

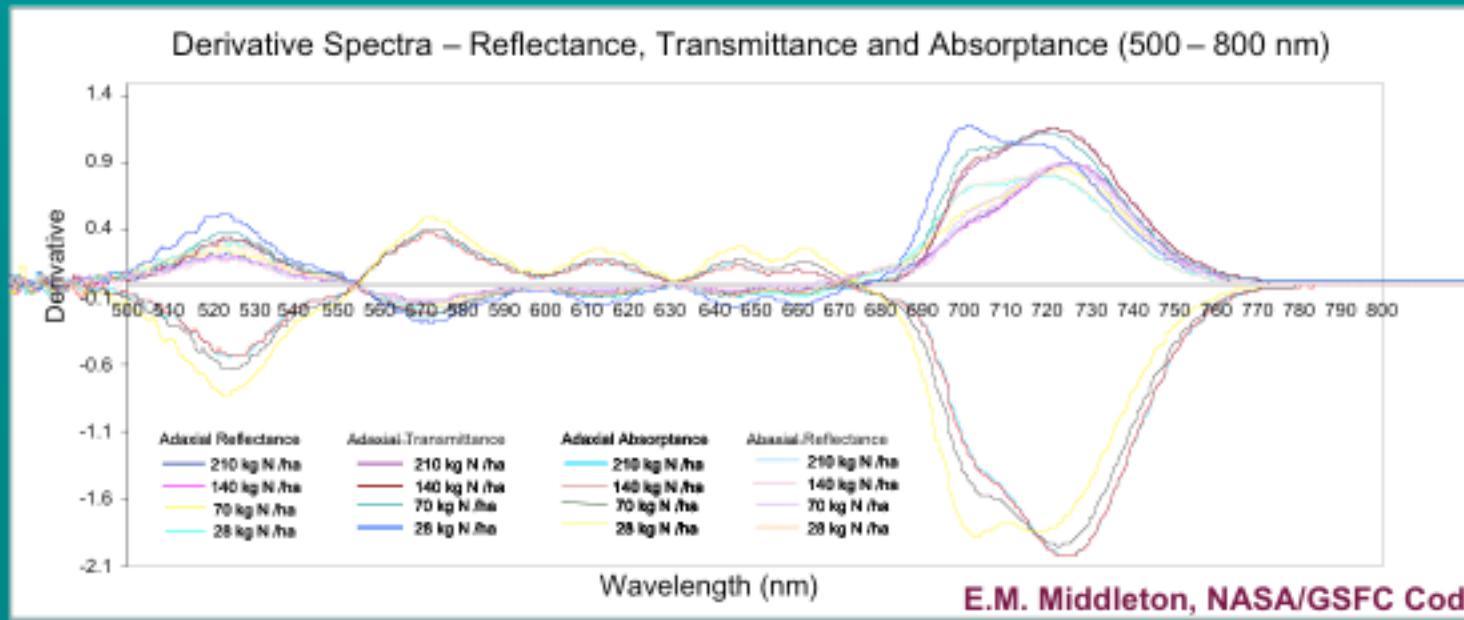
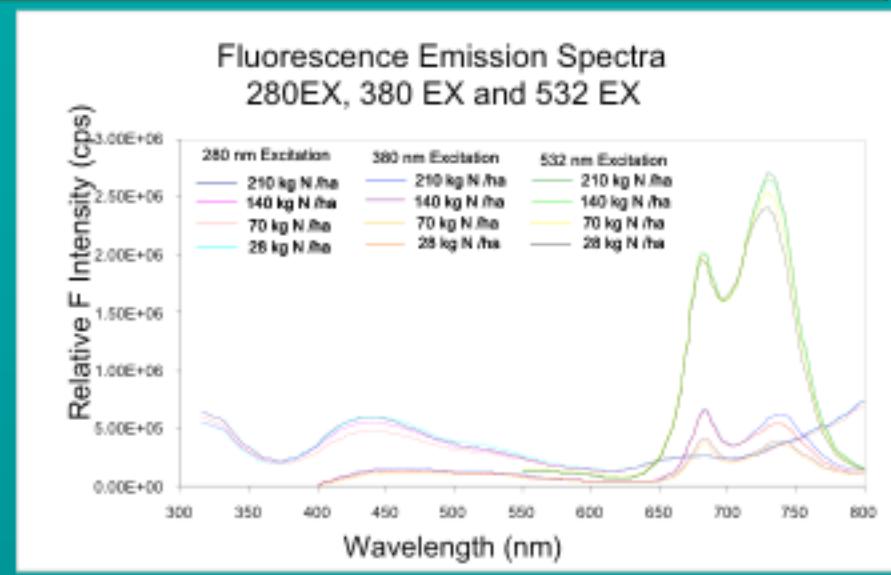
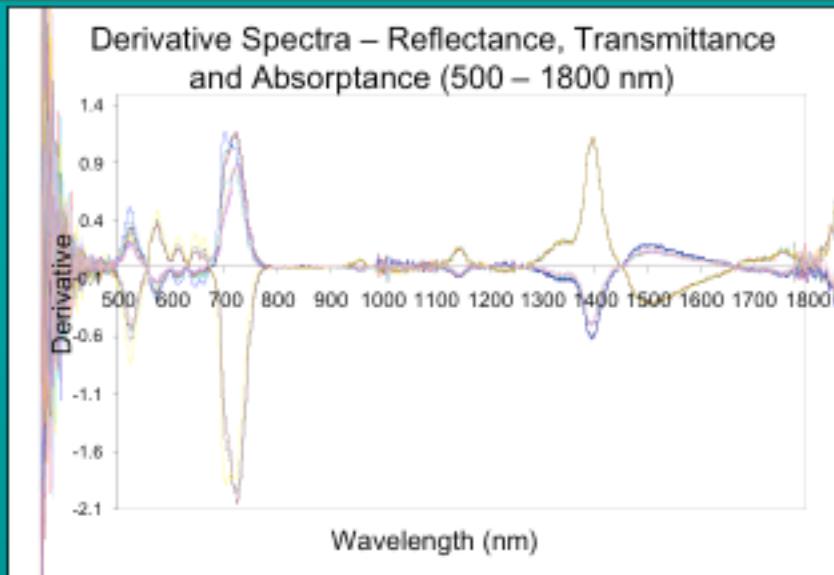


