# 2018 Hemp Trials for New York State Grain, Dual Purpose, and Fiber Production


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## Introduction

Hemp (*Cannabis sativa*) is a multipurpose crop that grows well in New York State (NYS). Hemp has less than 0.3 % tetrahydrocannabinol (THC) and is used for fiber, hempseed oil, and seed or grain production. In 2016, after decades of prohibition, NYS began to permit hemp research. Commercially available cultivars from Europe and Canada have been bred for enhanced production of oil, fiber or both but have limited or no testing in NYS. The 2018 Farm Bill removed hemp from the controlled substance list and relaxed restrictions on the cultivation of hemp and the sale, transport, and possession of hemp products. The market potential for hemp and its products, including food, personal care, health and supplements, animal feed, textiles and industrial products is estimated to grow to two billion dollars or more by 2020.

Because many available hemp cultivars were developed in environments very different than NYS, it is critical to test hemp cultivars to determine which are well adapted to NYS and will be high yielding across and within NYS's range of soil types and environments. This report presents data from hemp trials conducted by researchers from Cornell University in NYS in 2018. Grain, dual purpose (grain and fiber), and fiber hemp cultivars were tested in fields near the cities/towns of Ithaca, Geneva, Chazy, and Riverhead, as well as a certified organic field near Freeville. Data consist of grain and fiber yield and cannabinoid content. Additional analyses for quality components and mycotoxin concentrations are ongoing. In 2019, many of these cultivars, as well as additional cultivars from China and other countries, will be tested.

## Methods

Hemp grain, dual purpose (grain and fiber), and fiber trials were planted at six locations (Table 1). 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 and were analyzed using standard ANOVA (analysis of variance).

*Planting hemp grain trial in Riverhead, NY*

Seeding rates were based on pure live seed (PLS). Planting was accomplished using a cone seeder at 15 PLS per square ft for grain and dual purpose cultivars and 30 PLS per square ft for fiber cultivars. Trials were fertilized prior to planting with 70 pounds of nitrogen per acre as 22-9-9 and then, at three weeks, top dressed with 70 pounds per acre of nitrogen as ammonium sulfate (21-0-0). The organic Freeville strip trial was amended with 70 pounds of nitrogen per acre as 5-4-3 pelleted composted chicken manure.

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

| Location | Latitude | Planting date | Soil type | Natural Drainage Class* |
|---|---|---|---|---|
| Chazy, NY | 44.89 N | June 20 | Mino loam | Somewhat poorly drained |
| Freeville, NY | 42.52 N | June 11 | Rhinebeck silt loam | Somewhat poorly drained |
| Geneva, NY (CN) | 42.88 N | June 15 | Odessa silt loam | Somewhat poorly drained |
| Geneva, NY (RS) | 42.87 N | June 15 | Lima loam | Moderately well drained |
| Ithaca, NY (MG) | 42.45 N | June 12 | Niagara silt loam | Somewhat poorly drained |
| Riverhead, NY | 40.95 N | June 8 | Haven loam | Well drained |

*Tile drainage in most fields. All locations are part of Cornell University Agricultural Experiment Station (https://cuaes.cals.cornell.edu/) or Cornell AgriTech (https://agritech.cals.cornell.edu/), except for Chazy which is a field at the William H. Miner Agricultural Research Institute (http://www.whminer.org/).

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.

Fiber trials were harvested between flowering and seed set (~75 days after planting) with sickle bar mowers. Biomass was weighed, sampled for percent dry matter, and then spread out in an even layer for field retting. Hemp stems were monitored until fully retted. The retted plots were again weighed and sampled for percent dry matter. Yields are reported as retted stem dry weight 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, except that seed heads from the Ithaca dual trial were harvested by hand when each cultivar was determined to be sufficiently mature. The Riverhead grain and dual purpose trials were not harvested because of logistic issues related to combine availability. The grain trial at Geneva (RS) was completely overcome by weeds and was abandoned. Harvested grain was dried in forced air ovens at 35ºC until a stable moisture was achieved (6-8% moisture). Clean grain yield and test weight data have been collected. Grain samples from each plot have been preserved in order to collect thousand kernel weight (TKW) and near infrared spectroscopy (NIRS) scan. Using NIRS, equations will be developed in order to predict quality components, including crude protein, fiber as neutral detergent fiber (NDF), and fatty acid profile. Selected samples will be sent to a diagnostic lab, such as Dairy One (dairyone.com), in order to refine or further validate the NIRS equations.

