PLANT INDUSTRIES DIVISION

January 2017

2016 NDDA

Industrial Hemp Pilot Program

Research Summary

North Dakota Department of Agriculture

2016 Industrial Hemp Pilot-Program

INTRODUCTION

The North Dakota Department of Agriculture (NDDA) created the Industrial Hemp Pilot Program to research the growth, cultivation, and marketing of industrial hemp in North Dakota. The goal was to increase the understanding of how industrial hemp fits into the current agricultural landscape, and investigate how it may contribute to the economy of North Dakota.

LEGAL STATUS

Industrial hemp is a variety of the plant species *Cannabis sativa* L. and is considered a Schedule I Controlled Substance under the Controlled Substances Act (CSA, 21 U.S.C. §§801 et seq.; Title 21 C.F.R. Part 1308.11). Cultivation is highly restricted and only allowable for research purposes authorized under a provision of the Agricultural Act of 2014.

The Congressional Research Service's *Hemp as an Agricultural Commodity* written by Renee Johnson (2), states that:

> The Agricultural Act of 2014 ("farm bill," P.L. 113-79) provided that certain research institutions and state departments of agriculture may grow industrial hemp, as part of an agricultural pilot program, if allowed under state laws where the institution or state department of agriculture is located. The farm bill also established a statutory definition of "industrial hemp" as the plant *Cannabis sativa L.* and any part of such plant with a delta-9 tetrahydrocannabinol (THC) concentration of not more than 0.3% on a dry weight basis. The enacted FY2015 appropriations (P.L. 113-235) further blocked federal law enforcement authorities from interfering with state agencies, hemp growers, and agricultural research.

The term hemp refers to the agricultural crop of *C. sativa L.* which produces cannabinoids, but only trace levels of the psychoactive THC. Table 1 lists the cannabinoid compounds that are produced by *C. sativa.* The major omega-6 and omega-3 fatty acids produced in hemp are linoleic and linolenic acids which are said to be produced at the ideal 3:1 blend (3).

Table 1. List of Cannabinoids available for testing by MedScan Laboratories LLC.

Cannabinoid	Designation	Notes
Tetrahydrocannabinol	THC-A	Non-psychoactive, that converts to THC
Cannabidiol	CBD-A	Non-psychoactive
Cannabinol	CBN	Mild psychoactive
Cannibidivarin	CBD-V	Non-psychoactive
Cannibigerol	CBG	Non-psychoactive, High levels in Ind. Hemp
Cannibichromene	CBC	Non-psychoactive, 2nd highest level in Ind. Hemp
Tetrahydrocannabivarin	THC-V	Highest level of all cannabinoids in Ind. hemp
Delta-9 tetrahydrocannabinol	THC	Psychoactive

THE PILOT PROGRAM

NDDA announced the Industrial Hemp Pilot Program in October of 2015. Seventeen producer applications were received and reviewed by a committee created by the Agriculture Commissioner. The Commissioner deliberated on the committee recommendations and selected five pilot producers. Geographical spread, soil type, environmental conditions, and the proximity to processing facilities were also key considerations in the selection of the candidates.

The five growers planted a total of 70 acres of industrial hemp as part of this 2016 research program. Although not covered within the NDDA Industrial Hemp Pilot Program, the NDSU Langdon Research Extension Center ran a parallel program to assess the agronomic performance of nine different seed varieties. Unfortunately, excessively wet conditions following heavy rainfall events resulted in substantial plant stand losses, and the trials were abandoned. Industrial hemp does poorly in soggy, heavy soils.

Three hemp seed companies in Manitoba, Canada supplied the four varieties planted in the 2016 program (Table 2). The varieties selected were a mixture of high yielding grain varieties and a type known to produce high oil content. Very tall hemp varieties - those suitable for fiber production - were not chosen for the program, as there are no fiber processing facilities nearby. The objective was to select hemp types that yielded well under northern prairie conditions. The Manitoba Agriculture website (1) publishes the historical data of several varieties. Since 1998 Canada has grown industrial hemp for both the seed and fiber markets, with most of the production located in the Prairie Provinces of Manitoba, Saskatchewan and Alberta. Up to 118,000 acres have been grown annually in Canada over the 1998-2011 period (1). In Manitoba, grain yields ranged between 100 to 1200 lbs./acre, with a bushel weight of 44 lbs. at 10% moisture content.

