Genetic Architecture of Phenomic-enabled Canopy Coverage in Soybean

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Agronomy , Agricultural & Biological Engineering

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Soybean Canopy Phenotyping

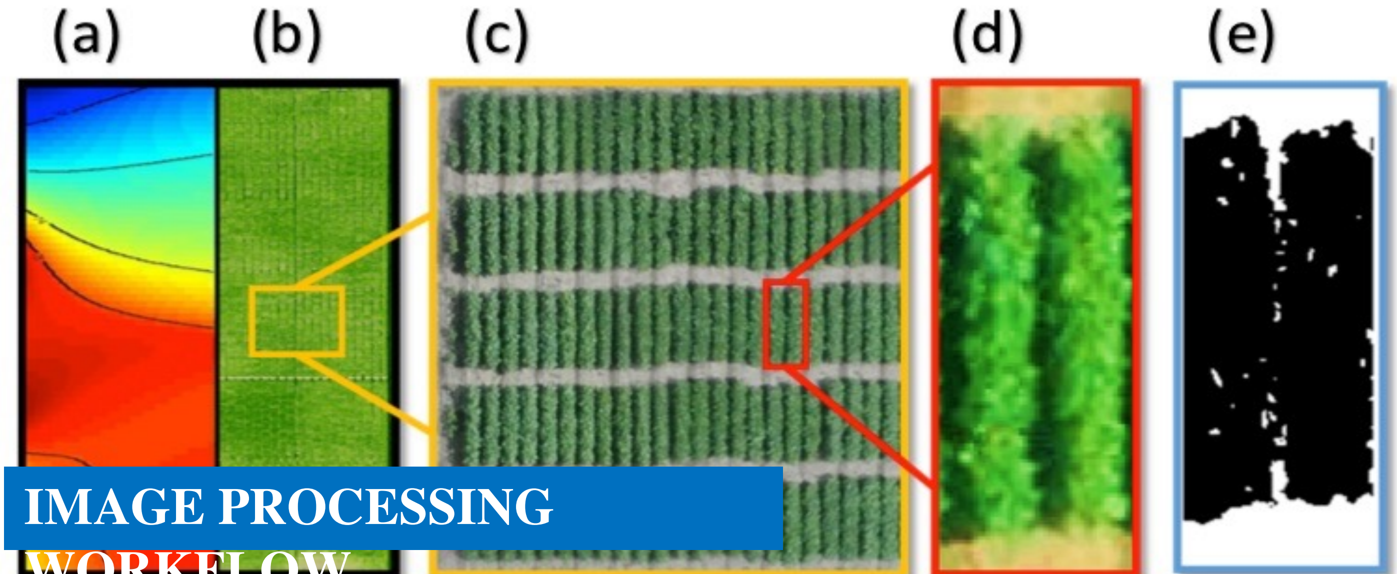
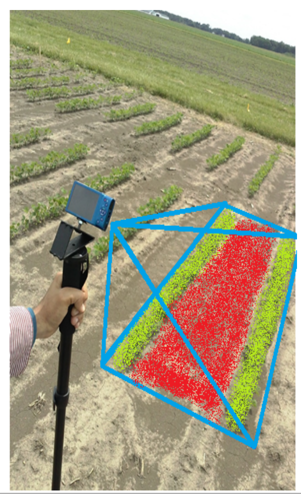
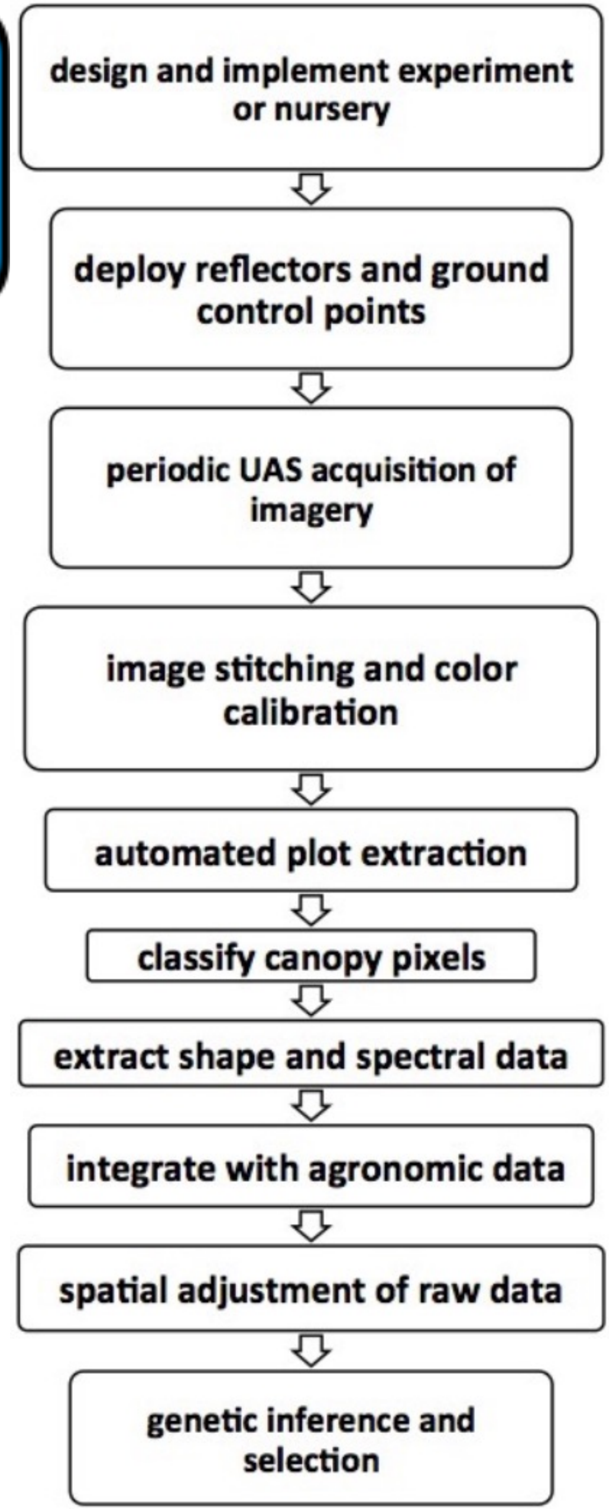


IMAGE PROCESSING WORKFLOW

(A) FIELD VARIATION (B) FIELD IMAGE (C) BLOCK OF PLOTS (D) INDIVIDUAL PLOT (E) CLASSIFIED PLOT.





