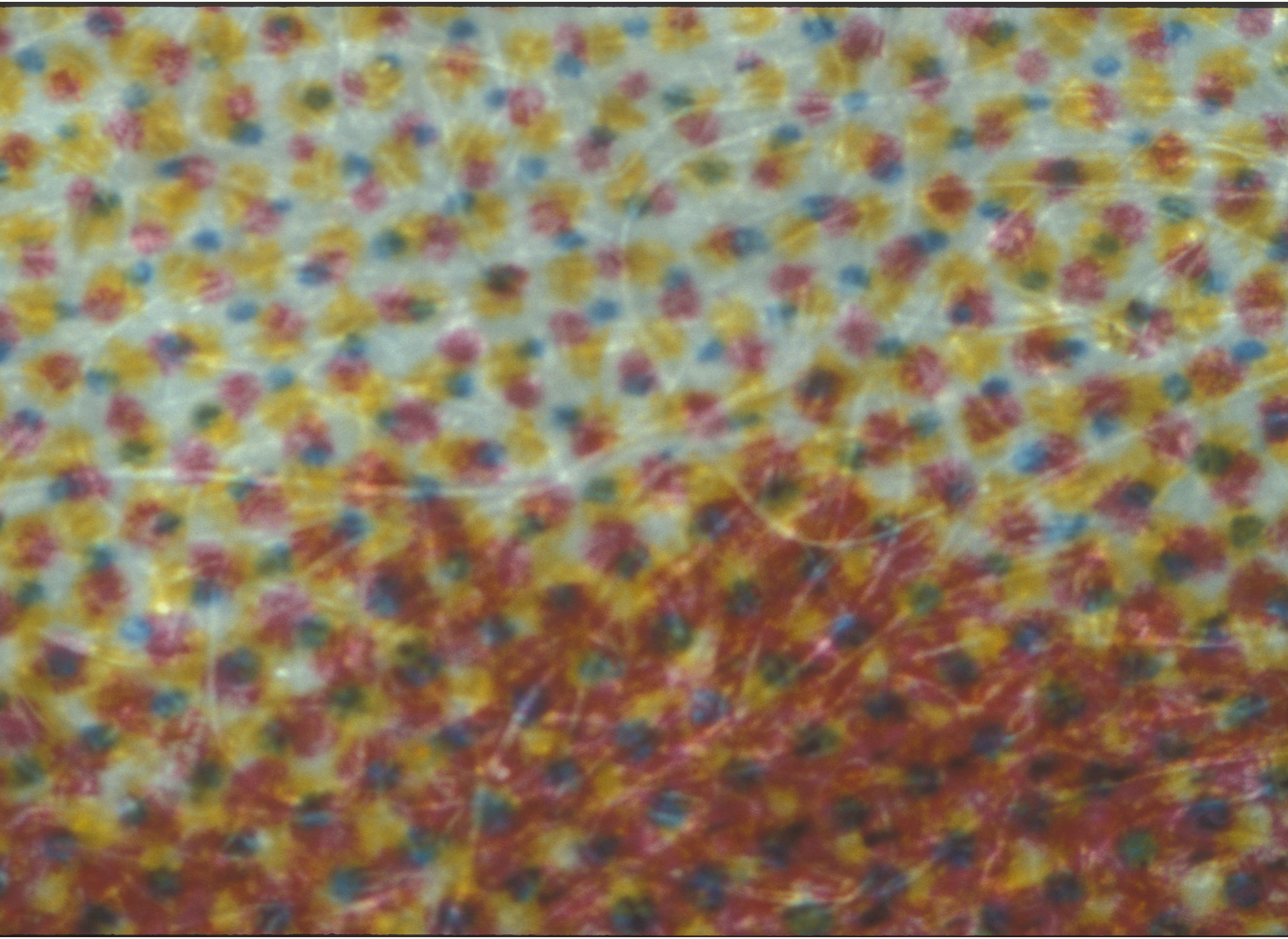
Bottom – Up Approach to Increase Yield under Water-Deficit?