**Table 2.** Fiber, grain, and dual purpose cultivar information.

| Entry | Seed Company | Purity | Germ | TSW | Days to Maturity |
|---|---|---|---|---|---|
| ***Fiber Type*** | | | | | |
| Carmagnola | Schiavi Seeds LLC | 0.9905 | 0.87 | 16.3 | - |
| Carmagnola Selezionata | Schiavi Seeds LLC | 0.9963 | 0.84 | 21.6 | - |
| Eletta Campana | Schiavi Seeds LLC | 0.9882 | 0.72 | 15.6 | - |
| Fibranova | Schiavi Seeds LLC | 0.9719 | 0.47 | 15.2 | - |
| Futura 75 | AssoCanapa | 0.9977 | 0.84 | 17.9 | 145 |
| SS Alpha | Sunstrand | 0.9685 | 0.42 | 16.7 | - |
| Tygra | AssoCanapa | 0.9996 | 0.85 | 13.9 | 135 |
| ***Grain Type*** | | | | | |
| CFX-1 | Hemp Genetics Intl | 0.9922 | 0.71 | 16.2 | 105 |
| CFX-2 | Hemp Genetics Intl | 0.9972 | 0.9 | 16.5 | 103 |
| CRS-1 | Hemp Genetics Intl | 0.9986 | 0.88 | 18.4 | 110 |
| Grandi | Hemp Genetics Intl | 0.9953 | 0.93 | 16.5 | 100-110 |
| Katani | Hemp Genetics Intl | 0.9934 | 0.75 | 15.6 | 100-110 |
| Pewter River | Winterfox Farms | 0.9929 | 0.39 | 22.0 | 90-120 |
| Picolo | Hemp Genetics Intl | 0.9991 | 0.97 | 16.2 | 100-110 |
| Portugal | Winterfox Farms | 0.9946 | 0.43 | 15.1 | 90-110 |
| Swift | Winterfox Farms | 0.9905 | 0.87 | 11.8 | 100-120 |
| USO-31 | AssoCanapa, UNISeeds | 0.9966 | 0.69 | 17.4 | 110 |
| X-59 | Legacy Hemp | 0.9985 | 0.94 | 15.9 | 100 |
| ***Dual Type*** | | | | | |
| Anka | UNISeeds | 0.9975 | 0.87 | 15.7 | 110 |
| Bialobrzeskie | AssoCanapa, Bija Seeds | 0.9994 | 0.92 | 14.0 | 135 |
| Canda | Parkland Industrial Hemp Growers | 0.9979 | 0.93 | 15.9 | 100-120 |
| Felina 32 | AssoCanapa, Schiavi Seeds | 0.9989 | 0.75 | 15.8 | 135 |
| Ferimon | UNISeeds | 0.9979 | 0.91 | 13.7 | 125 |
| Futura 75 | AssoCanapa | 0.9977 | 0.84 | 17.9 | 145 |
| Helena | Schiavi Seeds | 0.9996 | 0.86 | 12.8 | - |
| Joey | Parkland Industrial Hemp Growers | 0.9965 | 0.86 | 14.6 | 100-120 |
| Nebraska Feral | Winterfox Farms | 0.9719 | 0.57 | 10.7 | 120 |
| NWG-331 | New West Genetics | - | 0.95 | 11.2 | - |
| NWG-Elite | New West Genetics | 0.9938 | 0.89 | 9.8 | - |
| Rocky Hemp | Winterfox Farms | 0.9951 | 0.29 | 21.1 | 120-150 |
| SC-1 | PreProcess Inc. | - | - | 25.7 | - |
| Sterling Gold | Winterfox Farms | 0.9941 | 0.37 | 20.5 | 120-150 |
| Tygra | AssoCanapa | 0.9996 | 0.85 | 13.9 | 135 |
| Wojko | AssoCanapa | 0.9951 | 0.54 | 15.2 | 135 |

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

| Location | Grain | Dual Purpose | Fiber – green | Fiber - retted |
|---|---|---|---|---|
| Chazy, NY | 10/16 | 10/17 | 9/12 | 10/22 |
| Freeville, NY | 10/9-10/10 (3 Reps) | 10/10, 10/15 (3 Reps) | 9/6-9/7 | 9/28 |
| Geneva, NY (CN) | 9/17 | 9/17 | 9/4 | 10/1 |
| Geneva, NY (RS) | Not harvested | 9/21, 9/24 | | |
| Ithaca, NY (MG) | 9/21-10/12 (3 Reps) | 10/5-10/12 | 8/30-8/31 | 9/24 |
| Riverhead, NY | Not harvested | Not harvested | 9/14 | 10/18 |

## Results

### *Fiber Trials*

Seedling counts

For the fiber trials, seven cultivars were planted in six trials. Seed germination rates for the cultivars in the fiber trials ranged from 42 to 87%. Seeding rates were corrected so that the same number of viable seeds were planted in each plot. Even with this correction, there were significant differences in seedling density in the trials. Cultivars with higher germination rates had higher numbers of seedlings per square foot. This would suggest that there are seedling vigor differences in addition to germination differences. Overall, seedling stands were much denser for Riverhead and Chazy, compared to other trial locations (Fig. 1). Stand counts in seedlings per square foot ranged from 10-17 in Geneva (CN001 and RS059), 9-14 in Ithaca (McGowan), 11-18 in Freeville, 18-26 in Riverhead, and 22-31 in Chazy. Both Chazy and Riverhead had more soil moisture at planting than Freeville, Ithaca, and Geneva. In addition, soil temperatures were warmer at the time of planting in Chazy.

