Extension
UNIVERSITY OF WISCONSIN–MADISON

A4183-01

BADGER AG TECH

INDUSTRIAL HEMP GRAIN PRODUCTION

Lessons learned from a large-scale field study

Brian D. Luck, Jessica L. Drewry, Kevin J. Shinners, and Joshua C. Friede

Until recently, industrial hemp (*Cannabis sativa*) has not been produced in the United States since 1957 (**https://go.wisc.edu/7fhb7f**). There is renewed interest in the agricultural community in adding industrial hemp to diversify crop rotations. However, very little research, guidance, or information exists for farmers on how to effectively grow and manage this crop. In 2019, we obtained the necessary approvals and licenses from the Wisconsin Department of Agriculture, Trade, and Consumer Protection to grow industrial hemp for grain production to assess how best to manage and harvest grain from this potential cash crop.

Ten acres of industrial hemp were planted at the University of Wisconsin–Madison Arlington Agricultural Research Station in the second week of June 2019. Alfalfa was the crop previously grown in the field used for this study. Manure applied in fall 2018 was the only fertilization applied during this study. A burn-down application of glyphosate was applied in April 2019 and multiple passes of tillage were executed, due to the excessive rainfall in 2019, for seedbed preparation. The ANKA strain of industrial hemp was obtained from Valley Bio-Ag., a Canadian seed dealership. This variety is advertised as "dual purpose" for grain and fiber production. The seed was planted on 15-in. (about 5 acres) and 30-in. rows (about 5 acres) at a seeding rate of 21 lb/ac. A John Deere model 1590 grain drill was used to sow the seed and the average seeding depth was 0.5 in. Although emergence was not quantified, the stand in both the 15- and 30-in. treatments was considered sufficient to continue with the study.

FIGURE 1. **Industrial hemp crop growth in early July 2019. Mechanical cultivation applied (right) to control weeds in the 30-in. row spacing treatments. No weed control was applied to the 15-in. row spacing treatment after planting.**

Weed and pest assessments

Weed pressure within the industrial hemp crop was high throughout the growing season. Currently, there are no synthetic herbicides labeled for use in industrial hemp, so weed management presented limited options within the different row-spacing treatments. Due to the burn-down application of glyphosate and multiple tillage passes at planting, the field was free of standing weeds at the beginning of the growing season. Figure 1 shows the industrial hemp crop in early July 2019 with the 15-in. row spacing on the left and the 30-in. row spacing on the right. Mechanical cultivation was applied on July 8, 2019 to suppress weed pressure in the 30-in. rows while no weed management was applied in the 15-in. rows. Canopy closure occurred around the second week of July for the 15-in. rows while the canopy did not close until late July for the 30-in. rows. It was observed that weed pressure in the 30-in. rows was reduced by the mechanical cultivation. Although there was no weed control in the 15-in. row treatment, the crop grew vigorously and was observed to achieve similar height to the 30-in. plants. Plant height and canopy closure suppressed weed growth, observationally, in the 15-in. row treatment. Weeds were present at harvest in both the 15- and 30-in. row treatments. Some weed seed was present in the clean grain tank of the combine, however, the height of the industrial hemp seed heads excluded much of the weed seeds from entering the harvester due to the grain platform being above the height of the weeds.

Insect pest pressure in the industrial hemp crop appeared to be minimal during the growing season. Japanese beetle (figure 2) and tarnished plant bug were observed during the growing season, but the damage did not appear to decrease yields. No synthetic pesticides are currently labeled for treating industrial hemp for insects, so mitigation or management strategies were not implemented.

FIGURE 2. Japanese beetles located in the industrial hemp field in 2019. Insect pressure existed within the field, but damage to the plants was observed to be minimal and not a concern for grain production.

FIGURE 3. Badger Ag. Tech. Lab Director Dr. Brian Luck (left) and Faculty Associate Dr. Jessica Drewry (right) hand harvesting industrial hemp heads for yield estimation. Five random locations in both the 15-in. and 30-in. row spacing treatments selected for assessment.

