Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Managing Canola Nutrition for Crop Vigor, Yield and Nutrient Efficiency

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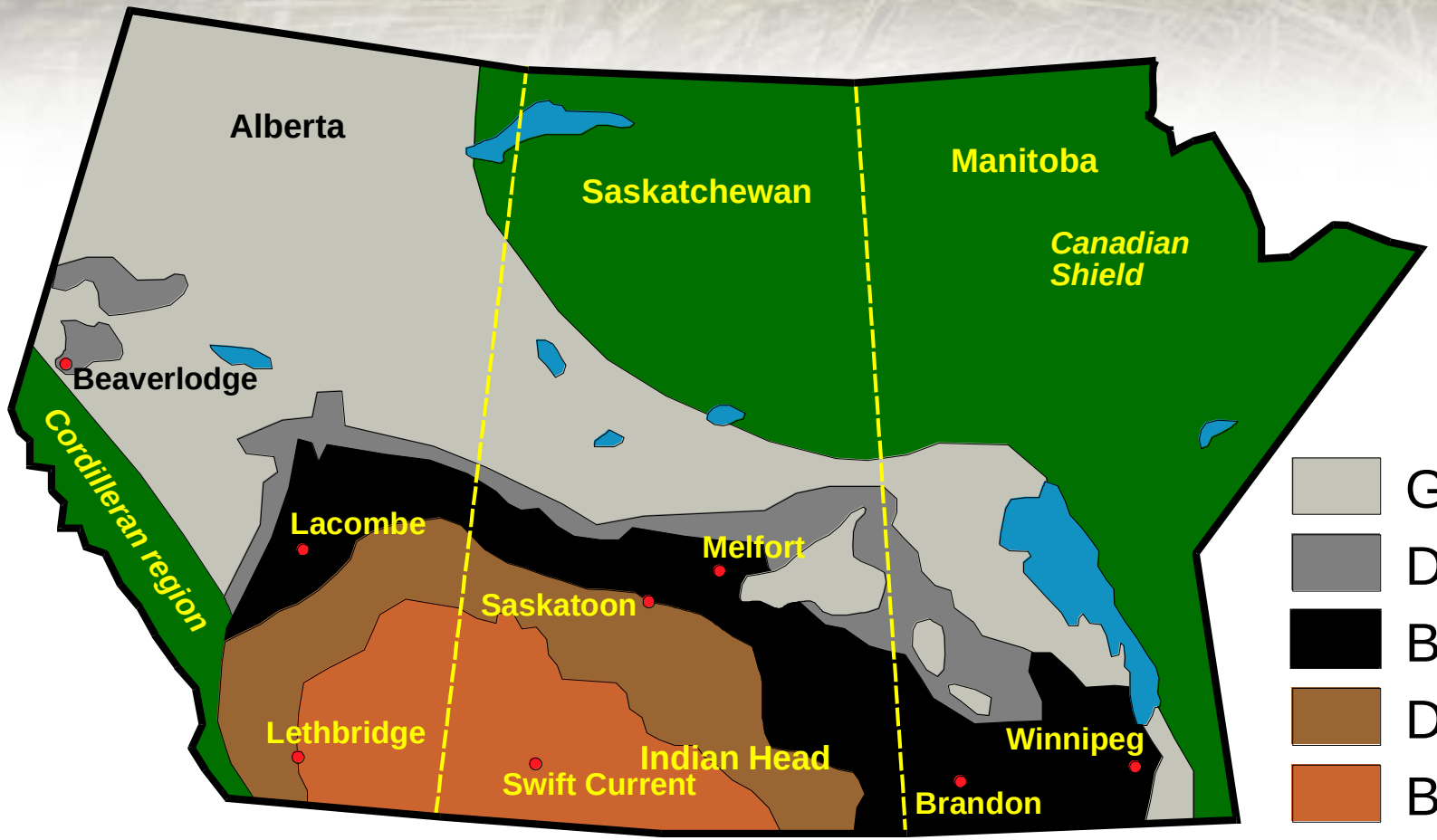
Canada

Canola is Hugely Important for Canadian Agriculture

- Generates about ¼ of all farm cash receipts
- Recently surpassed wheat for production value
- Contributes about $19.3 billion to Canadian economy, considering both production and value-added jobs
- About 90% of the production is exported
  - USA is largest market

Canola Growing Area in Canada

Major Soil Zones of the Prairie Region



Canadian Prairie Agriculture

- Soils are generally high in organic matter (~5%) with high CEC
- Most soils are pH 7.0 or above, although there are limited areas of high pH
- Seeding: late April to May
- Harvest: August to September
  - 90-120 frost-free days
  - Risk of frost in spring and fall
- Drought risk in most of region
  - Soil water recharged by winter snow
  - Highly variable seasonal precipitation

Environmental Conditions Have a Large Effect on Nutrient Management

- Yield potential and crop nutrient demand
- Pathways and amount of nutrient loss
- Mobility of nutrients in the soil
- Root growth and distribution
- Optimum source, placement and timing
- Impacts on N, P and S, the major nutrients for canola production

Need to consider soil characteristics and weather in nutrient management decisions

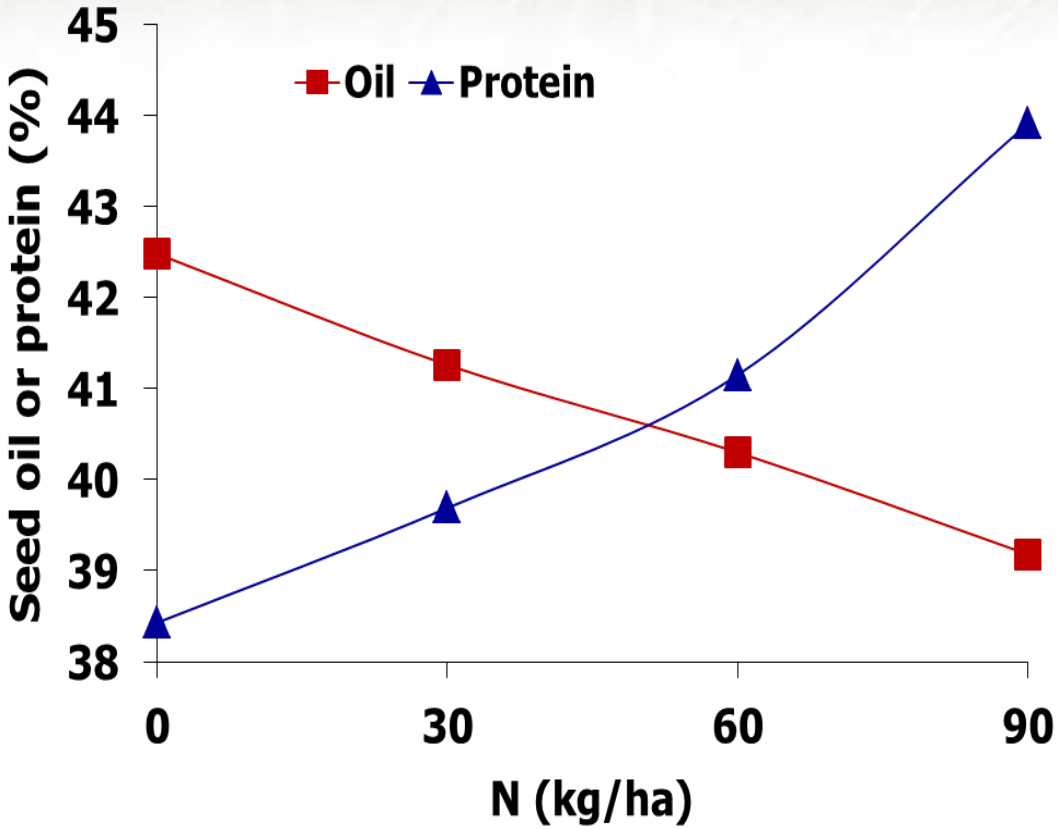
Canola is a Heavy User of Nutrients

- Adequate nutrient supply is critical for high canola yield and quality
- Removal of N, P and K is slightly higher than that of wheat on a per tonne basis
- Requirement and removal of S is much higher than that of wheat
  - High protein content
  - Glucosinolates
- Efficient nutrient management is important for both economics and environment

