2019 Cornell Hemp Trials for New York State

Grain, Dual Purpose, and Fiber Production

In 2019, hemp grain and fiber trials were established in three locations in Central New York (Table 1). All locations are part of Cornell University Agricultural Experiment Station (https://cuaes.cals.cornell.edu/) or Cornell AgriTech (https://agritech.cals.cornell.edu/). Data presented in this report consist of grain and fiber yield, cannabinoid content, and grain quality components. Analysis for mycotoxin concentration has been delayed due to the COVID-19 pandemic.

Table 1. Trial locations, planting dates, and site characteristics.

Location	Latitude	Planting date	Soil type	Natural Drainage Class*
Freeville, NY (ORG)	42.52 N	June 5	Howard gravelly loam	Well drained
Geneva, NY (RN)	42.88 N	June 12	Lima loam	Moderately well drained
Ithaca, NY (MG)	42.45 N	June 11	Williamson v. fine sandy loam	Moderately well drained

*Tile drainage in most fields.

Information in this report was collected due to the efforts and collaborations of many faculty, staff, and students at Cornell University:

SIPS Plant Pathology and Plant-Microbe Biology Section:

Chris Smart's Lab: Ali Cala, Colin Day, Garrett Giles

Gary Bergstrom's Lab: Jen Starr and Kevin Meyers

SIPS Horticulture Section:

Larry Smart's Lab: Rebecca Wilk, Craig Carlson, Deanna Gentner, George Stack, Jacob Toth, Ben DeMoras, Reagan Reed, Mariana Marrero, Teagan Zingg

Alan Taylor's Lab: Michael Loos

SIPS Plant Breeding and Genetics Section:

Don Viands' Lab: Julie Hansen, Jamie Crawford, Jesse Chavez, Ryan Crawford, Jason Schiller, Jay Johnson, Josh Knecht, Gabriel Sanchez, Johanna Gertin, Sabrina Giaimo, Dana Gong, Julie Houser, Nikolia Kanaris, Tiffany Lam, Yanni Ramirez, Jackson Santander, and Brian Zhong

SIPS Plant Biology Section:

Joss Rose's Lab: Glenn Philippe, Stephen Snyder

Methods

Replicated hemp grain, dual purpose (grain and fiber), and fiber trials were planted using a small plot cone seeder. Plots were six rows wide, with 7.5 inches (19.05 cm) between rows, resulting in plots that were 45 in (114.3 cm) wide and 20 ft (6.1 m) long. Trials were planted in a randomized complete block design with four replicates and were analyzed using standard ANOVA (analysis of variance).

Seeding rates were 20 pure live seeds (PLS)/ft^2 for grain and dual-purpose cultivars and 40 PLS/ft^2 for fiber cultivars with the intention of having 15 seedlings/ft^2 in the grain and dual-purpose trials and 30 seedling/ft^2 in the fiber trials. Trials were fertilized prior to planting with 75 lbs of nitrogen/acre as 22-9-9 and then, at three weeks, top dressed with 75 lbs/acre of nitrogen as ammonium sulfate (21-0-0). The organic Freeville cultivar trials were amended with 70 lbs of nitrogen/acre as 5-4-3 pelleted composted chicken manure prior to planting.

The cultivars included in the trials, as well as seed purity, germination rate, and gram weight per one thousand seeds are found in Table 2. We were unable to provide documentation proving that cultivars from CN Kenaf & Hemp Seed Farm were untreated and so were unable to include those nine entries in the Freeville organic trials. CN Kenaf & Hemp Seed Farm is in Zhangpu County in the southern Fujian province, People's Republic of China. Zhangpu County is located at latitude 24.117° N, comparable to that of Key West, Florida. These nine cultivars were photoperiod sensitiveand flowered too late in the season to produce seed in NY at 42° N. Although most were purported to be grain cultivars, we did not know prior to planting how these cultivars would perform, so all were planted at the lower seeding rate in the grain/dual-purpose trials. Due to the disparity in flowering time, data collected on these cultivars are presented separately.

Two to three weeks after planting, seedling counts were conducted. Throughout the growing season, weed pressure, flowering date, incidence of disease and insects, and height were measured. Within 14 days of harvest, the top 5 cm (2 inches) from 10 female plants per plot were sampled for cannabinoids. The inflorescences were dried at 35°C for 10-12 days and then ground for analysis with UV-HPLC. Harvest dates for all locations are found in Table 3.

Fiber trials were harvested between flowering and seed set with sickle bar mowers. Biomass was spread out in an even layer for field retting and monitored until fully retted. The retted plots were again weighed and sampled for percent dry matter. Yields are reported as retted stem dry weight in tons per acre.

Grain and dual-purpose trials were harvested with an Almaco SPC20 plot combine or a Hege 125 plot combine when all cultivars had at least 60% mature seed. Harvested grain was dried in forced air ovens at 35^{o}C until a stable moisture was achieved (6-8% moisture) and then cleaned to remove immature seeds and weed seeds. Samples from the cleaned grain were analyzed for test weight, thousand kernel weight (TKW) and quality components. Using near infrared reflectance spectroscopy (NIRS), equations have been developed to predict quality components, including crude protein, fiber as neutral detergent fiber (NDF), and fatty acid profile. Selected samples were sent to Dairy One (dairyone.com) to refine and further validate the NIRS equations.

Table 2: Fiber, grain, and dual-purpose hemp cultivar information

Entry		Purity (%)	Germination (%)	TSW (g)
Fiber Types				
Carmagnola	Schiavi Seed (Italy)	99.05	77	16.3
Carmagnola Selezionata	Schiavi Seed (Italy)	99.63	76	21.6
Eletta Campana	Schiavi Seed (Kentucky)	98.82	53	15.6
Fibranova	Schiavi Seed (Kentucky)	97.19	37	15.2
Hlukhivs'ki-51	Fiacre Seeds	99.88	81	16.7
Grain Types				
Canda	Parkland Industrial Hemp Growers	99.79	83	15.9
CFX-1	Hemp Genetics International	99.41	71	16.2
CFX-2	Hemp Genetics International	99.41	90	16.5
CRS-1	Hemp Genetics International	99.41	88	18.4
Earlina 8	UNISeeds	99.85	92	9.6
Grandi	Hemp Genetics International	99.41	93	16.5
Han-cold	CN Kenaf &Hemp Seed Farm	99.95	74	30.5
Han-FH-Q	CN Kenaf &Hemp Seed Farm	99.93	14	17.7
Han-FN-H	CN Kenaf &Hemp Seed Farm	99.92	85	18.8
Joey	Parkland Industrial Hemp Growers	99.65	75	14.6
Katani	Hemp Genetics International	99.41	75	15.6
Picolo	Hemp Genetics International	99.41	85	16.2
USO-31	UNISeeds	99.41	69	17.4
X-59	Legacy Hemp	99.85	85	15.9
Dual-Purpose Types				
Anka	UNISeeds	99.66	85	14.2
Bama	CN Kenaf &Hemp Seed Farm	99.99	67	30.8
Bialobrzeskie	Bija Seeds	99.35	92	14.0
Fedora 17	UNISeeds	99.85	93	15.1
Felina 32	2016-Assocanapa	99.35	75	15.8
Ferimon	UNISeeds	99.79	85	13.7
Futura 75	2016-Assocanapa	99.35	84	17.9
Han-NE	CN Kenaf &Hemp Seed Farm	99.93	74	25.4
Han-NW	CN Kenaf &Hemp Seed Farm	99.79	48	18.9
Helena	Schiavi Seed (Kentucky)	99.96	72	12.8
Hlesia	Fiacre Seeds	99.78	80	18.2
Hliana	Fiacre Seeds	99.86	88	17.0
Hlukhivs'ki-51	Fiacre Seeds	99.88	81	16.7
NWG-Elite	New West Genetics	99.41	85	10.5
Puma	CN Kenaf &Hemp Seed Farm	99.98	55	23.7
Si-1	CN Kenaf &Hemp Seed Farm	99.12	65	50.5
Tygra	Schiavi Seed (Kentucky)	99.55	85	13.9
Wojko	2016-Assocanapa	99.35	54	15.2
Yuma	CN Kenaf &Hemp Seed Farm	99.96	66	30.1

Table 3. Trial locations, type, and harvest/data collection dates.

