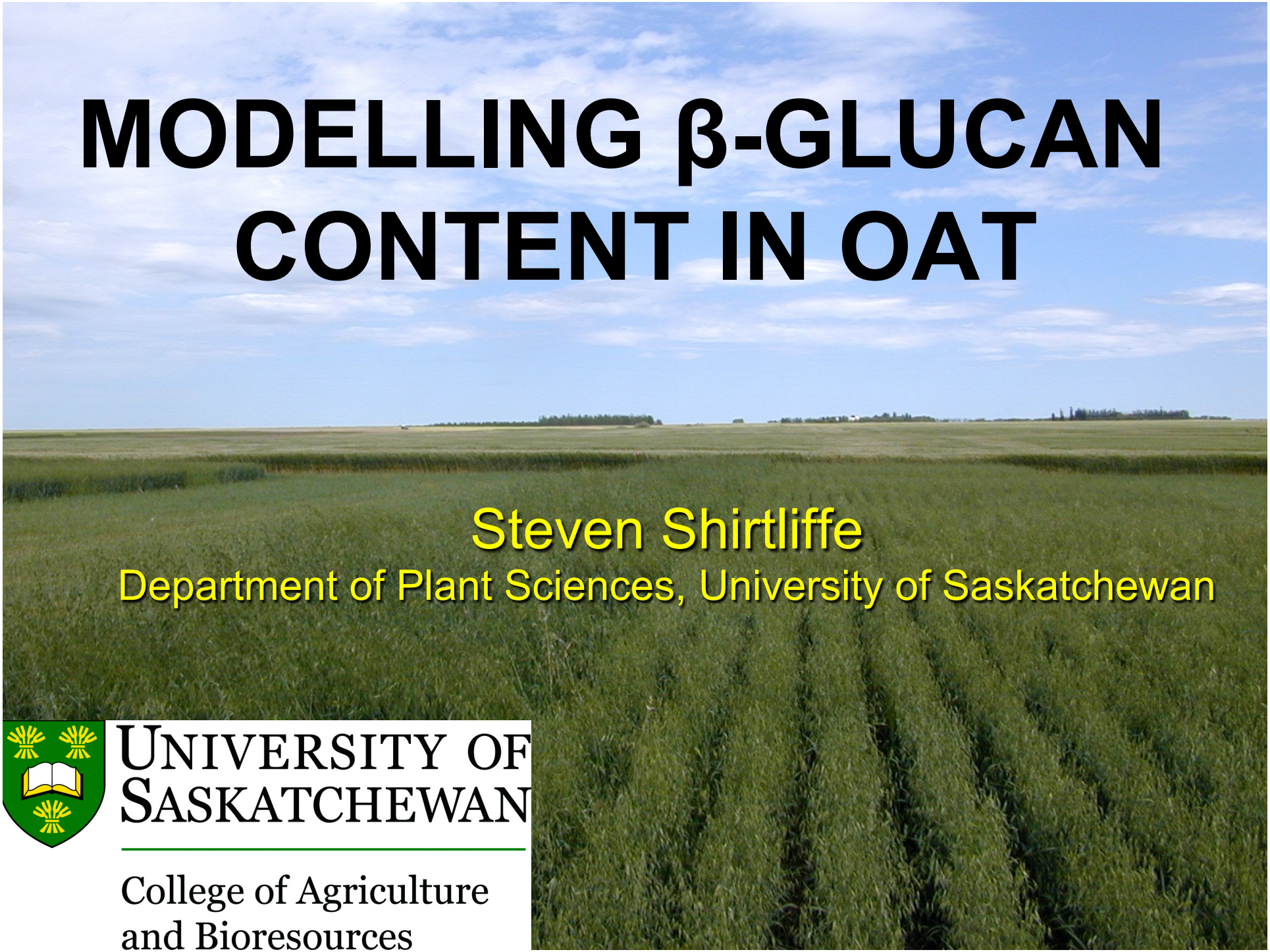
MODELLING β-GLUCAN CONTENT IN OAT



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β-glucan in oat

- Important for heath related benefits of oat
- Has been increased through plant breeding
- However in many years BG levels are relatively low

Environmental control β-glucan

- Environmental variables have equal effect compared to genetics
  - Doehlert et al. 2001
- Reduced water usually associated with increase BG
  - Brummer and Freed, 1994; Peterson et al. 1991; Peterson et al, 1995
- Increased temperature also associated with increased BG
  - Doehlert et al. 2001

β-glucan relationship to oat physical quality

- Oil content, breakage and protein positive association with BG
- Groat percentage negative correlation with BG
  - Yan et al, 2007

Modeling β-glucan

- Potential to understand environmental drivers
- Effect of environment and agronomy modelled on barley BG
  - Tiwari and Cummins (2008)

Objective

- To model the effects of environment and oat quality parameters on β-glucan content in oat

Data Set

- Western Cooperative Oat Registration Trials (WCORT)
  - 2001 to 2010
- 6-17 locations per year
- 28-36 genotypes per year
- Each genotype normally present only 2 years
- CDC Dancer control in all years
  - Usually two other control per year

β-glucan determination

- BG determined
  - NIR and flow-injection used predominantly
  - Nancy Ames
- 49 site-years BG tested
- 1641 data entries
  - one genotype with quality and environmental data

Environmental data

- precipitation
- average maximum temperature
- average minimum temperature
- cooling degree-days (days with average temperature above 18C)
- days with maximum temperature above 30 C.
- average monthly temperatures
- monthly temperature range
- growing season precipitation (May – August)

Seed physical quality

- Test weight
- thousand kernel weight
- percent plumps & percent thins
- percent groat