The research focus varied according to producer interest. Grower data was collected at each site, and included general agronomic practices, rainfall, observations of insect pests, weeds and diseases, crop establishment and development, and grain yield (Table 3a).

Table 2 exhibits the historical yield expectations amongst the test varieties under Manitoba conditions. All varieties were plant variety protected (PVP) and pedigreed (certified or foundation grade). Canadian seed laws specify that all hemp seed sold must be of a certified pedigree and tested by Canadian agencies to ensure a THC content below 0.3% on a dry weight basis. For instance, *cv Finola,* a variety bred for high oil content, generally produces the lowest grain yield relative to the other test varieties in nearly 20 years of Manitoba field trials. The other three varieties listed exhibited yields that were statistically equivalent over the same time period. This finding suggests that there could be large swings in seed yields year over year. It is important to note that growing industrial hemp carries considerable risk to the producer as it is not eligible for crop insurance, and markets and returns are not consistent year to year.

Table 2. Long-term agronomic characteristics of the industrial hemp cultivars selected for the 2016 NDDA Pilot Research Program

Cultivar	Seed Source	Flower Type	Use	Maturity (days)	% Seed Yield* (% of variety CRS-1)
CANDA	Parkland IHG Coop	Monoecious	Grain, fiber	110	86
CFX-1	Hemp Genetics Int.	Dioecious	Grain, fiber	105	106
CRS-1	Hemp Genetics Int.	Dioecious	Grain	110	100
FINOLA	Hemp Oil Canada Inc.	Dioecious	Grain, Oil	100	83% **

*Manitoba Agriculture data, Check variety CRS-1 @ 1548 lb/A [averaged over 21 site years]
** Note: cv Finola seed yield was significantly lower compared to the other grain varieties in long term yield trials in Manitoba. Finola is regarded as a high oil content low yielding variety.

Crop management is a key consideration in variety performance. For instance, one grower in the 2016 Minnesota Department of Agriculture Pilot Program grew *cv Finola* for cold press oil extraction. Hemp seed oil contains omega-6 and omega-3 polyunsaturated fatty acids and has been touted to provide health benefits. Harvest was delayed until the crop was completely ripe, apparently to reduce the amount of green seed content, and hence chlorophyll in the oil. Delaying harvest is a risky proposition, as excessive seed losses can result from shelling out and blackbird feeding. Experienced growers recommend that harvest begin at the onset of blackbird predation.

Photo 1. North Dakota industrial hemp crop (2016)

Hemp varieties are monoecious or dioecious. The former cultivars have both male and female flowers on the same plant, while the latter cultivars maintain separate male and female plants (see Photo 1). Plants tend to be 75-80% dioecious with the proportion of exclusively monoecious female plants being 10-15% and males about 10% (Photo 2). Under stressful Manitoba conditions (hot/dry) the proportion of pure male plants can increase to 20%, reducing yield. Pilot producers in ND observed that because hemp does not branch very well, there may be some benefit to boosting the planting density (above 10-12 plants/square foot) to improve yields. A side benefit to this practice is increased competition against weed growth. Future studies will be needed to investigate this phenomenon.

