Oregon State University Extension Service

Comparison of stem and fiber yield: Industrial hemp varietal trial

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Figure 1. Hemp varieties showed differences early in the season in this study.

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Introduction

Cotton is the most widely produced natural fiber in the world. But as a crop, *Gossypium hirsute L.*, as it is known scientifically, relies heavily on irrigation water and agrochemicals.

Hemp (*Cannabis sativa L.)* is one alternative with a smaller environmental footprint. Industrial hemp grows rapidly. It requires less water and fewer chemicals. Interest in hemp as a fiber crop has grown since its removal from the Controlled Substances Act following the passage of the 2018 U.S. Farm Bill, which regulated the crop as a traditional crop.

Industrial hemp must contain less than 0.3% tetrahydrocannabinol, or THC, a psychoactive compound found in other varieties of hemp.

Industrial hemp is widely recognized as a good source of fiber, particularly bast fiber. Bast fiber, used in textiles, is obtained from the outer cell layers of the stems. Hemp is also a source of hurd fiber, an absorbent material obtained from the pith.

Hemp production is greatly affected by cultivar, environment and management practices such as planting density, fertilization and irrigation. Identifying cultivars well adapted to local environmental conditions is key to optimizing bast fiber performance. Our research work evaluated hemp prospects as a suitable environmentally sustainable and economic alternative source of natural and bast fiber. This study sought to evaluate the fiber yield performance of three dioecious (NWG 2463, NWG 4113 and Jin Ma) and two monoecious (Bialobrzeskie and Henola) varieties of industrial fiber hemp. Monoecious varieties have both male and female sex organs, while the sex organs of dioecious plants occur in separate individuals.

Materials and methods

Treatments and experimental design

We evaluated five varieties:

- Three dual-purpose varieties, Henola, NWG 2463 and NWG 4113, bred for both grain and fiber.
- Two fiber varieties, Bialobrzeskie and Jin Ma.

Plants were seeded at 1 million seeds per acre on June 1, 2022. Seeding rates were adjusted for germination rates based on in-house testing. Experimental plots measured 20 feet long by 5 feet wide. They were seeded to a depth of 0.25 inches with an SRES cone drill planter, resulting in nine rows spaced 6 inches apart.

The experimental design was a randomized complete block design replicated four times. Before planting, plots were fertilized with 70 pounds N/acre using ammonium nitrate (24-0-0), based on soil test results.

Irrigation was applied using a handline system fitted with an impact sprinkler. We based the amount applied on evapotranspiration rates, for a total of 22 inches during the growing season.

Weeding was done by hand as needed. A small number of plants were affected by beet curly top virus (Figure 2). In general, insect pests and diseases were minimal, so no management strategies were necessary.

Figure 2. Signs of beet curly top virus and a ladybug observed in the field.

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Data collection

Prior to harvest, we measured plant height from the soil surface to the top of the canopy on three randomly selected plants from each plot. We harvested plants September 13–23, 2022, as individual varieties matured. Biomass yield was calculated on a per-plant basis. We measured 10 representative plants in each plot, marking stem diameter at the base of the third node from the soil surface using a caliper. We separated harvested plants into stems, leaves and inflorescences, and weighed each part. All plant parts were oven-dried at 60 °C for 72 hours until a constant dry weight was achieved. We analyzed data using PROC ANOVA procedure in SAS version 9.4 (SAS Institute, 2015) followed by LSD post-hoc analysis ($p \leq 0.05$) for differences among varietal means for the measured parameters (Table 1).

Results and discussion

All measured parameters (Table 1) showed significant differences and were notably higher in this study compared to similar studies with dioecious varieties.

Table 1. Impact of variety on plant characteristics and harvest yield of industrial hemp evaluated at the Klamath Basin Research and Extension Center, Klamath Falls, Oregon, 2022

Variety	Plant height (cm)	Stem diameter (mm)	Dry weight per plant (g/plant)	Leaf yield (lbs/acre)	Stem yield (lbs/acre)	Stem %	Bast fiber %	Bast fiber yield (lbs/acre)
Bialobrzeskie	228.0^{bc}	13.0^{b}	0.058^{d}	845^{bc}	9672^{c}	67.7^{b}	33.1^{a}	3246.4^{b}
Henola	196.0^{c}	10.0^{b}	0.061^{cd}	450^{c}	7447^{c}	55.9^{c}	29.8^{a}	2226.8^{b}
Jin Ma	309.9^{a}	19.5^{a}	0.264^{a}	1229^{7a}	37062^{a}	75.0^{a}	17.0^{b}	6295.8^{a}
NWG 2463	240.1^{b}	11.8^{b}	0.112^{bc}	1930^{bc}	14684^{bc}	51.5^{c}	21.3^{b}	3127.6^{b}
NWG 4113	250.0^{b}	11.5^{b}	0.164^{b}	3188^{b}	19479^{b}	51.7^{c}	19.1^{b}	3854.1^{b}
Mean	244.8	13.2	0.132	3742	17669	60.3	24.1	3750.1
SEM†	11.0	1.2	0.017	879	3069	2.0	1.8	720.0
P value	.0001›	.0001›	.0001›	.0000›	.0001›	.0001›	.0001›	0.0181

†SEM = standard error mean

* Within columns, means with the same letters are not statistically different ($p < 0.05$).

Plant height and stem diameter

Both plant height and stem diameter were highly influenced by variety (Table 1). These characteristics are not only highly correlated but are also good predictors of biomass and fiber yield. The mean plant height was 244.8 cm. The Jin Ma variety was the tallest at 309.9 cm. The shortest variety was Henola at 196 cm.

