Arcadia Biosciences

Nitrogen Use Efficiency Technology
Good for the Grower, Good for the Environment

Fertilizer Outlook and Technology Conference - Annapolis, MD
October 27, 2004

Mission

Arcadia develops plants that improve the environment and human health

Strategy

- **Identify** technologies that have achieved Proof of Concept and fit our mission
- **Develop** technologies by investing in optimization and validating performance in the field
- **Commercialize** through strategic partnerships with seed companies or selling directly into the target market

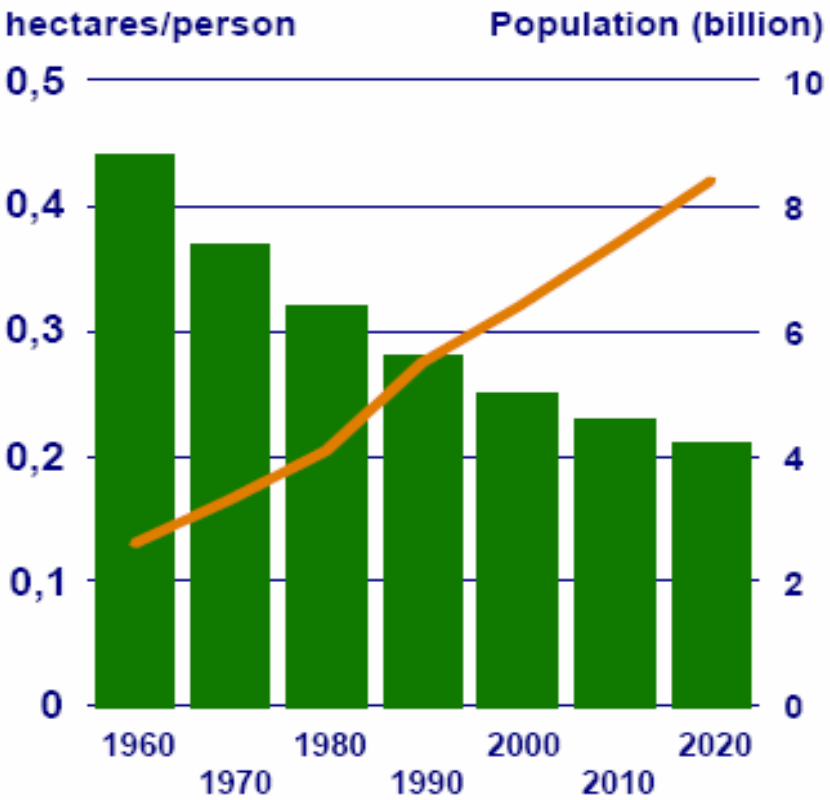
Current Programs

- **Environmental Benefit**
  - Nitrogen Use Efficient (NUE) Plants
  - Salt-Tolerant Plants
- **Human Health Benefit**
  - Specialty PUFA oils
  - Non-toxic Castor

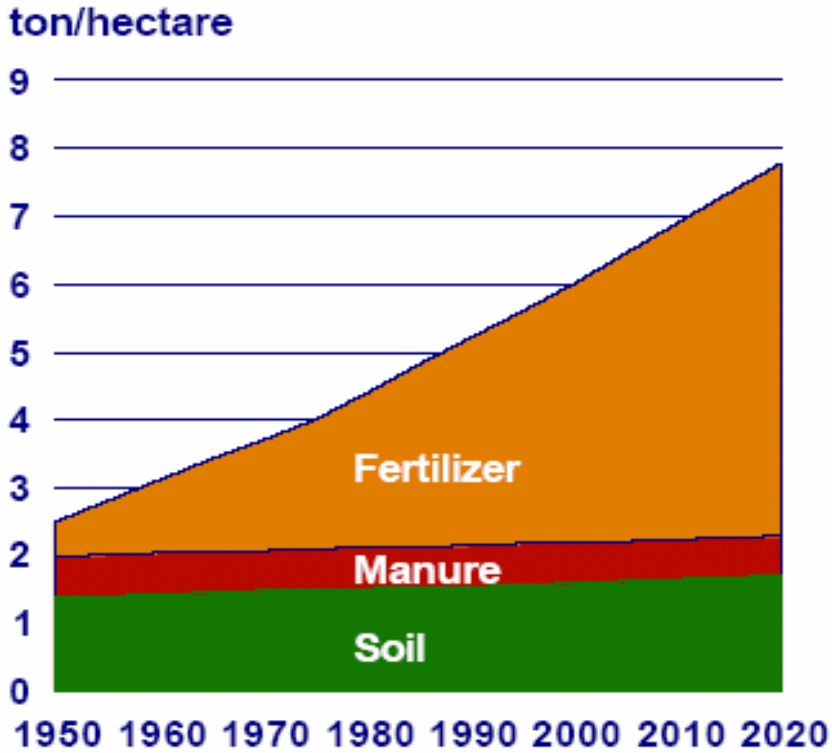
Nitrogen Use Efficiency Program

Pressure on Land Drives Nutrient Demand

Hectares per person decreasing...



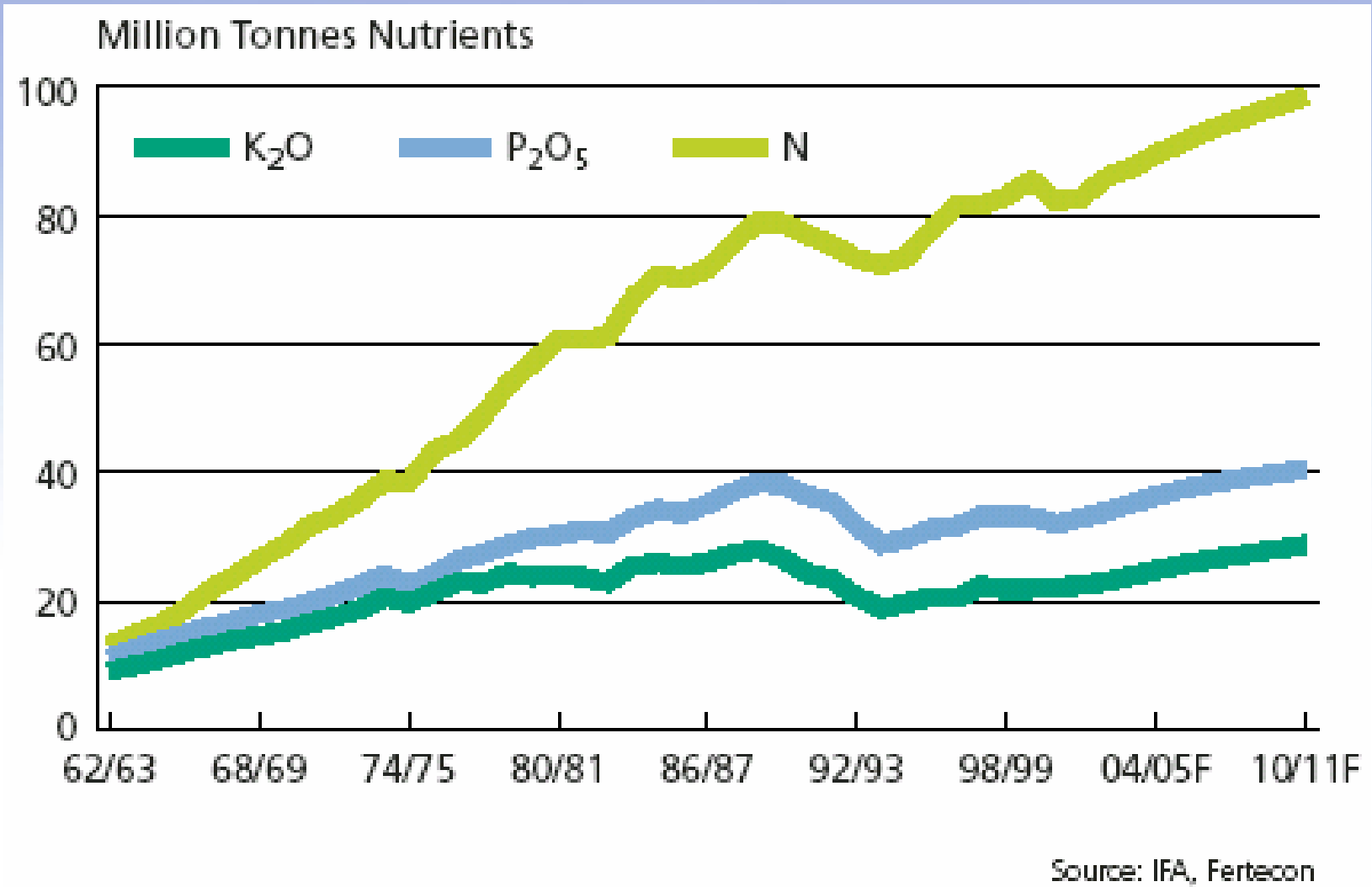
... and mineral fertilizer only sustainable large scale nutrient source



Expected global fertilizer growth 2-3% per year

Source: Norsk Hydro 2003

More Fertilizer Means More Nitrogen

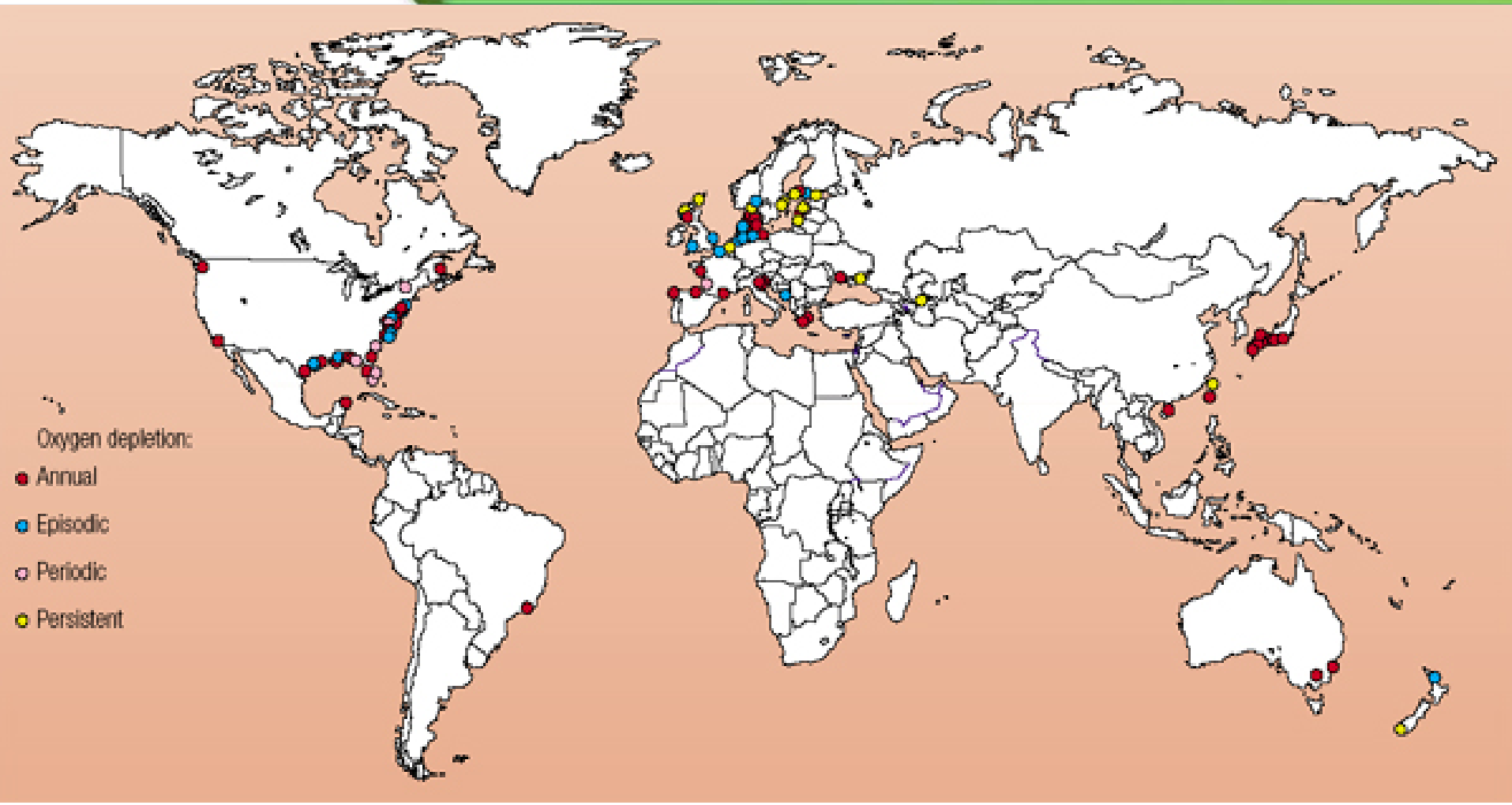


Source: IFA, Fertecon

Nitrogen, Agriculture and the Environment

- Nitrogen is a key input to modern agriculture
- Less than 50% of applied nitrogen is absorbed by plants, resulting in economic losses for farmers
- Unabsorbed nitrogen leads to environmental problems
  - Eutrophication of marine environments
  - Ground water pollution
  - Air pollution

