Influence of ENSO Phase on Optimal Corn Planting Dates in North Carolina

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Background

• Traditional planting dates in North Carolina
  • late March – early May
  • avoid corn earworm and corn borer damage

• New genetically modified hybrids
  • provide protection against these pests
  • later planting dates may be viable
  • growers have planted later with good results

• Drought stress during pollination and grain setting limits yield potential
Background

Corn Yield Residuals by County, 1969-2008

La Niña Years

El Niño Years

Greener – higher yields

Redder – lower yields

Objectives

1. Determine likelihood of drought stress during pollination and grain-setting for different planting dates, corn hybrids, and locations

2. Determine if optimal planting date and corn hybrid vary with ENSO phase

3. Determine if fall ENSO values can be used to help select planting date for following spring
Methods

Simulate daily drought stress and corn yield:

1. CSM-CERES-Maize 4.0.2
2. Climate data from 1950 – 2009 (COOP)
3. Twelve planting dates from Apr 1 – June 19
4. 0.76 m row spacing, 70,000 plants/ha
5. No nutritional or pest problems, no irrigation
6. Mid-maturity (N75-T2), and late-maturity hybrids (HS9977)
7. Primary mapped agricultural soil for the county, with average water-holding capacity
Methods

Three ENSO indices evaluated:

1. Japan Meteorological Agency (JMA)
2. Oceanic Niño Index (ONI)
3. Multivariate ENSO Index (MEI)
   - La Niña - values < -0.7
   - El Niño - values > 0.7

4. Each crop year categorized based on the preceding fall, winter, and spring index values.
Methods

1. Calculated average drought stress during week before and week after silking (flowering)

2. Compared these stress values and yield across:
   - Planting date
   - ENSO phase
   - Corn hybrid maturity

3. Used Spearman rank correlation coefficients to compare planting date rankings for each ENSO phase as determined by the various indices
Counties Simulated

1 = Pasquotank
2 = Washington
3 = Edgecombe
4 = Lenoir
5 = Johnston
6 = Sampson
7 = Robeson
8 = Union
Washington County, drought stress during week before & after silking
Washington County, simulated yield as % of maximum simulated non-irrigated yield

- 50%
- 55%
- 60%
- 65%
- 70%
- 75%
- 80%
- 85%
- 90%
- 95%
- 100%

Planting date (1950 - 2009)

Simulated yield, % of maximum

- mid-maturity hybrid
- late-maturity hybrid
Washington County, mid-maturity hybrid

Yield, % of no-stress yield

Drought stress index before & after silking

\[ y = -0.80x + 0.91 \]

\[ r^2 = 0.70 \]
Washington County, average silking dates (JMA used to categorize years)

Silking date
- El Nino
- La Nina
- Neutral

Silking dates:
- 6/13
- 6/23
- 7/3
- 7/13
- 7/23
- 8/2
- 8/12
- 8/22
- 28-Mar
- 17-Apr
- 7-May
- 27-May
- 16-Jun

Planting date (1950-2009)
- mid-maturity
- late-maturity

Graphs showing the relationship between planting dates and silking dates under El Nino, La Nina, and Neutral conditions.
Washington County, JMA Index, mid-maturity corn hybrid

Simulated water stress

- El Nino
- La Nina
- Neutral

Planting Date (1950-2009)
Washington County, JMA Index, late-maturity corn hybrid

![Graph showing simulated water stress over planting dates (1950-2009) with different water stress conditions: El Nino, La Nina, and Neutral.](image)
Washington County, JMA Index, El Niño years, mid-maturity hybrid

![Graph showing probability of exceedance for stress index week before and after silking for different dates: 1-Apr, 1-May, and 29-May. The graph plots stress index values against probability of exceedance.](Image)
Washington County, simulated water stress for JMA vs MEI Aug-Sep ENSO phase
### Washington County, correlation of relative planting date rankings

