Smart Machines for Weed Control & Beyond

Using machine learning to optimize every plant

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West Texas Agricultural Chemicals Institute Conference
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Over 60 people, with deep experience in advanced technologies and agriculture

20
Experts in AI/ML, Software, Robotics

8
Hardware & mechanical engineers

8
Agriculture scientists & engineering support

Commercial & academic experience at key companies & institutions
A new era in Agriculture

- **Hand Tools** (10,000 years)
- **Mechanical** (1900)
- **Chemical** (1950)
- **Biochemical** (1990)
- **Digital** (NOW)
Average US Corn Yields: No End in Sight

Average US Corn Yield, 1866-2009

Current Test Yield: ~300 bu/acre
~500


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TREAT EVERY PLANT THE SAME.

Accuracy and precision are critical elements to get right to avoid wasting costly products. It is also imperative to achieve the right rate, at the right droplet size, to optimize each plant’s performance and yield potential.
#47 GIO GONZALEZ

- Extension: 5.68 feet
- Spin Rate: 2881.55 RPM
- Velocity: 78.81 MPH
With machine learning we can teach equipment to see and optimize every plant in the field
Plant-level crop management using intelligent machines can apply to the entire farming cycle.

1. Prepare Soil
2. Establish Stand
3. Fertilize & Irrigate
4. Protect
5. Harvest

Learn & Optimize for Next Cycle
Blue River Technology decided to start with crop protection:

1. **Prepare Soil**
2. **Establish Stand**
3. **Fertilize & Irrigate**
4. **Protect**
5. **Harvest**

Learn & Optimize for Next Cycle
Ag machinery is specialized for each action

Prepare soil  Establish stand  Fertilize  Protect  Harvest
Smart machines need to sense their surroundings

- Prepare soil
- Establish stand
- Fertilize
- Protect
- Harvest

*Sense & Decide*

*Act*
...and verify & learn from their actions

- Prepare soil
- Establish stand
- Fertilize
- Protect
- Harvest

Diagram:
- Sense & Decide
- Verify & Learn
- Act

Cycle:
1. Sense & Decide
2. Act
3. Verify & Learn
4. Sense & Decide
3 core elements required for smart machines

- Prepare soil
- Establish stand
- Fertilize
- Protect
- Harvest
Blue River capabilities enable smart machines

- Sense & Decide
- Verify & Learn
- Act

Smart machines

- Computer vision
- Machine learning & deep learning
- Robotics
- Development & learning infrastructure
- Optimization
- On-board processing
- Spatio-temporal database and analysis
LettuceBot

5,000 plants cared for every minute

Blue River Technology - LettuceBot

https://youtu.be/jL4kcrumHA8
See & Spray technology for cotton weeding

Blue River Technology's See & Spray - close up & slow mo

https://youtu.be/UXkGkAGljMA
After teaching our system to identify cotton and weeds, it performed better than our agronomist.
See & Spray uses artificial intelligence to identify and spray individual plants in milliseconds

**Sense & Decide:** Blue River’s artificial intelligence identifies subtle differences between crops (green) and weeds (red)

**Act:** Only weeds are sprayed, reducing chemicals by >90%
Liberty (glufosinate) failed to control large pigweed
Arkansas herbicide trial, August 2016, day of spraying and after 12 days
Dicamba failed to control pigweed >6”
Arkansas herbicide trial, August 2016, day of spraying and after 12 days

Prior to application
12 days post
Paraquat + Caparol controlled pigweed of all sizes
Arkansas herbicide trial, August 2016, day of spraying and after 12 days
Testing Blue River Technology Nozzle Design

Objective
• Compare Blue River Technology nozzle designs with current application technologies (e.g. air-induction broadcast nozzles)

Equipment
• Blue River Technology nozzle manifold (40” width) was attached to a pushcart with all nozzles open during application

Herbicide Program
• Dicamba (Engenia) plus glyphosate (1X rate = 560 g ae/ha + 870 g ae/ha)
• Adjuvants were Reign at 1.0% (v/v) and Induce at 0.5% (v/v)

Locations
• Marianna, AR
• Lubbock, TX

Weeds
• Palmer amaranth

Results
• Herbicide applications through Blue River Technology nozzles were equivalent to current broadcast nozzles (e.g. Teejet AI) when comparing 1X rates

![Weed Control Chart]

- Palmer amaranth - TX
- Palmer amaranth - AR

Weed Control (%)
Arkansas – Dicamba Program

Dicamba + Glyphosate
20 GPA with Teejet nozzles

Dicamba + Glyphosate
50 GPA with BRT nozzles

Marianna, AR
Pictures taken 14 days after treatment

* Teejet AI110015 nozzles at 40 PSI
Texas – Dicamba Program

Dicamba + Glyphosate
20 GPA with Teejet nozzles*

Dicamba + Glyphosate
50 GPA with BRT nozzles

Lubbock, TX
Pictures taken 15 days after treatment

* Teejet AI110015 nozzles at 40 PSI
See & Spray saves costs and fights weed resistance

-90% Reduction in post-emergence herbicide costs by switching from blanket spray to spot spray

-50% Reduction in seed costs by switching from GMO to conventional seeds

Increased ability to fight resistant weeds using an unlocked toolkit of herbicide options

See & Spray application in cotton
See & Spray will see limited commercial release in 2018 for cotton, then expand to other row crops

**Phase 1:**
Lettuce Thinning  
*Proof of concept*

**Phase 2:**
Cotton Weeding  
*Full Commercialization*

**Phase 3:**
Weeding All Row Crops  
*Showing Versatility*

**Phase 4:**
Full See & Spray  
*Flexible spray tool*

- **2012 to 2016:**
  - Self-sustaining R&D operations

- **2017:**
  - Begin cotton machine delivery

- **2018:**
  - Expand to soybeans, peanuts, corn, and others

- **2019:**
  - Precise spot application of fertilizer, fungicide, growth regulator, etc

- **2020:**

- **2021+:**

**Timeline:**
- 2012 to 2016
- 2017
- 2018
- 2019
- 2020
- 2021+
See & Spray - Blue River Technology's precision weed control machine

https://youtu.be/-YCa8RntsRE
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