Nitrogen is Critical for Canola Growth

- Required for optimum yield
- Usually most limiting nutrient
- Largest fertilizer input
- Nitrogen can also affect canola quality

Nitrogen Increases Protein but Decreases Oil in Canola

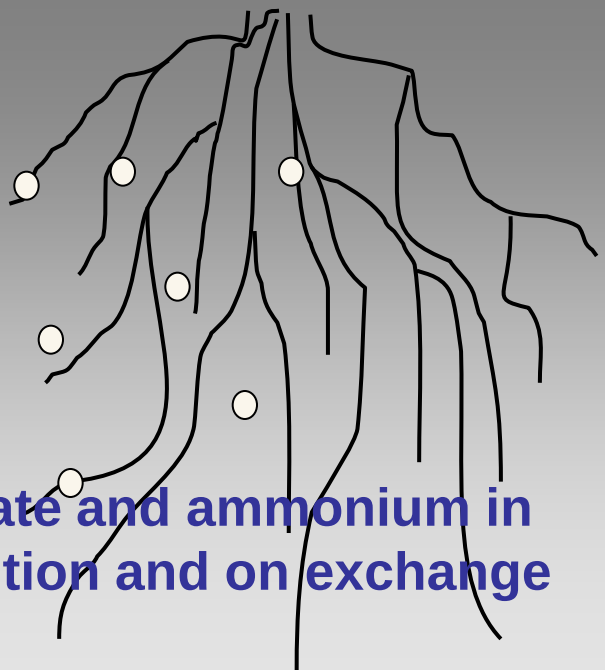


General Symptoms of Nitrogen Deficiency

- General yellowing,
  - More severe in older leaves
- Slow growth
- Stunted plants
- Fewer leaves
- Less branching
- Lower protein
- Early maturity
- Limited yield potential

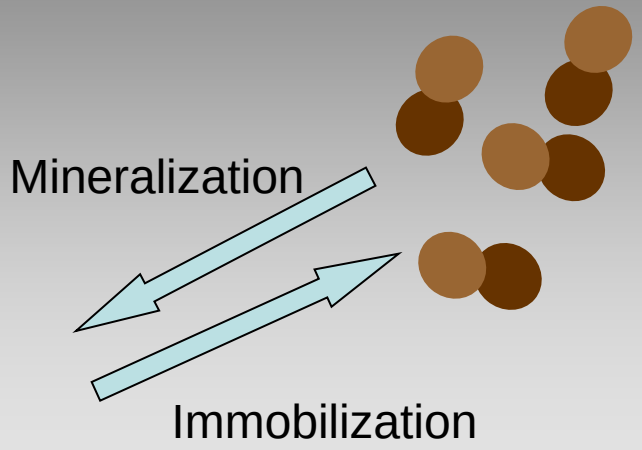
Plants Access N from Soil

Fertilizer additions make up the difference between crop demand and soil supply



Nitrate and ammonium in solution and on exchange

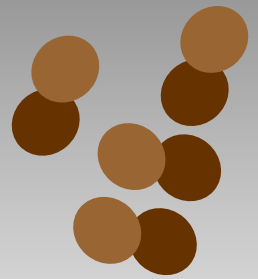
N released over the season by mineralization



Three Management Areas to Consider

Manage the crop to capture as much N as possible

Manage the soil and landscape considering N dynamics



Manage fertilizer source, rate, time and placement for best efficiency

Many Factors Affect Crops Ability to Capture N

Soil Characteristics

Weeds, diseases, insects

Fertilizer Management

Tillage system

Crop Genetics

Crop rotation

Seeding management

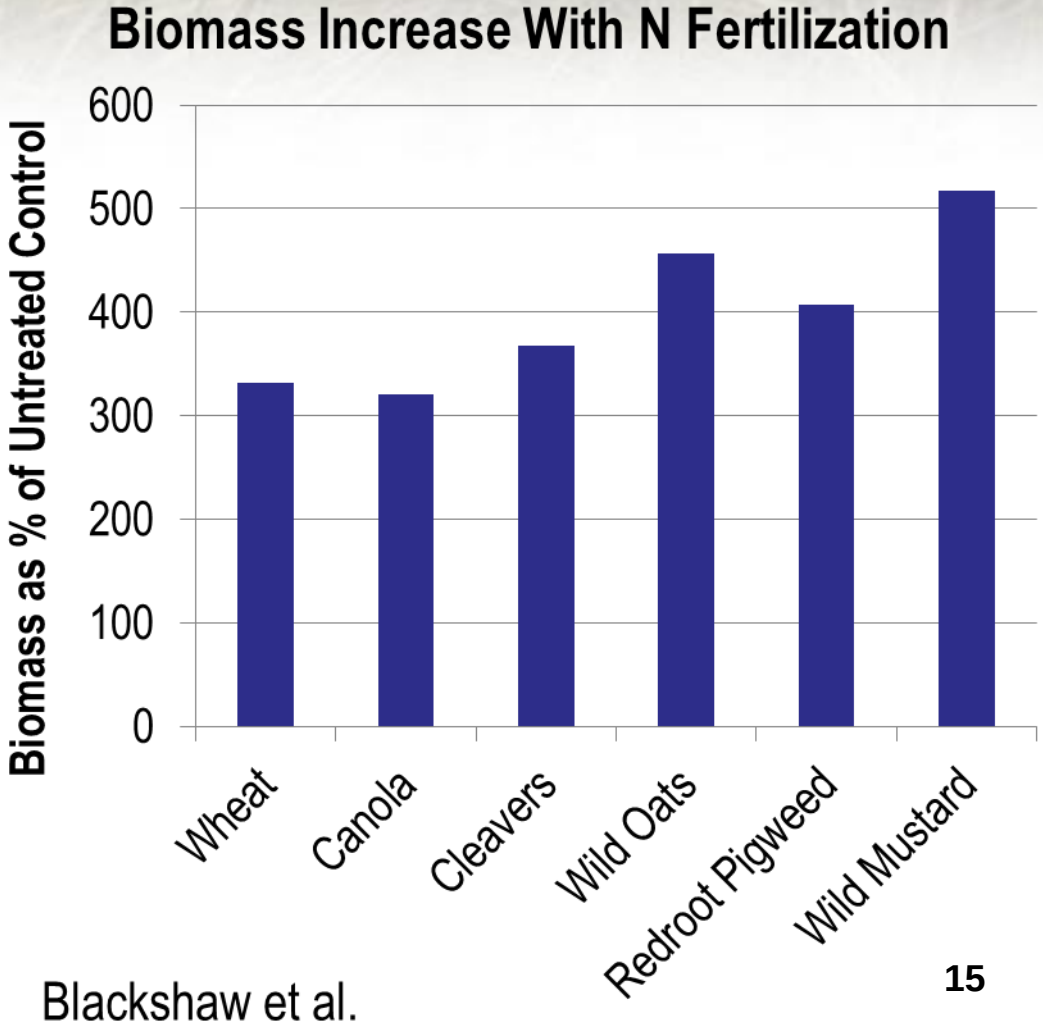
Improve Crop Competition with Weeds and Microbes for Solution Nitrate