Location	Grain	Dual Purpose	Fiber – green	Fiber - retted
Freeville, NY	8/29	9/9	-	-
Geneva, NY	9/5	9/10	8/22	11/21
Ithaca, NY	9/6	9/13-9/16	8/22	9/20

Results

Fiber Trials

Seedling counts

For the fiber trials, seed germination rates for the cultivars in the fiber trials ranged from 37 to 81%. Seeding rates were corrected so that the same number of viable seeds were planted in each plot. Bird feeding after planting in the Freeville organic trial led to stands averaging 1.3 seedlings per square foot and so the trial was abandoned. Stand counts in seedlings per square foot ranged from 20.1 - 31.3 in Geneva and 22.0 - 26.5 in Ithaca.

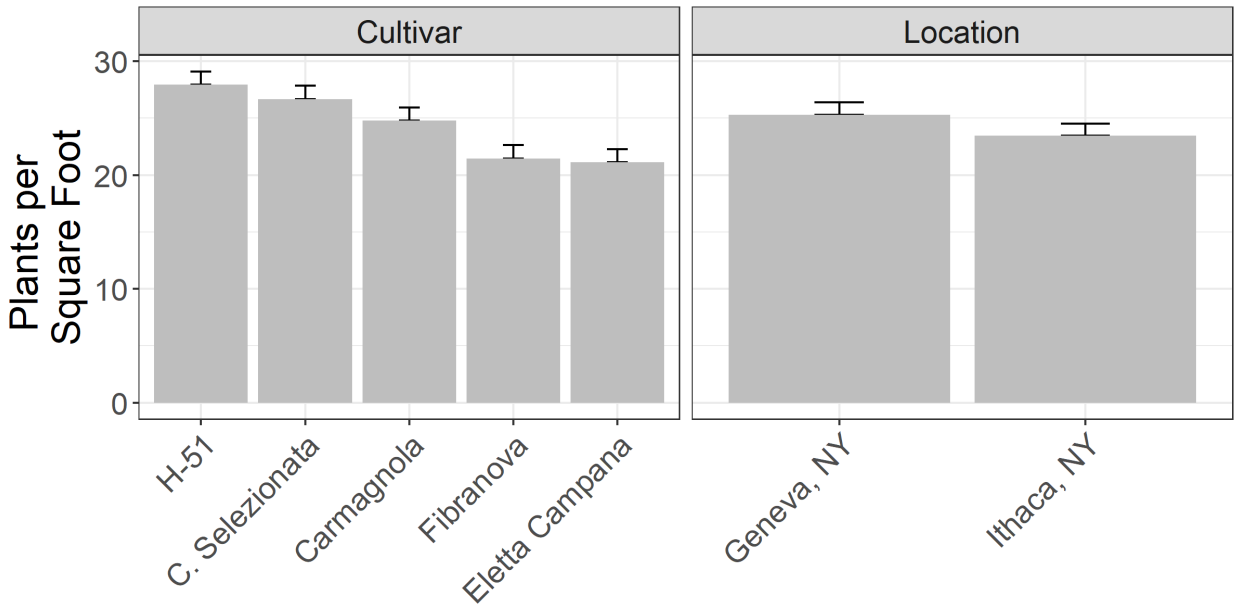

Figure 1. 2019 NY hemp seedling establishment for fiber cultivars and by trial location.

Harvest yields

Plots were cut, retted, weighed, and sampled for dry matter determination. Harvest dates ranged from the end of August through the middle of September. Plot weight times percent dry matter was used to estimate retted hemp straw yield (Fig. 2). Mean retted straw yields by trial location ranged from 2.25 - 3.71 tons/acre. Ithaca had the greatest mean retted straw yields, despite having fewer plants per square foot as entries at the Ithaca location were 43 cm taller on average. Overall, ‘Carmagnola’ and ‘Carmagnola Selezionata’ (C. Selezionata), were the highest yielding cultivars, followed by ‘Eletta Campana’ and ‘Fibranova.’ ‘Hlukhovs’ki-51’ (‘H-51’) had consistently lower yields across both fiber trial locations (Figures 2 and 3). ‘H-51’ was the earliest maturing, having ripe seed on all plants at harvest, and was on average 64 cm shorter than the other cultivars.

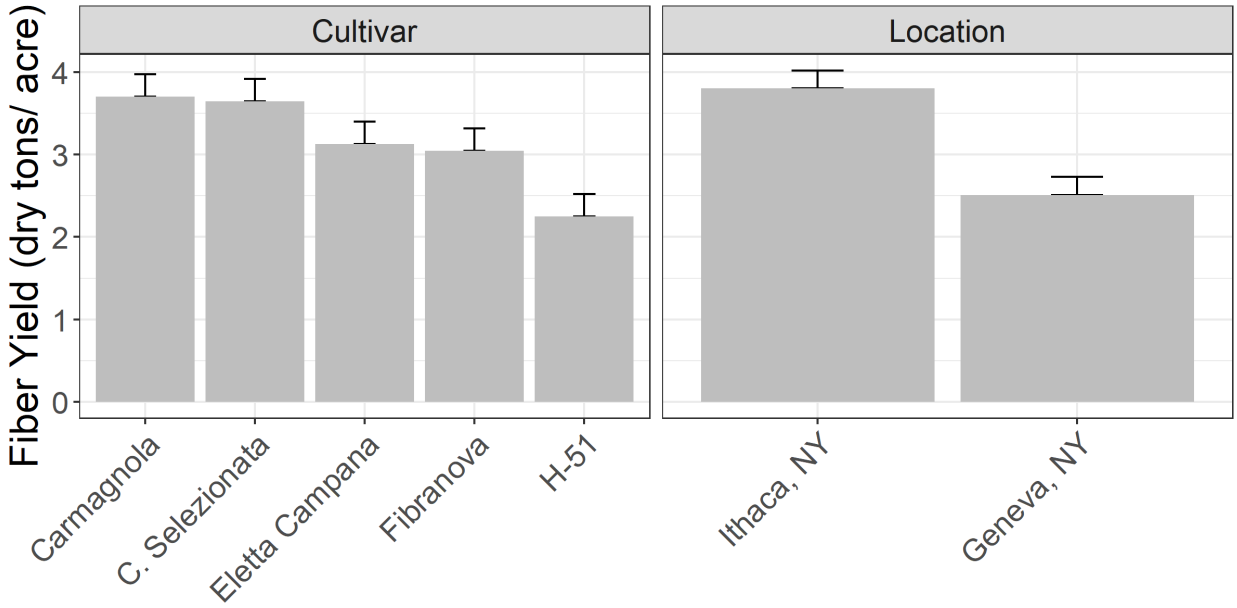

Figure 2. 2019 NY hemp retted fiber yield by cultivar averaged across six locations and by trial.

Grain Trials

Seedling counts

For the grain trials, 11 hemp cultivars were planted in three trials. The number of hemp plants per plot ("stand"), was greatest at the Geneva trial and lowest in the Freeville Organic trial (Fig. 3). Freeville had poor stands due to bird feeding immediately after seeding. Seedlings per square foot over locations ranged from 16.6 in Geneva and 4.9 in Freeville.