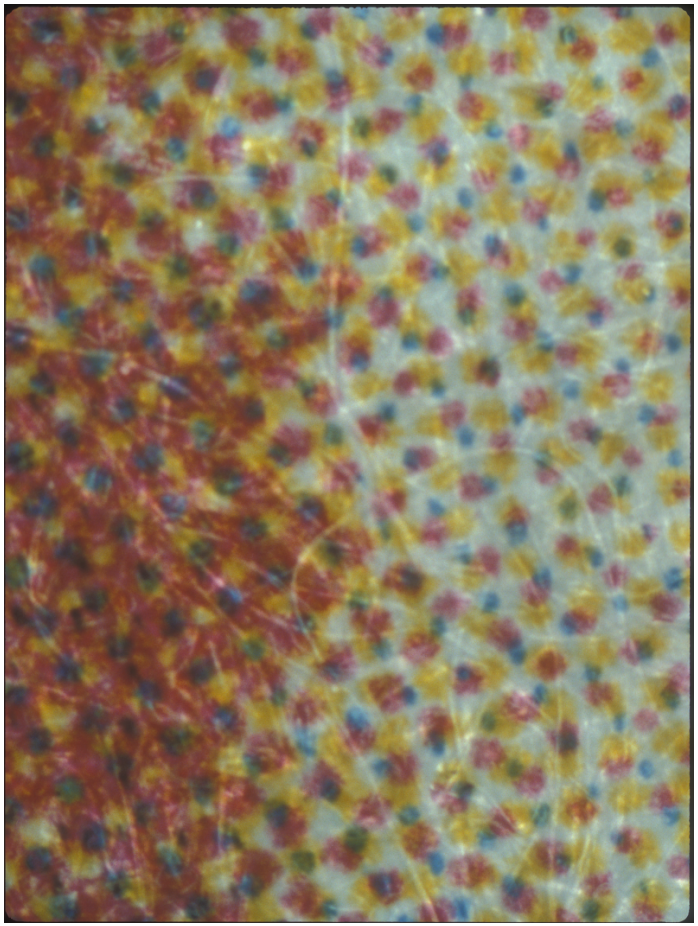


Essence of photo is not in the dots.

"Yield" of photo is holistic sensory response of viewer.

- **Shapes**
- **Smells**
- **Tastes**

“Bottom-Up” Limitations



- Pathway redundancies and physiological homeostasis for many traits
- Yield impact severely dampened at higher levels of complexity

Glyphosate and Bt transgenics not relevant example for improving abiotic environmental stress

- Success based on single chemicals alien to plants.
- Quite different to alter performance of entire pathways and interacting pathways.

Disconnects in Drought Research to Develop Improved Cultivars

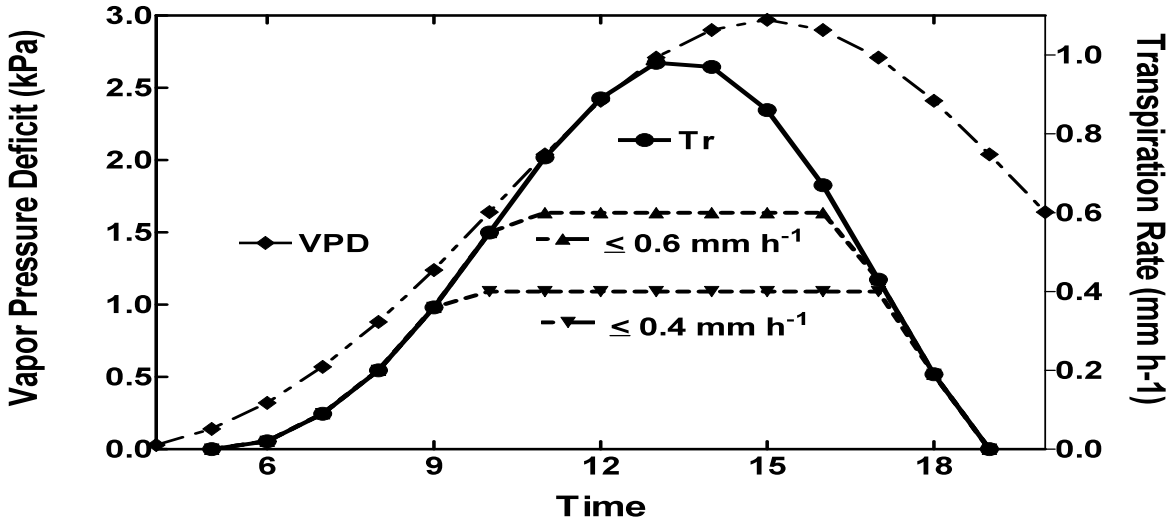
- **Drought survival is generally irrelevant.**
- **Osmotic adjustment not beneficial.**
- **Slow growth unacceptable**
- **Experimental difficulties:**
  - **Inappropriate rooting media**
  - **Rapid imposition of stress**

Is “Top Down” Approach Viable to Increase Drought Tolerance?