- Fast growing plants have root systems that better use soil N
- Genetics?
  - Select for early emergence, rapid root growth and early biomass accumulation
- Agronomics
  - Early seeding with high seeding rate
  - Effective starter fertilizer for pop-up
  - Quick crop emergence
  - Good weed control
  - Fall-seeded or perennial crops

Beneficial for overall crop production – not just nutrient uptake

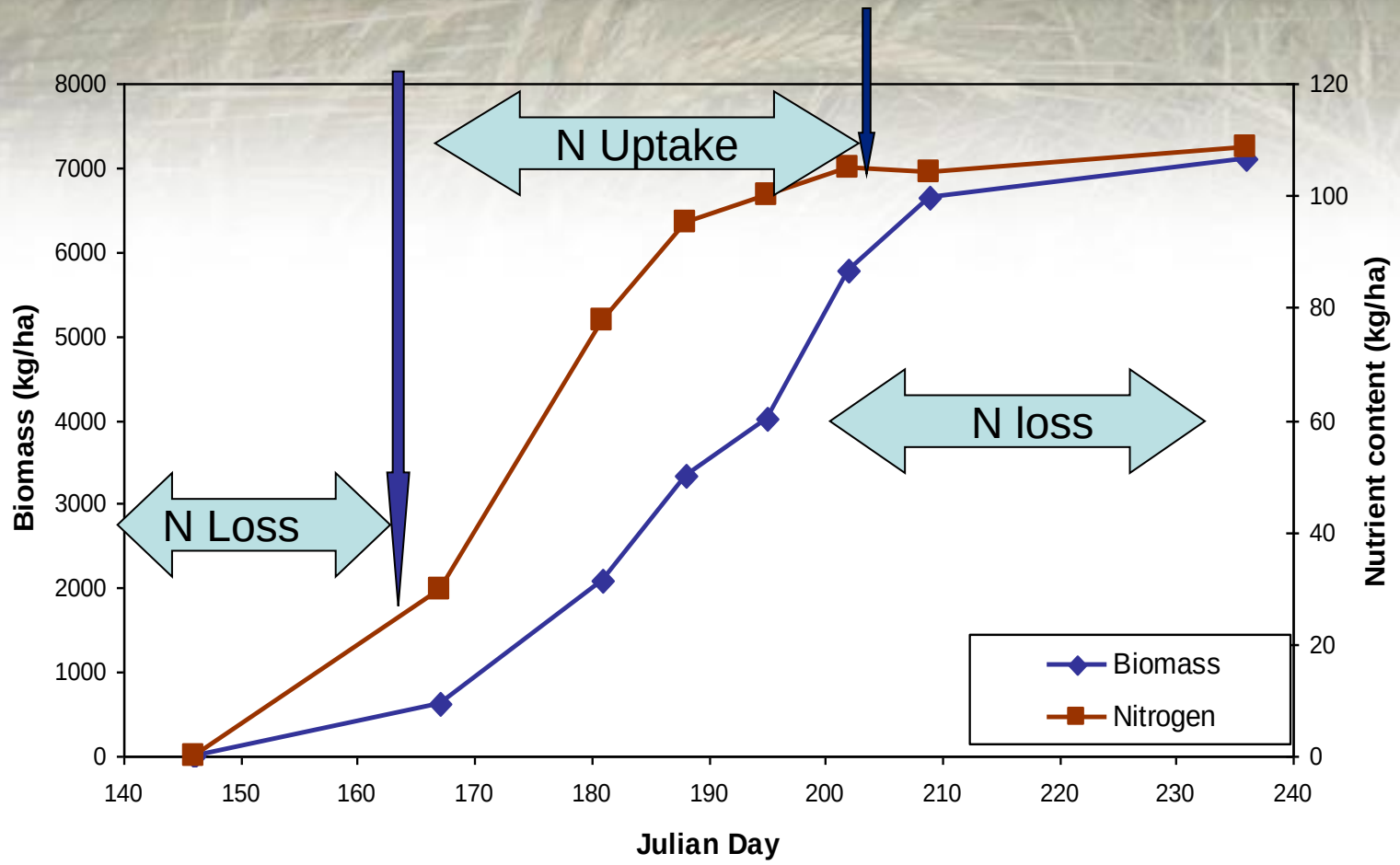
Weeds can be more N-responsive than crops

- Remove weeds early to reduce competition
- Banding N below the soil surface gives crop better access than weeds
  - Many weeds are shallow-rooted
- Optimize crop vigour to help canola compete



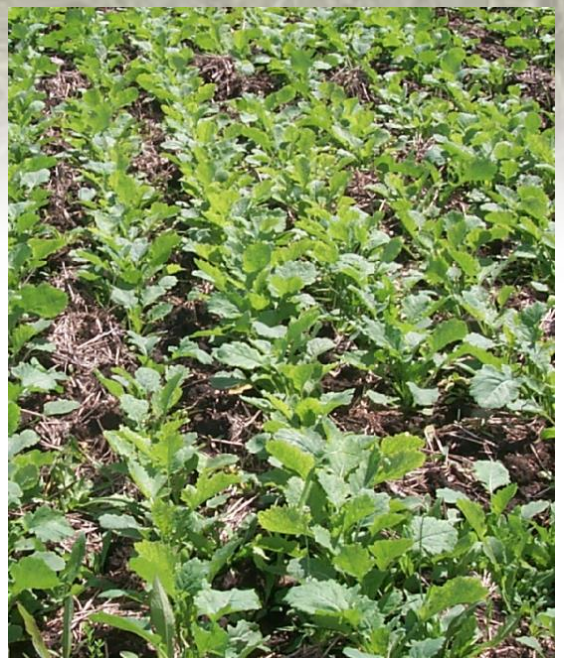
Blackshaw et al.

