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Using Temporal Remote Sensing Measurements to Assess Physiological Maturity in Cotton

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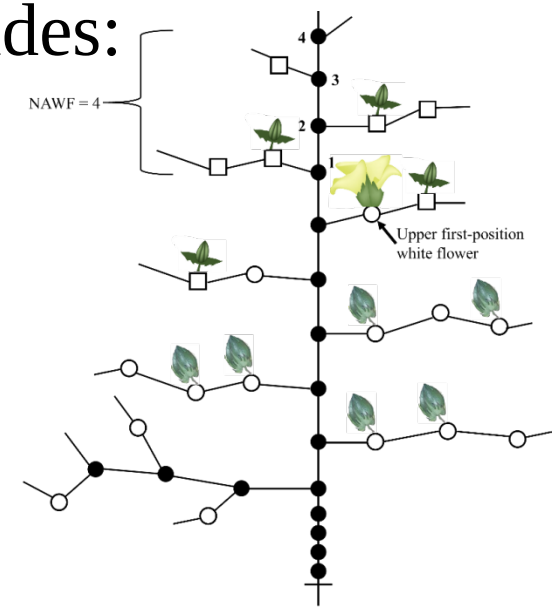
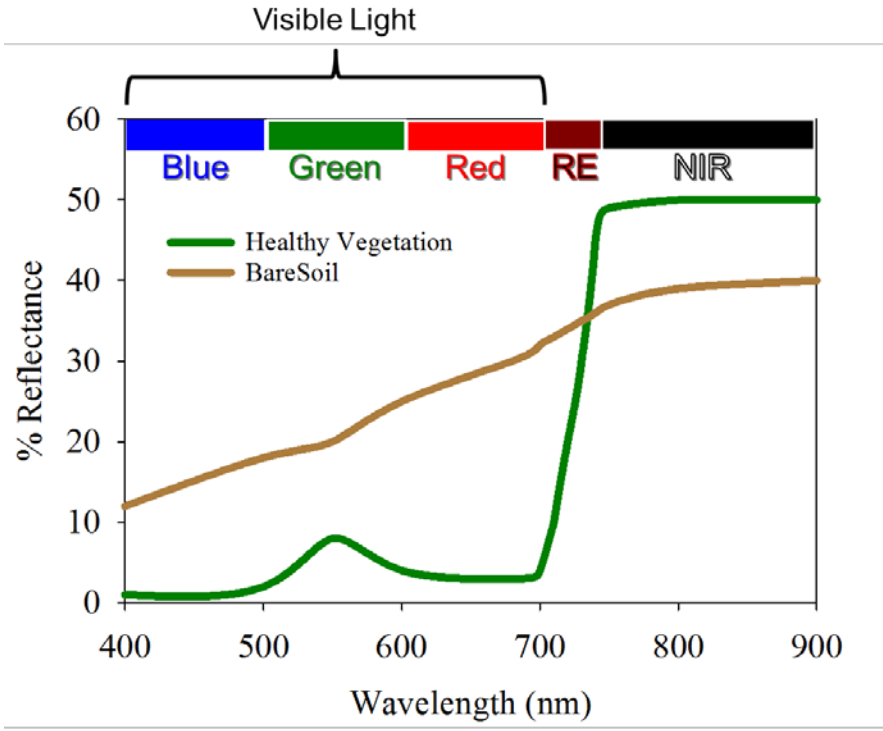
Introduction – Maturity

- Cotton is a perennial plant by nature but is managed as an annual row crop.
  - Due to its indeterminate growth, quantifying maturity can be difficult.
  - Researchers need a more efficient and objective method to assess maturity in cotton.
- One quantitative maturity estimate includes:
  - Nodes above white flower (NAWF)
    - Because of the time and labor required, not often used on large scale field trials and the more subjective percent open boll (POB) is used.
    - As the plant matures and sets additional bolls, the addition of new nodes slows, then ceases.[1]



Introduction – Vegetation Index

- Due to differential reflectance of light by plants at different wavelengths, vegetation indices can be used to quantify crop growth and health.
- Normalized Difference Red Edge (NDRE)
  - NDRE = $(\lambda_{NIR} - \lambda_{RE}) / (\lambda_{NIR} + \lambda_{RE})$
  - λ_{NIR} = Reflectance in the near infrared
  - λ_{RE} = Reflectance in the red edge
  - RE is associated with chlorophyll absorption[2]
  - NIR is associated with leaf cellular structure



