Overview of Floral Hemp Fertility and Production in North Carolina

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UVM Industrial Hemp Conference
February 20, 2020
Agronomic Services Division
Laboratory Sections

• Soil Testing
• Nematode Assay
• Plant, Waste, Solution, & Media Analysis
• Provide on-farm consultations
• Diagnose plant growth problems
• Advise to prevent or correct plant growth problems
Grown for seed, fiber, and flowers

• **Seed/fiber**
  • Agronomic crop
  • Seeds drilled or broadcasted
  • Harvested with combine
  • Male and female plants

• **Flower** (>95% licenses in NC)
  • Horticultural crop
  • Plant greenhouse produced transplants
  • Harvested by hand or mechanically
  • Female plants
Number of hemp licenses – 1,387
Floral hemp on 97% of the licenses

17,500 acres licensed (field production)
6,750,000 ft² licensed (GH production)
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6,750,000 ft² licensed (GH production)
Why Floral Hemp?

• Hemp flowers contain cannabidiol (CBD) – as well as other cannabinoids

• CBD has been reported to help with
  • Chronic pain
  • Anxiety and depression
  • Neurological disorders (epilepsy)
  • Arthritis and inflammation
  • Overcoming opioid addiction
How to take CBD

- **Topical application** *(oil, lotion, etc.)*
  - CBD extracted from dried hemp flowers and incorporated into cosmetics

- **Inhalation** *(smoking & vaping)*
  - CBD inhaled from fresh hemp flowers

- **Ingestion** *(soft gels, tea, gummies, etc.)*
  - Fresh or extracted CBD
  - CBD infused food and beverage is illegal
CBD comes from trichomes

**Trichomes**

- Glandular hairs
- Contain CBD
- Only on female flowers
- Will not fully develop if flowers are pollinated (produce seeds)
Hemp plants are either male or female (dioecious)

Determine plant sex at the pre-flowering stage

Grow female clones or remove males before pollination to maximize CBD production
DECISIONS BEFORE GROWING FLORAL HEMP

• **Planting.** Direct seed or transplants? Cultivar?

• **Direct seed.** Feminized seed or non-feminized seed?

• **Greenhouse produced transplants.** Female clones, feminized seedlings, non-feminized seedlings? Purchase or grow your own?

• **Production environment.** Outdoors, controlled (greenhouse or warehouse), protected (hoop house)?

• **Outdoor production.** Open bed, plasticulture, container?
SEED (Direct-Seed or Transplant)

- Genetics not stable
- Feminized seed (may have >20% males)
- Non-feminized seed (50% male)
- Prevent seed formation by culling males
- Genetics improving
- Industry seems to be moving from clones to seedlings

Poor germination (direct seeded)

Unstable genetics

Accidental pollination
**Female Clones**
- Vegetative propagation - cuttings from female stock plants
- Relatively uniform phenotype
- Stock (mother) plant maintenance
- ~$5/transplant

**Feminized Seedlings**
- Sexual (seed) propagation
- Tend to have unstable genetics (characteristics not uniform)
- Can have 20-30% male plants (need to cull males)
- No certifying agencies
- ~$1/transplant
ENVIRONMENT
(Outdoor, Greenhouse, Hoop House)

• Depends on your current infrastructure

• Most varieties are photoperiodic short days plants (flowering occurs when periods of light are less than periods of dark)

  • Outdoor or protected (hoop house): Flowering occurs ~6 wks after summer solstice (late-Jul, mid-Aug)

  • Controlled (greenhouse): Flower initiation can occur anytime with artificial light manipulation
FLORAL HEMP – FIELD

Plastic
(like strawberries or tomatoes)

Open fields / bare ground
(like tobacco)
Plasticulture Production

- Irrigation – Drip
- Weed control – Plastic (row middles a challenge)
- Nitrogen 80-150 lb/ac
- Split (50 lb N/ac pre-plant; remainder fertigated throughout season)
Open Bed Production

- Irrigation – Drip or none
- Weed control – Cultivate (late season a challenge)
- Nitrogen 80-150 lb/ac
- Split (50% pre-plant; 50% ~4 weeks after transplant)
FLORAL HEMP – GREENHOUSE

Containers. Fertigation. Lights
FLORAL HEMP – HIGH TUNNEL

- Grow in soil or containers
- Irrigation – Drip
- Fertilize pre-plant or thru drip
- No heat source or grow lights
### 2019 NCSU Cultivar Trials

Visit [https://industrialhemp.ces.ncsu.edu/](https://industrialhemp.ces.ncsu.edu/) for 2019 Hemp Strain Testing Results

