"Physiological and Spectral Parameters in Soybean Associated with Seed Yield"

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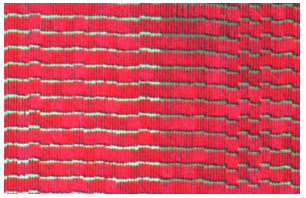
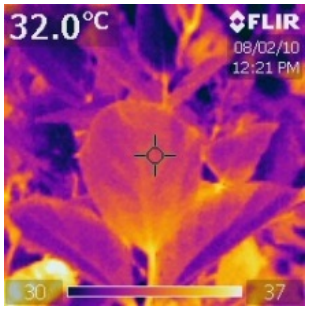
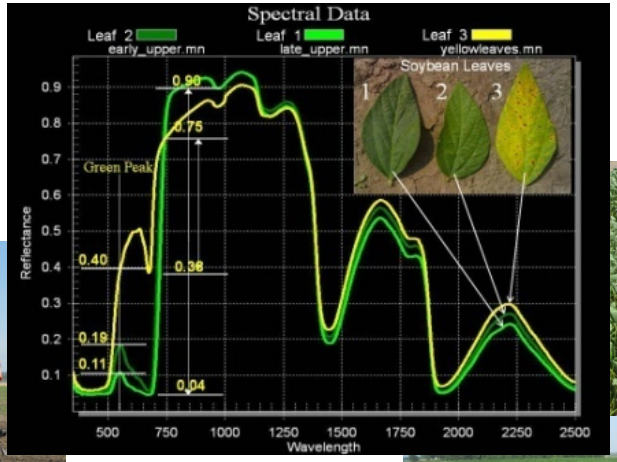
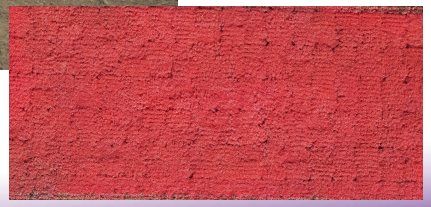
Kevin Price, Nan An, Vara Prasad and John Boyer









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Genetic Gain - MG III Cultivars

Year	Name		Year	Name		Year	Name		Year	Name	
1923	Dunfield	*	1978	Private 3- 1	*	1991	Private 3-16		1998	IA 3010	*
1927	Illini	*	1978	Cumberland		1992	Dunbar		1999	Private 3- 7	
1928	AK (Harrow)	*	1978	Oakland		1992	Thorne		2000	Private 3-20	
1934	Mandell		1979	Pella		1992	Private 3-17		2001	U98-311442	
1940	Mingo		1981	Williams 82		1993	Private 3-18		2001	IA 3014	
1943	Lincoln	*	1983	Private 3-15	*	1994	Private 3-19		2001	Private 3-21	*
1948	Adams		1984	Zane		1995	Macon	*	2002	Private 3- 8	*
1958	Shelby	*	1984	Harper		1995	IA 3004		2003	IA 3023	
1958	Ford		1986	Chamberlain		1996	Maverick		2004	NE3001	*
1960	Ross		1986	Private 3- 2		1996	Private 3- 4		2004	Private 3-13	*
1964	Wayne	*	1987	Resnik		1996	Private 3-11		2004	IA 3024	
1964	Adelphia		1987	Pella 86		1997	Pana		2006	Private 3-22	
1968	Calland	*	1989	Private 3- 9	*	1997	Private 3- 5		2006	Private 3-23	*
1971	Williams	*	1990	Private 3-10		1997	Private 3-12	*	2006	KS3406RR	
1974	Woodworth		1991	Private 3- 3		1998	Private 3- 6		2007	Private 3-14	*

* Spectral reflectance data collected

Genetic Gain - MG IV Cultivars

Year	Name		Year	Name		Year	Name	Year	Name	
1930	Macoupin	*	1977	Union		1991	Corsica	2000	Private 4-11	*
1933	Scioto		1980	Douglas	*	1992	Private 4- 3	2001	LS93-0375	
1935	Boone	*	1980	Private 4- 6	*	1992	Private 4-14	2001	Private 4- 4	*
1940	Chief	*	1980	Private 4- 7		1993	KS4694	2003	LN97-15076	
1940	Patoka		1981	Lawrence		1993	Private 4-15	2004	Private 4- 5	
1942	Gibson		1981	Sparks	*	1994	Private 4-16	2005	LD00-3309	*
1948	Wabash		1984	Private 4-13	*	1994	Stressland	2006	Private 4-19	*
1952	Perry		1985	Private 4- 1	*	1995	Cisne	2007	KS4607	*
1953	Clark	*	1986	Morgan		1995	Mustang	2007	Private 4-21	
1963	Clark 63		1988	Flyer	*	1996	Omaha	2008	Private 4-20	*
1968	Cutler	*	1988	Spencer		1996	Private 4-17	2010	Private 4-22	*
1971	Bonus		1989	Private 4- 2		1997	Private 4-18	2010	Private 4-24	
1973	Private 4-12	*	1990	Private 4- 8		2000	Private 4-23	*		
1977	Franklin		1990	Private 4- 9		2000	Private 4-10			

* Spectral reflectance data collected

Introduction

Objective

- Characterize the changes in physiological and spectral reflectance traits that have occurred with breeding advancements

Materials and Methods

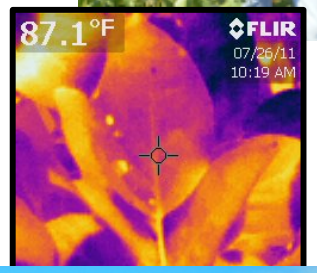
Experimental Design

- Dryland and Irrigated
- Manhattan, KS
- 2010 - 2012
  - 60 Group III cultivars
  - 54 Group IV cultivars
  - Releases from 1920's - 2010
  - Randomized Complete Block Design
  - 4 replications
  - Four-row plots
    - 3.4 m long
    - spaced 76 cm apart

