Yield Gains in Sunflower

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What is Genetic Gain?

• Improvement in some trait that is due to genetic changes (breeding), NOT agronomic (improvement in cultural practice)
  – Yield
  – Disease resistance
  – Herbicide resistance
  – .... etc.
Sunflower in USA

• Native species (*Helianthus annuus* L.)
• Domesticated by Native Americans
• First scientific breeding in Russia
• Open-pollinated varieties in US – 1950-1970
• Hybrid system developed around 1970
Sunflower breeding basics

B1 x B2

F1

...

F4

CMS x F4

F5

...

Finished B line

Finished A line

x

Finished B

x F5

BC1

x F6

BC2

...

x Finished B

R1 x R2

F1

...

F4

F5

...

Finished R line = Hybrid Variety
Market classes

• Oilseed
  – High oleic (85-93 % oleic acid)
  – NuSun (mid oleic)
  – Traditional (high linoleic)

• Non-oil (confection)
  – Shield or round type
  – Long seeded (2cm+ length)
Production challenge #1 - Birds

- Unpredictable and hard-to-control event
- Major reason for farmer abandonment of sunflower
Production challenge #2 – Sclerotinia and Phomopsis

- *Phomopsis helianthi* causes a stem lesion resulting in premature ripening and lodging
- *Sclerotinia sclerotiorum* can cause similar stem lesions but also a head rot
- Resistance is quantitatively inherited, but broad-sense heritability is high under controlled environments (0.7-0.8)
- Marker assisted breeding in infancy
Production challenge #3 – Downy mildew and rust

• Downy mildew – seedling disease that causes dwarfing of plant and yield elimination
• Rust – adult plant disease
• Controlled by vertical resistance genes, some with markers
Production challenge #4 -- insects

- **Head infesting:**
  - Banded sunflower moth – ND
  - Sunflower midge -- ND
  - Red sunflower seed weevil – SD -> host plant resistance reduces infestation by factor of 10
  - Sunflower moth – KS, CO, TX

- **Stem infesting:**
  - Dectes stem borer – TX to ND
  - Stem Weevil – KS
Production challenge #5 -- weeds

• Weed control
  – Preplant herbicides
  – Imidazolinone and sulfonylurea herbicide systems
  • Conventionally bred
Studies in Genetic Yield Gain

• Oil yield = seed yield * oil content
• Argentina – meta-analysis of historical data
  – Oil content increases driving oil yield progress
  – Verticillium resistant hybrids resulted in the highest yield
  – Backcross conversion resulted in no yield gain
• South Africa – historical hybrid field study
  – Seed yield driving oil yield progress
• USA – both types of studies in progress
OIL SUN
\[ y = 0.698x - 1291.5 \]
\[ R^2 = 0.3055 \]

NON-OIL SUN
\[ y = 0.5596x - 1015.6 \]
\[ R^2 = 0.2344 \]

SOY
\[ y = 1.2126x - 2317.3 \]
\[ R^2 = 0.7774 \]

MAIZE
\[ y = 1.4294x - 2749.6 \]
\[ R^2 = 0.7389 \]
Sunflower breeding has concentrated more on preserving existing yield potential (defensive breeding) and improving quality than pushing new yield gains.
Future prospects

• Breeders need to balance yield gains with yield stability from defensive breeding
  – Slow yield gain will likely continue if current paradigms are kept → genetic gain gaps will widen
  – Alternative breeding methods are needed to make breeding more efficient since
    • The crop does not capture as much research investment as some others
    • It is grown on increasingly marginal land
    • Genetically Modified sunflower is nonexistent
Critical breeding research needs

• Doubled haploid
  – Rapid population development
  – Rapid development of CMS analogues of “female” heterotic group lines

• Expansion of genomic tools
  – SNPs are widely used today / full genome nearly complete
  – More fine mapping and development of “holistic” genomic selection programs
... but play to strengths

• Naturally drought resistant → climate change
• Non-GM status may have considerable value in the future for some foods and markets – labeling
• Very amenable to manipulation of fatty acids
• Extremely high oil (40-50% of seed mass)
• Over 50 species of *Helianthus* are interfertile
• Crop rotation options!
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