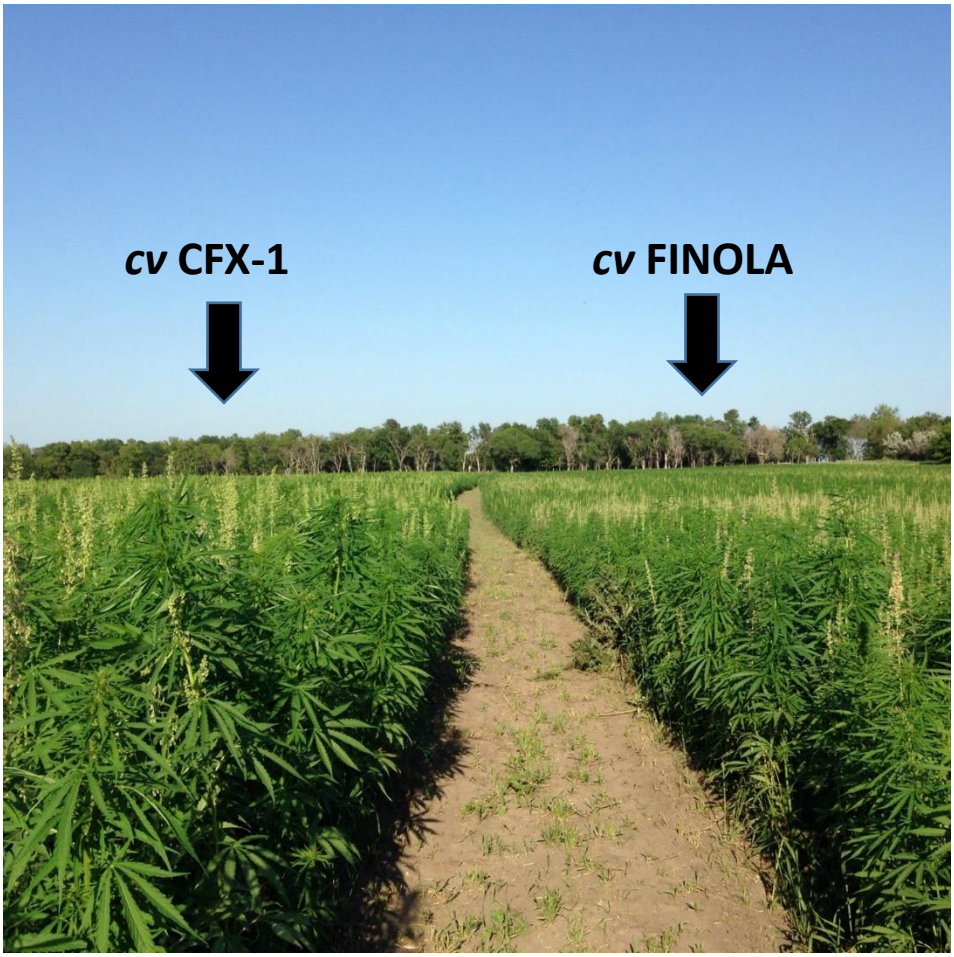

Photo 2. Industrial hemp pilot producer variety trial (Benson County July 2016).
Note: Monoecious plants - white stalks (male flowers) can constitute 10-20% or more of the plant stand.

2016 RESULTS - MATERIALS AND METHODS

In May of 2016, NDDA imported 2,175 pounds of industrial hemp seed through the three Manitoba suppliers; Hemp Oil Canada (*cv Finola*), Parkland Industrial Hemp Growers (*cv Canda*), and Hemp Genetics International (*CFX-1, CRS-1*). (Table 3a).

Table 3a. Site details for the 2016 NDDA Industrial Hemp Pilot Research Program.

Trial County	Research Focus	Cultivar	Acres
LaMOURE	Grain yield	CANDA	15
LaMOURE	Grain yield (comparison on two soil types)	CANDA	14 + 1
GRANT	Grain yield	CRS-1	5
	Grain yield	CFX-1	5
BENSON	Variety performance, grain yield	CFX-1	7.5
	Variety performance, grain yield	FINOLA	7.5
FOSTER	Variety performance, grain yield, processing, marketing	CANDA	7.5
	Variety performance, grain yield, processing, marketing	FINOLA	7.5

Previous crops were spring wheat, flax, corn, or soybeans. There are no registered pesticides (insecticides, herbicides, fungicides, nor seed treatments) for use in industrial hemp crops. With this being the case, producers were very cognizant to select their cleanest fields. In all but one instance, the growers pre-treated their fields with glyphosate to contain any early season weed growth. Hemp grows best under warmer soil conditions, and hence is planted later than other commercial crops. This late planting may allow for an additional flush of weeds that can be eliminated by the pre-plant burn-off application of glyphosate. Most fields were fertilized by the growers either the previous fall, or prior to planting.

Planting took place between May 24 and June 13, 2016. Growers used a range of newer and older planting equipment and there were no apparent seed flow problems (Table 4). The Grant County trial field was sandy with a less firm seed bed. Plant depth and dry conditions may have been the cause for the observed thin plant stand. Planting density should be set to achieve 10-12 live seeds/square foot. Planting should take place once soils warm and into a firm and moist seed bed. Hemp is highly photo sensitive, and planting later will reduce the crop height, but not result in lower yields, nor later maturity. Early May plantings favor producing very tall plant stands (suitable for fiber production) but will not provide significant gains in earlier harvesting nor seed yields. Final plant heights were between 4.0’ to 7.2’ tall.

