

## Full Circle Microbes + Wintermute Case Study

### Executive Summary

Across the United States, the agricultural industry consumes over \$20B in fertilizer while generating more than 1.04B tons of wasted plant biomass. These practices combine to produce over 109M metric tons of CO2 equivalent greenhouse gas emissions, harming the environment and wasting valuable nutrients contained in the leftover biomass.

Full Circle Microbes is a Vermont based startup driven by their mission of transforming organic waste that harms the planet into sustainable fertilizer that helps it. They're focusing their efforts on the burgeoning hemp industry with their microbial inoculant developed to provide value to hemp growers in three key ways:

- Reducing fertilizer cost
- Increasing sellable yield
- Improving sustainability

In 2019, Full Circle Microbes partnered with Wintermute Cannabis Collective to pilot their microbial inoculant in the field and evaluate its efficacy in recycling hemp waste into a nutrient source. The goal was to demonstrate how inoculated hemp waste can replace fertilizer for the benefit of hemp growers and the environment.



Wintermute operates a hemp farm in Ryegate, Vermont growing hemp for CBD flower and extract of unparalleled quality. They've developed deep expertise in cannabis cultivation from years of growing in California and Vermont. The cultivation team at Wintermute understands that producing the highest quality CBD products requires diligent care for the soil and a healthy soil microbiome. They avoid synthetic fertilizers, knowing that these salt-based nutrients impact the taste of the flower and overshadow the natural flavors and feeling of the plant they know and love so well.

Full Circle Microbes and Wintermute, both dedicated to sustainability and the highest quality agriculture practices, connected in early 2019 and quickly realized that their goals were closely aligned. Shortly thereafter, they made plans to test the impact of the fertilizer produced through Full Circle Microbes' microbial inoculant recycling approach. Through this pilot, Full Circle Microbes and Wintermute showed that plants treated with inoculated hemp waste produced harvest yields that were 9-16% higher than those receiving the standard nutrient mix. These results show great potential to help farms save money and increase yield while helping the environment and are detailed in the sections below.

## Pilot Overview

Wintermute and Full Circle Microbes began their pilot in June 2019 to test different nutrient management practices involving inoculated hemp waste and Wintermute's standard nutrient blend. Each experimental group included three *Cannabis sativa* plants of the same genetic strain, given the following nutrient inputs:

- **Standard nutrients only:** consisting of specially blended off-the-shelf fertilizers, auger planted, nutrients administered in middle layer of soil
- **Standard nutrients + inoculated hemp:** auger-planted, nutrients + hemp in middle layer of soil
- **Inoculated hemp only:** auger-planted, hemp in middle layer of soil
- **Standard nutrients + inoculated hemp:** auger-planted, nutrients + hemp as a topdressing
- **Inoculated hemp only:** auger-planted, hemp as topdressing
- **Inoculated hemp only:** waterwheel-planted, hemp as topdressing

Leftover biomass from Wintermute's indoor grow facility was inoculated with Full Circle Microbes to create the inoculated hemp waste. These crop residuals were primarily comprised of stalks and fan leaves that were processed with a wood chipper to increase surface area and make the output easier to apply. The chipped hemp waste was then inoculated with Full Circle Microbes and stored in sealed containers to facilitate microbial action over 4 weeks. The standard nutrient blend was composed of commercially available potting soil mixed in a recipe that Wintermute has developed over years of refining and improving their cultivation practices.

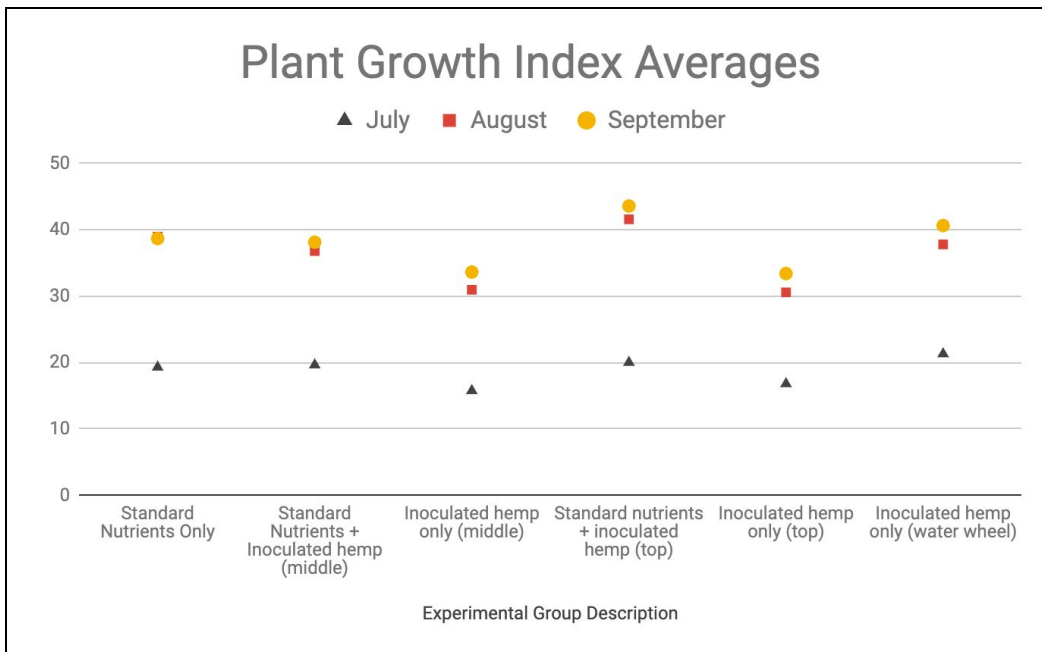
Five of the six groups were planted and fertilized using an auger, whereas the sixth group was planted with a waterwheel approach to evaluate how the inoculated hemp waste could be applied efficiently at a large scale. All plants received nutrients only at the time of planting and were not given any amount of the Calcium Magnesium blend that is often provided in the flowering stage to increase yield. This second round of nutrient application was omitted in this plant growth trail to keep the focus exclusively on the initial nutrient source and eliminate confounding factors.

