2011 Soybean Breeders Workshop

Summary Report for Research on Soybean Response to Abiotic Stress.

Jim Specht – Coordinator

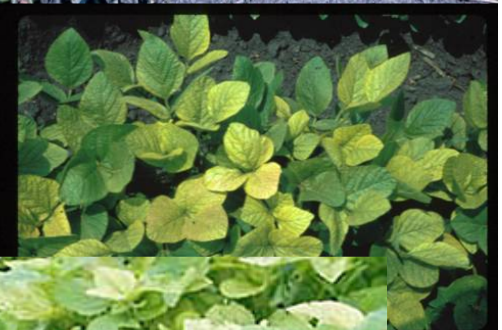
Iron-Deficiency Chlorosis

- Silvia R Cianzio - Iowa State University

- Ted Helms - North Dakota State University

- James H. Orf – University of Minnesota

IDC in soybean Close –up pictures in field plots



Iron deficiency chlorosis (IDC)

Silvia R. Cianzio & Randy Shoemaker

IOWA STATE UNIVERSITY

USDA ARS

Iron deficiency chlorosis

Applied research

- **Objective**: germplasm lines with improved IDC for public use.
  - Population development by single crosses
  - F4-derived lines classified by maturity are evaluated for agronomic traits and IDC on calcareous soil.

Sources of IDC resistance

- **Germplasm releases**
  - AR2 (ISURF Docket # 033810)
  - AR3 (ISURF Docket # 033800)
  - Molecular markers for the germplasm lines

Some data for AR2 and AR3. Data are averages of 3 years for chlorosis scores, and 1 year for seed yield

Genotypes	Chlorosis scores			Seed Yield
	Ames	Humboldt	Slater	Kg/Ha
		Lines		
AR2	1.5	1.9	2.0	49.8
AR3	1.5	1.9	1.4	44.9
		Parents		
P9254	2.0	1.9	1.2	63.9
A97-770012	2.1	2.0		51.5

IDC – Basic research – It is in progress, conducted to identify QTLs. Nothing to report yet.

Future applied research for improving IDC

-Field tests will be complemented with nutrient solution screening

-Use of Additional Molecular information

Salt Tolerance

- Pengyin Chen – University of Arkansas

Salt Tolerance Screen

Aluminum Tolerance

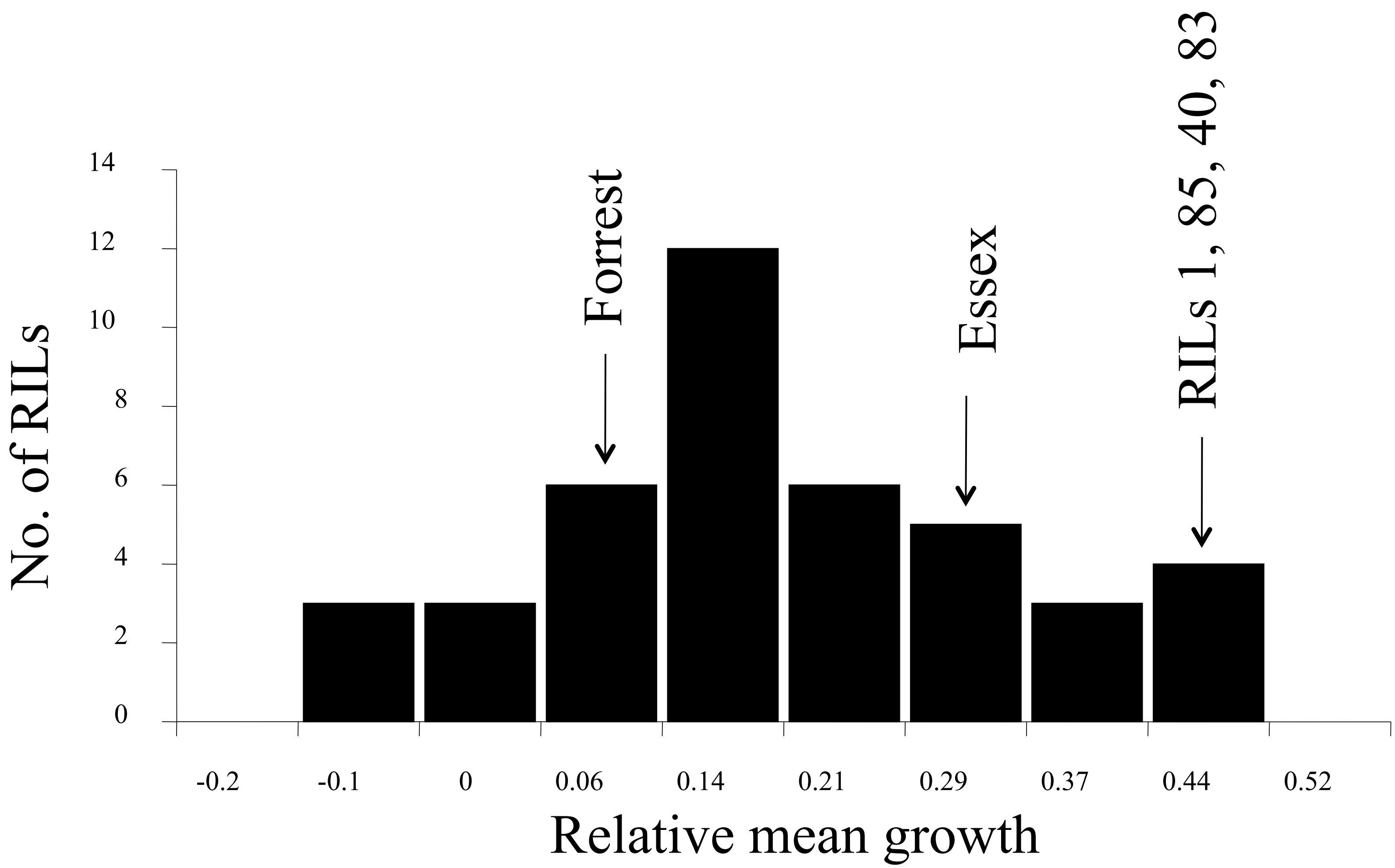
- David Lightfoot – Southern Illinois University

Al toxicity hydroponics

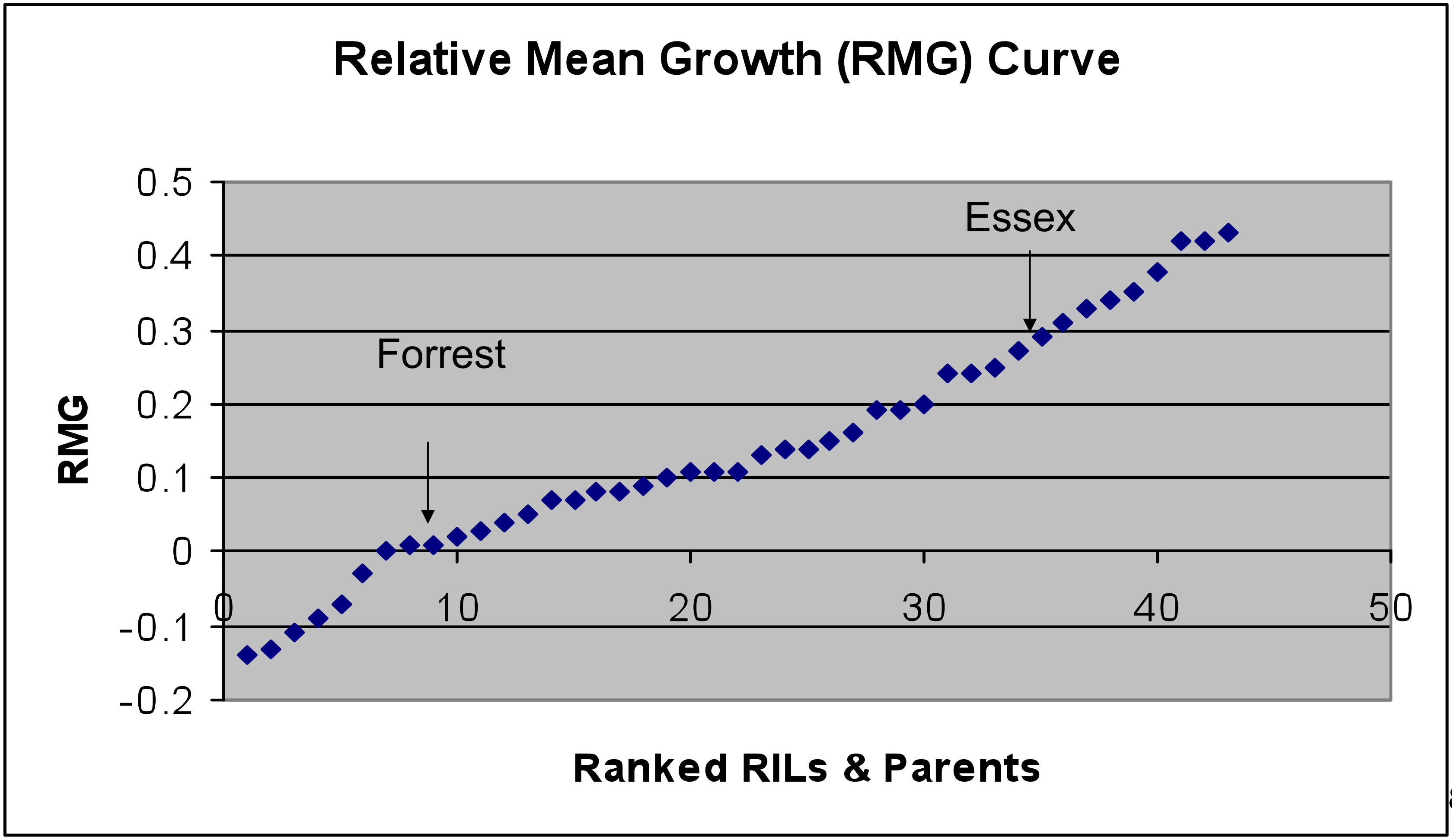
Toxicity symptoms of root growth due to Al stress