Yield measurement

Yield estimation was completed within both row-spacing treatments (figure 3). The heads of hemp plants were harvested at five randomly selected locations within each treatment. One row was harvested at each location for a distance of 17.5 ft. The heads were dried in a forced-air oven at 131°F for 72 hours. An Almaco stationary thresher was used to separate the seeds from the head and the collected seeds were weighed to estimate yield. Results showed a statistically greater yield for the 15-in. row treatments (table 1). Total yield estimation was calculated assuming the mean yield for each treatment was applied over the entire five acres allocated to each treatment.

TABLE 1. Grain yield estimation results from both the 15-in. and 30-in. row treatments. Yield was corrected to 12% moisture wet-basis.

Row spacing (in.)	Average yield (lb/ac)	Standard deviation (lb/ac)	Letter grouping*
15	2,551	442	A
30	1,783	172	B
Total estimated yield (10 ac)	**~21,670**	—	—

*Different letter grouping signifies statistical differences between average yield (P=0.01; alpha=0.05).

Combine setup and harvest

A Case IH 6130 (model year 2012) combine fitted with a MacDon Industries D65 draper platform (30-ft. cutting width) was used to harvest industrial hemp grain in 2019 (figure 4, Case IH 6150 pictured). Header reel rotational speed was initially adjusted to match ground speed. At this setting poor crop delivery across the cutter bar assembly was observed. Based on this observation the reel speed was adjusted to slightly greater than ground speed, which yielded better crop delivery across the cutter bar assembly. The reel remained in the aft position for the duration of the harvest. Forward reel positions caused the crop to stall on the cutter bar assembly and generated poor cutter bar performance. It was difficult to find the best reel height setting because the crop varied greatly in height. Reel height remained in the fully down or near to the fully down position. In this position the best crop delivery and cutter bar performance was observed. However, low reel height settings caused the taller plants to be displaced forward or under the cutter bar causing yield losses. Furthermore, taller plants had the tendency to become lodged in the reel and subsequently dropped to the ground ahead of the harvest platform causing further yield losses.

FIGURE 4. Combine harvester and MacDon header parked next to the industrial hemp field in August 2019. Harvest date for the industrial hemp field was September 25, 2019.

FIGURE 5. Fibers wrapped around the straw chopper rotor at the exit of the threshing rotor when operated at the low speed setting. Increasing the speed from low to high eliminated this issue.

Significant crop stalling was observed on the crop side of the harvest platform. Most of the stalling was the result of crop lodging in the framework of the reel support structure or the reel cam mechanism and caused further accumulation of crop. Ultimately, the mass of the crop accumulation would provide enough friction to be conveyed to the feeder house of the combine. Significant accumulation of grain at the cutter bar and any other "dead space", on the harvest platform was observed. The harvest platform height varied between a combine monitor indicated value of 50–70 (40 to 60 in. above ground level).

Combine settings were initially set in accordance to recommendations of the Canadian Hemp Trade Alliance's website (**http://www.hemptrade.ca/eguide/harvest-management/combine-settings**). After some harvesting, issues with excessive grain loss, grain shattering, and material-other-than-grain (MOG) in the clean grain tank were observed. To reduce grain loss, cleaning fan speed was reduced from 1100 rpm to 950 rpm. Reduced grain shattering was observed by reducing threshing rotor speed by 20 rpm. To reduce MOG in the grain tank both sieves were closed from setting 10 to setting 1. These changes were observed to reduce these issues; however, no data was collected to quantify losses.