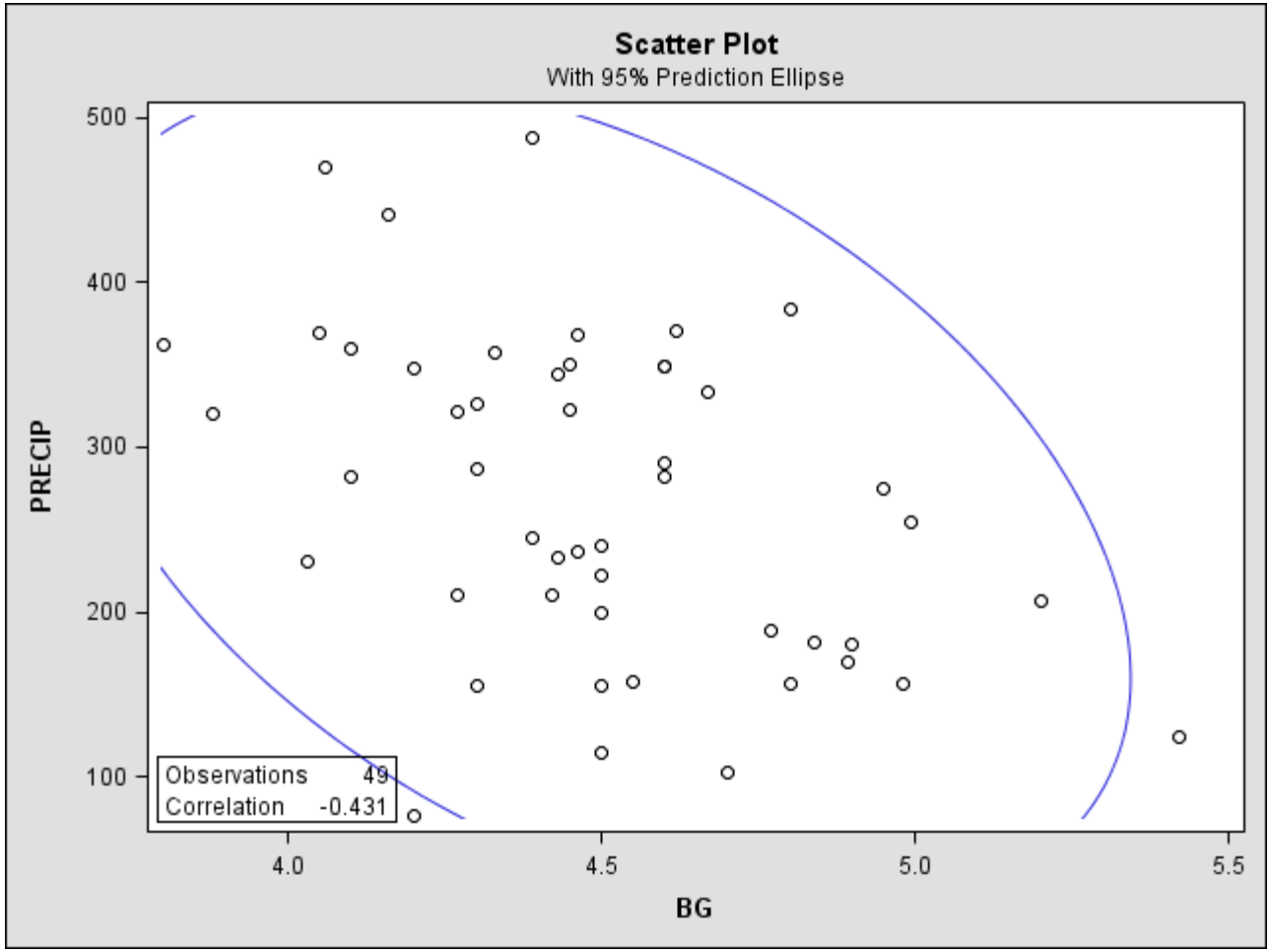
Crop development

- Days to heading
- Days to maturity

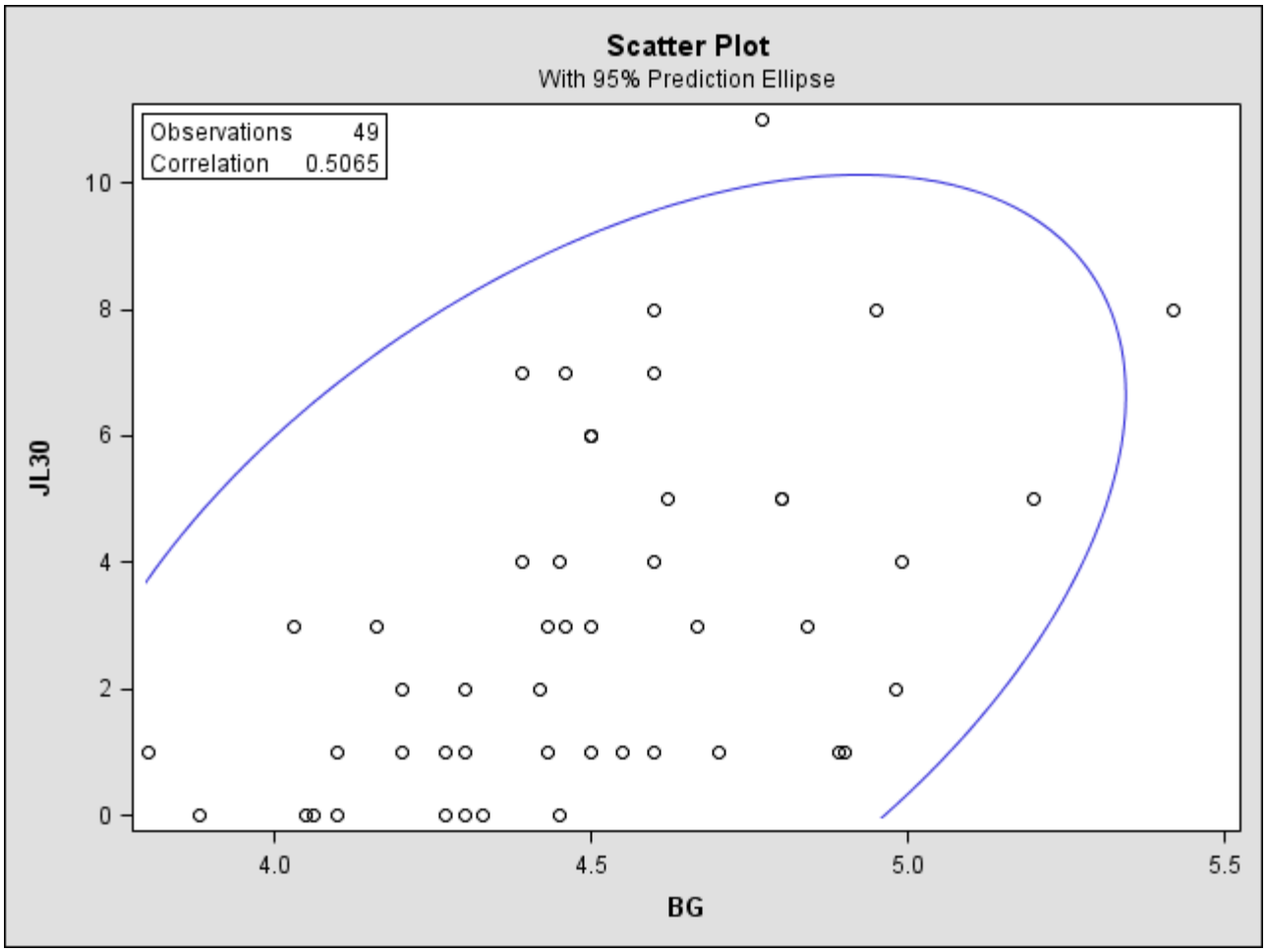
Analysis approach

- Initial exploratory analysis with correlation
- Only on CDC Dancer

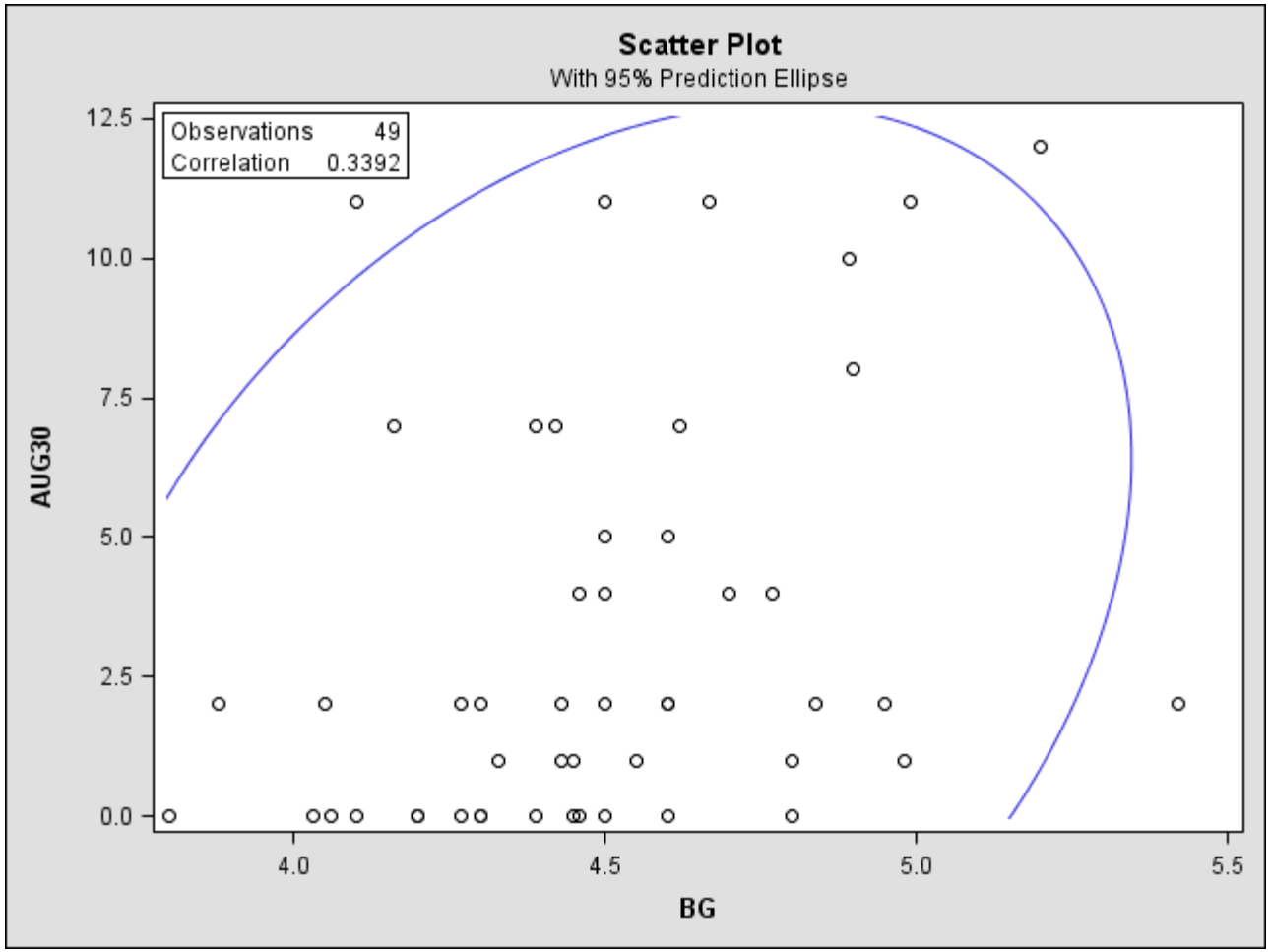
Seasonal precipitation (PRECIP) & β-glucan (BG)



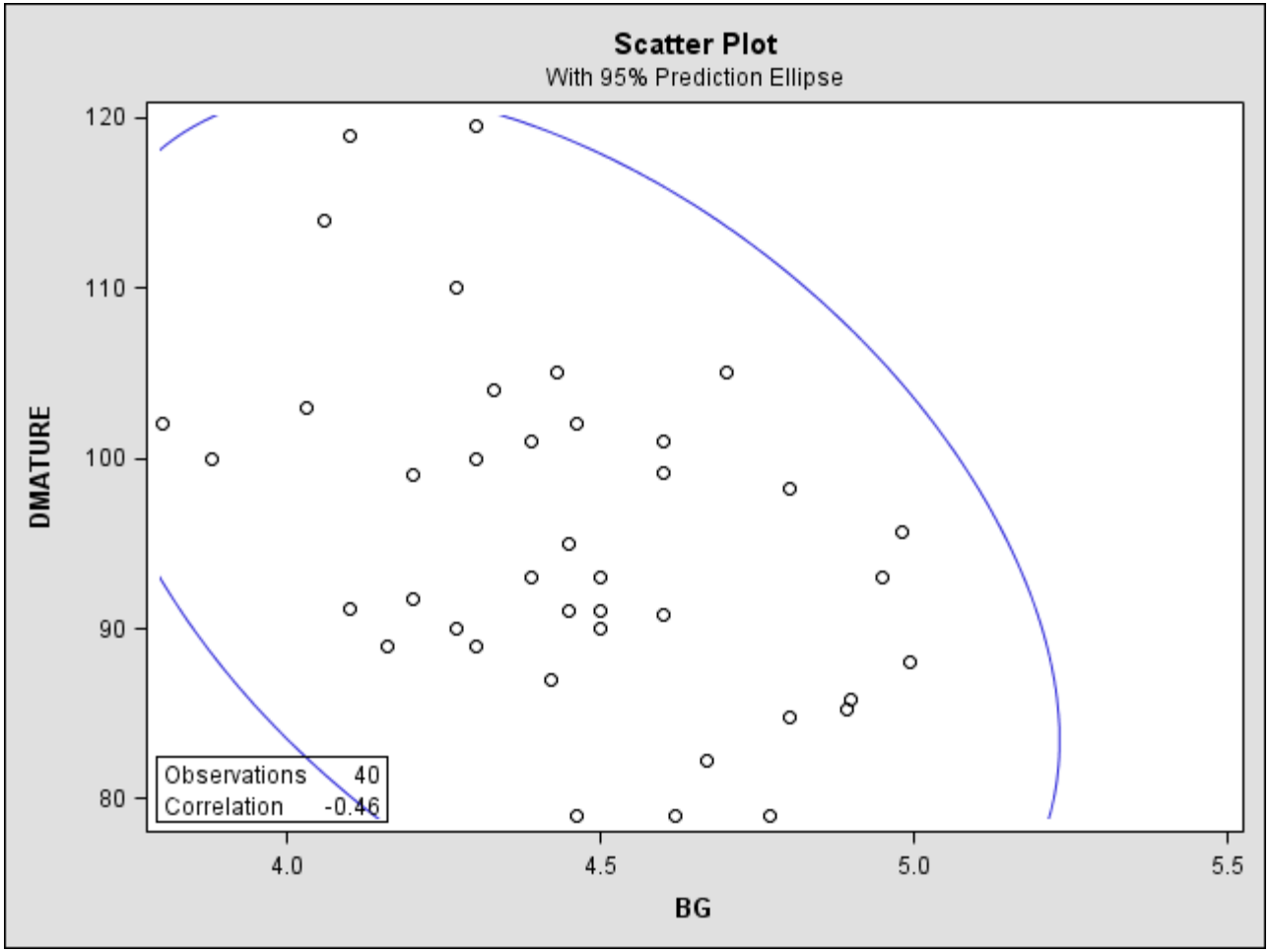
Days in July with max temperatures >30 C (JL30) & β-glucan (BG)



