Advances in variable-rate nozzle design for fertility and pest management

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Introduction. Mechanization and spraying

When You Buy or Build A Field Sprayer

Circular 249

Agricultural Extension Service, University of Arizona, Tucson

Operating Field Dusters In Arizona

Circular 261

Agricultural Extension Service, University of Arizona

Akerson, Curley, and Yates. 1957

Welchert, Roney, and Shields. 1958
Introduction. Conventional spraying system
### Output Sensitivity to Speed of Operation:

**Example:**

Applying 20 gpa of mixture, on 20” spacing, with XR11002VS at 3mph

\[
gpm \text{ (per nozzle)} = \frac{\text{rate (gpa)} \times \text{spacing (in)} \times \text{speed (mph)}}{5940}
\]

\[
gpm \text{ (per nozzle)} = 0.20 \rightarrow 40 \text{ psi}
\]

Increasing speed to 4 mph

\[
gpm \text{ (per nozzle)} = 0.27 \rightarrow 73 \text{ psi}
\]

Changing the speed to 5mph:

\[
gpm \text{ (per nozzle)} = 0.34 \rightarrow 115 \text{ psi}
\]
Introduction. Transition into GPS-based systems

- JohnDeere GS3 2630
- Trimble FMX
- AgLeader Integra

GPS to Radar adapter
Application equipment. Hardware integration
Application equipment. Hardware integration

Field display
Application module
Passive element
Flow control valve
Trimble FMX display for steering, application rate, and boom section control
Conventional spraying systems for liquid injection/streaming

Key points:
- Electronic interface between spraying components and field computer works great
- Physical system has limitations for VR applications
Flow control in liquid injection and above ground streaming applications

Key points:
- To double flow rate causes pressure to quadruple
- Orifice flow control takes more time to build up pressure
- Application range is very limited

Flow rate = $c \sqrt{\text{pressure}}$
### Application equipment. Flow control

#### StreamJet

**SJ3 Fertilizer Nozzles**

<table>
<thead>
<tr>
<th>Pressure (psi)</th>
<th>Capacity (GPA)</th>
<th>Flow Rate (GPM)</th>
<th>Nozzle Size (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.11</td>
<td>10.9</td>
<td>3/8</td>
</tr>
<tr>
<td>30</td>
<td>0.13</td>
<td>12.6</td>
<td>3/4</td>
</tr>
<tr>
<td>40</td>
<td>0.15</td>
<td>15.1</td>
<td>1</td>
</tr>
<tr>
<td>50</td>
<td>0.16</td>
<td>15.8</td>
<td>1.2</td>
</tr>
<tr>
<td>60</td>
<td>0.17</td>
<td>18.6</td>
<td>1.5</td>
</tr>
<tr>
<td>70</td>
<td>0.14</td>
<td>13.6</td>
<td>2</td>
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<tr>
<td>80</td>
<td>0.17</td>
<td>17.5</td>
<td>2.5</td>
</tr>
<tr>
<td>90</td>
<td>0.20</td>
<td>19.8</td>
<td>3</td>
</tr>
<tr>
<td>100</td>
<td>0.21</td>
<td>21.3</td>
<td>3.5</td>
</tr>
<tr>
<td>110</td>
<td>0.22</td>
<td>22.6</td>
<td>4</td>
</tr>
<tr>
<td>120</td>
<td>0.24</td>
<td>24.3</td>
<td>4.5</td>
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<tr>
<td>130</td>
<td>0.26</td>
<td>25.8</td>
<td>5</td>
</tr>
<tr>
<td>140</td>
<td>0.28</td>
<td>27.3</td>
<td>5.5</td>
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<tr>
<td>150</td>
<td>0.30</td>
<td>28.8</td>
<td>6</td>
</tr>
<tr>
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<td>0.32</td>
<td>30.3</td>
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<tr>
<td>170</td>
<td>0.34</td>
<td>31.8</td>
<td>7</td>
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<tr>
<td>180</td>
<td>0.36</td>
<td>33.3</td>
<td>7.5</td>
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<tr>
<td>190</td>
<td>0.38</td>
<td>34.8</td>
<td>8</td>
</tr>
<tr>
<td>200</td>
<td>0.40</td>
<td>36.3</td>
<td>8.5</td>
</tr>
</tbody>
</table>

