0.00
NWG 2730	8.00	348480	203	10.0*	54.3	44.6	1.10
NWG 4000	15.2	662112	185	8.30	47.4*	52.6	0.00
NWG 4113	9.70	422532	184	8.00	43.9*	53.8	2.40
Orion 33	8.80	383328	216	9.90*	2.40	62.2*	35.4*
Silesia	9.60	418176	205	8.60	2.50	60.0	37.5*
Vega	11.7	509652	199	8.90	0.00	53.3	46.7
X-59	12.7*	553212*	179	9.60*	26.5	67.4*	6.10
LSD (p=0.10)	3.39	147758	35.6	2.05	15.5	20.0	23.5
Trial mean	10.8	469167	205	8.8	18.7	61.3	20.0

† Within a column, treatments marked with an asterisk performed statistically similar (p=0.10) to the top performers, listed in **bold**.

Hemp varieties are classified as either monoecious or dioecious. The definitions of these classifications are as follows: monoecious plants are defined by having both the male and female reproductive organs in the same individual, while dioecious plants have male and female reproductive organs in separate individuals. All hemp is naturally dioecious, and varieties will revert to this natural state without human intervention. Therefore, monoecious characterization is generally a result of careful plant breeding and maintenance with the goal of increasing grain yield and fiber quality. A monoecious variety stand will still consist of all three sexes of plants, with the majority of the stand presenting as monoecious. The number of pure males to be expected in each variety is usually acknowledged in the variety description written by the plant breeder. Routinely, there is up to 10% pure males within a monoecious variety, but the number of males in a stand

can increase from year to year and from field to field in both monoecious and dioecious varieties due to stress. Stress can manifest from a variety of biotic and abiotic factors such as weather events or lack of nutrients, and plants are most vulnerable to stress in the early stages of crop growth. In dioecious varieties, male plants can account for up to 50% of the plant population.

Futura 83 produced the highest grain yield at 2123 lbs ac⁻¹ and was statistically similar to Bialobrzieskie, Carmenecta, Fedora, NWG 2730, Orion 33, and X-59 (Table 6). Futura 83, Orion 33, and X-59 were all top yielding varieties between 2022 and 2023 (Figure 1). According to the USDA, the average yield for grain hemp in the US in 2022 was estimated at 452 lbs ac⁻¹. All of the varieties in our trial surpassed that national average, with the exception of Earlina 08FC, which yielded below the average at 341 lbs ac⁻¹. The lowest yields reported for Earlina 08FC may have been a result of improper harvest timing due to a lack of familiarity with the variety. Yields from our variety trials across 2021-2023 have ranged from 1180-1481 lbs ac⁻¹ with those trialed across each year represented below. Numerous varieties have been evaluated in the trial for multiple years, where others were new to the trial this year, so yield information may only represent a single season.

Table 6. Harvest yields and grain moisture by variety for industrial grain hemp, Alburgh, VT, 2023.

Variety	Harvest date	Grain moisture %	Thousand kernel weight g	Seeds seeds lb ⁻¹	Yield at 10% moisture lbs ac ⁻¹
Anka	6-Sep	16.6* ‡	19.1	23828	1252
Bialobrzieskie	6-Sep	18.7	17.8	25591	1491*
Carmenecta	13-Oct	20.4	23.0	19734	1506*
Earlina 08FC	6-Sep	10.8	14.3	32816	341
Fedora 17	6-Sep	15.4*	19.7	23055	1640*
Felina 32	6-Sep	20.8	17.9	25370	1074
Ferimon 12	6-Sep	18.1	18.2	24977	1129
Futura 83	15-Sep	27.1	20.1	22556	2123
Henola	6-Sep	18.2	16.1	28219	1260
NWG 2463	15-Sep	25.1	17.8	25747	1223
NWG 2730	15-Sep	24.7	15.9	28550	1654*
NWG 4000	15-Sep	21.4	16.9	27179	1354
NWG 4113	15-Sep	24.8	17.0	26822	957
Orion 33	6-Sep	12.8*	19.7	23119	2063*
Silesia	6-Sep	13.2*	18.6	24385	1544*
Vega	6-Sep	13.3*	19.8	22923	862
X-59	6-Sep	14.5*	19.2	23624	2038*
LSD (0.10)		6.14	1.39	2371	648
Trial mean		18.6	18.3	25206	1383

‡ Within a column, treatments marked with an asterisk were statistically similar (p=0.10) to top performers listed in **bold**.