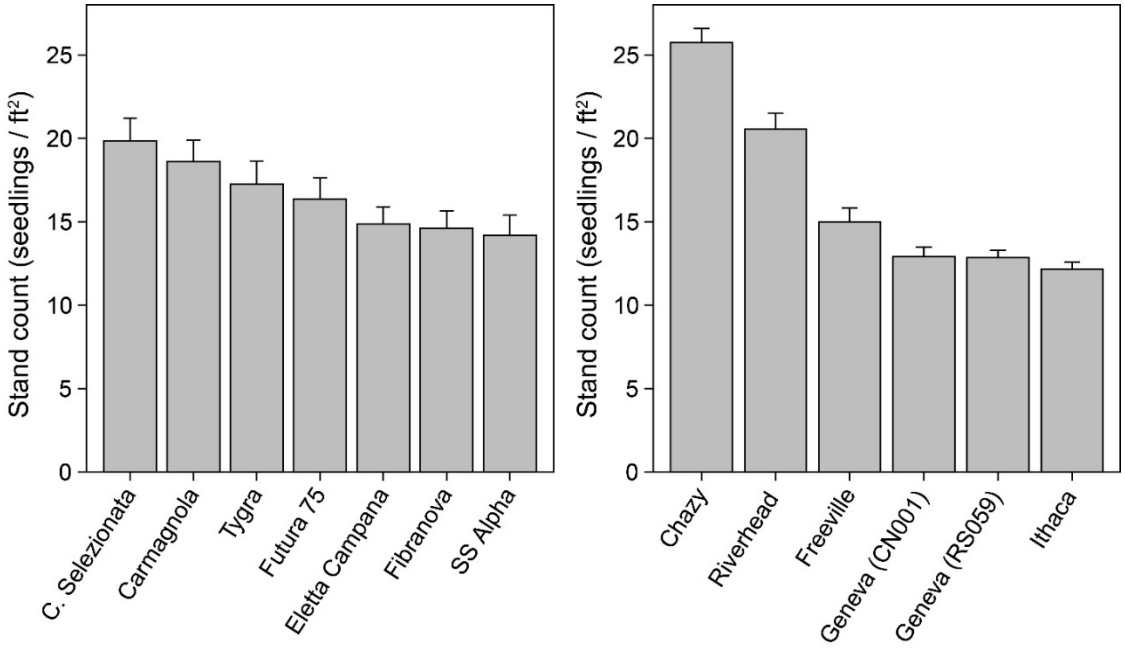


**Figure 1.** 2018 NY hemp seedling establishment for fiber cultivars and by trial location.

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 2.25-3.65 tons per acre. Freeville and Geneva (RS059) had the highest mean retted straw yields, whereas Geneva (CN001) and Chazy had the lowest mean retted straw yields.

*Retted straw in fiber trial in Geneva, NY*

Overall, ‘Carmagnola’, ‘Carmagnola Selezionata’ (C. Selezionata), and ‘Eletta Campana’ were the highest yielding cultivars (>3.2 tons per acre), but were not significantly different from ‘Fibranova’, ‘SS Alpha’, and Futura 75. ‘Tygra’ had consistently lower yields across all fiber trial locations (Figures 2 and 3), with a mean of 1.7 tons per acre. ‘Tygra’ had the earliest maturity and had ripe seed on all plants at harvest; this may explain its lower yields.

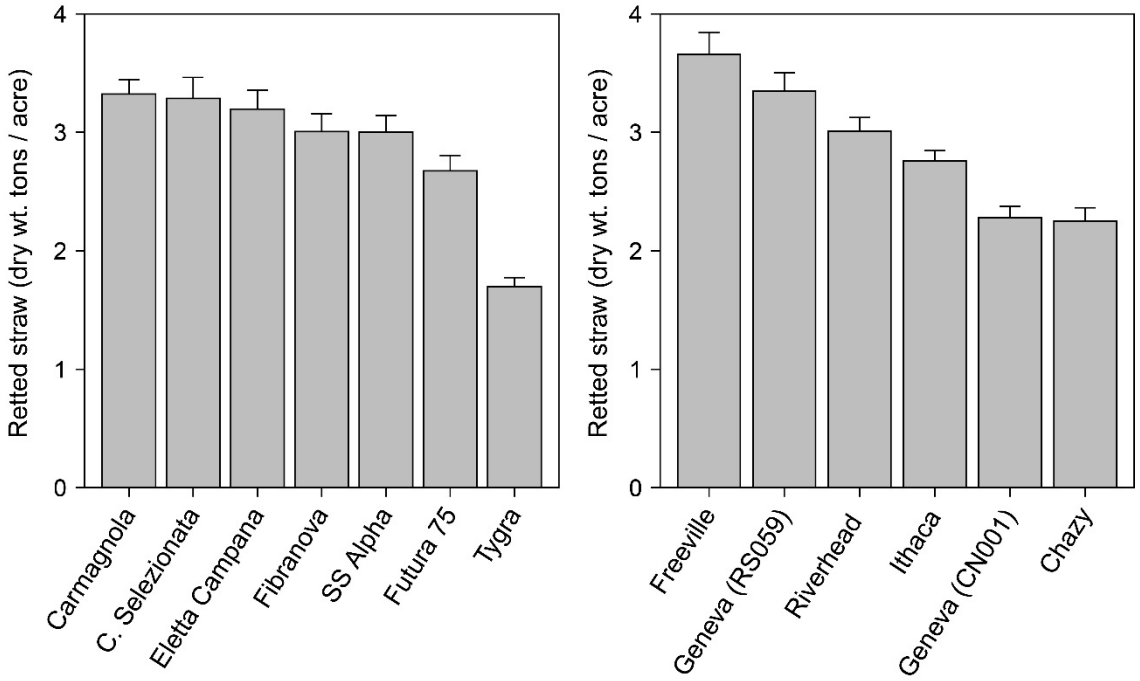


**Figure 2.** 2018 NY hemp retted fiber yield by cultivar averaged across six locations and by trial.

***Grain Trials***

Seedling counts

For the grain trials, eleven hemp cultivars were planted in six trials. The number of hemp plants per plot, or stand was greatest at Riverhead, Long Island and Chazy (Fig. 3). Geneva (RS059) had poor stands due to below average precipitation during the first few weeks of seedling establishment. All hemp cultivars had similar establishment and the average number of seedlings per square foot over locations ranged from 7 to 9.