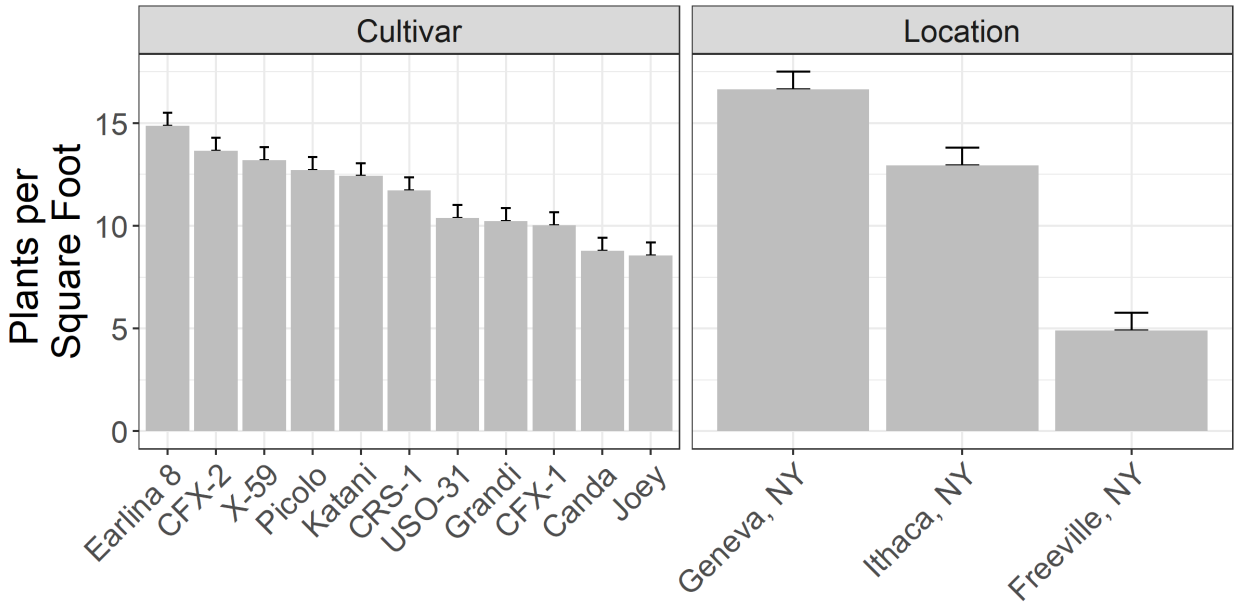

Figure 3. 2019 NY hemp seedling establishment for grain cultivars and by trial location.

Harvest yields

Plots were harvested and threshed grain was cleaned and dried to 8% moisture. Harvest dates ranged from the end of August through early September. Means for grain cultivars and trials are presented below (Fig. 4). By cultivar, grain yields ranged from 444 to 1103 pounds/acre. By location, grain yields ranged from 409 pounds/acre in Freeville to 1276 pounds/acre in Ithaca. Freeville had an enormous amount of bird feeding pressure at harvest.

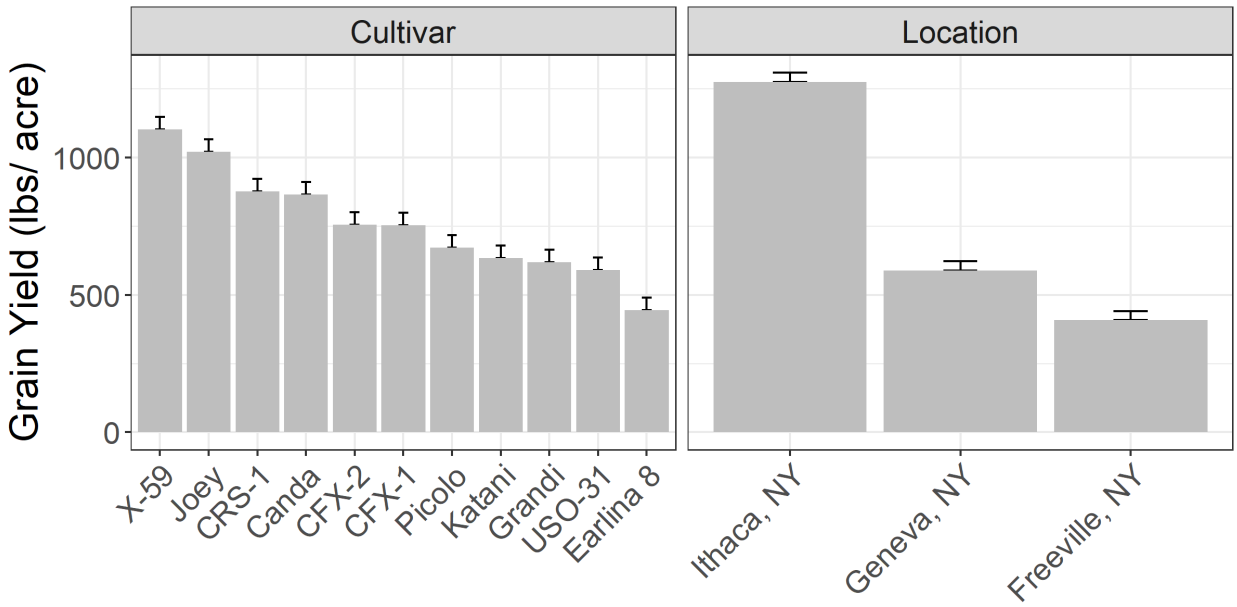

Figure 4. 2019 NY hemp grain yield by cultivar averaged across four locations and by trial.

Dual Purpose Trials

Seedling counts

For the dual-purpose trials, thirteen hemp cultivars were planted in three locations. Stand counts in seedlings per square foot ranged from 4.2 - 10.7 in Freeville, 9.2 - 16.7 in Ithaca, and 12.8 - 21.8 in Geneva (Fig. 5).

Harvest yields

Plots were harvested and threshed grain was cleaned and dried to 6 - 8% moisture. Harvest dates ranged from early to the middle of September. Means for dual-purpose cultivars and trials are presented below (Fig. 6). By cultivar, dual-purpose grain yields ranged from 368 to 1047 pounds/acre. By location, dual-purpose grain yields ranged from 230 pounds/acre in the Freeville trial to 805 pounds/acre in the Ithaca trial. Because the cutter bar on our plot combine is unable to cut above 75 cm, instead of reporting fiber yields, we are reporting the mean heights of these dual-purpose cultivars (Fig. 7). The mean height of the tallest entry was 45 cm taller than the shortest entries in the dual-purpose trial.

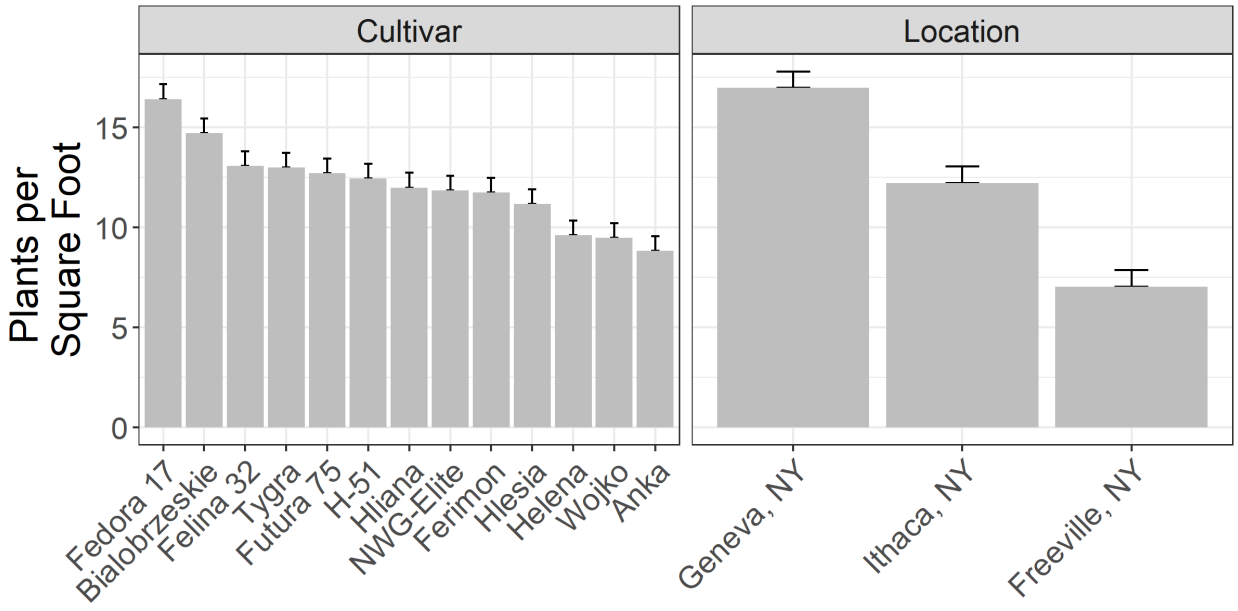

Figure 5. 2019 NY hemp seedling establishment for dual-purpose cultivars and by trial location.