Segregation within NILs for Resistance to Al toxicity

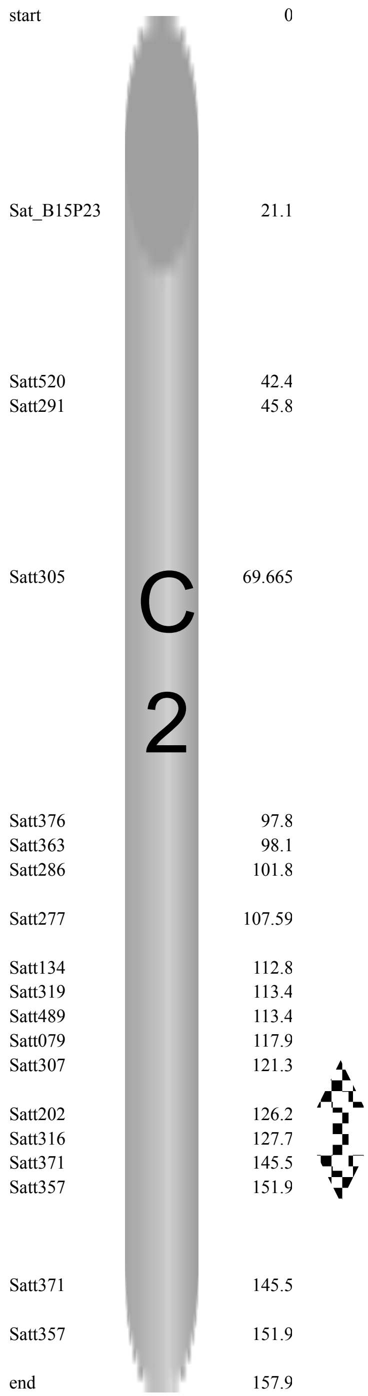
Figure 3. Trait distributions for tolerance to Al.

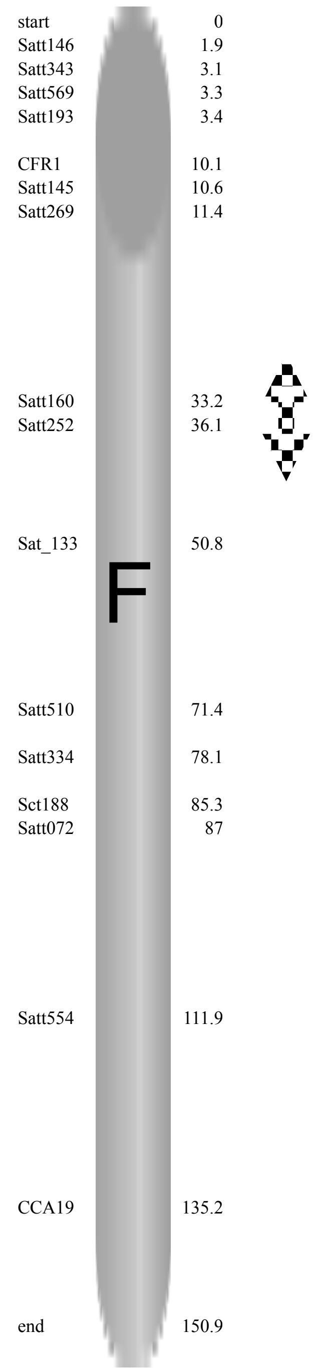


Mean Root Length +Al



Al Toxicity Resistance has 2 Major Loci and several minor loci





Heat Tolerance (heat-induced seed deterioration)

- J. Rusty Smith, USDA-ARS-CG, Stoneville, MS

The Early Soybean Production System (ESPS) - A Heat Stress Environment

- Consists of using early-maturing varieties planted early in the spring into fall-prepared stale seed beds.
- Often includes the use of glyposhate-resistant varieties, efficient irrigation scheduling, raised seed beds, and narrow rows.
- Is the production system of choice in the Midsouthern USA.
- Has played a significant role in improving soybean production in the Midsouth.

Potential Problems of the ESPS

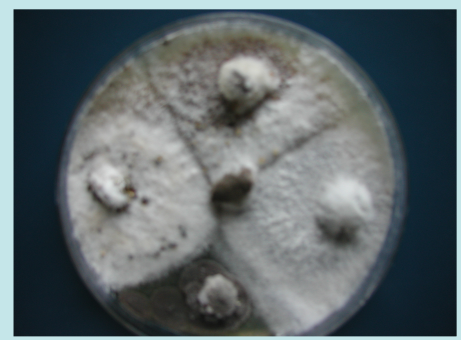
- Seed-filling period, seed maturation, and harvest occur during the hottest time of the year.
- High temperature may negatively affect seed yield and seed quality.

Low Germination - A Heat-Related Seed Quality Concern

Hard Seed

Wrinkled Seed

Phomopsis



Research Goal:

- ❑ Develop and release improved germplasm with high germinability.
- ❑ Identify molecular markers linked to traits affecting high germinability.

Identification of Soybean Accessions with High Germinablity

- ❑ 486 candidate accession (MG II-IV).
- ❑ 25 ancestral lines of U.S. cultivars.
- ❑ Cultivar checks.
- ❑ 2002-2003 Field, Greenhouse 2005.
- ❑ Standard germination, AA germination, hard seed, seed wrinkling, and *Phomopsis*.

Standard Germination and Mean Maximum Temperature During Senescence for 486 Soybean Accessions

MG	No. Lines	SG Mean	SG Range	Mean Max Temp. R7 to R8
		%	%	°F
II	120	81	19-93	93
III	139	72	20-93	93
IV	246	76	11-93	93

Sample Results

Entry	MG	SG	Hard Seed	Wrinkled Seed	*Phomopsis*
		%	%	%	%
Lincoln	III	51	2	35	28
Mandarin O.	0	27	40	40	10
PI 603756	II	93	0	0	6
PI 587982A	IV	92	0	0	0
PI 597413	II	30	34	40	54
PI 227213	II	29	34	75	22
PI 416862	III	25	9	30	72
PI 594619	III	4	93	0	26
Stressland	IV	66	4	5	22

Flood / Water-Logging Tolerance

- Pengyin Chen – University of Arkansas

/5 (Left) vs. R1 (Right) Flood Screen

Field Flood Screen

Varietal Differences

Drought or Water Deficit Stress Tolerance

- H. Roger Boerma – University of Georgia
- Pengyin Chen – University of Arkansas
- David A. Lightfoot – Southern Illinois Univ.
- James H. Orf – University of Minnesota
- Shawn Conley – University of Wisconsin
- James E. Specht – University of Nebraska

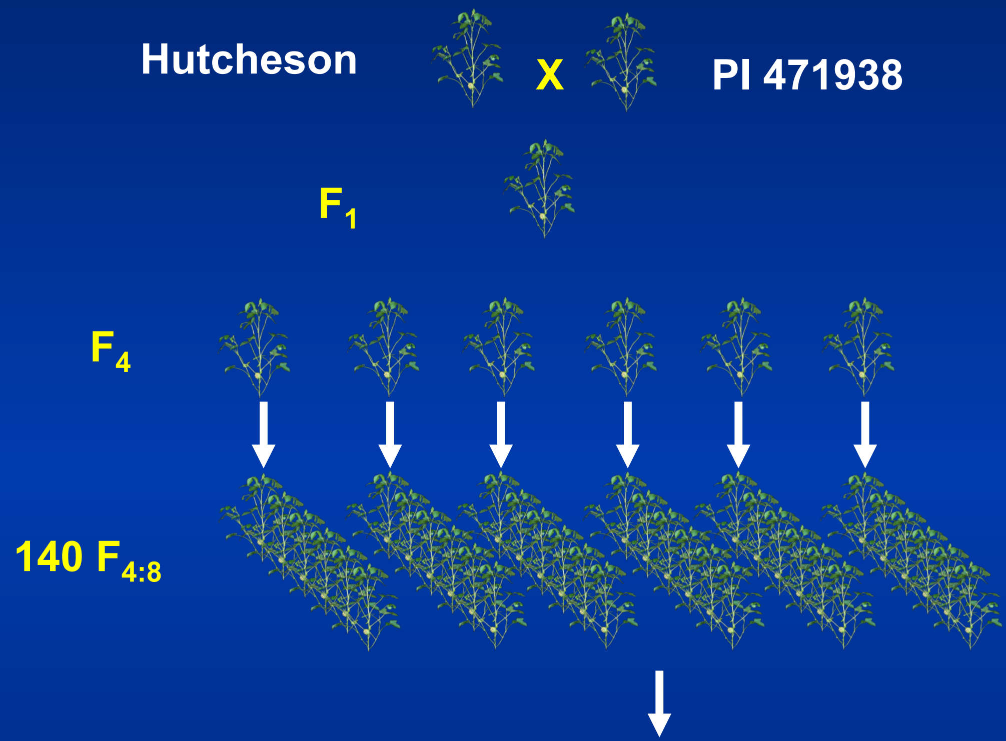
Locations of Fibrous Root QTL in Benning x PI 416937