The difference in stem diameter was significant. Jin Ma stems measured 19.5 mm, while stems of the other varieties ranged from 10 mm to 13 mm (Table 1). Stem diameter is generally inversely proportional to plant density. Seeding rates can influence this, with subsequent effects on plant populations. Stem diameter in this study is notably higher than stem diameter reported in other areas.

Dry weight, leaf and stem yields

Variety had a significant effect on dry weight, leaf and stem yields (Table 1). In all cases, the Jin Ma (fiber type) variety produced significantly higher yields than the other varieties. This performance is consistent with a previous study in Georgia. Jin Ma produced the highest dry weight per plant (0.264 g/plant), while Bialobrzeskie produced the lowest (0.058 g/plant). Leaf yields averaged 3,742 lbs/acre and ranged from a low of 450 lbs/acre (Henola) to a high of 12,297 lbs/acre (Jin Ma).

For stem yield, the average ranged from 7,447 lbs/acre (Henola) to 37,062 lbs/acre (Jin Ma), with a mean of 17,669 lbs/acre. Stem yield is an important characteristic and shows a direct relationship with bast fiber yield. As expected, the varieties with the highest stem yields produced higher bast fiber yields (Table 1).

Fiber content and fiber yield

Hemp variety significantly affected both fiber content and fiber yields (Table 1), which is consistent with a previous study in Finland. Overall, bast fiber content averaged 24.1% among all varieties. Bialobrzeskie (fiber type) and the predominantly grain variety Henola produced significantly higher fiber content compared to the remaining three varieties. Conversely, Jin Ma (fiber type) produced the highest bast fiber yield at 6,295.8 lbs/acre compared to the remaining fiber (Bialobrzeskie) or dual-purpose varieties (Henola, NWG 4113, NWG 2463), which did not differ in their fiber yields.

Bast fiber yield is a product of stem yield and bast fiber content, and both are instrumental in overall bast fiber yields. Jin Ma, which produced the lowest bast fiber content, produced significantly more bast fiber yield compared to all other varieties due to its superior stem yield performance. Stem diameter was inversely related to fiber content (Figure 3). Generally, bast fiber content increases with decreasing stem diameter.

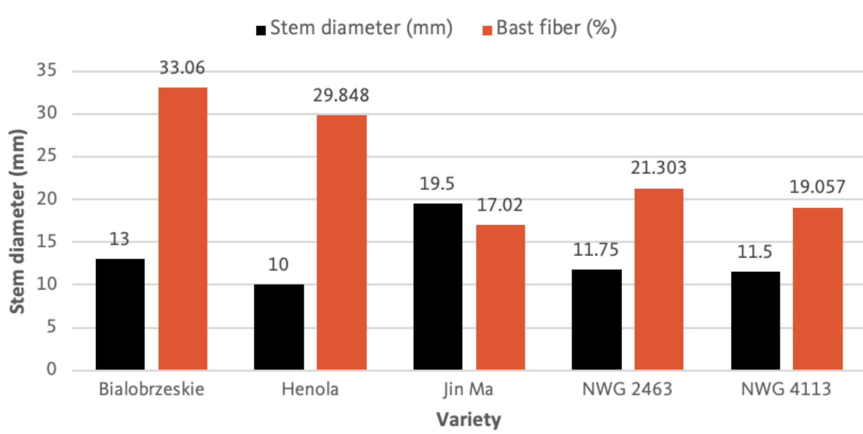

Figure 3a. Stem diameter and percentage of bast fiber of five varieties of hemp.

Credit: © Oregon State University

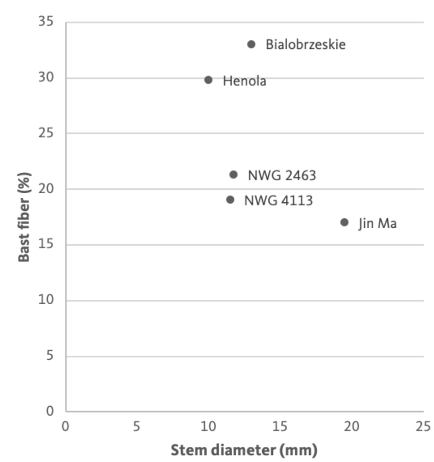

Figure 3b. The relationship of bast fiber to stem diameter.

Credit: © Oregon State University

Figure 4. Hemp at 50 days.

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Figure 5. Hemp at harvest showing phenotypic varietal difference. Jin Ma (right rear) was the tallest variety averaging over 300 cm. Jin Ma had the thickest stems and produced the largest biomass. Plants were not flowering at time of harvest.

Credit: Everald McLennon, © Oregon State University

Conclusion

Results from this study clearly showed which varieties performed best at this location. Varieties differ in their ability to produce concentrations of bast fiber, one indication of fiber quality. The greatest bast fiber content was associated with Bialobrzeskie and Henola varieties, compared to the three other varieties, which were similar in their bast fiber content. These varieties showed good adaptability and can be considered for local adaptation and cultivation.

Conversely, when total fiber yield is the main consideration, Jin Ma excels. Jin Ma recorded the lowest bast fiber content, but owing to its considerably larger stem diameter, higher growth rates and stem yields, its fiber yield was greater. "Planting this variety earlier could also be a consideration due to its late maturing tendencies.

This varietal evaluation provides grounds to study other agronomic variables such as planting density, which is a major factor affecting hemp fiber yield and quality. Additionally, given this region's limited supply of irrigation water, further studies should examine how different varieties respond to differing agronomic practices, such as changes in the amount and scheduling of irrigation.

For more information, visit the Global Hemp Innovation Center (https://agsci.oregonstate.edu/hemp) at Oregon State University.

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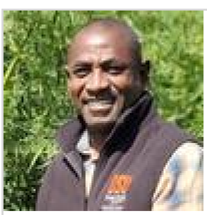

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