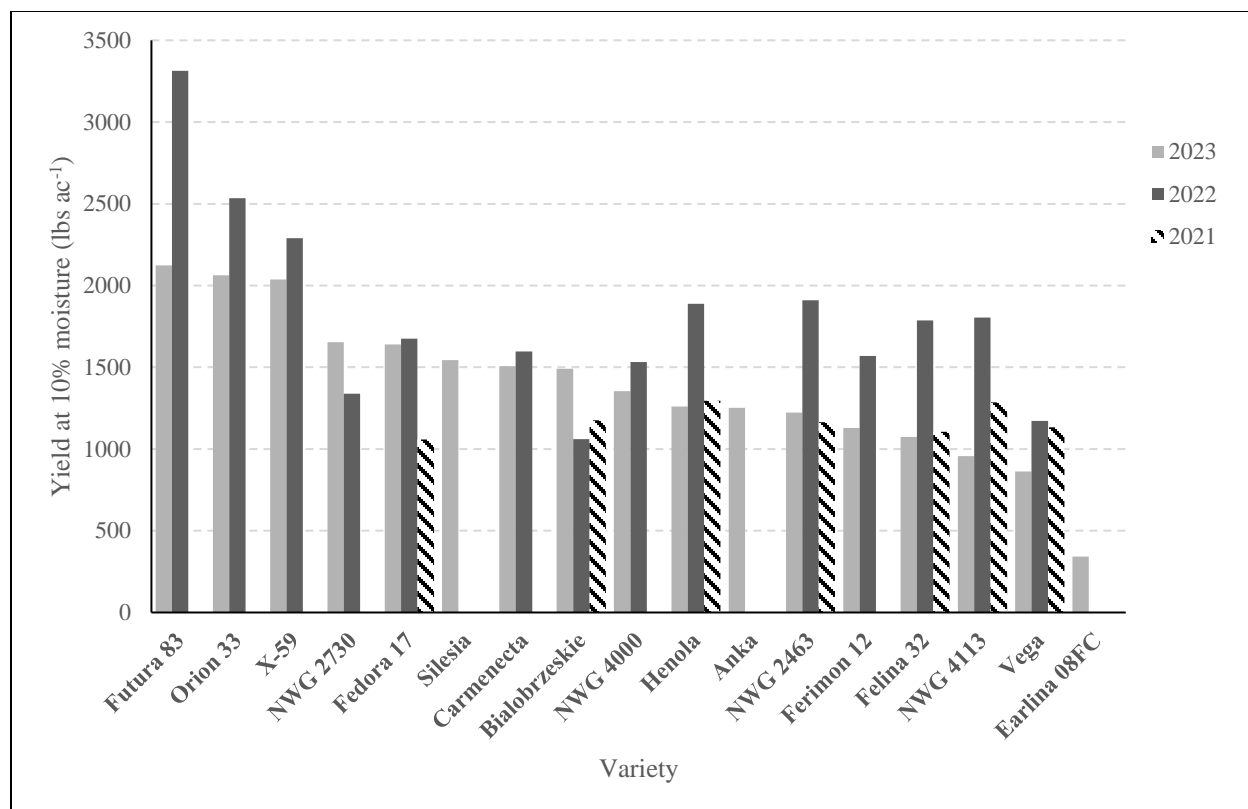


Figure 1. Hemp variety grain yields from 2021, 2022, 2023. Alburgh, VT.

DISCUSSION

As in past years, the timing of grain maturity differed widely amongst varieties with harvest spanning from 6-Sep to 13-Oct. This is especially important to take into consideration when selecting grain varieties for your region. Those varieties harvested in the beginning of September are likely best suited for northern climates and would have the opportunity to fully mature, whereas those harvested late into October would be better suited for more southern regions. Based on past experiences, the trial was outfitted with both an air cannon and a laser to reduce bird predation as the seeds matured. In addition to bird predation, timing of harvest is also critical to produce a successful crop. Some shattering will be observed once grain is approaching ideal maturity as plants are indeterminate and will continue to develop. However, waiting too long can result in complete shattering or loss due to predation. The period for the 17 harvested varieties ranged over a month showing that many would be suitable for production in Vermont depending on growing area. However, Yuma was another late maturing variety not included in the statistical analysis as grain heads remained immature after our first frost on 31-Oct. While this variety had large seed and was entered into the grain trial, it is best suited to fiber production. Grain hemp should be harvested at a seed moisture range of 10-20% and then dried down to less than 10% for storage. Harvesting seed that is too dry increases risk of yield loss from shattering and can reduce the quality of the grain. Harvesting plants at moistures near 20% also helps prevent dry hemp fibers from getting wrapped in the combine. A wide number of new or more accessible varieties yielded well in our 2022 and 2023 trials and will be further evaluated in 2024. It is important to remember that these data represent only one year of research and in only one location. Additional research needs to be conducted to evaluate varieties under more growing conditions.

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