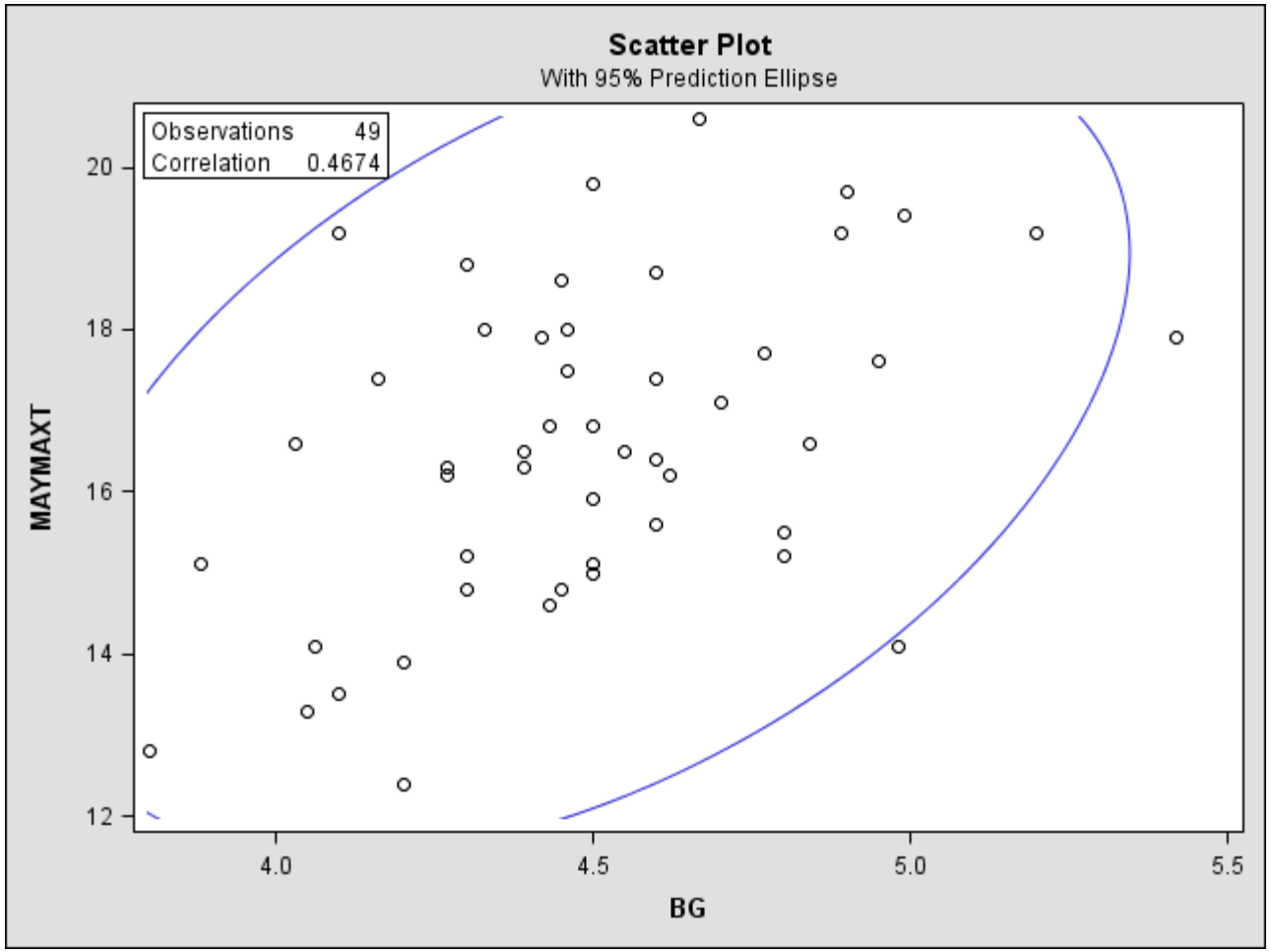
Days in August with max temperatures >30 C (AUG30) & β-glucan (BG)



Days to maturity (DMATURE) & β-glucan (BG)



Average May maximum temp (MAYMAXT) & β-glucan (BG)



Standardizing and removing genetic effect from β-glucan

- The genetic effect of BG removed by standardizing relative to controls
  - CDC Dancer and Morgan – low BG controls
    Leggett and Ronald – high BG controls
- Used PROC MIXED to calculate and then remove the genetic effect
- Increase in β-glucan 0.34% in 10 years
- "Non-genetic β-glucan" (NGBG)

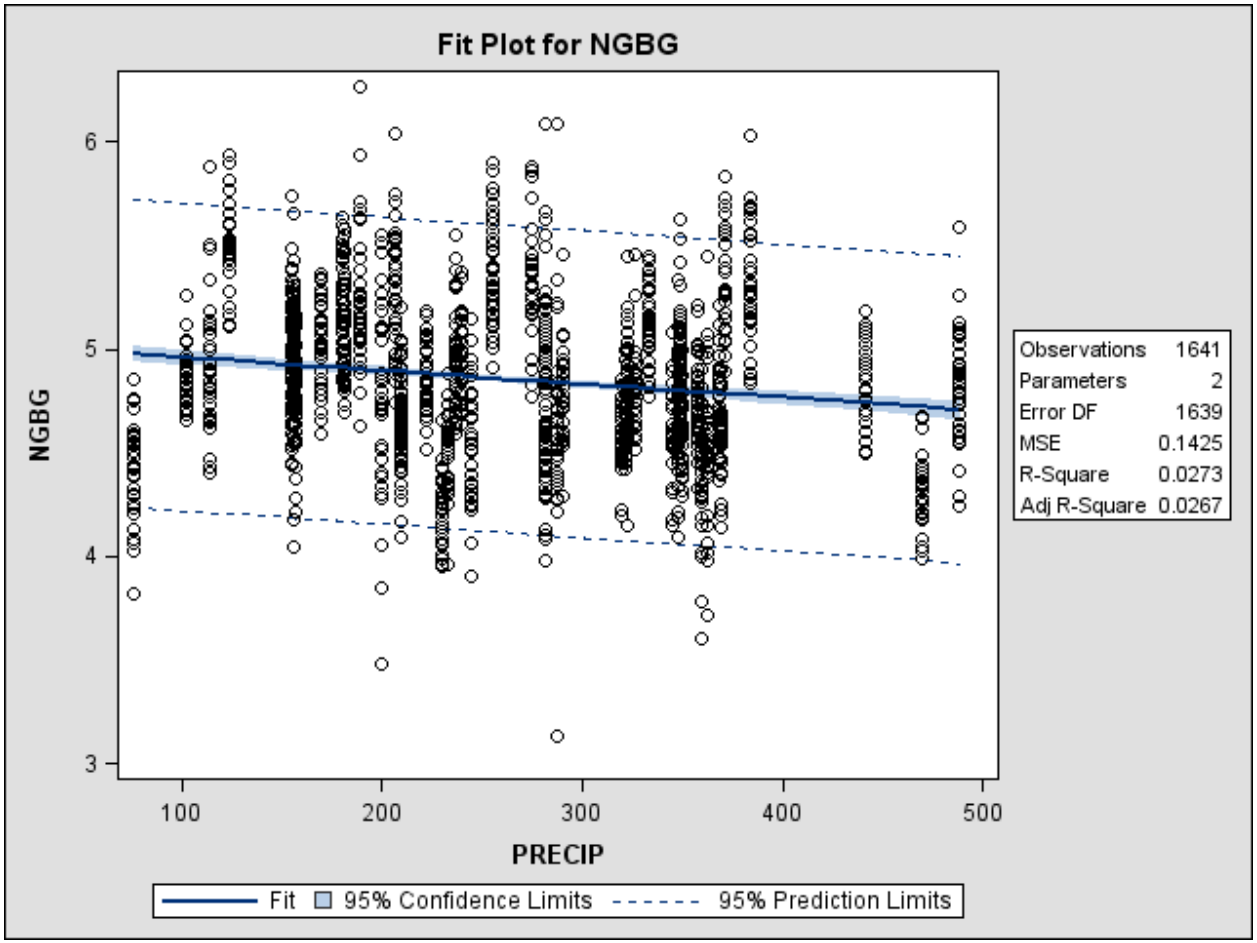
Stepwise multiple linear regression

- Multiple linear regressions variables
- Iterative process in which variables are removed
- Controlled for colinearity
  - vif and collinnoint option in PROC REG of SAS
  - common sense