More rapid establishment increases competitiveness



Vigorous growth increases crop ability to capture N

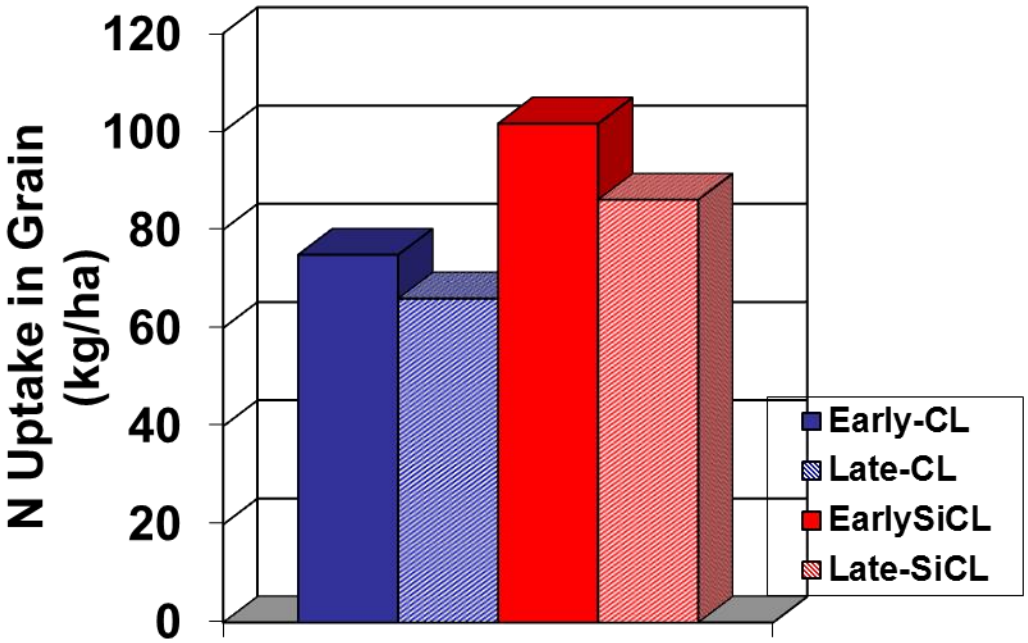
Early Season Establishment



- Early seeding
- Good seed vigour
- Seeding technology
  - Seed bed quality
  - Residue management
  - Safe rate of seed-placed fertilizer
  - Opener and packer system suited to crop and environment
  - Conservation of seed-bed moisture
  - Removal of weeds, diseases and insects

Nitrogen Recovery Increased with Early Seeding

- Higher yield with early seeding date
- Earlier establishment increased N recovery in the grain

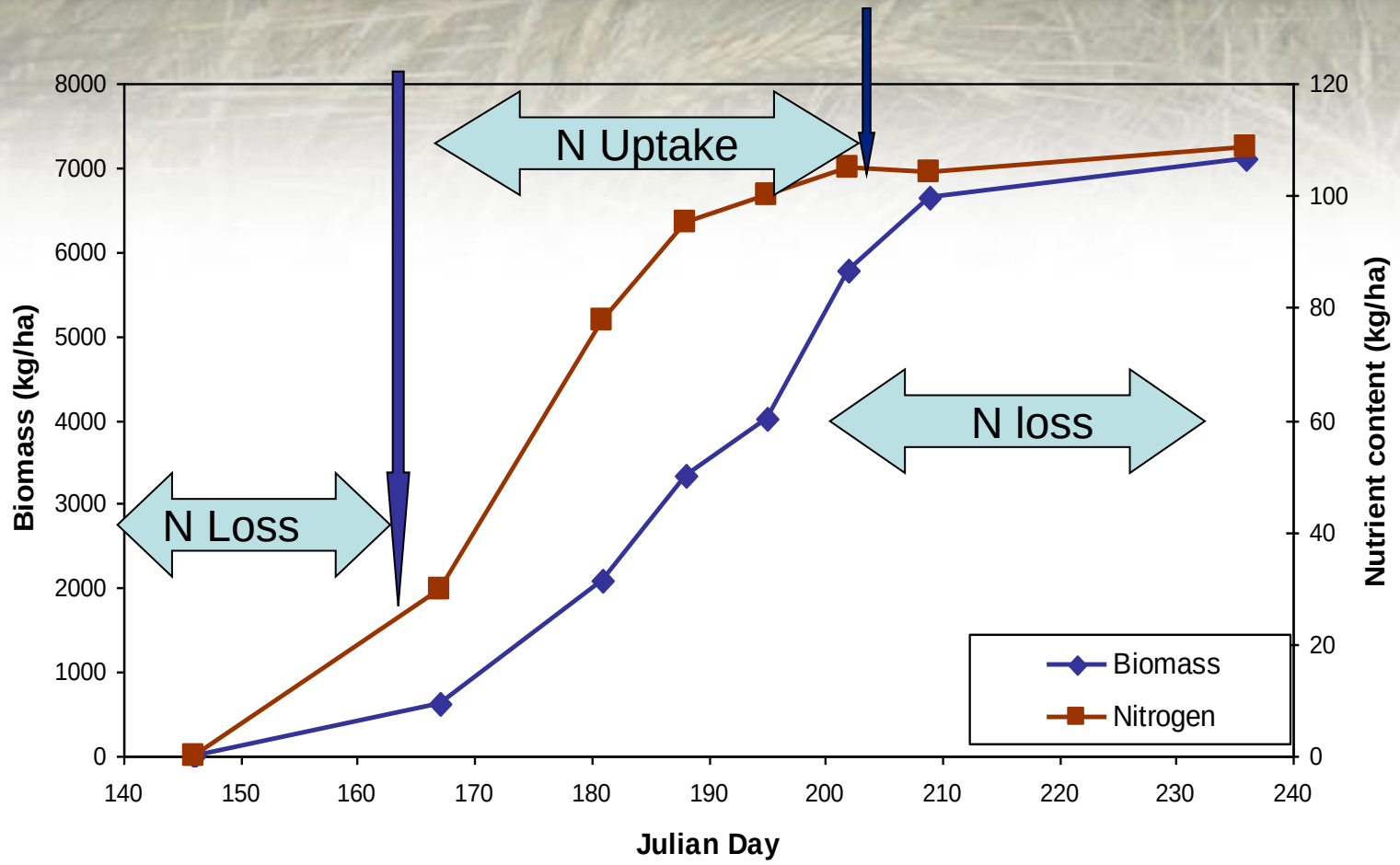


Basic Fertilizer Management Tools are the “4 Rs”

