Fact Sheet Series 23-2

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Organic Industrial Hemp Trials

Summary

- We report the preliminary results of two single-site year trials of organic hemp production for grain in Wisconsin. These preliminary findings can help guide future research.
- Planting later (early June) may be beneficial for hemp production in Wisconsin.
- While planting on 30" rows may have a positive impact on stand counts and weed biomass, it is not yet clear if farmers should move away from the standard production guidelines of drilling on 7.5" rows.
- Methods for mechanical weed control may need to be adjusted based on planting depth.
- Planting deeper may allow for more mechanical weed control without impacting stand counts.

BACKGROUND: HEMP PRODUCTION IN WI

Hemp used to be an important crop in Wisconsin in the early 20th century and recent legal changes mean farmers can once again grow industrial hemp.
In the early 1900s Wisconsin was a top producer of hemp in the US and one of its main uses was for fiber and rope production (1). Hemp is also produced for edible seeds and oil (2). Hemp production began to decline in the 1930's and disappeared in 1970 when laws were passed that did not make exceptions for the non-psychoactive hemp plant. But, renewed interest in hemp led to its inclusion in the 2018 farm bill (2), and in 2021, the U.S. passed a final rule allowing farmers to legally grow industrial hemp under the U.S. Domestic Hemp Production Program after they apply for a license (3).

Regulations for growing hemp in Wisconsin today
Wisconsin growers can apply for a USDA Hemp Producer License though the U.S. Domestic Hemp Production Program (3). For hemp growers, it is important to note that hemp is still considered a controlled substance in some states so the legality of CBD products differs across state lines (4).

Organic industrial hemp research
Dr. Erin Silva's group at the University of Wisconsin - Madison examined organic industrial hemp production for grain and fiber in Wisconsin, and those results are reported here.

Organic industrial hemp, Arlington Agricultural Research Station, Arlington, WI

2019 ORGANIC INDUSTRIAL HEMP TRIAL

2019 Trial Overview

Objective	To investigate the effect of planting date, row spacing, and weed control measures on organic hemp production for grain in WI.
Location	Arlington Agricultural Research Station, (AARS) Arlington, WI
Variety	Legacy Hemp X-59
Seeding rate	30 lbs/ acre at ¼" deep (for all plots)
Planting equipment	John Deere 1590 no-till drill
Treatments	Early and late planting dates, 7.5" and 30" rows, mechanical weed control and no weed control. All treatment combinations were tested.
Data collected	Plant size and structure, stand count, weed biomass and yield.

The 2019 trials focused on three aspects of agronomics and weed control:

- **Planting date:** Planting date is considered a weed control strategy in organic systems. The timing of planting relative to soil and climate conditions as well as weed flushes is critical. For this trial, the early and late target planting dates were May 15 and June 1, respectively. On these dates, conditions were suboptimal for uniform stand establishment. On May 15, the seedbed was cloddy and some weeds and alfalfa from the previous year were still visible; in the 9 days prior to planting, it rained almost every day. June 1 was pushed to June 6 to favor seed bed preparation; the seedbed was in good condition for planting but conditions were dry. Three and six days after planting, 0.08" and 0.94" of rain occurred, respectively.
- **Row spacing:** Most industrial hemp is planted on a 7.5" or narrower row spacing. For this trial, we tested a wider row spacing rows because this allowed for an extended period of mechanical weeding with a row cultivator.
- **Mechanical weed control:** The mechanical weeding treatments were adaptation to the row spacing; details of all weed control passes are included **Table 1**.