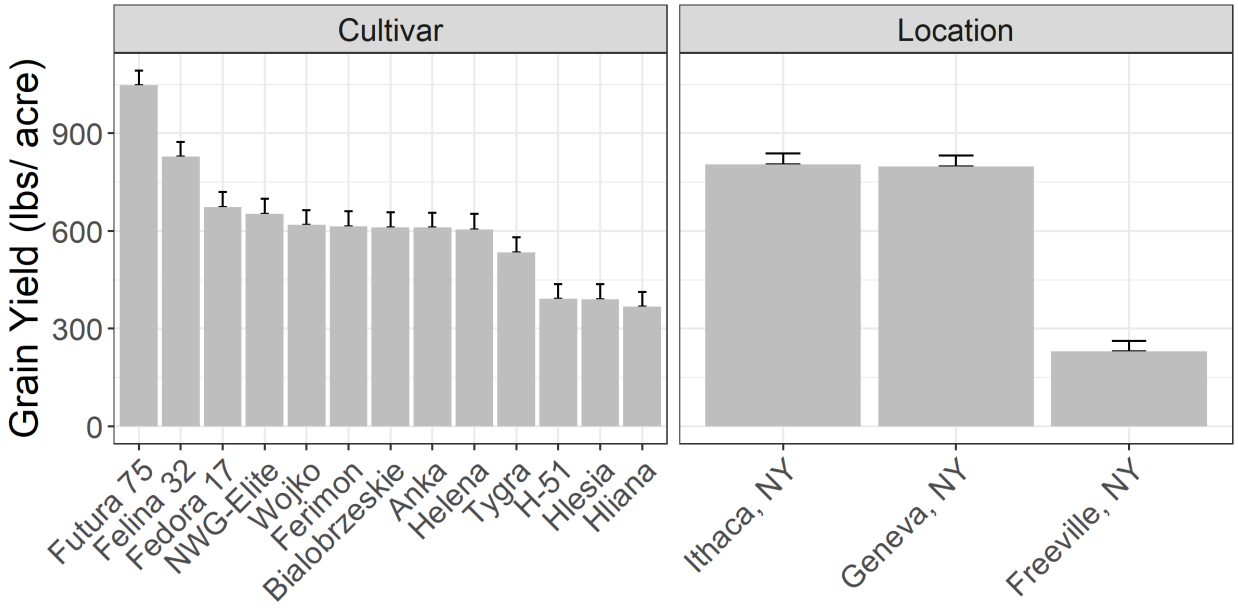

Figure 6. 2019 NY hemp dual purpose grain yield means by cultivar and trial.

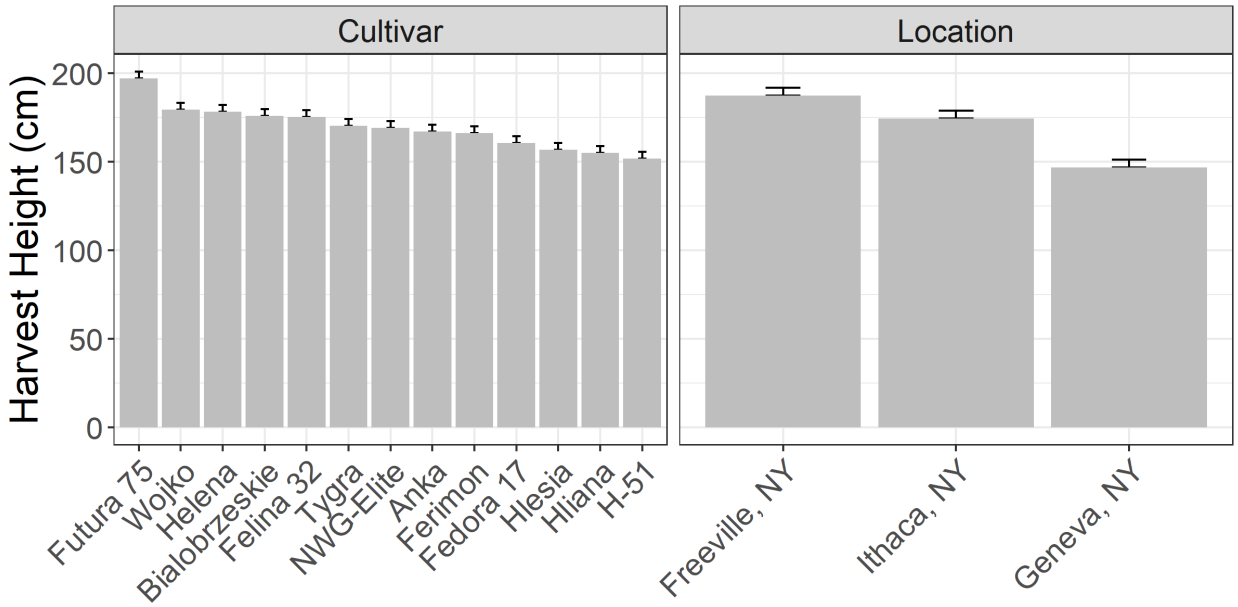

Figure 7. 2019 NY Hemp dual-purpose height means by cultivar and trial.

Chinese Cultivars from CN Kenaf & Hemp Seed Farm

All nine cultivars from CN Kenaf & Hemp Seed Farm were planted in the Geneva trials, but because of very poor germination (14%), 'Han-FH-Q' was not included in the Ithaca trial. The other eight cultivars had germination rates ranging from 48% - 85%. Seeding rates were corrected to reflect seed size and germination. Plants per square foot ranged from 7.9 to 20.0. The three cultivars that were earlier maturing and were harvested for grain were also the top three for stand (mean=17.4 seedlings per square foot). The six cultivars harvested exclusively for fiber averaged 10.4 seedlings per square foot (Figure 8).

The entries were still vegetative or beginning to flower when all other entries were harvested for grain. Grain harvest, completed in two replications of three entries, occurred a full month after all other grain harvest was complete. These three entries were among the four shortest Chinese cultivars (Figure 9). Ithaca harvest was completed by hand and not with a combine, so grain yields in Ithaca will be inflated. Chinese cultivar grain yields ranged from 1853 to 2167 pounds/acre in the Ithaca trials compared with the 1366 pounds/acre average of the two highest yielding cultivars in the grain and dual trials. In Geneva, only 'Han-FN-H' was harvested for grain, and yielded 1167 pounds/acre compared with the 1132 pounds/acre average of the two highest yielding cultivars in the grain and dual trials (Figure 10).

In the same week as grain harvest, all remaining plots were cut with a sickle bar mower and left for retting. Because stands were thinner than in standard fiber trials, the hemp stems had a much larger diameter: many plants were 8 cm or wider at the base (compared to 3 cm maximum in the fiber trial). The thicker stems also had a much larger percentage of hurd to bast fibers and took a longer time to ret. Since this harvest occurred late in the fall, the plots in Ithaca were weighed before the stems were fully retted so that the field could be prepared for early spring planting. Because of this, the fiber yields in Ithaca are significantly inflated (Figure 11).

