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2022 Kansas State University Industrial Hemp Dual-Purpose Variety Trials

Kraig Roozeboom[1] and Jason Griffin[2]

Introduction

Hemp is a broad term used to describe the many varieties of *Cannabis sativa* L. that produce less than 0.3% tetrahydrocannabinol (THC). The crop is globally significant and has recently been approved in the United States. There are many uses for industrial hemp, and the market for industrial hemp is rapidly growing as more states are legalizing its production. Industrial hemp is marketed for oil, grain, and fiber. Varieties have been selected for improved fiber and grain production that can service these markets. However, little research-based information is available regarding adaptability or production of these varieties in Kansas. The objectives of this research were to evaluate commercially available varieties of industrial hemp at two locations in Kansas.

Procedures

Wichita Variety Trial

Research plots were prepared at the Kansas State University John C. Pair Horticultural Center near Wichita, KS. The location is a flat sandy loam soil (Canadian-Waldeck fine sandy loam) averaging 32 inches of precipitation annually. The experimental plot was industrial hemp in 2019, 2020, and 2021, and buffalograss for the previous 12 years. The plot was disked after the 2021 growing season and a wheat cover crop was planted in October. The wheat was terminated with glyphosate in April 2022. Prior to planting, the plot was disked and cultivated with a springtooth harrow. On June 17, 2022, 13 varieties of dual-purpose industrial hemp (Table 1) were seeded at a rate of 20 pure, live seeds (PLS) per square foot (871,200 PLS per acre). Experimental plots were 4.5 ft × 22 ft with 5 rows planted at 9-in. spacing. Plots were seeded to a depth of approximately 0.5 inch with a Hege 1000 drill outfitted with a Zero-Max gear box. Irrigation was applied daily until germination, then weekly as needed to prevent wilting.

On July 12, 2022, plots were fertilized with urea (46-0-0) at a rate of 50 pounds of nitrogen per acre using a turf-type drop spreader. Plots were hand weeded as necessary to control weeds.

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Plots were harvested and data collected on September 15, 2022. Due to extensive disease pressure (damping-off) early in the growing season most plots were determined to be a complete loss. However four varieties (Futura, Orion, NWG2730 and NWG2463) had sufficient plant stands and were determined acceptable for harvest. Samples and data were collected from 10.76 square feet. Data included plant number, plant height, grain weight, stem weight, and total plant biomass (stem weight + grain weight). Grain was threshed and collected by hand and cleaned using a custom-made Zig-Zag style seed cleaner. Stem weight was obtained after drying in a forced air drying oven for three days at 160°F.

The experimental design was a randomized complete block design with 13 varieties replicated 4 times. Data were subjected to analysis of variance and means separated by Fisher's Protected LSD where appropriate.

Manhattan Variety Trial

The same 13 hemp varieties (Table 1) were evaluated at the K-State Research and Extension Ashland Bottoms Research Farm (latitude 39.1220, longitude -96.639) near Manhattan, KS. The predominant soil series in the experimental area was a Wymore silty clay loam. Soil samples were obtained before planting to characterize the site. Results of soil tests averaged across the experimental site were pH = 6.1; organic matter = 2.7% (loss on ignition); P = 4.6 ppm (Melich III); and K = 248 ppm (ammonium acetate extraction with ICP spectrometry).

The experimental site has been managed without tillage for several years and was in soybeans the previous year. A winter wheat cover crop was planted November 5, 2021 to provide uniform residue cover and suppress weed emergence. Triple superphosphate (0-46-0) was applied at a rate of 120 pounds per acre in furrow with the wheat seed to supply 55 pounds of P_2O_5 per acre. The cover crop was terminated with glyphosate on May 13 when it was at boot to early heading stages. Cover crop residue was left undisturbed to suppress weed emergence in the hemp.

Plots were planted on May 23 with a Great Plains No-Till cone drill at a rate of 20 pure, live seeds (PLS) per square foot (871,200 PLS per acre). Seeding rates for individual varieties ranged from 28 pounds per acre for a variety with small seed to 42 pounds per acre for a variety with large seed (Table 1). Seed was placed into moist soil at a depth of 0.75 inches. Plots were 6-ft wide and 30-ft long and consisted of 9 rows spaced at 7.5 inches.

Nitrogen fertilizer was applied to the emerged hemp on June 20. Dry urea (46-0-0) was applied with a Gandy (Owatonna, MN) turf drop spreader to achieve uniform distribution of the target rate of 130 pounds nitrogen per acre.

