Integrating Germplasm Evaluation, High-Throughput Phenotyping and Breeding to Improve Soybean

Soybean Expo
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Integrating Germplasm Evaluation, High-Throughput Phenotyping and Breeding to Improve Soybean New Germplasm

- Variety Development
  - Yield
  - Composition
  - Disease resistance
- Selection Techniques
  - Genomics
  - HTP
Soybean Yield
Kansas

Bushels per Acre


Yield Linear (Yield)
New Germplasm

Impacts of Genetic Bottlenecks on Soybean Diversity

Fig. 1. Genetic bottlenecks imposed on crop plants during domestication and through modern plant-breeding practices. Boxes represent allelic variations of genes originally found in the wild, but gradually lost through domestication and breeding. Such lost alleles can be recovered only by going back to the wild ancestors of our crop species.
Table 3. Major contributing U.S. soybean ancestors or first progeny selected for diversity analysis and the percentage of genes theoretically contributed to U.S. cultivars†.

<table>
<thead>
<tr>
<th>Ancestor</th>
<th>All cultivars</th>
<th>Northern cultivars</th>
<th>Southern cultivars</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lincoln</td>
<td>17.9</td>
<td>24.2</td>
<td>2.9</td>
<td></td>
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<tr>
<td>Mandarin (Ottawa)</td>
<td>12.2</td>
<td>17.2</td>
<td>0.0</td>
<td>China</td>
</tr>
<tr>
<td>CNS</td>
<td>9.4</td>
<td>3.0</td>
<td>24.7</td>
<td>China</td>
</tr>
<tr>
<td>Richland</td>
<td>8.2</td>
<td>11.3</td>
<td>0.8</td>
<td>China</td>
</tr>
<tr>
<td>S-100</td>
<td>7.5</td>
<td>1.8</td>
<td>21.3</td>
<td>China</td>
</tr>
<tr>
<td>Ogden</td>
<td>4.9</td>
<td>4.3</td>
<td>6.4</td>
<td></td>
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<tr>
<td>A.K. (Harrow)</td>
<td>4.9</td>
<td>6.9</td>
<td>0.0</td>
<td>China</td>
</tr>
<tr>
<td>Dunfield</td>
<td>3.6</td>
<td>3.5</td>
<td>3.9</td>
<td>China</td>
</tr>
<tr>
<td>Mukden</td>
<td>3.5</td>
<td>4.9</td>
<td>0.0</td>
<td>China</td>
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<tr>
<td>Jackson</td>
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<td>10.6</td>
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<td>Illini</td>
<td>2.2</td>
<td>3.1</td>
<td>0.04</td>
<td>China</td>
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<tr>
<td>Perry</td>
<td>2.1</td>
<td>2.1</td>
<td>2.1</td>
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<tr>
<td>Roanoke</td>
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<td>0.2</td>
<td>6.5</td>
<td>China</td>
</tr>
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<td>Capital</td>
<td>1.7</td>
<td>2.4</td>
<td>0.0</td>
<td>China</td>
</tr>
<tr>
<td>Haberlandt</td>
<td>0.8</td>
<td>0.1</td>
<td>2.5</td>
<td>N. Korea</td>
</tr>
<tr>
<td>Ralson</td>
<td>0.6</td>
<td>0.1</td>
<td>1.9</td>
<td>N. Korea</td>
</tr>
<tr>
<td>Arksoy</td>
<td>0.5</td>
<td>0.04</td>
<td>1.7</td>
<td>N. Korea</td>
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<tr>
<td>Korean</td>
<td>0.5</td>
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<tr>
<td>Total</td>
<td>85.9</td>
<td>86.1</td>
<td>85.3</td>
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</table>
Table 1. Estimated number of seed bank entries worldwide for selected crops [reprinted from (8)].

<table>
<thead>
<tr>
<th>Crop</th>
<th>Entries</th>
<th>Collections of 200+</th>
<th>Percent wild species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>410,000</td>
<td>37</td>
<td>60</td>
</tr>
<tr>
<td>Rice</td>
<td>215,000</td>
<td>29</td>
<td>10</td>
</tr>
<tr>
<td>Maize</td>
<td>100,000</td>
<td>34</td>
<td>15</td>
</tr>
<tr>
<td>Soybean</td>
<td>100,000</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>Potato</td>
<td>42,000</td>
<td>28</td>
<td>40</td>
</tr>
<tr>
<td>Tomato</td>
<td>32,000</td>
<td>28</td>
<td>70</td>
</tr>
<tr>
<td>Cotton</td>
<td>30,000</td>
<td>12</td>
<td>20</td>
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</table>
Identify/Develop New Sources of “Good” Germplasm

Yield
Heat and drought stress
Composition
Disease resistance
Test: 14 Select

Bushels per acre vs Entry number.
Test: 15 SEQ

Bushels per acre vs. Entry number graph.

