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Industrial Fiber Hemp Varietal Evaluation in Western Nevada

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Abstract: Performance data (e.g., bast and hurd fiber yield) from industrial fiber hemp (*Cannabis sativa* L.) are crucial for producers involved in fiber hemp cultivation. From this varietal evaluation, producers can use the information to select a variety from the pool of varieties to cultivate in Nevada. The top performing varieties (Enectarol and Futura 83) based on bast and hurd fiber yields in this varietal trial compared favorably to those in other growing regions in the country and were greater than the national median fiber yield value reported in 2023. This indicates that once a suitable variety is selected, industrial fiber hemp can be successfully cultivated in Nevada.

Introduction

Industrial fiber hemp (*Cannabis sativa* L.) crop production has gained traction in U.S. agriculture with the passage of the Federal Agriculture Improvement Acts (Farm Bills) of 2014 and 2018 allowing state institutions for pilot hemp research and producers respectively, to cultivate hemp under federal and state regulations. In 2023, the estimated harvested area in the United States for industrial hemp grown in the open for fiber was 12,106 acres, which produced 49.1 million pounds of fiber valued at $11.6 million (USDA-NASS, 2024). In the United States, the national median and average fiber yields in 2023 were 2,320 lb/acre and 4,053 lb/acre, respectively (USDA-NASS, 2024). Therefore, integrating alternative crops such as industrial fiber hemp can improve the economic viability and sustainability of crop production systems in semiarid Nevada (Gorchs et al., 2017).

This growing interest in hemp cultivation as a source of natural fibers (bast and hurd) stemmed from its diverse applications in producing innovative biomaterials (e.g., Vandepitte et al., 2020; Tang et al., 2022). The bast fiber is the long and string-like fiber in the bark of hemp stalks and is used for fabric, insulation, carpeting, paneling, batteries, cordage, pulp recycling, bagging and fiberboard, among other applications. On the other hand, the hurd fiber is the short fibers located in the stem core and is used for fiberboard, mortar, paper filler, absorbent, animal bedding, mulch, plastic, paints, hempcrete and sealants, among other applications (e.g., Shahzad, 2011; Gabrion et al., 2022).

Producers considering the cultivation of hemp will require information on varieties that are adaptable and productive (fiber yield) under local conditions. Given that industrial hemp varieties are known to differ in their latitudinal adaptations (Žydelis et al., 2022), evaluating multiple varieties under local conditions will help identify suitable varieties to cultivate in Nevada. This varietal trial sought to evaluate the fiber yield production potential of several industrial fiber hemp varieties in western Nevada.

Materials and Methods

This two-year fiber hemp varietal evaluation was conducted during the summers of 2022 and 2023 at the Main Station Field Laboratory, University of Nevada, Reno. The soil at the trial sites is a Voltaire loam (a fine-loamy, mixed, superactive, calcareous, mesic Fluvaquentic Endoaquolls). Before seeding in both years, soil samples were randomly collected across the experimental area to a depth of 15 cm (6.0 inches), composited and sent to a commercial laboratory for analysis (Ward Laboratories Inc., Kearney, Nebraska). The initial soil test properties for the two years are provided in Table 1. Total precipitation during the two growing seasons from June to September of 2022 and 2023 was 10.3 inches (262 mm) and 2.4 inches (61 mm), respectively.

Table 1. Initial soil analysis from the experimental site in 2022 and 2023.

Parameter	2022	2023
pH	7.4	7.1
Organic matter (%)	5.1	4.8
Cation Exchange Capacity (CEC) (meq/100 g)	25.1	20.6
Nitrate-Nitrogen (NO_3-N) (mg/kg)	59.6	50
Phosphorus (P) (mg/kg)	26.5	23.6
Potassium (K) (mg/kg)	477	348
Magnesium (Mg) (mg/kg)	746	638
Calcium (Ca) (mg/kg)	3021	2668
Sodium (Na) (mg/kg)	256	239
Sulfur (S) (mg/kg)	25.2	23.9
Zinc (Zn) (mg/kg)	1.5	1.55
Iron (Fe) (mg/kg)	17.5	24.3
Manganese (Mn) (mg/kg)	3.4	3.9
Copper (Cu) (mg/kg)	1.45	1.59

Unit Conversion: 1 mg/kg soil = 1 ppm.

Experimental design and information of variety used

In 2022, 10 fiber hemp varieties were evaluated, and in 2023, 12 fiber hemp varieties were tested. In both years, the varieties were laid out in a randomized complete block design experiment with four replications each. Basic information on the fiber hemp varieties used is provided in Table 2.