- Right Rate
- Right Source
- Right Timing
- Right Placement

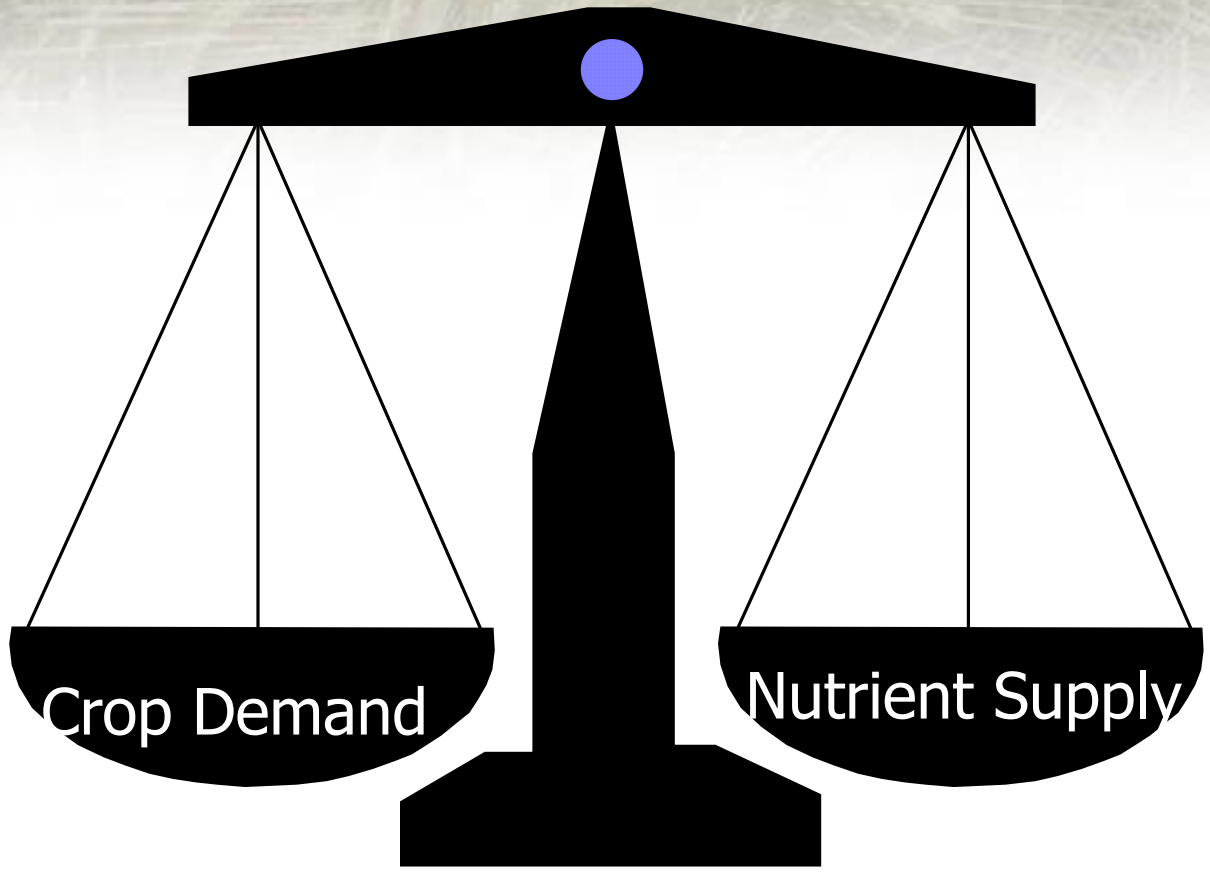
Matches Rate, Source, Timing and Placement to Field Conditions to Improve Nutrient Use Efficiency

Amount and Timing of N Supply Must Match Crop Demand



For Optimum Yield and N Use Efficiency

Effective Nutrient Management Balances Crop Demand with Nitrogen Supply in Both Rate and Timing of Supply



Fertilization = Crop demand - Soil Supply

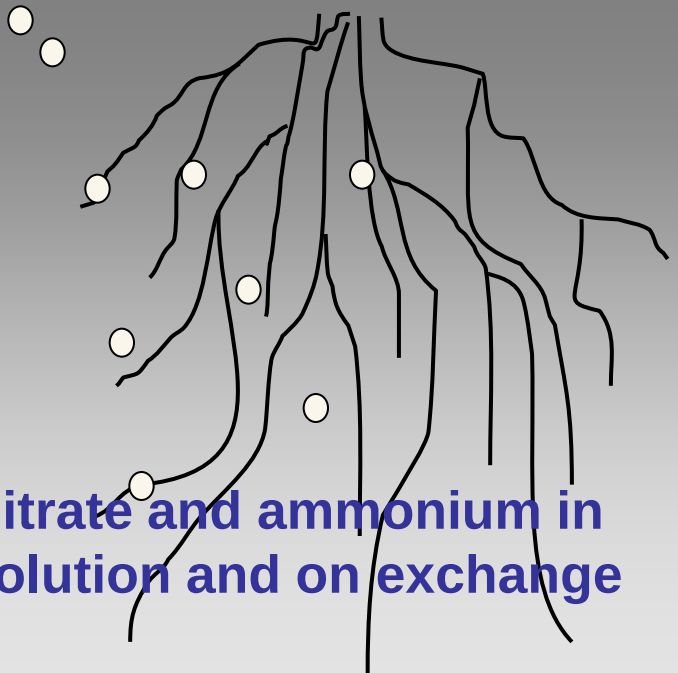
How Much Nitrogen is Needed by a Canola Crop?

- A 2.2 t ha^{-1} canola removes about 85 kg N ha^{-1} in the seed
  - About 50 kg more taken up but recycled in residue
  - Total of about 135 kg needed for growth
- Crop demand will be affected by yield potential
- Supply includes soil N and nutrient applications

Plants Access N from Soil

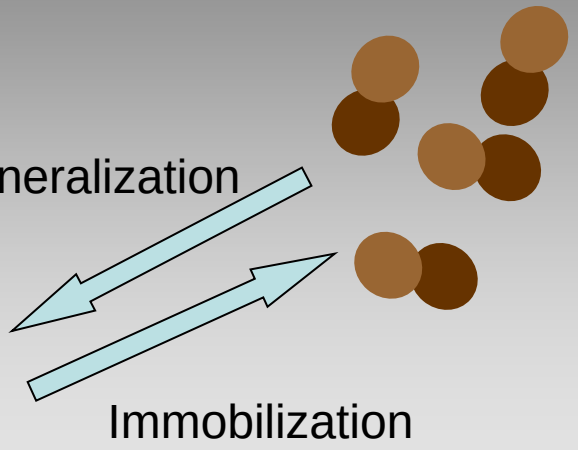
Fertilizer additions make up the difference between crop demand and soil supply

Accurate prediction of soil N supply is needed for selection of proper rate to avoid over- or under-fertilization and improve NUE