Table 4. Planting equipment used by the Pilot Program producers 2016.

County	Planting Equipment (May 24-June13)
LAMOURE	Case 6200 Double disc press drill
GRANT	Concord Hoe Air Drill Dutch with openers and disc closers
BENSON	Haybuster 107 Seed Drill
FOSTER	JD 1990 Air Seeder

Table 3b. Site details for the 2016 NDDA Industrial Hemp Pilot Research Program.

County	Hemp Var	Soil Type	Planting Depth (in)	Planting Row Spacing (in)	Final Plant height (in)
LAMOURE 1	Canda	Svea Barnes Loam	.75 ± .25	6	60
LAMOURE 2	Canda	Svea Barnes Loam	.75 ± .25	6	86
LAMOURE 3	Canda	Svea Barnes Loam	.75 ± .25	6	63
GRANT 1	CRS-1	Sandy loam	.5-.75	10	84
GRANT 2	CFX-1	Sandy loam	1-1.25	10	84
BENSON 1	CFX-1	Heimdal-Emrick Loam	.5-1	7	85.2
BENSON 2	Finola	Heimdal-Emrick Loam	.5-1	7	56.4
FOSTER 1	Canda	Clay loam	.75	7.5	78
FOSTER 2	Finola	Clay loam	.75	7.5	48

SAMPLING INDUSTRIAL HEMP - THC CONTENT

NDDA staff collected random samples from each hemp field to evaluate the THC content in the foliage and involucral leaves of the hemp inflorescences. Sampling was timed when approximately half of the seeds were resistant to compression (Photo 3). The THC content in hemp is known to peak when the seeds begin to ripen. Seed forms quickly, usually about 10 days after the first flower.

Photo 3. Industrial hemp stage at sampling time for THC analysis (2016).

Established Canadian hemp sampling protocols involved collecting the top 2-2.5 inches of 60 randomly selected industrial hemp inflorescences. The samples were evenly split into two 30-plant sets. Each set for THC analysis were bagged, and labelled and one set was couriered immediately to the federally accredited laboratory MedScan Laboratory Inc., in Williston, ND. The second duplicate sample set was sealed and retained by the pilot producer as a backup-set. Standard published analytical methods were followed by MedScan Labs to determine the delta-9-tetrahydrocannabinol (THC) content. The results of the analyses are shown for each field in Table 5. In all cases the THC content found in these plant parts were at trace levels. The THC content from the nine fields sampled, amounted to only 0.7% to 14% of the allowable THC content by dry weight.

Table 5. Delta-9 THC in industrial hemp samples, at seed ripening stage.

Producer	Cultivar	% THC** (dry weight)
LaMOURE	CANDA	.002
	CANDA (2 fields)	.012 + .037
GRANT	CRS-1	.007
	CFX-1	.007
BENSON	CFX-1	.007
	FINOLA	.008
FOSTER	CANDA	.004
	FINOLA	.044

PEST ISSUES

No significant insect pest pressures were seen at any site. Cutworm, Bertha armyworm, corn borers (photo 4a), Lygus bugs, aphids and grasshoppers on occasion can be a problem.

Bees were found to be very numerous at flowering time at several field locations, as were lady beetles.

Weed pressure was particularly light on all fields, except for some volunteer wheat at the Benson County location; and at the Grant County location where there was a mixture of annual weeds in one field under a thin crop stand and an open canopy (Photo 4b). Sandy soil, with uneven and inconsistent planting depth were attributed to the spotty emergence. Lack of significant rain through June resulted in a poor plant stand with significant weed issues and lower yields. The extra handling at harvest was necessary to remove the moist weeds, and dry down the hemp seed to a safe level for storage (10-11% moisture content).

Both wheat and wild buckwheat (*Polygonum convulvulous*) are problematic as it is most difficult to separate out of hemp seed. Wheat also may cause issues with processors who hope to maintain gluten-free facilities. Ideally, all fields need to have a low inherent weed population as there are no registered pesticides for use in hemp production. Growers are strongly urged to apply a pre-plant spray of non-residual herbicide (such as glyphosate or glufosinate-ammonium) to contain any early season weed growth. Hemp is very competitive against weeds. It emerges very rapidly (3-4 days) in warm/moist soils and can quickly shade and outcompete weeds. Growers commented on how quickly hemp develops.