Ocean “Eutrophic Zones” are a Global Issue



Source: United Nations Environment Programme, **GEO Yearbook 2003** (Nairobi: 2004), compiled from Boesch 2002, Caddy 2000, Diaz et al. (in press), Green and Short 2003, Rabalais 2002

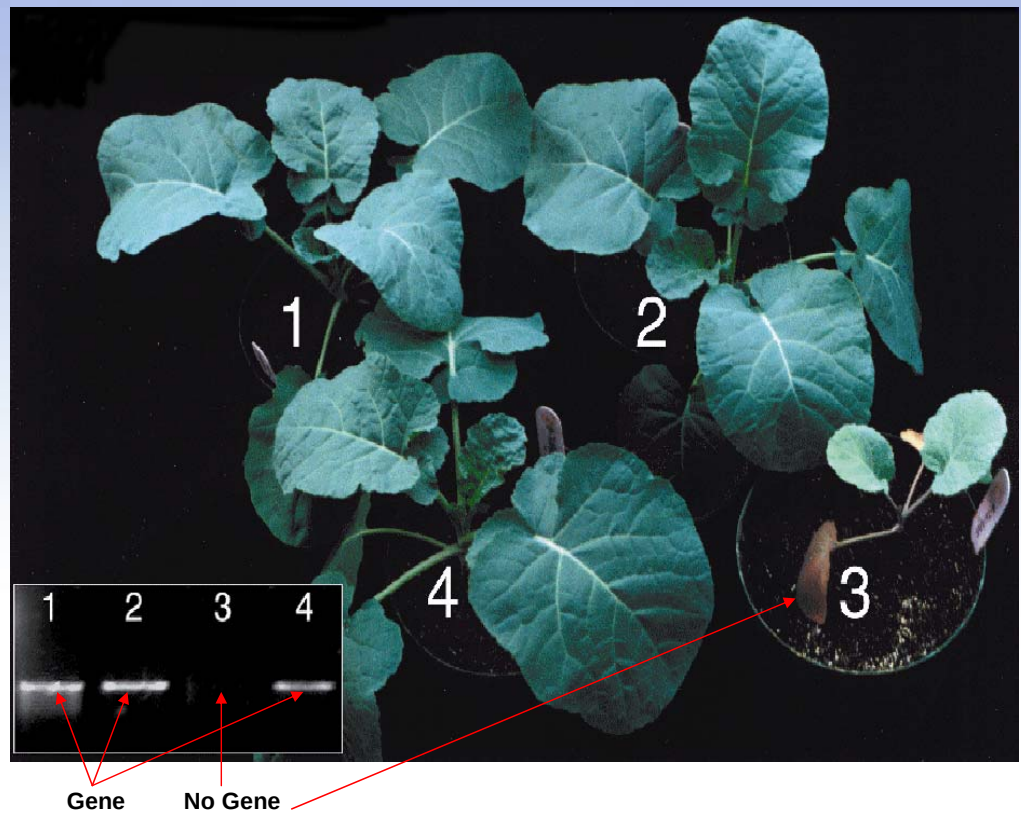
Nitrogen Use Efficiency (NUE)

Objective

- Plants that use nitrogen more efficiently

Status

- Transgenic Arabidopsis, tobacco, canola and rice
- Four successful canola field trials to date
- **Canola that produces yields equivalent to control with up to 66% less nitrogen fertilizer**

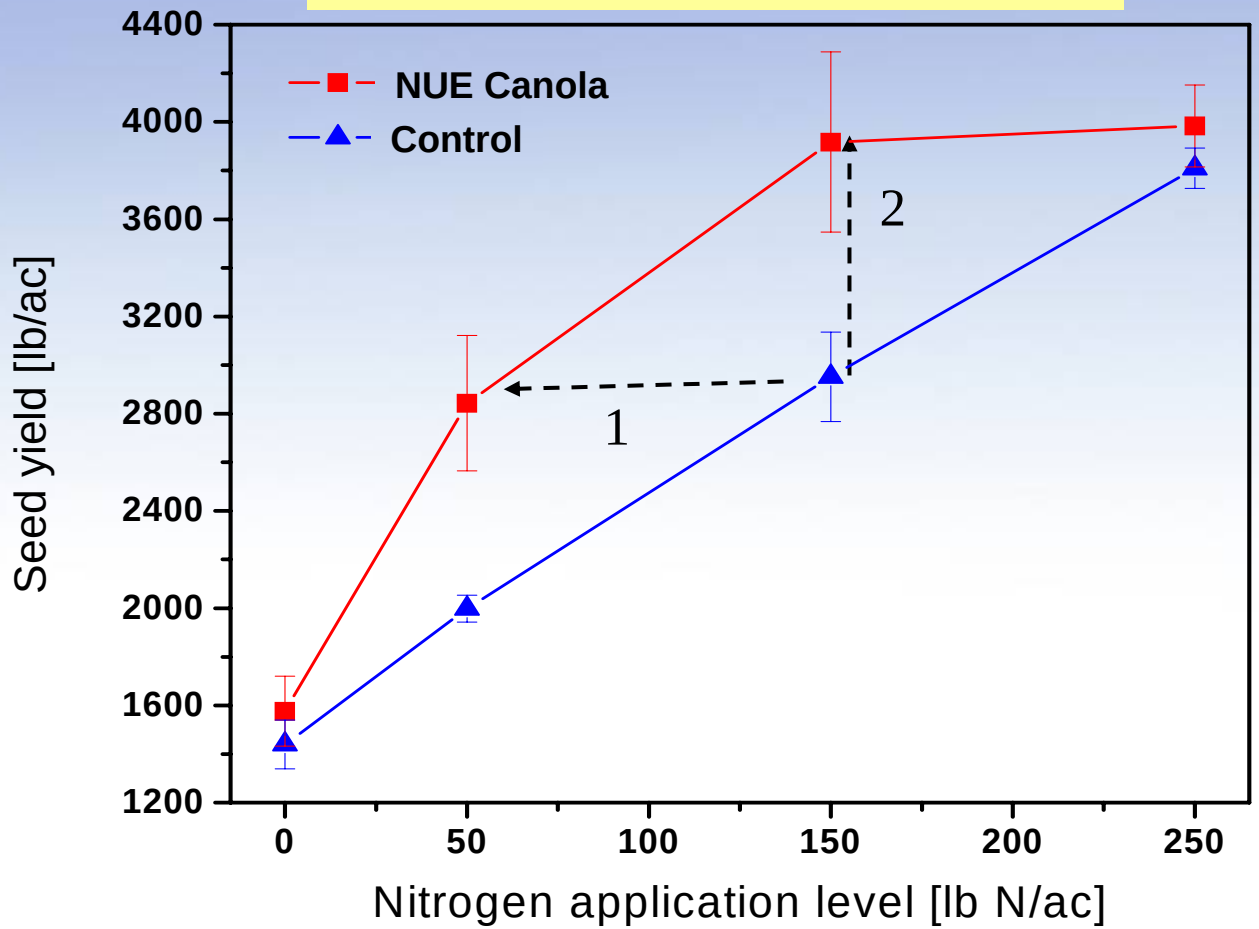


NUE Canola Field Trials

NUE Canola Plants Achieve Higher Yields at the Same Rates or Equal Yields Using Less Nitrogen Fertilizer

Field Trial #1: 02-03 CA Canola Seed Yield Comparison

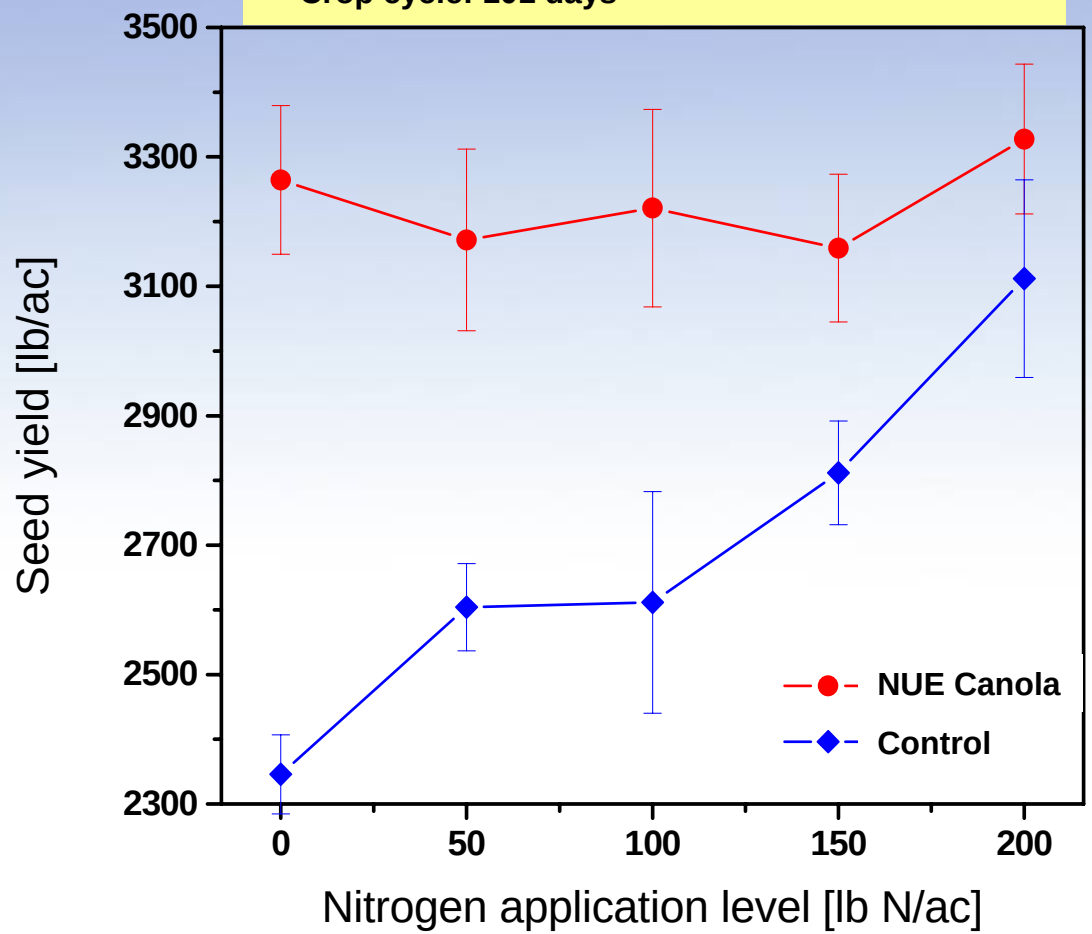
- **Plant-available nitrogen from the soil: 87 lbs./ac**
- **Crop cycle: 148 days**