Nitrate and ammonium in solution and on exchange

N released over the season by mineralization

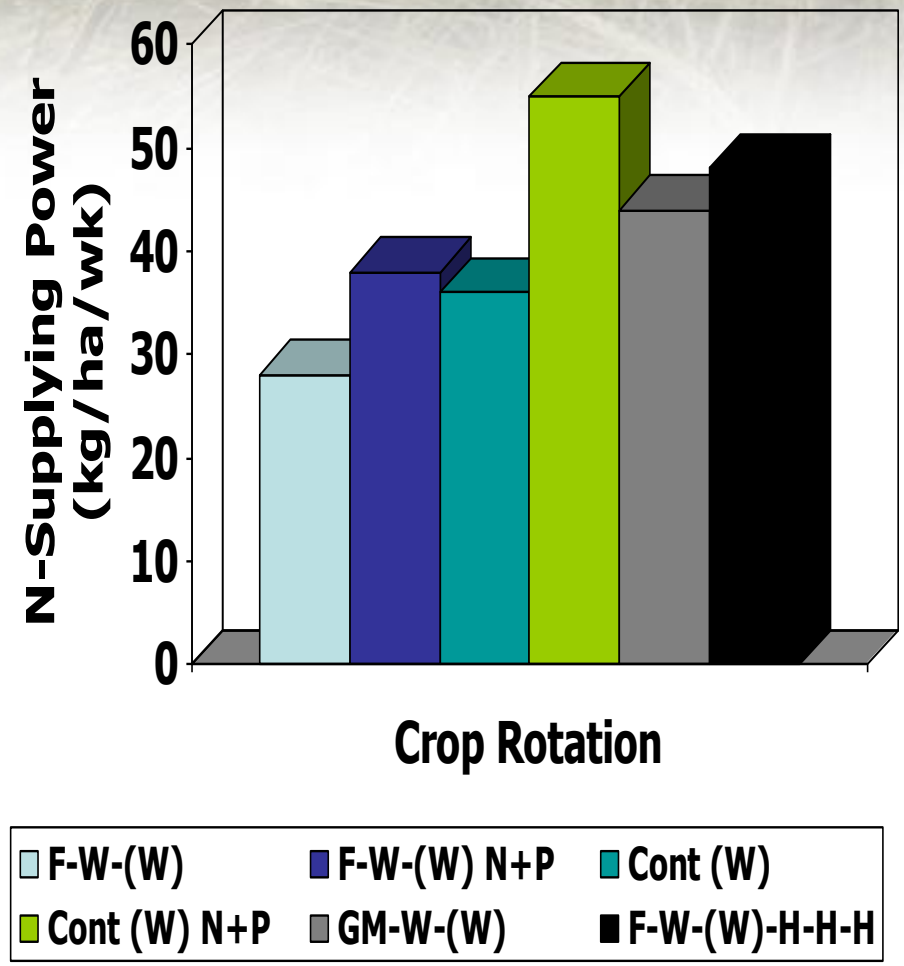


Consider Soil N Supply When Calculating N Application Rate

- Fertilizer = Crop demand – N from soil
- Soil N supply influenced by factors such as
  - Previous crop removal and fertilization
  - Release from manure
  - Release from alfalfa and pulse crops
  - Long-term management
    - fallow, residue return, tillage system
  - Nitrogen loss before crop uptake

Soil N Supply is Influenced By

- Manures, alfalfa, pulse crop
- Previous years' crop yield and fertilization
- Long-term management
  - fallow, residue return, tillage system
  - Take advantage of past soil-building practices



Soil management practices will influence N dynamics

- Tillage
- Residue return
- Manure application
- Drainage
- Compaction

- Crop yield potential
- Microbial activity
- Microclimate
- Aeration
- Nutrient stratification
- Organic matter
- Nutrient cycling
- Rooting patterns

Affects both nutrient supply and demand

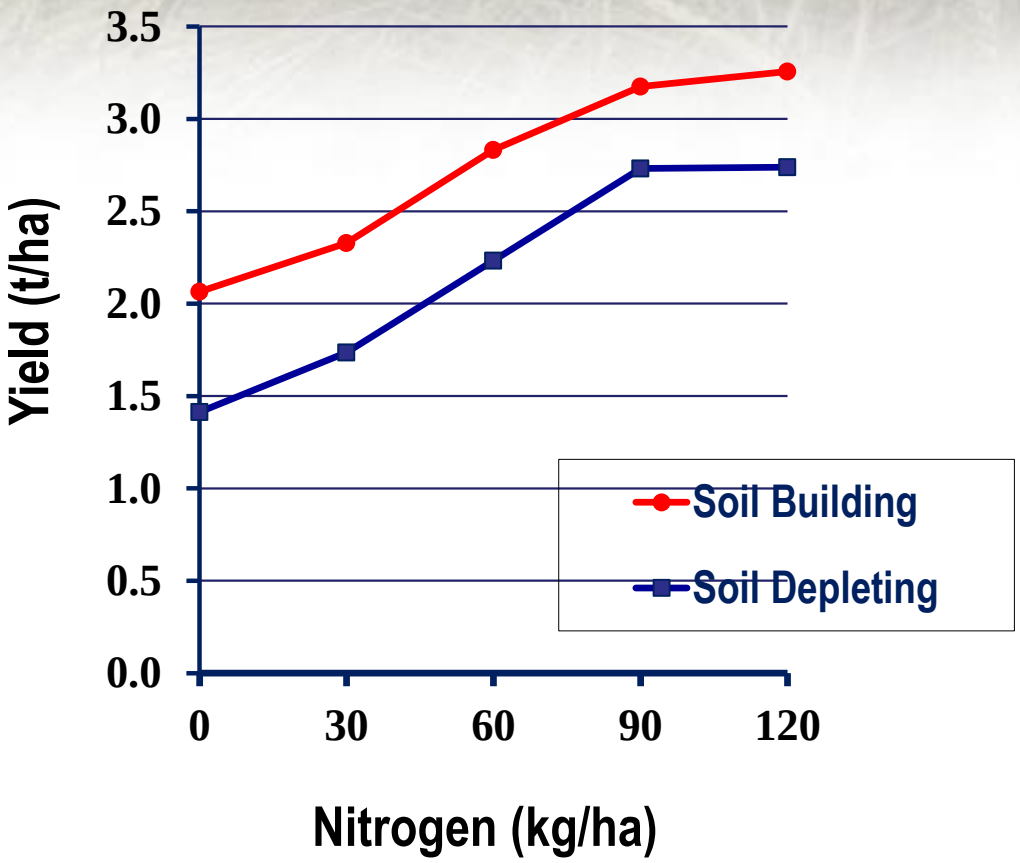
Conventional tillage and fallow systems may rely more on stored nitrate while soil building practices increase mineralization contribution

- Soil nitrate released and stored over fallow period
  - "Mine" organic matter to release N
- Intensive tillage increases mineralization and amount of nitrate in soil at seeding

- Continuous cropping and reduced tillage reduce the stored nitrate
- N fertilization and higher yield increase residue return to the soil
- May increase the importance of N mineralization from SOM and crop residues over the growing season

Building Soil Quality Improves Crop Yield Potential and Crop N Recovery Across N Rates

- Long-term no-till rather than intensive tillage
- Continuous cropping rather than fallow
- N fertilizer for optimum yield rather than "mining" rates



Lafond - Unpublished

Crop Rotation Influences N Supply

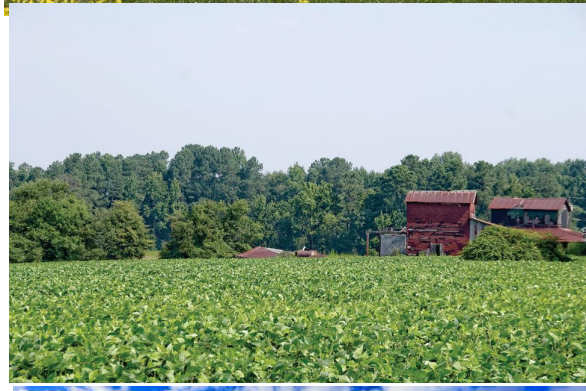
- Inclusion of legume crops
  - Improve N supply to following crop
- Intensification of cropping
  - More removal of N
    - Is it replaced or depleted?
  - Greater return of crop residues
    - Influences organic matter
    - Affects N mineralization