Photo 4a. European corn borer infesting a hemp stalk (Grant County 2016).

Photo 4b. Thin canopy, dry conditions encourages weed development (Grant County) 2016.

No plant diseases were observed. Hemp is reported to be susceptible to some seedling diseases such as *Pythium* and *Rhizoctonia*. *Sclerotinia* (white mold) and *Botrytis* are also said to be the most serious foliar diseases for hemp. The foliar diseases generally form at the top of the plant in the inflorescences.

HARVESTING INDUSTRIAL HEMP

All harvesting was completed in September 2016. Harvest equipment is listed in Table 7. The hemp crop was straight cut, and no difficulties were reported, other than the combine speed being run intentionally slow to avoid any potential plugging or wrapping issues with the volume of green material. Some growers in Canada swath the crop; however, it is prone to sprout. Normally the seed moisture content at harvest should be 18-19%; and seed is considered dry and safe for storage 10% moisture. Hemp plants may appear quite green at normal harvest time. The seed matures rapidly at this stage and may shell out readily during the harvest operation (Photo 5).

Seed cleaning was required in all instances to reduce the amount of moist foreign material in the sample and lower the moisture content to a safe level for storage and processing.

Normal yields obtained in Manitoba are 800-1200 lbs/acre. The pilot producers were pleased with the results and harvested between 895 to 1266 lbs/acre – right in line with Canadian yield expectations for these varieties. Unfortunately, the Grant County test site yielded only 219 lbs/acre due to in part to a sparse plant stand and very dry conditions at the end of May into early July (Table 6). In fact, the May-August rainfall was only 4.8" at the Elgin NDSU Station. The variability in yields should caution potential growers willing to grow hemp on stubble with low soil moisture reserves.

Table 6. Monthly rainfall totals- Pilot sites (2016)

	Rainfall Totals (Inches)			
	Foster	**LaMoure**	**Grant**	**Benson**
May	**1.1**	**3.7**	**0.8**	**2.2**
June	**1.6**	**2.8**	**0.7**	**3.5**
July	**4.5**	**3.9**	**1.6**	**4.5**
August	**3.6**	**3.0**	**1.7**	**0.8**
September	**1.8**	**3.9**	**2.3**	**3.0**
TOTALS	12.6	17.3	7.1	14.0

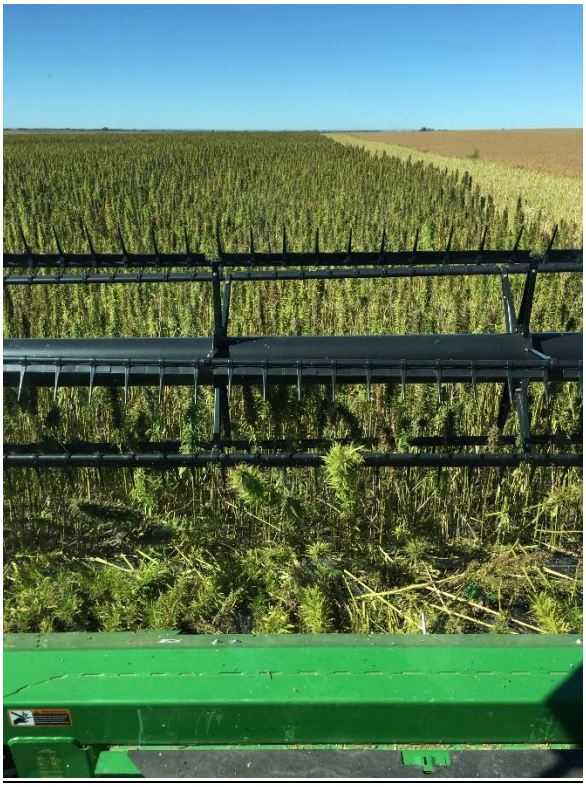

Photo 5. Harvesting industrial hemp (LaMoure County).

Table 7. Harvesting equipment used by the pilot program producers in 2016.

County	Harvesting Equipment (Sept 10-22)
LAMOURE	JD5680 combine with JD 635 Flex Draper Head
GRANT	NH CR 940 Twin Rotor Combine with NH 30 foot draper head
BENSON	JD 9650 cylinder walker with 30 foot rigid head
FOSTER	JD 8770 with JD flex head

Because industrial hemp does appreciably branch/tiller, the stubble that remains is composed of long individual fibrous stocks that are tough to work down and generally moist such that burning will not be very effective (Photo 6). Normally the stubble is left standing over the winter and then rolled in spring to produce a dense soil cover to facilitate successful burning.