## Theme # 3

Spectral Indicators Related to  
Carbon & Nitrogen Dynamics



# Leaf Optical Properties



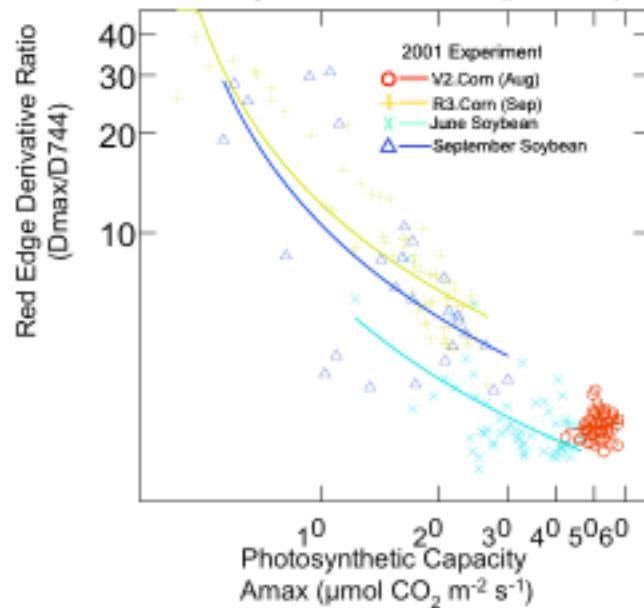


# Spectral Reflectance and Fluorescence Indices and Photosynthesis



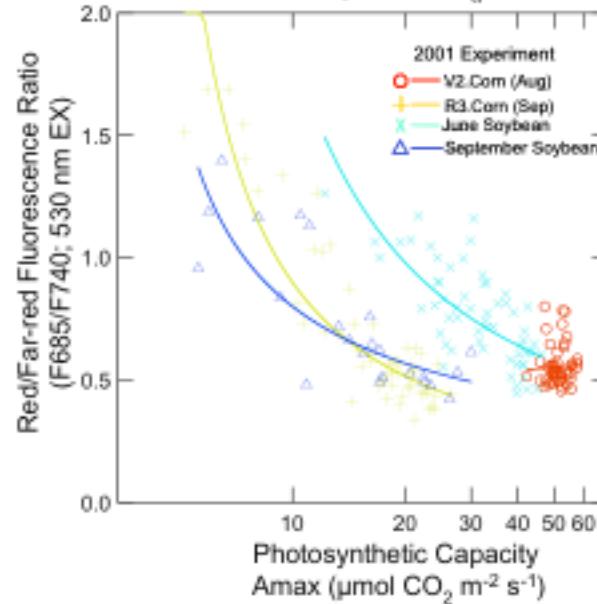
Red Edge Reflectance Ratio  
(Dmax / D744) vs. Amax

Corn (*Z. mays*) and Soybean (*G. max*) 2001  
n = 176 regression,  $r^2 = 0.97$  ( $p < 0.01$ )



Red / Far-red Fluorescence Ratio  
(F685 / F740) vs. Amax

Corn (*Z. mays*) and Soybean (*G. max*) 2001  
n = 189 correlation,  $r = 0.79$  ( $p < 0.000$ )



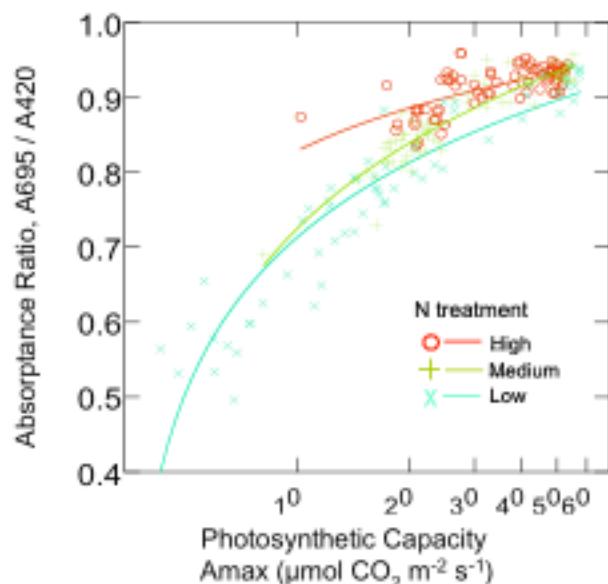


# Relationships of Spectral Optical Properties to Photosynthesis and N Treatment



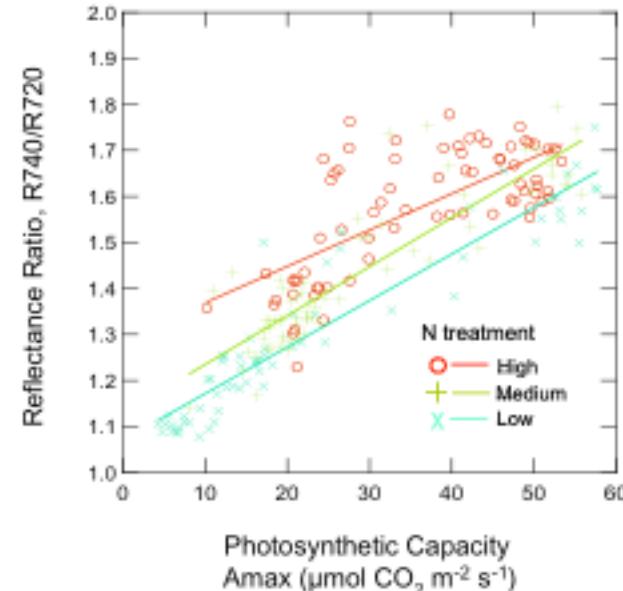
Absorptance Ratio ( $A_{695} / A_{420}$ ) vs.  $A_{max}$