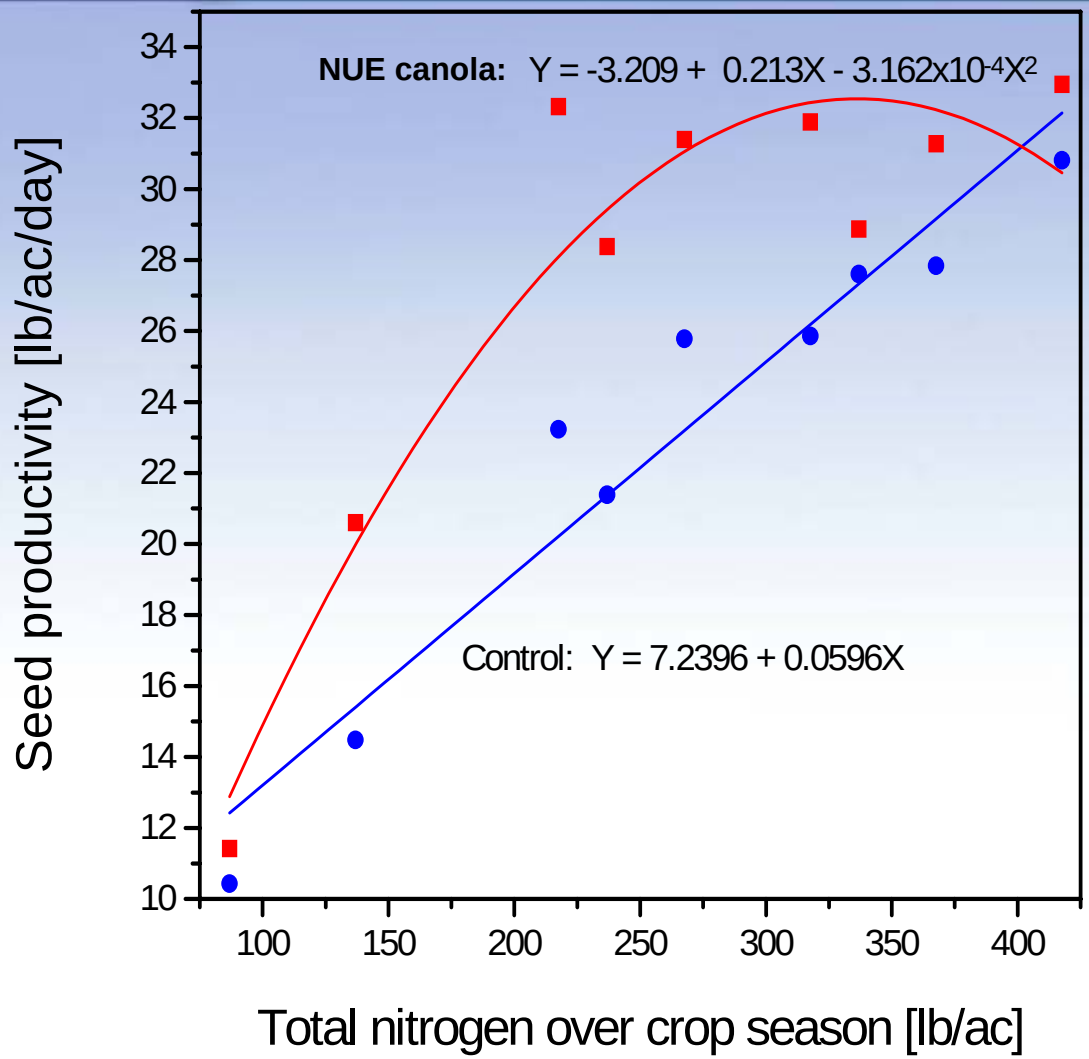
1: Same yield, less N
2: Same N, greater yield