UAS Image Acquisition

Slide from A. Hearst

2013-2015:
20,000 plots
80,000 images
SoyNAM primary target

Flight Dates

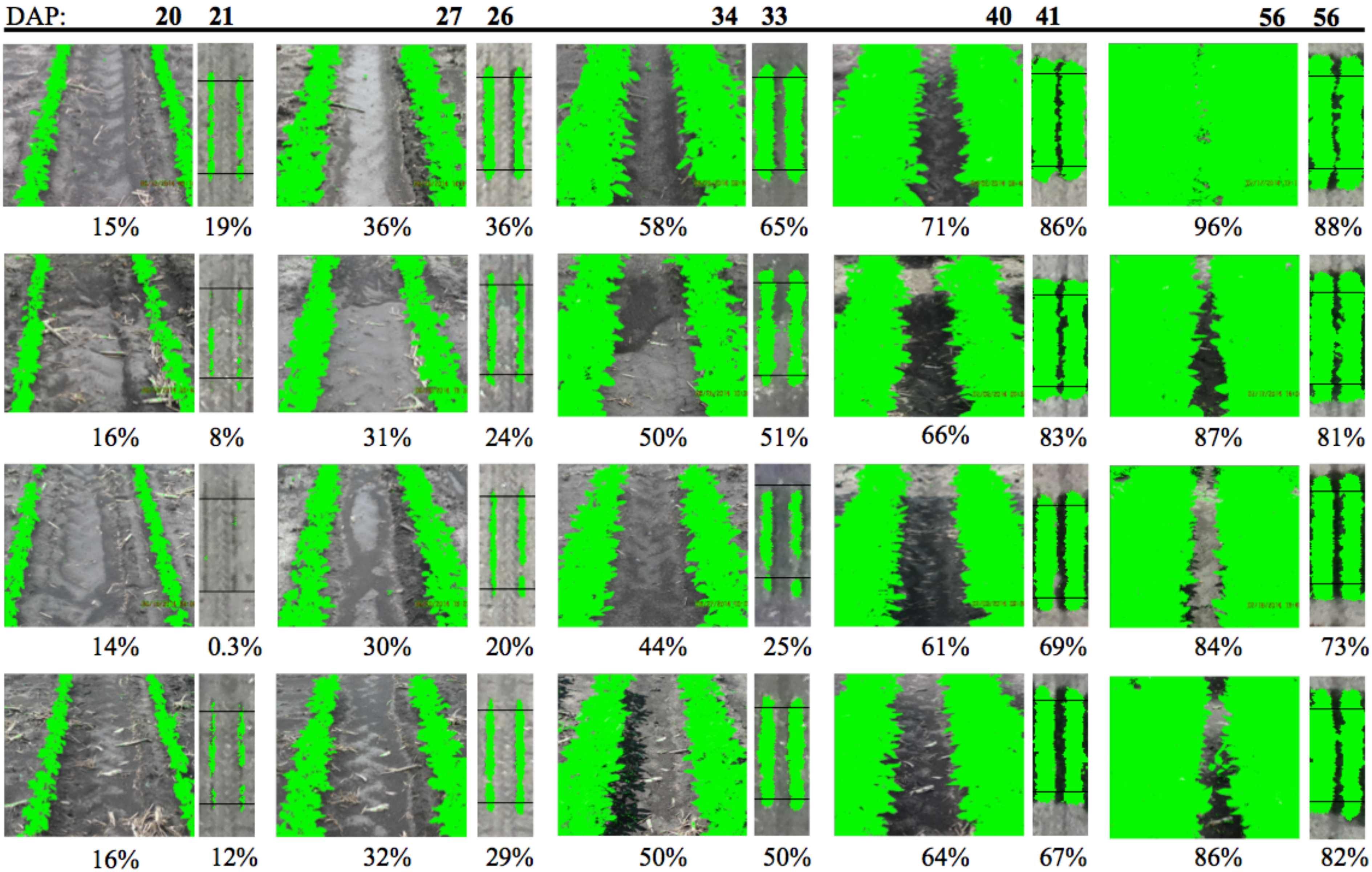
Canopy Coverage and Light Interception

"Soybean canopy coverage and light interception measurements using digital imagery"
Larry C. Purcell (2001)
Crop Science, Vol. 40 No. 3.

Comparisons of canopy coverage values with LI measured near solar noon indicated that there was a one-to-one relationship