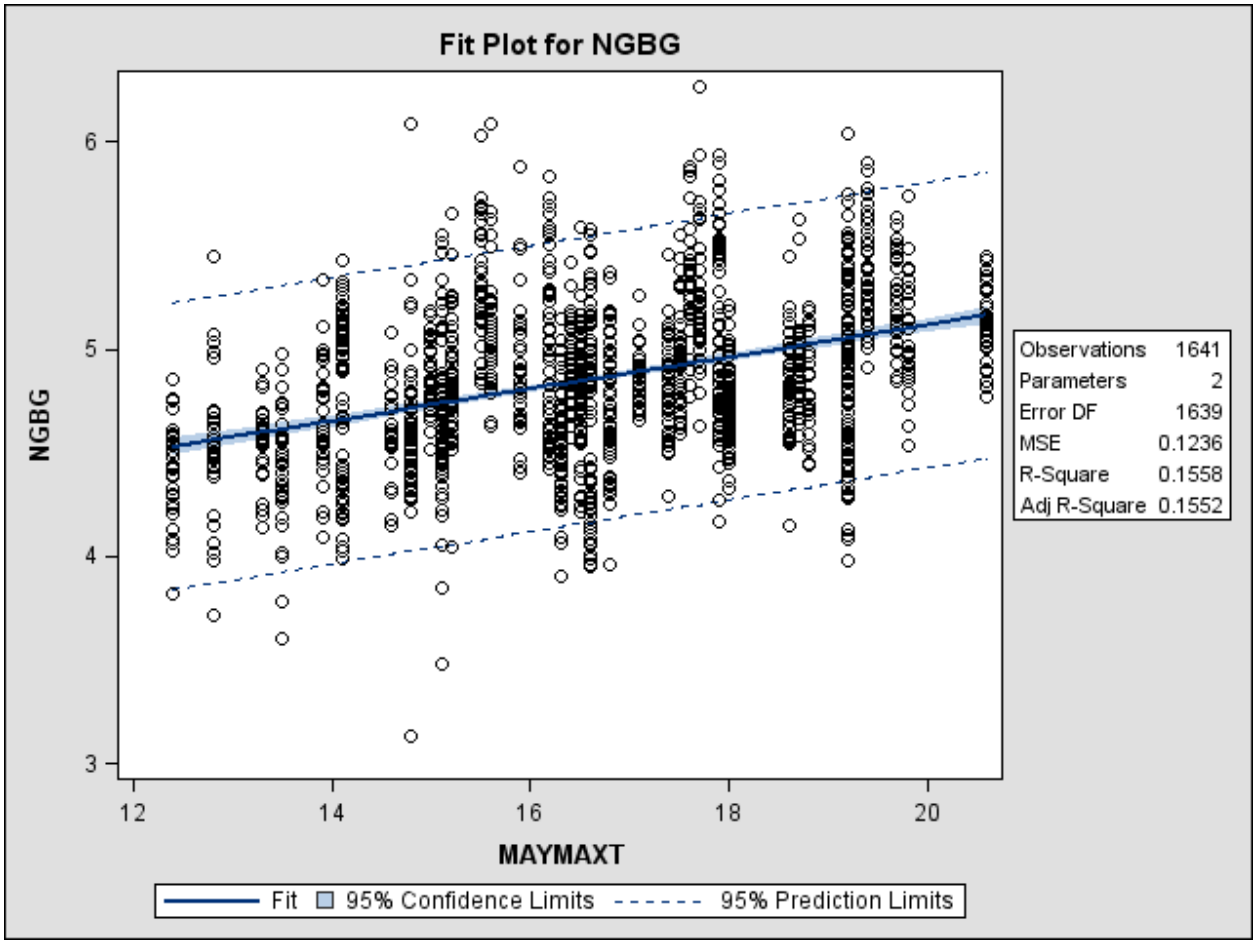
The 5 Significant environmental parameters:

- PRECIP: growing season precipitation (May – September) in mm
- JL30: to number of days in July with max. T greater than 30 C;
- MAYMAXT: average max. T in May;
- AUGMAXT the average max. T in August
- AUGTDIFF the diff. between that average max. and min. T in August.
- $R^2 = 0.40$

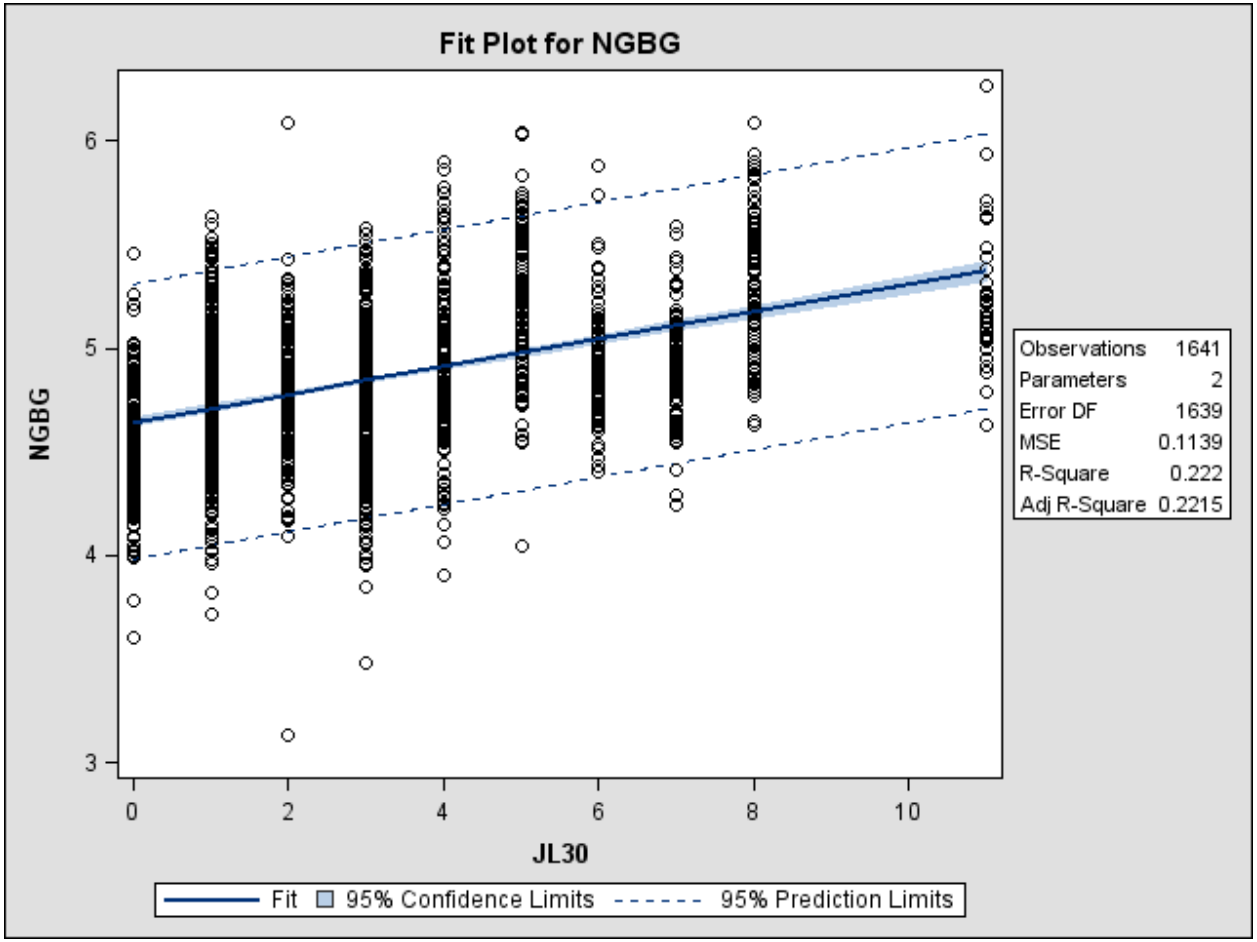
Effect of precipitation (PRECIP) on non-genetic β-glucan (NGBG)