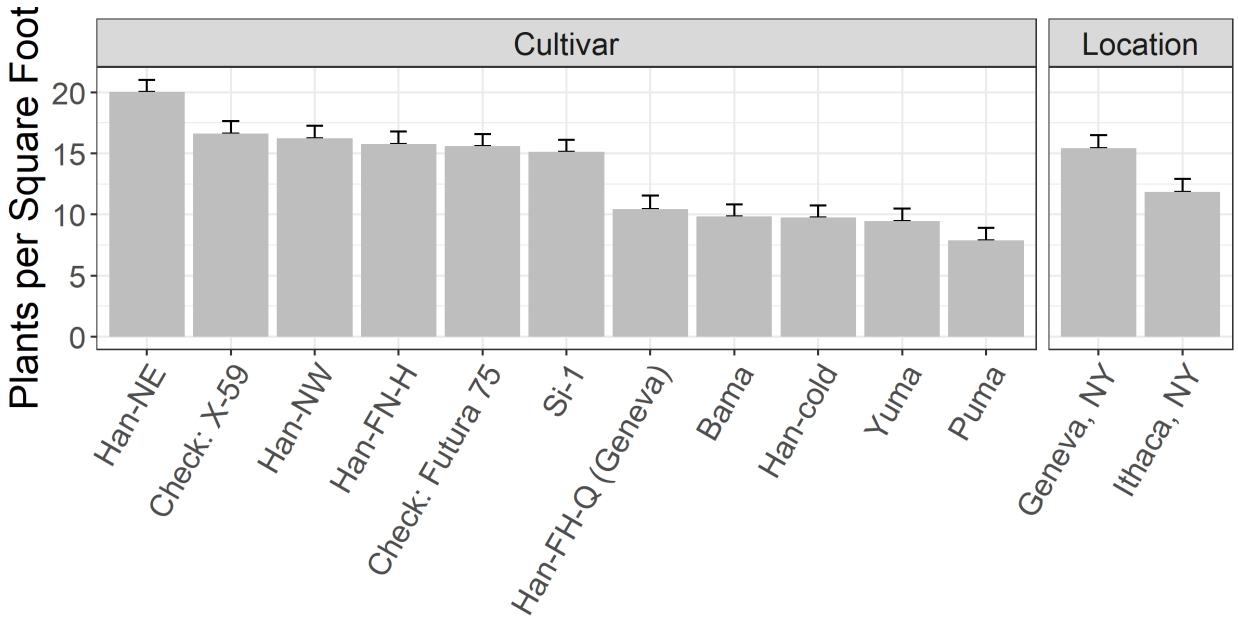

Figure 8: 2019 NY hemp seedling establishment for Chinese cultivars and by trial location.

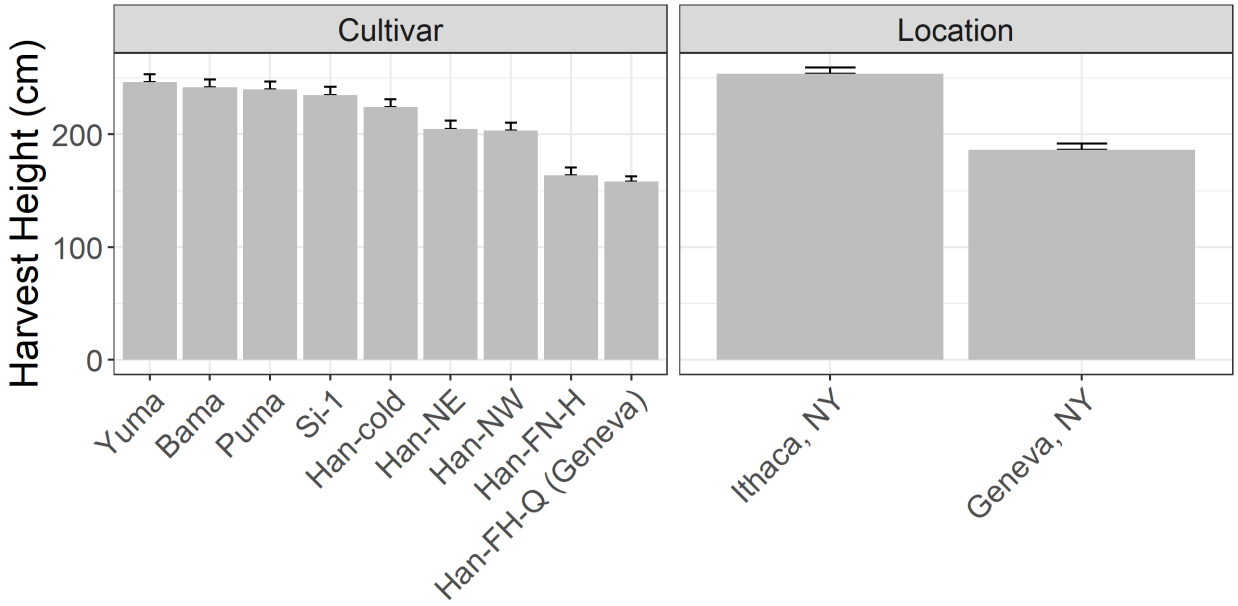

Figure 9: 2019 NY hemp height at harvest for Chinese cultivars and by trial location.

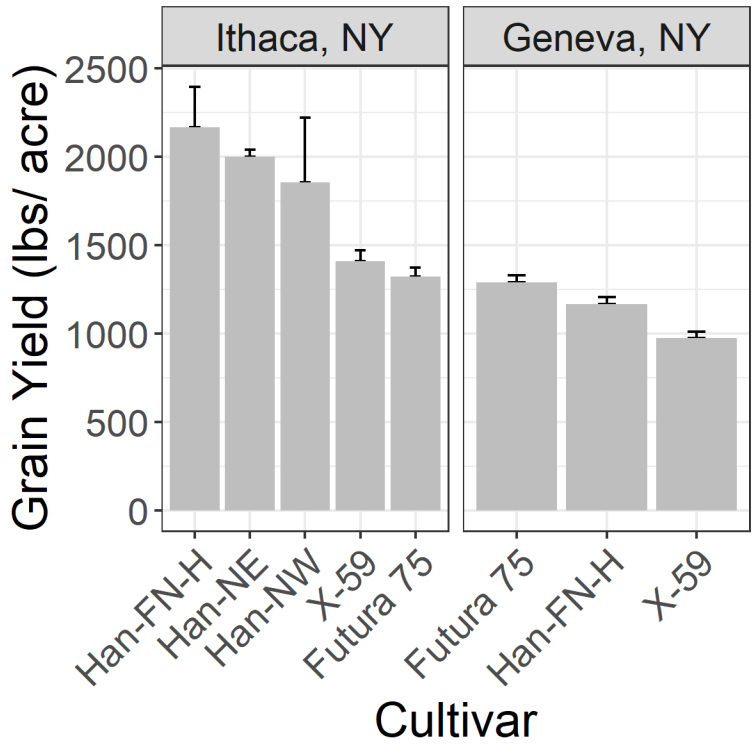

Figure 10: 2019 NY grain yields for Chinese cultivars by trial location.

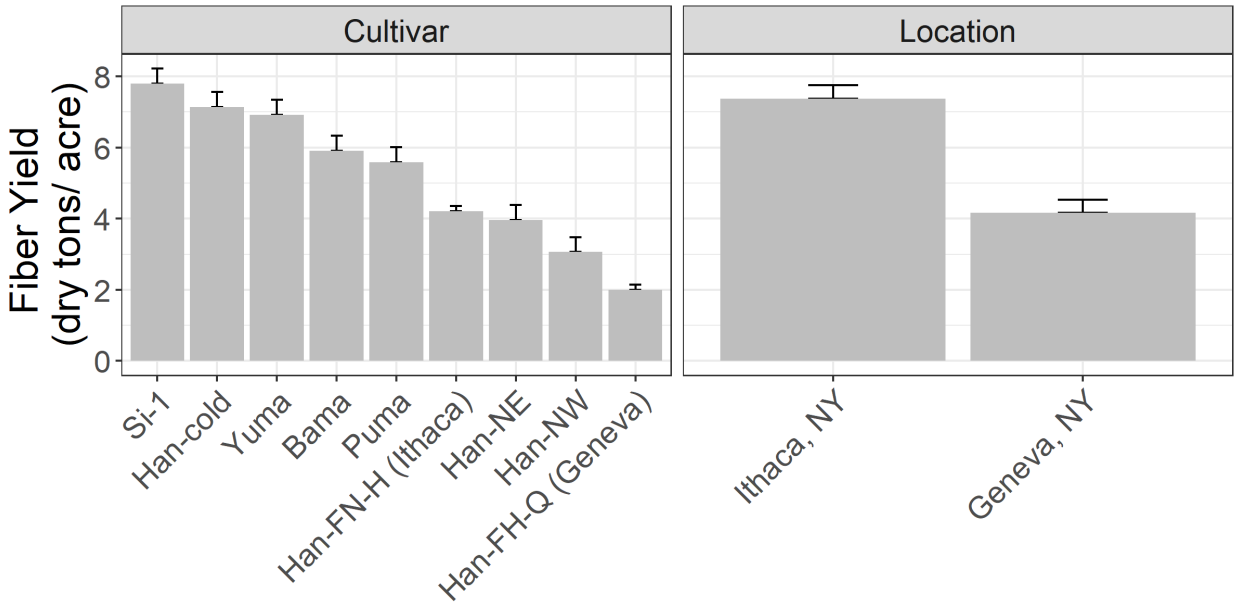

Figure 11: 2019 NY fiber yields for Chinese cultivars and by trial location.