Field Trial #2: 2003 MN Canola Seed Yield Comparison

- Plant-available nitrogen from the soil: 218 lbs./ac
- Crop cycle: 101 days

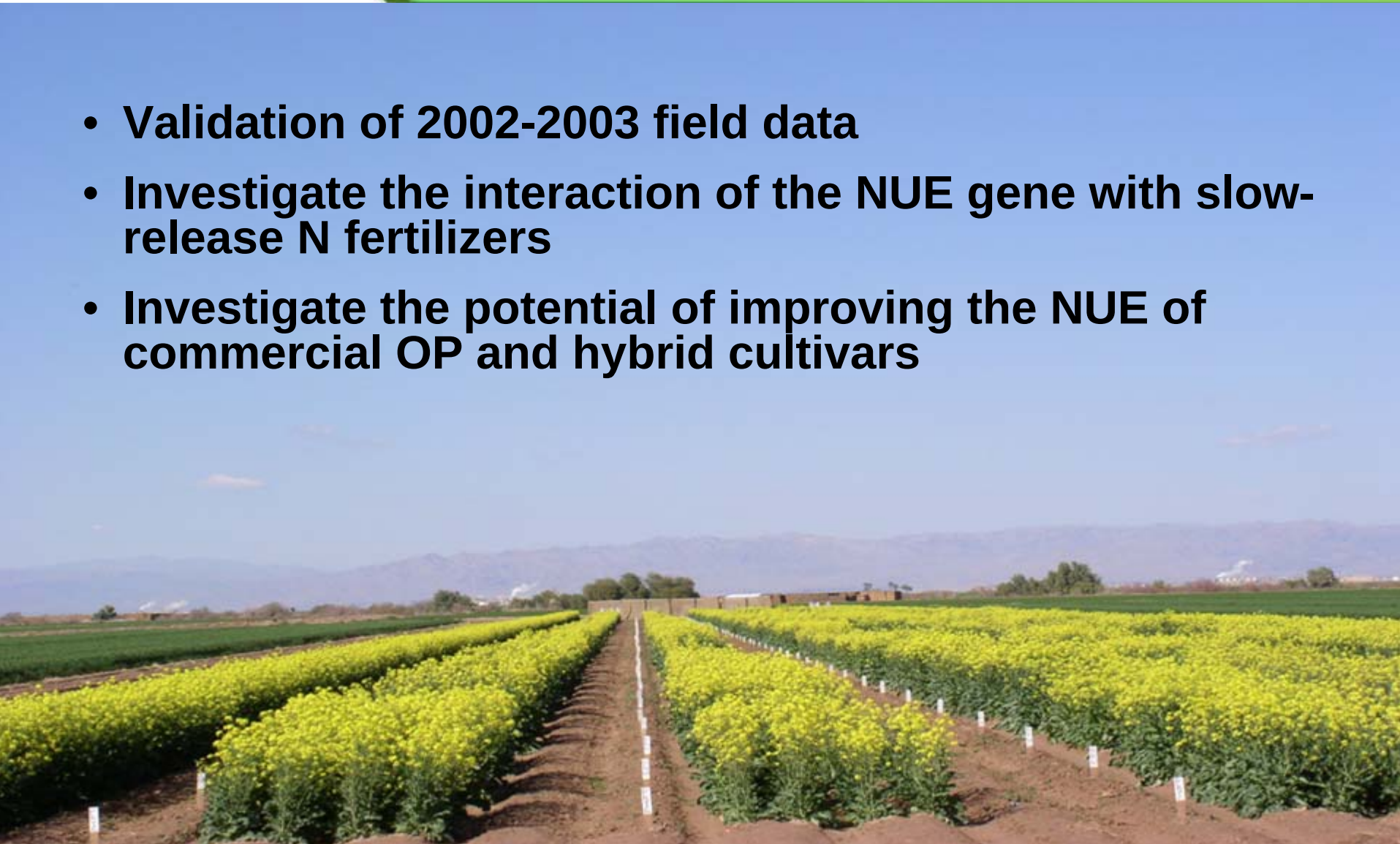


Field Trials #1 & #2 Integrated Yield Data

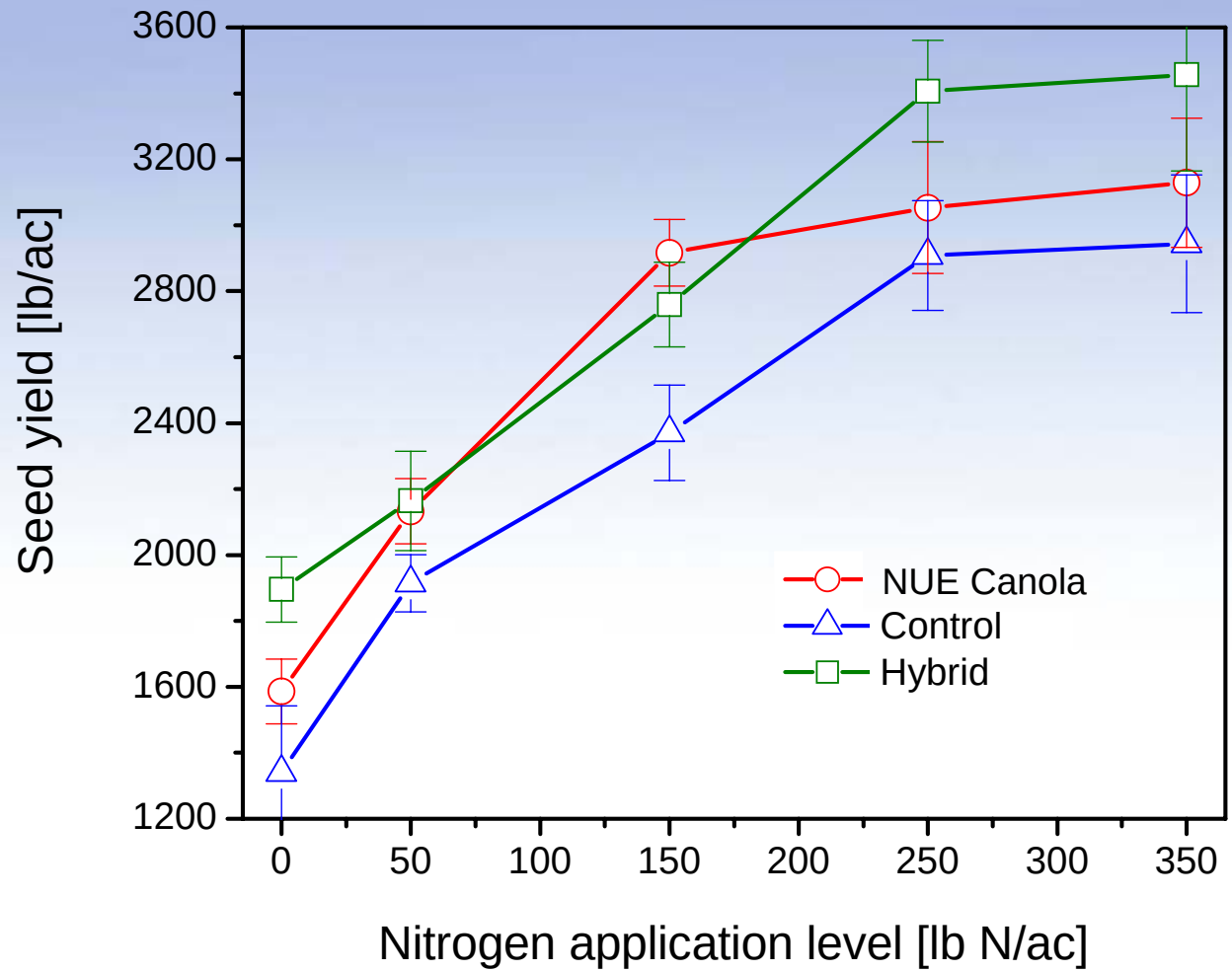


Field Trial #3: 03-04 CA Canola Objectives

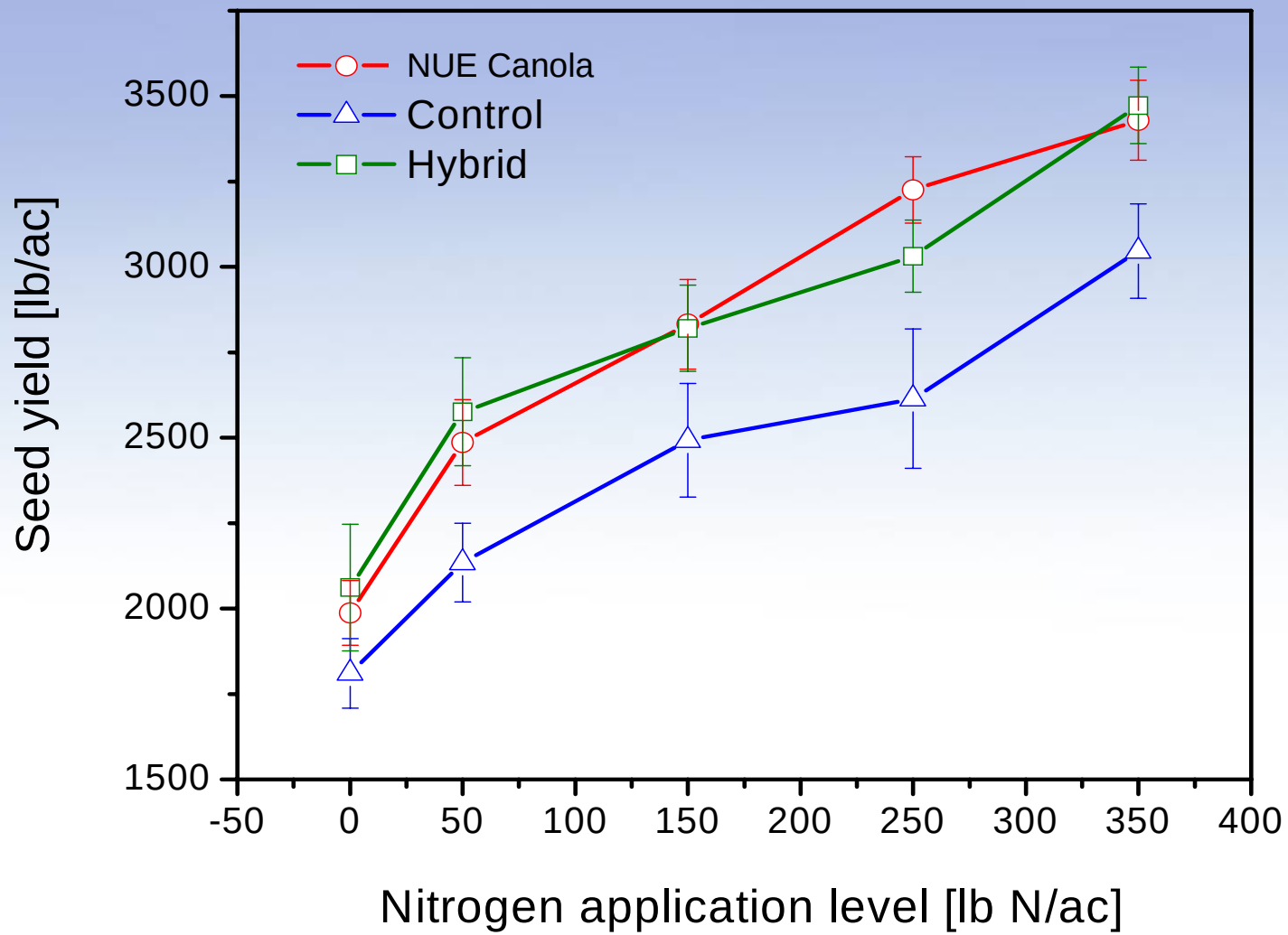
- Validation of 2002-2003 field data
- Investigate the interaction of the NUE gene with slow-release N fertilizers
- Investigate the potential of improving the NUE of commercial OP and hybrid cultivars



Field Trial #3: 03-04 CA Canola Seed Yield - Urea Fertilizer



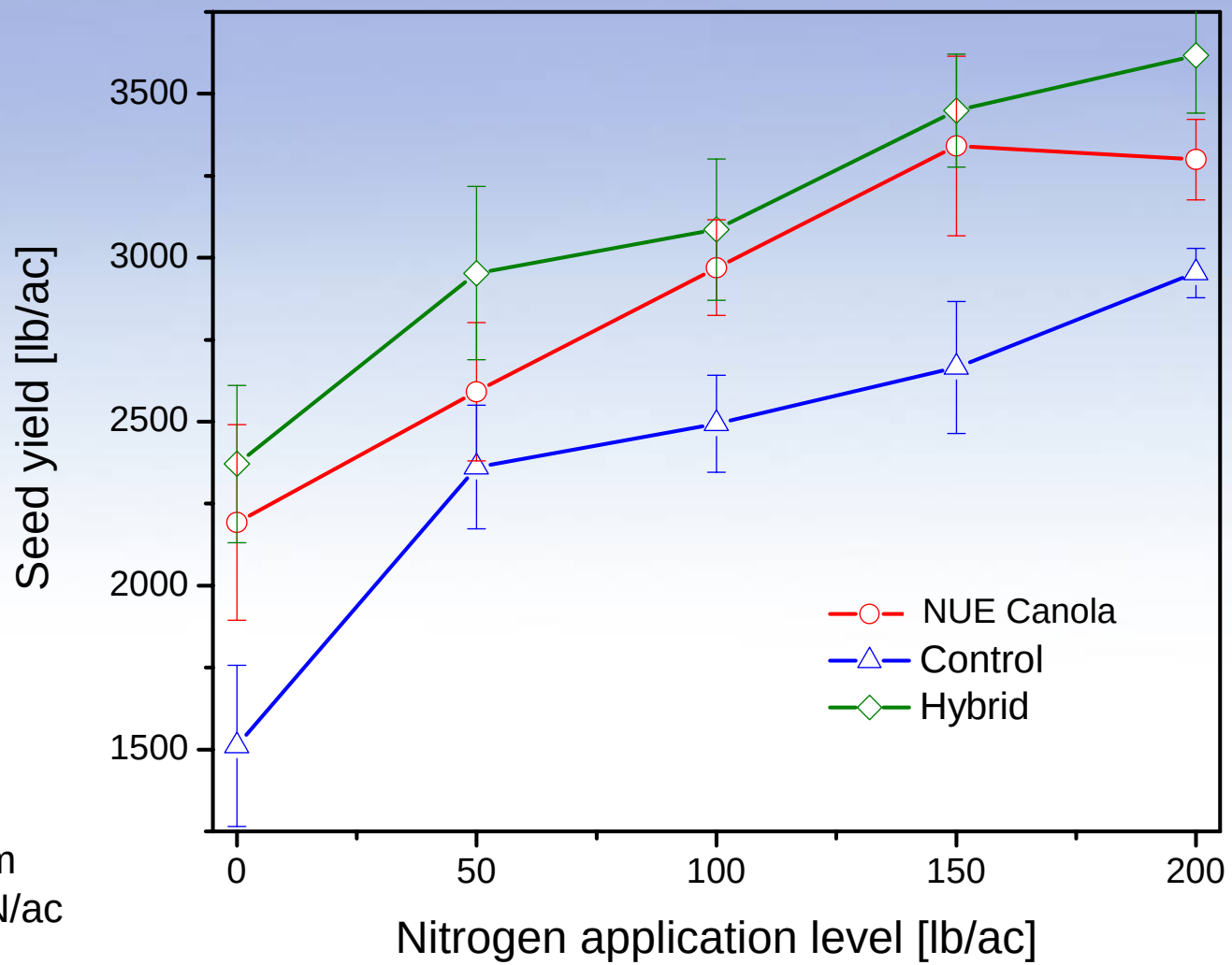
Field Trial #3: 03-04 CA Canola Seed Yield - Slow Release N



Field Trial #4: 2004 ND Canola Objectives

- **Validation of 2003 field data**
- **Evaluate F1 hybrids from crosses between transgenic lines and OPs and inbred lines**
- **Evaluate new events**