Correspondence Between Ground & Air

B. Hall (2015)



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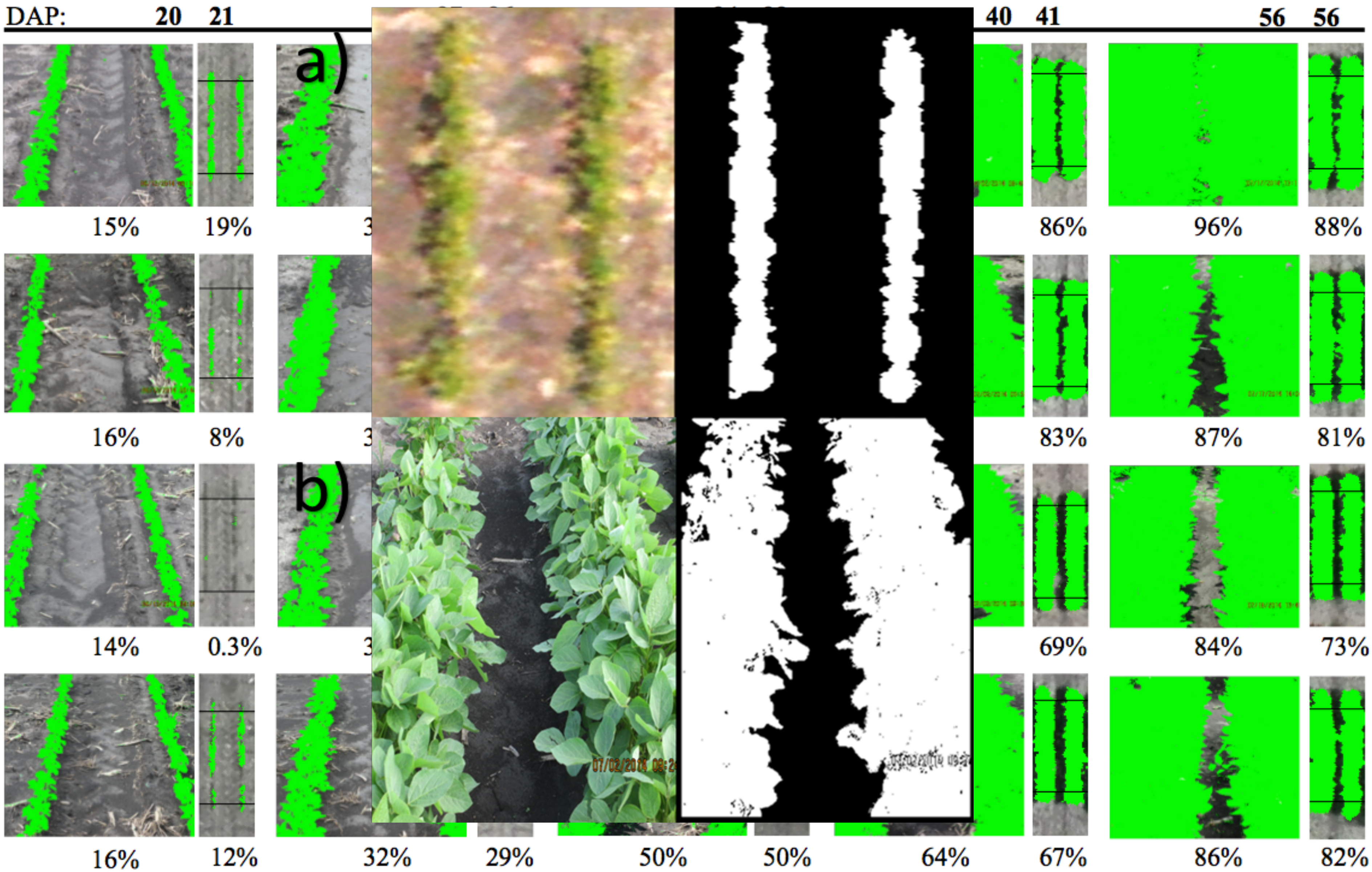
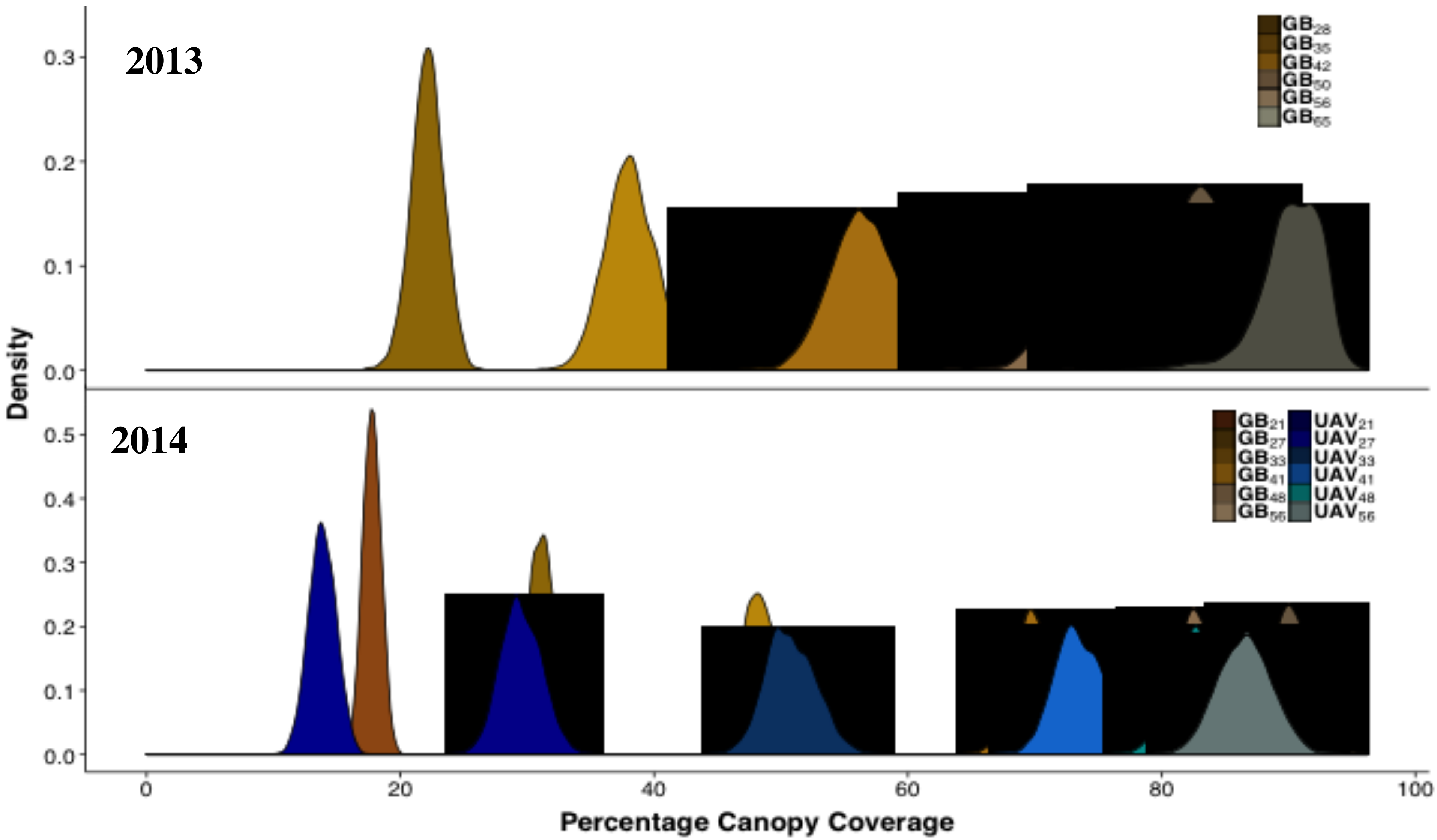