Corn (*Z. mays*) and Soybean (*G. max*) 2001  
 $n = 199$  regression,  $r^2 = 0.92$  ( $p < 0.000$ )



Reflectance Ratio ( $R_{740}/R_{720}$ ) vs.  $A_{max}$

Corn (*Z. mays*) and Soybean (*G. max*) 2001  
 $n = 200$  regression,  $r^2 = 0.87$  ( $p < 0.000$ )

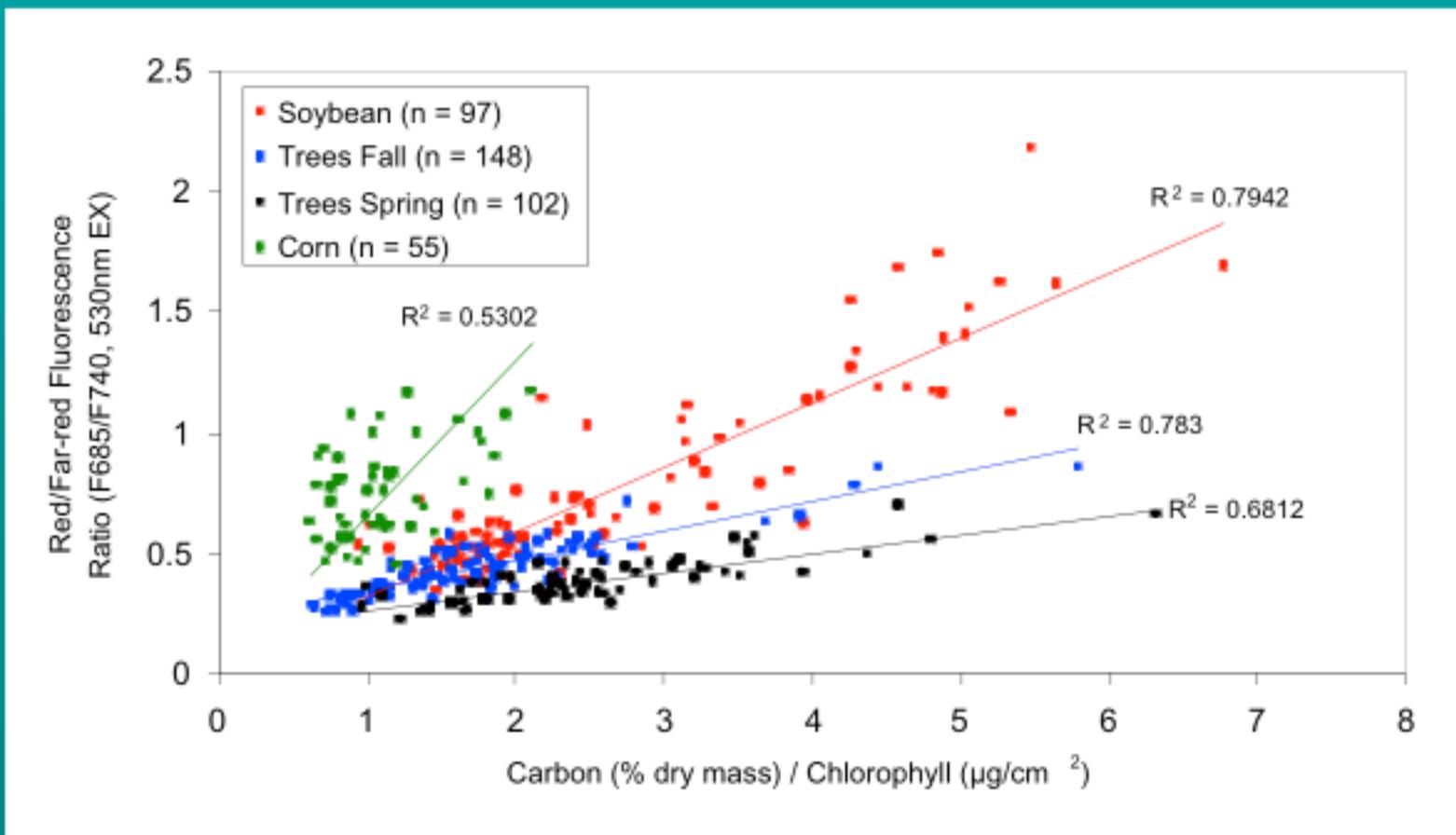




# Chlorophyll Fluorescence as an Indicator of Photosynthetic Carbon Assimilation



The Red to Far-Red fluorescence ratio with a 530 nm excitation relates to the degree to which light energy absorbed by chlorophyll leads to photosynthetically sequestered carbon.





