Research, Breeding and Development of Soybean Varieties

(Investigación, Mejoramiento y Desarrollo de Variedades de Soja)

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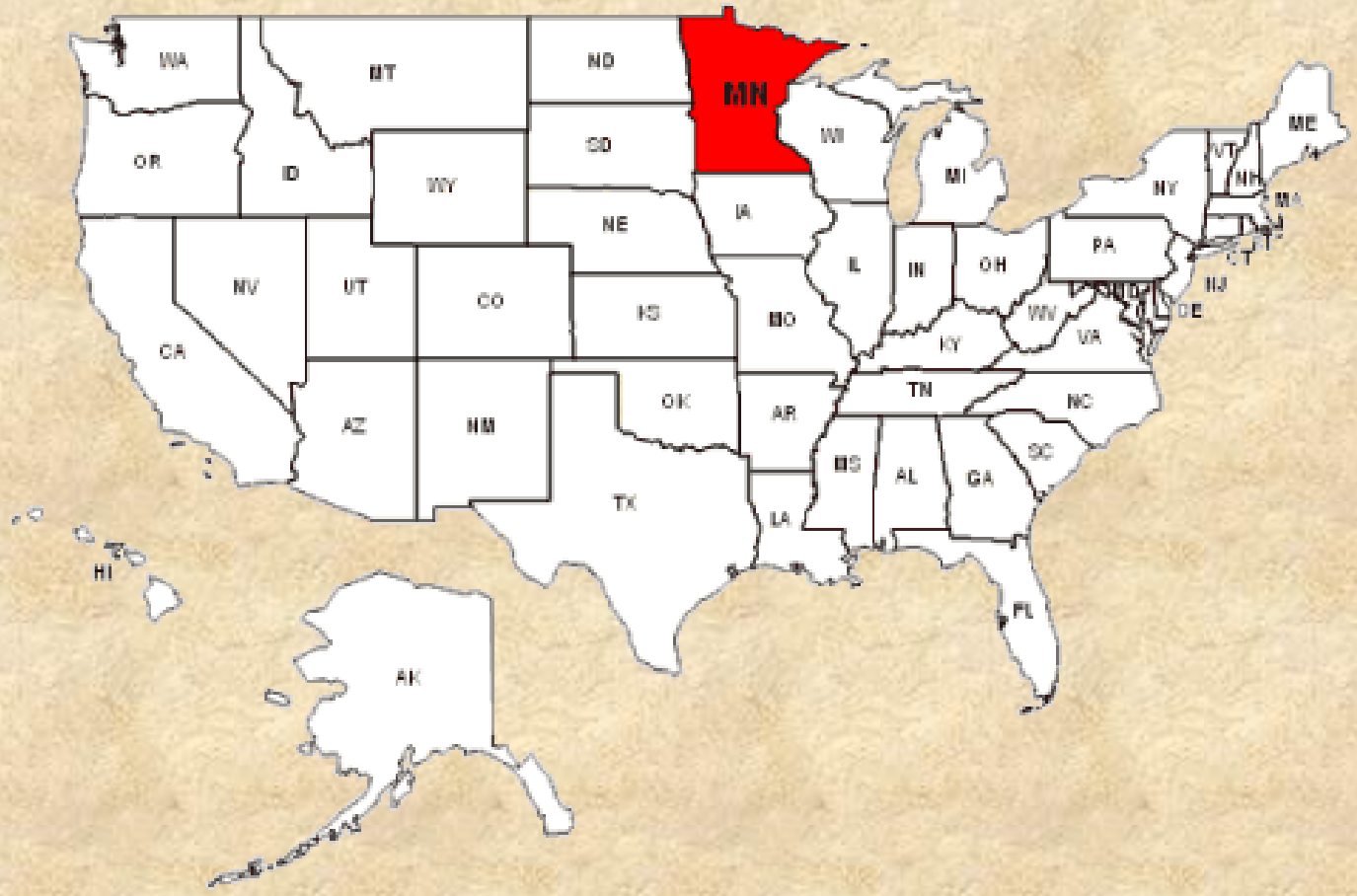
Where is Minnesota?

