Why Care about Growth and Development?

- **Pesticide applications**
  - Herbicides
  - Fungicides

<table>
<thead>
<tr>
<th>POSTEMERGENCE CORN HERBICIDE</th>
<th>CORN GROWTH STAGE OR PLANT HEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amexon</td>
<td>V8</td>
</tr>
<tr>
<td>Capreno</td>
<td>V1 to V6 broadcast; V6 to V8 directed</td>
</tr>
<tr>
<td>DiFlexx</td>
<td>Broadcast V6 or 36&quot;; V7 to V10 or 36&quot; directed; 15 days before tassel</td>
</tr>
</tbody>
</table>

**General Guidelines**

- Do not include adjuvants after the V8 stage and prior to the VT stage of growth
Why Care about Growth and Development?

- Pesticide applications
- Critical stages for management
- Diagnosing yield impacts
Why Care about Growth and Development?

- Pesticide applications
- Critical stages for management
- Diagnosing yield impacts
- Corn develops by GDUs not calendar days

Staging Method Comparison

Leaf Collar Method
- Visible on the underside of the leaf
- Leaf opening forms a “V”

Horizontal Leaf Method
- Total leaves up to the last leaf tipped down below horizontal position
Late Season Staging

Staging Vegetative Corn

<table>
<thead>
<tr>
<th>Staging Vegetative Corn</th>
<th>Vegetative Development Staging Methods</th>
<th>Growth Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf Collar</td>
<td>Horizontal Leaf</td>
<td>Leaf Tip</td>
</tr>
<tr>
<td>V1</td>
<td>NA*</td>
<td>3.5</td>
</tr>
<tr>
<td>V2</td>
<td>3.0</td>
<td>5.0</td>
</tr>
<tr>
<td>V3</td>
<td>4.5</td>
<td>6.5</td>
</tr>
<tr>
<td>V4</td>
<td>5.5</td>
<td>8.0</td>
</tr>
<tr>
<td>V5</td>
<td>6.5</td>
<td>9.0</td>
</tr>
<tr>
<td>V6</td>
<td>8.0</td>
<td>10.5</td>
</tr>
<tr>
<td>V7</td>
<td>9.0</td>
<td>12.0</td>
</tr>
<tr>
<td>V8</td>
<td>10.0</td>
<td>13.0</td>
</tr>
<tr>
<td>V9</td>
<td>11.5</td>
<td>14.5</td>
</tr>
<tr>
<td>V10</td>
<td>12.5</td>
<td>15.5</td>
</tr>
<tr>
<td>V11</td>
<td>13.0</td>
<td>16.5</td>
</tr>
<tr>
<td>V12</td>
<td>13.5</td>
<td>17.0</td>
</tr>
<tr>
<td>V13</td>
<td>14.0</td>
<td>17.5</td>
</tr>
<tr>
<td>V14</td>
<td>15.0</td>
<td>18.0</td>
</tr>
<tr>
<td>V15</td>
<td>15.5</td>
<td>NA*</td>
</tr>
</tbody>
</table>
Germination to Emergence (VE-V1)

Germination
Seeds absorb 30 -35% moisture

How long can a seed survive without any additional input?
(Just endosperm)

Leaf Collar

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Germination to Emergence  
Leaf Collar (VE-V1)

Germination
Seeds absorb 30-35% moisture

How long can a seed survive without any additional input? (Just endosperm)
~14 days

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Germination to Emergence  
Leaf Collar (VE-V1)

Radicle
Coleoptile

Good conditions occur within 1 day of radicle emergence

Germination
Seeds absorb 30-35% moisture

How long can a seed survive without any additional input? (Just endosperm)
~14 days

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Germination to Emergence

**Leaf Collar (VE-V1)**

- Germination: Seeds absorb 30-35% moisture
- How long can a seed survive without any additional input? (Just endosperm) ~14 days
- Good conditions within 1 day of radicle emergence
- What stops elongation of the mesocotyl?

