

# Drought Breeding in the Midwest

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- ❏ Soybeans subjected to water stress every year somewhere in U.S.
- ❏ Drought stress occurs mainly during flowering and pod-fill (July, August, September).
- ❏ However time of stress and severity of stress varies considerably.
- ❏ As a result a considerable portion of year to year variation in yield is associated with rainfall.



# Drought

- ✿ **“A complex and poorly understood phenomenon that affects more people than any other natural disaster.”** (Wilhite, 1993)
- ✿ **A sustained period of time without significant rainfall.** (Linsley et al., 1959)
- ✿ **When such a shortage of rainfall begins to limit plant growth and development** (Quizenberry, 1982)

# Responses to Drought

## ■ Yield Reduction

- By affecting characteristics associated with yield

## ■ Morphological Responses

- Reduction in leaf water potential, loss of turgor  
(Pandey et al., 1984)
- Increase in canopy-air temperature differences  
(Boyer, 1970, Brady et al., 1975)
- Leaf orientation, leaf loss  
(Meyer and Walker, 1981; Kramer, 1980)
- Increase in lipids  
(Clark and Levitt, 1956; Myers et al., 1986)



# Responses to Drought

## ■ Morphological Responses (cont'd)

### ■ Reduction in stem length

(Bousslama and Schapaugh, 1984)

### ■ Variation in growth rates and depth of rooting

(Taylor et al., 1978)

## ■ Physiological Responses

### ■ Altering of stomatal behavior

### ■ Osmotic adjustment



# Responses to Drought

## 🌿 Biochemical Responses

### 🌿 Decrease in nitrogenase activity

(Albrecht et al., 1984)

### 🌿 Petiole Ureide concentration

### 🌿 Changes in hormone concentrations

- 🌿 ABA

- 🌿 Cytokinin

- 🌿 Ethylene

## 🌿 Type and degree of response dependent on the timing and severity of drought



**What does  
Drought look like  
in the field?**



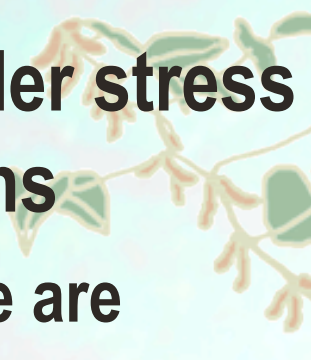








# Screening for Tolerance

- **Select for high yield in ideal environments**
  - **Select for high yield under stress conditions**
    - **Selections specific to stress environments**
  - **Select for low reduction of yield under stress conditions relative to ideal conditions**
    - **Assumes yield and drought tolerance are separate, heritable characters**
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## **Drought Research Activities - MN**

- **Screening of PI's for drought tolerance.**
- **Rescreening of PI's and lines.**
- **Drought tolerance of selected commercial cultivars.**
- **Study of crosses with southern material.**



## Our Experience

- **Begin when some (20 - 30%) of plants show wilting during warmest time of the day.**
- **Take ratings when differences are most apparent - from about 10:00 am to 2:00 pm.**
- **Observe all plots from same perspective.**
- **Avoid rating when winds strong or in gusts.**
- **Rate every 3-5 days.**



# Canopy Wilting Rating Scale

- 0 - no wilting**
- 1 - slight wilting-wilting on a few plants**
- 2 - some wilting-half or more of plants wilted**
- 3 - significant wilting-most plants wilted**
- 4 - severe wilting-leaf scorching or firing on many plants**
- 5 - completely wilted-yellow, brown or dead leaves on many plants**



# Screening PI's

- 150 PI's screened under dry land conditions.
- Wilting scores and yield:
  - Yields very low (700 kg/ha)
  - Four wilting scores taken
- Large range of materials
- Best PI's were rescreened in irrigated and non-irrigated.
- Some PI's of interest:
  - PI 612717, PI 593939, PI 578507, PI 578428A,
  - PI 612713A, PI 578474



## Rescreening of PI's

- Lines grown dry land and under irrigation.
- Maturities similar in both environments.
- Dry land yields very low (700 kg/ha) irrigated 3080 kg/ha
- Several lines had above average yields and low wilting scores:  
PI 437285, PI 464923, PI 184044, PI 248399
- Protein higher in dryland 38.4% vs 37.7%  
Oil lower in dryland 16.6% vs 18.0%







## Midwest Breeding Efforts

- Elite cultivars from maturity group O and I were crossed with drought tolerant southern material derived from PI 416937, PI 471938, and NTCPR94-5157
- Segregants that matured in Minnesota and Nebraska were selected.
- Wilting scores were taken.
- In MN yield trials lines with high yield and low wilting scores compared to checks were identified.