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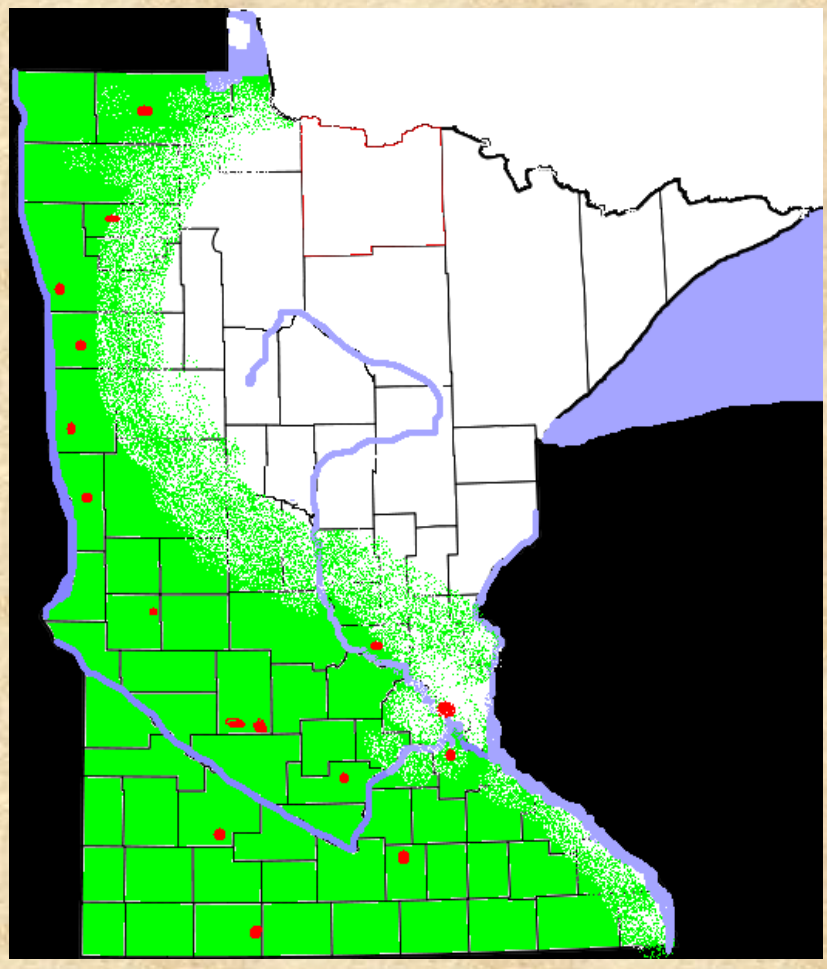
Minnesota Agriculture

- 75,000 Farms
- 18 million hectares
- 140 hectares Average Size
- 2.9 million hectares of Soybean

Soybean Production - 2008



- 2.7 Million hectares Harvested
- Value - $2.6 Billion
- Field Trial Locations

Soybean Breeding Project

- Began: 1946
- Project Leader: Jim Orf
- Technical and Scientific Support:
  Phil Schaus, Art Killam, Darcy Weston, Gerald Decker, Rafael Echinique, Leo Moros.
- Grad Students: Michelle Menken, Landon Ries, Mukhtar Agoub, Ilene Jones, Dhanjay Mani.

Objectives

1. Development of new high-yielding, hazard-resistant, high quality general and special purpose varieties adapted to the various maturity requirements of Minnesota and surrounding states (Groups 00 through early II).
2. Generation of new information on soybean genetics and breeding methodology that will facilitate the development of improved varieties and/or germplasm.
3. To contribute to the training of graduate students in plant breeding.
4. Testing of varieties which have been developed in other programs (public or private) and that may be marketed in Minnesota.