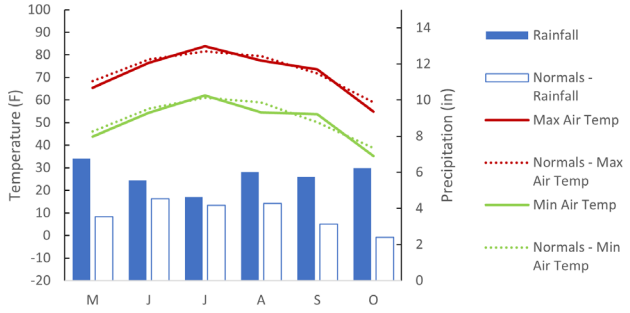
Climate date for the site is presented in **Figure 1.**

For more production information
Check out UW-Madison's guide to agronomic considerations for industrial hemp (5) and research reports and updates (6). The Midwestern Hemp Research Collaborative also reports their research trials though the Midwestern Hemp Database (7).

Table 1. 2019 Mechanical weed control operations.

	Date	Operation	Crop Stage
Early-planted (May 15)	5/31	All plots: Rotary hoeing/tine weeding	1st true leaf
	6/14	30" plots: row cultivation	2 to 4 sets of true leaves
	6/17	30" plots: row cultivation	-
	6/20	30" plots: row cultivation	-
Late-planted (June 6)	6/18	Tine weeding attempted; stopped due to high crop damage	1st true leaves
	6/21	Tine weeding	2 sets of true leaves
	6/27	7.5" plots: tine weeding; 30" plots: row cultivation	2 to 4 sets of true leaves
	7/2	7.5" plots: tine weeding	3 to 6 sets of true leaves
	7/3	30" plots: row cultivation	-
	7/9	30" plots: row cultivation	-

Figure 1. Monthly averaged maximum and minimum air temperatures and total monthly precipitation plotted against 1971-2000 normals at the Arlington Agricultural Research Station, Arlington, WI, 2019.



2019 Results-plant size and structure

For plant size and structure, a few trends were observed and are shown in **Table 2** and **Figure 2**.

- **Plant height:** Taller hemp plants tended to have a higher head base height, longer head length, and thicker stem diameter. Plots planted earlier tended to have taller plants.
- **Base of head height:** When harvesting hemp, the height of the combine must be set at an optimal height to maximize the amount of grain harvested and minimize the risk of fiber wrapping in the combine. In some treatments, the height of the base of the heads was fairly uniform across the plot, but this did not seem to be explained by row spacing, planting date or weed control alone. Row spacing appeared to affect head base height; 7.5" rows tended to have a higher base head height vs 30" rows.
- **Head length:** Head length tended to be longer in plots that were planted early. Heads also tended to be longer if mechanical weed control was used. Plants with a larger stem diameter tended to have a longer head length.
- **Stem diameter:** The circumference of the stem is important for ease of harvest and fiber production. For fiber production, long thin stems are preferable. For harvest, it is not yet clear which is preferable. The stem diameter tended to be larger in plots that were planted early or if mechanical weed control was used.

Figure 2. Effect of planting date (early, May 15; late, June 6), row spacing and mechanical weed control on organic hemp plant size and structure in the 2019 trial.