Fiber wrapping occurred in several locations on the combine. The most significant fiber wrapping was observed at the residue chopping rotor at the exit of the threshing rotor (figure 5). Changing the chopping rotor to high speed eliminated this issue. The feeder house slats and drive drums were additional locations where fiber wrapping occurred. Minor wrapping occurred at the cleaning fan shafts inboard of the support bearings and inboard of the lower cleaning fan drive sheave. Minor fiber wrapping inboard of the feeder house drive sheave was also observed. Overall fiber accumulation over the harvested area was not excessive, however, fiber wrapping should be assessed often if harvesting more than 10 acres. Where fiber wrapping occurred, the fibers remained loose until large amounts of fiber accumulated. It is important that when wrapping of fibers is observed that the problem be dealt with immediately. Plant stubble often became lodged in the framework on the underside of the combine and dislodged a shaft speed sensor for the clean grain elevator once. Wrapped fibers can damage bearing seals or cause enough friction to create a fire hazard.

Final Case IH 6140 combine settings for harvesting industrial hemp in 2019 were as follows.

- Feed house drum: Upper position typically used when harvesting corn
- Feeder house gear: Low
- Threshing rotor speed: 430 rpm
- Concave Clearance: 41 mm
- Cleaning fan speed: 950 rpm
- Upper sieve: Combine Setting 1 (8 mm)
- Lower sieve: Combine setting 1 (1 mm)
- Chopping rotor speed setting: High
- Chopping rotor stationary knives: Out position

Unloading the harvested hemp seed from the clean grain tank and through the unloading auger was done at low engine speed to minimize seed damage. The grain harvested was well cleaned at the final combine settings and was determined to be in good condition at harvest (figure 6).

The harvested industrial hemp seed was 15% moisture (wet-basis) at harvest. The seed was immediately subjected to air drying after harvest to prevent spoilage. The seed was cleaned to remove plant material and unwanted weed seeds from the final product. Total yield collected from the 10-acre field was 8,629 lb of dry (corrected to 12% moisture wet-basis) and clean seeds. Substantial losses were observed and attributed to the plants dropping seeds prior to harvest, predation of birds eating seed in the field, combine harvesting methods and header inadequacies, and the seed cleaning process.

Recommendations

Lessons learned from growing and harvesting industrial hemp during the 2019 growing season are as follows.

- The crop grew well in southern Wisconsin.
- Narrower row spacing improved yield and helped with weed suppression.
- The ANKA variety had highly variable crop height which made harvest challenging.
- The combine can be set to harvest the industrial hemp grain and produce a clean product.
- The combine harvester guidelines from Canadian Hemp Trade Alliance are a good starting point but will likely need modifications to account for individual field conditions.
- Harvesting at a higher moisture content will prevent losses and shatter but immediate (within 2 hours of harvest) drying will be required to eliminate spoilage. Fiber wrapping can also be increased when harvesting at a higher moisture content.

FIGURE 6. **Industrial hemp seed is unloaded from the combine (top). Industrial hemp seed after harvest and unloading into a wagon (bottom).**

Acknowledgements

The authors would like to thank MacDon Industries for donating the use of the draper header for industrial hemp harvest. We would also like to acknowledge the efforts of the Arlington Agricultural Research Station staff for their assistance in planting and managing the crop throughout the growing season and the Badger Bean Team for use of the Almaco stationary thresher. Funding for THC testing of the industrial hemp crop was provided by the University of Wisconsin–Madison Division of Extension and College of Agriculture and Life Sciences internal industrial hemp research funding.

Extension
UNIVERSITY OF WISCONSIN–MADISON

Authors: Brian D. Luck is assistant professor and Extension specialist; Jessica L. Drewry is assistant faculty associate; Kevin J. Shinners is professor; Joshua C. Friede is associate instrumentation specialist. All are with the Department of Biological Systems Engineering at the Univeristy of Wisconsin–Madison. Division of Extension publications are subject to peer review.

Title image courtesy of Jeff Nelson, assistant faculty associate, University of Wisconsin–Madison Department of Biological Systems Engineering.

This publication is available from your Wisconsin county Extension office (**counties.extension.wisc.edu**) or from Division of Extension Publishing. To order, visit our website at **learningstore.extension.wisc.edu** or call toll-free 1-877-947-7827.

Industrial Hemp Grain Production: Lessons Learned from a Large-Scale Field Study (A4183-01) 04-2020