Germplasm Evaluation

PI471938: slow wilt canopy alleles

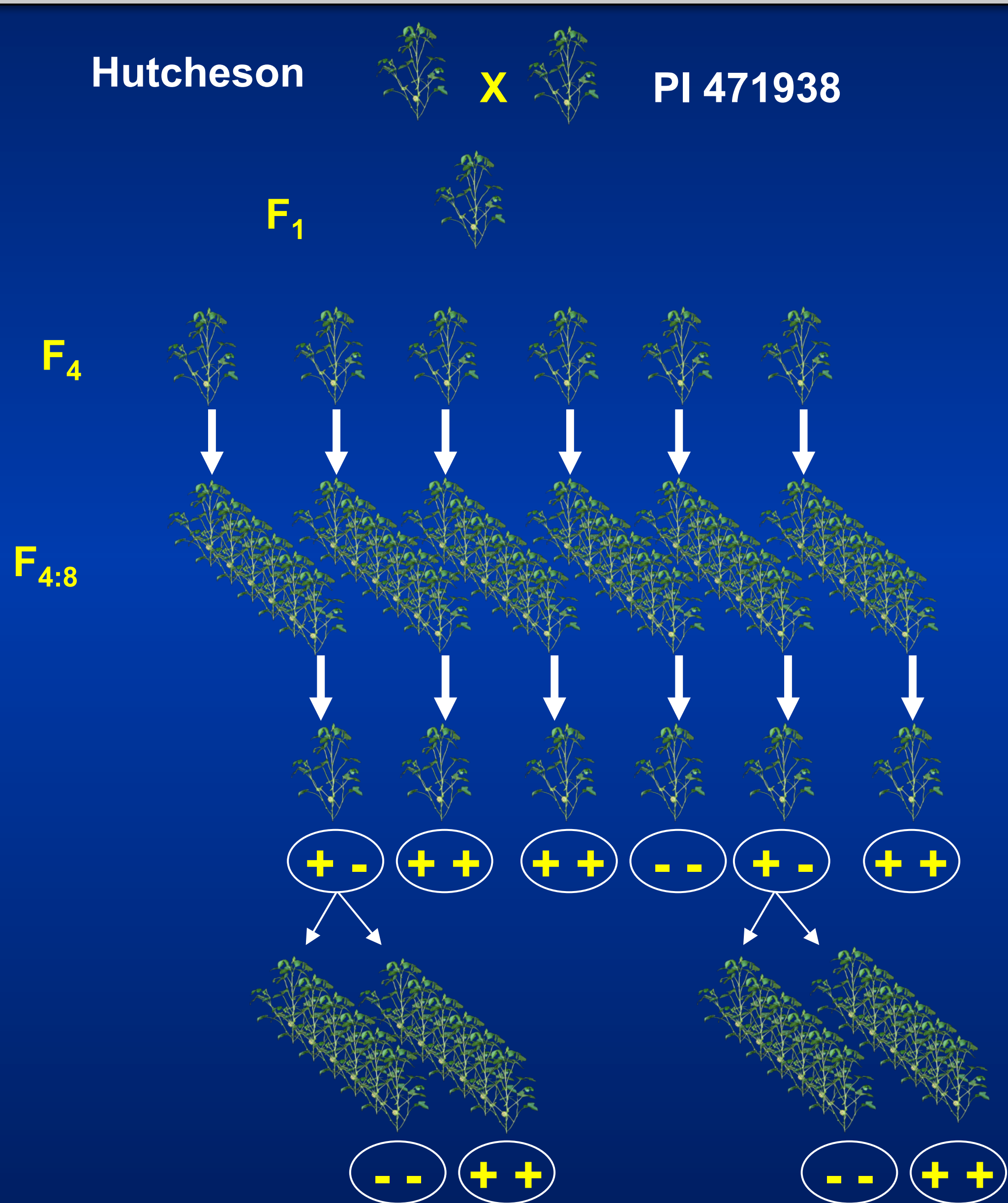
PI416937: fibrous root alleles

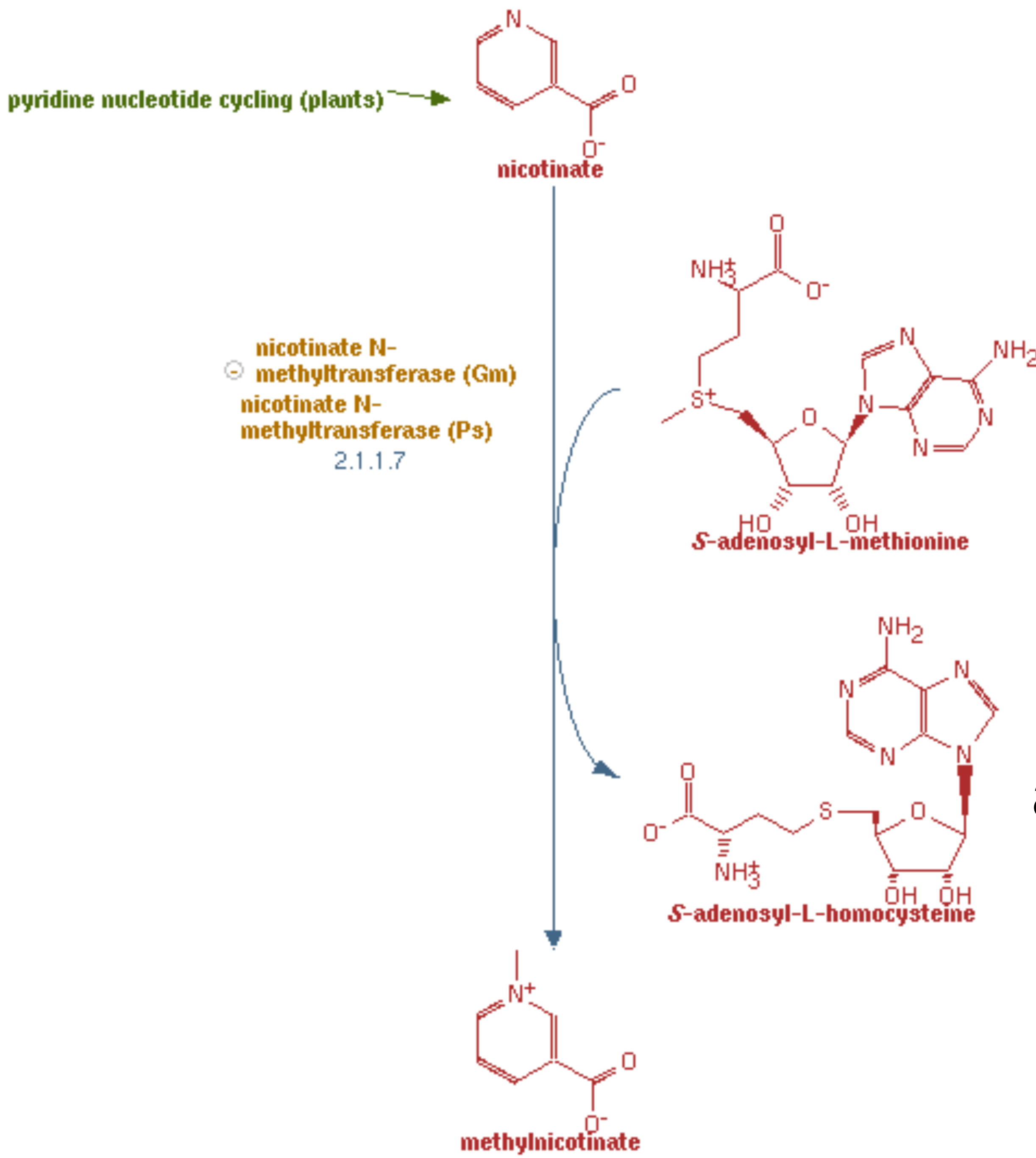
Hutcheson x PI 471938 Mapping Population



- 14 environments (5 rain-fed and 9 irrigated environments)
- RCB design with 3 replications

Development of Near Isogenic Lines for QTLs on LG-D2, LG-F and LG-K





Trigonelline

induces leaf movements, accumulates upon drought stress, acts as an osmoprotectant, and functions as a hormone involved in cell cycle control

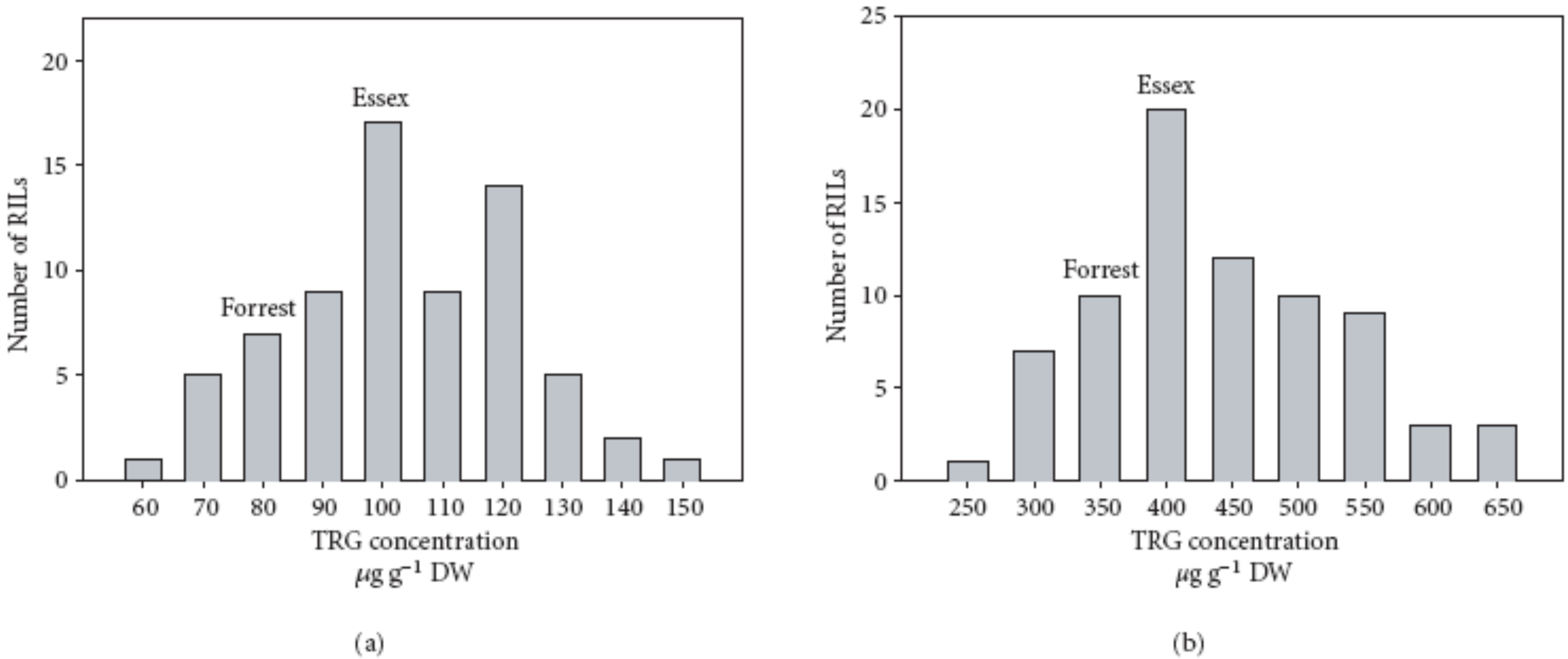


Figure 1. Trigonelline (TRG) concentration and normal distribution of RILs derived from a cross of Essex with Forrest. The mean trigonelline concentration for individual parents is presented. (a) Frequency distribution of TRG estimated on the basis of fresh weight of leaf sampled at pod setting stage; (b) on the basis of dry weight of leaf.