Crop establishment and management

Before seeding, glyphosate [active ingredient (a.i.), N-(phosphonomethyl) glycine] was used at an application rate of 1 pound a.i./acre for weed control in the experimental area. In both years, fiber hemp varieties were planted into a prepared seedbed. Each plot measured 20 feet long by 5 feet wide with 5 feet wide alleyways between blocks and plots. All varieties were seeded at a rate of 45 pounds pure live seed/acre in the first week of June each year using a Wintersteiger Plotseed XL seeder in eight rows spaced 8 inches apart. Phosphorus fertilizer was applied based on a soil test recommendation of 50 pounds P_2O_5/acre using triple superphosphate (0-45-0) shortly after sowing. Nitrogen was also applied uniformly at a rate of 80 pounds N/acre using urea (46-0-0). Plots were fertilized by hand broadcasting before planting. Supplemental irrigation was applied through a solid-set sprinkler system weekly for the first three weeks and thereafter at two-week intervals using reference evapotranspiration data from a nearby weather station. The total water applied was 24.8 (630 mm) and 23.5 inches (597 mm) for the 2022 and 2023 growing seasons, respectively. Weeds were not significant in the plots, so intermittent hand weeding was carried out during the growing seasons.

Table 2. Information for industrial hemp varieties used for fiber evaluation in Nevada.

Variety†	Origin	Use‡	Reproduction⁋
Altair	Canada	Grain & Fiber	Monoecious
Anka	Canada	Grain & Fiber	Monoecious
Bialobrzeskie	Poland	Fiber	Monoecious
Carmenecta	Italy	Fiber	Dioecious
CFX-2	Canada	Grain	Dioecious
Enectarol	Italy	Fiber	Dioecious
Fedora 17	France	Fiber	Monoecious
Futura 83	France	Fiber	Monoecious
Henola	Poland	Grain & Fiber	Monoecious
Hliana	Ukraine	Grain & Fiber	Monoecious
Joey	Canada	Grain & Fiber	Monoecious
X-59	Canada	Grain	Dioecious

†**Variety:** Total potential delta-9 tetrahydrocannabinol (THC): All varieties tested by the Nevada Department of Agriculture were below the 0.36% regulated legal limit and were all compliant with the department's hemp program. There are several fiber hemp seed suppliers across the U.S.A. that producers can source seeds from.

‡**Use:** While some varieties are listed as grain and fiber or grain as their principal use, all were evaluated for the fiber potential in this two-year varietal evaluation.

⁋**Reproduction:** Monoecious varieties have separate male and female flowers on the same plant. Dioecious varieties have separate male and female plants.

Figures 1a and b. These photos show different morphological features of fiber hemp varieties evaluated during 2022 and 2023 at the Main Station Field Laboratory, Reno, Nevada.

Data collection

Data collected were midseason leaf area index, end-of-the-season plant height [soil surface to the tip of the panicle (apical point)], and stem diameter from five randomly selected plants in each plot. Before harvesting, hemp varieties were sampled (flower and plant material) by Nevada Department of Agriculture personnel to determine the delta-9-tetrahydrocannabinol (THC) content. To determine dry stem, bast, and hurd fiber yields of each variety, hemp was harvested using a sickle bar mower to a stalk height of 2 inches above the ground at the end of the growing seasons (mid-September) from an area of 20 square feet. The top part of the hemp plant containing the panicle and leaves, was removed to keep the stem only. Thereafter, the hemp stalk was weighed (fresh) and a subsample of 0.5 kg was collected for water retting (five days) to remove the fiber. Bast and hurd fiber were then oven-dried separately to determine their content. The bast fiber and hurd fiber biomass were calculated for each variety by multiplying the total stem yield by the percent fiber or hurd.

Statistical Analysis

Variety means for each parameter were compared statistically using the Least Significant Difference (LSD) test at the probability level of alpha = 0.05. The LSD value for means comparison among each parameter represents the minimum value between any two varieties to determine if the difference was due to variety only. Data were analyzed using the General Linear Model (GLM) procedures of SAS version 9.4 (SAS Institute, 2015).

Results and Discussion

Table 3. Fiber hemp varietal plant characteristics and yield in Reno, Nevada, 2022.