Finally, Successes in Using "Top Down" Approach for Physiological Traits

- Heat Stress in cowpea seed set
- Water-use efficiency in wheat
- Water-deficit tolerance of N_2 fixation in soybean
- Photoperiod insensitivity in bahiagrass
- ➢ Maximum transpiration rate in soybean

Hypothesis to Conserve Water: Limited Hydraulic Conductance



Challenges for the "Top Down" Approach

1. Early assessment of trait benefit.
2. Ability to phenotype for trait.
3. Breeding for trait and improved yield.
4. Cultivar selection and marketing

1. Early assessment of trait benefit.

- **Experiments to mimic anticipated genetic modification.**

- **Simulation studies to assess yield response across environments and seasons.**

Simulations using Simple, Mechanistic Soybean Growth Model

- Growth function of RUE and radiation interception
- Transpiration function of growth and water use efficiency
- Growth and Development moderated by Fraction Transpirable Soil Water

GIS Data Base

(Pioneer Hi-Bred International, Inc.)

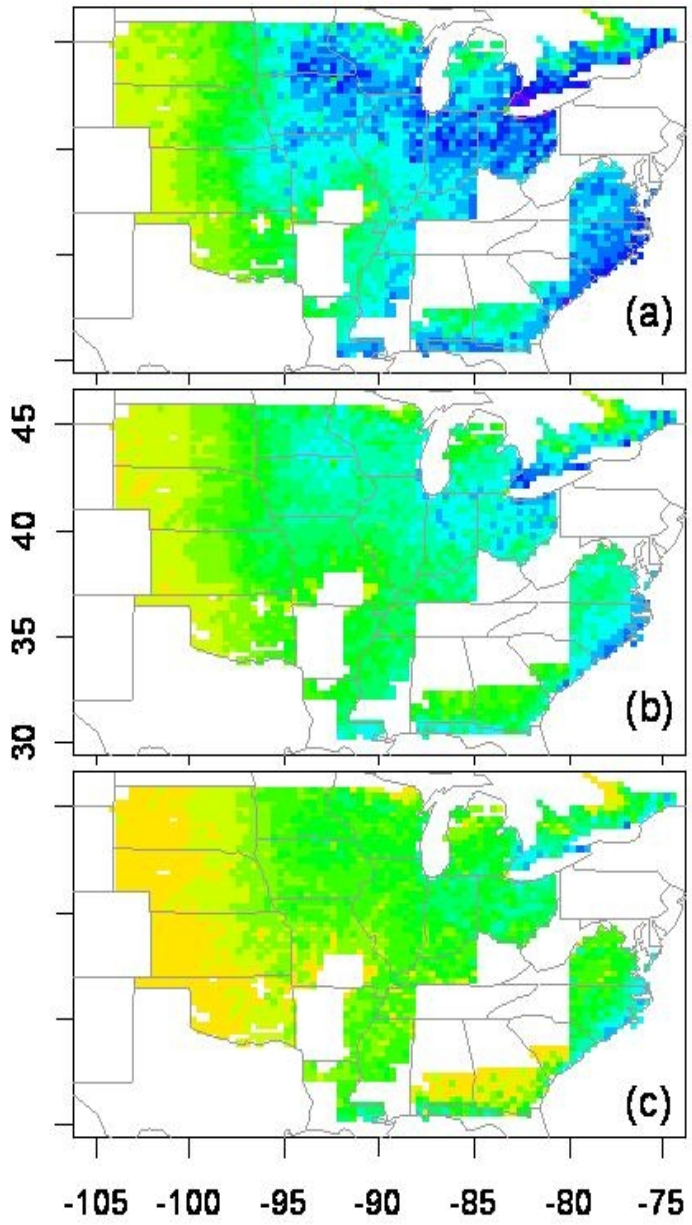
- **30 x 30 km grid system for U.S cropping areas (2655 grids for soybean)**
- **Weather (approx. 50 years for most grids)**
- **Soil**
- **Soybean Maturity Group**
- **Sowing Date**