Photo 6. Post-harvest crop residue management (LaMoure County) 2016.

INDUSTRIAL HEMP PROCESSING

All grain was processed at Healthy Oilseeds LLC., located in Carrington, ND. The grain was crushed to extract hemp oil, the remainder milled to produce either a finely-ground high-protein flour or, extruded into pellets (Photo 8). Seed contains 30-35% oil of a desirable fatty acid profile; and flour contains around 25% protein. Reliable foreign markets for these commodities exist. A grain dehuller is also being considered in the future as the markets for industrial hemp commodities increase. Dehulled hemp or "hemp hearts" are a high demand commodity. The fiber stalks remained in the field.

Photo 7. Processed industrial hemp commodities.

Representative samples of each of the above commodities (Photo 7) have been sampled (Photos 8a, 8b) by NDDA staff following a U.S Drug Enforcement Administration (DEA) request, then couriered to MedScan laboratory to analyze for cannabidiol (CBD), and THC. Cannabidiol (CBD) is produced at higher levels than THC in hemp and is then extracted for its supposed medicinal properties (i.e. anticonvulsive, anti-epileptic and anti-microbial). As expected, the final analytical step of the processed commodities has shown low THC content (Table 8). This should result in unencumbered trade of the hemp commodities being held by the pilot producers.

Photo 8a: (Left) Hemp meal sampling

Photo 8b: (Right) Hemp oil sampling

Table 8. THC and CBD content contained in harvested and processed samples.

COMMODITY	Mass % THC	ug/g THC	Mass % CBD	ug/g CBD
Seed	0.124	1243	0.638	6384
Flour	0.008	82	0.015	153
Pellets	0.007	74	0.101	1009
Oil	<0.001	<1	<0.001	<1

In addition, samples of roasted grain will also be germination tested by the North Dakota State Seed Department to verify seed sterility prior to any sale or movement. Other uses for industrial hemp are shown below (Table 9), and are anticipated with as acres and processing capabilities increase.

Table 9. Industrial hemp uses

Food Uses	Hemp Oil Product Uses	Hemp Fiber Product Uses
Confectionary items	Cooking	Fabric
Beer	Salad Dressing	Insulation
Flour	Dietary Supplements	Carpeting
Feed	Body Care Products	Paneling
Dietary	Fuel	Pulp and Paper
Snacks	Detergents	Recycling Additive
Non-dairy Milk and Cheese	Spreads	Automobile Parts
Baking	Paint	Animal Bedding and Mulch

Economics of Industrial Hemp

All the grain was transported to the sole processor, Healthy OilSeeds LLC in Carrington, ND. The proprieter provided an extra incentive to encourage grower delivery, and paid a premium ($1.00/lb). At the time of writing, typical industry returns range from $0.62 to $1.00 USD.

Each grower penciled out their individual costs to produce the hemp crop. Current seed cost is approximately $2.25/lb (approx $56.00/acre). Three of the four growers (Table 10) had decent returns. Only one grower had poor returns, but will market his products separately to improve the bottom line.

Table 10. Economic analysis by growers on the profitability of Industrial Hemp under the NDDA Industrial Hemp Pilot Research Program (2016).

Grower County	Acres Planted	Yield (lb/A)	Yield (bu/A)	GrowerCosts $/A	Gross Return $/lb **	Net Profit $/A
LaMoure	30	1266	28.8	$441.73	$1	$824.27
Foster	15	895	20.3	$387.27	$1	$507.73
Benson	15	1171	26.6	$303.85	$1	$867.15
Grant**	10	219	5.0	$330.35	Unknown	Unknown

Conclusions

Industrial hemp holds promise as a viable alternative crop for North Dakota producers. Based upon the industrial hemp grower experiences, the crop appears to be well adapted over most of North Dakota's agricultural conditions. Generally the field trials had low weed pressures, good plant stands, and lacked significant diseases and other pests. The pilot program growers were comfortable growing the new crop and were able to plant, maintain, and harvest hemp without significant modifications to their current farming equipment and practices. Both the seed yields and economic returns were impressive for the first time growers.

References

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