*Harvesting the Geneva (CN001) grain trial*

Harvest yields

Plots were harvested and threshed grain was cleaned and dried to 6-8% moisture. Harvest dates ranged from the middle of September through the middle of October. Means for grain cultivars and trials are presented below. (Fig. 4). By cultivar, grain yields ranged from 456 to 1152 pounds per acre. By location, grain yields ranged from 511 to 805 pounds per acre. The Geneva location was harvested earliest, while the Chazy location was harvested latest and these may account for their status as the highest and lowest yielding locations respectively. At Freeville and Ithaca, yields were likely suppressed by late harvest and weed competition. 'Pewter River' and 'Portugal' were both taller and later maturing in NY than described by the providing seed company. These varieties should have been included in the dual purpose trial and not in the grain trials.

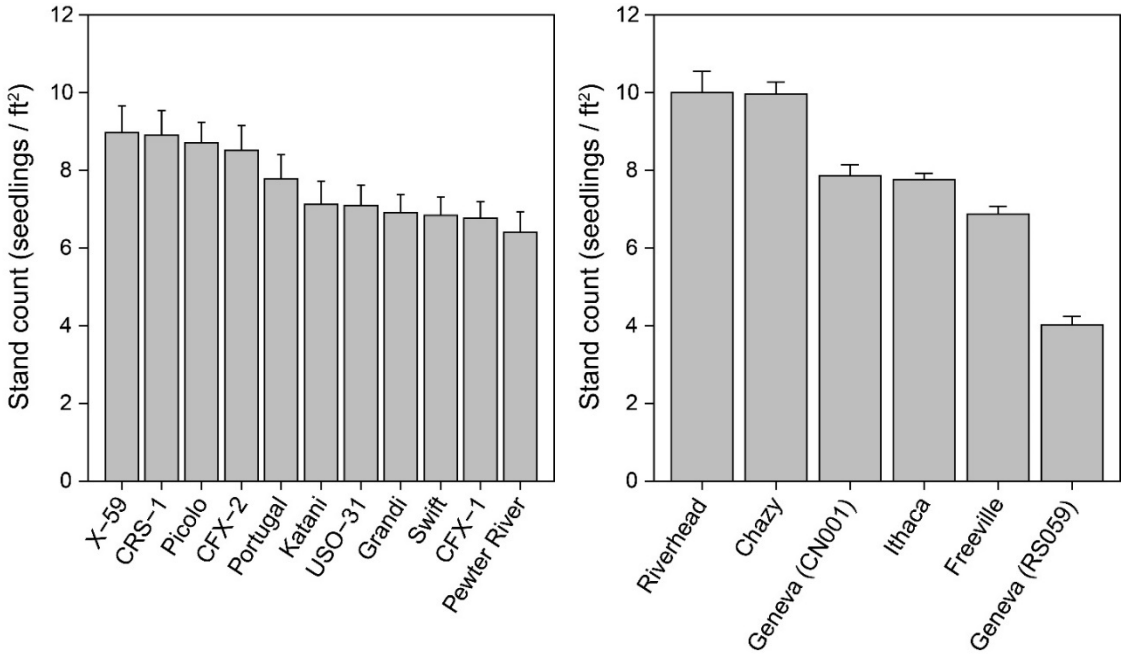


**Figure 3.** 2018 NY hemp seedling establishment for grain cultivars and by trial location.

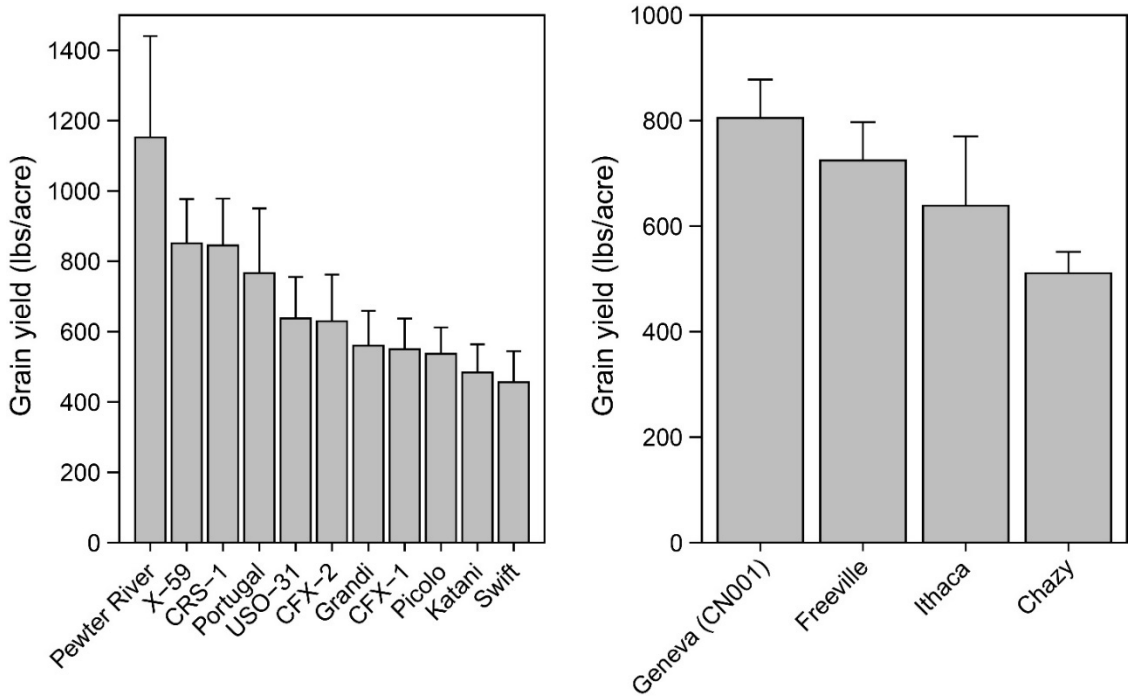


**Figure 4.** 2018 NY hemp grain yield by cultivar averaged across four locations and by trial.

***Dual Purpose Trials***

Seedling counts

For the dual purpose trials, fourteen hemp cultivars were planted in five trials, cultivars 'Rocky Hemp' and 'Sterling Gold' were planted at three and four of the five trials respectively, while cultivar 'SC-1' was only planted at the Geneva trials. This was because of limited seed availability in those cultivars. All dual purpose cultivars had similar seedling establishment, with a 6 to 9 seedlings per square foot (Fig. 5).

Harvest yields

Plots were harvested and threshed grain was cleaned and dried to 6-8% moisture. Harvest dates ranged from the middle of September through the middle of October. Means for dual purpose cultivars and trials are presented below (Fig. 6). By cultivar, dual purpose grain yields ranged from 271 to 816 pounds per acre. By location, dual purpose grain yields ranged from 225 to 815 pounds per acre.

The dual purpose trial consisted of many varieties that had not been tested in NY previously. The days to maturity advertised by the seed companies did not align with what we observed. We had intended this be a trial for later maturing varieties, but the dual purpose trial included cultivars that we observed to be 100 days to maturity, as well as those that are 150+ days to maturity, at the locations we evaluated. The performance of a cultivar was greatly determined by the timeliness of the harvest. That being said, some varieties performed very well in most locations. 'Futura 75' yielded better than the mean in all five harvested locations. 'Helena' and 'Nebraska

Feral' yielded better than the mean at four of the five locations. 'Anka,' 'Canda,' and 'NWG-331 yielded better than the mean at three of the five locations. Grain yields were greatest for the dual purpose organic trial in Freeville and lowest for the dual purpose trial in Chazy (Fig. 6), likely in part because of the timing of the harvest.