## **Theme # 4**

**Understanding the Underlying  
Photochemistry/Photobiology**

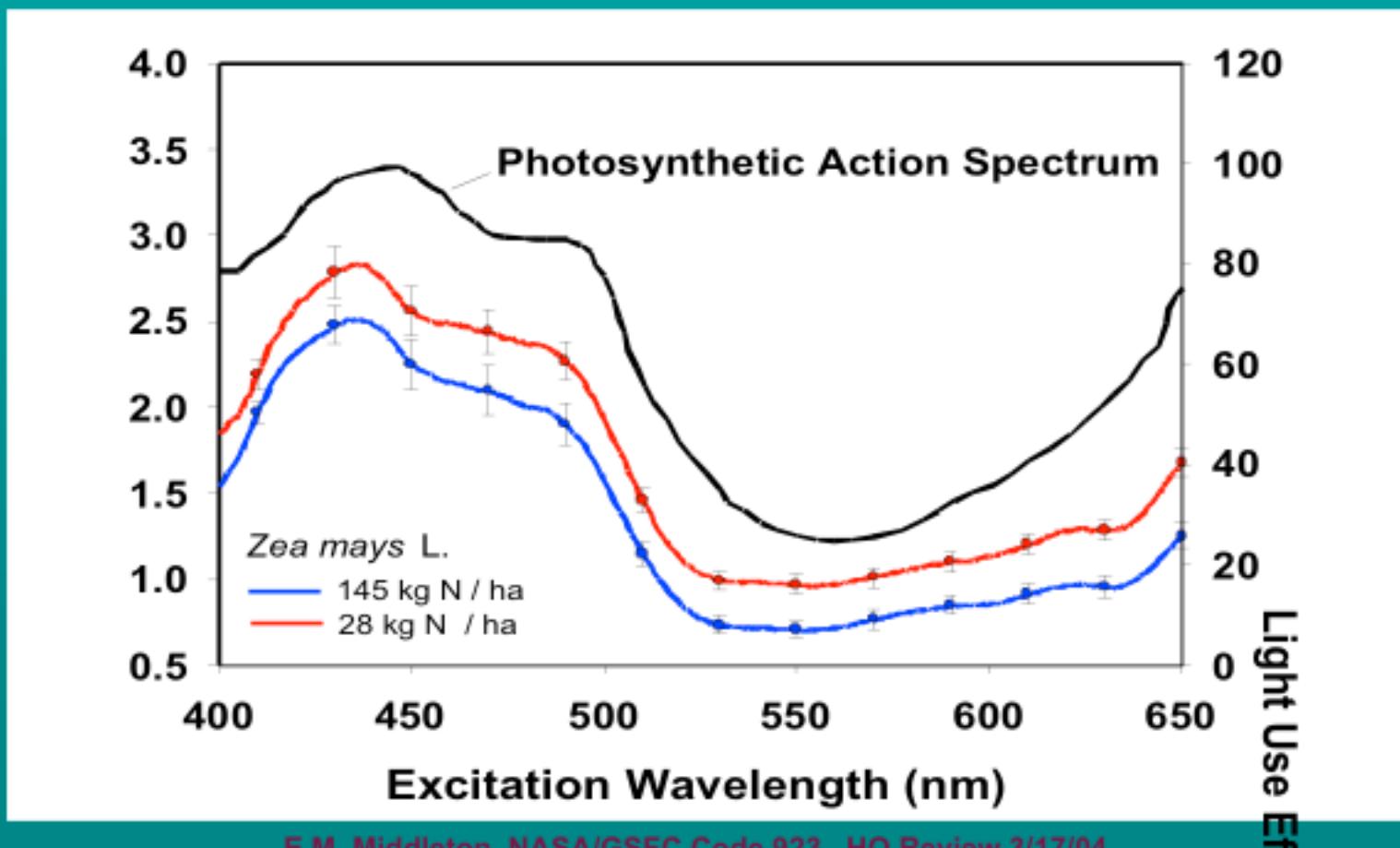
**Understanding the Behavior of  
Red/Far-Red Fluorescence Ratio**



# Chlorophyll Fluorescence as an Indicator of Photosynthetic Light Use Efficiency



The ratio of Red to Far-Red fluorescence emissions as a function of excitation wavelength relates to the relative efficiency to which light is used for photosynthesis.