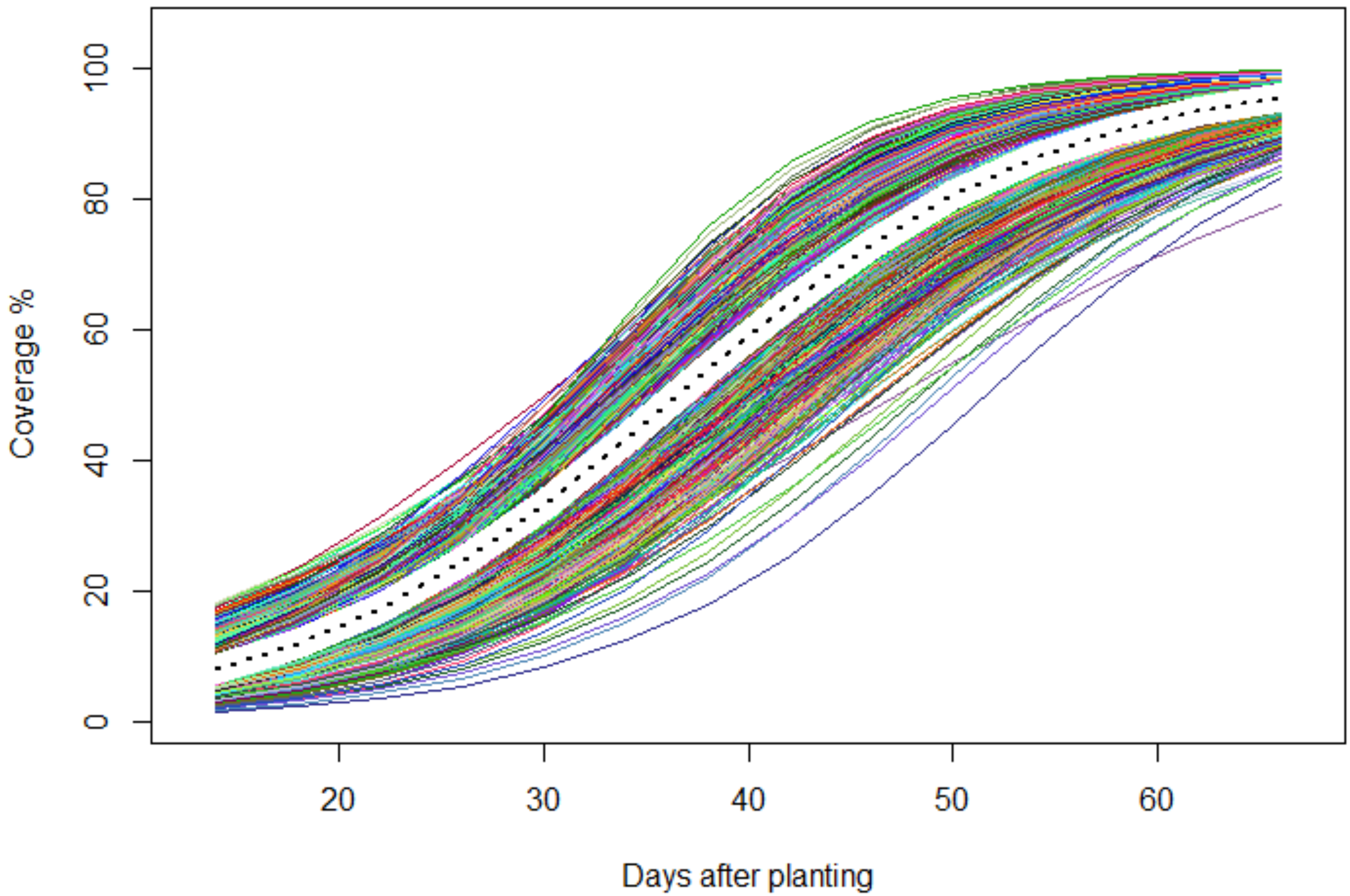
Distribution of Seasonal Canopy Coverage in SoyNAM

B. Hall (2015)



Canopy Development in SoyNAM

Xavier *et al.* (2017)



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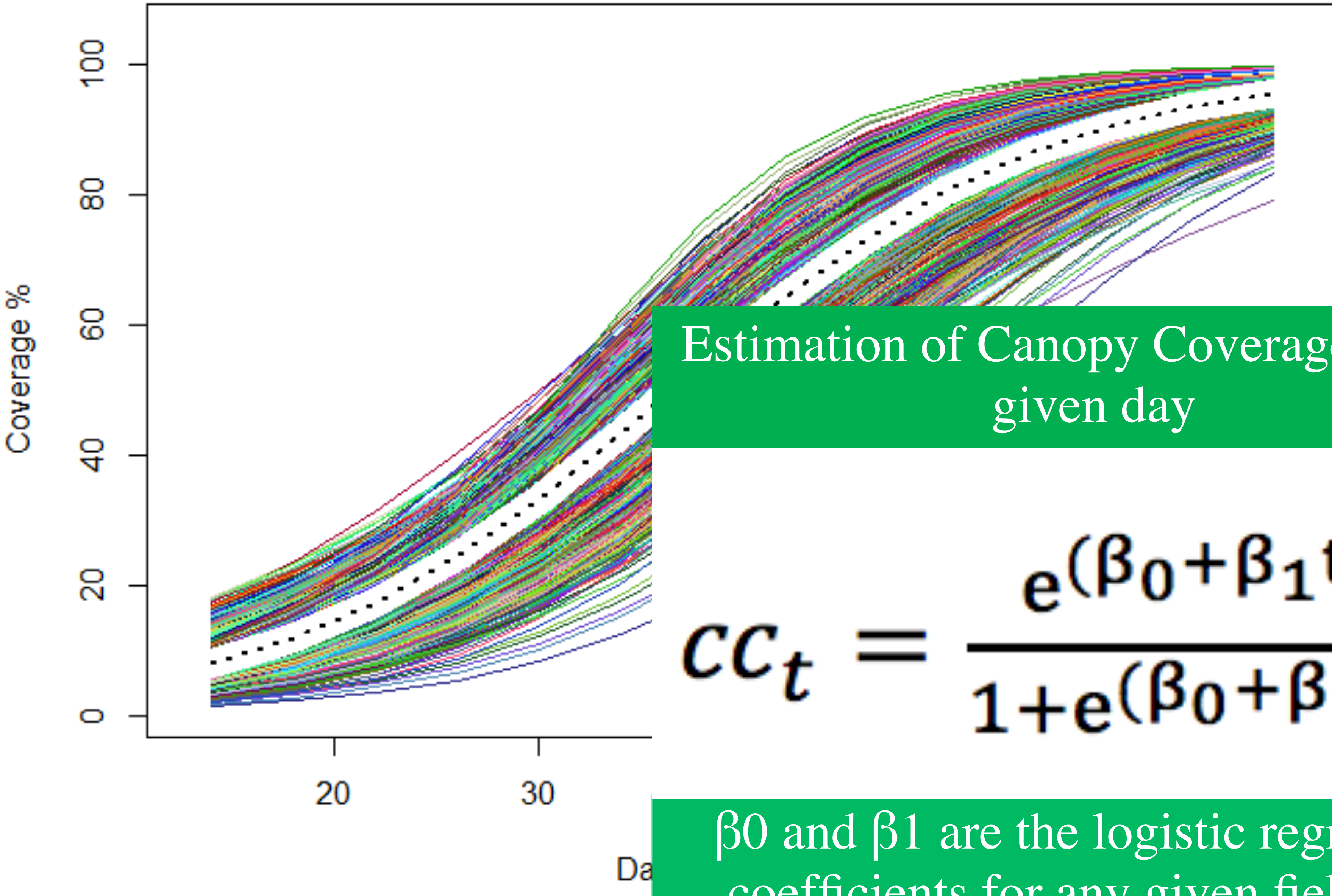


Estimation of Canopy Coverage on any given day

$$cc_t = \frac{e^{(\beta_0 + \beta_1 t)}}{1 + e^{(\beta_0 + \beta_1 t)}}$$

$\beta 0$ and $\beta 1$ are the logistic regression coefficients for any given field plot

Calculation of Genotypic Values

Xavier *et al.* (2017)

$$y = 1\mu + f(x) + \mathbf{Zu} + \mathbf{Wg} + \mathbf{e}$$

y is the vector of observed phenotypes

μ is the intercept

f(x) is a non-linear function that accounts for the spatial heterogeneity of field variation, where f(x) is computed as the average phenotypic value of neighbor plots

