

Drought Breeding in the Midwest

J.H. Orf

Department of Agronomy and Plant Genetics
University of Minnesota

orfix001@umn.edu
www.soybeans.umn.edu

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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?**

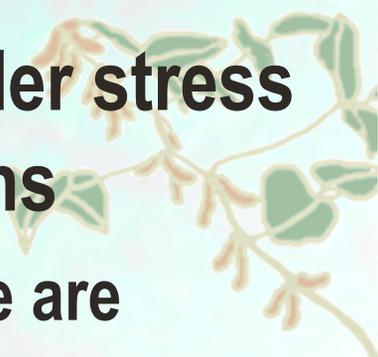








Screening for Tolerance

- **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 ($p=.05$)

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

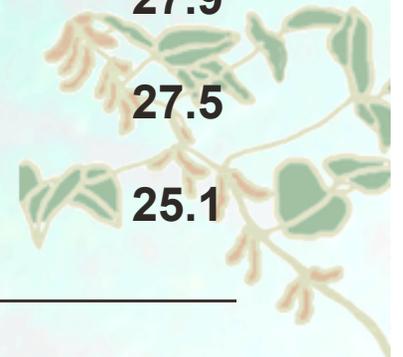
Conclusions

- **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



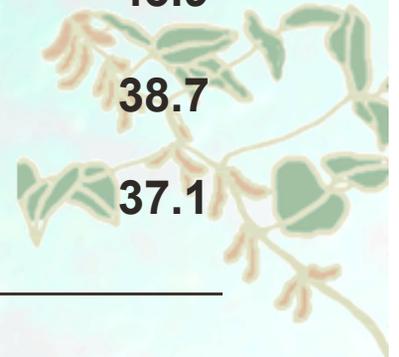
2010 Becker and Rosemount

WILTING			
LINE	PEDIGREE	SCORE	YIELD
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



2010 Becker and Lamberton

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



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!**