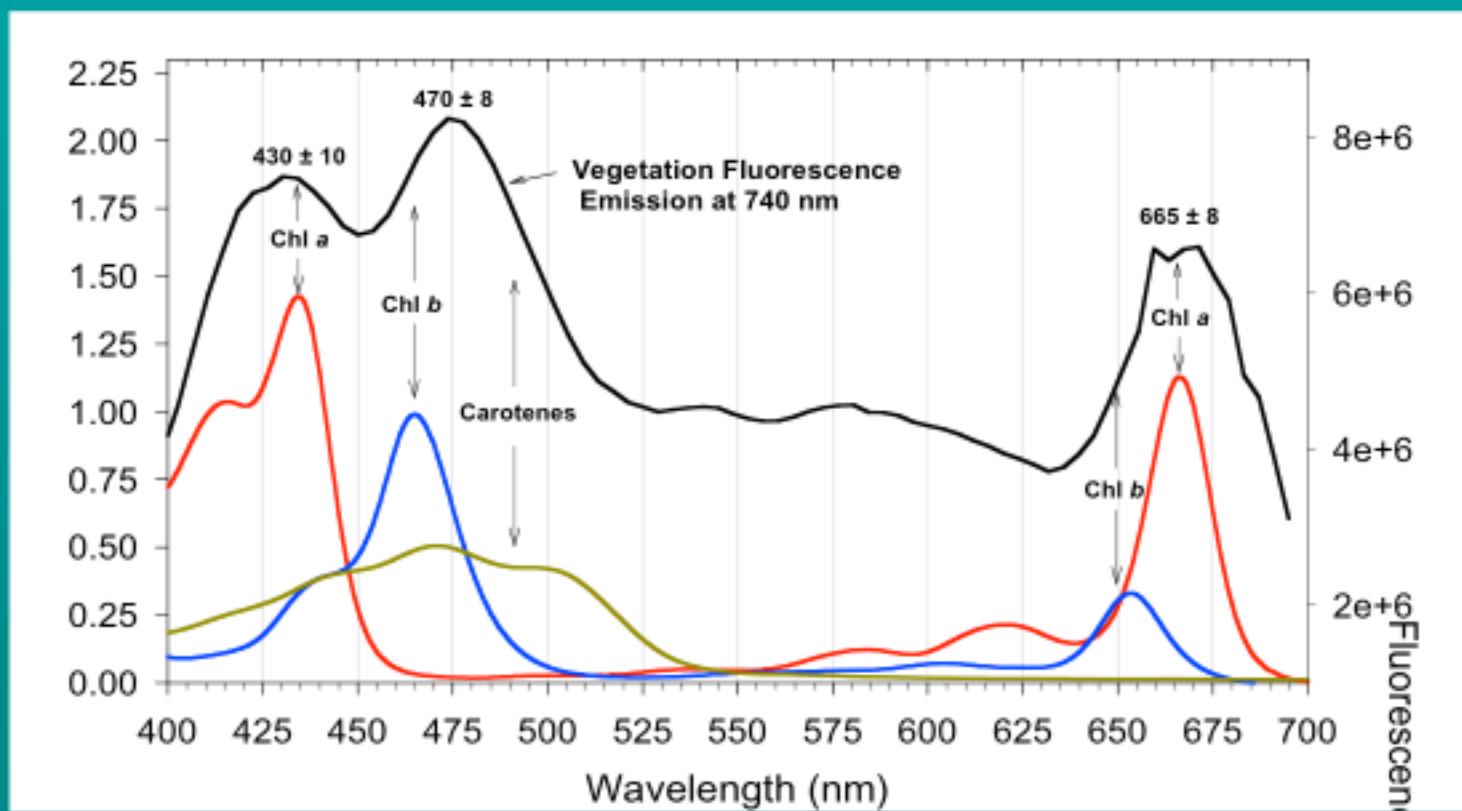




# Dual Excitation Ratios Separate Photosynthetic Pigment Concentrations



The fluorescence feature, although emitted exclusively through Chl a, exhibits additional maxima coinciding with the absorptive properties of the non-fluorescing secondary photosynthetic antenna pigments.



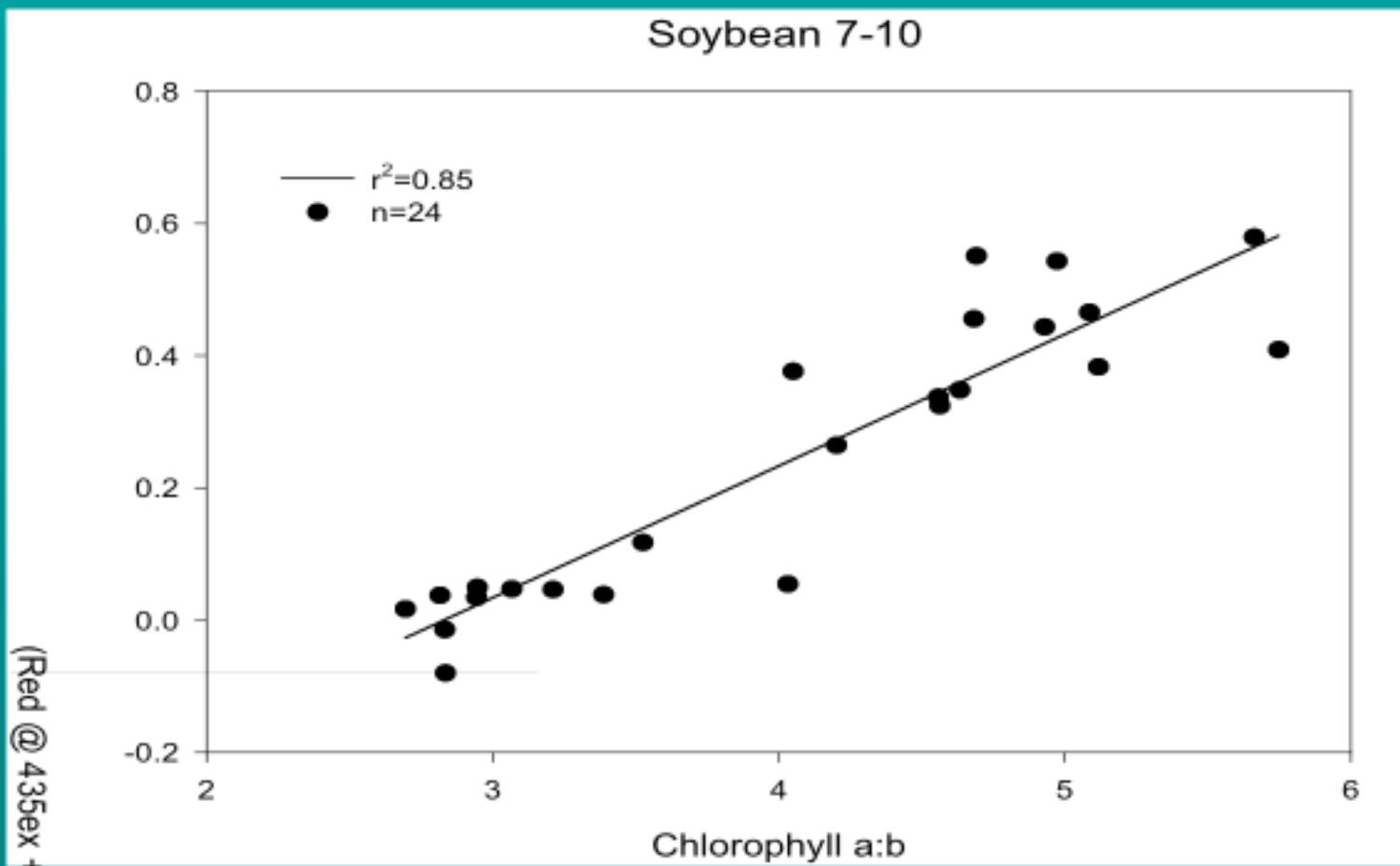
Corp, L.A., Middleton, E.M., McMurtrey, J.E., Entcheva Campbell, P.K., Butcher, L.M., "Fluorescence Sensing Systems: Optimizing Sensitivity to Vegetation Parameters", *Applied Optics*, submitted 4/2004.