Z is the incidence matrix of environment

u is the vector of regression coefficients of environment effects

W is the incidence matrix of genotypes

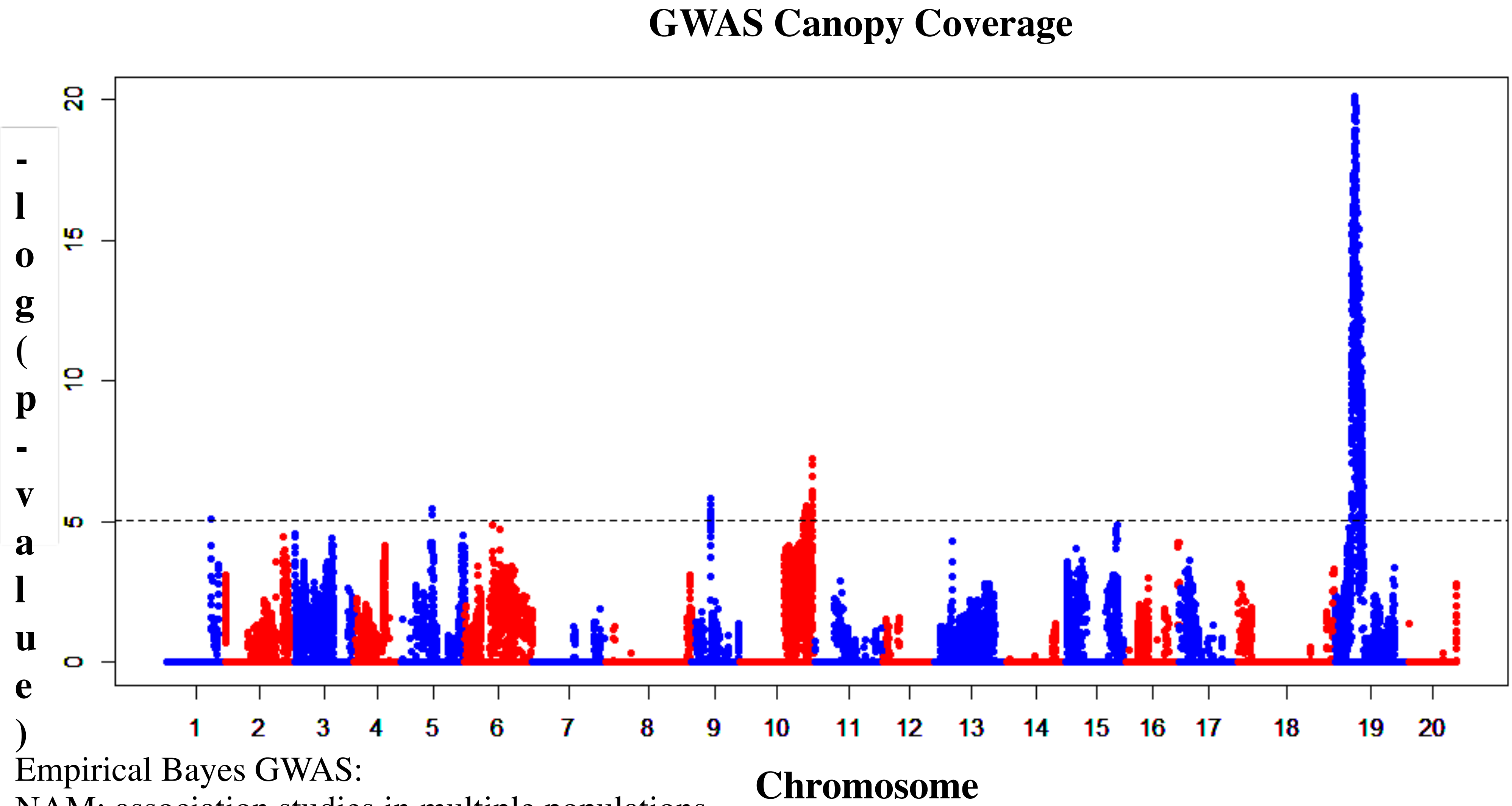
g is the vector of genetic values

e is the vector of residuals.

u~N(0,Iσ2u) g~N(0,Iσg2) e~N(0,Iσe2).

Genetic Architecture of CC

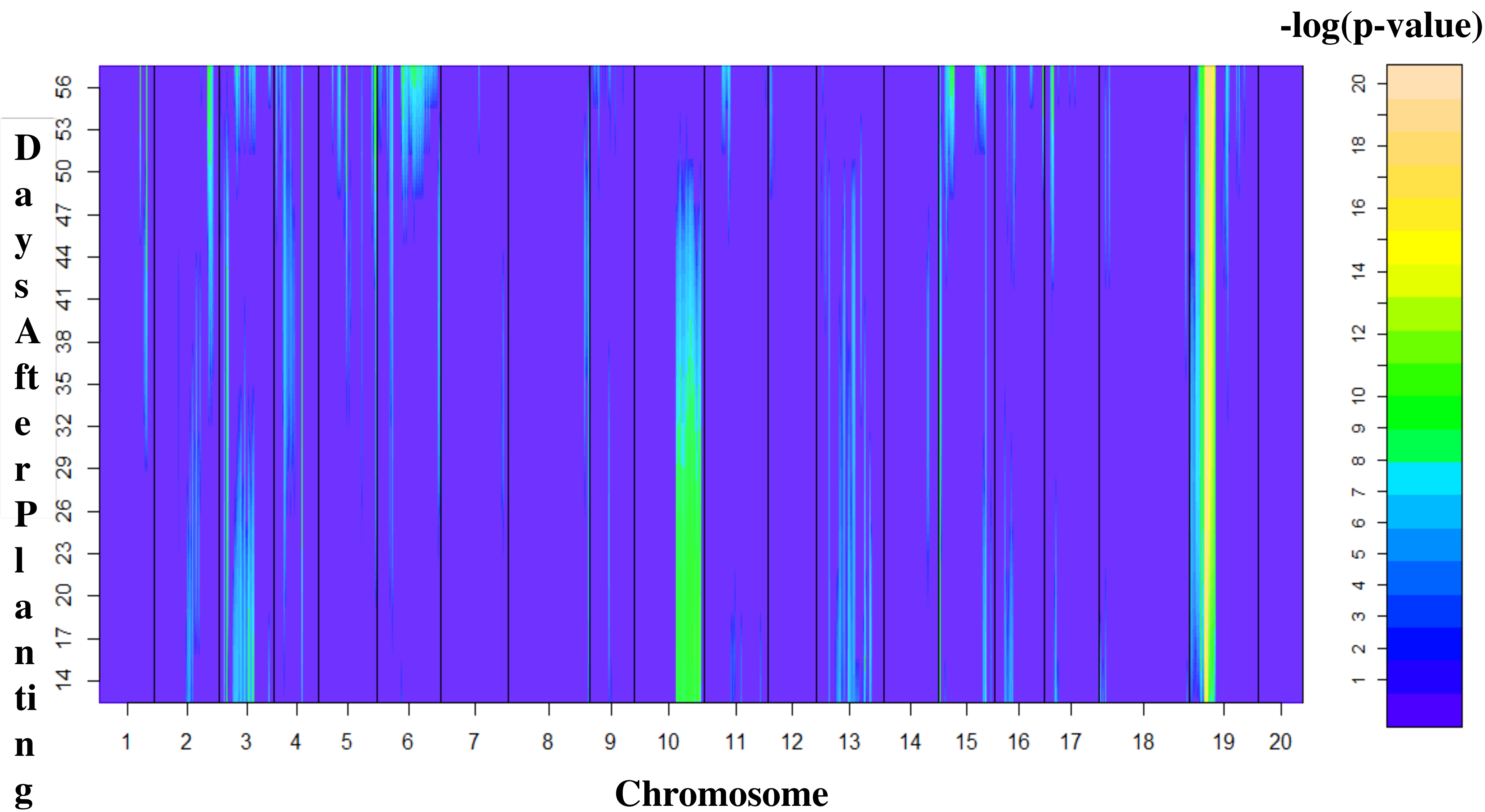
Xavier *et al.* (2017)