Objectives

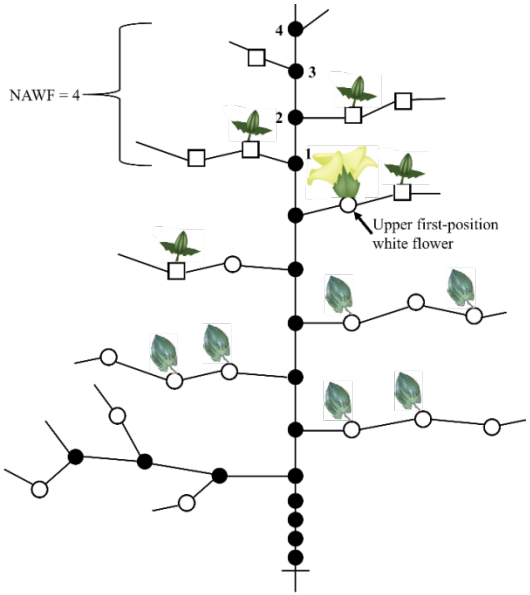
1. Develop maturity score based on NDRE inflection point, namely Growth Inflection Point.
2. Identify relationship between Growth Inflection Point (GIP) and NAWF.

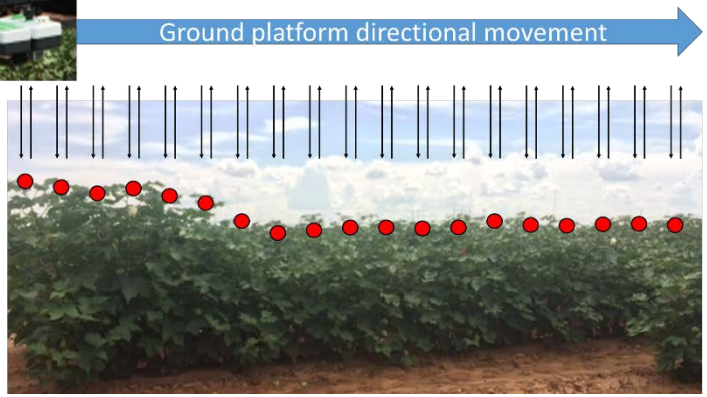
Materials & Methods

- 3 Year Study (2015-2017)
- 9 commercially available cotton cultivars
  - 3 Maturity Classifications (Early, Early-Mid, and Mid)
- 3 Irrigation Treatments
  - 20% ET, 40% ET, and 60% ET
- Randomized split-block design
  - Main Effect – Irrigation
  - Sub Plot – Cultivar
- 4 reps/ entry

Materials & Methods – Data Acquisition

- Crop Circle "Phenom Series" by Holland Scientific
  - ACS-430 active multispectral sensor measures reflectance in three wavelengths
    - Red – 670 nm
    - Red Edge 730 nm
    - Near Infrared – 780 nm
  - Speed set to 4.83 km hr^{-1}, (~ 1 hour per hectare)
- NAWF
  - Subplot of 5 plants $plot^{-1}$
  - Taken once during full bloom