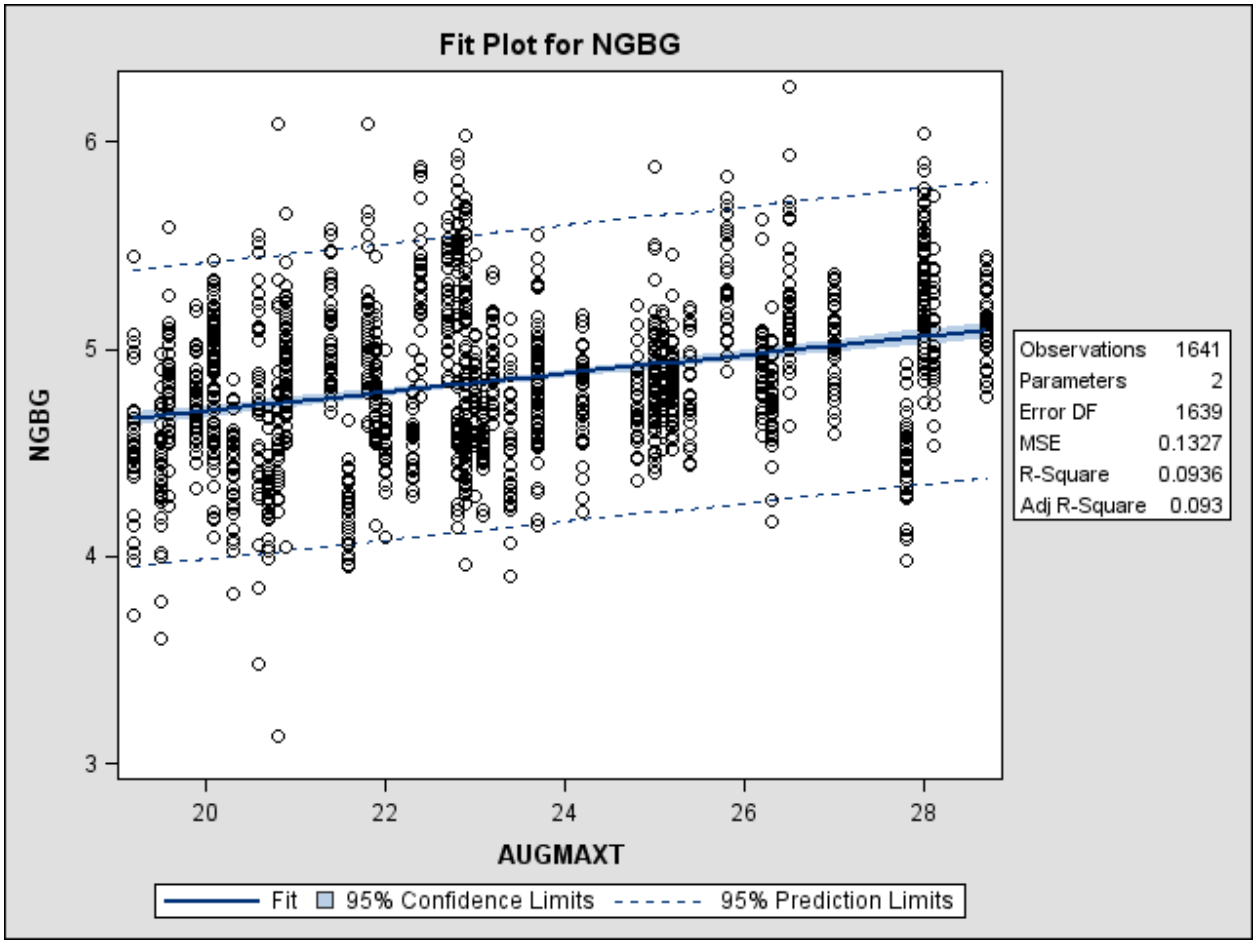
Effect of avg. May max. temp. (MAYMAXT) on non-genetic β-glucan (NGBG)



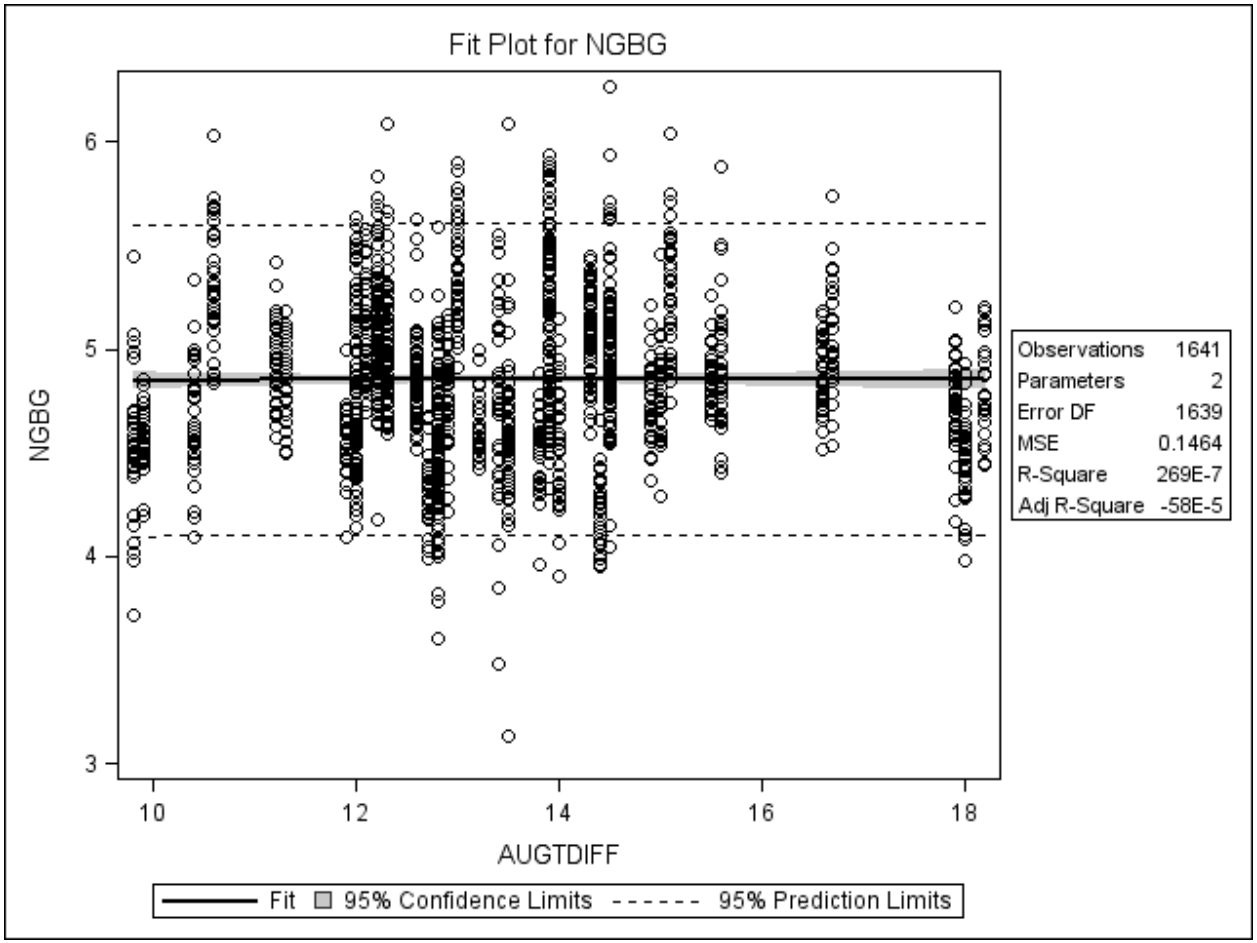
Effect of number of days in July > 30 C (JL30) on non-genetic β-glucan (NGBG)

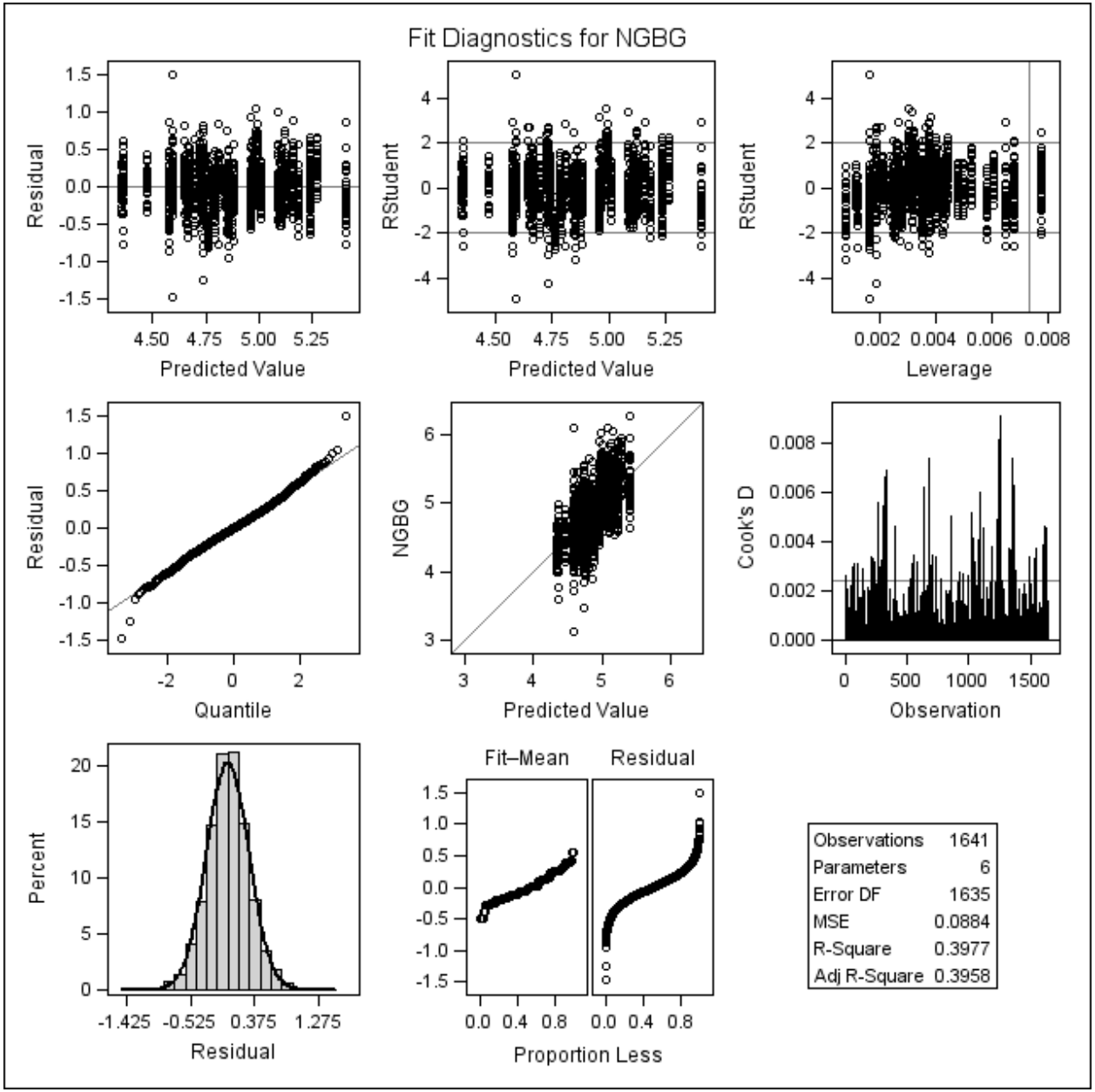


Effect of avg. August max. temp. (MAYMAXT) on non-genetic β-glucan (NGBG)