Empirical Bayes GWAS:
NAM: association studies in multiple populations.
A Xavier, S Xu, WM Muir, & KM Rainey (2015)
Bioinformatics.

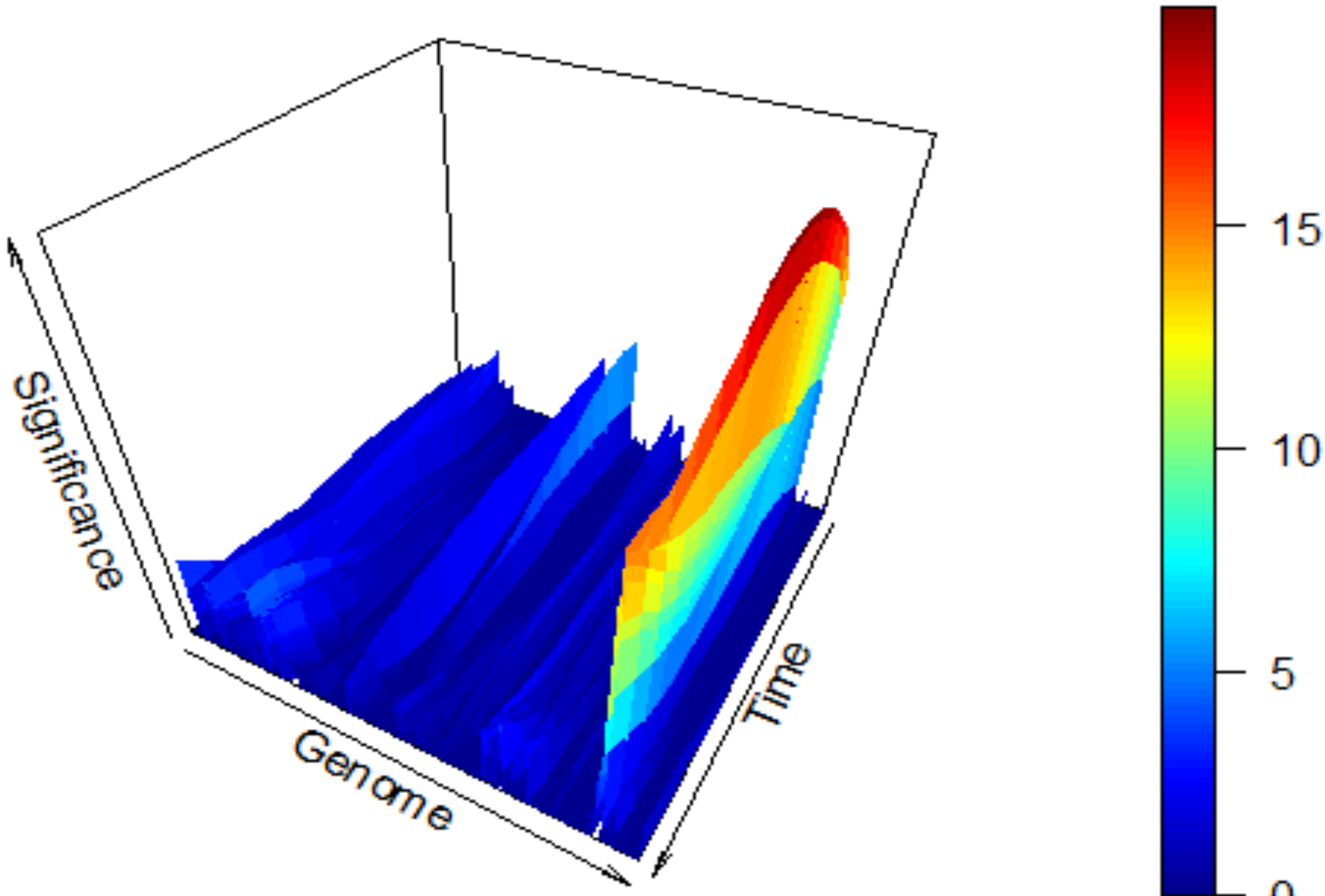
Genetic Architecture of CC Over Time

Xavier *et al.* (2017)