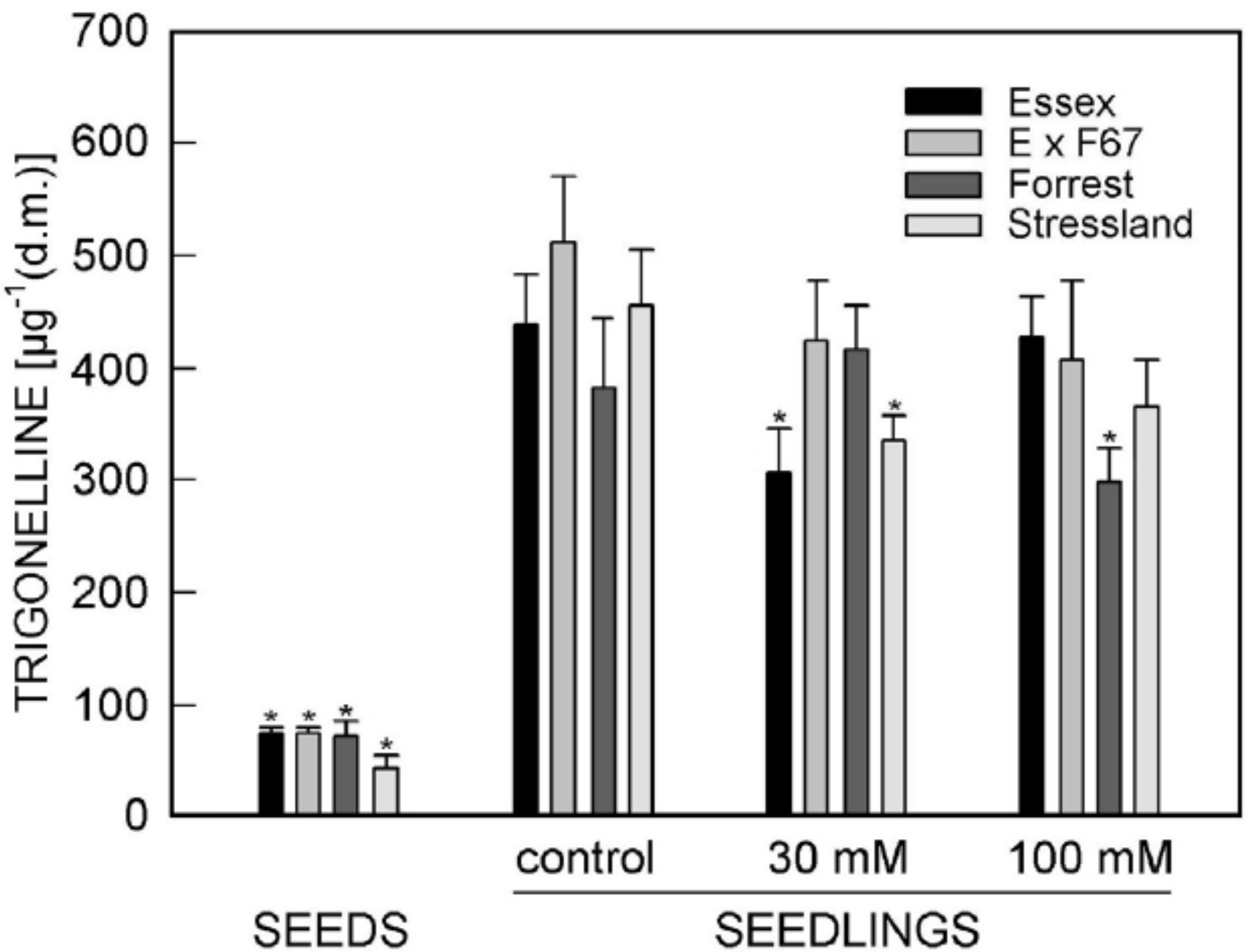


Fig. 3. Trigonelline (TRG) content in non-treated mature seeds and seedlings treated with different NaCl concentrations during germination (means ± SE, n = 30, * indicates significant difference at $P < 0.05$ as compared with the control).

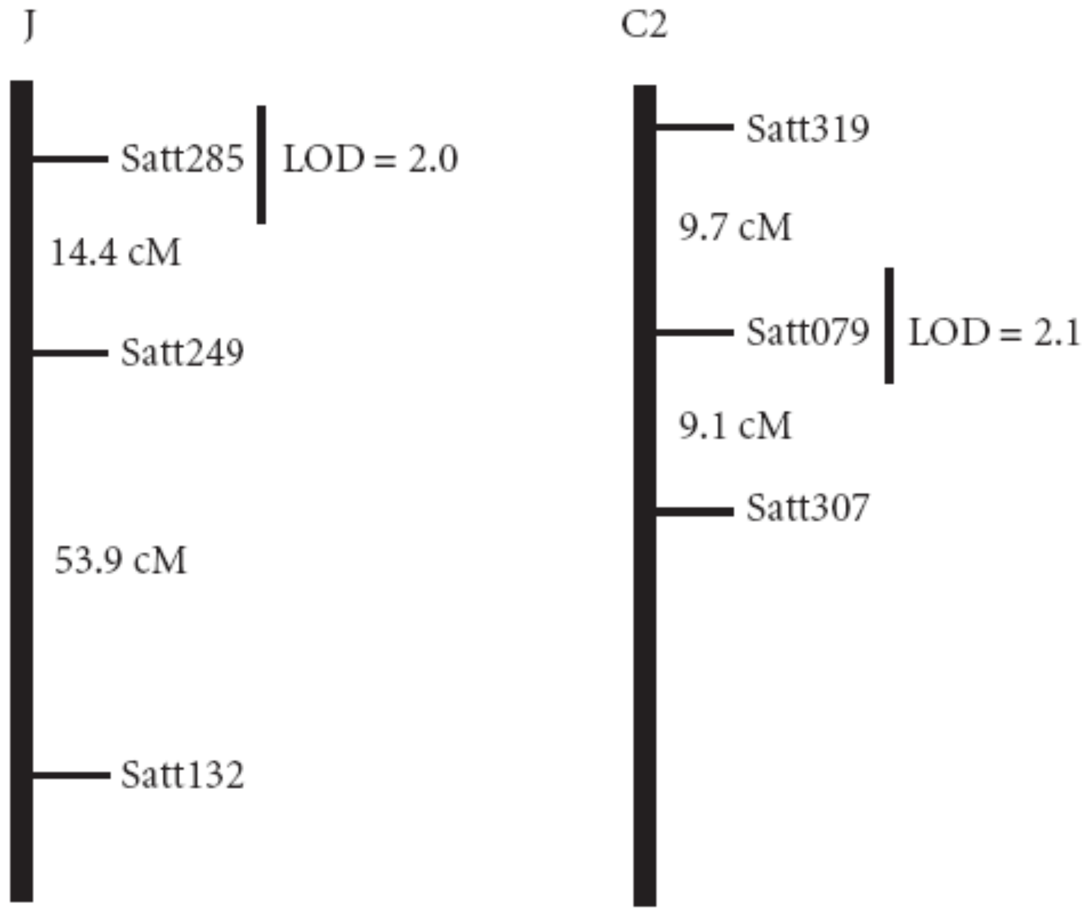
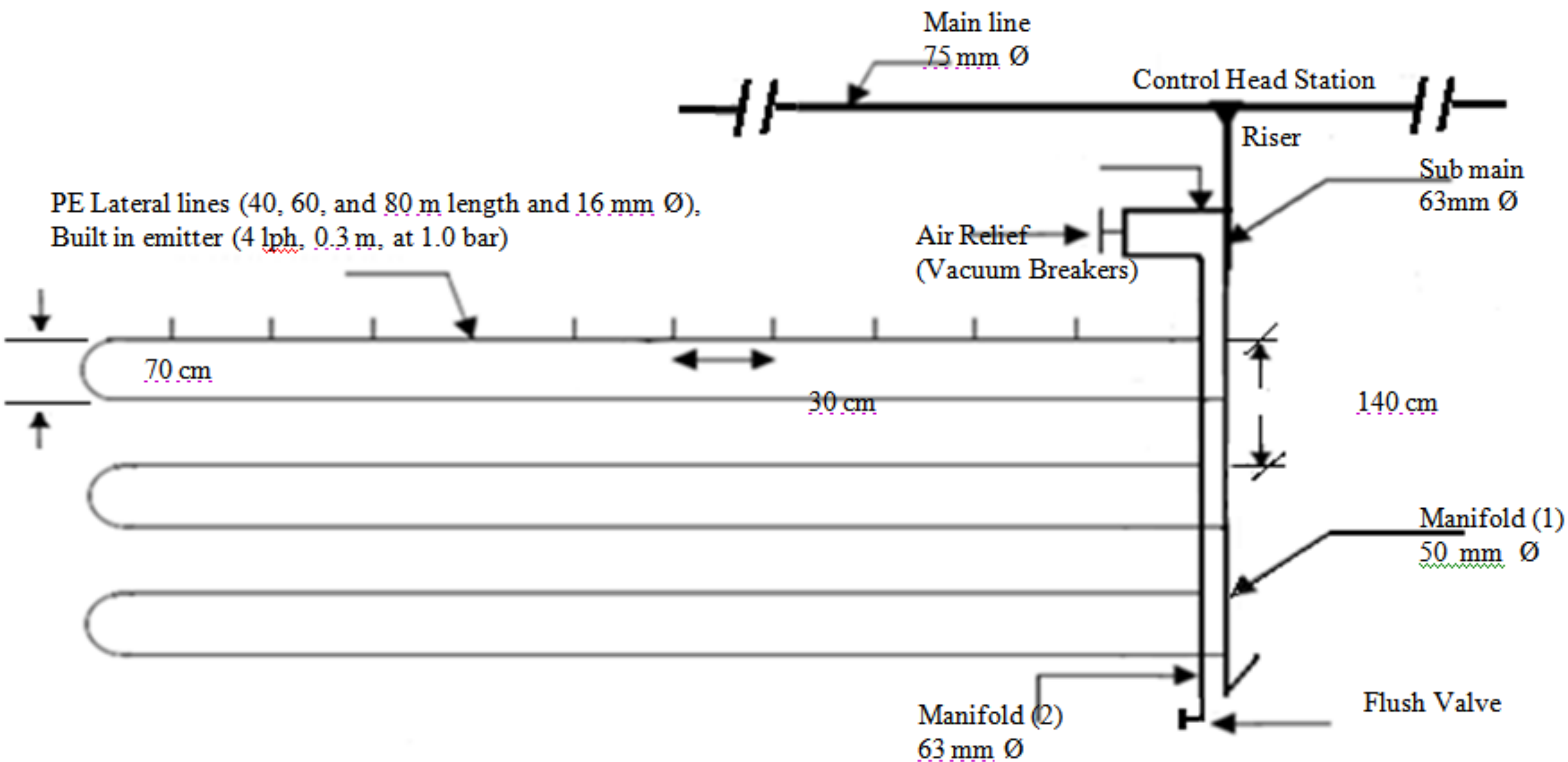