# Crosses with Southern Material (Thesis Study)

- PI 471938 x MN0302 (Nepal)
  - N94-7784 x MN0302 (Egypt)
  - NTCPR94-5157 x MN0302 (US)
  - M96-6809 x MN0302 (China, PI416937)
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- 66 lines/population, 3 reps
  - Irrigated and non-irrigated Becker
  - Non-irrigated Rosemount
  - Wilting scores: 5 times Becker, 3 times Rosemount





# Observations

- Lines blocked by maturity (range mid 0 - late II).
- In general (within maturities) lines showed similar responses at Becker and Rosemount for wilting (range 0.56 - 0.89).
- 5 - 10% of lines were among the best in all three environments.



# Trait Evaluation

- ✘ Lines matured over approximately 5 weeks
- ✘ Significant ( $p < .05$ ) correlations were observed between traits and maturity date
- ✘ Lines were grouped by maturity dates into 5 maturity classes, and analyses were done within these maturity classes
- ✘ Lines observed as a significant ( $p < .05$ ) source of variation for yield, RYR, wilt score, and height




# Wilting

- Significant correlations of Becker wilt scores with RYR at Becker

	Maturity Class				
	1	2	3	4	5
Date 1	.825	.517*	.314*	.258*	.081
Date 2	.914*	.624*	.418*	.122	.006
Date 3	.878*	.611*	.408*	.226*	.131
Date 4	.683	.509*	.642*	.172	.080
Date 5	.920*	.111	.516**	.285*	.017
Date Avg.	.890*	.611*	.488*	.257*	.082

\*,\*\* Indicates significance at  $p=.05$ , and highly significant, respectively

# Cross Evaluation

- ✿ Erratic nature of drought in MN dictates that crosses be evaluated on the basis of yield as well as RYR
  - ✿ Crosses observed as significant sources of variation for yield at all environments except one, and for RYR at Becker ( $p=.05$ )
  - ✿ Analysis of wilting scores did not find crosses to be a significant source of variation ( $p=.05$ )
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## Protein and Oil

- Environment significant ( $p < .01$ ) for protein and for oil
- Protein higher and oil lower under stress
- Environment non significant for total protein + oil
- Lines significant for all three traits ( $p < .01$ )
- No correlations with drought tolerance traits

# Conclusions

- **Wilting should be a useful indicator of drought tolerance. Need multiple environments**
- **Plant height doubtful, but needs more testing**
- **Cross 2 exhibited most tolerance**  
**Crosses 1 & 3 may be useful**  
**Cross 4 showed least tolerance**

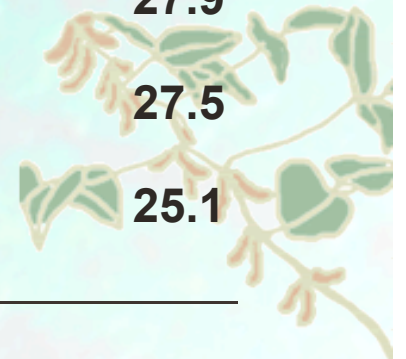


# 2010 Becker and Rosemount

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<b>WILTING</b>			
<b>LINE</b>	<b>PEDIGREE</b>	<b>SCORE</b>	<b>YIELD</b>
M05-243040	MN1003SP x PI 578425	1.5	34.3
M05-242024	Parker x PI 592960	1.5	31.8
M06-358091	PI 437161 x M94-275024	1.5	28.9
Hendricks	M74-349 x M77-210	2.5	27.9
M06-358117	PI 437161 x M94-275024	1.5	27.5
Sheyenne	P9071 x A96 492041	3.0	25.1

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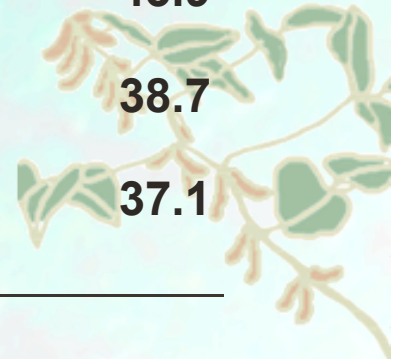


# 2010 Becker and Lamberton

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WILTING			
<u>LINE</u>	<u>PEDIGREE</u>	<u>SCORE</u>	<u>YIELD</u>
MTC00-112-412	N94-7784 x MN0302	1.5	46.1
M05-243012	MN1003SP x PI 578425	1.5	44.7
M05-248003	MT600-113-54 x MN1003SP	1.5	43.9
Sheyenne	P9071 x M77-210	3.0	43.9
Hendricks	M74-249 x M77-210	2.5	38.7
M05-248081	MTC00-113-54 x MN1003SP	1.0	37.1

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## 2010 Preliminary Tests

**Test 1:** 9 of 20 wilting score 1.5 or better  
best checks – 2.5 Hendricks  
– 3.0 Sheyenne  
6 of 9 better in yield than Sheyenne

**Test 2:** 17 of 44 wilting score 1.5 or better  
best checks – 2.5 Hendricks  
– 3.5 MN1410  
7 of 17 better yield than MN1410



## Final Comments

- **Selection for genotypes with low wilting scores effective**
- **Crossing with Southern low wilting types successful in transferring Trait.**
- **Breeding lines with low wilting scores and competitive yield are promising**



**Thank  
You!**