Field Trial #4: 2004 ND Canola Seed Yield Comparison

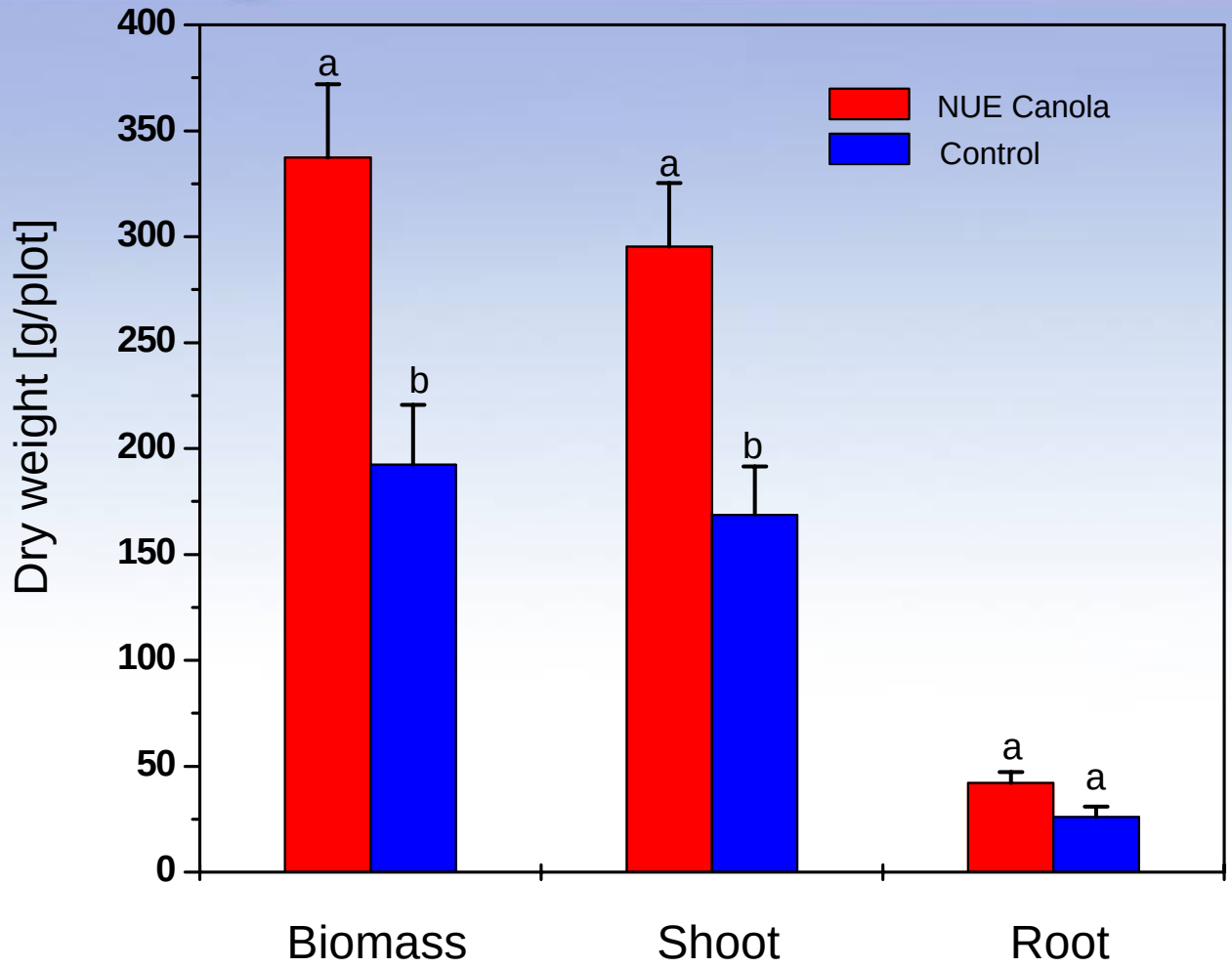


Silty Loam
42.9 lbs N/ac

NUE Canola - Biomass

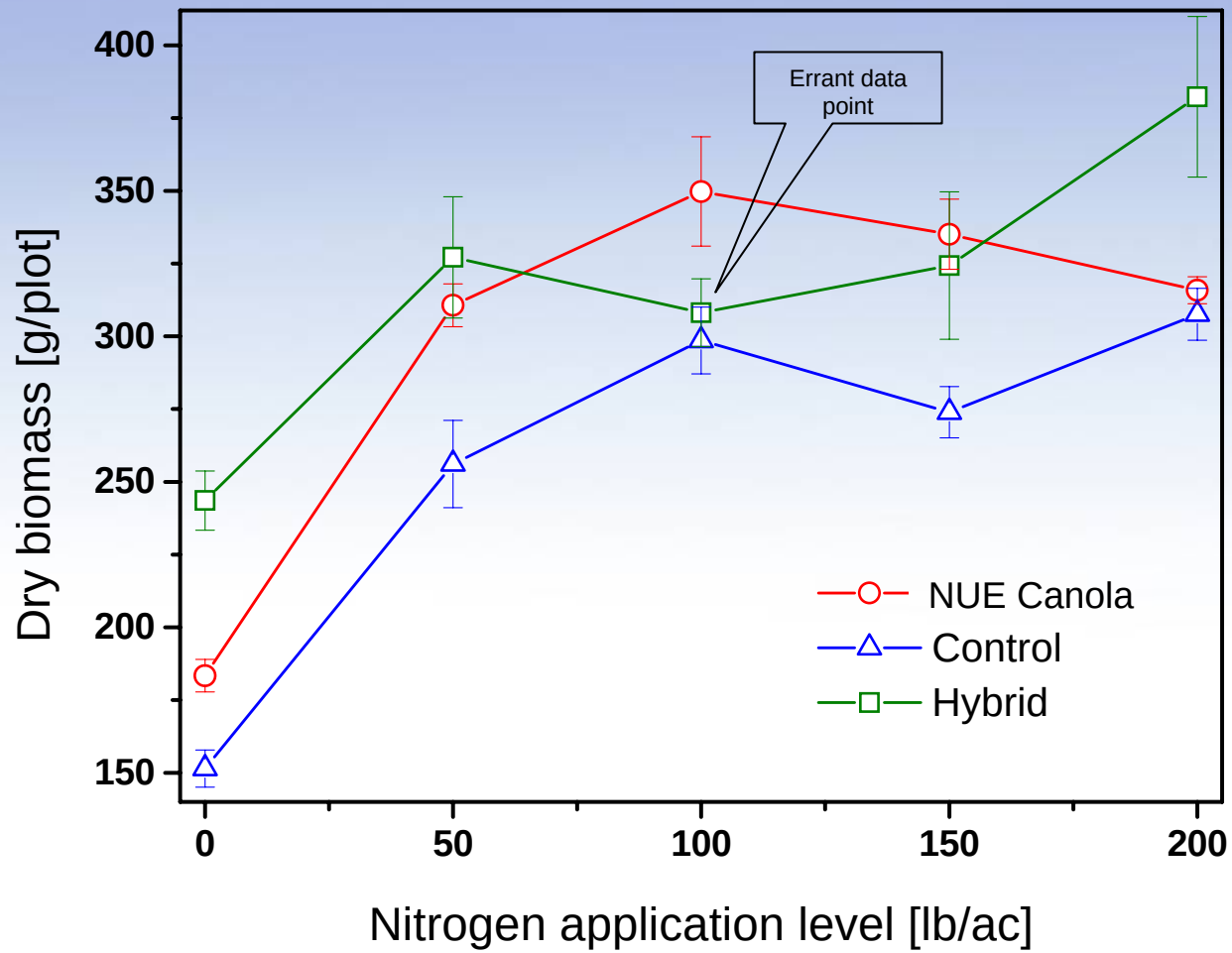
Higher seed yields result from increased plant biomass

Plants With NUE Gene Produce More Biomass



Plants sampled from Block 5, Brawley CA on Jan 22, 2003, just prior to fertilization

Field Trial #4: 2004 ND Canola Biomass Comparison



Pre-Flowering Biomass

NUE Canola

Control

Photos taken at 0 lb urea-N/ac from HB6R9A8-10 on June 27, 2003 at TRF, MN

NUE Canola - Trait Transfer

The NUE gene can be readily moved into other canola varieties via conventional plant breeding

The NUE gene should function in the same manner in other crop species

Trial #4: 2004 ND Canola F1 Hybrids

Commercial Variety x Control

Biomass Data

DW g/plot: 311.47

DW g/plant: 8.75

Commercial Variety x NUE Canola

Biomass Data

DW g/plot: 437.77 +40.5%

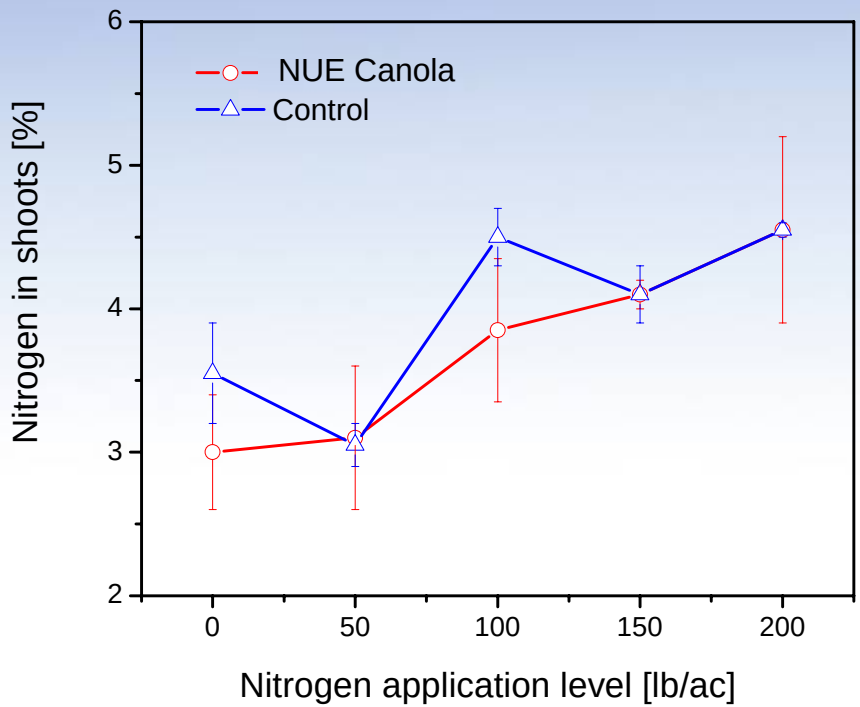
DW g/plant: 15.10 +72.5%

NUE Canola - Composition

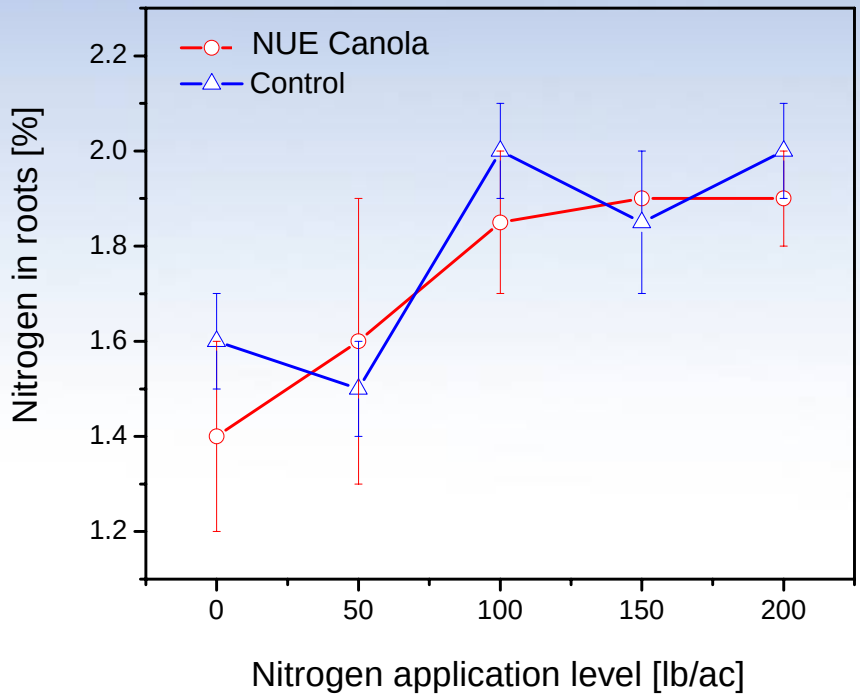
There are no substantial compositional differences between NUE canola and control canola plants