# Non-Destructive Determination of Plant Pigment Ratios



Plant stress can influence the relative concentrations of photosynthetic pigments. Here the normalized dual Chl F excitation ratio exhibits a linear relationship with the ratio of Chl a to Chl b.

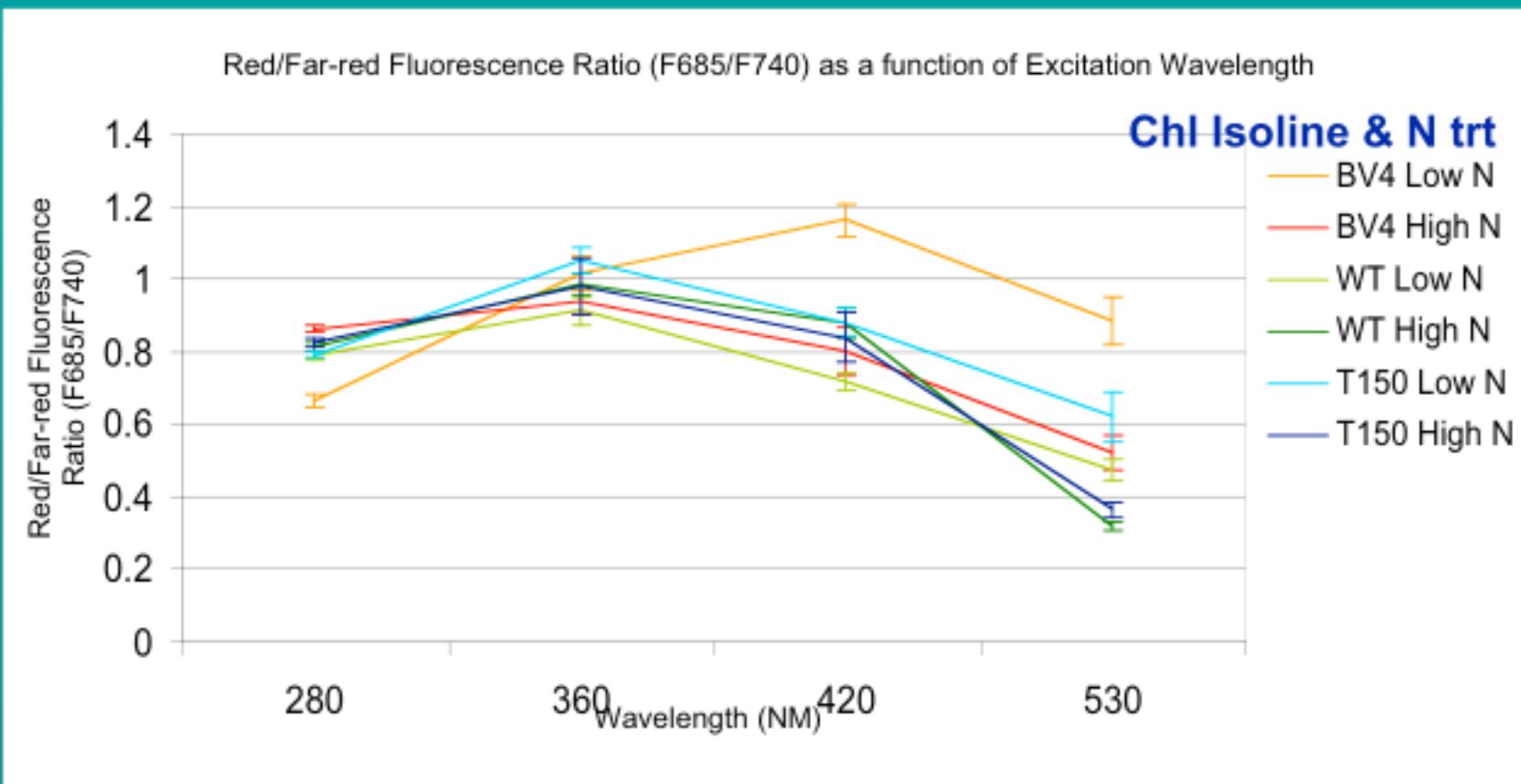




# Sensitivity of R/FR Fluorescence Ratio

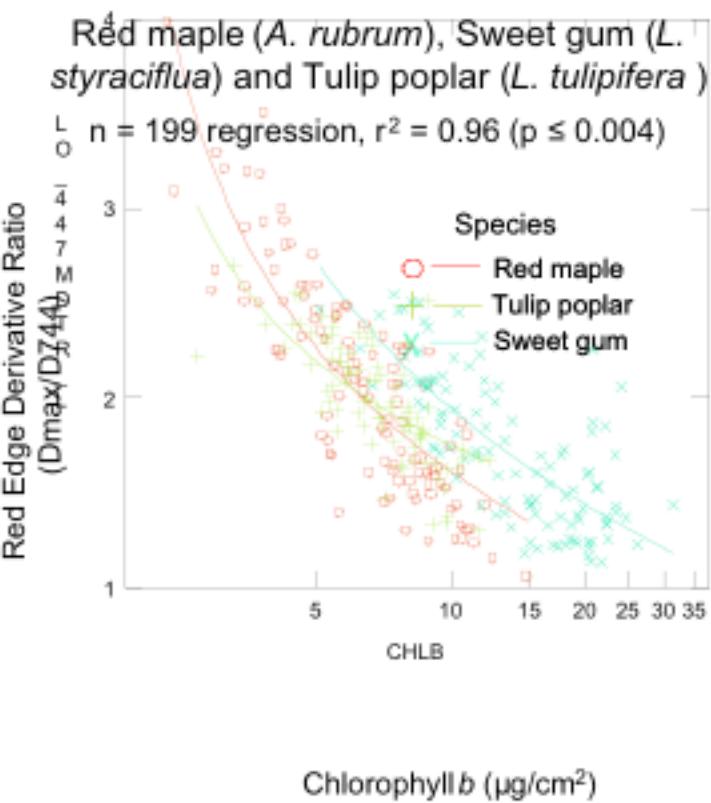
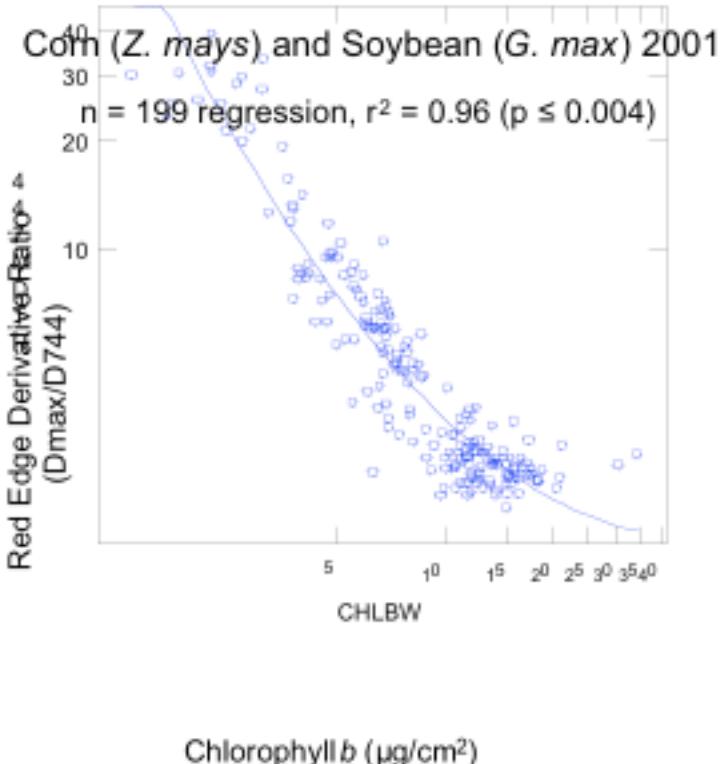


Two Chlorophyll *b* deficient soybean isolines (BV4 and T150) and one wild type (WT) soybean