Cropping Sequence

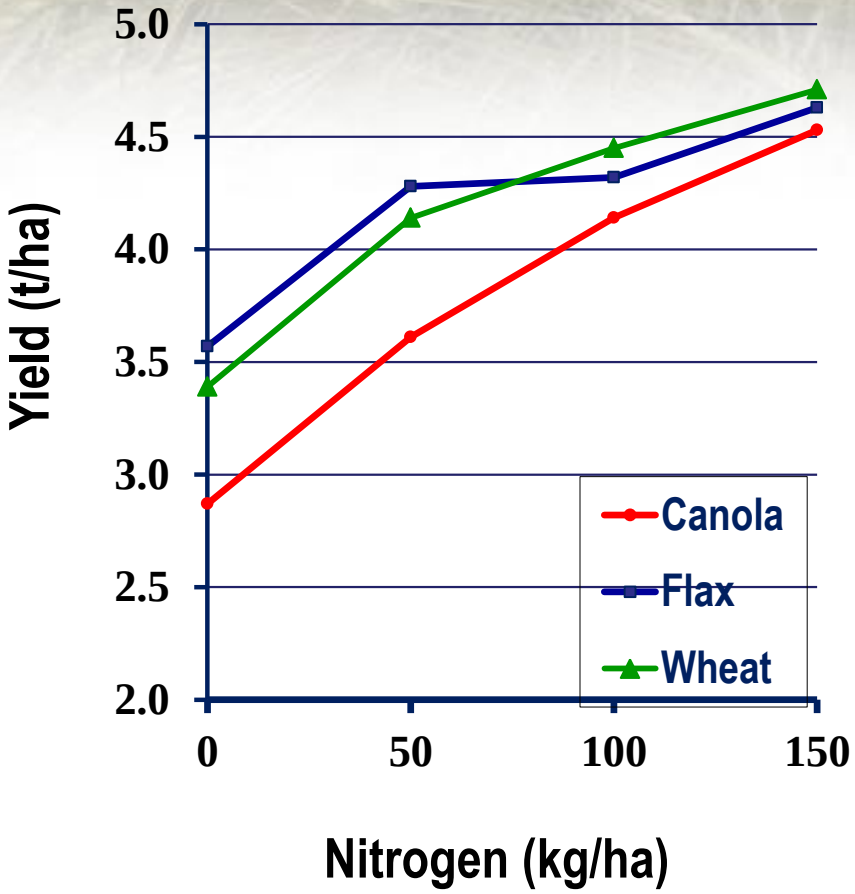
- Crop yield potential
  - Affects nutrients required by crop
- Nutrient cycling
  - Affects supply of nutrients from the soil
- Soil physical changes
  - Affect rooting and nutrient uptake
- Microbial associations
  - Influence cycling and plant access to nutrients



Affects crop yield potential and nutrient dynamics

Preceding Crop Can Affect N Response

- Canola may deplete N and increase N needed for maximum yield
- Affects disease profile, soil microbial community
- Diversified rotations often improve yield potential and N recovery