Soybean Breeding Project - by the Numbers

- 16 Locations plus winter nursery in Chile
- 54 hectares
- 20-25,000 yield plots
- 20-30,000 Plant Rows
- 150 - 200 populations generated per year
- >100 Varieties Released or Licensed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SUPERBEAN
RESEARCH AREA
KEEP OUT

Soybean Breeding Project

- Maturity Groups 00 to II
- Yield
- Earliness
- Disease & Insect Res.
- IDC
- Protein and Oil
- Fatty Acids
- Amino Acids
- Sugars & Carbohydrates
- Isoflavones
- Low Lipoxygenase
- Genetic Diversity
- Trypsin Inhibitor
- Low Phytate
- Food Types
- Organic Selection
- Drought Tolerance
- Forage Types

Time for Variety Development

- Cross ½ year
- Selfing 1-2 years
- Selection 1 year
- Yield evaluation 2-4 years
- Product evaluation 1 year
- Seed multiplication 1-2 years
- Total 6-10 years

Crosses

- Mainly between high-performing but relatively unrelated genotypes.
- Complementary for desirable characters.
- Regular introduction of new germplasm in crosses of "adapted" x "exotic."
- Done mainly in the field at St. Paul (two dates of planting) or Rosemount but also in growth chambers and in Chile during January and February.
- Use easily identified marker genes, when feasible


Large


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Driven to Discover℠

- F_1's - mainly in Chile nursery, but also in field at St. Paul and growth chambers.

- F_2's - mainly in field in Minnesota (split between St. Paul and Rosemount), but to some extent in Chile nursery - harvested as plants to initiate a pedigree program or as pod to initiate a modified single seed descent (m.s.s.d.) program.


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GOBIERNO DE CHILE
INIA
LA PLATINA
INSTITUTO DE INVESTIGACIONES AGROPECUARIAS
MINISTERIO DE AGRICULTURA

F_3's

- Bulk population of m.s.s.d. program in Chile nursery or at St. Paul and Rosemount (pod harvest).
- Progeny rows at Rosemount for the pedigree program (*row and plant selection).

F_4's

- Bulk population of m.s.s.d. program at St. Paul and Rosemount or in Chile.
- Progeny rows at Rosemount for the pedigree program.
- Individual plants harvested from both programs.
- Marker assisted selection for soybean cyst nematode.

White to light yellow soybean cyst nematode females on soybean roots

F_5's

Progeny rows at two Minnesota locations.

- Earlier materials at Rosemount and Morris

- Later material at Rosemount and Waseca

- Rows selected for agronomic traits, bulk-harvested for further evaluation of seed quality and oil and protein

NIR

- Samples are analyzed for protein and oil concentration by Near Infra-Red Spectroscopy (NIRS) using a Perten diode array instrument
- Protein and oil estimates are expressed on a 13% moisture basis

F_6's

- Tests for phytophthora reaction (seedlings).
- Preliminary tests for yield, lodging and other agronomic and quality traits-small plots, two locations.
- If necessary, tests for soybean cyst nematode resistance and/or brown stem rot resistance, and/or white mold resistance.

F_7's

- Local tests in small plots, two or three locations.
- Small unpurified increases
- Select 50 "typical" plants per selected line for initiating purification.


Discover Horticulture
5420

F_8's

- Tests in large plots locally and in small plots regionally (preliminary tests).
- Progenies of 50 plants grown for observation; off-type rows discarded, remainder bulked for increase (Original Breeder's Seed).


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F_9's

- Tests in large plots locally and in small plots regionally (uniform regional tests).
- Small increase of purified seed (Breeder's Seed).

F_{10}'s

- Continued local and regional tests
- Foundation seed produced and shared with other states.
- "Product" testing of special purpose varieties.

F_{11}'s

- Continued local and regional tests.
- Seed of new variety(ies) further increased and released to seed growers.


MN-1603-SP

Additional aspects of the program:

- Fee-testing of proprietary varieties
  - Three maturity groupings.
  - Three locations for each grouping
  - Special soybean cyst nematode test.
  - Transgenic tests in each maturity grouping.
  - Special purpose variety test.