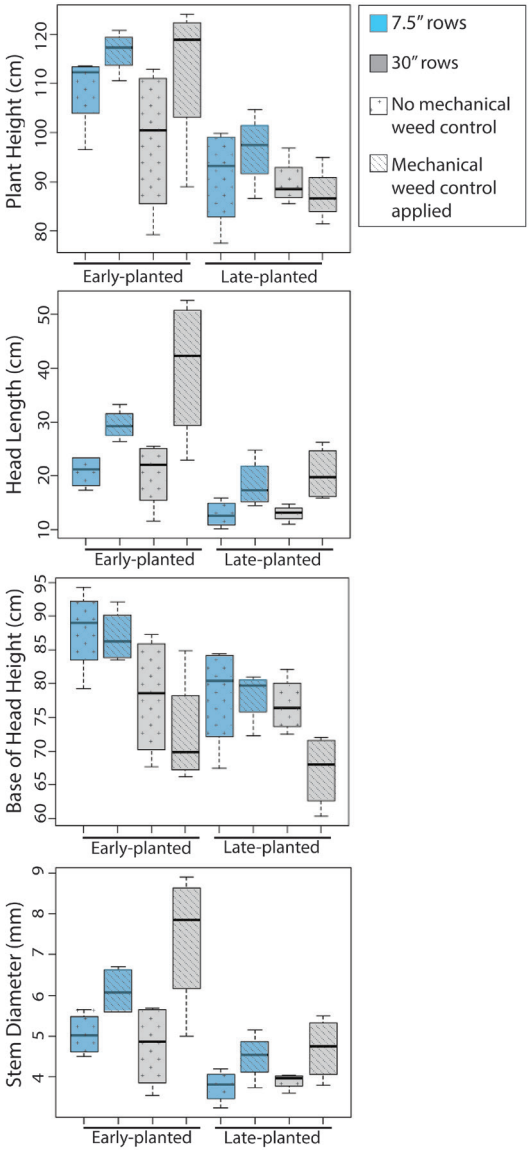


Table 2. Effect of planting date, row spacing and weed control on organic hemp plant size and structure in the 2019 trial.

Treatments			Results				
Planting date	Row spacing (in)	Mechanical weed control*	Plant height (cm)	Base of head height (cm)	Head length (cm)†	Stem diameter (mm)	Number of branches
Early (May 15)	7.5	No	109 abc	88 a	21 ab	5.0 ab	0.0
		Yes	116 a	87 ab	29 ab	6.1 ab	0.3
	30	No	98 abc	78 abc	20 ab	4.7 ab	0.0
		Yes	113 ab	73 bc	40 a	7.4 a	1.0
Late (June 6)	7.5	No	91 bc	78 abc	13 b	3.8 b	0.0
		Yes	97 abc	78 abc	18 b	4.5 b	0.0
	30	No	90 c	77 abc	13 b	3.9 b	0.0
		Yes	87 c	67 c	20 ab	4.7 b	0.0

Mean values presented for each treatment. Letters represent significant differences at a p-value of 0.1. *See the table above for details on mechanical weed control passes; 30" rows received additional weed control passes compared to 7.5" rows. †Head length was calculated by deducting the head's base height from the overall plant height.

2019 Results – stand count, weed biomass and yield

Overall, stand count and weed biomass tended to be impacted by row spacing, while yields were variable as shown in **Table 3** and **Figure 3**.

- **Emergence and Stand count:**
  - Seeds had a test weight of 27,840 seeds/lb and a germination test rate of 88%. Seeds were planted at 30 lbs/ac for a final count of 835,200 seeds/ac or 734,976 viable seed/ac. The average stand counts across treatments were 326,625 plants/ac for early-planted plots and 507,162 plants/ac for late-planted plots, resulting in 44% and 69% emergence, respectively.
  - For the late planted plots, hemp stand emergence was also studied. Emergence was very uneven. None of the seeds had emerged on June 14 and new seedlings were still emerging until June 20.
  - Higher stand counts were observed in plots planted on 30" rows compared with 7.5" rows. Within the 30" row plots, those that did not have mechanical weed control tended to have higher stand counts compared to those with mechanical weed control.
- **Weed biomass:** Plots with higher weed pressure had lower stand counts. Plots planted on 7.5" rows had higher weed biomass than those planted on 30" rows; however, as part of the trial design 30" rows received row cultivation passes until the height of the plant exceeded that of the toolbar, while 7.5" plots only received tine weeding or rotary hoeing soon after planting.
- **Yield:** Yields were variable across treatments. Late-planted plots had slightly higher yields, but differences were not significant and due to the harvest method, yield data are not necessarily representative of what would be achieved on a working farm.