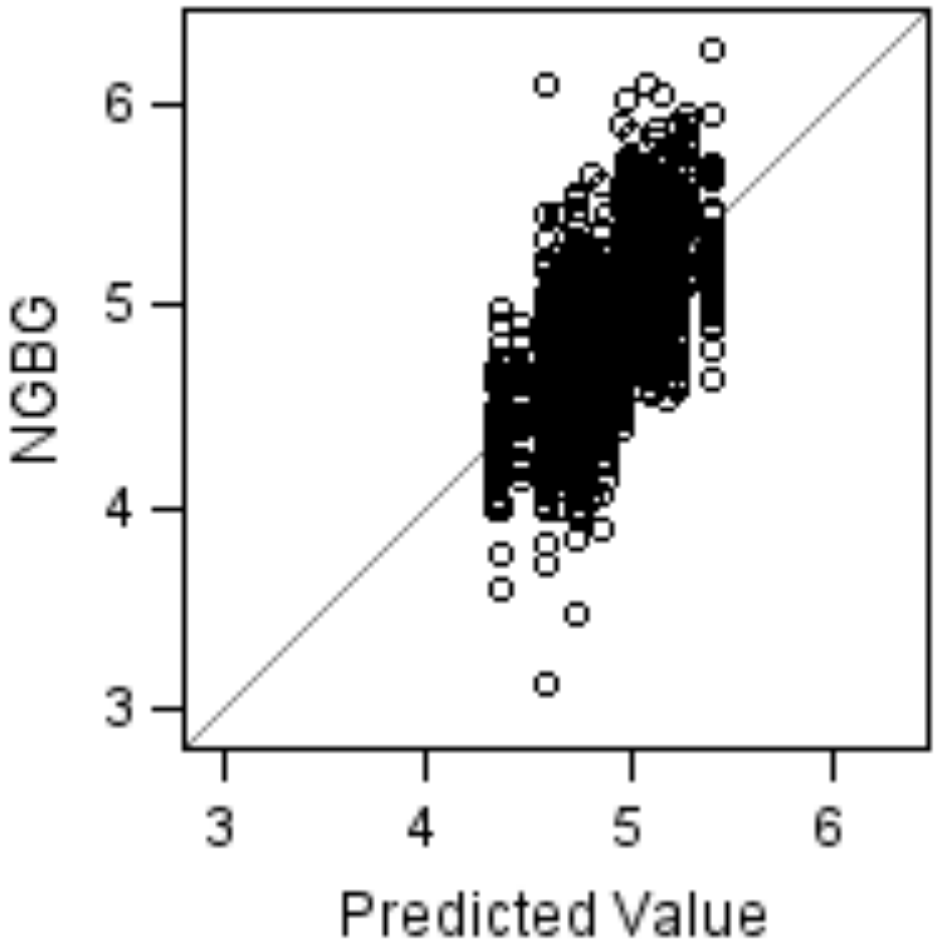


Effect of August avg. temp. range (max. – min. T; AUGDIFF) on NGBG




Fit Diagnostics for NGBG
Residual
Predicted Value
RStudent
Predicted Value
RStudent
Leverage
Residual
Quantile
NGBG
Predicted Value
Cook's D
Observation
Percent
Residual
Fit–Mean
Residual
Proportion Less
Observations 1641
Parameters 6
Error DF 1635
MSE 0.0884
R-Square 0.3977
Adj R-Square 0.3958

Observed vs. expected BG values



THE equation:

