Yield Gains in Sunflower

Brent S. Hulke
USDA-ARS-Northern Crop Science Laboratory
Larry W. Kleingartner
National Sunflower Association

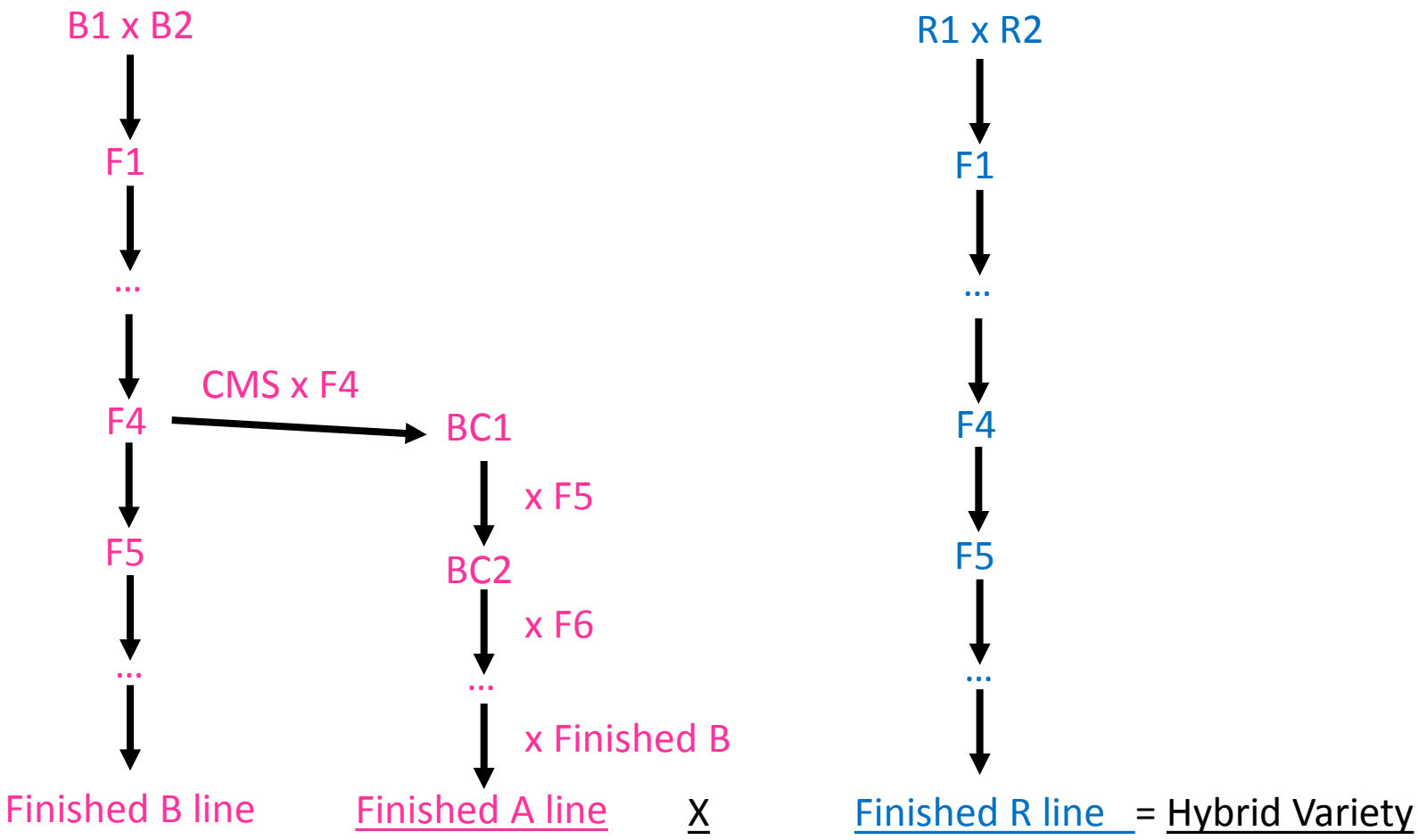
What is Genetic Gain?