Variety	Plant height(cm)	Stem diameter (mm)	Stem yield(lb/ac)	Bast fiber (%)	Hurd fiber(%)	Bast fiber yield(lb/ac)	Hurd fiber yield(lb/ac)
Enectarol	197^{a}	14.9^{a}	**7896^{a}**	36.6^{a}	63.4	**2985^{a}**	**4911^{ab}**
Futura 83	199^{a}	14.5^{a}	**7651^{a}**	29.9^{abc}	70.1	**2323^{ab}**	**5328^{a}**
Henola	137^{b}	9.1^{b}	3725^{bc}	37.1^{a}	62.9	1367^{bc}	2358^{bcd}
Bialobrzeskie	150^{b}	8.9^{b}	3535^{bc}	35.3^{ab}	64.7	1271^{bc}	2264^{cd}
Anka	145^{b}	9.4^{b}	4762^{ab}	26.7^{abc}	73.3	1263^{bc}	3499^{abc}
Altair	131^{b}	8.6^{bc}	3000^{bc}	29.2^{abc}	70.8	871^{c}	2129^{cd}
Fedora 17	133^{b}	8.4^{bc}	2822^{bc}	28.6^{abc}	71.4	833^{c}	1989^{cd}
Carmenecta	164^{ab}	13.7^{a}	2621^{bc}	23.1^{bc}	76.9	617^{c}	2005^{cd}
Hliana	87^{c}	5.6^{c}	1372^{c}	35.6^{a}	64.4	538^{c}	834^{d}
X-59	85^{c}	7.2^{bc}	1082^{c}	19.0^{c}	81.0	176^{c}	907^{d}
Mean	142	10	3835	30.7	69.3	1237	2598
CV	18.4	22.6	62.2	28.5	12.6	77.6	70.6
LSD (0.05)	36.7	3.2	3354	12.3	NS	1349	2579

Table information: CV, coefficient of variation (a measure of the relative precision of a given trial/amount of unexplained variation in a trial); LSD, Least Significant Difference; NS, not significant. Within columns, means with the same letter superscript are not different ($P > 0.05$).

Table 4. Fiber hemp varietal plant characteristics and yield in Reno, Nevada, 2023.

Variety	LAI (m^2/m^2)	Plant height (cm)	Stem diameter (mm)	Plant population at harvest (m2)	Stem yield (lb/ac)	Bast fiber (%)	Hurd fiber (%)	Bast fiber yield(lb/ac)	Hurd fiber yield (lb/ac)
Futura 83	5.8^{a}	231^{a}	9.2^{c}	56^{ab}	**11117^{a}**	23.9^{bc}	76.1^{de}	**2658^{a}**	**8459^{a}**
Enectarol	5.8^{a}	225^{a}	11.4^{b}	53^{abc}	**10292^{a}**	25.5^{bc}	74.5^{de}	**2629^{a}**	**7663^{a}**
Carmenecta	4.8^{abc}	226^{a}	14.5^{a}	21^{g}	7028^{b}	21.7^{cd}	78.3^{cd}	1516^{b}	5512^{b}
Bialobrzeskie	4.0^{cd}	180^{b}	7.7^{cd}	41^{bcde}	5118^{bc}	26.6^{b}	73.4^{e}	1352^{bc}	3767^{bcd}
Fedora 17	4.4^{bcd}	171^{bc}	7.4^{cd}	60^{a}	5703^{bc}	21.8^{cd}	78.2^{cd}	1227^{bc}	4476^{bc}
Altair	4.0^{cd}	153^{cd}	6.7^{d}	47^{abcd}	4650^{bcd}	25.5^{bc}	74.5^{de}	1155^{bc}	3495^{cde}
Henola	5.2^{ab}	150^{cd}	7.1^{cd}	45^{abcd}	3400^{cde}	33.0^{a}	67.0^{f}	1110^{bc}	2290^{def}
Anka	4.7^{abc}	176^{b}	7.4^{cd}	45^{abcd}	4382^{cd}	19.6^{de}	80.4^{bc}	912^{bcd}	3470^{cde}
Hliana	3.3^{d}	139^{d}	7.2^{cd}	25^{fg}	2543de	33.6^{a}	66.4^{f}	850^{cde}	1693^{ef}
Joey	4.0^{cd}	136^{d}	7.3^{cd}	28^{efg}	1645^{e}	23.2^{bcd}	76.8^{cde}	384^{def}	1262^{f}
X-59	3.4^{d}	104^{e}	6.5^{d}	37^{cdef}	1468^{e}	15.9^{ef}	84.1^{ab}	229^{ef}	1239^{f}
CFX-2	4.1^{bcd}	112^{e}	6.8^{d}	32^{defg}	1284^{e}	15.4^{f}	84.6^{a}	197^{f}	1087^{f}
Mean	4.5	167	8.3	41	4886	23.8	76.2	1185	3701
CV	18.7	9.4	19	27.2	34.3	12.1	3.8	37.5	34.1
LSD (0.05)	1.2	22.8	2.3	16	2413	4.1	4.1	639	1819

Table information: CV, coefficient of variation (a measure of the relative precision of a given trial/amount of unexplained variation in a trial); LSD, Least Significant Difference; NS, not significant. Within columns, means with the same letter superscript are not different ($P > 0.05$).