- β-glucan (%) = 4.2

- 0.00077 * PRECIP

+ 0.054 * JL30

+ 0.068 * MAYMAXT

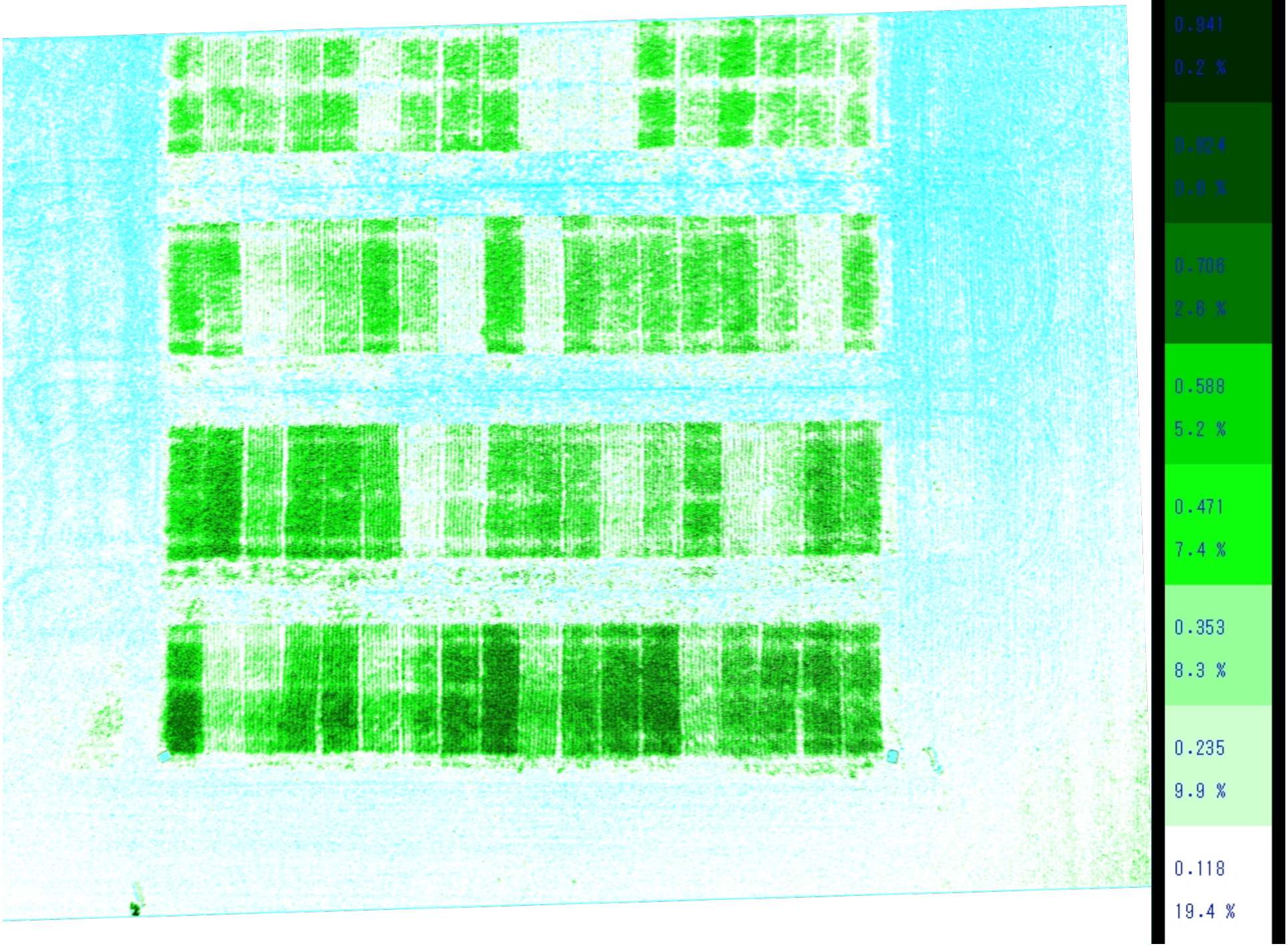
+ 0.023 * AUGMAXT

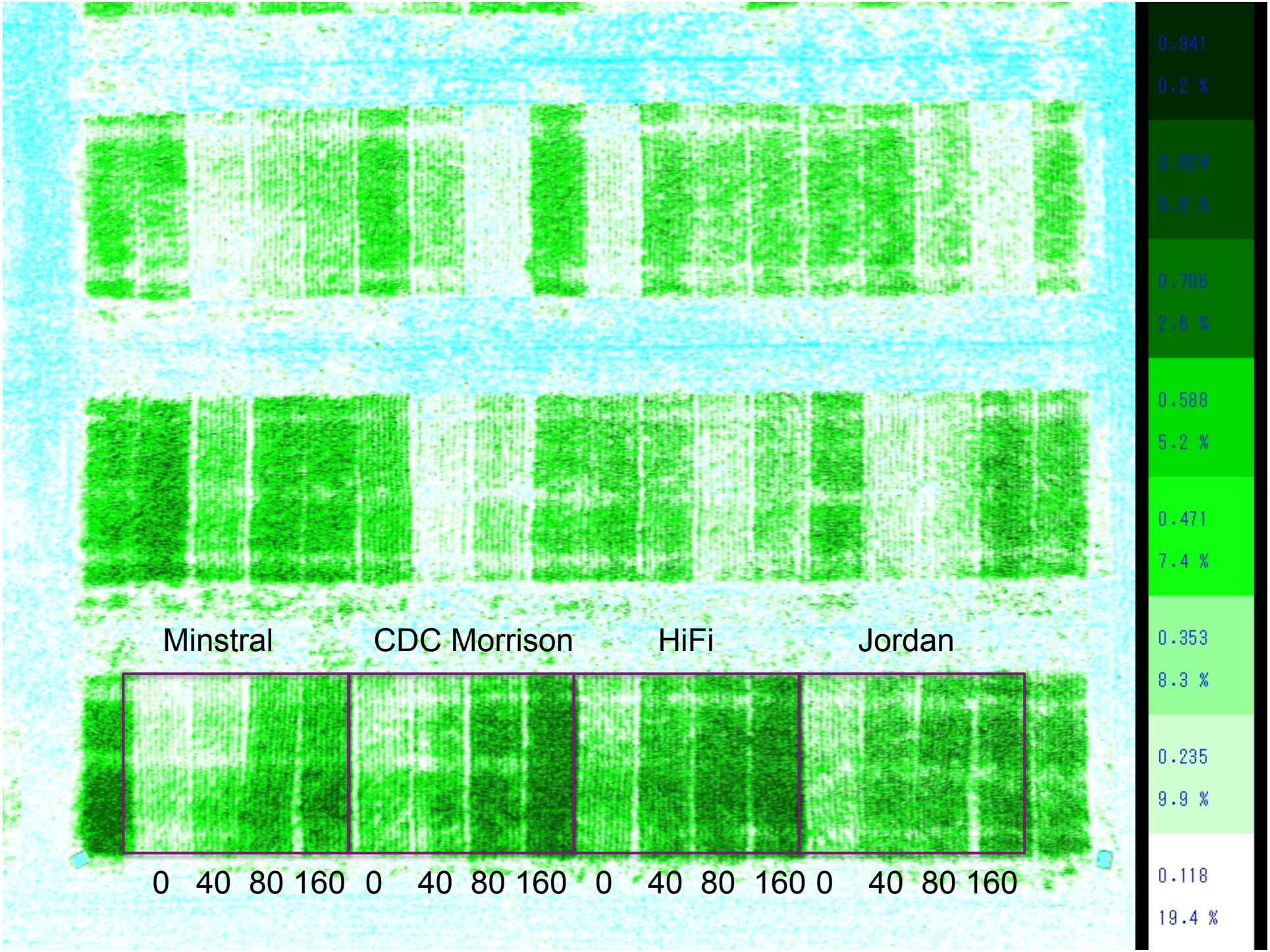
- 0.074 * AUGTDIFF

$R^2 = 0.40$

Conclusions:

- Temperature was the driving environmental factor affecting BG in this 10 year period
- Sourcing oats from areas with higher maximum Temperatures should result in higher BG values
- What are physiological mechanisms behind this?


0.941
0.2 %
0.824
0.6 %
0.706
2.6 %
0.588
5.2 %
0.471
7.4 %
0.353
8.3 %
0.235
9.9 %
0.118
19.4 %


0.941
0.2 %
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0.471
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0.353
8.3 %
0.235
9.9 %
0.118
19.4 %
Minstral
CDC Morrison
HiFi
Jordan
0 40 80 160 0 40 80 160 0 40 80 160 0 40 80 160

Acknowledgements

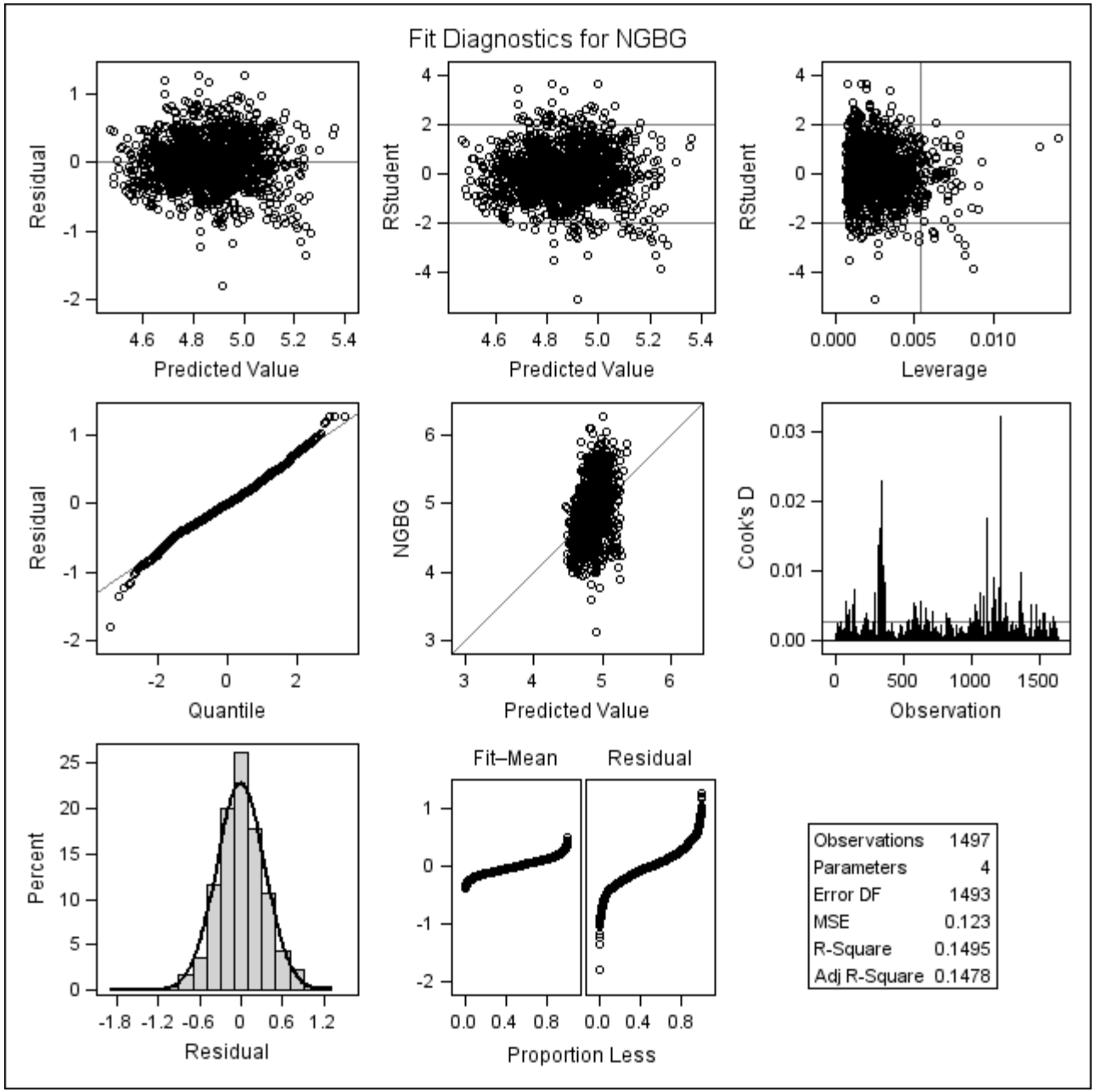
- Everyone who grew the WCORT trial!