Samples and data were collected from a 10-ft length of four, bordered rows (25 ft^2) in each plot. Emerged plants were counted in June and again at harvest. Plant survival (%) was calculated as (harvest plant number/June plant number) × 100. Hand weeding was used to control weeds that emerged after planting. Harvest consisted of hand cutting plants at ground level from the entire 25-ft^2 sample area within each plot. The entire sample was dried at 140°F for 7 days. After drying, total biomass weight was determined, plants were threshed using an ALMACO BT14 belt thresher (Nevada, IA), and resulting stalks and grain fractions were weighed to determine stalk and grain yield. Weight of leaves, flower parts, and fine stems was calculated by subtracting grain + stem weight from total biomass.

The experimental design was a randomized complete block design with 13 varieties replicated four times. Data were subjected to analysis of variance using the SAS GLIMMIX procedure with replications considered random to determine least-square means and mean separations for each response variable at $\alpha = 0.05$.

Results

Wichita Variety Trial

Due to excessive disease pressure (damping off), only four varieties were determined to have plant populations sufficient to be harvested (Table 2). Of those, Orion had the greatest plant density with over 170,000 plants per acre. The other three varieties averaged just over 118,000 plants per acre. Plant density is a critical component of weed control in industrial hemp and should be considered when selecting varieties.

Plant density was the only variable where the varieties differed (Table 2). Plant height, grain yield, stem weight, and total plant biomass were all similar among the four varieties. Plant height averaged 3.2 ft with only six inches separating the tallest variety (NWG2730) from the shortest (NWG2463). Grain weight averaged 1057 pounds per acre with NWG2730 yielding the most. Stem weight and total plant biomass among the varieties averaged 3370 and 4426 lb per acre, respectively. In both instances NWG2730 had the greatest dry weight.

Manhattan Variety Trial

Although all varieties were planted with the same number of pure, live seed, plant density varied by twofold (Table 3). The varieties with the fewest plants per acre at emergence were Bialobrzeskie, Futura 83, Lara, and X-59, all with fewer than 160,000 plants per acre. Enecterol, Fedora 17, Felina 32, NWG-2463, and NWG-2730 all had about 200,000 or more plants per acre. At harvest Bialobrzeskie, Lara, USO 31, and X-59 had less than 130,000 plants per acre, but most other varieties had 150,000 or more plants per acre. Only three varieties (Bialobrzeskie, USO 31, and X-59) had less than 80% of plants survive until harvest, a possible indicator of greater susceptibility to fungal diseases that caused some degree of stand loss in all varieties.

Although total biomass production was less in 2022 than in 2021, several varieties produced more than 3,000 pounds of dry biomass per acre (Table 4). Three varieties (Bialobrzeskie, USO 31, and X-59) produced less than 1,500 pounds of biomass per acre and had relatively low plant survival and harvest plant density. Biomass yield was significantly correlated with both percent survival ($r = 0.57$) and harvest plant density ($r = 0.68$) (Table 5). Stalk yield and pounds of flower parts and fine stems were highly correlated with biomass yield ($r = 0.95$ and 0.79, respectively).

Grain yields were less than 500 pounds per acre for all varieties in 2022 (Table 4) compared to as much as 1,500 in 2021 and more than 2,000 in 2020. This could be partially explained by lack of precipitation in much of July and August (aside from a large rainfall event in late July) and by machine threshing in 2022 that likely removed lightweight seed more aggressively than the hand threshing conducted in previous years. Other factors that may have resulted in reduced grain yield in 2022 were significant bird feeding and seed shattering before harvest. Two varieties, NWG-2463 and NWG-2730, produced more than 460 pounds of grain per acre. Six varieties (Bialobrzeskie, Fedora 17, Felina 32, Ferimon 12, Lara, and USO 31) produced about 200 pounds of grain per acre or less. Although grain yield was significantly correlated with total biomass yield, the correlation was not particularly strong (r = 0.47) (Table 5). The correlation of grain yield with flower parts and small stems was also significant (r = 0.56), which could be partially driven by the inclusion of lightweight seed in the flower fraction. Grain yield was only weakly correlated with plant density at emergence (r = 0.28) and not correlated with harvest plant density or percent survival.