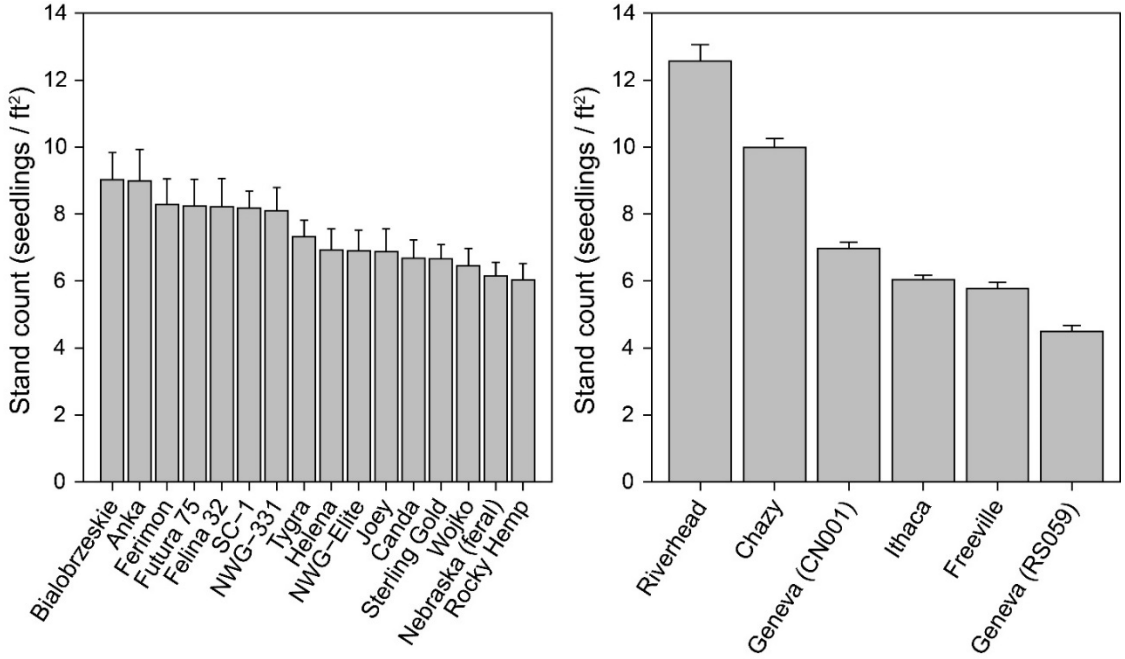


**Figure 5.** 2018 NY hemp seedling establishment dual purpose cultivars and by trial location.

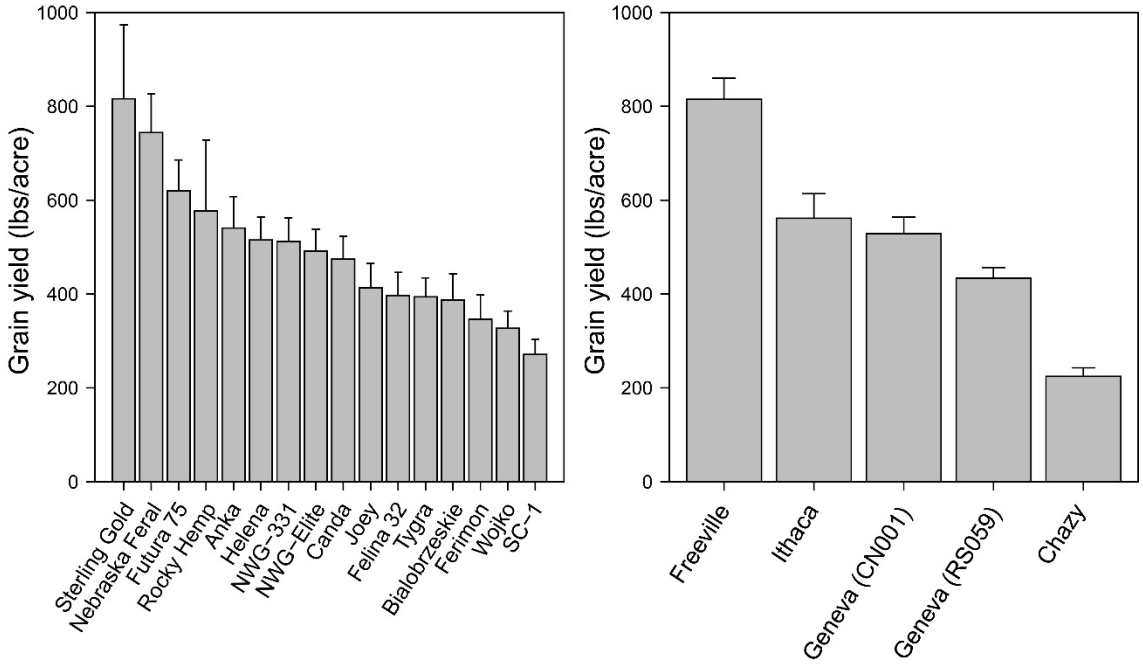


**Figure 6.** 2018 NY hemp dual purpose grain yield means by cultivar and trial.

***Cannabinoids***

Analysis of cannabinoids was conducted on female flower shoots from all plots across all trials, excluding the fiber trial in Riverhead, NY and grain trial in Chazy, NY. The greatest mean $\Delta^9$-THC content of a cultivar in any trial was 'SS Alpha' at the fiber trial in Freeville, NY, which was 0.28% (Fig. 7). The lowest mean $\Delta^9$-THC content of any cultivar was 'USO-31', which was < 0.005% across all locations. Importantly, all cultivars in grain dual purpose and fiber trials met regulatory compliance for $\Delta^9$-THC content.

*Sampling hemp shoots for cannabinoids*

Total CBD (CBD + 0.88*CBDA) varied significantly by cultivar, with trial averages ranging from 0.17% to 3.11%. The greatest mean CBD content of a cultivar in any trial was 'Nebraska Feral' at the dual purpose trial in Chazy, NY, which was 4.65%. The lowest mean CBD of any cultivar in any trial was 'Portugal' (0.09%) in the Freeville, NY grain trial. While high CBD did correspond with low THC for most cultivars, there were a handful of cultivars with CBC:THC ratios ~1. For instance, although 'Sterling Gold', 'Rocky Hemp', and 'SC-1' had below average % CBD in dual purpose trials, all three maintained higher CBC:CBD ratios. Promising dual purpose cultivars with exceptional grain yield and total CBC, CBD, and CBG content were 'Nebraska Feral' and 'Futura 75', whereas 'Carmagnola Selezionata' and 'Carmagnola' had relatively high fiber yields, as well as CBC, CBD, and CBG content (Fig 8).