Saskatchewan Oat Development Commission

University of Saskatchewan
College of Agriculture and Bioresources

PEPSI

QUAKER


Fit Diagnostics for NGBG
Residual
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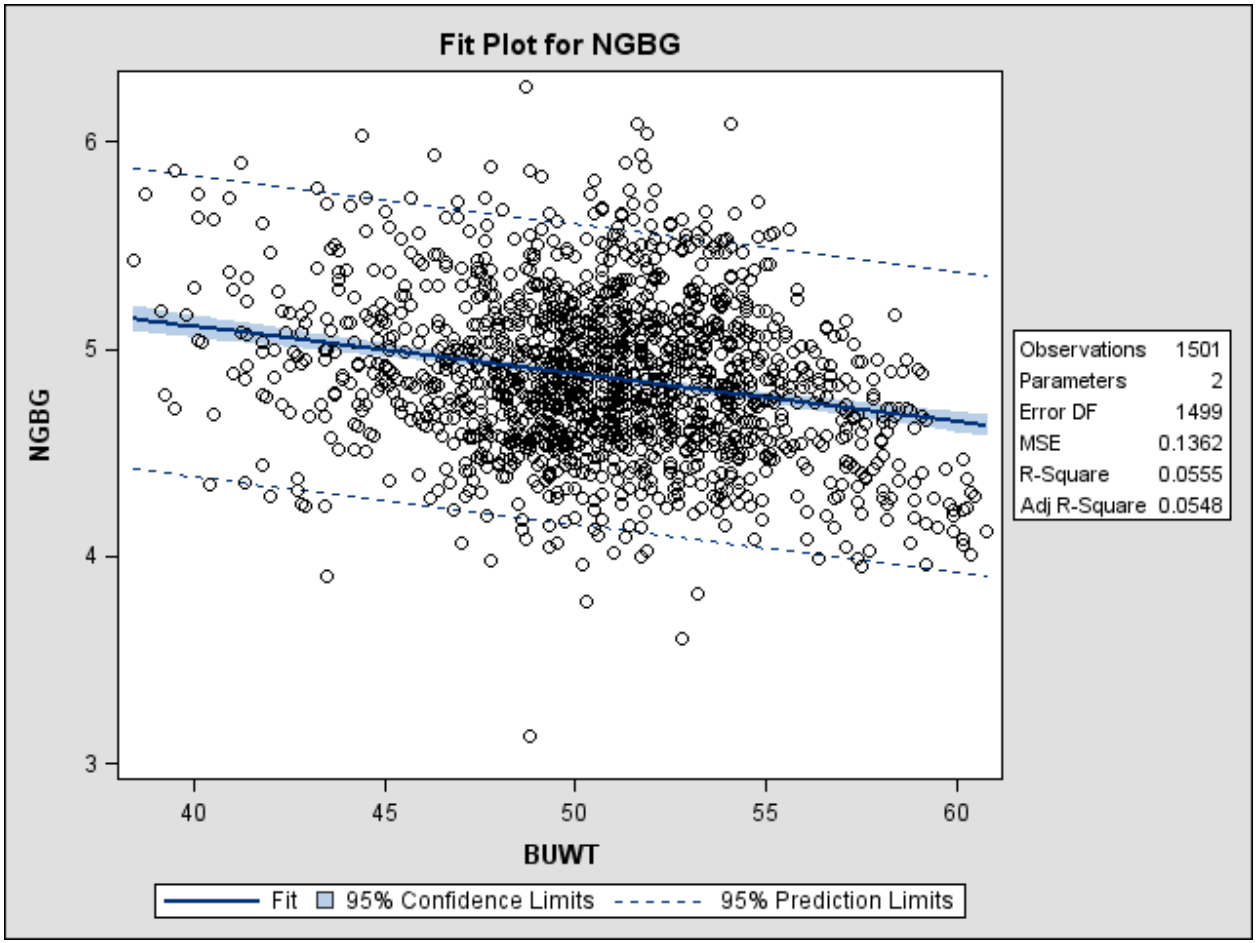
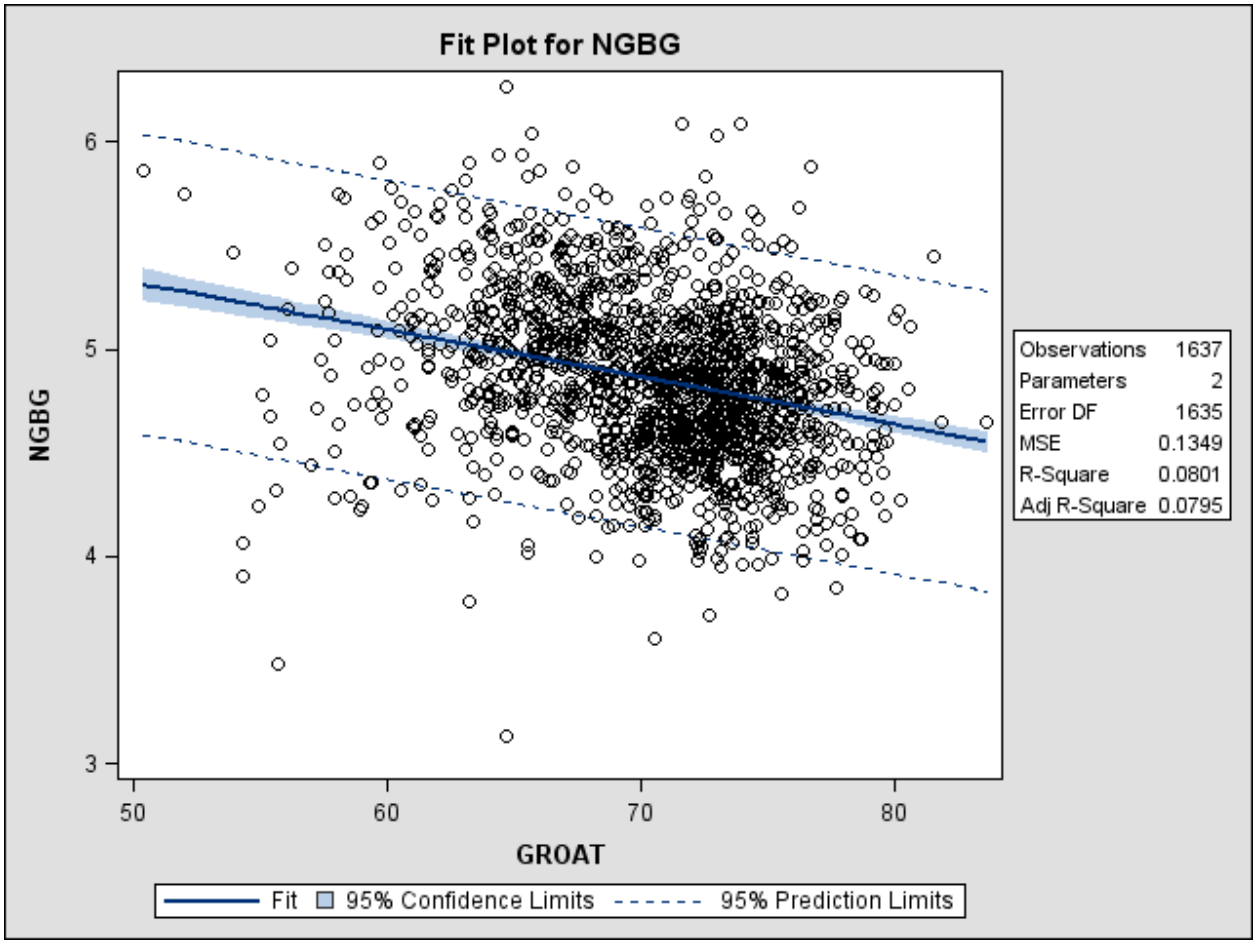
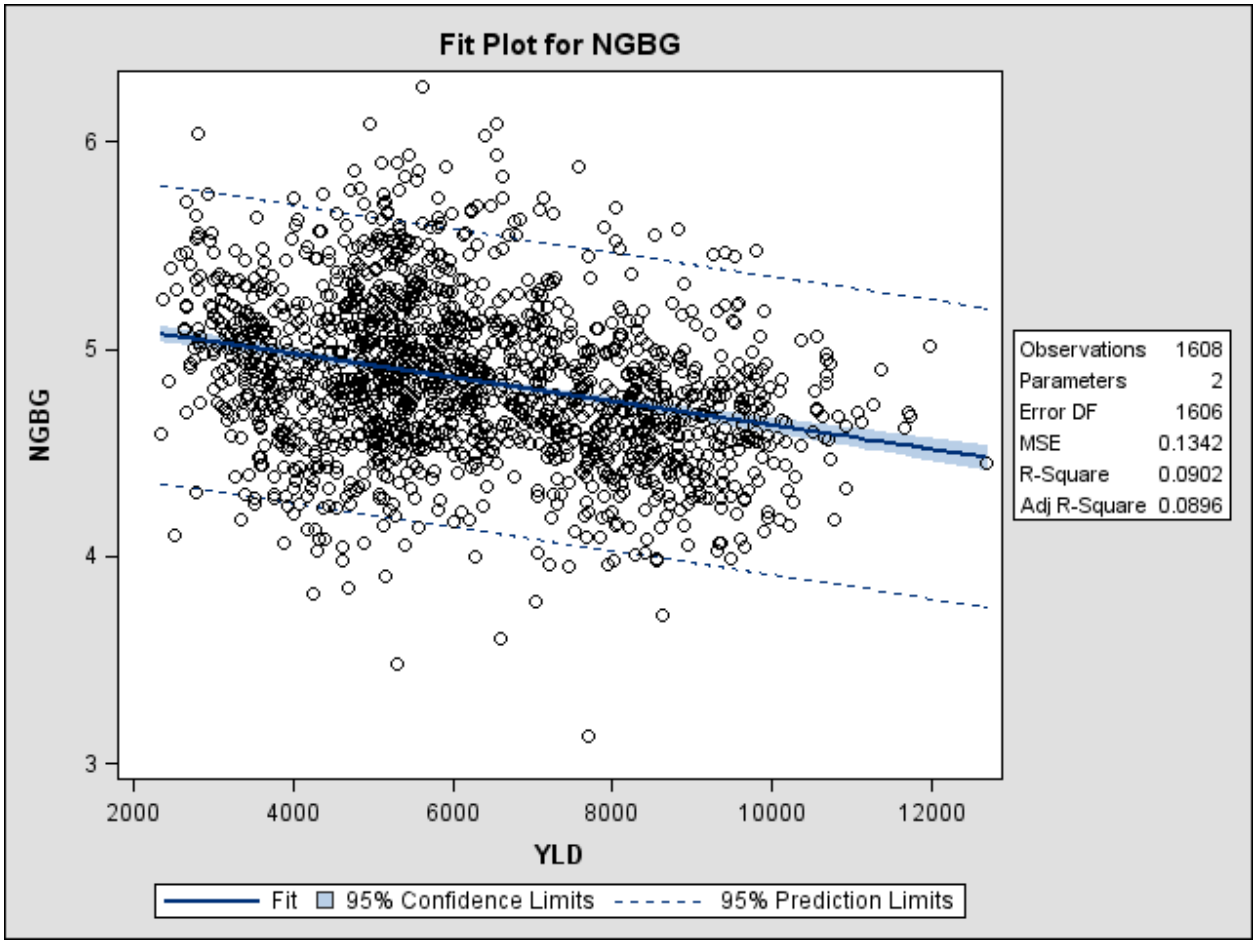
NGBG
Predicted Value
Cook's D
Observation
Percent
Residual
Fit–Mean
Residual
Proportion Less
Observations 1497
Parameters 4
Error DF 1493
MSE 0.123
R-Square 0.1495
Adj R-Square 0.1478


Fit Plot for NGBG
NGBG
6
5
4
3
40
45
50
55
60
BUWT
Observations 1501
Parameters 2
Error DF 1499
MSE 0.1362
R-Square 0.0555
Adj R-Square 0.0548
Fit
95% Confidence Limits
95% Prediction Limits


Fit Plot for NGBG
NGBG
6
5
4
3
50
60
70
80
GROAT
Observations 1637
Parameters 2
Error DF 1635
MSE 0.1349
R-Square 0.0801
Adj R-Square 0.0795
Fit
95% Confidence Limits
95% Prediction Limits


Fit Plot for NGBG
NGBG
6
5
4
3
2000
4000
6000
8000
10000
12000
YLD
Observations 1608
Parameters 2
Error DF 1606
MSE 0.1342
R-Square 0.0902
Adj R-Square 0.0896
Fit
95% Confidence Limits
95% Prediction Limits