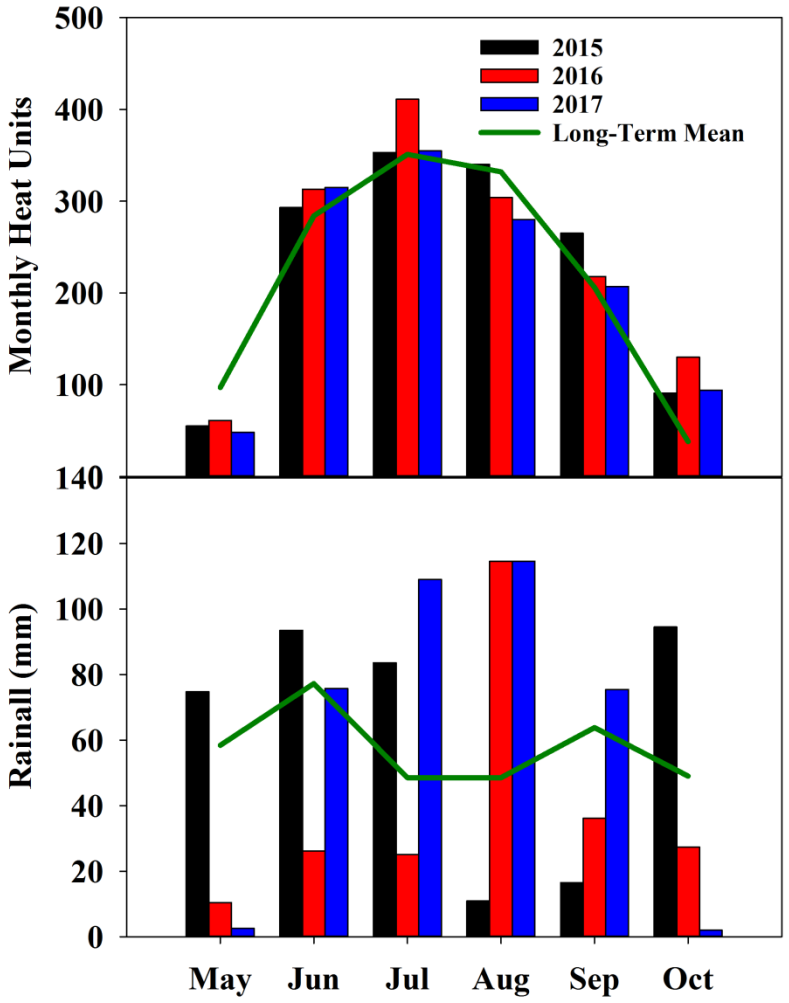




Results & Discussion

Environmental Conditions

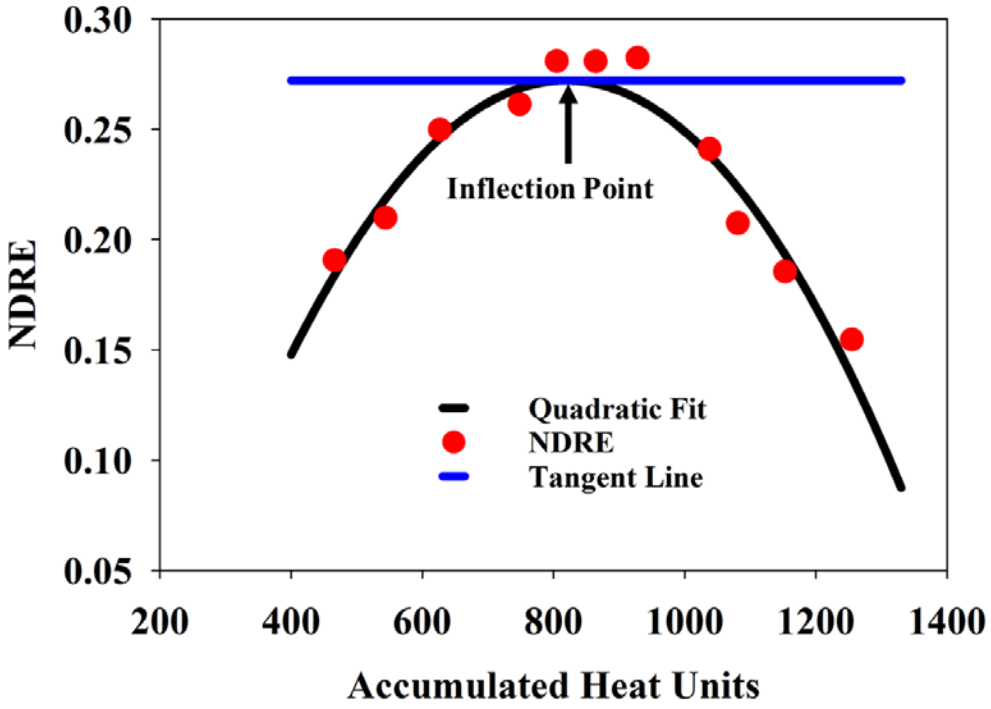
- Different growing conditions observed for the 3 years.
- 2015
  - Wet and hot early, fb hot and dry conditions during boll production and development.
- 2016
  - Hot and dry early, fb hot and wet conditions during late summer
- 2017
  - Average temperatures early, cooler temperatures during boll production and development, wet June-September.