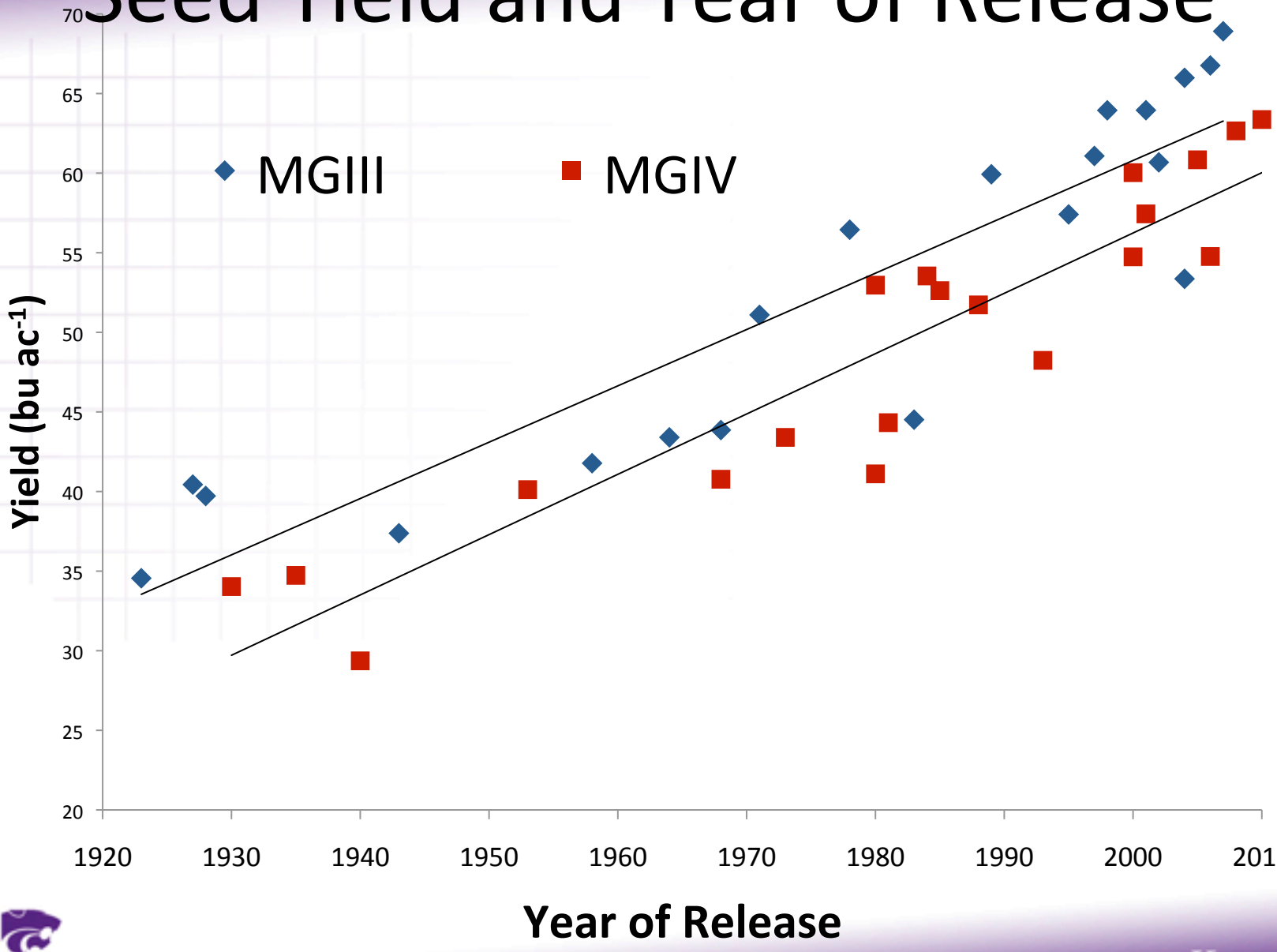
Materials and Methods

Traits measured

- Yield
- Maturity
- Lodging
- Height
- Chlorophyll content (Chlor) - Minolta SPAD 502 meter
- Canopy temperature (CT) - Flir Bcam infrared camera
- Spectral Reflectance
  - ASD Field Spec 3 spectroradiometer
    - 350nm-2500nm
      - 2151 individual bands
  - 2 readings per plot
    - 1m above canopy
    - ± 2 hours of noon
    - Cloudless, sunny days
    - Each reading mean of 10 scans
    - From R1-R6
  - Spectra reduced from 350nm-2500nm
    - to 400nm-1310nm (910 bands)
    - Eliminate noise (Naes et al., 2004)
  - Formed 10nm band regions (Lin et al., 2012)



Seed Yield and Year of Release



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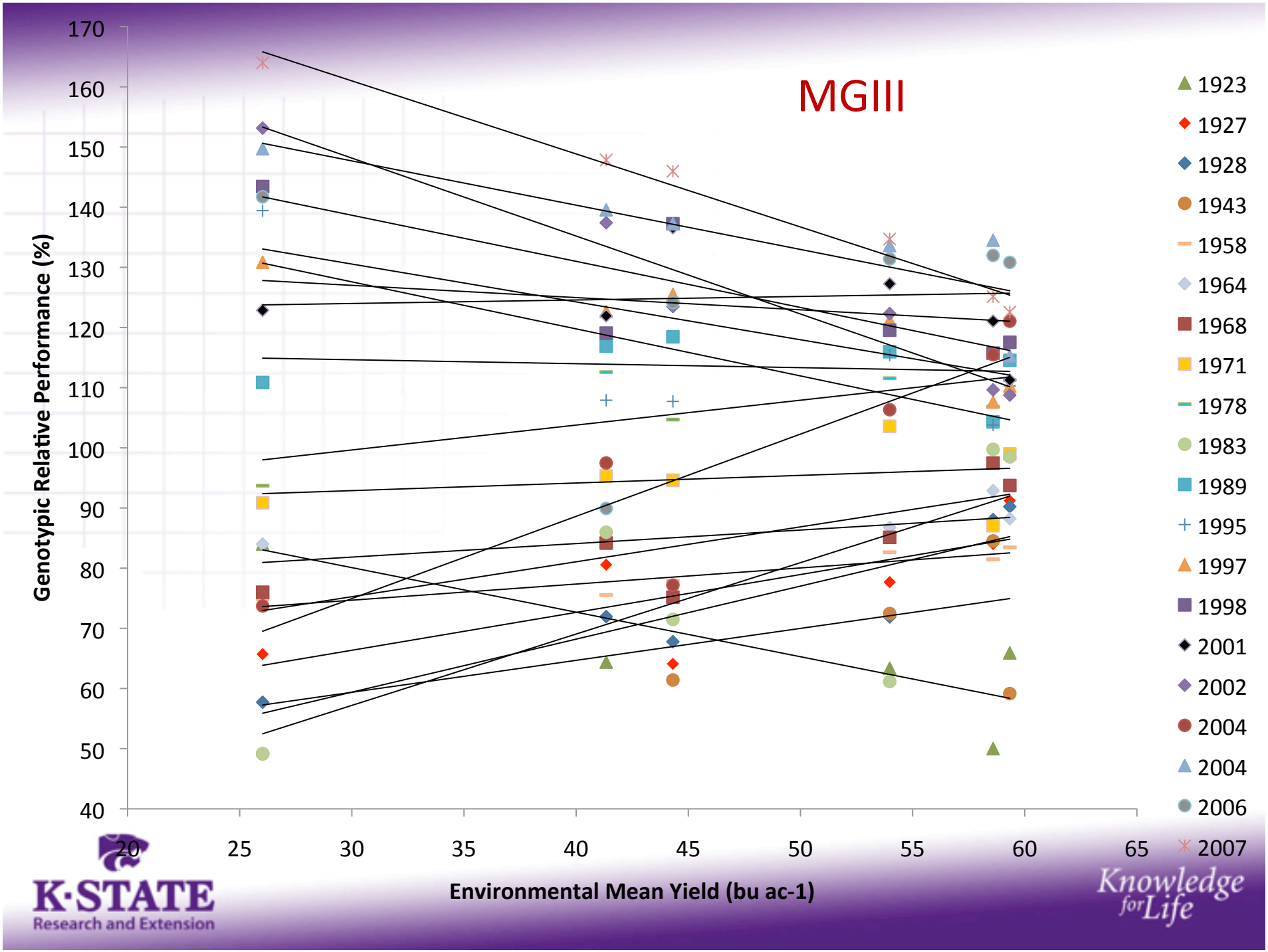