Several parameters were evaluated among the varieties of industrial fiber hemp over a two-year duration (Tables 3, 4). Parameters such as plant height, stem diameter, leaf area index (LAI) and plant population are useful to help ascertain biomass (stem, bast fiber and hurd fiber) production differences among varieties, along with the quality of fiber produced. Except for hurd fiber in 2022, the fiber hemp plant traits of height, stem diameter, bast and hurd fiber proportion differ among the varieties evaluated and aligned well with those reported in several fiber hemp varietal trials across the country (Hanson et al., 2015, 2017, 2018; Williams et al., 2017; DeDecker et al., 2021; Duley et al., 2022; Lee et al., 2022; Monserrate et al., 2022; Darby et al., 2023; Darby and Sullivan, 2024; McLennon et al., 2024). There were several top-ranking varieties in the proportion of bast and hurd fiber in the two years of trial in Nevada (Tables 3, 4). Darby et al. (2023) reported the mean trial proportion of bast fiber at 34.9% and hurd fiber at 65.1%. Monserrate et al. (2022) reported a bast fiber percent range of 22% to 35% from a trial in New York. Our top-ranking varieties produced similar and, in some instances, greater bast and hurd fiber proportions than those studies (Tables 3, 4).

However, we focus on highlighting varietal performance based on the parameters that are most important to producers. For the 2022 trial, the overall stem yield was greatest for the varieties Enectarol and Futura 83 (Table 3). The hemp varieties Enectarol and Futura 83 produced the greatest quantity of bast fiber yield, which were 2.4 times greater and 1.9 times greater for each variety, respectively, than the trial mean (Table 3). The variety X-59, along with Altair, Fedora 17, Carmenecta and Hliana, were among those that produced the lowest bast yield (Table 3). The top performing varieties in the quantity of hurd fiber yield produced were Futura 83, Enectarol and Anka (Table 3).

In the 2023 trial, varietal differences occurred among all the evaluated parameters (Table 4). Among the varieties evaluated, Futura 83 and Enectarol were ranked among the greatest in stem yield (Table 4). Bast fiber proportion was greatest for Henola and Hliana, while for hurd fiber proportion, CFX-2 and X-59, were ranked among the greatest (Table 4). The quantity of bast fiber yield produced was greatest for Enectarol and Futura 83, and these two varieties produced 2.2 times greater and 2.3 times greater bast fiber yield, respectively, than the trial mean (Table 3).

Growth and productivity (bast and hurd yield) of industrial fiber hemp varieties differ across geographical locations. For example, hemp growth and development are affected by temperature and day length, and as such, varieties differ in their latitudinal adaptation, which ultimately will affect yield output (Pahkala et al. 2008; Amaducci et al., 2015; Žydelis et al., 2022). So, we compared the fiber hemp production results (trial mean and individual varieties) in Nevada to those in other states across the country. The purpose is to provide local producers with strong decision-support information to validate that fiber hemp can be produced successfully in Nevada and to help them select the most suitable varieties for cultivation in local environments. Depending on locations in the states of Illinois, Kentucky, Maryland, Michigan, New York, North Dakota, Oregon, Vermont and Wisconsin, the mean trial stem yields of 2022 and 2023 in this study were sometimes greater or lower than fiber hemp stem yields reported in varietal trials across those regions (Hanson et al., 2015, 2017, 2018; Williams et al., 2017; Fiorellino and Ristvey, 2020; DeDecker et al., 2021; Duley et al., 2022; Lee et al., 2022; Monserrate et al., 2022; Darby et al., 2023; Darby et al., 2024; McLennon et al., 2024). For the bast fiber yield, the trial means in this study (2022 and 2023) were lower for the bast fiber but greater for hurd fiber than those reported by Darby et al. (2023). In addition, the top two performing varieties (Enectarol and Futura 83) in our evaluation had similar stem, bast and hurd fiber yields compared to the same varieties in Illinois and Vermont (Lee et al., 2022; Darby et al., 2023). Plant population at harvest is a crucial determinant of fiber hemp yield and varies significantly among the varieties evaluated (Table 4). For the 2023 evaluation, the plant populations at harvest were lower than those reported in Vermont by Darby et al. (2023). This may suggest that the plant population may have been an influential factor when yields are lower compared to other states.

Conclusions

Producers trying to choose superior fiber hemp varieties for cultivation should be guided by multi-year and location evaluation data. The results from this two-year varietal evaluation indicated that Enectarol and Futura 83 were the overall top-performing varieties in stem, bast and hurd fiber yields in this western Nevada environment. However, given the year-to-year variation in production, such as stem yield, careful attention must be given to fiber hemp seed quality (that is, germination rate and purity of seed purchased), and agronomic practices used (such as seeding rate, crop fertility and irrigation management) to maximize production. Based on comparisons of fiber hemp yield data in other states and the national median and average fiber yield values reported, industrial fiber hemp can be successfully grown in Nevada.

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