Introduction

Background:
New trait technologies incorporating 2,4-D tolerance in corn, soybean, and cotton increase the use of 2,4-D. This may result in a greater potential for drift to non-transformed crops. There is clear evidence that 2,4-D drift reduces soybean yield, however, the impact of 2,4-D drift on soybean growth and yield components on glyphosate-tolerant soybean cultivars has not been reported.

Objective:
Our objective was to quantify 2,4-D drift on glyphosate-tolerant soybean growth, yield components, and seed composition.

Materials and Methods

Experimental procedure:
• Location: Fowler, IN
• Randomized complete block
• Planted 38 cm rows at 350,000 plants ha⁻¹

Treatment:
• 2,4-D
  • 0, 0.112, 1.12, 11.2, 560, 1120, 2240, 4480 g ae ha⁻¹
• Application timing
  • R1 on Becks 342NRR
  • R2 and R4 on Croplan RC 2057

Measurements:
• Crop injury visual rating
• 14 DAT
• 30 DAT
• Yield components
• Machine harvested yield
• Plant growth characteristics
• Protein and oil concentration measured by near-infrared reflectance spectroscopy

Statistical analysis:
• Fishers LSD t-test (P ≤ 0.05)
• Path analysis

Results

Soybean Growth and Reproduction

Table 1. Effect of eight 2,4-D rates on soybean yield components, growth, and seed composition. Within columns means followed by the same letter are not significantly different (P ≤ 0.05) using Fishers LSD t-test.

<table>
<thead>
<tr>
<th>2,4-D (g ae ha⁻¹)</th>
<th>Yield (Mg ha⁻¹)</th>
<th>Seed mass (g 100 seeds)</th>
<th>Seed pod⁻¹</th>
<th>Pod no. m⁻²</th>
<th>Percent reproductive nodes (%)</th>
<th>Node no. m⁻²</th>
<th>Plant ht. (cm)</th>
<th>Oil concentration (g kg⁻¹)</th>
<th>Protein concentration (g kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.19ab</td>
<td>13.95bc</td>
<td>2.45a</td>
<td>753a</td>
<td>85.0a</td>
<td>238b</td>
<td>51.6a</td>
<td>187a</td>
<td>347b</td>
</tr>
<tr>
<td>0.112</td>
<td>3.09ab</td>
<td>14.6a</td>
<td>2.50c</td>
<td>85.5a</td>
<td>323ab</td>
<td>58.4a</td>
<td>183a</td>
<td>348b</td>
<td></td>
</tr>
<tr>
<td>1.12</td>
<td>3.00ab</td>
<td>14.8a</td>
<td>2.44a</td>
<td>82.7a</td>
<td>328a</td>
<td>58.6a</td>
<td>183a</td>
<td>350b</td>
<td></td>
</tr>
<tr>
<td>11.2</td>
<td>2.86b</td>
<td>14.4bc</td>
<td>2.42a</td>
<td>82.5a</td>
<td>320b</td>
<td>58.8a</td>
<td>179a</td>
<td>351b</td>
<td></td>
</tr>
<tr>
<td>560</td>
<td>1.20c</td>
<td>13.0bcd</td>
<td>2.17b</td>
<td>47.4b</td>
<td>353a</td>
<td>64.6a</td>
<td>166a</td>
<td>327a</td>
<td></td>
</tr>
<tr>
<td>1120</td>
<td>0.18d</td>
<td>10.6e</td>
<td>1.69kd</td>
<td>28.7c</td>
<td>80c</td>
<td>24.7c</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2240</td>
<td>0.01d</td>
<td>12.3cd</td>
<td>1.93bc</td>
<td>7c</td>
<td>23d</td>
<td>4.9d</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4480</td>
<td>0.00d</td>
<td>10.0a</td>
<td>1.63d</td>
<td>1c</td>
<td>3d</td>
<td>2.4d</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Key Results:
- 560 g ae ha⁻¹ decreased soybean yield by 60% and reduced pods m⁻² and plant height by 40%
- 2240 and 4480 g ae ha⁻¹ were detrimental to plant growth
- 0.112 to 11.2 g ae ha⁻¹ did not change seed composition

Yield Reduction by Visual Rating

Table 2. Estimated reduction in yield by visual rating at 31 DAT.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield reduction (YR) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 g ae ha⁻¹</td>
<td>10 12 24 29</td>
</tr>
<tr>
<td>0.112 g ae ha⁻¹</td>
<td>25 20 32 37</td>
</tr>
<tr>
<td>1.12 g ae ha⁻¹</td>
<td>34 43 48 53</td>
</tr>
<tr>
<td>11.2 g ae ha⁻¹</td>
<td>50 58 58 62</td>
</tr>
<tr>
<td>560 g ae ha⁻¹</td>
<td>75 58 58 62</td>
</tr>
<tr>
<td>1120 g ae ha⁻¹</td>
<td>90 100 78 80</td>
</tr>
<tr>
<td>2240 g ae ha⁻¹</td>
<td>90 78 78 78</td>
</tr>
<tr>
<td>4480 g ae ha⁻¹</td>
<td>90 78 78 78</td>
</tr>
</tbody>
</table>

Key Results:
- Drift at R1 reduced yield slowly at visual ratings between 10 and 50%, but a visual rating of 90% reduced yield 100%
- Drift at R4 reduced yield at a greater rate than drift at R1 or R2
- Visual ratings of 90% reduced yield by 76 to 100%

Application Timing

Table 2. Three-way path coefficient analysis of direct and indirect effects of 2,4-D application timing on soybean yield components averaged across application timing (R1 Becks 342NRR, R2 CropLan RC2057, R4 CropLan RC2057).

Indirect effect
- Seed mass and seeds pod⁻¹
- Seed mass and pods m⁻²
- Seed pod⁻¹ and pods m⁻²

Direct effect
- Seed mass → yield
- Seeds pod⁻¹ → yield
- Pods m⁻² → yield

Key Results:
- Pods m⁻² always had a positive direct influence on yield
- Pods m⁻² had the greatest impact on yield at R1 and R4 applications
- Seed mass influenced yield most at the R2 application

Conclusions

- Low rates of 2,4-D (0 to 11.2 g ae ha⁻¹) did not change yield components
- 1120 to 4480 g ae ha⁻¹ reduced yield components and plant growth
- Pods m⁻² was one of the most important yield components
- Visual ratings can be used to determine soybean yield loss from 2,4-D drift