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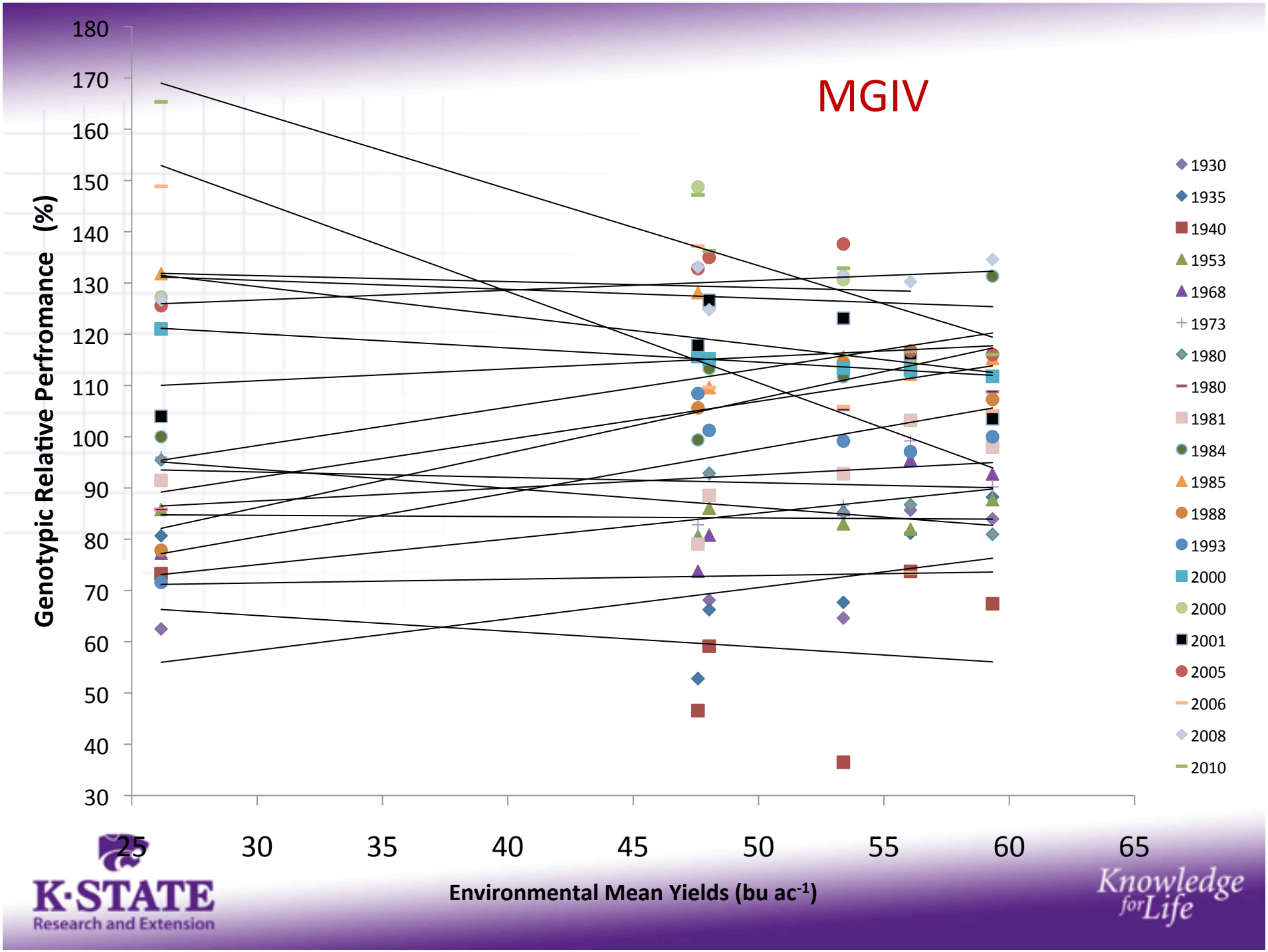

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