Each test required >130,000 model runs

75%
(wet)

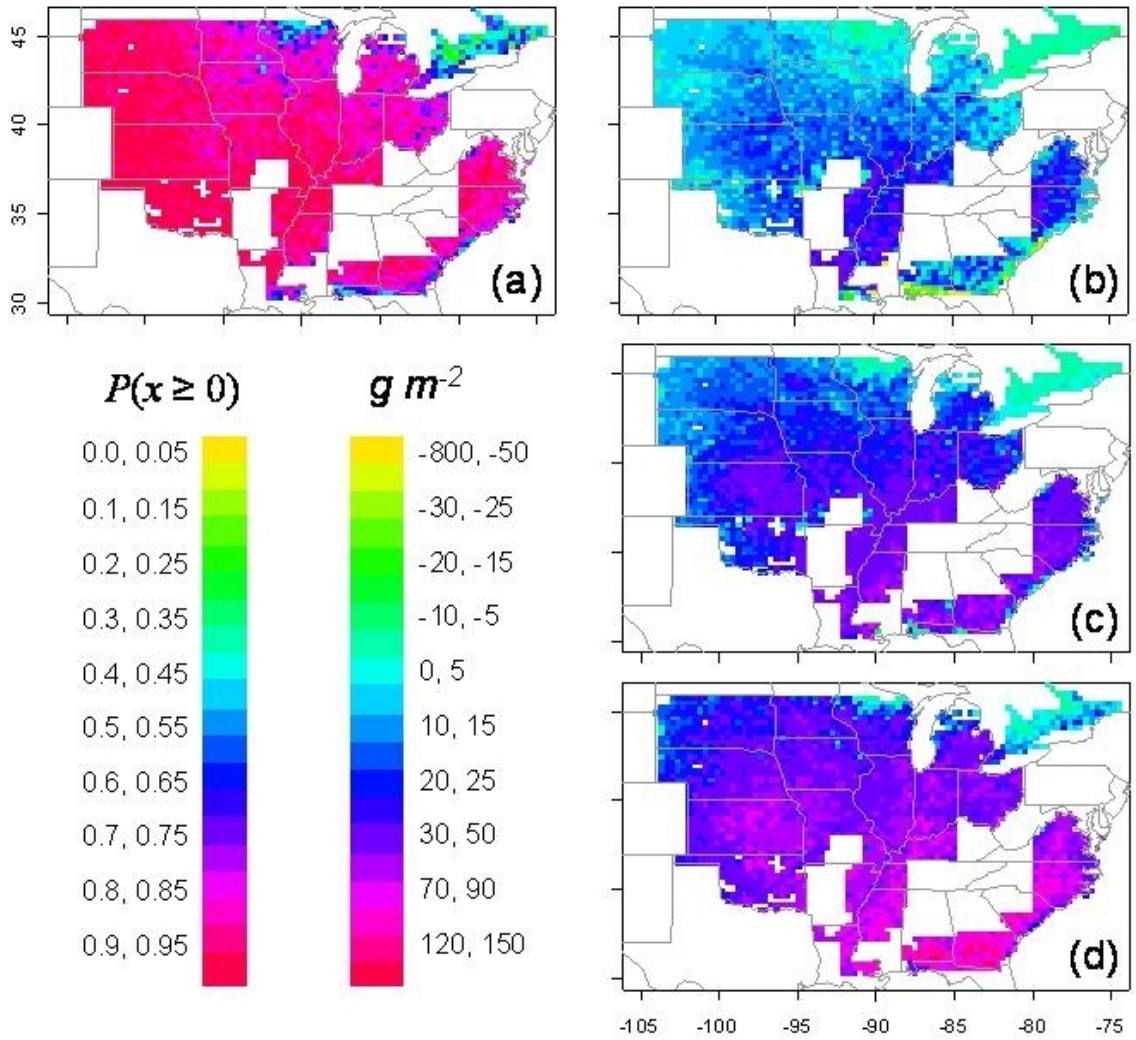
Median

25%
(Dry)



Soybean Yield
(g dry m^{-2})

Simulated Yield Response to Maximum Transpiration Rate



75%

Median

25%

2. Ability to phenotype for trait

Miflin (2000): "Undue or sole emphasis on genomics will lead to an ever increasing gap between the genetic information acquired and an understanding of the phenotype, a 'phenotype gap' ".