Figure 2. Location of microsatellite markers and three QTLs conditioning trigonelline biosynthesis in soybean grown under conventional field condition. The markers were assigned to the linkage groups C2, J, and L based on the soybean genetic linkage map [39]. END indicates the likely position of the telomere on designated linkage group. Names and distances of markers, and peak LOD score for the interval are given. The QTL LOD scores are from single locus analyses of additive gene effects using Mapmaker/QTL 1.1.

The ExF population in a dry year (2010) spreads maturity dates

Layout of a closed circuit drip irrigation system (CM2DIS).



Drip Irrigation Allows Water Deficit At Specific Rates All Season

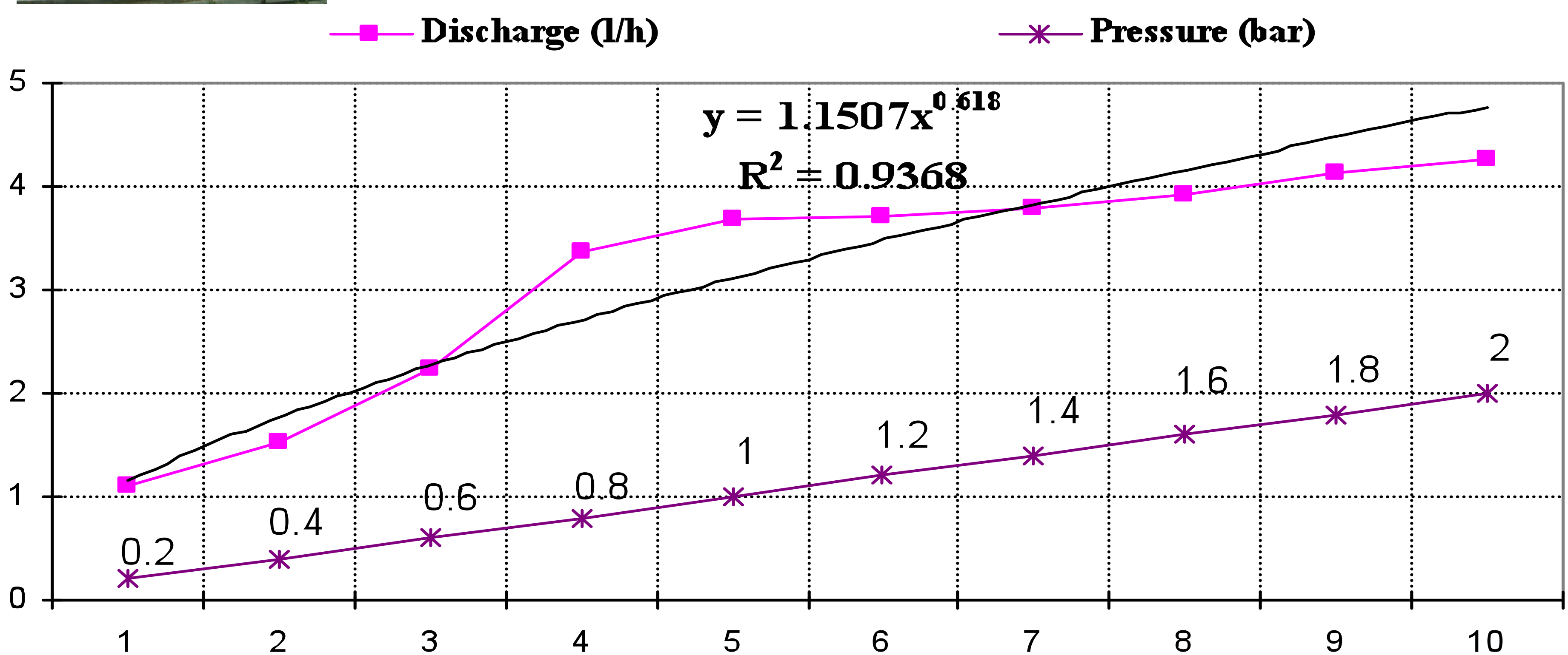
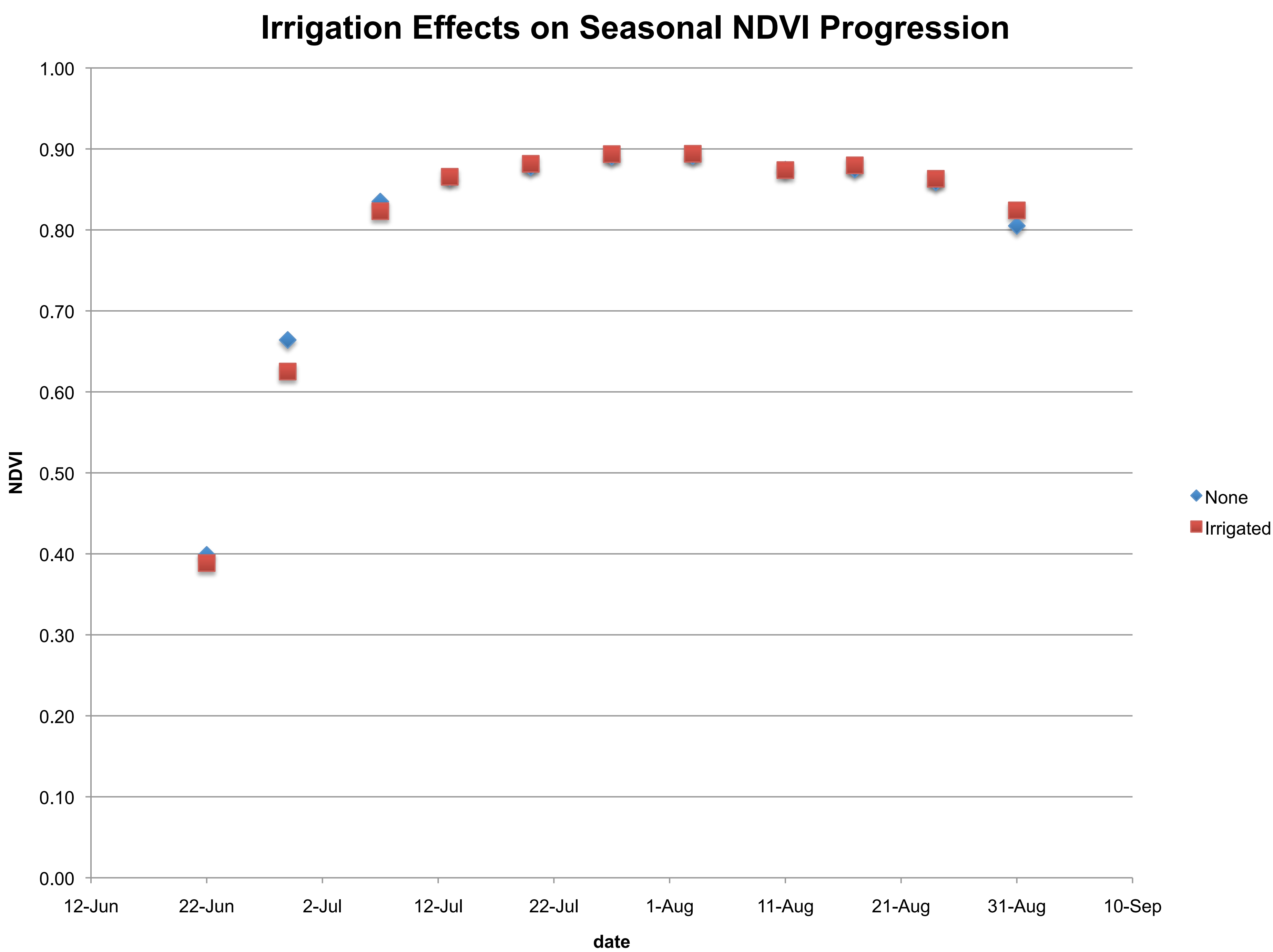


Fig. (6). Effect of different water pressures on discharge rates of emitters in the CM1DIS design (slope 0%).