2006
SOYBEAN
BREEDING
ROSEMOUNT
PVTS, Specials,
NEL'S,
Diversity
BOOK 1
421-3

Disease nurseries (single row plots)

- Genotypes from regular breeding program, regional testing, and variety testing.

  Special tests:

  - Danvers- iron chlorosis
  - Foxhome – iron chlorosis
  - Lamberton - soybean cyst nematode
  - Westbrook - soybean cyst nematode
  - Waseca - Soybean cyst nematode

Yield

- Objective of all breeding programs
- Progress will continue
- Considerable research to identify “yield” genes
- Yield a complex trait with many loci, including interactions


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Protein (Oil)

- Considerable genetic variation for protein and oil
- Negative relationship between yield and protein; oil and protein
- Exceptions to relationships exist
- Major loci for protein being researched
- Sunlight (photosynthesis) fixes carbon goes to protein, oil carbohydrates (proportion of each varies by plant species and genotype)

Iron Chlorosis

- A complex trait, causes of iron chlorosis complex
- Genetic variation exists
- Generally lower yield with better iron chlorosis tolerance
- Limited area where a problem, thus not a high priority in many programs
- Molecular markers may be somewhat helpful
- Varieties with adequate levels of tolerance available now and in the future

Soybean Cyst Nematode

- SCN becoming a problem further north
- SCN must be managed (rotate, rotate, rotate) it cannot be eliminated
- Resistance complex (several genes needed) Rhg_1, Rhg_2, Rhg_3, Rhg_4, Rhg_5
- Nematode populations variable
- Molecular markers can aid breeding efforts
- Resistant varieties to some nematode types available now and in the future
- CystX resistance

Soybean Aphid

- Sources of resistance with simple inheritance identified
- Molecular markers identified to make breeding easier
- Breeding and testing process will take time
- Resistant varieties potentially available within about 5 years
- Frequency of aphid problem uncertain

Quality Characteristics

- Seed size
- Hilum color
- Protein
- Oil
- Seed shape
- Carbohydrates
- Isoflavones
- Seed Color
- Taste
- Appearance

Quality Characteristics

Seed Size

- Large <2000 seeds per pound
- Small >4000 seeds per pound
- Some applications use average size varieties

Seed Shape

- For most food applications uniform round shape preferred.


Got BioDiesel?

Quality Characteristics

- Protein
- Protein content
- Amino acid profile, methionine, cysteine, threonine
- Protein characteristics (11s – 7s)
- Soybean meal

Quality Characteristics

- Oil
- Content
- Altered fatty acids
- low linolenic
- low saturates
- mid oleic
- high stearate
- high oleic (transgenic)
- combinations


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Quality Characteristics

Carbohydrates

- Soluable – higher sucrose
- Low stachyose and raffinose
- Lower structural carbohydrates

Isoflavones

- Limited market for higher levels
- Low levels

Quality Characteristics

Other Traits in Program

- Lower trypsin inhibitor
- Lipoxygenase nulls
- Low phytate
- Null P34 (allergen)
- Edamame types
- Forage types
- Combinations of traits

Thank You!

- Minnesota Agricultural Experiment Station
- Minnesota Soybean Research and Promotion Council
- North Central Regional Soybean Research Program
- United Soybean Board
- USSEC
- INIA – La Platina

- Cooperative tests with soybean researchers in U.S. and Canada
- Regional testing of Plant Introductions and lines from crosses involving Plant Introductions.
- Cooperative tests with researchers investigating use of molecular markers in breeding programs.
- Trueness to variety tests.

Food Soybean Market

- Varieties must be a non-GMO
- Varieties must be developed using conventional breeding techniques
- Conventional varieties can be grown using conventional or organic production systems

Drought Tolerance

- Genetic variation for drought tolerance present in germplasm
- A complex trait
- Type of environment to target varieties a challenge for breeders
- Drought tolerant varieties may be available in 5-10 years