Major Challenge: Develop physiological phenotyping tools.

Multi-level Physiological Phenotyping

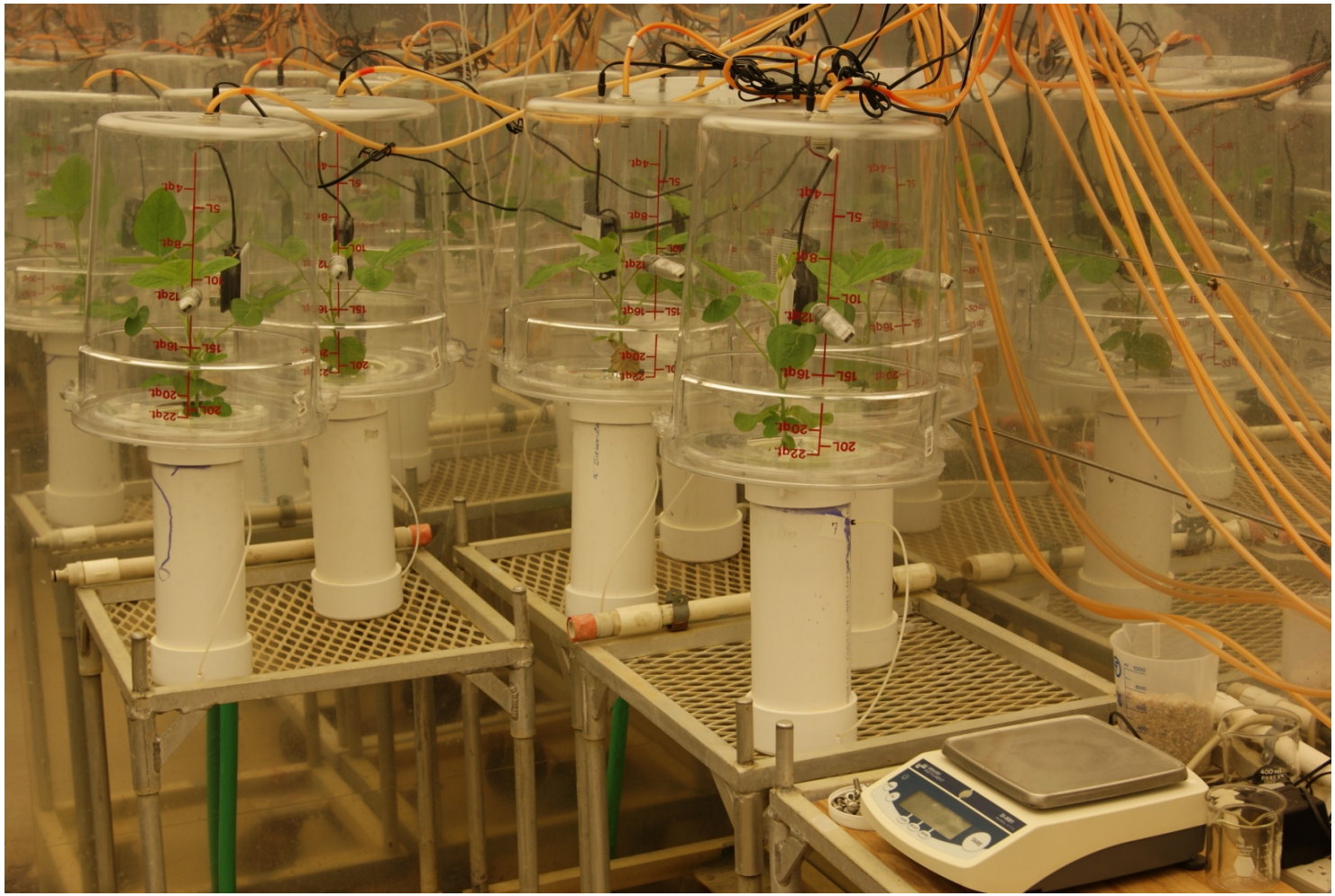
- Crude phenotyping, but capability of examining many genotypes.