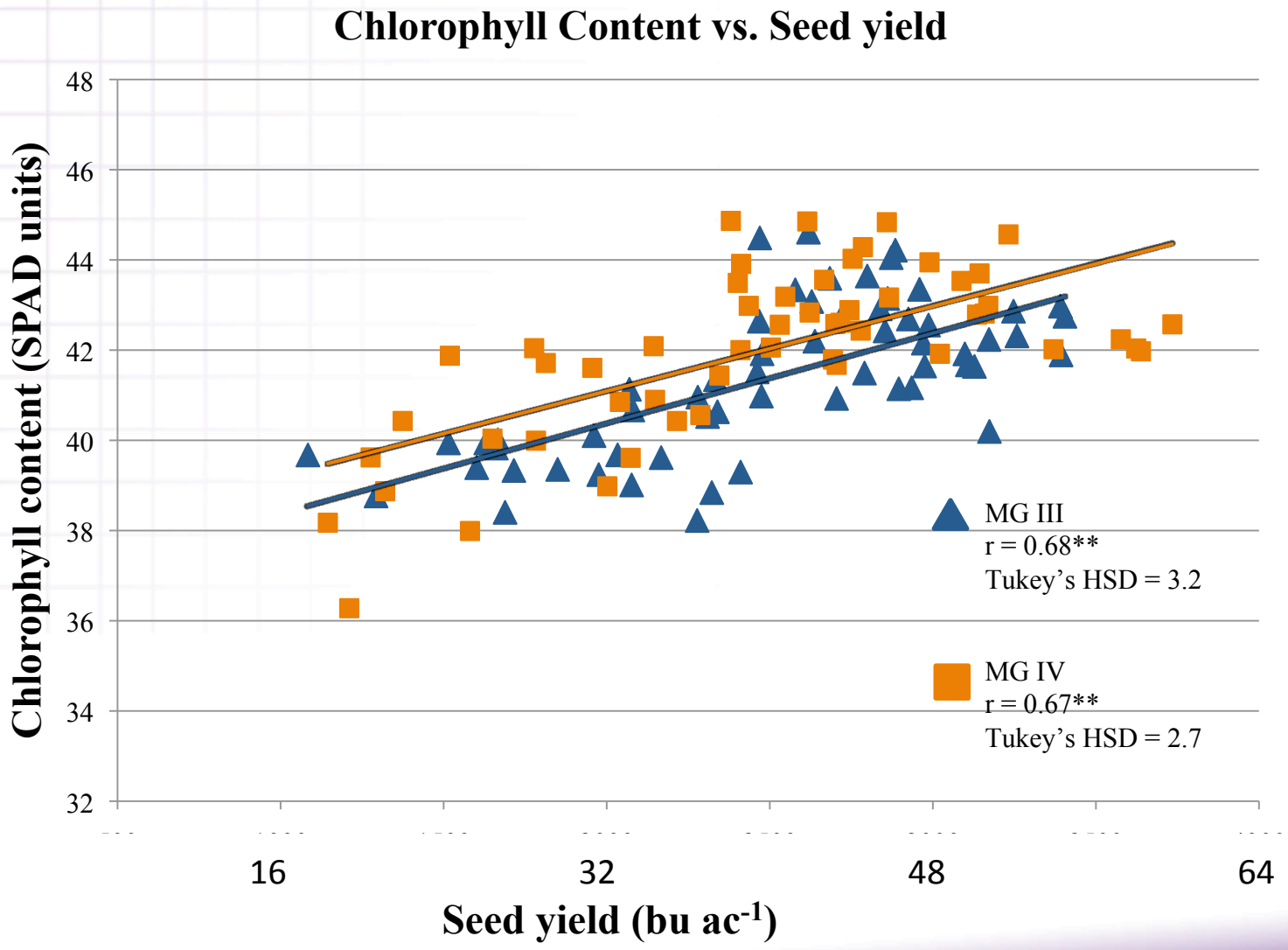
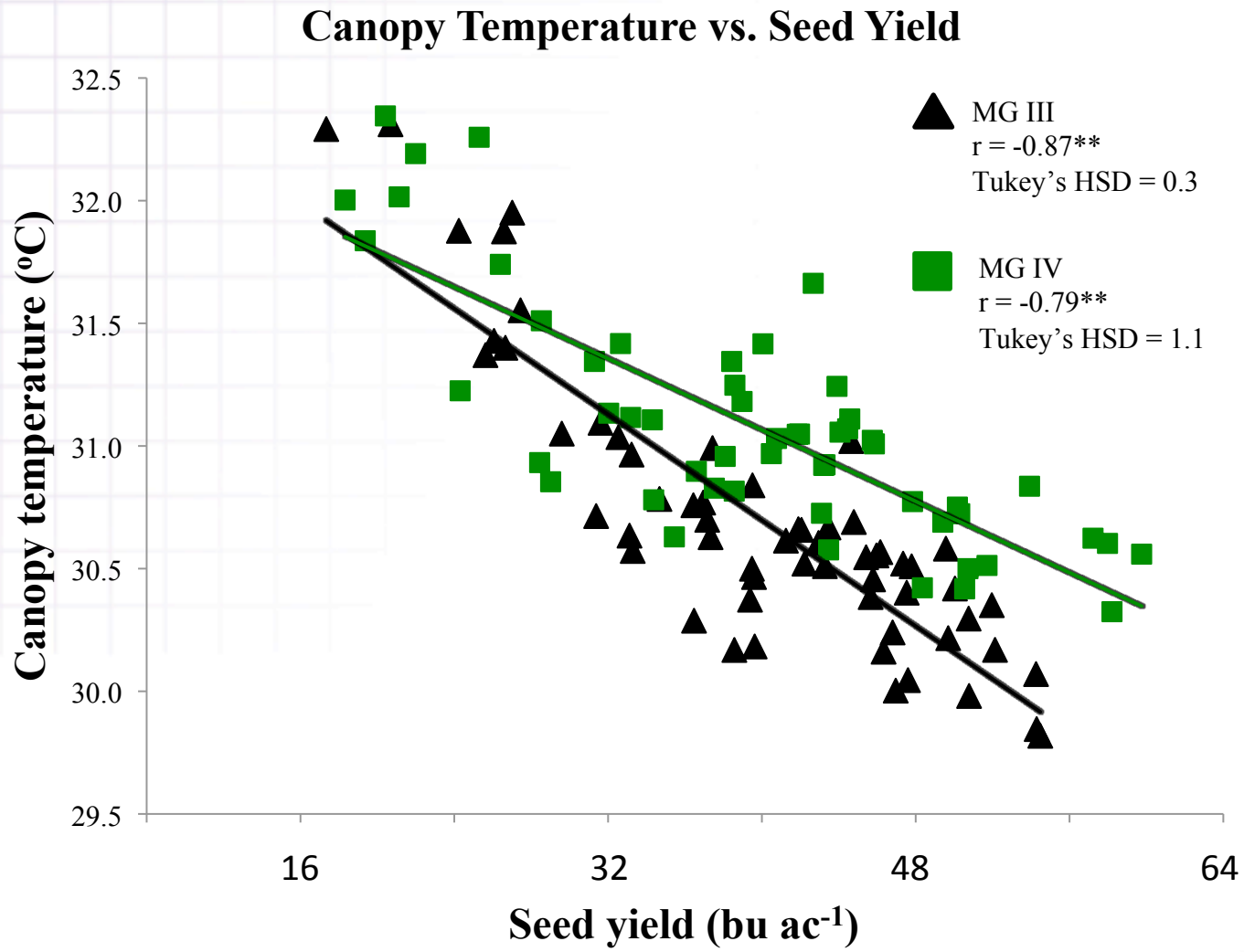
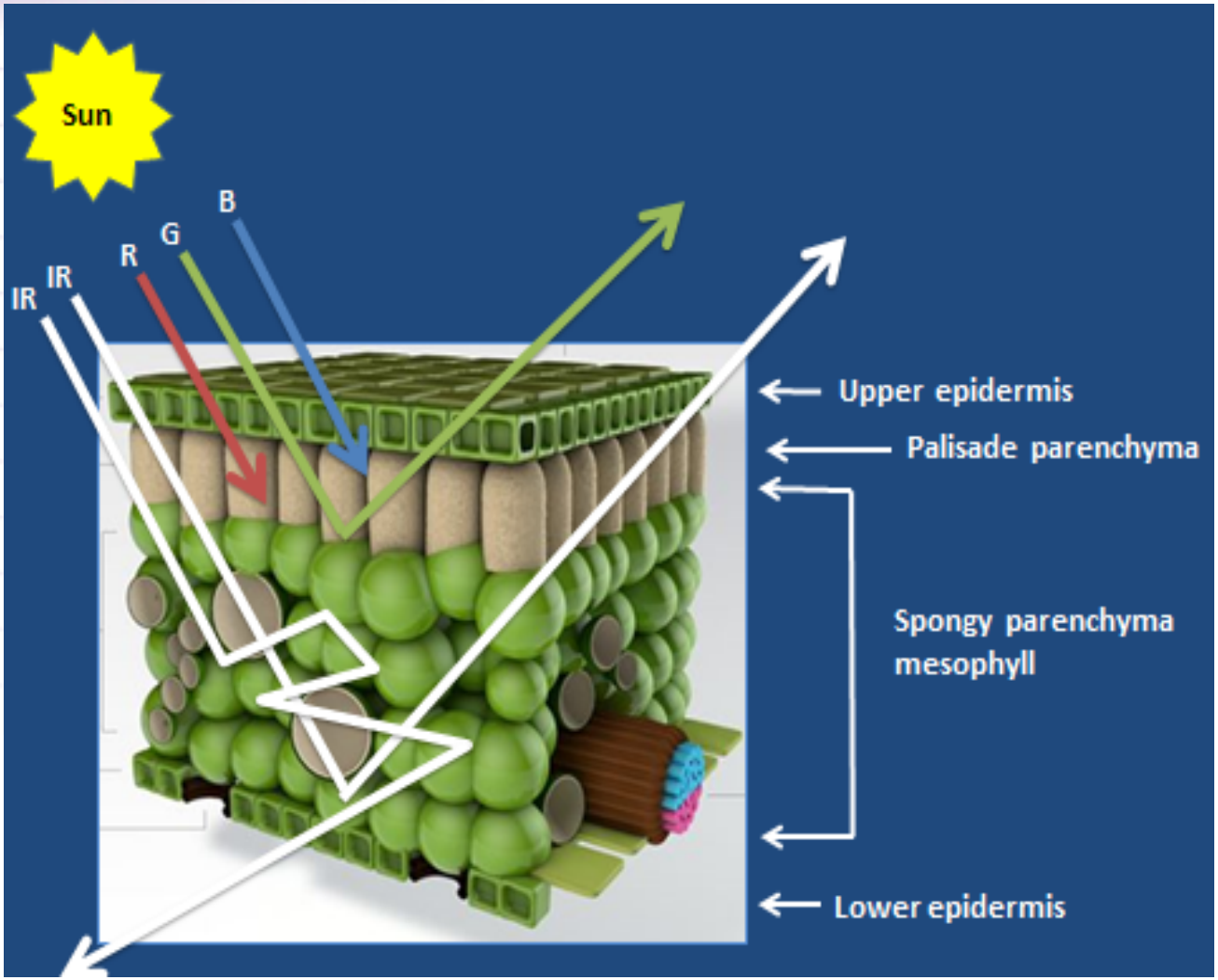
Results