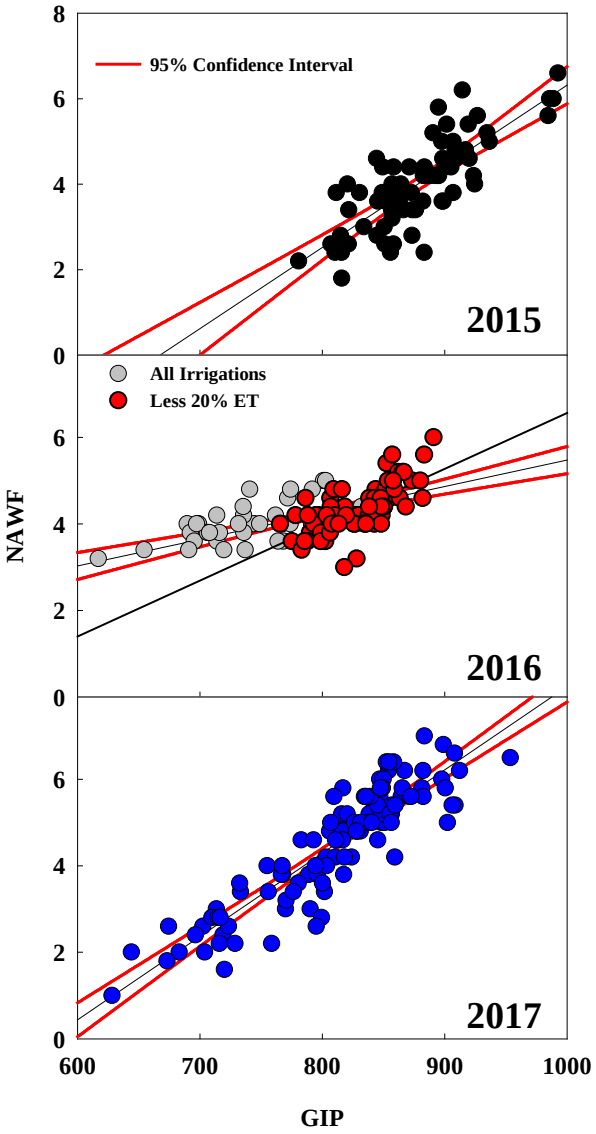
Growth Inflection Point (GIP)

- Identifying Growth Inflection Point
  - Quadratic equation
    - $f(x) = -7.08*10^{-7}x^2 + 1.16*10^{-3}x - 0.20$
  - First derivative
    - $f'(x) = -1.42*10^{-6}x + 1.16*10^{-3}$
  - Set equal to zero and solve for x
    - *GIP = 821*

- GIP is within the range of accumulated heat units documented for physiological cutout (556 – 889).[3]



Regression Analysis



- Statistically significant relationship between Growth Inflection Point (GIP) and NAWF.
  - 2015
    - $r^2 = 0.63$; *p*-value <0.0001
    - NAWF = 1.9×10^{-2}(GIP) – 12.7
  - 2016
    - $r^2 = 0.38$; *p*-value <0.0001
    - NAWF = 6.1×10^{-3}(GIP) – 0.64
    - Less 20% ET treatment,
      - r^2=0.47; NAWF = 1.3×10^{-2}(GIP) – 6.3
  - 2017
    - $r^2 = 0.81$; *p*-value <0.0001
    - NAWF = 1.9×10^{-2}(GIP) – 11.1
- Similar regression equations in 2015 and 2017.

Conclusions

- Quantifying maturity in cotton can be difficult due to its indeterminate growth.
- Estimates of GIP were within range of heat units documented for physiological cutout (556 – 889).[3]
- Statistically significant correlations between GIP and NAWF in all three years.
- GIP as a method of maturity estimation looks promising, and should be tested across a wider range of environments and cultivars to better identify limitations.
- GIP would benefit researchers from a rapid and efficient method in measuring maturity from data that is already being captured in many programs.

References

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Acknowledgements

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