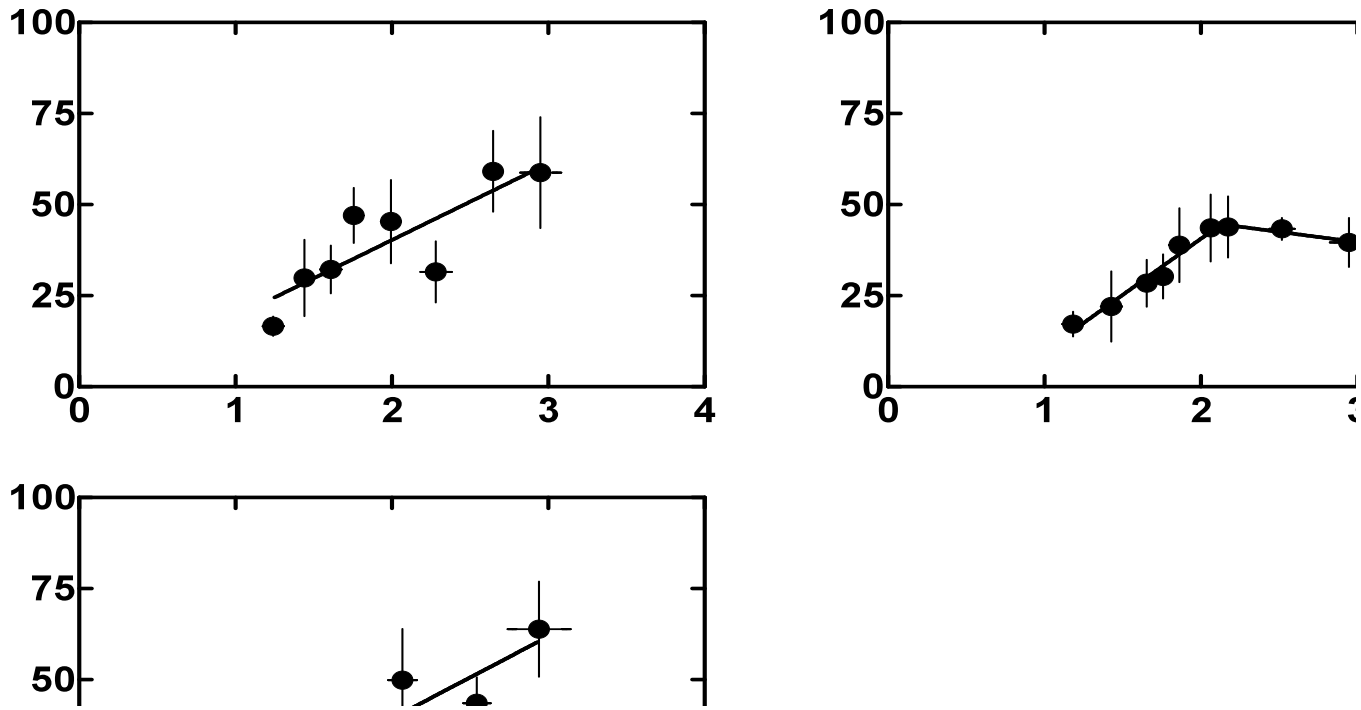
- Intermediate level in sophistication and capability in genotype numbers.

- Refined physiological measurement.