Chlorophyll Content vs. Seed yield
Chlorophyll content (SPAD units)
48
46
44
42
40
38
36
34
32
MG III
r = 0.68**
Tukey's HSD = 3.2
MG IV
r = 0.67**
Tukey's HSD = 2.7
16
32
48
64
Seed yield (bu ac-1)

Results

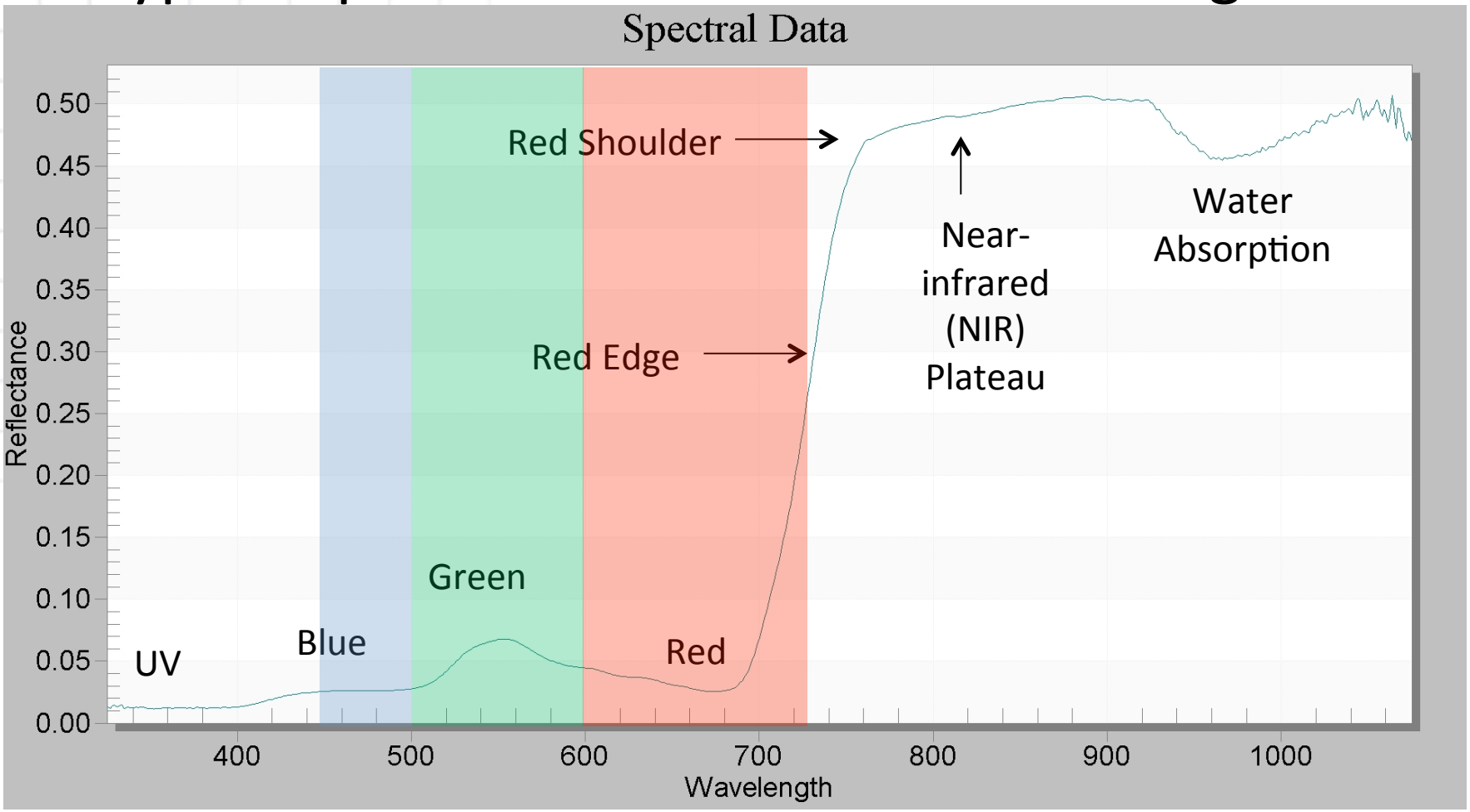

Canopy Temperature vs. Seed Yield
Canopy temperature (ºC)
32.5
32.0
31.5
31.0
30.5
30.0
29.5
16
32
48
64
Seed yield (bu ac-1)
MG III
r = -0.87**
Tukey's HSD = 0.3
MG IV
r = -0.79**
Tukey's HSD = 1.1

Introduction



Cellular leaf structure and its interaction with visible and infrared radiation

Typical spectral reflectance from a living leaf



Spectral Differences Among Genotypes

Source	DF	Wavebands (nm) 415	550	680	715	915	940	990	1100	1140	1245	1300
MGIII												
Gen	19	10.18**	17.33**	12.62**	14.69**	5.11**	4.46**	4.62**	3.46**	3.89**	4.68**	4.73**
Env	5	18.26**	11.01**	8.68**	8.26**	45.06**	38.91**	40.82**	36.37**	14.89**	28.29**	23.57**
Gen x Env	95	3.32**	3.53**	3.15**	3.51**	2.11**	1.99**	1.85**	1.74	1.51	1.72	1.73
MGIV												
Gen	19	9.09**	16.34**	8.46**	14.86**	2.99**	2.54**	2.75**	2.91**	2.16**	2.12**	2.11**
Env	5	112.34**	137.64**	139.74**	139.59**	50.73**	59.32**	55.46**	49.5**	64.9**	61.1**	58.8**
Gen x Env	95	1.01	1.41	1.11	1.47*	0.79	0.62	0.62	0.61	0.47	0.5	0.51

** = Pr > 0.01

* = Pr > 0.05

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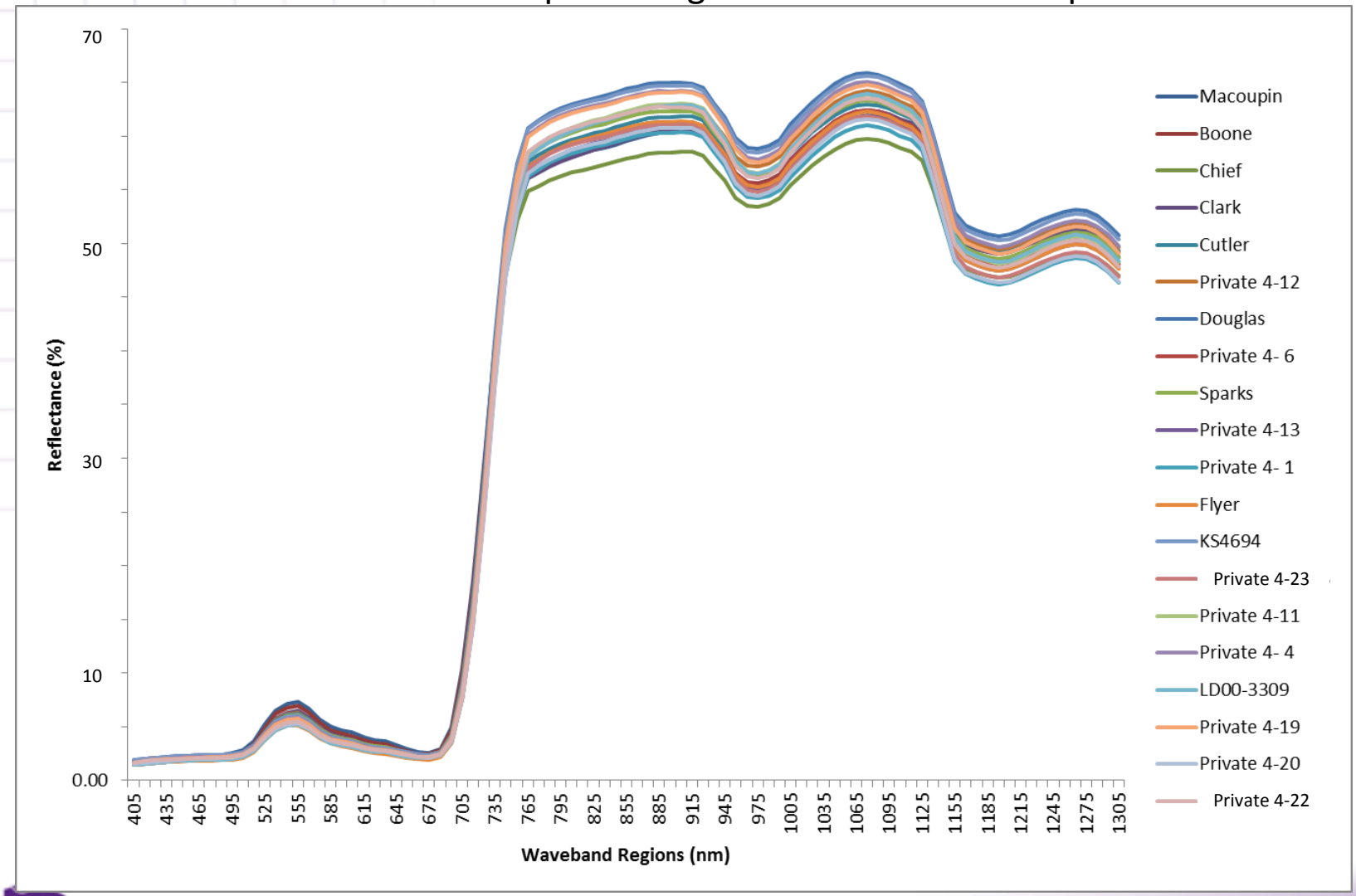
Mean spectral response curves of MGIV genotypes. Wavebands are 10nm intervals and reflectance is the percentage of a white reference panel.