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Table 1. Variety, origin, seed characteristics, and seeding rates for dual-purpose industrial hemp varieties (*Cannabis sativa*) planted in 2022

Variety name	Source	Seed size	Germination[†]	Seeding rate[‡]
		seeds/pounds	%	pounds/a
Bialobrzeskie	International Hemp	34,892	88	28
Enecterol	International Hemp	21,913	95	42
Fedora 17	Hemp Seed Warehouse	27,161	92	35
Felina 32	Hemp Seed Warehouse	27,161	98	33
Ferimon 12	Hemp Seed Warehouse	28,891	95	32
Futura 83	Hemp Seed Warehouse	23,873	90	41
Henola	International Hemp	30,239	84	34
Lara	Omni Trade Inc	29,647	74	40
NWG-2463	New West Genetics	29,647	80	37
NWG-2730	New West Genetics	34,625	90	28
Orion 33	Hemp Seed Warehouse	25,200	94	37
USO 31	Hemp Seed Warehouse	25,627	93	37
X-59	IND Hemp	31,720	90	31

[†]From pre-plant germination tests.
[‡]Pounds of seed per acre seeded at Manhattan to achieve a uniform rate of 20 pure, live seed per square foot for all varieties based on germination, purity (99% for all varieties), and seed size.

Table 2. Plant density, height, and yield of four industrial hemp varieties evaluated at Wichita, KS, in 2022

Cultivar	Plant density		Plant height	Biomass	Stover	Grain
	plants per acre		feet	------------- pounds per acre -------------		
Futura	100,362	b[†]	3.2	3,433	2,677	757
NWG2463	129,500	b	2.9	3,164	2,306	857
NWG2730	125,453	b	3.5	6,793	5,057	1,737
Orion	171,992	a	3.1	4,315	3,439	875
Mean	131,862		3.2	4,426	3,370	1,057

[†] Values within a column followed by the same letter are not significantly different at $\alpha = 0.05$.

Table 3. Plant density and survival of 13 dual-purpose industrial hemp varieties evaluated at Manhattan, KS, in 2022

Variety	June		Harvest		Plant survival†
	---------- plants per acre ----------				%
Bialobrzeskie	118,483	g‡	81,893	e	73
Enecterol	210,395	abc	195,585	a	93
Fedora 17	220,849	ab	175,983	abc	80
Felina 32	199,069	abcd	173,805	abc	86
Ferimon 12	186,001	bcde	162,479	abc	87
Futura 83	152,460	efg	153,767	abc	99
Henola	170,755	cdef	135,472	bcd	83
Lara	136,779	fg	129,373	cde	95
NWG-2463	230,433	a	203,425	a	88
NWG-2730	220,849	ab	183,823	ab	86
Orion 33	177,725	cdef	168,577	abc	95
USO 31	166,835	def	123,711	cde	74
X-59	157,687	defg	87,120	de	54

† Calculated as Harvest/June plant density; values >100% indicate emergence of additional plants after plants were counted in June. Most of the late-emerging plants contributed little to grain or stem yield.
‡ Values within a column followed by the same letter are not different at $\alpha = 0.05$.

Table 4. Harvest information for 13 dual-purpose industrial hemp varieties evaluated at Manhattan, KS, in 2022

Variety	Total biomass		Stalks		Flowers, leaves, branches		Grain	
	---------- pounds per acre ----------							
Bialobrzeskie	1,460	de	956	e	416	c	88	f
Enecterol	3,347	ab	2,382	ab	642	abc	324	abc
Fedora 17	1,945	cd	1,225	de	564	abc	157	cdef
Felina 32	2,617	bc	1,657	cd	834	a	127	def
Ferimon 12	1,729	de	1,129	de	505	bc	95	ef
Futura 83	3,592	a	2,555	a	765	ab	272	bcd
Henola	1,969	cd	965	e	605	abc	399	ab
Lara	2,041	cd	1,200	de	636	abc	205	cdef
NWG-2463	2,613	bc	1,493	cde	651	abc	469	a
NWG-2730	3,227	ab	1,964	bc	797	a	466	a
Orion 33	3,097	ab	1,983	abc	845	a	269	bcde
USO 31	1,445	de	1,004	e	370	c	72	f
X-59	989	e	235	f	465	c	289	bcd

† Values within a column followed by the same letter are not different at $\alpha = 0.05$.

Table 5. Pearson correlation coefficients for data characterizing industrial hemp variety performance near Manhattan, KS, in 2022

	June density	Harvest density	Survival, %	Biomass	Stalk	Flowers
Harvest density	**0.71**					
Survival, %	-0.02	**0.68**				
Biomass	**0.42**	**0.68**	**0.57**			
Stalk	**0.37**	**0.67**	**0.59**	**0.95**		
Flowers	**0.34**	**0.51**	**0.42**	**0.79**	**0.59**	
Grain	**0.28**	0.22	0.09	**0.47**	0.21	**0.56**

Values in bold are significant ($\alpha = 0.05$).