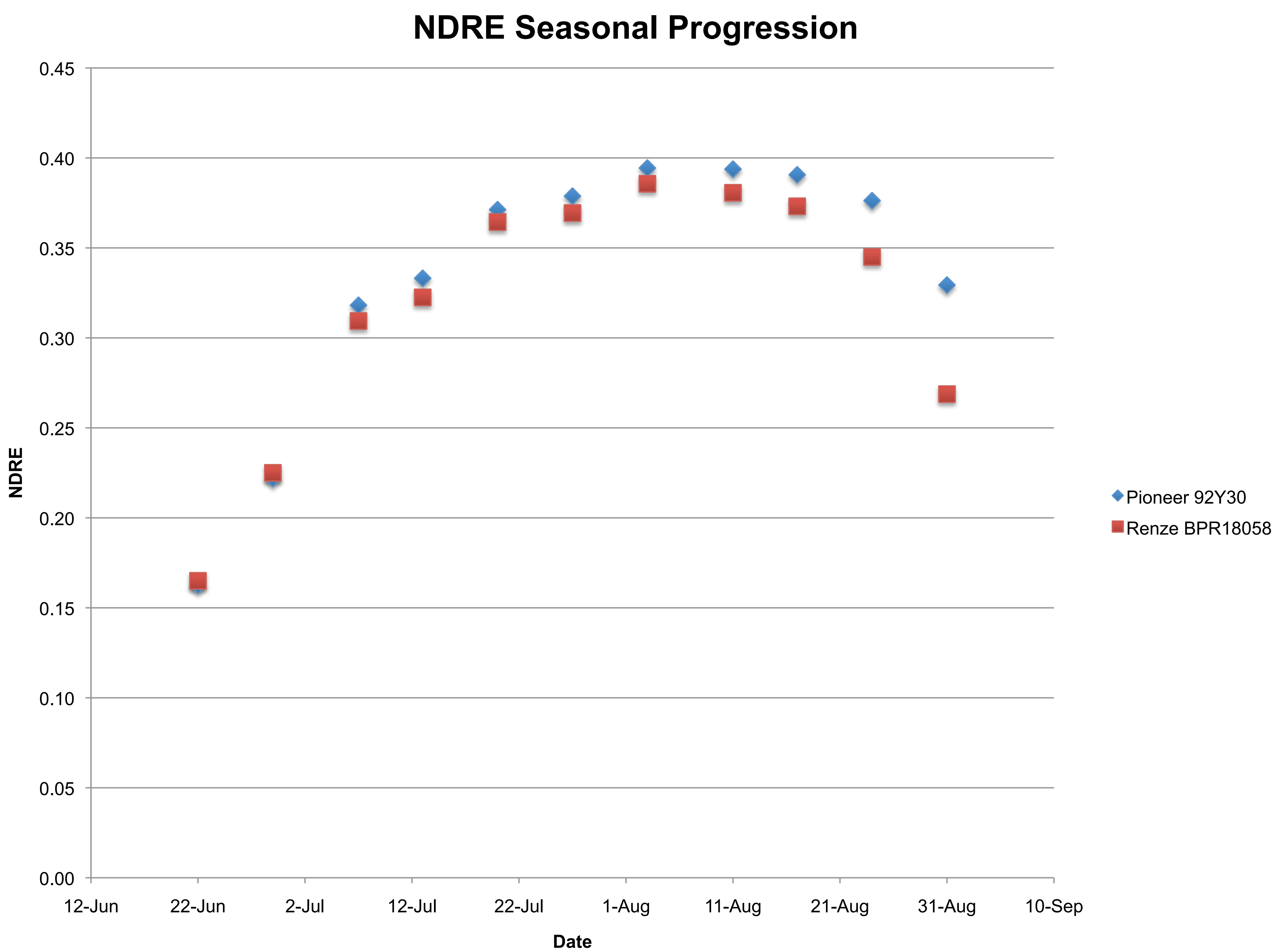
Soybean Yield and WUE in RILs

Ril FxH 62	Closed circuits drip irrigation system		slope 0 %	No of Replications =3
Irrig Sys. Design	No. of Rep.	L=40 m Yield kg/ha	L=60 m Yield kg/ha	L=80 m Yield kg/ha
CM1DIS	R1	4872.24	4768.86	4652.12
	R2	4893.21	4348.67	4423.38
	R3	4926.61	4783.58	4352.46
	Mean	**4897.35**	**4633.70**	**4475.98**
Water appl. (m3/ha)		**7638.29**	**10382.71**	**13782.14**
WUE (Kg/m3)		**0.64**	**0.45**	**0.32**

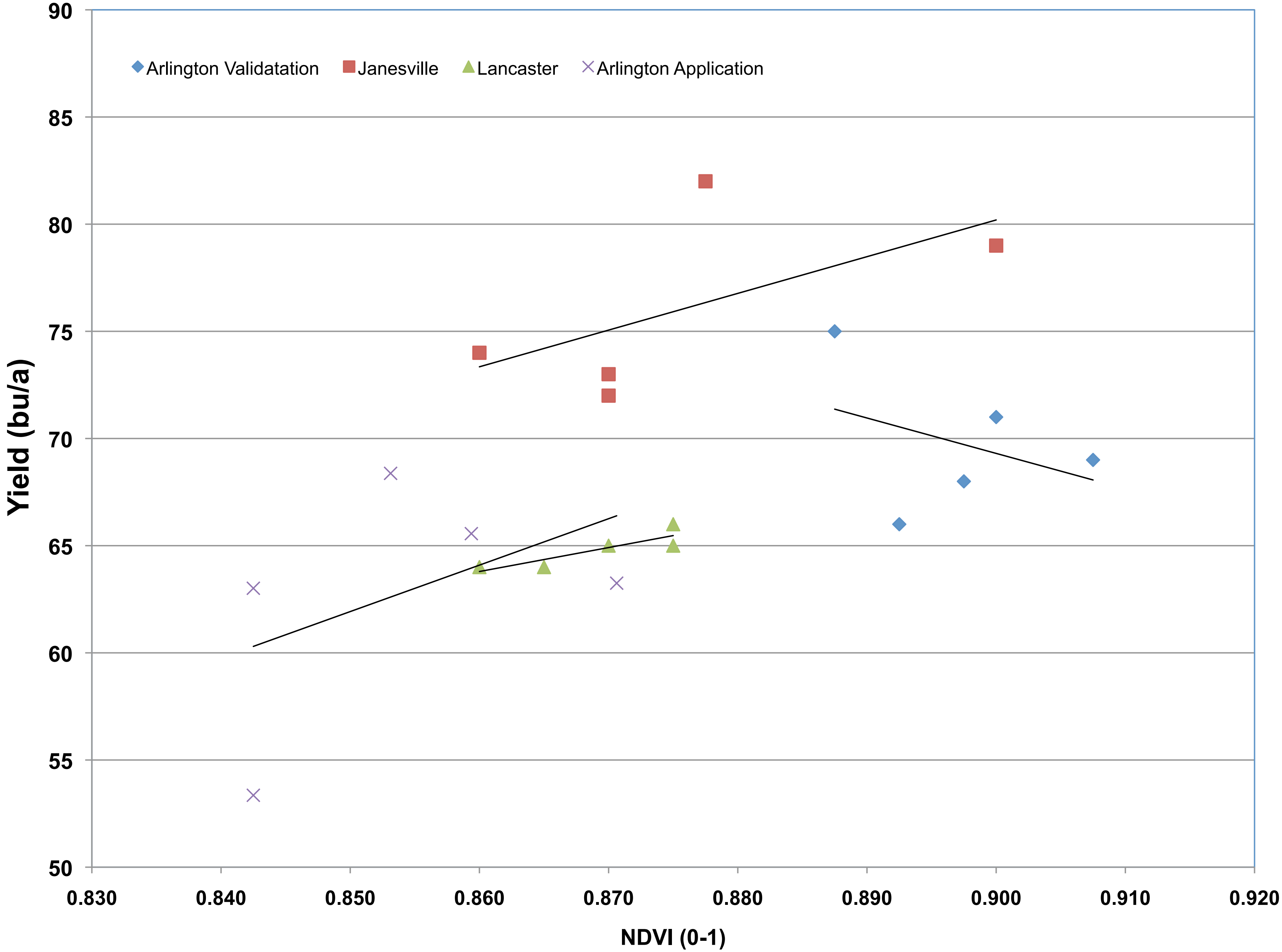
Ril ExF 75	Closed circuits drip irrigation systems		slope 0 %	No of Replications =3
Irrig Sys. Design		L=40 m Yield kg/ha	L=60 m Yield kg/ha	L=80 m Yield kg/ha
CM1DIS	R1	4756.35	4536.42	4358.93
	R2	4659.38	4489.61	4289.59
	R3	4724.28	4534.14	4175.81
	Mean	**4713.34**	**4520.06**	**4274.78**
Water appl. (m3/ha)		**7638.29**	**10382.71**	**13782.14**
WUE (Kg/m3)		**0.62**	**0.44**	**0.31**