Grain quality

Harvested grain had very different quality characteristics both among cultivars and locations. The thousand kernel weight (TKW) of the largest seeded entry was almost three times the size of the smallest one (9.0-26.6 grams). TKW also varied widely by location with cultivars averaging 16.5 grams in Ithaca and 13.2 grams in Geneva (Figure 12). Crude protein ranged from 23.7-26.7% of the dry weight and was somewhat inversely correlated with the seed size. By location, values ranged from 24.1% in Freeville to 26.3% in Geneva (Figure 13).

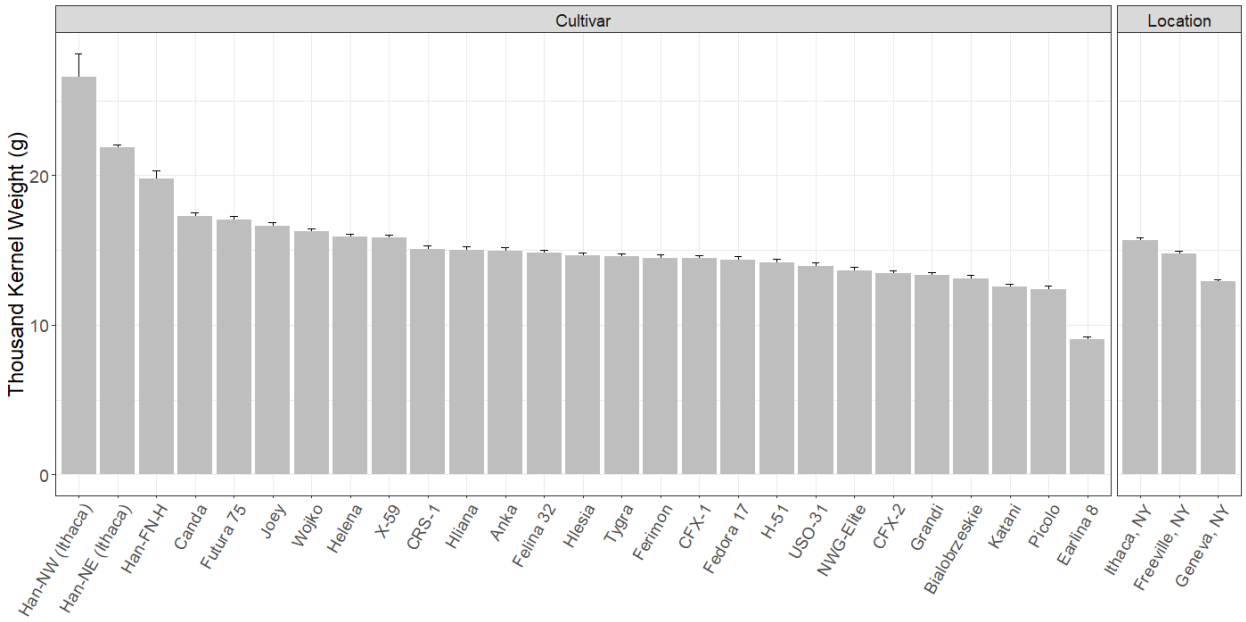

Figure 12: 2019 Thousand kernel weights (TKW) for all harvested for grain by cultivar and trial location.

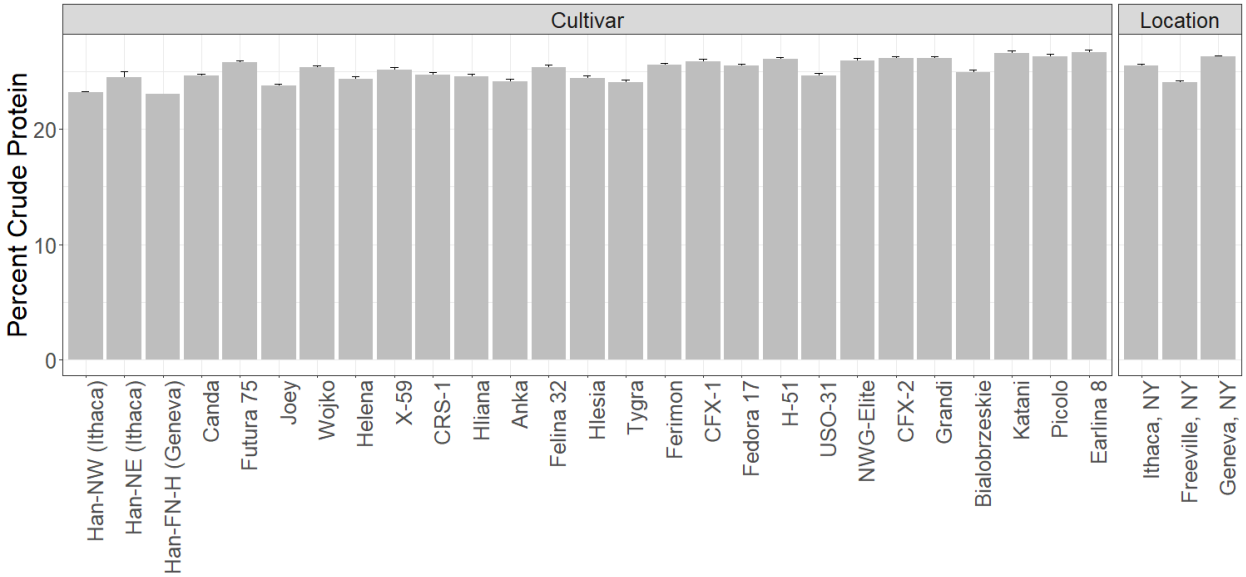

Figure 13: 2019 Crude protein content for all harvested grain by cultivar and trial location.

Total fatty acids ranged from 28.2-31.9 % of the dry weight with Omega-3s averaging 4.9% and Omega-6s averaging 17.5% of the dry weight. By location, total fatty acids ranged from 29.1% in Geneva to 30.8% in Freeville (Figure 14). Fiber content in the grain ranged from 31.7-37.8% of the dry weight. By location, fiber values ranged from 33.8 % in Geneva to 35.9 % in Freeville (Figure 15).

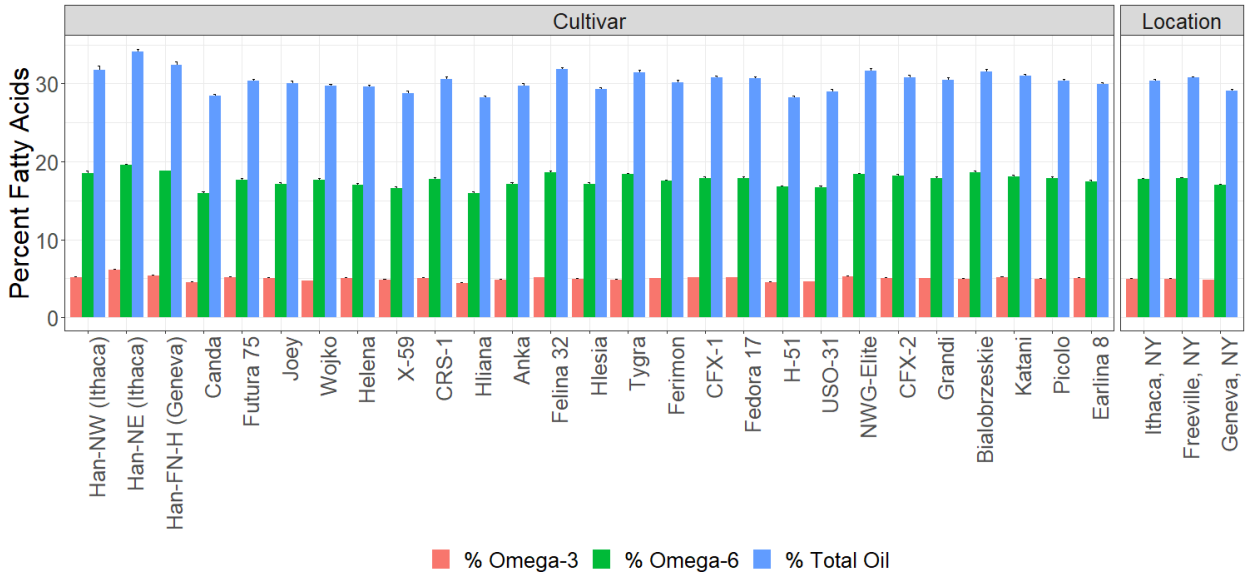

Figure 14: 2019 Fatty acid content for all harvested grain by cultivar and trial location.