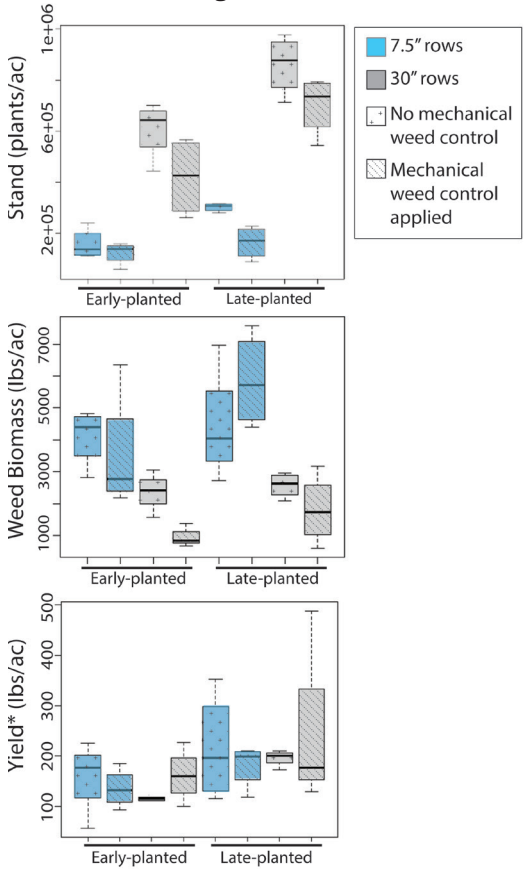


Figure 3. Effect of planting date (early, May 15; late, June 6), row spacing and mechanical weed control on organic hemp stand count, weed biomass and yield in the 2019 trial. *Due to harvest method, yield data are not necessarily representative of what would be achieved on a working farm.

Table 3. Effect of planting date (early, May 15; late, June 6), row spacing and mechanical weed control on organic hemp stand count, weed biomass and yield in the 2019 trial.

Treatments			Results		
Planting date	Row spacing (in)	Mechanical weed control†	Stand count (plants/ac)	Weed biomass (lbs/ac)	Yield (lbs/ac)§
Early	7.5	No	155,350 cd	4,110 ab	153*
Early	7.5	Yes	122,850 d	3,519 ab	135
Early	30	No	608,400 abc	2,367 ab	115*
Early	30	Yes	419,900 abcd	965 b*	161
Late	7.5	No	301,600 bcd	4,435 ab	214
Late	7.5	Yes	163,800 cd	5,855 a	181
Late	30	No	861,250 a	2,574 ab	194*
Late	30	Yes	702,000 ab	1,808 b	242

Mean values presented for each treatment. Letters represent significant differences at a p-value of 0.1. *There is missing data for some plots in the treatments marked with asterisks. †See the table above for details on mechanical weed control passes; 30" rows received additional weed control passes compared to 7.5" rows. §Due to harvest method, yield data are not necessarily representative of what would be achieved on a working farm.

Organic industrial hemp maturity gradient and hemp harvest, Arlington Agricultural Research Station, Arlington, WI

2020 ORGANIC INDUSTRIAL HEMP TRIAL

2020 Trial Overview

Objective	To investigate the effect of planting depth, row spacing, and planting population on organic hemp production for grain in WI.
Location	Arlington Agricultural Research Station, Arlington, WI
Variety	Anka
Seeding rate	30 lbs/ acre at ¼" deep (for all plots)
Planting equipment	John Deere 1590 no-till drill, Brillon seeder
Treatments	Planting population (41lbs/ac and 82 lbs/ac), row spacing (brillon seeder,* 7.5" and 30"), planting depth (Brillon seeder,* 0.25"and 1"). All treatment combinations were tested.
Data collected	Stand count, weed biomass and yield.

*Broadcast-type seeding, seeds are free-flowing from the seed box and cultipacker rollers help with shallow incorporation.

The 2020 trial examined planting depth, row spacing and planting population and treatments were informed by the 2019 trials results.

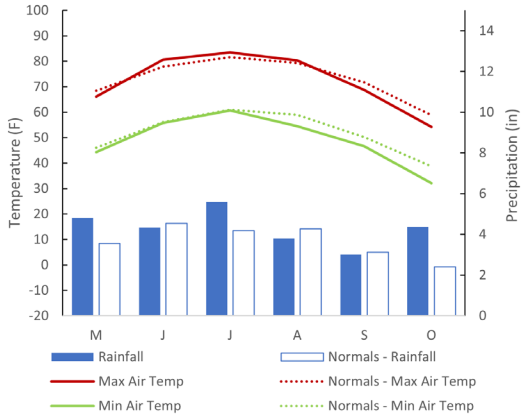
- **Planting depth:** It is typically recommended to plant hemp at a depth of ½" or less; however, the 2019 trial

indicated that this may limit the options for mechanical weed management. In 2020, deeper planting was tested to see if it improved the seedling's resilience to tine weeding.