**Diagram:**
- Radicle
- Coleoptile
- Mesocotyl

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Germination to Emergence Leaf Collar (VE-V1)

Good conditions
Within 1 day of radicle emergence

Coeloptile → Mesocotyl → Coleoptilar Node → Seminal roots

Germination
Seeds absorb 30 - 35% moisture

How long can a seed survive without any additional input? (Just endosperm)

~14 days

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Germination to Emergence (VE-V1)

- Good conditions within 1 day of radicle emergence
- Gives rise to nodal root systems

Germination
Seeds absorb 30-35% moisture

How long can a seed survive without any additional input? (Just endosperm)

**~14 days**

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3.0 Stage (V2)

- Seminal Root System
  - Maximum Size
- Nodal Root System
  - Visible

Placement should be consistent unless planted shallow

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4.5 Stage (V3)

Nodal Root System is equal to Seminal Root System

Plant standing due to combined strength of leaf sheaths

Nodal Root System

How many nodal roots will originate from the stalk over a season?
Nodal Root System

How many nodal roots will originate from the stalk over a season?

Approx. 70

6.5 Stage

Primary Ear Initiated
~6.5 Stage
Corn Development and Ear Formation

Primary Ear Initiated ~6.5 Stage

Ears Initiate “acropetally”

Lowest node first

Ear Shoot

Stalk Node

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Corn Development and Ear Formation

Primary Ear Initiated ~6.5 Stage

Ears Initiate “acropetally”
Lowest node first

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Node
Strachan 2016
CRM 103-118
Early maturing

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Strachan 2016

Ear shoots at node 14 near base of stalk of a 2013 corn plant.
Corn Development and Ear Formation

Ear Shoots at 11.5
*Agropetal Initiation*

Ear Shoots at V18
*Basilpetal development*

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Cold Temperature Impacts
(Lejeune and Bernier 1996)
Primary ear abortion under chilling temperatures

**41-50F**

When applied at:

- V6 stage – loss of primary ear
- V3 stage – loss of secondary ears

Corn Development and Ear Formation

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Corn Development and Ear Formation

6.5 Stage

Ear Shoot

Stalk Node

Primary Ear

Cold Temperature Impacts

(Lejeune and Bernier 1996)

Primary ear abortion under chilling temperatures

41-50F

When applied at:

V6 stage – loss of primary ear
V3 stage – loss of secondary ears

• Flooding with chilling temp. increased primary ear abortion

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Yield Components

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Simulated Hail Machine

Plant Damage and Yield Components

Planting Date

Kernel Rows
Ear

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Plant Damage and Yield Components

(a) Kernels/Row

Plant Damage and Yield Components

(b) Kernel Weight (grams/plant)

Planting Date

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Plant Damage and Yield

Corn Yield Components

Next Slides
   Ear Formation
   Rapid Plant Growth

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8.0 Stage

Leaf Collar
(V6)

All leaves have been initiated

Growing point above soil surface

Knee-high Corn: ~19 inches tall

Corn Development and Ear Formation

- Yield components occur in sequence at key stages of plant development
  - ~9.0 stage – row number

  Strongly controlled by genetics

  Ovules later divide (produce paired rows)

Cheng et al. 1983

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Corn Development and Ear Formation

- Yield components occur in sequence at key stages of plant development
  - ~9.0 stage – row number
  - ~13.5 stage – max. potential kernels

Kernel Rows
\[ \text{Ear} \]

Strongly controlled by genetics
Reduced row number indicates stress ~V7

Strachan 2004
Corn Development and Ear Formation

- Yield components occur in sequence at key stages of plant development
  - ~9.0 stage – row number
  - ~13.5 stage – max. potential kernels

Long-Term Stress:
- ovules are sacrificed
- usually at the tip

“Blunt Ear Syndrome”

Potential Kernels

More

Less

Development

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Other diagnostics

**Internodes**

What would a shorter or longer internode tell us?

Corn Development and Ear Formation

- **Arrested Ear Development**
  - **Nonionic Surfactant (13.5-15.0)**
  - Observed within 7 days of application
  - Variable symptoms: lack of silk development, ovule development ceases

**Hypotheses:**

1. Ethoxy units in surfactant break down to form ethylene oxide (natural plant hormone)
2. Rain water washes surfactant from leaf surface into developing ear, and its taken up in high concentrations

*Jones and Westmoreland 1998*
Arrested Ear Development: 13.5-15.0

From Gary Mungvold, ISU 2007/08

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V(n) Stage

- Total number of leaves depends on the maturity
  - 16-18 leaves for <100 day corn
  - 18-21 leaves for 100-110 day corn

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Vegetative: Growing Degree Days