- 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



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

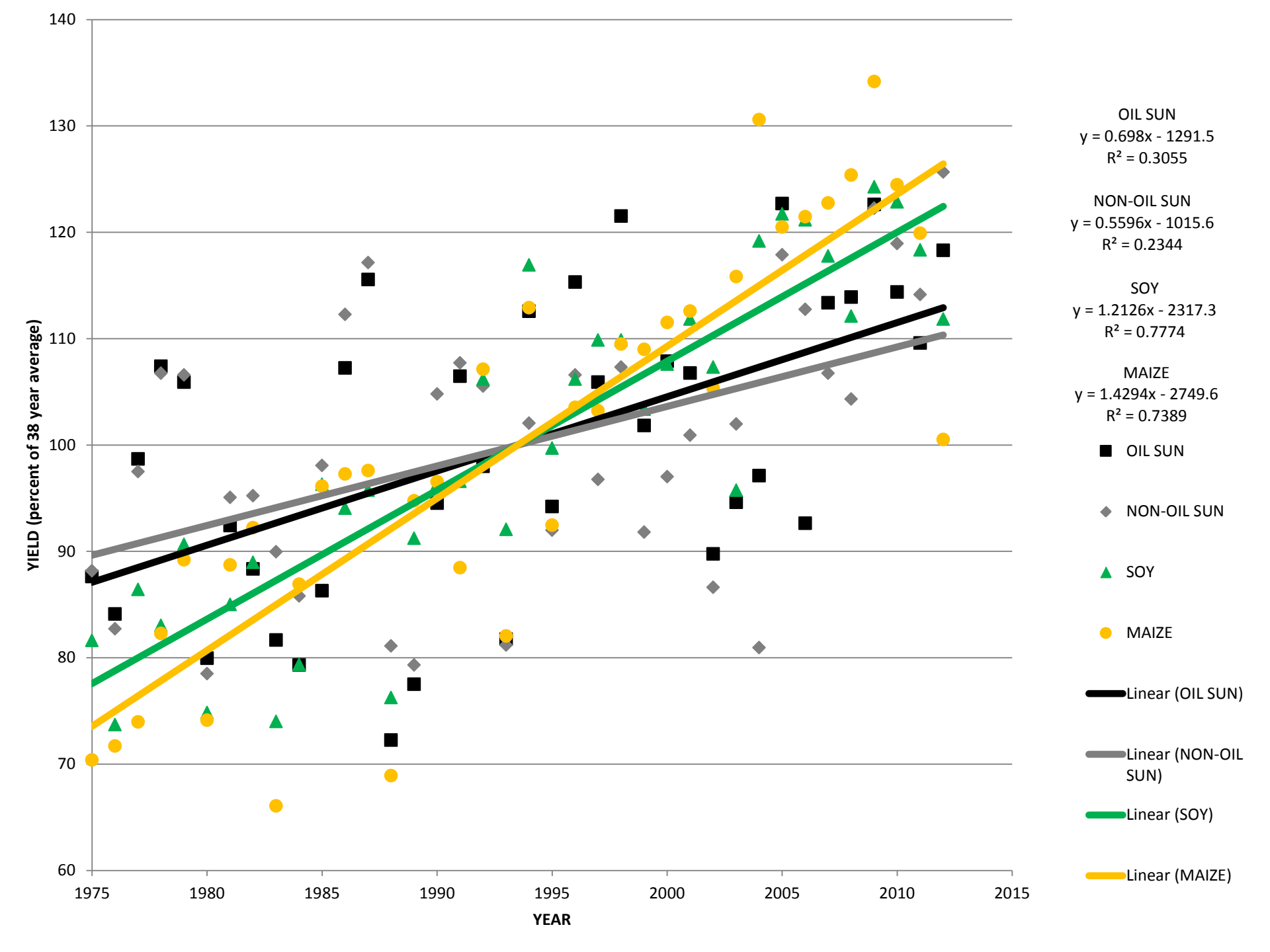
- Head infesting:
  - Banded sunflower moth – ND
  - Sunflower midge -- ND
  - Red sunflower seed weevil – SD -> host plant resistance reduces infestation by factor of 10
  - Sunflower moth – KS, CO, TX
- Stem infesting:
  - Dectes stem borer – TX to ND
  - Stem Weevil – KS

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


140
130
120
110
100
90
80
70
60
YIELD (percent of 38 year average)
1975
1980
1985
1990
1995
2000
2005
2010
2015
YEAR
OIL SUN
y = 0.698x - 1291.5
R² = 0.3055
NON-OIL SUN
y = 0.5596x - 1015.6
R² = 0.2344
SOY
y = 1.2126x - 2317.3
R² = 0.7774
MAIZE
y = 1.4294x - 2749.6
R² = 0.7389
OIL SUN
NON-OIL SUN
SOY
MAIZE
Linear (OIL SUN)
Linear (NON-OIL SUN)
Linear (SOY)
Linear (MAIZE)

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!

Acknowledgements

- USDA-ARS
- National Sunflower Association
- National Sclerotinia Initiative
- The sunflower industry, for assistance with the monograph chapter