No Significant Differences in N Content in Shoots and Roots

Shoots

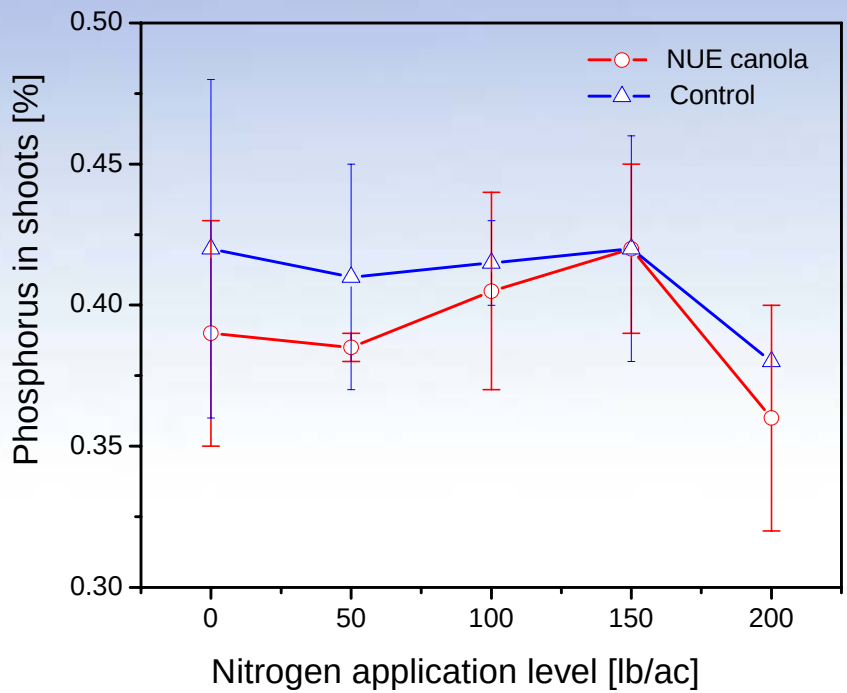


Roots

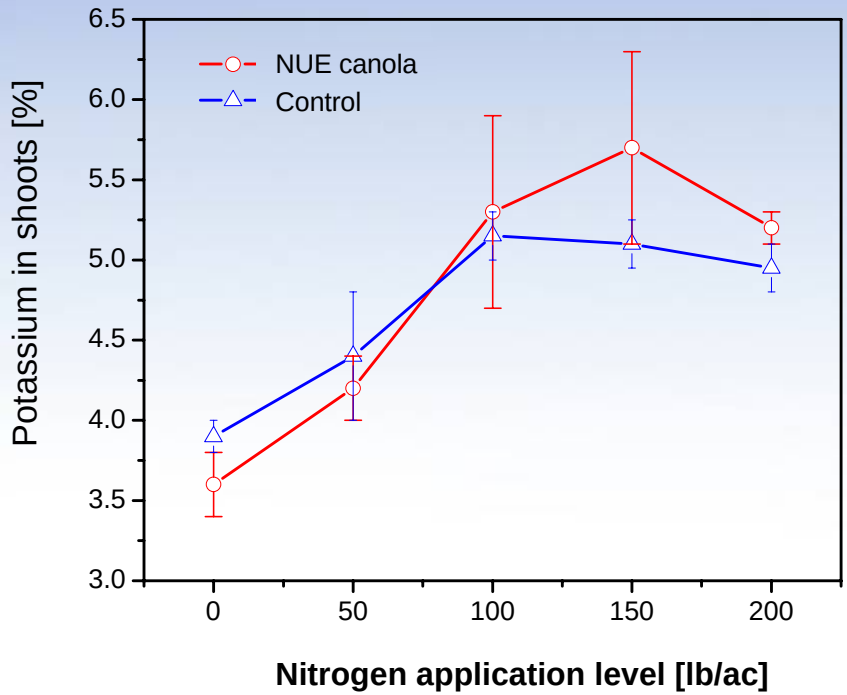


No Significant Differences in P and K Contents in Shoots

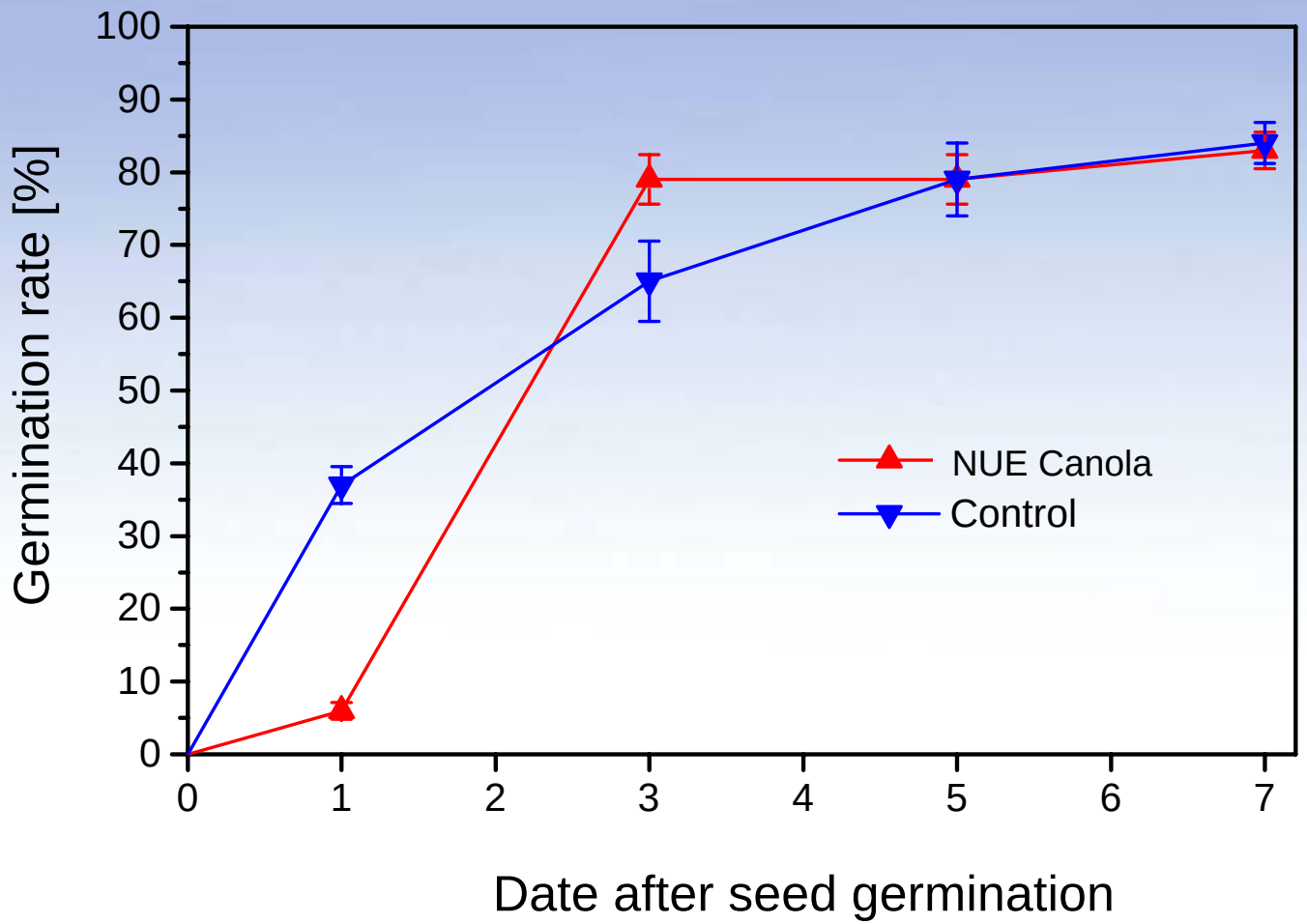
Phosphorus



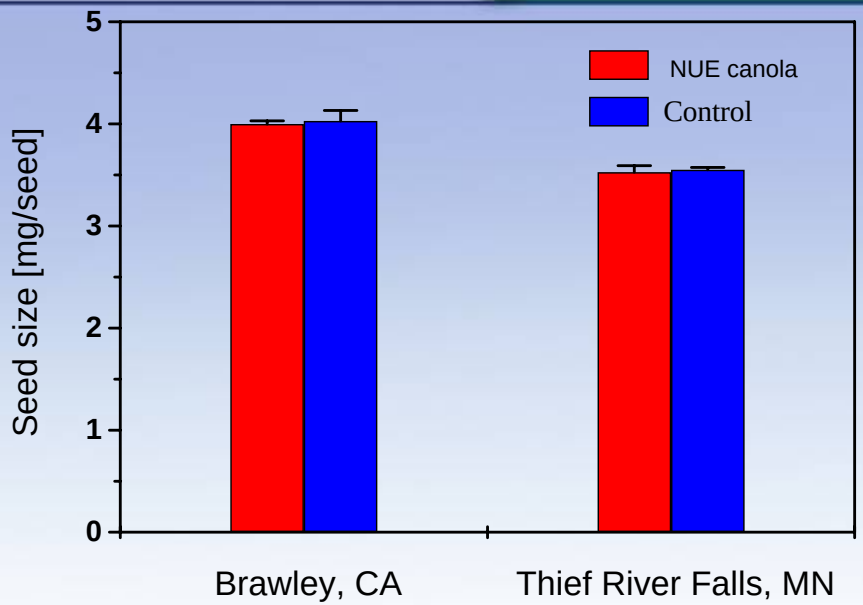
Potassium

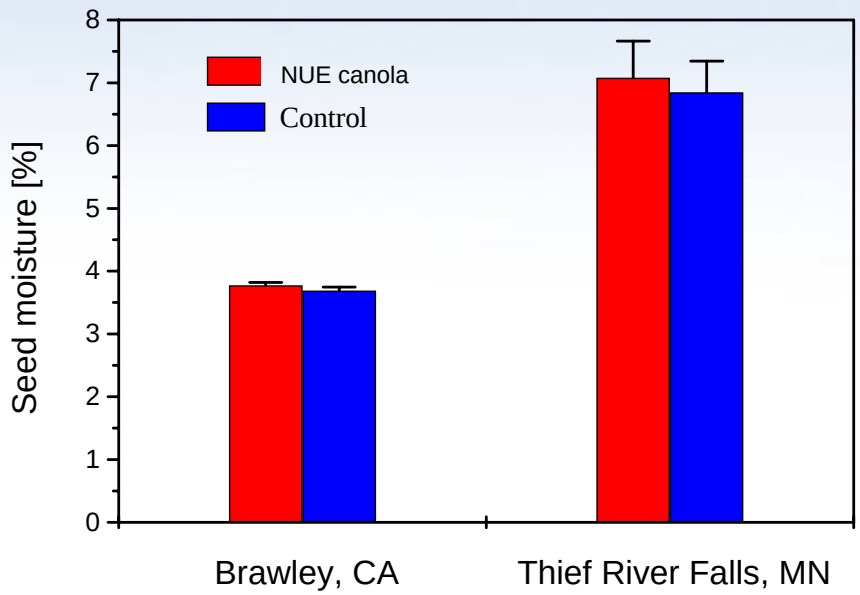


No Difference in Germination

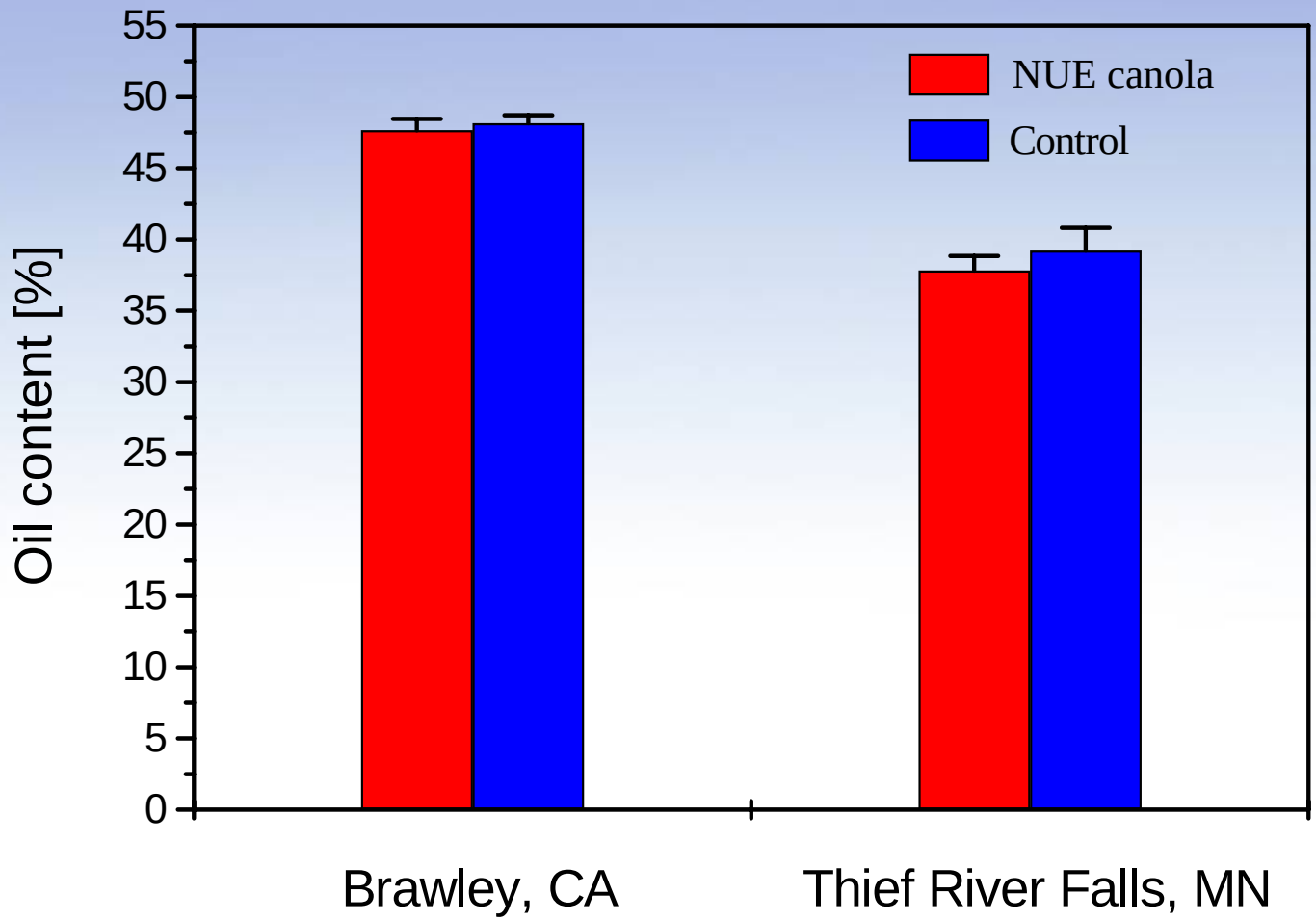


No Difference in Seed Physical Properties

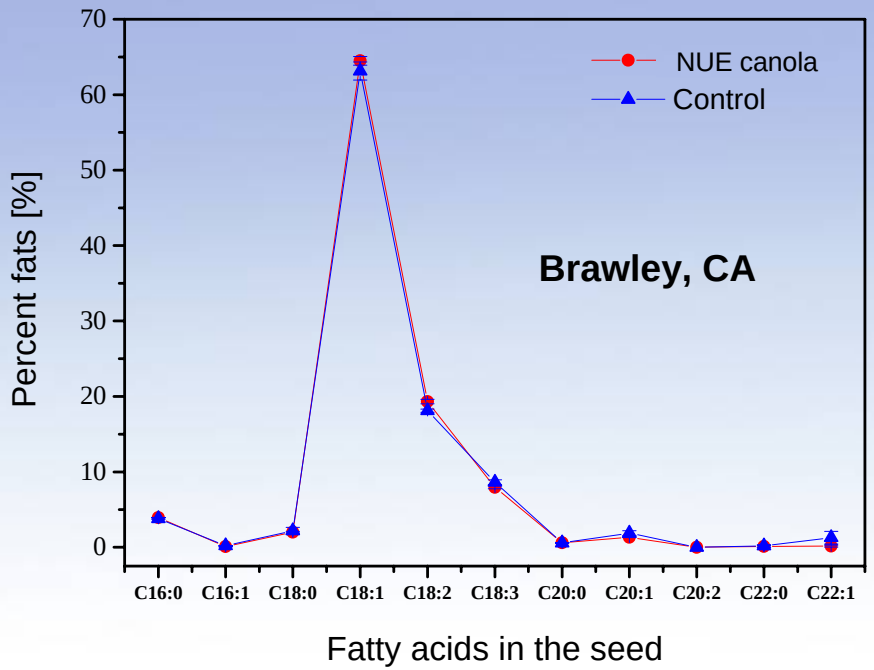


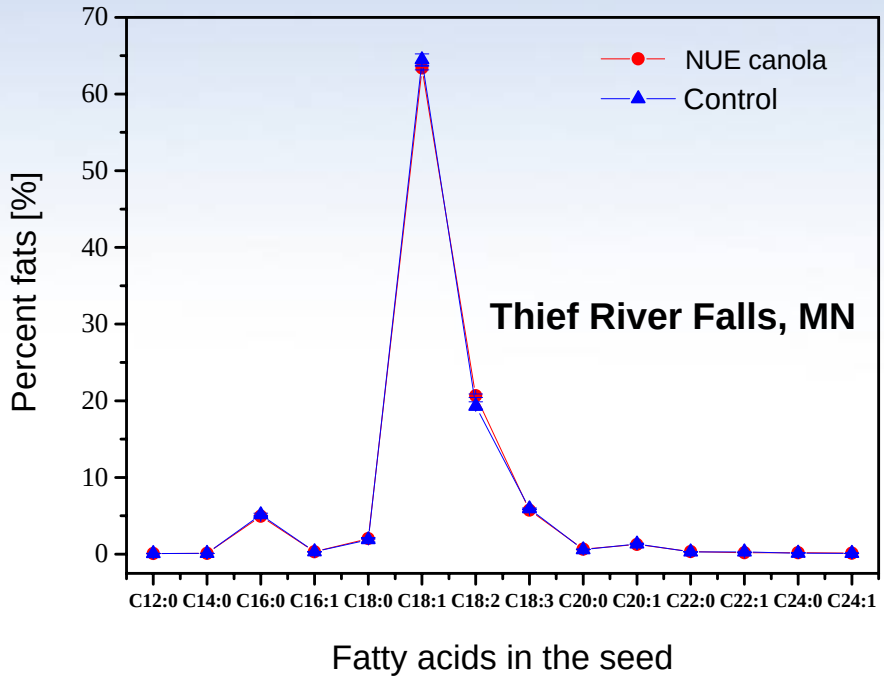


No Differences in Seed Oil %

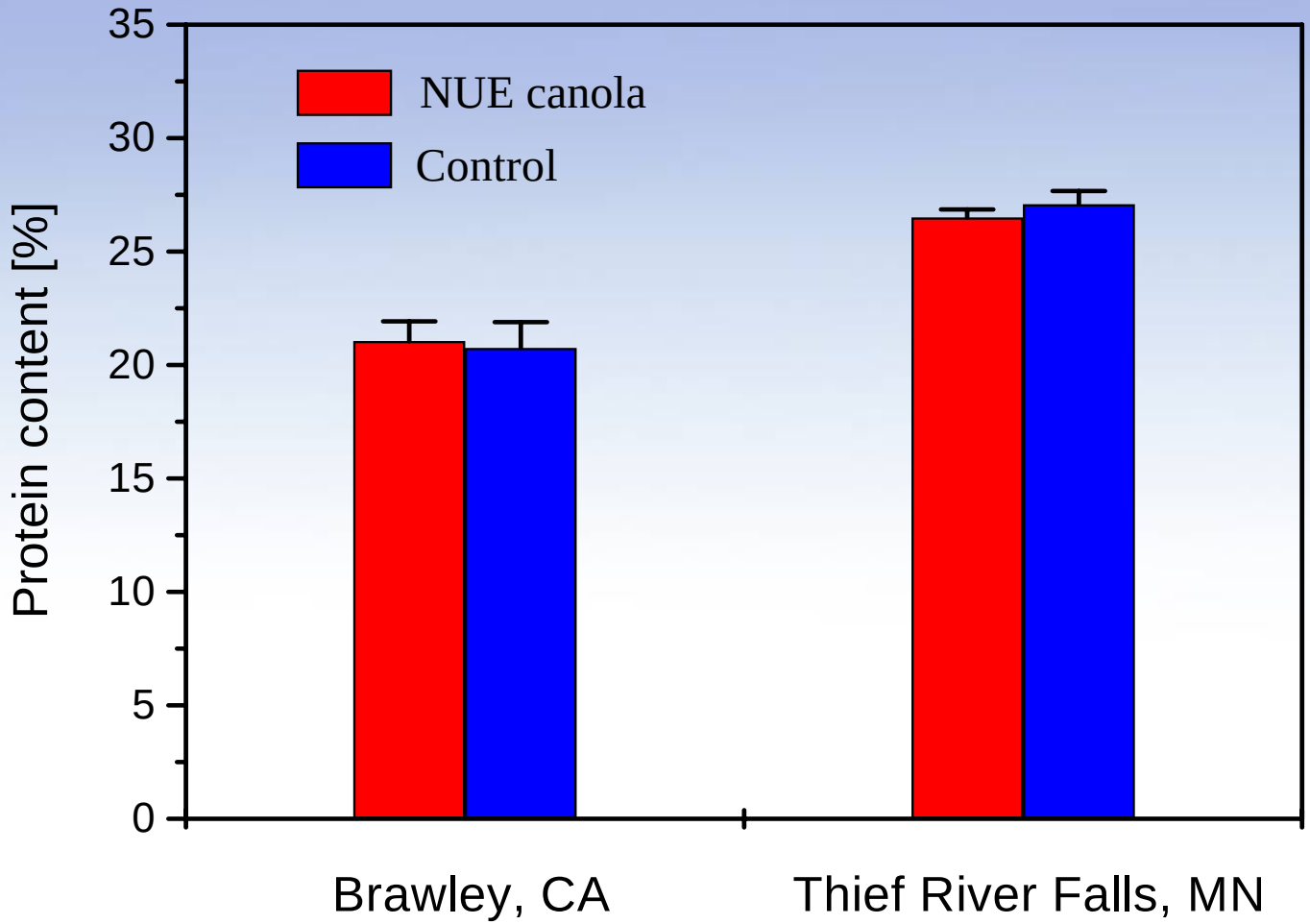


No Differences in Fatty Acid Composition of Oil

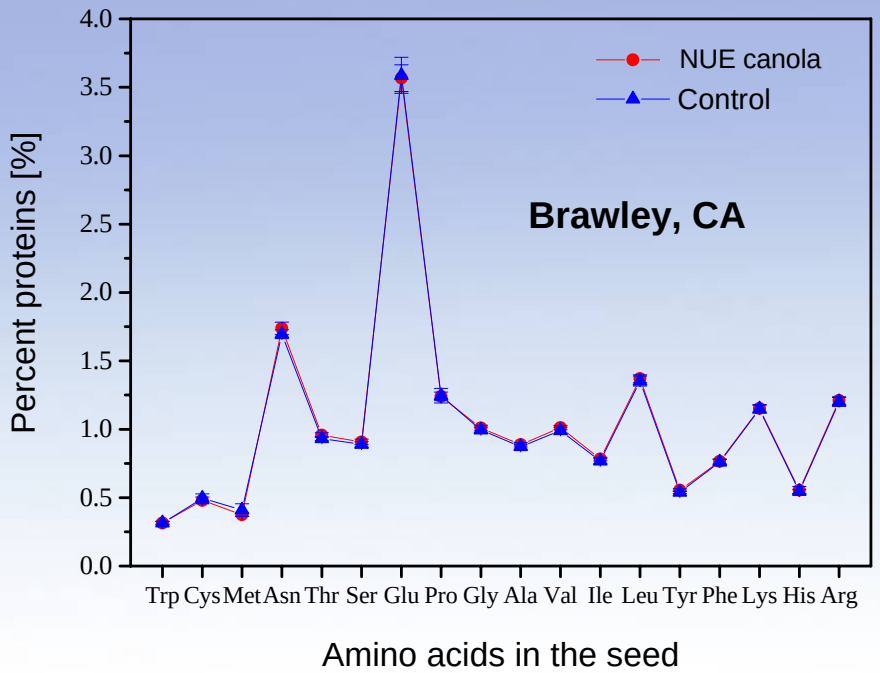