<table>
<thead>
<tr>
<th>Varieties*</th>
<th>Floral Yield (lb/plant)**</th>
<th>Total THC (%)</th>
<th>Total CBD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boax</td>
<td>&gt;1.5</td>
<td>0.6 - 0.8</td>
<td>13 - 16</td>
</tr>
<tr>
<td>Suver Haze</td>
<td>&gt;1.5</td>
<td>0.6 - 0.7</td>
<td>13 - 15</td>
</tr>
<tr>
<td>Cherry Wine</td>
<td>1-1.5</td>
<td>0.4 - 0.6</td>
<td>10 - 15</td>
</tr>
<tr>
<td>Sweeten</td>
<td>1-1.5</td>
<td>0.2 - 0.7</td>
<td>6.0 - 16</td>
</tr>
<tr>
<td>T1</td>
<td>0.5-1</td>
<td>0.3 - 0.6</td>
<td>7.0 - 12</td>
</tr>
</tbody>
</table>

* Varieties among the top 10 cultivars grown in NC
** Bucked (de-stemmed dry yield)

### TAKE HOME MESSAGE

Test for THC during flower production and harvest before you go hot!!!
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**Outdoor production.** Open bed, plasticulture, container?
Planting Date in North Carolina

- Overall, most growers seemed to plant early-May through late-June.
- Some planted mid-April; a few planted in late at mid-August.
- In 2019, the late planting date (early July) appeared to reduce yields in at the Mountain Horticulture Crops and Piedmont Research Stations compared to the May and June plantings.
Spacing (In-Row and Between-Row)

• 4-6 in-row on 4-6 foot centers

• Lessons learned in 2018
  • In-row spacing
  • Between row spacing

• Depends on variety, planting date, harvest date, planting equipment, harvest equipment

Planting date, spacing, mulching, pruning, and cultivar studies conducted by Drs. Jeanine Davis and Angela Post (NC State University) in 2018 and 2019 and will be conducted by Drs. Jeannine David and David Suchoff (NC State University) in 2020
Open beds
- In-Row: Cultivation
- Between-Row: Cultivation

Plasticulture
- In-Row: Plastic
- Between Row: Mechanical, live mulch, dead mulch, hand work

Weed Control

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Staking / Pruning / Topping

• Questions based on marijuana production model
• Lessons learned in 2018
• In summary, little if any yield increase
• Labor intensive

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https://industrialhemp.ces.ncsu.edu/
Moving on to Fertility and Plant Nutrition
<table>
<thead>
<tr>
<th>Target pH</th>
<th>Phosphorus and potassium* rates (based on soil test results)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.2 for mineral soil</td>
<td>• Phosphorus ($P_2O_5$)</td>
</tr>
<tr>
<td>5.5 for mineral-organic soil</td>
<td>• 0 lb/A at P-Index of 70</td>
</tr>
<tr>
<td>5.0 for organic soil</td>
<td>• 150 lb/A at P-Index of 0</td>
</tr>
<tr>
<td><strong>Nitrogen rate</strong>*</td>
<td>• Potassium ($K_2O$)</td>
</tr>
<tr>
<td>50 lb/A for fiber</td>
<td>• 0 lb/A at K-Index of 80</td>
</tr>
<tr>
<td>100-150 lb/A for seed/grain</td>
<td>• 150 lb/A at K-Index of 0</td>
</tr>
<tr>
<td>No recommendation for flower</td>
<td></td>
</tr>
</tbody>
</table>

*Dr. Michelle McGinnis (NCDA Agronomic Division), Drs. Matthew Vann, Keith Edmisten, David Suchoff, and Ms. Maggie Short (NC State University) are currently evaluating N and K rate effects on yield and cannabinoid concentrations and developing plant leaf tissue sufficiency ranges.
**GH Floral Hemp Nitrogen Management (Containers)**

**FIGURE 2:**
RECOMMENDED FERTILIZATION RATES BASED ON CANNABIS PLANT GROWTH

<table>
<thead>
<tr>
<th>DEVELOPMENT STAGE</th>
<th>FERTILIZER RATE (PPM N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Vegetative</td>
<td>100 to 125</td>
</tr>
<tr>
<td>Late Vegetative</td>
<td>150 to 200</td>
</tr>
<tr>
<td>Peak Flowering</td>
<td>200 to 225</td>
</tr>
<tr>
<td>Pre-Harvest</td>
<td>100 to 150</td>
</tr>
</tbody>
</table>

<https://www.cannabisbusinesstimes.com/article/10-building-blocks-to-plant-nutrition/>
### Figure 3:
Recommended Pourthru Electrical Conductivity (EC) Levels Based on Cannabis Plant Growth