Reproductive Growing Degree Days
VT - Tasseling

- All branches of tassel fully visible, extended outward and not held by upper leaves
- Not staged based on the presence of pollen
- Most susceptible stage to hail damage

Reproductive Stages

- Staging is not based on the vegetative appearance of the plant
- Focus only on the upper ear to stage the plant & field
- Look at kernels in the middle of the ear
- Six reproductive stages total whereas soybean has eight
- Use number & names when referring to corn R stages
  - Example: R1 = Silking
R1 – Silking Stage

- 1 or more silks emerged
- Silks
  - Receptive for 5 or more days
  - Can grow 1½ in. per day
- Pollen
  - fertilization in 24 hrs after landing
- High water use (0.32 in. day)

Timing of Water Stress

Water Use / Plant
Water Stress at Corn Stage

Minimal yield impact from drought due to low water use

- 0.08" day
- 0.10" day
- 0.18" day
- 0.26" day
- 0.32" day
- 0.24" day
- 0.10" day

- 4% yield loss day stress
- 8% yield loss day stress
- 4% yield loss day stress
- 3% yield loss day stress

Rhoads and Bennett (1990) and Shaw (1988)
Drought Management

- Increased tolerance to drought
  - Reduced tassel weight
  - Anthesis silking interval (ASI)

Duvick et al. 2004
Drought Management

- Increased tolerance to drought
  - Reduced tassel weight
  - Anthesis silking interval (ASI)

- Plant Breeding and ASI
  - Old Hybrids: +2-3 days (+1wk)
  - New Hybrids: nearly same time

Bänziger et al. 2000
R2 – Blister Stage

- Occurs approx. 10-12 days after R1
- Kernel
  - growth begins following fertilization
  - Severe stress can easily abort kernels
    - inadequate carbohydrate supply

R3 – Milk Stage

- Occurs approx. 18-20 days after R1
- Interior resembles “milk”
- Minimal decrease in water content since R2; ~80% moisture
- Increase in grain dry matter; ~15% of final
- Kernel abortion with severe stress
**R4 – Dough Stage**

- Occurs approx. 24-26 days after R1
- Interior is similar to “dough”
- Decreasing water content; ~70% moisture content
- Increase in grain dry matter; ~25-30% of final

**R5 – Dent Stage**

- Approx. 31-33 days after R1
- Kernels are indented at the tops
- Decreasing water content 60% moisture
- Increase in grain dry matter ~45% of final
R5 – Dent Stage

Endosperm

- Liquid (milk)
- Solid (starch)

Liquid

Endosperm

R5.25 Early Dent
R5.5 Mid Dent
R5.75 Late Dent

Milk line progresses from the top of the kernel (early dent) to the bottom (late dent).

Nutrient Loss

Silage

Liquid (milk)

R6 – Physiological Maturity

- Occurs approx. 64-66 days after R1
  - Significant time, R5 began: ~33 days
- Kernels have reached maximum dry weight and are mature
  - ~35% moisture +/-2%
- PM always comes before Black Layer (BL) formation
  - ~28% moisture +/-4%
When did this happen?

Ear Development Issues

**Multi-Ear**
- Not a new phenomenon
  - Bonnet 1966
  - Nielson 1998-99
  - Elmore 2006
- Possible Hypothesis
  - Cold-shock, heat-shock, wide temp. swings
  - Stress to primary ear (silk clipping)
  - Genetic factor?

**Ear Symptomology**
- Normal Secondary Ear
- Short Husks
- Barbell Ears
- Multi-ear
When did this happen?

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Ear Development Issues

Barbell Ears

- Kernels form at tip or butt of ear, at both locations but the entire length of ear
- Very slender cob
- Stress timing: V12 – Tassel?
- Chilling temperatures during ear formation

Ear Symptomology

- Normal Secondary Ear
- Short Husks
- Barbell Ears

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When did this happen?

Ear Development Issues

**Short Husks**

- Some ears protrude beyond the husk (hybrid specific)
- Potential to aid in dry-down
- More severe symptoms observed in 2016
- Stress timing: Before or at Tasseling (VT)
- Husks leaf and ear elongate a slight different times

**Ear Symptomology**

- Normal Secondary Ear
- Short Husks
Summary

- Staging is critical component of many management decisions
- Corn yield components are set at different times during development
  - Can be used as a diagnostic for when things happened
- Acute vs. Chronic impacts on yield components

Thank You

What questions do you have?