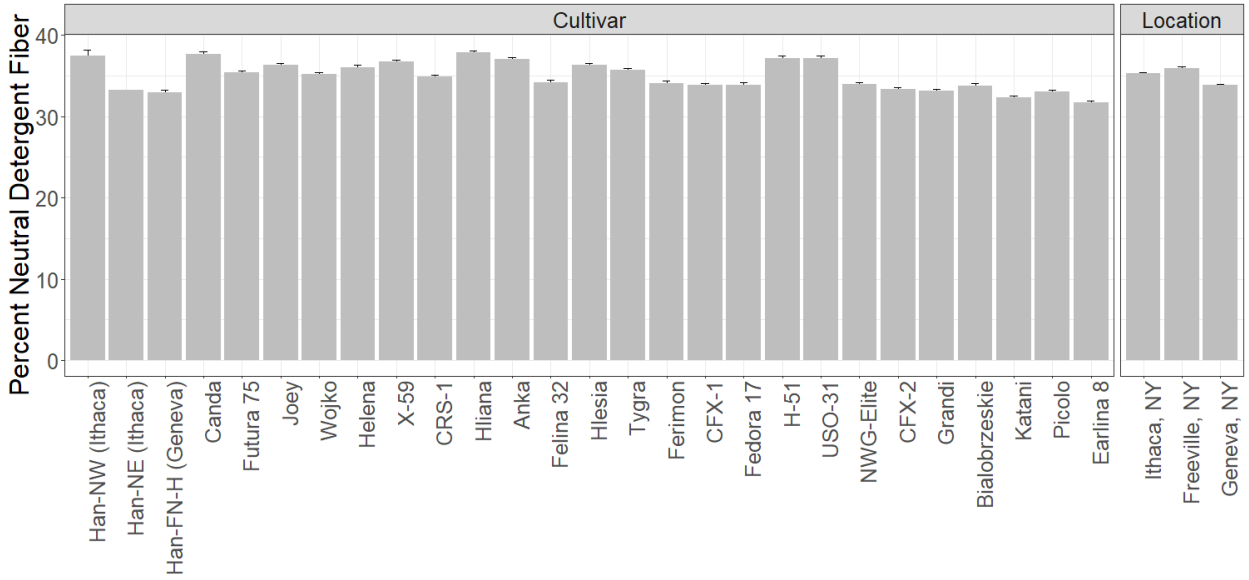

Figure 15: 2019 Fiber content for all harvested grain by cultivar and trial location.

Cannabinoids

Analysis of cannabinoids was conducted on the top 5 cm of female flower shoots from all plots across all trials. Two cultivars exceeded the mean Δ^9-THC content 0.3%: 'Han-FN-H' in Geneva (0.795%) and in Ithaca (0.440%) and 'Si-1' in Geneva (0.499) (Fig. 16). All other cultivars in grain dual purpose and fiber trials met regulatory compliance for Δ^9-THC content. 'Hlesia', 'Hliana', and 'H-51' each had a mean Δ^9-THC content <0.005% across all locations. Fiber and grain produced by cultivars non-compliant for Δ^9-THC content were destroyed.

Total CBD (CBD + 0.88*CBDA) varied significantly by cultivar, with trial averages ranging from 0.588% to 1.024%. The greatest mean CBD content of a cultivar in any trial was 'Futura 75' at the dual-purpose trial in Freeville, NY, which was 2.232%. The lowest mean CBD of any cultivar in any trial was 'Hlesia' (0.011%) in the Geneva, NY dual-purpose trial. CBD, CBC, and CBG content also varied significantly by cultivar (Fig 17).

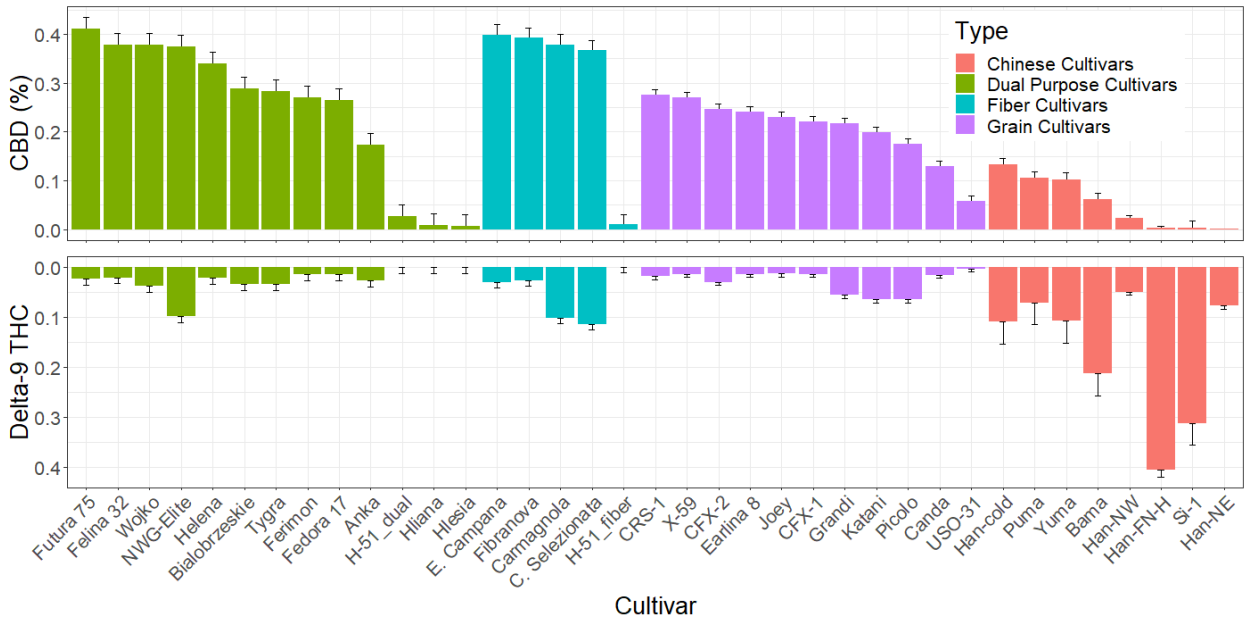

Figure 16. Total CBD and Δ^9-THC by % dry weight by cultivar, averaged over all trial locations. For both panels, cultivars are ordered by hemp type, then % CBD (top panel).