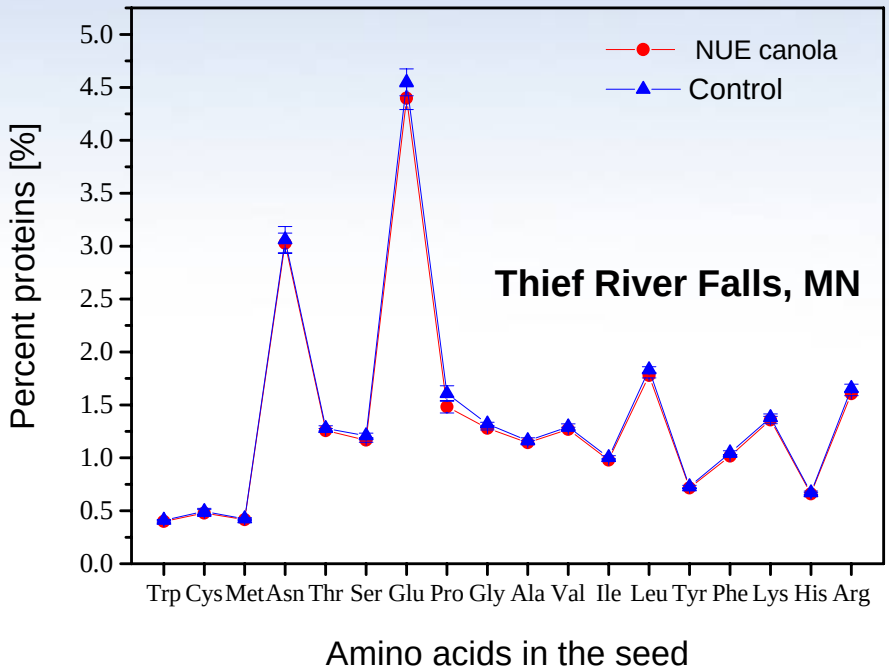


No Differences in Seed Protein %

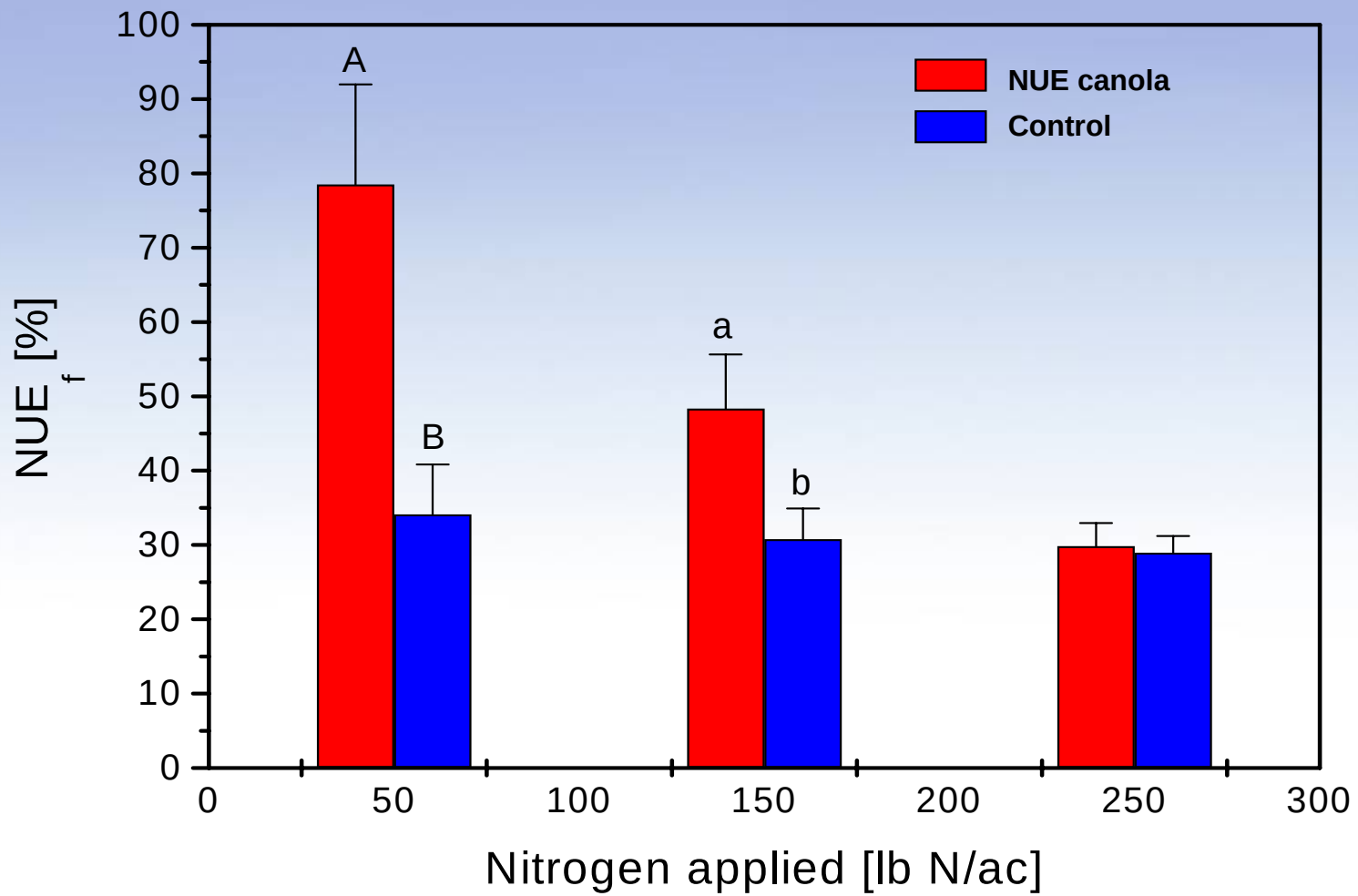


No Differences in Seed Amino Acids





NUE Canola Plants Use N Fertilizer More Efficiently

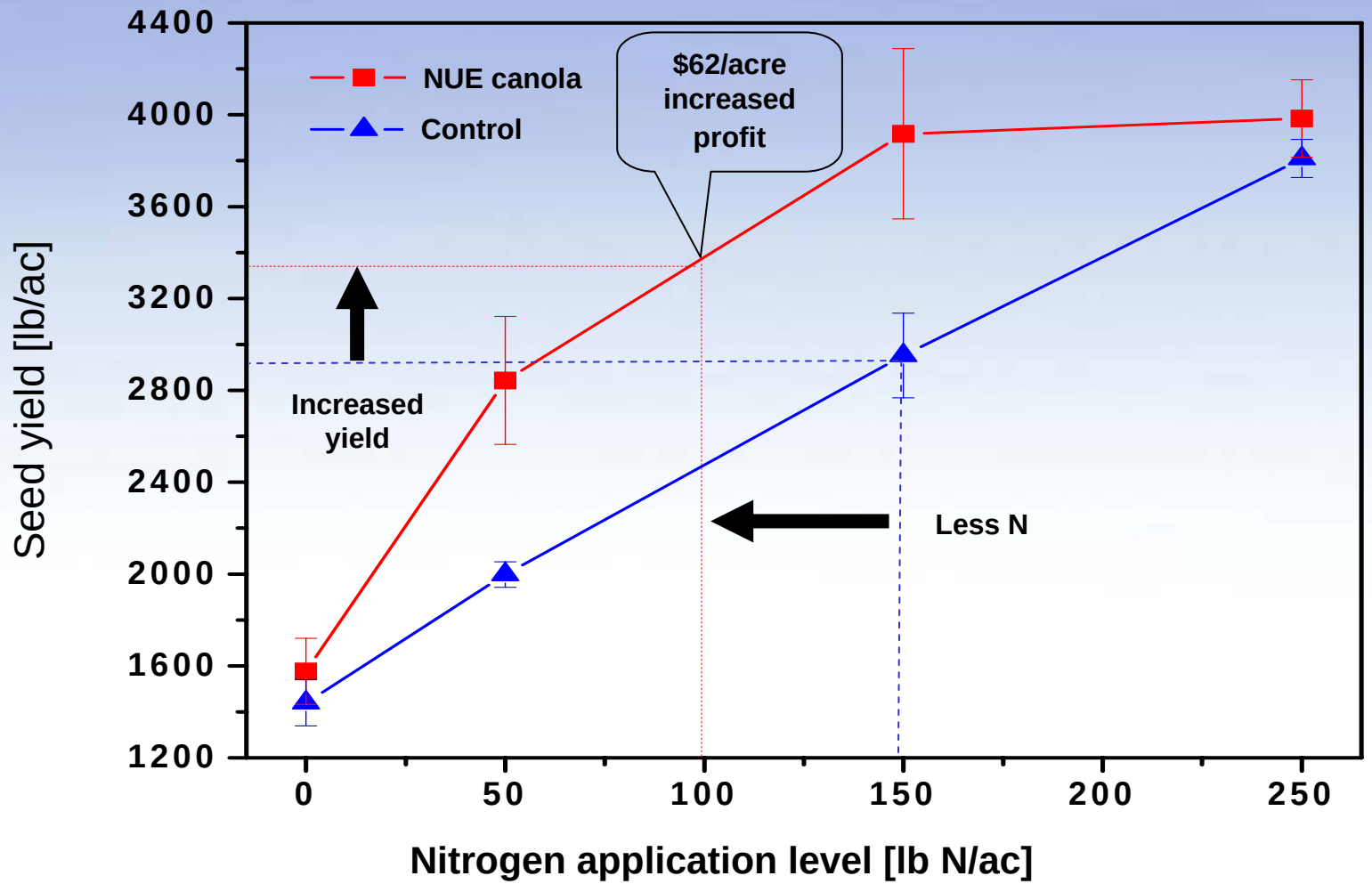


Data from Brawley California, 2002-2003

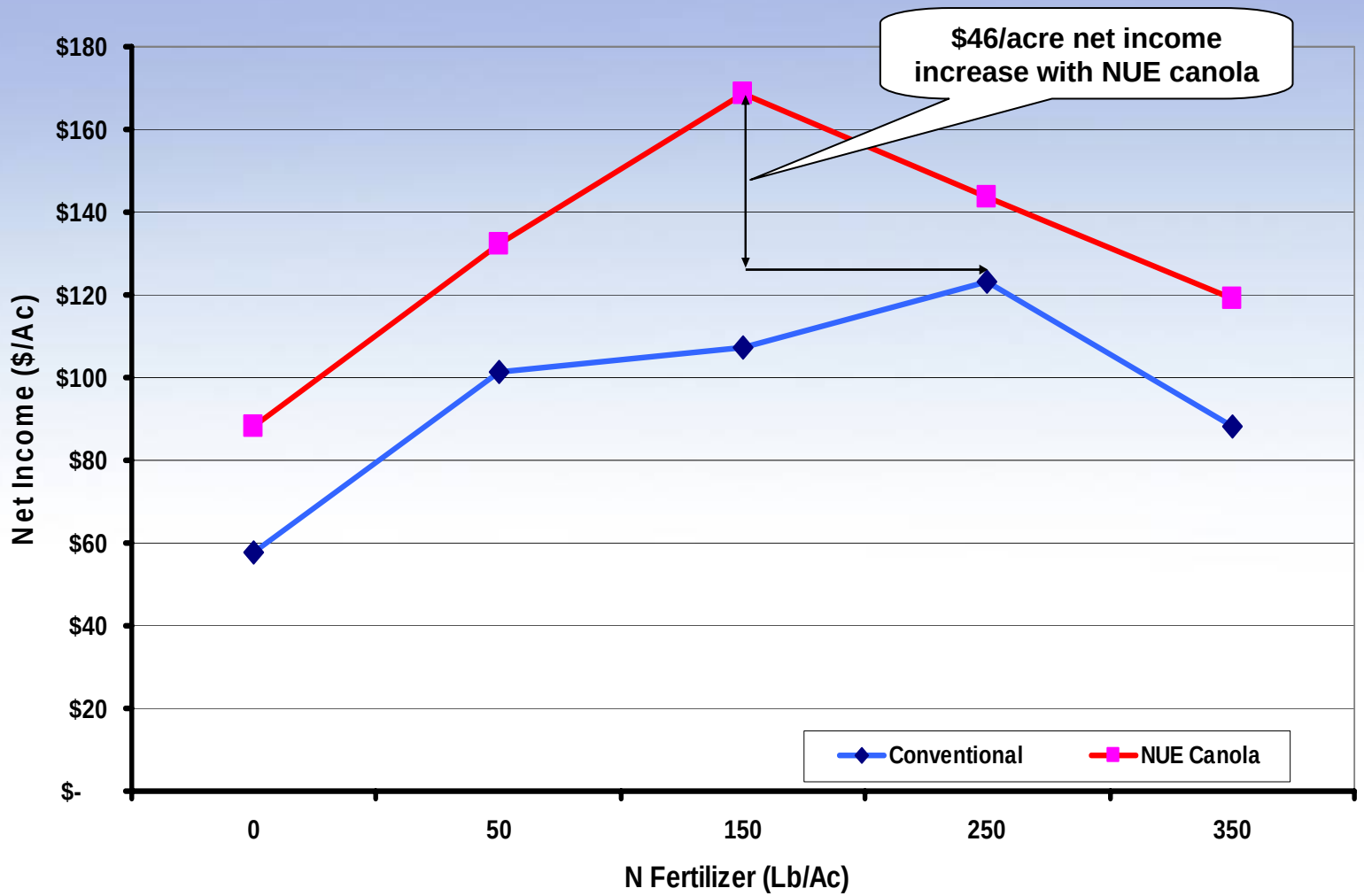
Economic Impact of NUE Gene

- N Reduction: Field trials from four continuous crop seasons demonstrate that the NUE gene can reduce N fertilizer requirements by up to 66% in canola
- Yield Increase: At conventional N application rates, the NUE gene increases yield by 30-40%

Compromise in Required N Reduction Situations



NUE Canola Economics



NUE Technology Can Preserve Existing Markets

- In the past ten years Denmark has decreased nitrogen fertilizer use by about 48% with the protein content of winter wheat declining by 17% (from 12% to 10% in dry matter)*
- Applying the NUE technology to wheat, a 48% reduction in N would result in a 40% yield (protein) increase

* Fertilizer Nitrogen Use Efficiency – British Sulfur Conference, 2004

NUE Technology May Open New Markets

- Reducing the amount of fertilizer required to grow a viable crop by 50% to 60% may make fertilizer affordable to currently inaccessible markets in Africa and South America
- Our salt tolerant technology will allow crops to be grown in previously nonproductive areas. This new production can create a market for fertilizer that does not currently exist