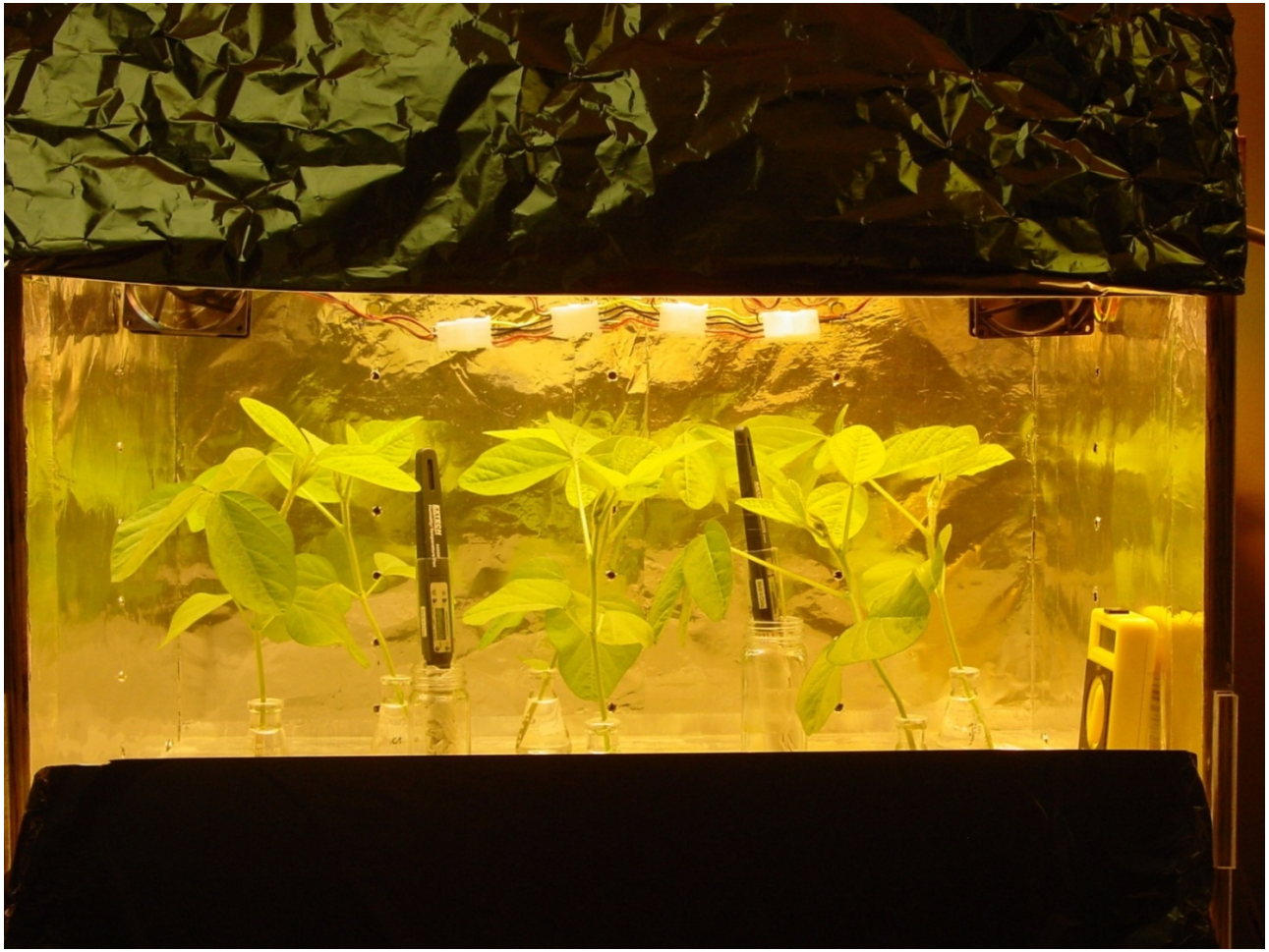
Crude Phenotype: Initial-Visual Phenotype