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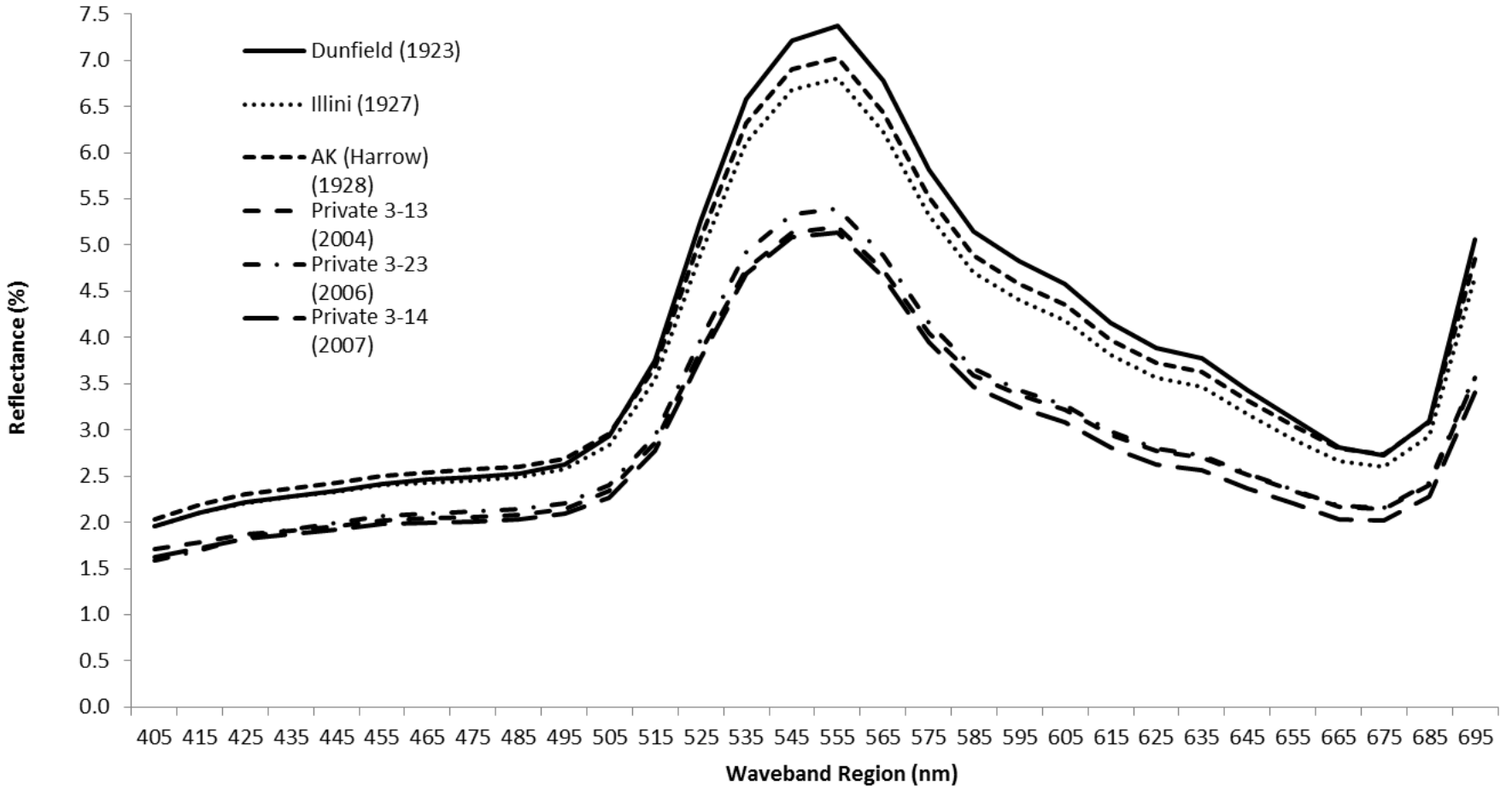