#### Graph

- **Lb/Acre** vs. **Pressure (psi)**
- **SJ3-03 (Blue)**
- **SJ3-06-VP (Grey)**

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*Images and diagrams are not included in the text representation.*
Application equipment. Flow control
Variable-rate Technology: Hardware

Latest developments in nozzle technologies to improve VR spraying
- variable-orifice
- pulse-controlled flow (single/multiple nozzle)
John Deere Introduces ExactApply™ Intelligent Nozzle Control for Sprayers

Factory-installed solution improves spray resolution accuracy for all crops and applications

OLATHE, Kansas (August 30, 2016) – Producers and ag service providers can gain greater accuracy over their spray applications with John Deere ExactApply intelligent nozzle control system available on new John Deere 4-Series Sprayers. Starting with 2018 models, this latest application technology provides sprayer operators a comprehensive solution that maintains consistent droplet size and pattern through a wide range of speeds, while reducing the potential for overlaps, skips and drift.

ExactApply nozzle control maintains consistent droplet size and pattern through a wide range of speeds.
Products

Case IH Introduces AIM Command FLEX™ Advanced Spray Technology

24 Aug 2016

RACINE, Wis. — Case IH announces new AIM Command FLEX™ advanced spray technology for greater application accuracy, as well as special 25th Anniversary Patriot models to celebrate the company's legacy of sprayer leadership.

Ultimate in spray control
AIM Command FLEX helps operators deliver consistent, flexible and accurate application, regardless of speed and terrain — resulting in more efficient use of crop protection products. Using pulse width modulation (PWM) technology, the system enhances sprayer productivity by controlling product flow and pressure more precisely than conventional rate controllers.
Raven Announces Enhancements to Hawkeye™ Nozzle Control System

SIOUX FALLS, S.D. (Jan. 19, 2016) — Raven Industries’ (NASDAQ: RAVN) Applied Technology Division announced ground-breaking new enhancements to its innovative Hawkeye™ Nozzle Control System. The enhancements include virtual section capability, Sidekick Pro™ direct injection compatibility, new sprayer kits, and Hawkeye HD - individual nozzle on/off.

Hawkeye HD
Hawkeye HD will give customers individual nozzle on/off, with unparalleled precision that reduces costly skips or overlaps. Customers using Hawkeye today can upgrade to HD with a simple unlock - no need to change hardware to take advantage of this feature.
Duty Cycle: Percentage of time occupied by the cycle of operation of nozzle

Operates keeping pressure (therefore droplet size) constant as flow changes

Application equipment. Pulse width modulation

**Turbo TeeJet® Induction Flat Spray Tips**

**Typical Applications:**
See selection guide on page 4 for recommended typical applications for Turbo TeeJet Induction tips.

**Features:**
- 110° wide angle, air induction, tapered flat spray tip pattern based on the patented outlet orifice design of the original Turbo TeeJet® nozzle.
- Patented orifice design provides large, round passages to minimize plugging.
- Depending on the chemical, produces large air-dropped drops through a Venturi air aspirator resulting in less drift.
- All polymer construction for excellent chemical and wear resistance.
- Compact size to prevent tip damage.
- Removable pre-orifice.
- Ideal for use with automatic spray controllers.

<table>
<thead>
<tr>
<th>Tip Size</th>
<th>RPM</th>
<th>GPM</th>
<th>Capacity</th>
<th>Spray Pattern Extension</th>
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<tbody>
<tr>
<td>110°V</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>20</td>
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</tbody>
</table>

**Wide operating pressure range: 15–100 PSI (1–7 bar).**

**Automatic alignment when used with 25598-NYR Quick TeeJet® cap and gasket.**
See page 64 for additional information.

**CONTACT PRODUCT**

**SYSTEMIC PRODUCT**

**DRIFT MANAGEMENT**

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**EXCELLENT**

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