<table>
<thead>
<tr>
<th>Hybrid Maturity</th>
<th>ENSO Phase</th>
<th>Spearman's Rank Correlation Coefficient</th>
<th>JMA vs MEI</th>
<th>JMA vs ONI</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Aug-Sep</td>
<td>Jan-Feb</td>
<td>Mar-Apr</td>
</tr>
<tr>
<td>Mid</td>
<td>El Niño</td>
<td>0.94</td>
<td>0.85</td>
<td>0.38</td>
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<tr>
<td></td>
<td>La Niña</td>
<td>0.85</td>
<td>0.76</td>
<td>0.92</td>
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<tr>
<td></td>
<td>Neutral</td>
<td>0.97</td>
<td>0.92</td>
<td>0.98</td>
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<tr>
<td>Late</td>
<td>El Niño</td>
<td>0.97</td>
<td>0.86</td>
<td>0.46</td>
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<tr>
<td></td>
<td>La Niña</td>
<td>0.91</td>
<td>0.65</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>0.98</td>
<td>0.93</td>
<td>0.96</td>
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<tr>
<td>Mean</td>
<td></td>
<td>0.94</td>
<td>0.83</td>
<td>0.77</td>
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</tbody>
</table>
Washington County, relative planting date rankings in years categorized as El Niño by JMA Index and Mar-Apr MEI
Washington County, mean rainfall during 2-week period centered on given date

JMA

Rain, 2-week sum, mm

El Nino  La Nina  Neutral

mid maturity silking  4/1 plant  5/1 plant  5/29 plant

Date, 1950-2009

2-Apr  22-May  11-Jul  30-Aug
Washington County, mean rainfall during 2-week period centered on given date

Rain, 2-week sum, mm

MEI Mar - Apr

mid maturity silking
5/1 plant
5/29 plant
4/1 plant

Date, 1950-2009
Washington County, planting date rankings, fall & spring MEI El Niño, mid maturity

SRCC = 0.64

SRCC = 0.83
Average planting date rankings across all 8 counties, JMA Index, mid-maturity hybrid

- **El Nino**
- **La Nina**
- **Neutral**

Planting Date (1950-2009)
Conclusions

1. Simulated water stress during critical pollination and grain setting period is higher for almost all planting dates in El Niño years in NC.

2. Fall MEI (Sep – Oct) or ONI (Aug – Oct) values can be used to help select corn planting dates to minimize risk of water stress during this period.

3. Growers should avoid planting corn around May 1 in an El Niño year.

4. Delaying planting as late as possible appears to reduce the risk of stress in a neutral year.

5. It appears to be better to plant in May than in April or June in a La Niña year.
Acknowledgements

Financial assistance for this project was provided by the Corn Growers Association of North Carolina and Pioneer Hybrid International, Inc.

The idea for the project arose in a workshop with university extension specialists sponsored by the Southeast Climate Consortium.
Washington County, ratio of rainfall to reference ET for 2-week period centered on given date, JMA Index

Washington County, Ratio of Rainfall / Reference ET

<table>
<thead>
<tr>
<th>Date (1950-2009)</th>
<th>Ratio</th>
<th>El Nino</th>
<th>La Nina</th>
<th>Neutral</th>
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<tbody>
<tr>
<td>6-Jun</td>
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<tr>
<td>16-Jun</td>
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<tr>
<td>26-Jun</td>
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<tr>
<td>6-Jul</td>
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<tr>
<td>16-Jul</td>
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<td>26-Jul</td>
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<td>5-Aug</td>
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<td>15-Aug</td>
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<tr>
<td>25-Aug</td>
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silking, May 1 plant mid-maturity

silking, May 1 plant late-maturity
Washington County, relative planting date rankings of water stress around silking

<table>
<thead>
<tr>
<th>Planting Date</th>
<th>JMA Oct</th>
<th>MEI Aug-Sep</th>
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<tbody>
<tr>
<td></td>
<td>El Niño</td>
<td>La Niña</td>
</tr>
<tr>
<td>April 1</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>April 8</td>
<td>4</td>
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<td>April 15</td>
<td>8</td>
<td>11</td>
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<td>April 23</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>May 1</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>May 8</td>
<td>11</td>
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<td>6</td>
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<tr>
<td>May 22</td>
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<tr>
<td>May 29</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>June 5</td>
<td>5</td>
<td>4</td>
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<td>June 12</td>
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<td>9</td>
</tr>
<tr>
<td>June 19</td>
<td>1</td>
<td>12</td>
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Washington County, rainfall for El Niño years classified by MEI Sep-Oct

![Graph showing rainfall data for different El Niño conditions.](chart.png)
Lenoir County, simulated water stress, JMA Index, mid-maturity hybrid

![Graph showing simulated water stress over planting dates from 28-Mar to 16-Jun for El Nino, La Nina, and Neutral conditions.](image_url)