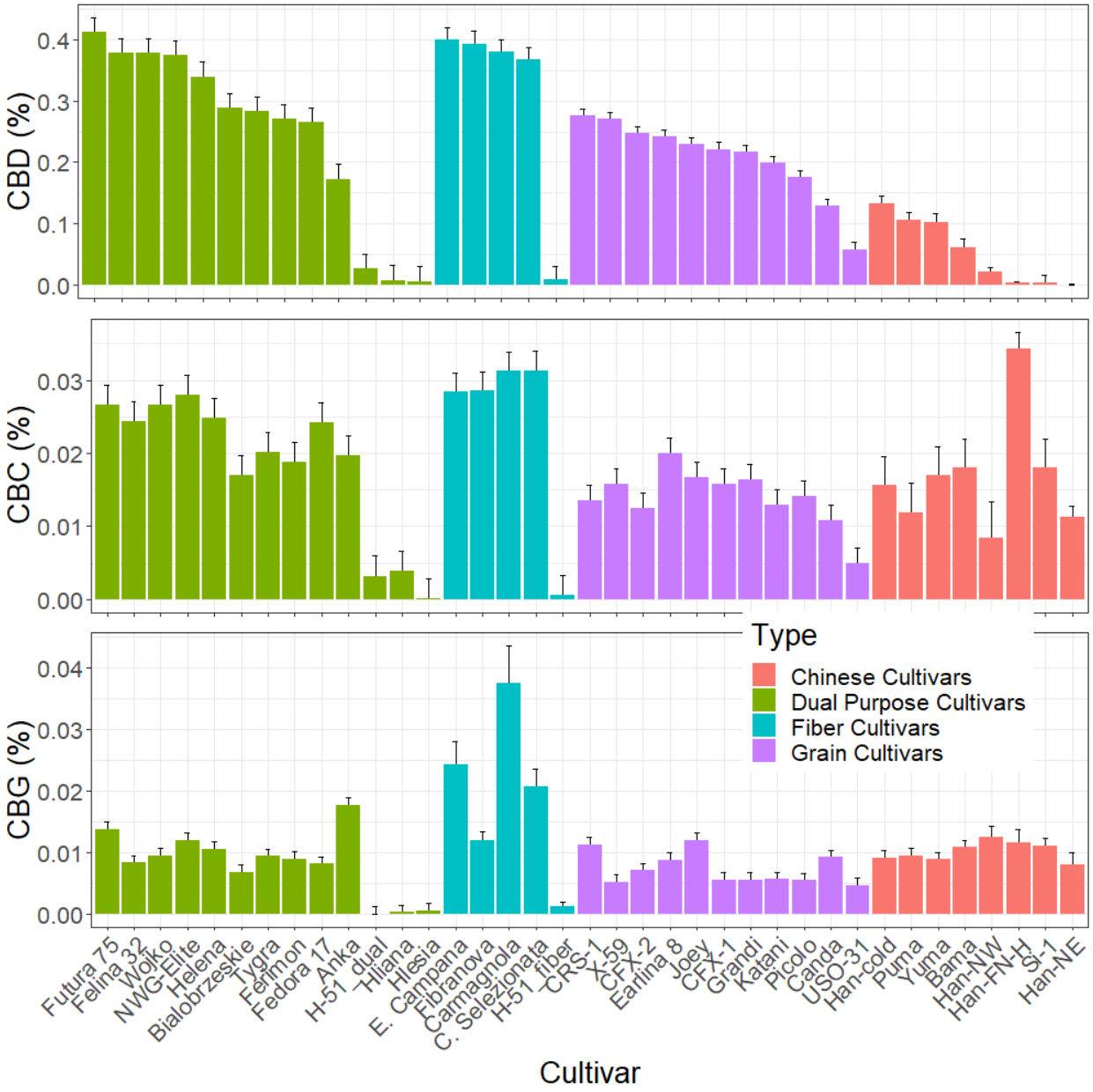

Figure 17. Total CBC, CBD, and CBG by % dry weight by cultivar, averaged over trial locations. Cultivars are ordered by hemp type, then % CBD.

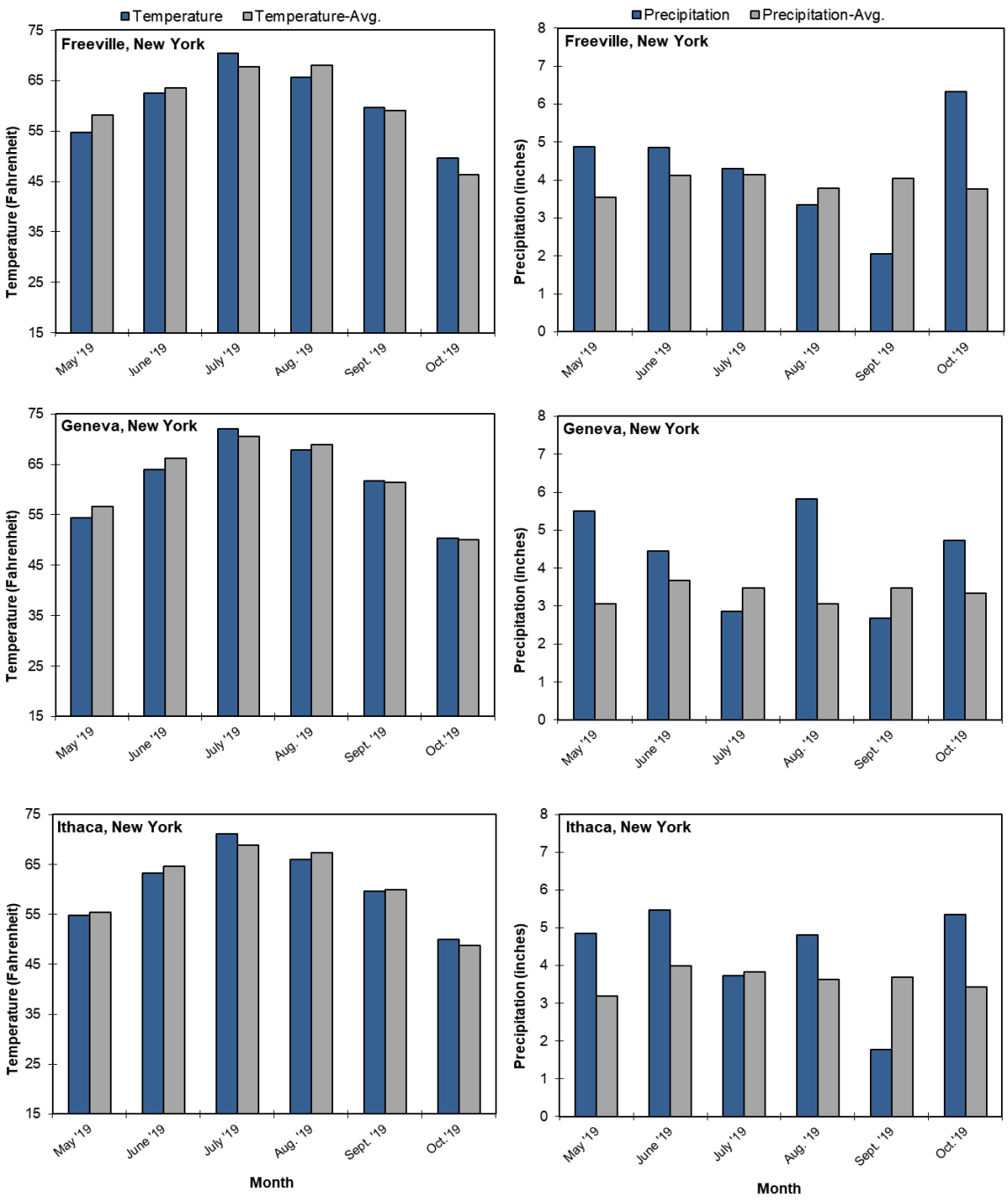

Figure 18. Growing season temperature and precipitation for locations: Freeville, Geneva, and Ithaca, NY (May 2019 - October 2019). Weather data from the Northeast Regional Climate Center at Cornell University (http://www.nrcc.cornell.edu/).

Discussion

Birds had an enormous impact on field establishment and grain yields in 2019, especially in Freeville. Because of this, Freeville will no longer be used as a trial site going forward. A propane bird-scare cannon was used at the Ithaca location and provided some protection for the trials, but there was a point in the fall when the flock of song birds was unfazed by the noise and instantly returned to the trial to continue feeding. In the future, a "laser scarecrow" may be used for bird control in Geneva. At a minimum, trial locations going forward need to be located farther from tree lines and buildings where birds can shelter.

The cultivars from CN Kenaf & Hemp Seed Farm were phenotypically distinct from the cultivars we have included in past years. The very late flower dates and resulting large biomass produced by some of these cultivars make them excellent candidates for fiber production in New York. The larger size of harvested grain and higher fatty acid content could be useful depending on the crops intended end use. Using molecular marker analysis, we learned that these populations all had a high proportion of plants expressing THCA synthase and are at risk of being non-compliant for total THC.

In 2020, we established replicated plot trials in Ithaca and Geneva. Entries that were lower yielding in previous years were excluded. The Geneva location had poor establishment because of dry conditions and the Ithaca location had poor establishment in some trials due to broken planting equipment. Once the seeder was repaired, grain and dual-purpose trials in Ithaca were replanted, and four cultivars were planted in a strip trial in Geneva for harvest with a newly purchased stripper header.

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