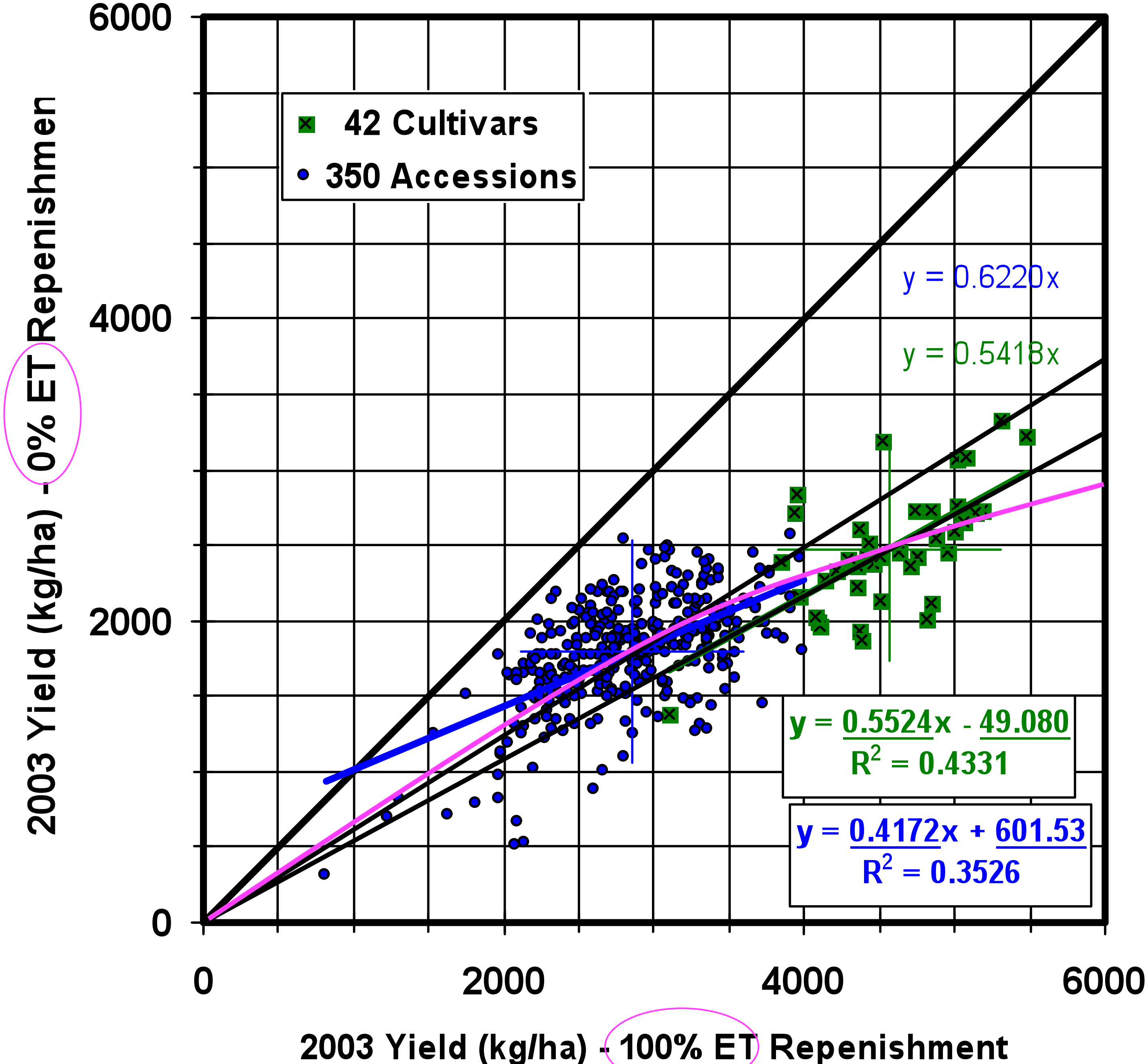
Irrigation Effects on Seasonal NDVI Progression
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
NDVI
12-Jun
22-Jun
2-Jul
12-Jul
22-Jul
1-Aug
11-Aug
21-Aug
31-Aug
10-Sep
date
None
Irrigated



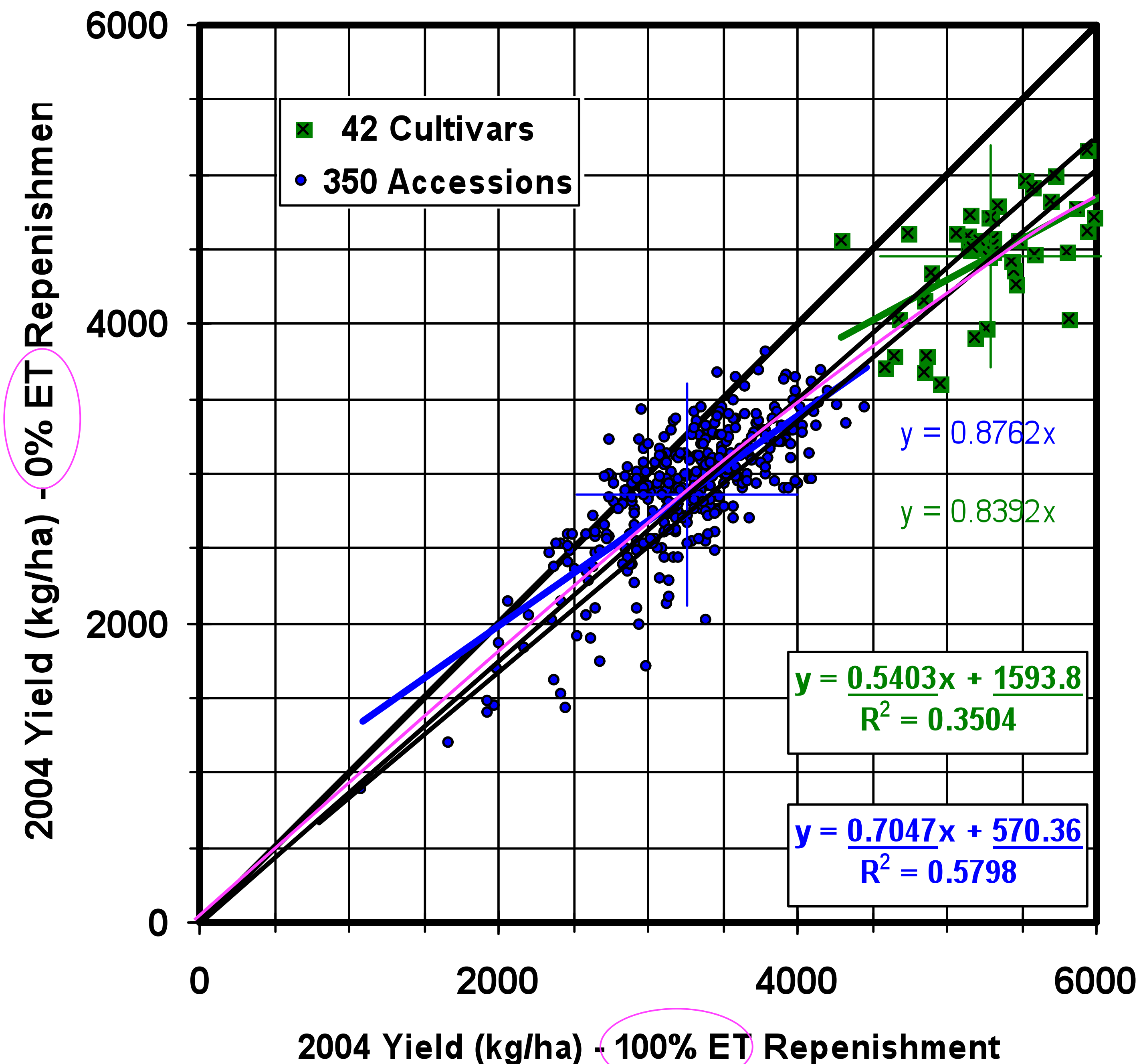
NDRE Seasonal Progression
NDRE
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
Date
12-Jun
22-Jun
2-Jul
12-Jul
22-Jul
1-Aug
11-Aug
21-Aug
31-Aug
10-Sep
Pioneer 92Y30
Renze BPR18058



Arlington Validatation
Janesville
Lancaster
Arlington Application
Yield (bu/a)
90
85
80
75
70
65
60
55
50
0.830
0.840
0.850
0.860
0.870
0.880
0.890
0.900
0.910
0.920
NDVI (0-1)



42 Cultivars
350 Accessions
y = 0.6220x
y = 0.5418x
y = 0.5524x - 49.080
R^2 = 0.4331
y = 0.4172x + 601.53
R^2 = 0.3526
0
2000
4000
6000
2003 Yield (kg/ha) - 0% ET Repenishmen
2003 Yield (kg/ha) - 100% ET Repenishment

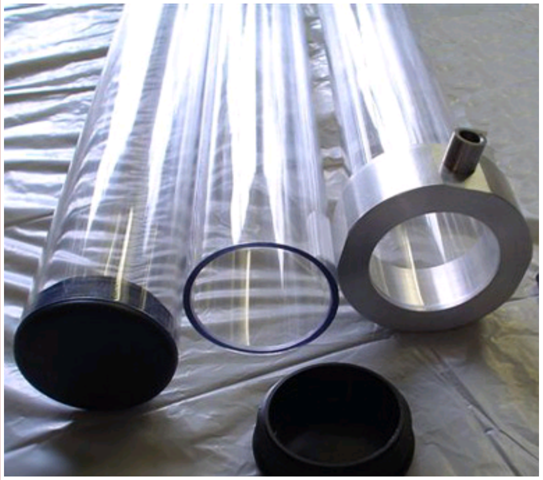


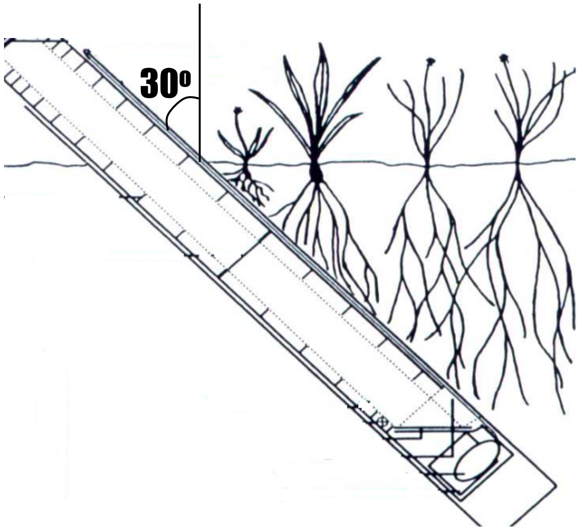
6000
4000
2000
0
0
2000
4000
6000
42 Cultivars
350 Accessions
y = 0.8762x
y = 0.8392x
y = 0.5403x + 1593.8
R2 = 0.3504
y = 0.7047x + 570.36
R2 = 0.5798
2004 Yield (kg/ha) - 0% ET Repenishmen
2004 Yield (kg/ha) - 100% ET Repenishment