variety were exposed to 75% (High) and 12.5% (Low) of the recommended N fertilization rate. The Red/ Far-red fluorescence ratio from a green (530 nm) excitation separated both the isolines and the N treatments.





# Red Edge Reflectance Derivative Ratio and Chlorophyll *b*

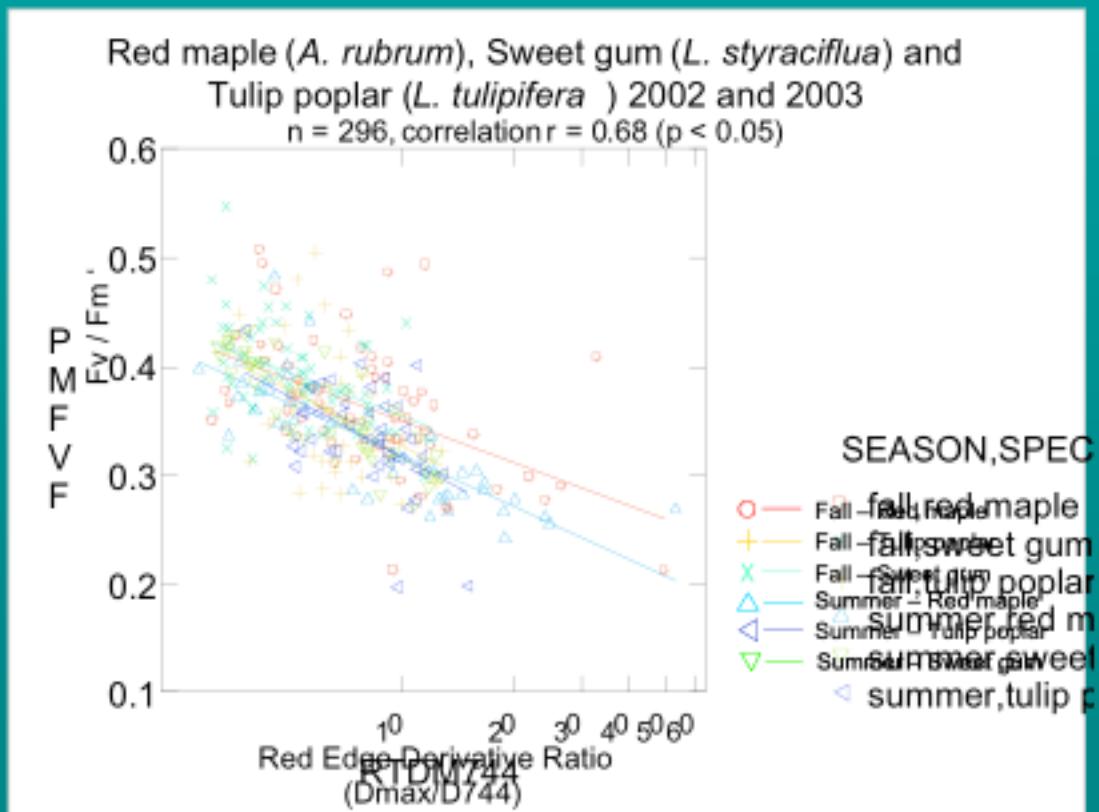




# Chlorophyll Fluorescence Kinetics and Reflectance



Chlorophyll Fluorescence kinetics and the Red Edge Reflectance Derivative Ratio distinguish species and phenology in tree saplings