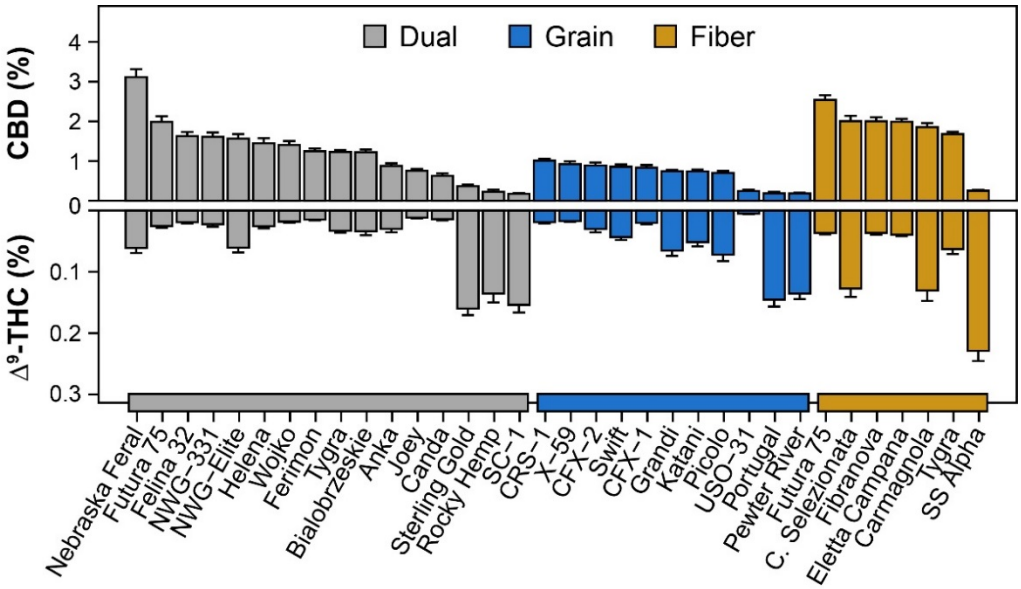


**Figure 7.** Total CBD and $\Delta^9$-THC by % dry weight by cultivar, averaged over all trial locations. For both panels, cultivars are ordered by hemp type, then % CBD (top panel).

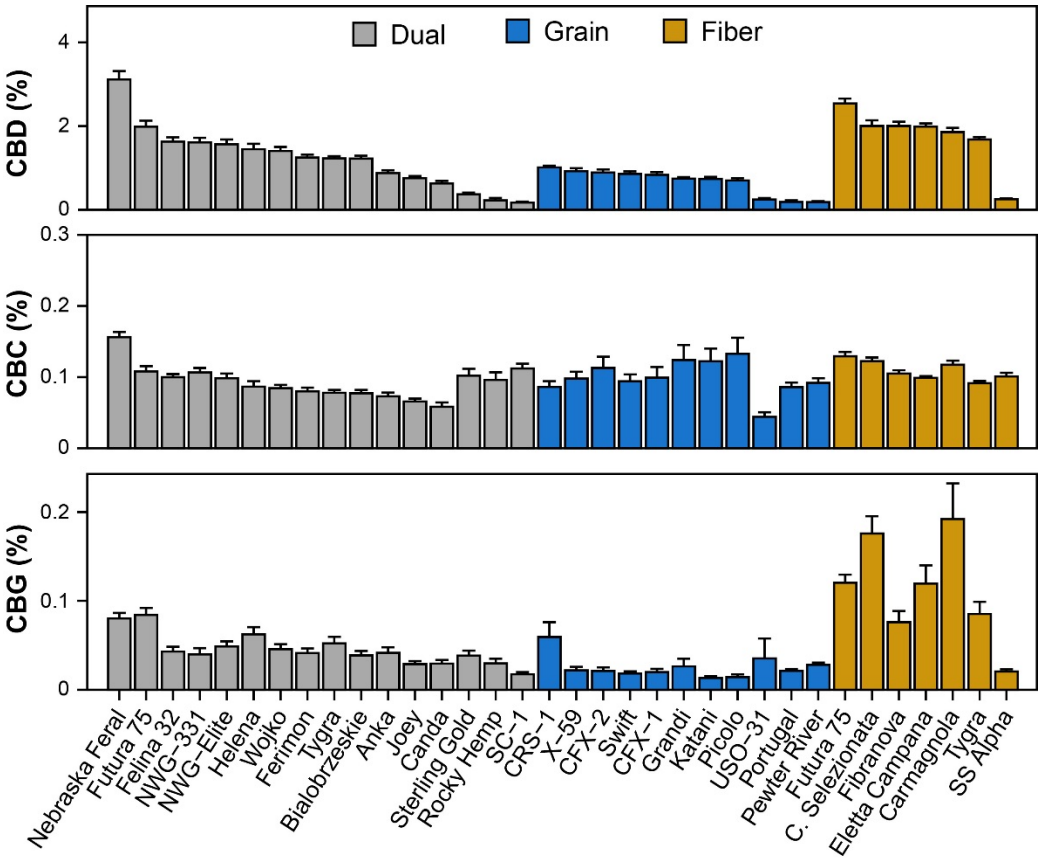


**Figure 8.** Total CBC, CBD, and CBG by % dry weight by cultivar, averaged over trial locations. Cultivars are ordered by hemp type, then % CBD.