<table>
<thead>
<tr>
<th>Development Stage</th>
<th>Top Irrigation (mS/cm)</th>
<th>Sub-Irrigation or Capillary Mat (mS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Vegetative</td>
<td>1.0 to 1.5</td>
<td>0.67 to 1.0</td>
</tr>
<tr>
<td>Late Vegetative</td>
<td>1.5 to 2.0</td>
<td>1.0 to 1.3</td>
</tr>
<tr>
<td>Peak Flowering</td>
<td>2.0 to 2.5</td>
<td>1.3 to 1.7</td>
</tr>
<tr>
<td>Pre-Harvest</td>
<td>1.5 to 2.0</td>
<td>1.0 to 1.3</td>
</tr>
</tbody>
</table>

Values vary with irrigation method. (Top versus Sub-Irrigation)

Plant leaf tissue nutrient analysis*

- Excellent tool to manage in-season fertility
- Diagnostic tool to help identify cause(s) of plant growth problems
- Results compared to crop specific target nutrient ranges of the most recently mature leaves (MRML)
- Lab reports indicate if nutrients are sufficient, low/deficient, or high/excessive

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Plant leaf tissue nutrient analysis

Boron toxicity

Potassium deficiency

Phosphorus deficiency
Collecting representative plant leaf tissue samples

Collect the most recently mature leaf (MRML) or the most recently expanded leaf. It is generally the 3rd to 5th leaf down from the growing point.

For hemp, collect 1-2 MRMLs from 20-30 plants growing in like conditions (30-40 leaves is ideal).
Compare lab results to crop specific target nutrient ranges

- No **sufficiency ranges** for hemp
- **Survey ranges** in Plant Analysis Handbook* used as guidelines by most labs and advisors

Compare lab results to crop specific target nutrient ranges

- **Sufficiency Ranges**—established through yield based studies replicated over space and time

- **Survey Ranges**—established based on observational data; believed to approximate the critical values for deficiency or toxicity however additional research under a wide range of growing ranges is required to very this assumption
Compare lab results to crop specific target nutrient ranges

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Survey Range (%)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>3.30 - 4.76</td>
</tr>
<tr>
<td>P</td>
<td>0.24 - 0.49</td>
</tr>
<tr>
<td>K</td>
<td>1.83 - 2.35</td>
</tr>
<tr>
<td>Ca</td>
<td>1.47 - 4.42</td>
</tr>
<tr>
<td>Mg</td>
<td>0.40 - 0.81</td>
</tr>
<tr>
<td>S</td>
<td>0.17 - 0.26</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Survey Range (ppm)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>100 - 150</td>
</tr>
<tr>
<td>Mn</td>
<td>41 - 93</td>
</tr>
<tr>
<td>Zn</td>
<td>24 - 52</td>
</tr>
<tr>
<td>Cu</td>
<td>5 - 7</td>
</tr>
<tr>
<td>B</td>
<td>56 - 105</td>
</tr>
<tr>
<td>Mo</td>
<td>0.5 - 1.5</td>
</tr>
</tbody>
</table>

NCDA is conducting a hemp leaf tissue nutrient survey

- Fine-tune published nutrient survey ranges to cultivars and environments specific to North Carolina

- Compare plant tissue nutrient concentration of 29 floral hemp varieties grown over a broad range of locations and fertility management practices

- Compare plant tissue nutrient concentrations to the Plant Analysis Handbook IV survey ranges
Survey sample locations

- Mountain Horticultural Research Station: 5 varieties
- Piedmont Research Station: 24 varieties
- Martin: 1 variety, 5 farms
- Hyde: 1 variety, 8 farms
- Scotland & Hoike: 8 varieties, 9 farms
- Robeson, Bladen, & Columbus: 7 varieties, 8 farms
Leaf Tissue Nutrient Survey

Calcium survey range 1.5-4.4%
Boron survey range 56-105 ppm
Magnesium survey range 0.4-0.8%

Ranges too high??
Leaf Tissue Nutrient Survey

- **Phosphorus survey range**: 0.24-0.49%
- **Manganese survey range**: 41-93 ppm
- **Zinc survey range**: 24-52 ppm

Ranges reasonable??
Leaf Tissue Nutrient Survey

Sulfur survey range 0.17-0.26%

Copper survey range 5-7 ppm

Iron survey range 100-150 ppm

Ranges too narrow??
Plant nutrient survey in 2020

- Expand across the state
- NCSU Extension cultivar trials in the coastal plain as well as piedmont and mountains
- Commercial farms
  - Different varieties
  - Different fertility programs
- Out-of-state samples
  - If interested, contact me
  - Michelle.Mcginnis@ncagr.gov
Other NCSU Resources from Brian Whipker and Whipker Research Team


TAKE HOME MESSAGE

• We have learned a lot in 2018 and 2019
  • NCSU Research
  • Commercial growers
• There is still a lot to learn
  • Variety is the top issue
  • Fertility
    • Optimal N and K rates on yield and cannabinoid
    • Optimal B rate for yield and cannabinoids
  • BMPs for disease and insect prevention and control
Questions?

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