## Theme # 5

**Unraveling the Relationship of Fluorescence and Reflectance**

**Contribution of Fluorescence to Red Edge Reflectance**

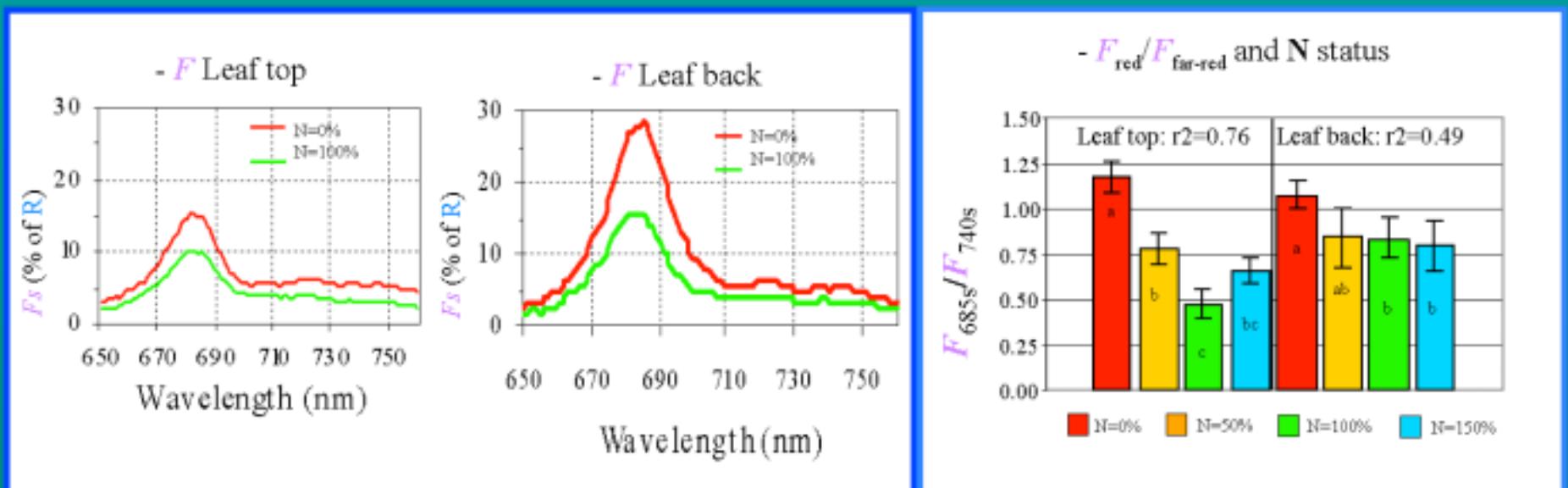
**Correlation Between Reflectance and Fluorescence**



# Contribution of Fluorescence to Reflectance

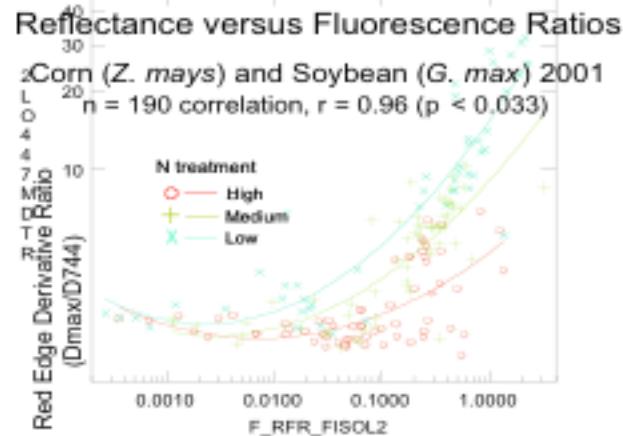


Contribution of *fluorescence (F)* to vegetation *reflectance (R)* properties: Depending on soil N availability *F* ( $F_s$ ) can contribute as much as 10-30% to the apparent *R* of corn foliage. Differences in  $F_{red}/F_{far-red}$  ratio can be indicative of N availability.





# Correlation of Fluorescence to Reflectance

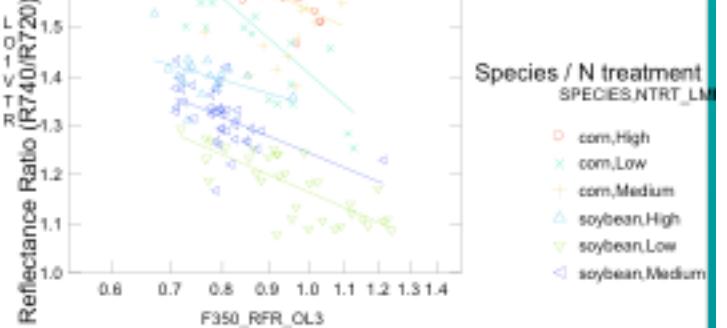


FIS Red/Far-red Image Ratio

## Reflectance versus Fluorescence Ratios

Corn (*Z. mays*) and Soybean (*G. max*) 2001

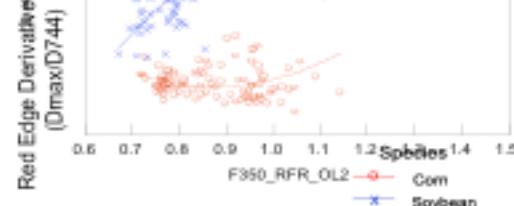
n = 190 correlation, r = 0.94 (p < 0.000)



## Reflectance versus Fluorescence Ratios

Corn (*Z. mays*) and Soybean (*G. max*) 2001

n = 190 correlation, r = 0.96 (p < 0.033)



Red/Far-red Fluorescence Ratio  
(F685/F740; 350 nm EX)

Red/Far-red Fluorescence Ratio  
(F685/F740; 350 nm EX)