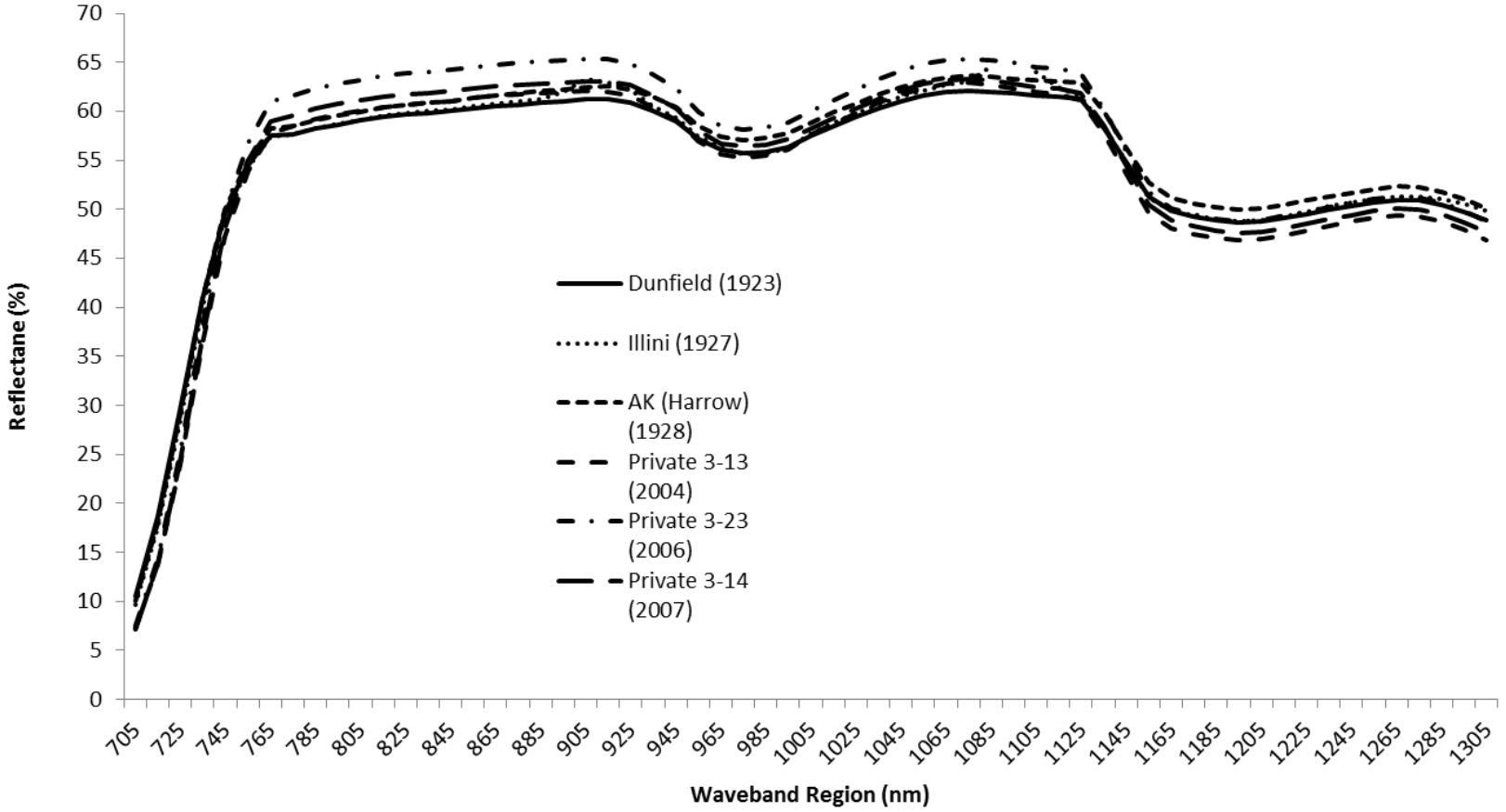
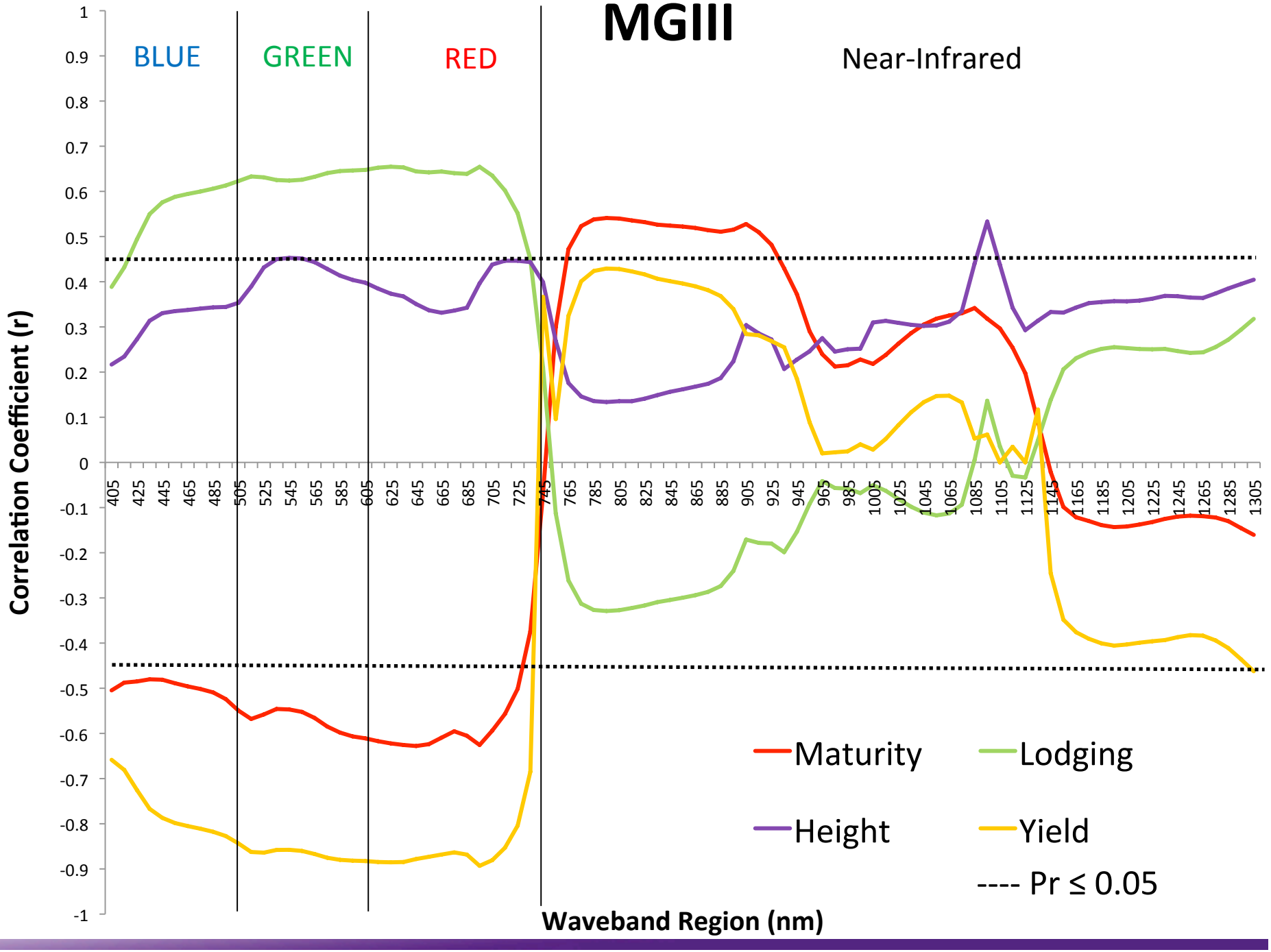
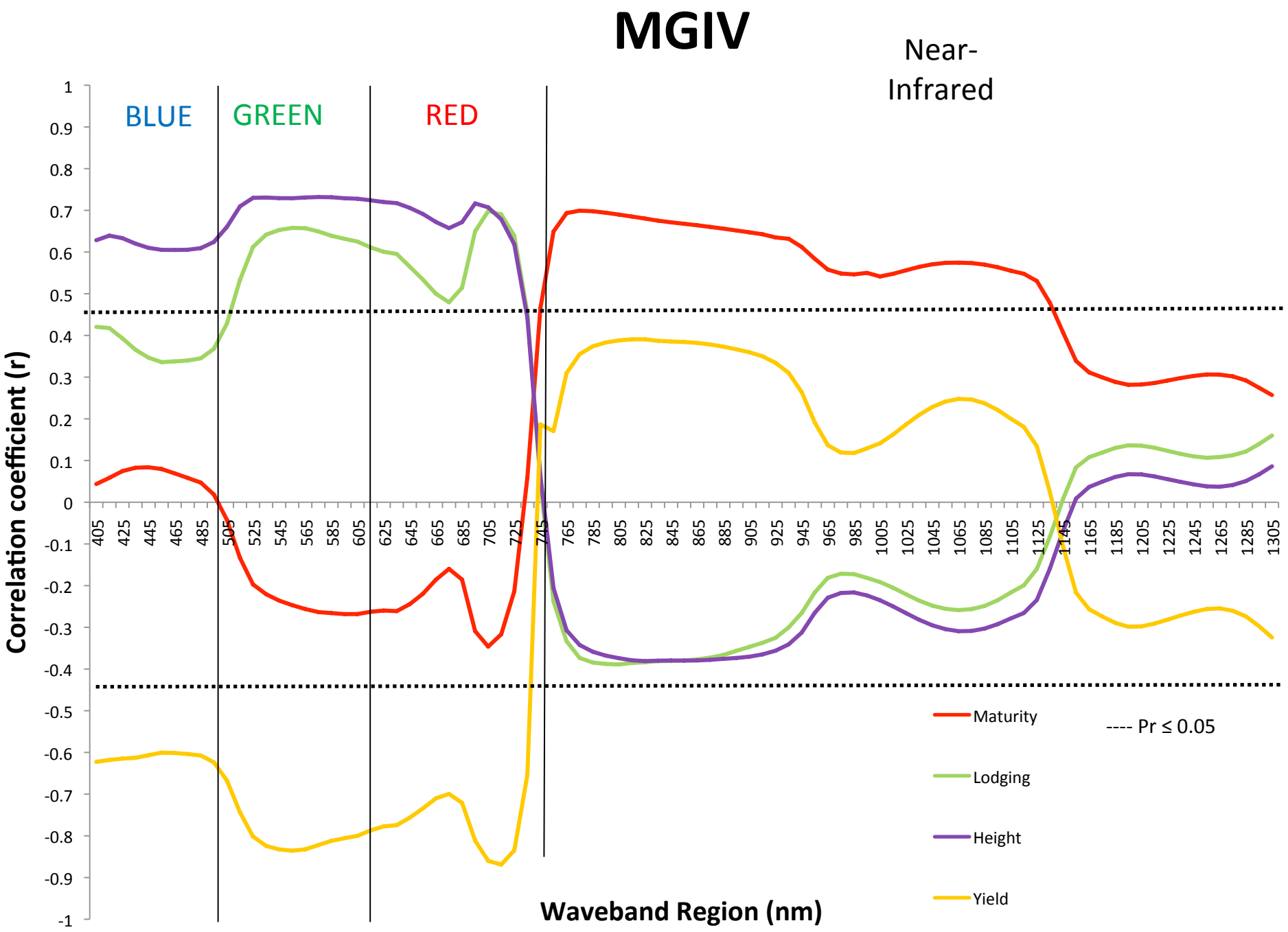
MGIII