- **Row spacing:** Most industrial hemp is planted on a 7.5" or narrower row spacing. We again compared this typical planting pattern to planting on 30" rows, which allows for an extended period of mechanical weeding with a row cultivator. We also tested a Brillon seeder (broadcast-type seeding with cultipackers rollers to help with shallow incorporation).
- **Planting population:** Industrial hemp can be grown for multiple purposes including fiber and grain. For fiber, it is recommended to plant twice as much seed. If the industry develops, Wisconsin could be a strong player in hemp fiber production (as it has been historically) and planting more seeds per acre can help with weed control. For these reasons we compared the recommended planting populations for hemp grain and hemp fiber.

A planting date of early June was used for all treatments (as weather and field conditions allowed). For mechanical weed control, a row cultivator was used in plots with 30" rows (cultivation dates: June 25, June 30, July 1 and July 9). No other mechanical weed control was performed as weed pressure was lower with the later planting date and good conditions, thus we were unable to assess if deeper planting helped with tine weeding. All treatments were harvested for grain at the end of September. Climate data is shown in **Figure 4**.

Figure 4. Monthly averaged maximum and minimum air temperatures and monthly total precipitation plotted against 1971-2000 normals at the Arlington Agricultural Research Station, Arlington, WI, 2020.



2020 Trial Results

Overall, impacts from the planting population and planting depth were observed on stand count and weed biomass, see **Table 4** and **Figure 5**.

- **Stand count:** Stand count was significantly higher with the higher planting population (p=0.1), except when the Brillon seeder was used. The 7.5" row spacing had significantly slightly higher stand counts compared to 30" rows at the same planting population (p=0.1).
- **Weed biomass:** Weed biomass was highest with the Brillon seeder and tended to be lower with the 1" planting depth, although differences were not statistically significant. Plots with 30" rows showed a decrease in weed biomass compared with 7.5" rows at the same seeding rate, although the difference was not significant.
- **Yield:** Yield was particularly low due to a delayed harvest and yield data is not necessarily representative of what would be achieved on a working farm due to harvest method. Planting population, row spacing and planting depth had no clear effect on yield in this study.

Table 4. Effect of planting population, row spacing and planting depth on stand count, weed biomass and yield in the 2020 trial.

Planting population (lbs/ac)	Row spacing (in)	Planting depth (in)	Stand count (plants/ac)	Weed Biomass (lbs/ac)	Yield† (lbs/ ac)
41	7.5	0.25	373,620 abc	2,404 ab	83
41	7.5	1	351,585 abc	1,641 b	120*
41	30	0.25	300,885 bc	1,823 b	90*
41	30	1	345,150 abc	721 b	59*
41	Brillion seeder‡	Brillion seeder‡	108,420 c	5,536 a	77*
82	7.5	0.25	574,470 ab	1,747 b	102
82	7.5	1	781,170 a	1,178 b	67
82	Brillion seeder‡	Brillion seeder‡	174,135 bc	N/A§	97*

Mean values presented for each treatment. Letters represent significant differences at a p-value of 0.1. *There is missing data for one plot in each of the treatments marked with asterisks. †Due to harvest method, yield data are not necessarily representative of what would be achieved on a working farm, and are particularly low due to delayed harvest. ‡Broadcast-type seeding, seeds are free-flowing from the seed box and cultipacker rollers help with shallow incorporation. §Not available due to plots being too weedy.