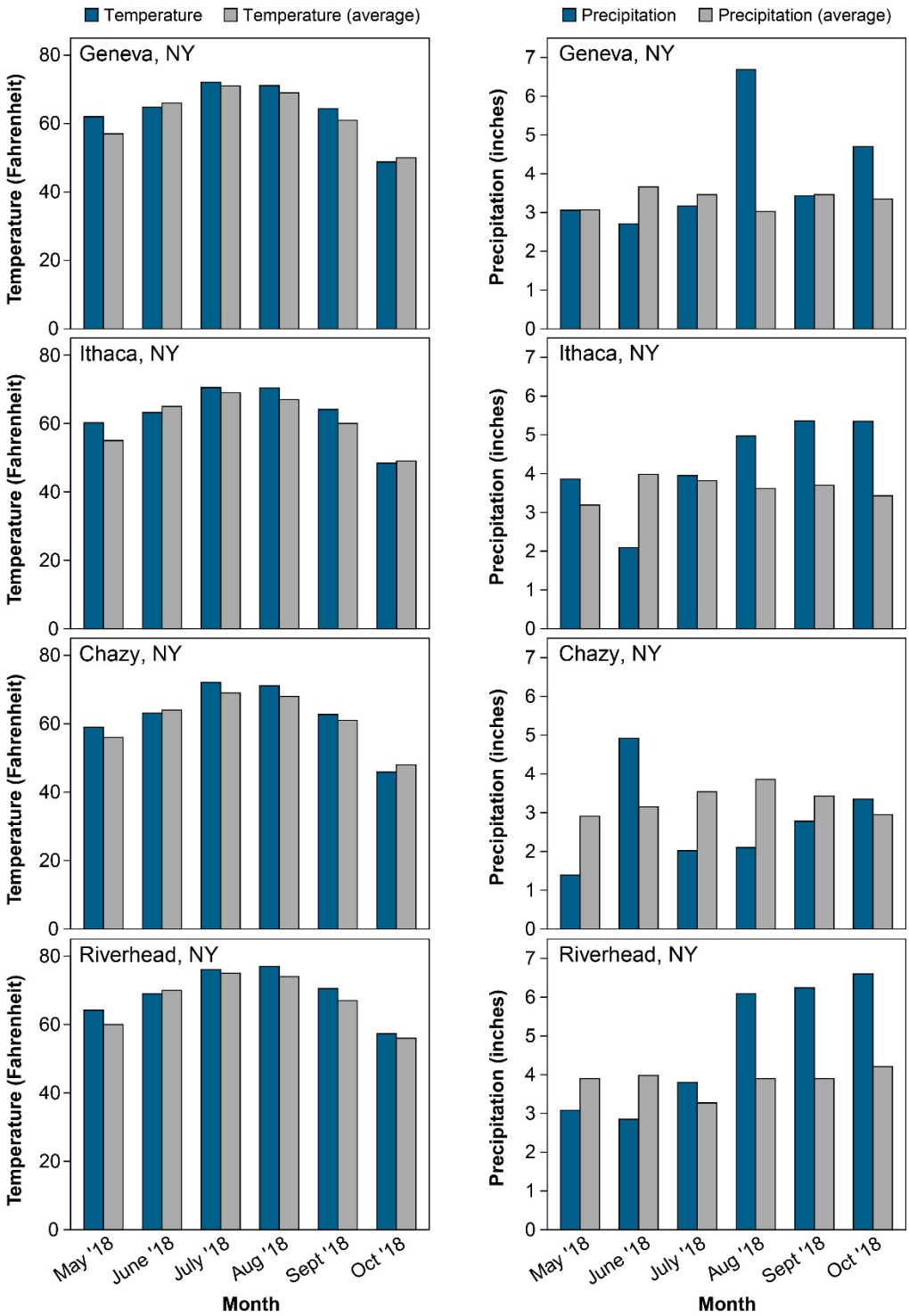


**Figure 9.** Growing season temperature and precipitation for growing locations. Geneva, Ithaca, Chazy, and Riverhead, NY temperature and precipitation (May 2018 - October 2018). Freeville was not included because weather data was not significantly different from Ithaca. Weather data from the Northeast Regional Climate Center at Cornell University (http://www.nrcc.cornell.edu/).

## Discussion

The weather had an enormous impact on our trials in 2018. All locations except Chazy were drier than average at the time of planting and for weeks after planting (Fig. 9). This resulted in lower seedling density and the seedlings that were present in the trials had a much slower growth rate that we observed in 2017. Plots of slow growing, sparse seedlings allowed for weed establishment and in many cases the weeds out competed the hemp plants and severely compromised yields. In spite of these challenges, the highest yielding cultivars in hemp grain trials (grain and dual purpose) in NYS averaged 984 pounds per acre which is comparable to average yields in non-irrigated hemp fields in Canada. Similarly, the hemp straw yield of the highest yielding cultivars in the fiber trials in NYS averaged 3.32 tons per acre which is also comparable to Canadian yields.

The hemp cultivars in our grain and dual purpose trials varied greatly in their number of days to maturity. Some cultivars are very short season (<90 days) and others were very long season (>120 days). However, in four of our five locations, all cultivars were harvested within a few days, which penalized early-maturing cultivars when the trial was harvested late and penalized late-maturing cultivars when the trial was harvested early. This fall, we purchased an additional combine so we can harvest cultivars in a timely matter. In addition, we will not plant grain trials in locations that do not have access their own combining equipment.

In 2019 we will continue to plant replicated trials in three locations closest to researchers' home bases to ensure timely harvest. The cultivars that have performed the best for the last two years will be planted in strip trials in two additional locations.

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