Genetic Architecture of CC Over Time

Slide from Alencar Xavier



Genetic Architecture of CC

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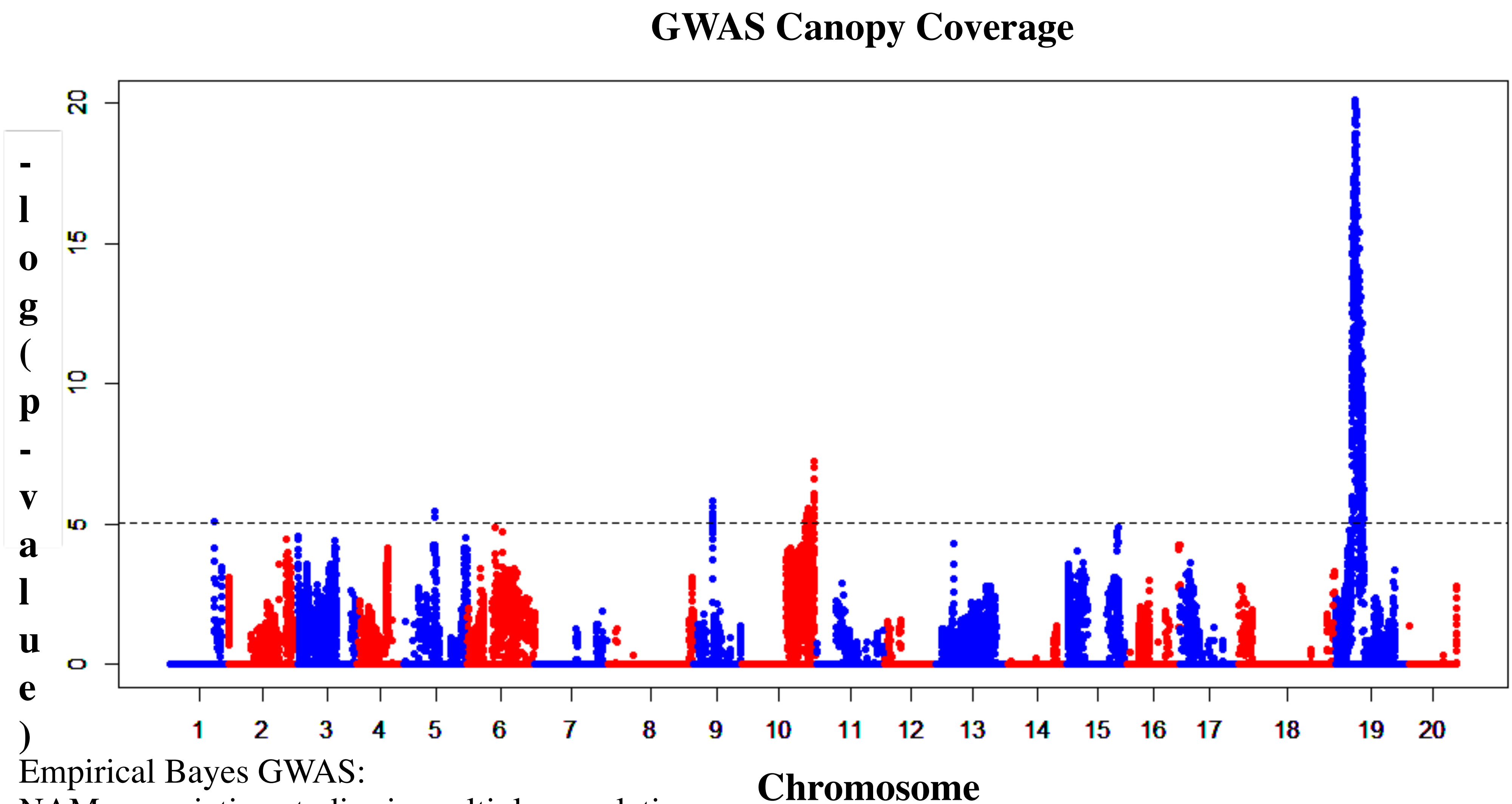

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Average Canopy Coverage (ACC)

Xavier *et al.* (2017)

ACC value is an arithmetical mean of multiple seasonally observed values of canopy coverage.

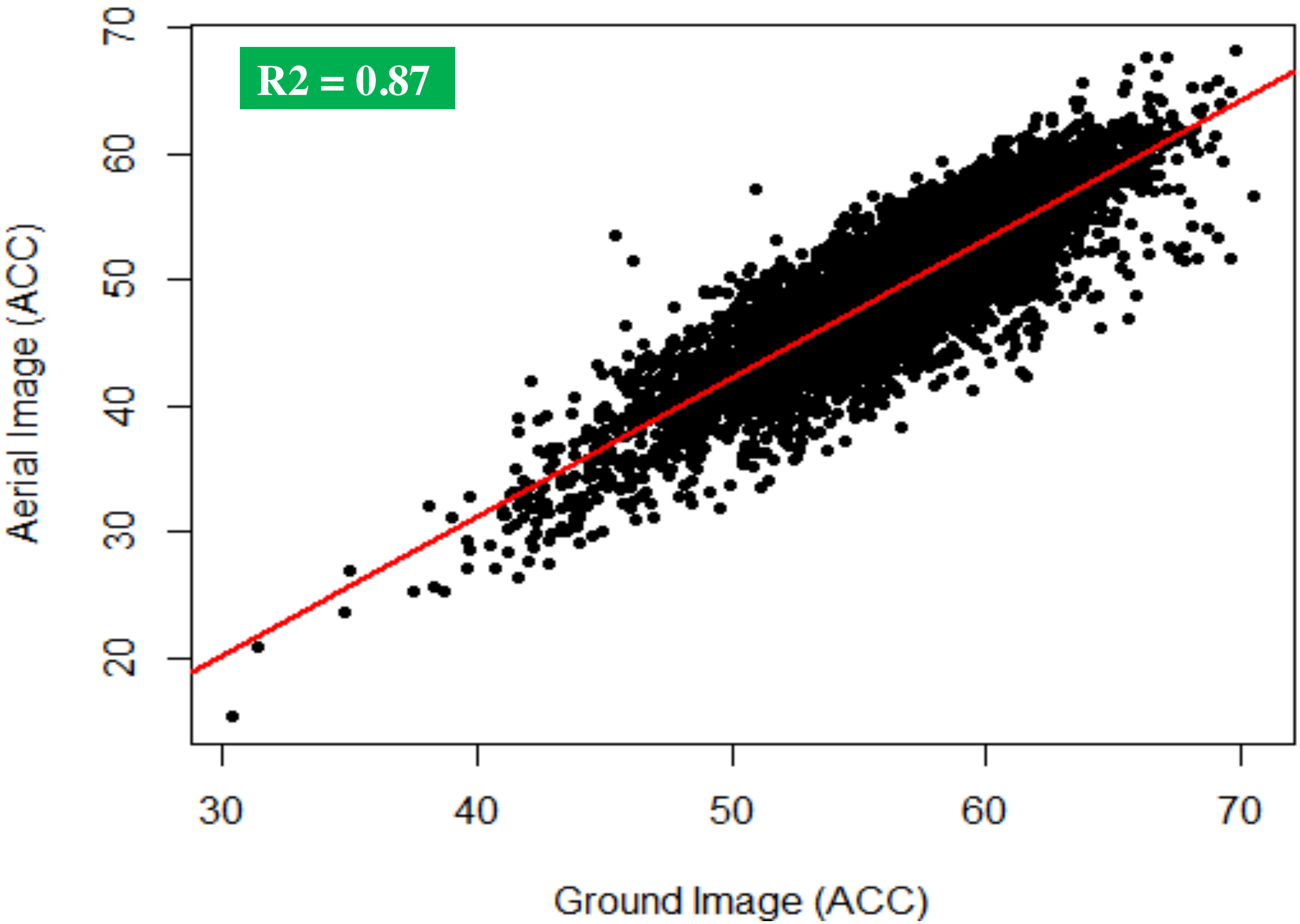
$$ACC = \int_{t_0}^{t_n} f(cc_t)\,\partial(cc_t) = \frac{1}{N}\sum_{t_0}^{t_n} cc_t$$

N = number of observed days

t0 and tn =the first and last day when canopy coverage was assayed

ACC: Correlation Between Ground & Air

Xavier *et al.* (2017)



Canopy Coverage QTL

Xavier *et al.* (2017)

SNP	Period of Significant Association (DAP)	Allelic Effect GY (kg.ha-1)	Allelic Effect R8 (DAP)	Allelic Effect ACC (%)
Gm01_50911939_C_T	56	-26.04	-1.12	-0.36
Gm05_37467797_A_G	53-56	-44.71	0.08	-0.65
Gm06_14104090_T_C	56	99.58	0.50	0.55
Gm09_4034850_C_T	14-35, 59-64	12.24	-0.60	-0.44
Gm010_44120764_T_C	14-23	5.95	-0.59	0.04
Gm010_44630777_C_A	14-26	51.61	1.06	0.33
Gm019_1586092_T_C	14-64	47.30	-0.24	1.34

Quantitative Properties of ACC

Xavier *et al.* (2017)

Genetic (G) and environmental (E) variances and heritabilities for grain yield (GY), average canopy coverage (ACC) and days to maturity (R8).