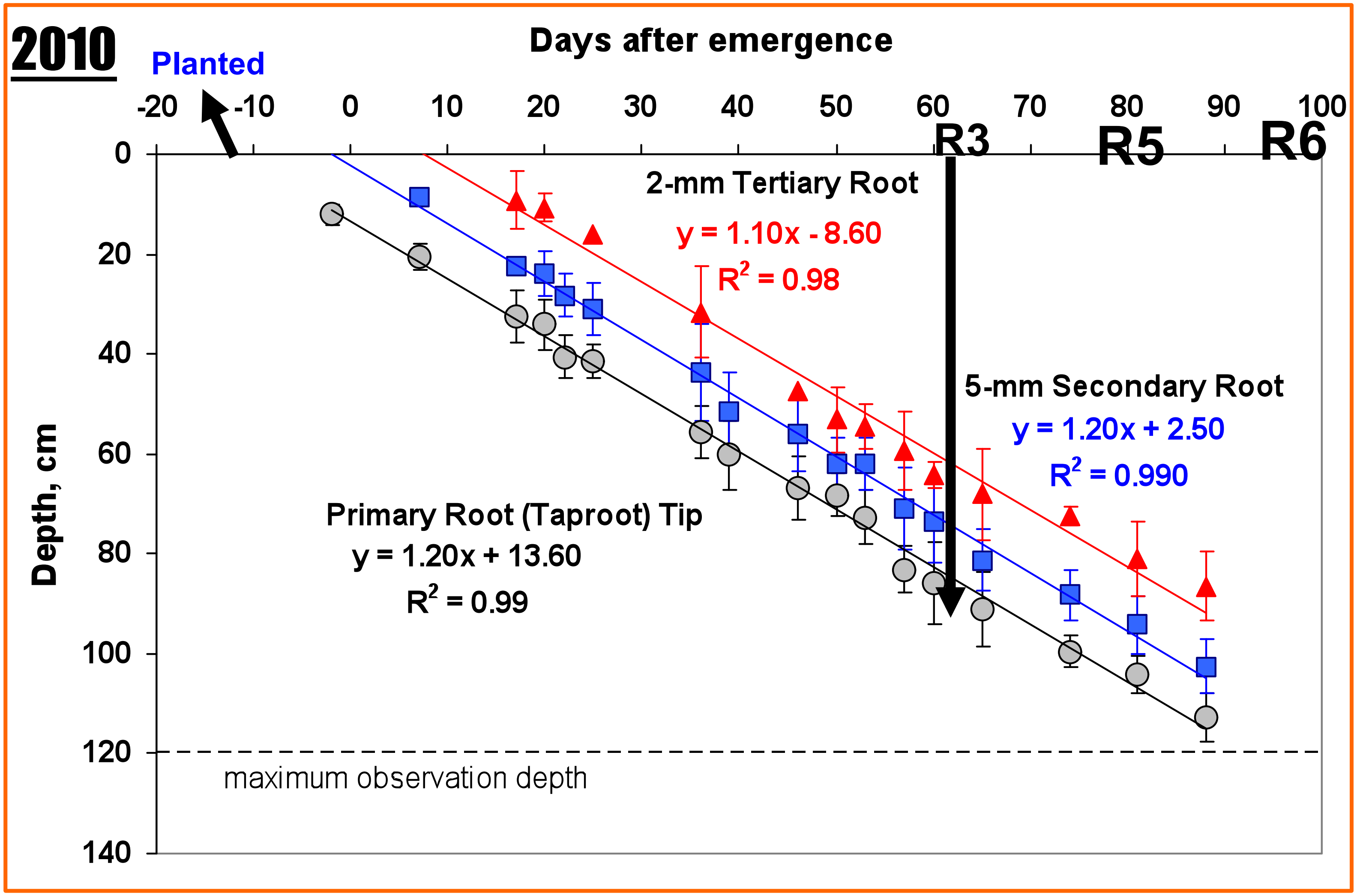
Approach

Minirhizotrone Method

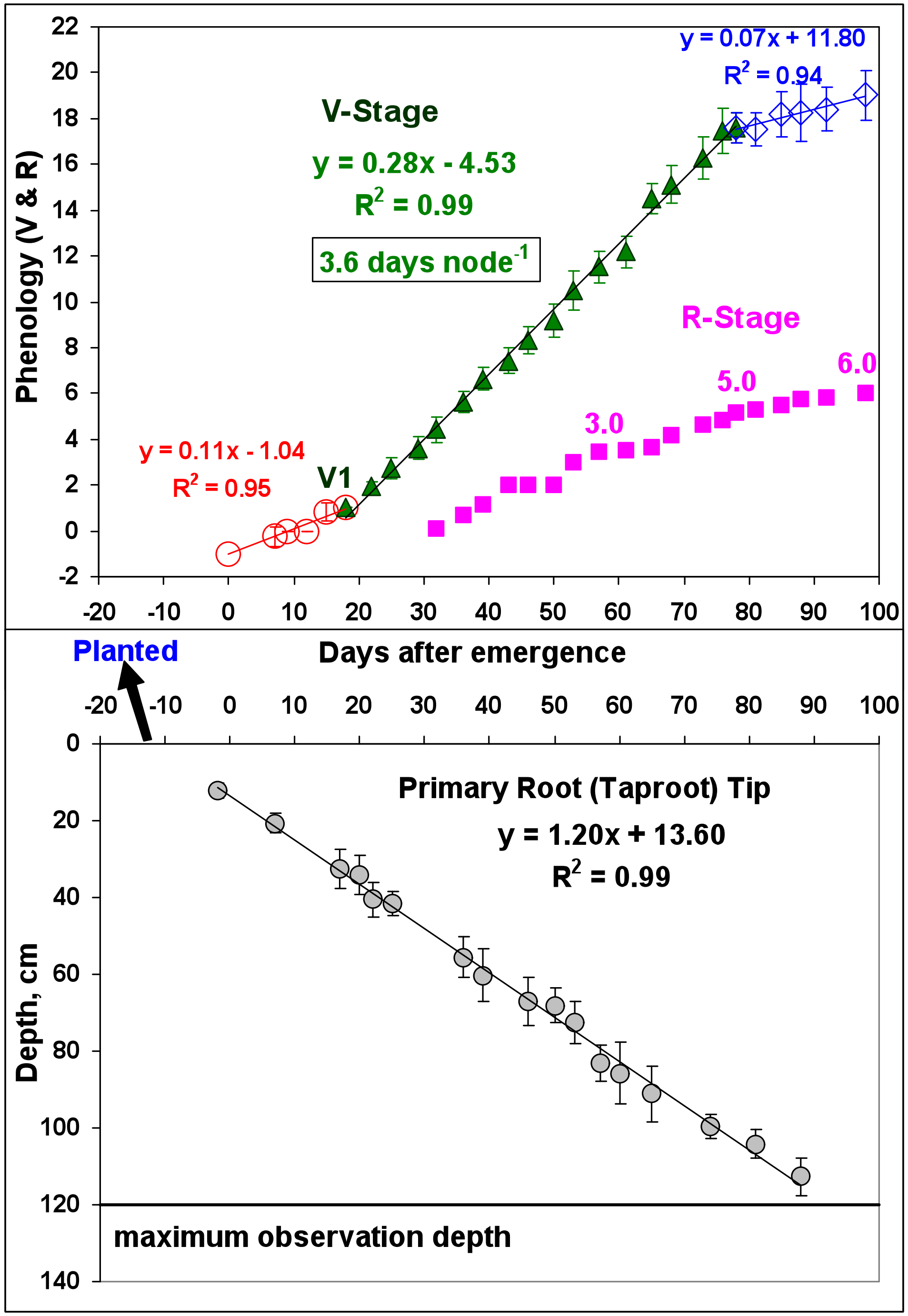
A set of minirhizotrone set-up consisting of acrylic tubes were placed into the soil to monitor root development at incremental depths.







CI-600: CID-Technology



V-Stage
y = 0.28x - 4.53
R2 = 0.99
3.6 days node-1
y = 0.07x + 11.80
R2 = 0.94
R-Stage
3.0
5.0
6.0
y = 0.11x - 1.04
R2 = 0.95
V1
Phenology (V & R)
Days after emergence
Planted
Primary Root (Taproot) Tip
y = 1.20x + 13.60
R2 = 0.99
maximum observation depth
Depth, cm

Approach

Site: <u>Lincoln, NE</u> **Variety:** <u>P93M11</u>, **Density of 20 plants / m of row, in-rows spaced 76.2 cm apart.**

1.6 m long inserted 1.2 m deep with hydraulic proble at a 30 degree angle from vertical

Water Depletion Sensors 15, 30, 45, 60, 75, 90, 105, 120 cm depths

	2009	2010
Planted:	May 1, 2009	April 28, 2010
No. of Tubes:	15	18
Sets of Sensors:	2	6
Software:	Rootfly	UTHCSA Image Tool

Approach

Supplemental Root Examination

Using a back hoe, shovel, knife and measuring tapes