K-STATE
Research and Extension
Knowledge for Life
# K13-1515: Elite line with Unique Grandparent

## 2015 SCN U4

<table>
<thead>
<tr>
<th>Entry</th>
<th>Yield</th>
<th>Seed</th>
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<td></td>
<td>All</td>
<td>Infested</td>
</tr>
<tr>
<td></td>
<td>bu/a</td>
<td>rank</td>
</tr>
<tr>
<td>No. Locations</td>
<td>9</td>
<td>5</td>
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<tr>
<td>LD07-3395bf</td>
<td>53.8</td>
<td>13</td>
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<tr>
<td>K13-1515</td>
<td>57.4</td>
<td>3</td>
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<tr>
<td>Mean</td>
<td>55.2</td>
<td>53.1</td>
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<tr>
<td>LSD(.05)</td>
<td>3.4</td>
<td>5.2</td>
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<tr>
<td>C.V. %</td>
<td>11.6</td>
<td>13.5</td>
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<tr>
<td>Replications</td>
<td>25</td>
<td>13</td>
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</table>
Canopy Wilting

Fast wilting

Slow wilting
Genomic Selection

New Selection Techniques

High Throughput Phenotyping
Cellular leaf structure and its interaction with visible and infrared radiation
Variety Development

Yield
Composition
  Protein and oil
  High oleic
Disease resistance
  SCN
  SDS
Heat and drought stress
K-State Soybean Releases

Conventional (non-glyphosate resistant GR)
KS4313N (high yield, SCN Resistance)
KS5004N (high yield, SCN Resistance)

Conventional / Special Purpose (non-GR)
KS4607 (high protein)
KS4910sp (large seeded)
KS5005sp (large seeded)

Glyphosate Resistant (GMO)
KS3406RR
KS5507NRR SCN Resistance from Hartwig

Germplasm
K1639-2 Aphid and SCN Resistance
## Potential 2017 Releases

### 2-year summary

<table>
<thead>
<tr>
<th>Entry</th>
<th>Locations</th>
<th>Yield</th>
<th>Seed</th>
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<tbody>
<tr>
<td></td>
<td>All</td>
<td>Infested</td>
<td>Non-infested</td>
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<tr>
<td>Entry</td>
<td>bu/a rank</td>
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<td>bu/a rank</td>
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<tr>
<td>LD06-7620</td>
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<td>4</td>
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<td>5</td>
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<td>K11-2363</td>
<td>1</td>
<td><strong>56.6</strong></td>
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### Table 3 continued. Topeka, Shawnee County Dryland Soybean Performance Test, 2013-2015

<table>
<thead>
<tr>
<th>BRAND</th>
<th>NAME</th>
<th>ACRE YIELD, BUSHELS</th>
<th>YIELD AS % OF TEST AVERAGE</th>
<th>2015</th>
<th>2014</th>
<th>2013</th>
<th>2-Yr. AVG</th>
<th>3-Yr. AVG</th>
<th>Mat</th>
<th>Lodge score</th>
<th>Ht (in)</th>
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<tr>
<td>AGROW</td>
<td>AG4232</td>
<td>89.5</td>
<td>112</td>
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<td>48</td>
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<tr>
<td>KANSAS AES</td>
<td>K4313NRRT</td>
<td>86.1</td>
<td>108</td>
<td>10/7</td>
<td>3.8</td>
<td>41</td>
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<tr>
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<td>41</td>
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<td>106</td>
<td>10/13</td>
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<td>40</td>
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<tr>
<td>MORSEY</td>
<td>37X15</td>
<td>82.5</td>
<td>103</td>
<td>10/4</td>
<td>2.0</td>
<td>44</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
Searching for New Gene Combinations

Hybridization - crossing two genetically unlike plants
Hybridization
Hybridization
Acknowledgements

K-State:
Agronomy
• Brent Christenson
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• Nathan Keep
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• Tim Todd
• Harold Trick
Statistics
• John Boyer
• Leigh Murray
• Nick Bleodow
Vet. Medicine
• Deon van der Merwe
Biol. and Ag. Eng.
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• Nicholle Hatton

Univ. of Missouri
• Henry Nguyen
• Grover Shannon
• Pengyin Chen
Univ. of Arkansas
• Larry Purcell
UNL – Calmit
• Brian Leavitt
Univ. of Georgia
• Zenglu Li
Univ. of Illinois
• Brian Diers
USDA, NC
• Tommy Carter
William T. Schapaugh, Jr.
Soybean Breeder and Professor of Agronomy

Education
Iowa State University  B.S.  1975  Agronomy
Purdue University    M.S.  1977  Plant Breeding, Genetics
Purdue University    PhD   1979  Plant Breeding, Genetics

Personal Statement. Dr. Schapaugh has established a successful track record of developing cultivars with both high levels of soybean cyst nematode (SCN) resistance and improved yield potential. Over 30 soybean cultivars have been released from his program since 1979. Seven cultivars possess resistance to soybean cyst nematode. Four Roundup Ready® cultivars have been released to seed producers. Thirteen releases have been special purpose cultivars, suitable for use in food, feed or industrial products. Dr. Schapaugh’s professional contributions include: participation in the development of an effective system to transform soybean plants and successfully transformed several soybean plants with a chitinase gene, determining that considerable time and labor could be saved by planting plots to harvest length, thereby eliminating end-trimming without reducing precision, characterizing the genotype by environmental interaction in tests dealing with the evaluation of tofu and soy milk products, which enabled the development of a strategy to test effectively for these products during the breeding process, quantifying the relative performance of SCN-resistant and susceptible varieties across multiple locations in Kansas and evaluating the effect of resistance source rotations on the race structure of three different SCN field populations.

Positions and Honors
Professional Experience and Positions Held:
Professor, Kansas State University Agronomy Dep., 1989 to present
Interim Department Head, April 2010 to August 2012
Associate Prof., Kansas State University Agronomy Dep., 1983-1989
Assistant Prof., Kansas State University Agronomy Dep., 1979-1982

Academic, Professional and Scholarly Societies:
Soybean Breeders’ Workshop Coordinator (1997-99), SoyCAP Representative (2004 to 2007), CSREES Review Team Member for the Louisiana Ag Center (2005), Soybean Genetics Committee (2007 to 2010, Co-chair 2009-10).


**Honors:**

2012 Fellow American Society of Agronomy
2012 Fellow Crop Science Society of America

**Selected Peer-reviewed papers**