	GY	**R8**	**ACC**
Var (G)	78.80	208.36	25.54
Var (E)	56.12	9.39	8.10
[illegible]	[illegible]	[illegible]	[illegible]

Phenotypic (P), Spearman (S), genetic (G) and environmental (E) correlations among grain yield (GY), average canopy coverage (ACC) and days to maturity (R8).

	GY-ACC	**R8-ACC**	**GY-R8**
Cor(P)	0.63	0.31	0.42
Cor(S)	0.70	0.38	0.46
Cor(G)	0.88	0.77	0.72
Cor(E)	0.18	-0.06	0.23

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POSTER SESSION: FABIANA MOREIRA

Acknowledgements

Three graduate students projects:

1. **Alencar Xavier**, Quantitative Genetics, Dow AgroSciences, **Analyses**
2. **Ben Hall**, Ph.D. student Soybean Agronomy, Purdue, **Canopy Traits from M.S.**
3. **Anthony Hearst,** Ph.D. student, NSF Fellow, Purdue Agricultural & Biological Engineering, **UAS Flights + Image Analysis,** advised by **Dr. Keith Cherkauer**

Chris Hoagland and **Curtis Brackett** (Rainey Lab Technical Support)

Bill Muir, **Shizhong Xu** and **Bill Beavis** (Quantitative Genetics)

Brian Diers, Jim Specht, Bill Beavis (SoyNAM Developers & ... reviewer)

Qijian Song and Perry Cregan (Genotypic Data)

Concept of Canopy Coverage

Shaun Casteel, Purdue Soybean Agronomy

Larry Purcell, Arkansas Soybean Agronomy + consultation

DOW
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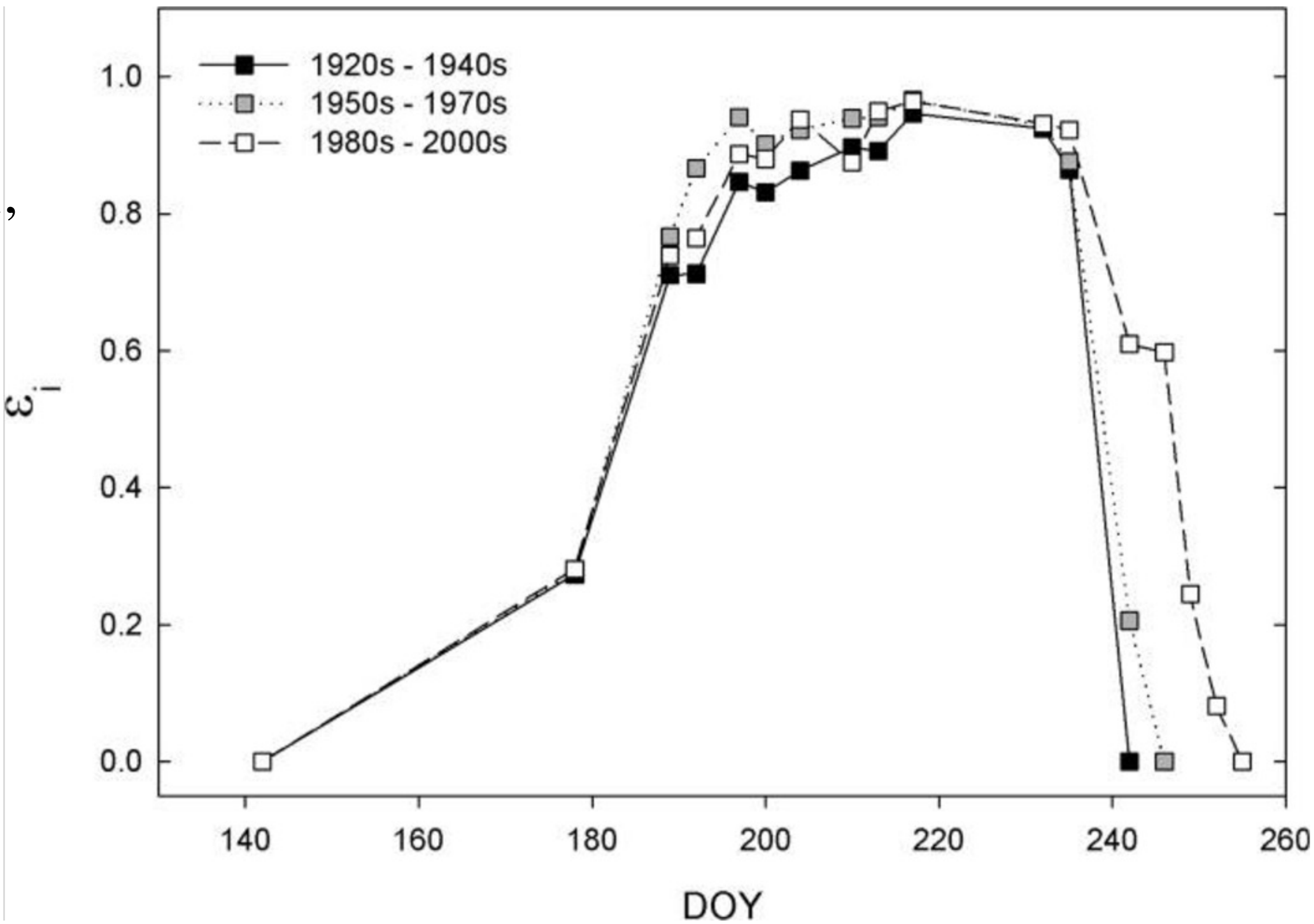
Lack of Variation in Historical Cultivars

Historical gains in soybean (*Glycine max* Merr.) seed yield are driven by linear increases in light interception, energy conversion, and partitioning efficiencies. Koester *et al*. J Exp Bot. 2014 65(1).

-there was difference in the rate of canopy closure in older or newer cultivars, and most cultivars approached 90% closure by ~60 d after planting

-the time to canopy closure did not change in historical soybean cultivars



Interception efficiency (εi) across the growing season in 2013 for each of the 24 soybean cultivars grouped by year of release