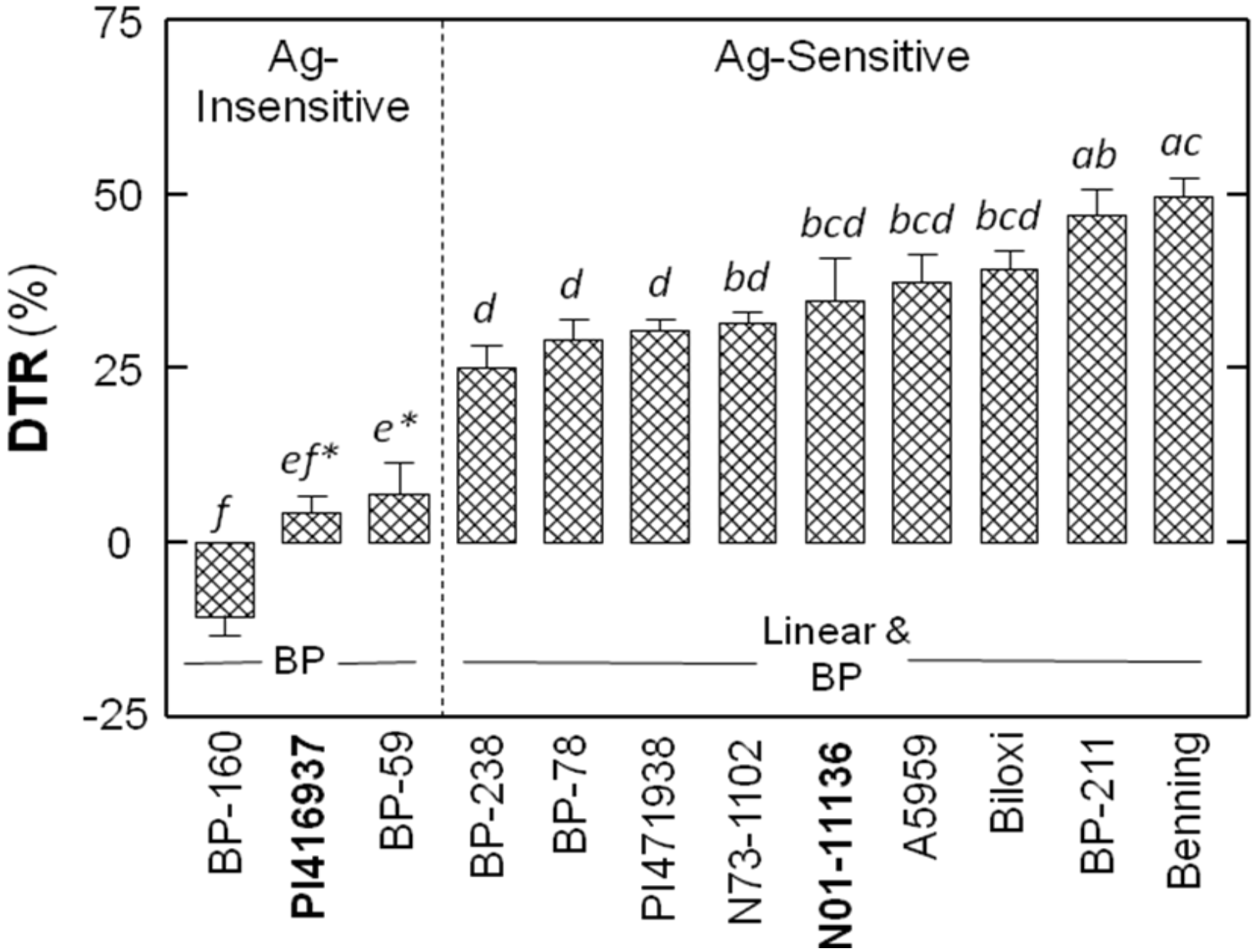
Advanced Phenotyping: Measure Transpiration Rate




100
75
50
25
0
0
1
2
3
4
100
75
50
25
0
0
1
2
100
75
50

Intermediate Phenotyping: Exposure to Ag^{+} as Aquaporin Inhibitor




75
50
25
0
-25
DTR (%)
Ag-Insensitive
Ag-Sensitive
f
ef*
e*
d
d
d
bd
bcd
bcd
bcd
ab
ac
BP
Linear & BP
BP-160
PI416937
BP-59
BP-238
BP-78
PI471938
N73-1102
N01-11136
A5959
Biloxi
BP-211
Benning

QTL for Ag^{+} Response

PI416937 x Benning

	Satt 339	Satt 462
Phenotypic variation	22.0	14.5
Chromosome	Gm03	Gm19
R2	6.7**	4.7*
LOD score	3.7	3.1

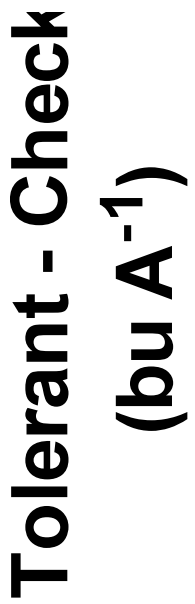
3. Breeding for water conservation (Goal)

- **Parental Selection: Use all three levels of phenotyping**
- **During Genotype Selection: Phenotype by silver response (including marker)**
- **Confirmation of Superior Genotype: Measurement of VPD response**

4. Cultivar selection and marketing

- **Mean yield likely not sufficient for stress trait.**
- **Evidence of yield response across environments.**

Maximum Transpiration Trait



T. Carter, ARS-USDA, Raleigh, NC

Information for Risk Assessment by Farmers

- Probability of yield gain by location/environment
- Anticipated amount of yield change

Challenges for the "Top Down" Approach

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