Dunfield (1923)
Illini (1927)
AK (Harrow) (1928)
Private 3-13 (2004)
Private 3-23 (2006)
Private 3-14 (2007)
Reflectance (%)
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
405 415 425 435 445 455 465 475 485 495 505 515 525 535 545 555 565 575 585 595 605 615 625 635 645 655 665 675 685 695
Waveband Region (nm)

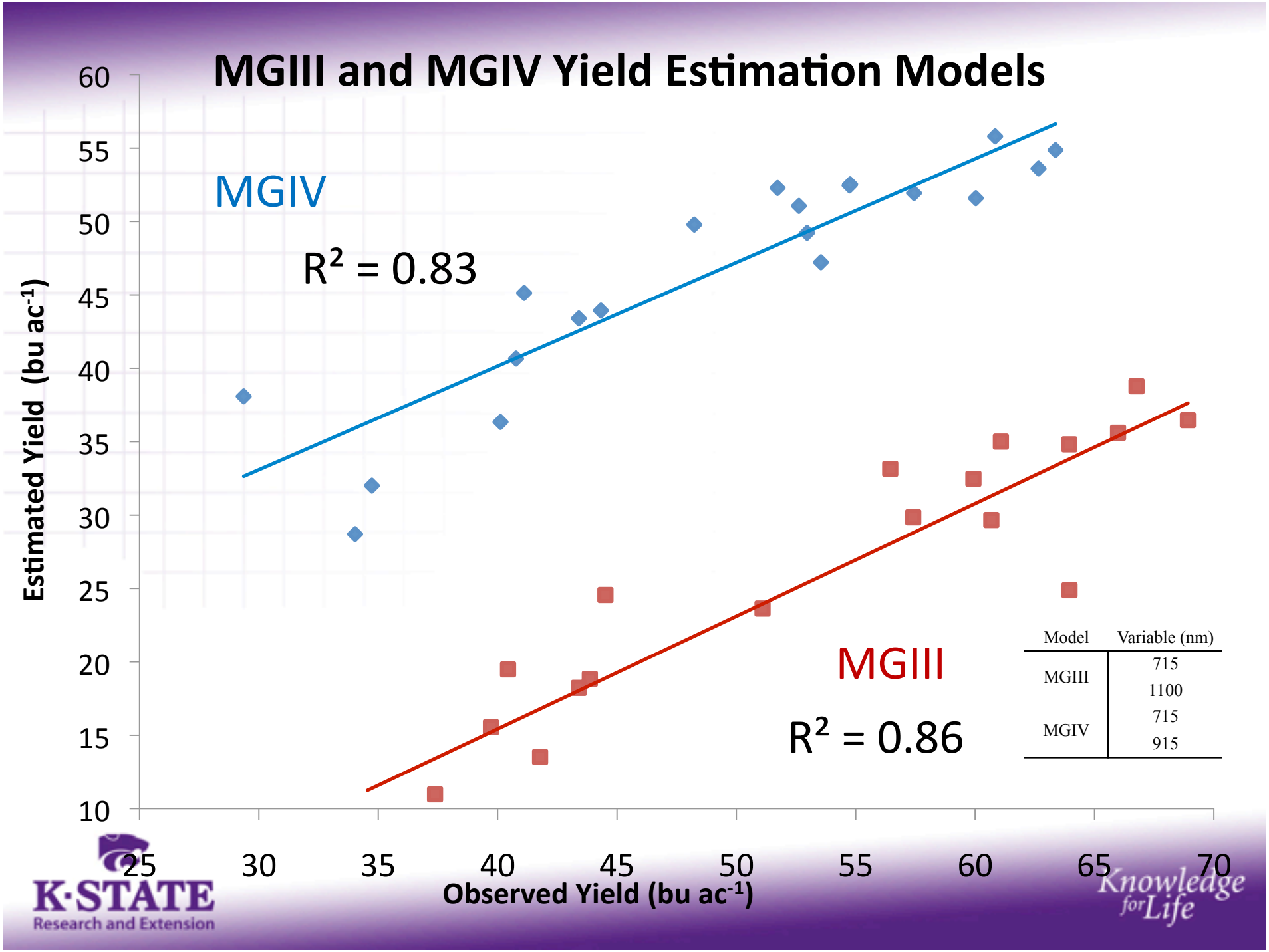
MGIII


Reflectane (%)
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
705
725
745
765
785
805
825
845
865
885
905
925
945
965
985
1005
1025
1045
1065
1085
1105
1125
1145
1165
1185
1205
1225
1245
1265
1285
1305
Waveband Region (nm)
Dunfield (1923)
Illini (1927)
AK (Harrow) (1928)
Private 3-13 (2004)
Private 3-23 (2006)
Private 3-14 (2007)


MGIII
BLUE
GREEN
RED
Near-Infrared
Correlation Coefficient (r)
Waveband Region (nm)
Maturity
Lodging
Height
Yield
---- Pr ≤ 0.05


MGIV
Near-Infrared
BLUE
GREEN
RED
Correlation coefficient (r)
Waveband Region (nm)
Maturity
Lodging
Height
Yield
---- Pr ≤ 0.05

MGIII and MGIV Yield Estimation Models



Model	Variable (nm)
MGIII	715
	1100
MGIV	715
	915

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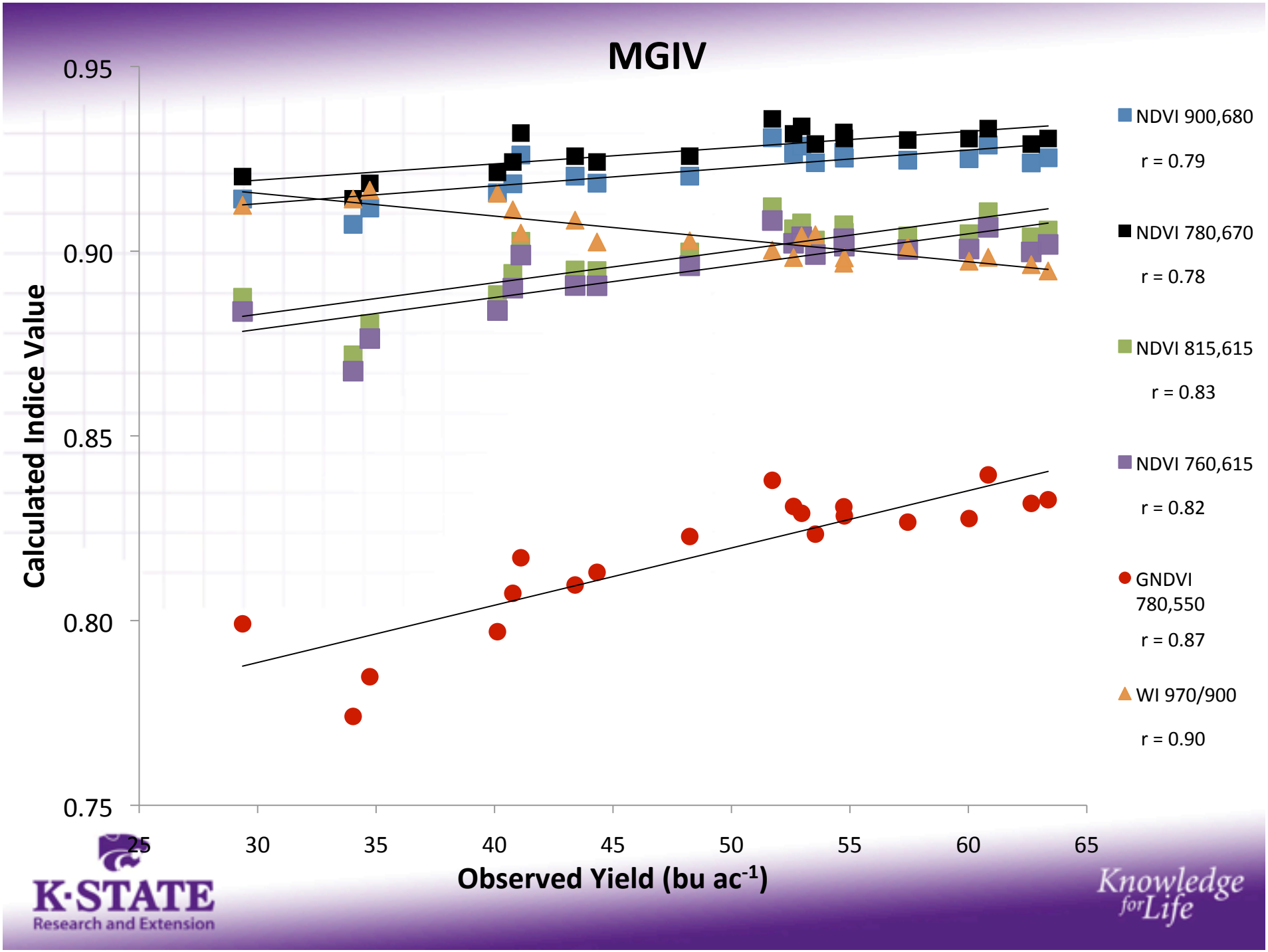
MGIV
Calculated Indice Value
0.95
0.90
0.85
0.80
0.75
25
30
35
40
45
50
55
60
65
Observed Yield (bu ac-1)
NDVI 900,680
r = 0.79
NDVI 780,670
r = 0.78
NDVI 815,615
r = 0.83
NDVI 760,615
r = 0.82
GNDVI 780,550
r = 0.87
WI 970/900
r = 0.90
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Conclusions

- More recently released cultivars had higher yields, higher leaf chlorophyll contents, lower canopy temperatures, lower reflectance values in the VIS and red-edge spectra portions and higher values in the NIR portion of the spectra than earlier released cultivars.
- Canopy temperature and canopy reflectance measurements accounted for a large portion of variability in seed yield among genotypes.
- However, CT and some regions of the spectra can reflect cultivar variation in maturity, lodging and height.
- Attempting to build upon these results to develop applications in high throughput phenotyping.

Acknowledgements

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