Full Circle Microbes and Wintermute collected data from planting through harvest and processing, focusing on the following metrics:

- **Growth phase:**
  - Plant height
  - Canopy width
  - Canopy depth
  - Growth index average =  $(\text{Plant height} + \text{Canopy width} + \text{Canopy depth})/3$
- **Harvest and processing phase:**
  - Total biomass weight
  - Sellable yield weight
  - Leftover biomass weight
  - Harvest index (ratio of sellable biomass to leftover biomass)

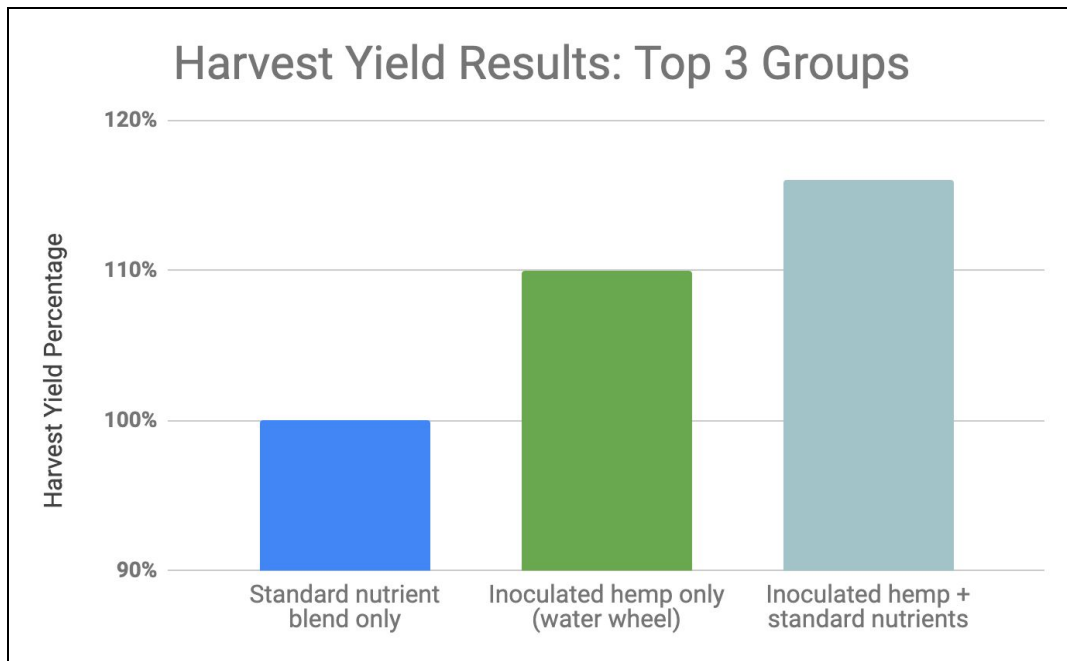
## Results

Figure 1 shows the growth index average, calculated by adding (plant height + canopy width + canopy depth) and dividing the total by 3:



The combination of standard nutrients and inoculated hemp waste (column 4) produced the greatest growth in terms of height and canopy size.

Figure 2 shows the sellable biomass from the top 3 output groups, demonstrating that plants receiving inoculated hemp waste produced the greatest yield:



These data illustrate that treating hemp plants with inoculated hemp increased the harvest yield by 9 and 16%, respectively.

## Ongoing Efforts

Following these successful plant growth trials culminating in Fall 2019, Wintermute worked with Full Circle Microbes to recycle all of their 2019 harvest residuals, amounting to approximately 3,000lbs of hemp stalks and fan leaves. This recycled biomass will be a valuable resource for the 2020 grow season, returning bioavailable nutrients to the fields while reducing the cost and need for fertilizer. The Research and Development team at Full Circle Microbes, led by Director of Microbiology Dr. Victoria Holden, is further developing their microbial inoculant to make it even more effective at hemp recycling. They're working to optimize their inoculant for the breakdown of lignin, the hemp polymer that's most resistant to degradation and which shields nutrients from absorption. Solving this technical challenge will create a recycled hemp output that's even more effective as a fertilizer substitute. Together, Wintermute and Full Circle Microbes will continue their efforts to help the environment and produce the highest quality CBD hemp.



**Left:** Wintermute COO Justin Decatur and Full Circle Microbes CEO Charles Smith in front of an inoculated pile of Wintermute's 2019 harvest residuals

**Right:** Kevin Drake and Justin Decatur take flight with the knowledge that they're helping the planet and their business by recycling their harvest residuals with Full Circle Microbes (*No magical pitchforks or rakes were harmed in this recycling initiative*)