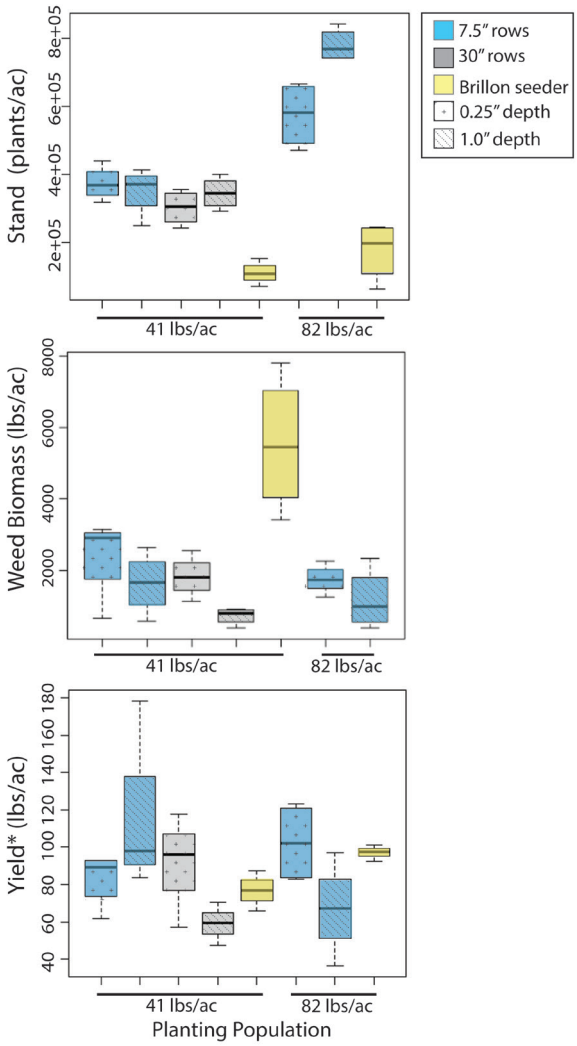


Figure 5. Effect of planting population, row spacing and planting depth on organic hemp stand count, weed biomass and yield in the 2020 trial. *Due to harvest method, yield data are not necessarily representative of what would be achieved on a working farm and are particularly low due to delayed harvest.

CONCLUSIONS

Here we report the results of two single-site year studies of organic hemp production in Wisconsin. A few trends were observed for the effects of planting date, row spacing, weed control and planting population on organic hemp production in Wisconsin. Further studies are needed, but these early findings will help guide future research.

- **Planting date:** In 2019, planting later (early June) tended to result in a higher stand count and slightly higher yield with a narrower stem diameter (which is better for fiber production). This later planting date was then used in 2020 trials.
- **Row spacing:** In 2019, 30" rows had higher stand counts, but this same effect wasn't observed in the 2020 trials. In both years, there tended to be lower weed biomass in plots with 30" row spacing. Row spacing had no clear effect on yield in either year.
- **Weed control:** In 2019, adding mechanical weed control tended to lower stand counts, possibly due to the shallow planting depth of 0.25", but did not have a consistent impact on yield. In 2020, we found that 1" planting depth lowered the weed biomass compared to planting at 0.25" depth without having a clear impact on yield or stand count.
- **Planting population:** a higher planting population increased the stand count with no clear effect on yield.

Organic industrial hemp at the Arlington Agricultural Research Station, Arlington, WI.

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For more information on organic hemp certification:
The Organic Trade Association has a guide specifically for certification of organic hemp (7).

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The OGRAIN (Organic Grain Resource and Information Network) program is housed in the Organic and Sustainable Agriculture Research and Extension Program within the University of Wisconsin-Madison Department of Plant Pathology under the leadership of associate professor Dr. Erin Silva. OGRAIN provides resources and support for new, transitioning, and experienced organic grain farmers throughout the upper Midwest. We host a variety of events, support a producer listserv (join by emailing join-ograin@lists.wisc.edu) and provide educational materials at https://ograin.cals.wisc.edu/. To contact us, email Erin at emsilva@wisc.edu, or call (608) 890-1503.

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