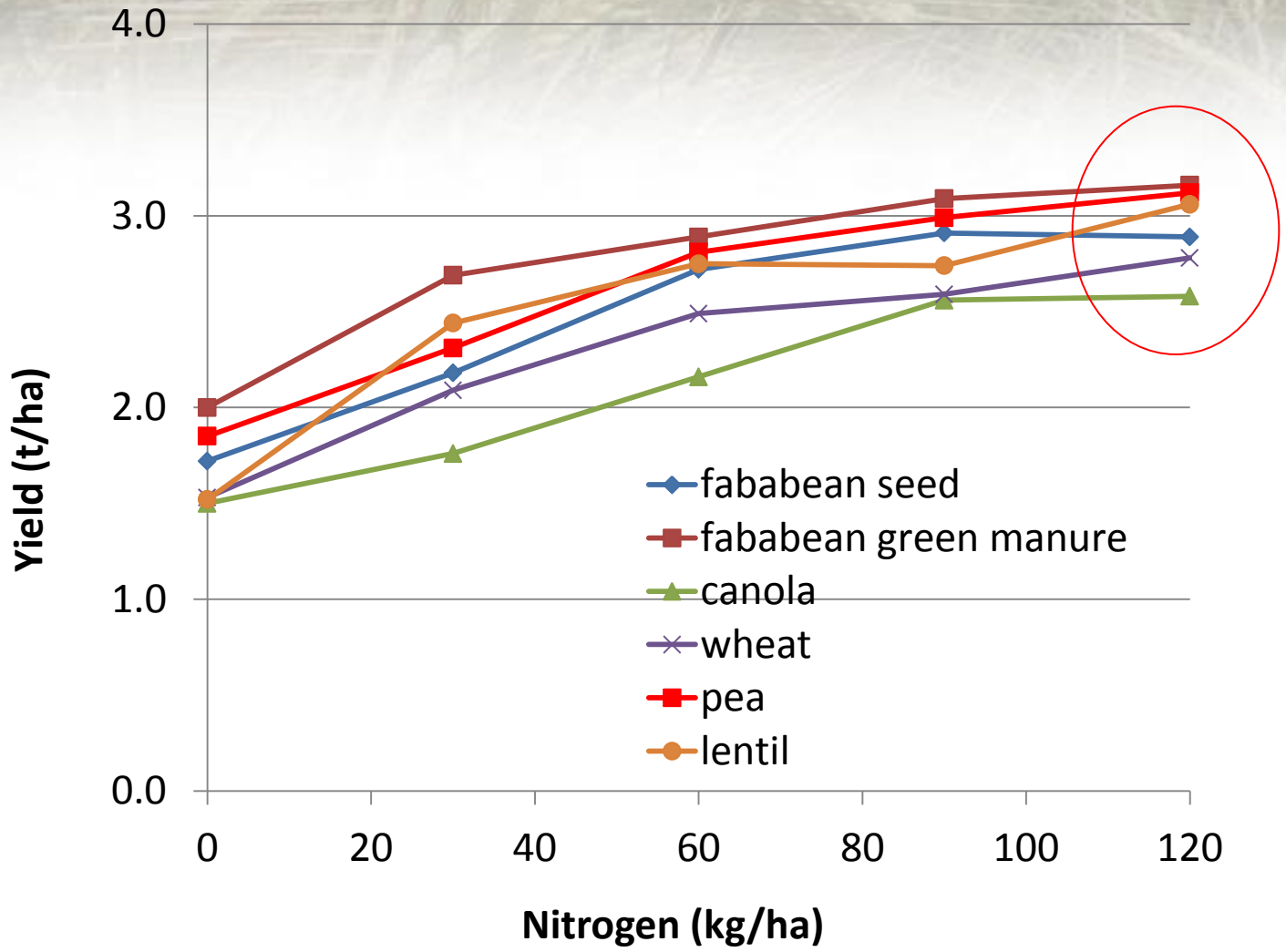






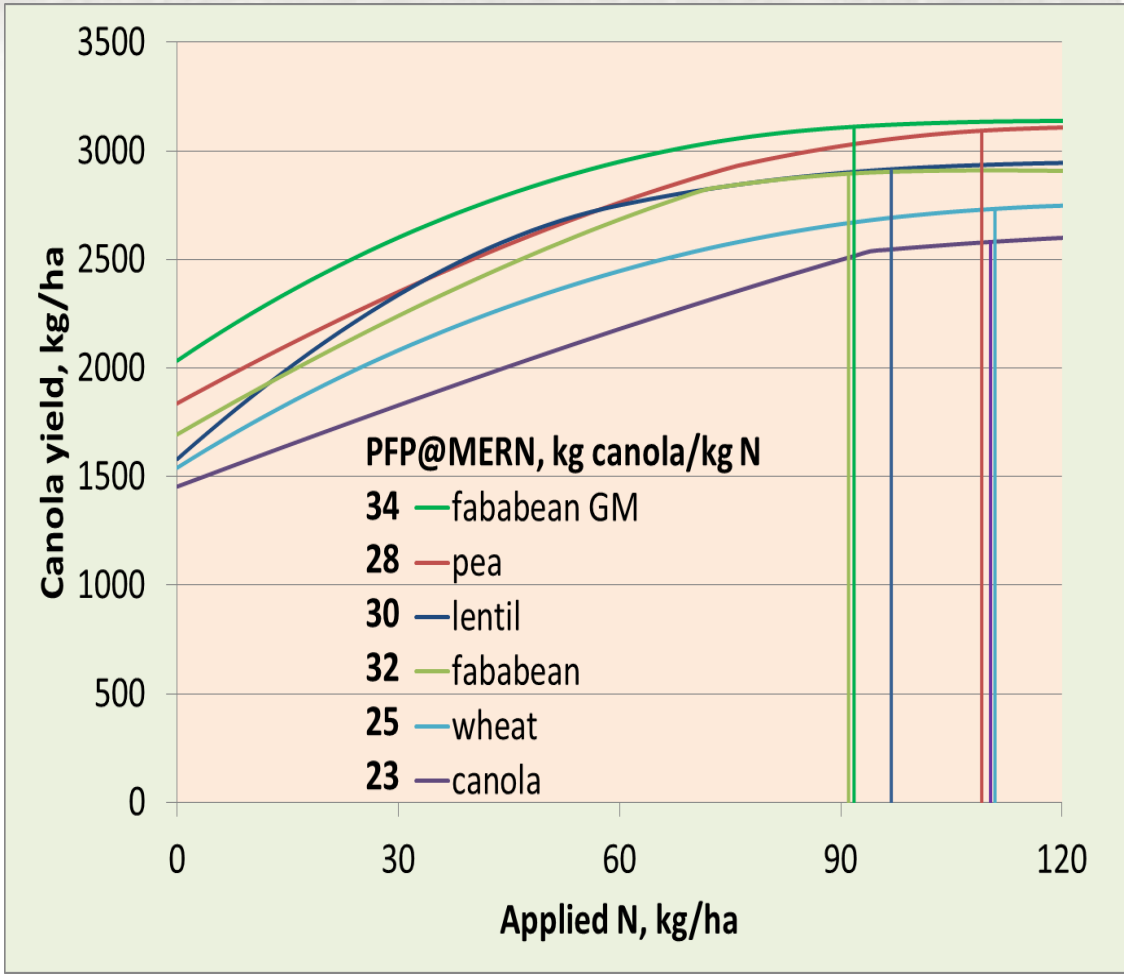
Forage crops, pulse crops or plough-down green manure legumes can increase N supply

Legumes provide both N and non-N benefits



Cropping Sequence Affects N Use Efficiency

- Legumes provided both N and non-N benefits
- Canola yield after wheat or canola was lower than legumes, even with high N input
- Lowest yield potential with canola on canola
- Nitrogen use efficiency declined with poor rotation
- Fababean GM (green manure) contributed N and raised yield potential.



Manage to Optimize Nitrogen Use Efficiency

- Nitrogen losses can be high, with poor management or under bad conditions
- Management practices can be used to minimize losses
  - Identify paths of N loss
  - Adopt practices to reduce those losses
- Most potential for improvement in systems with high potential loss
  - Moist, warm conditions
  - Fertilizer in the soil for a long time before crop uptake

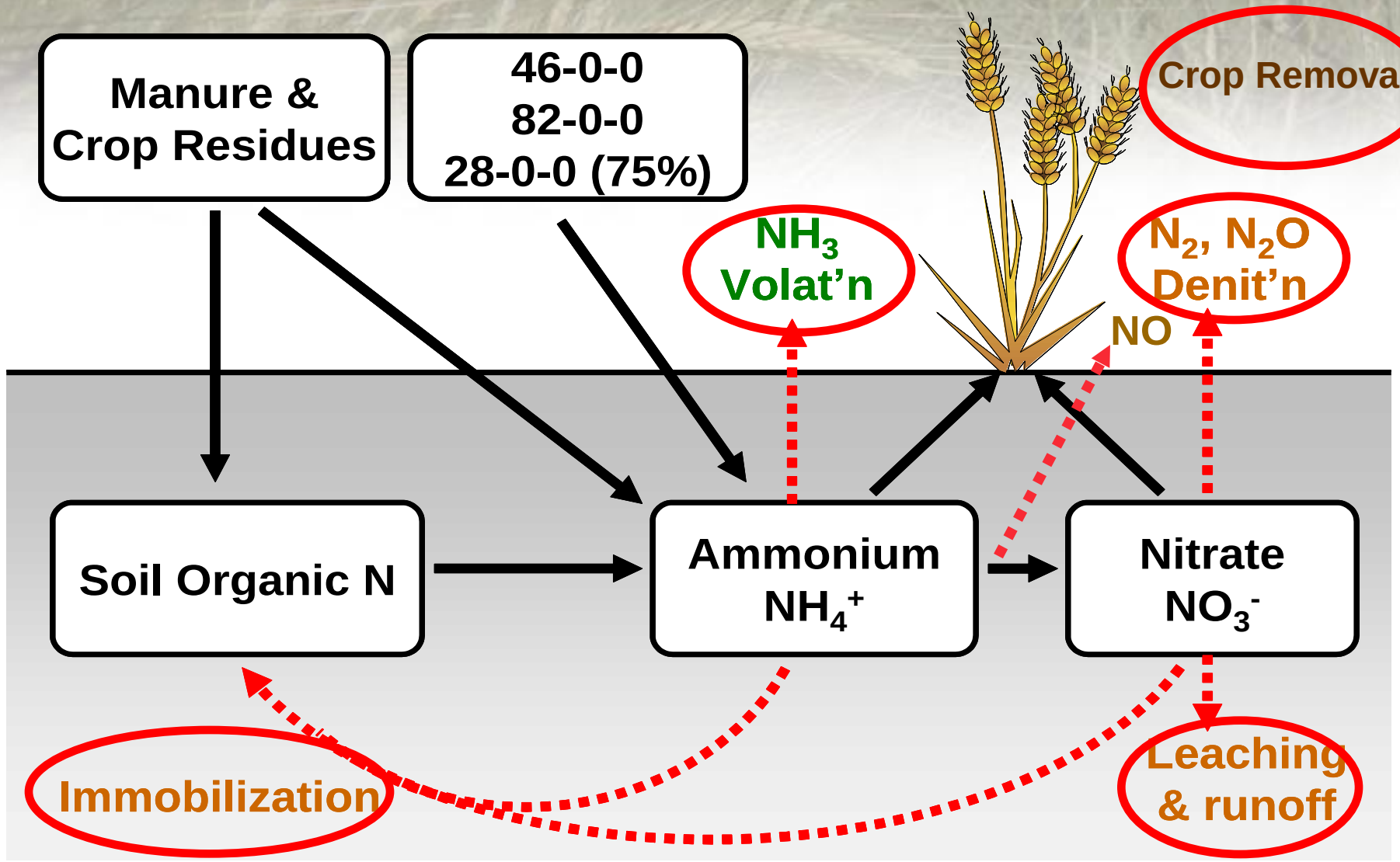
Producers Have Adopted Many 4R Principles

But it is still estimated that NUE is only 50%
IN THE YEAR OF APPLICATION

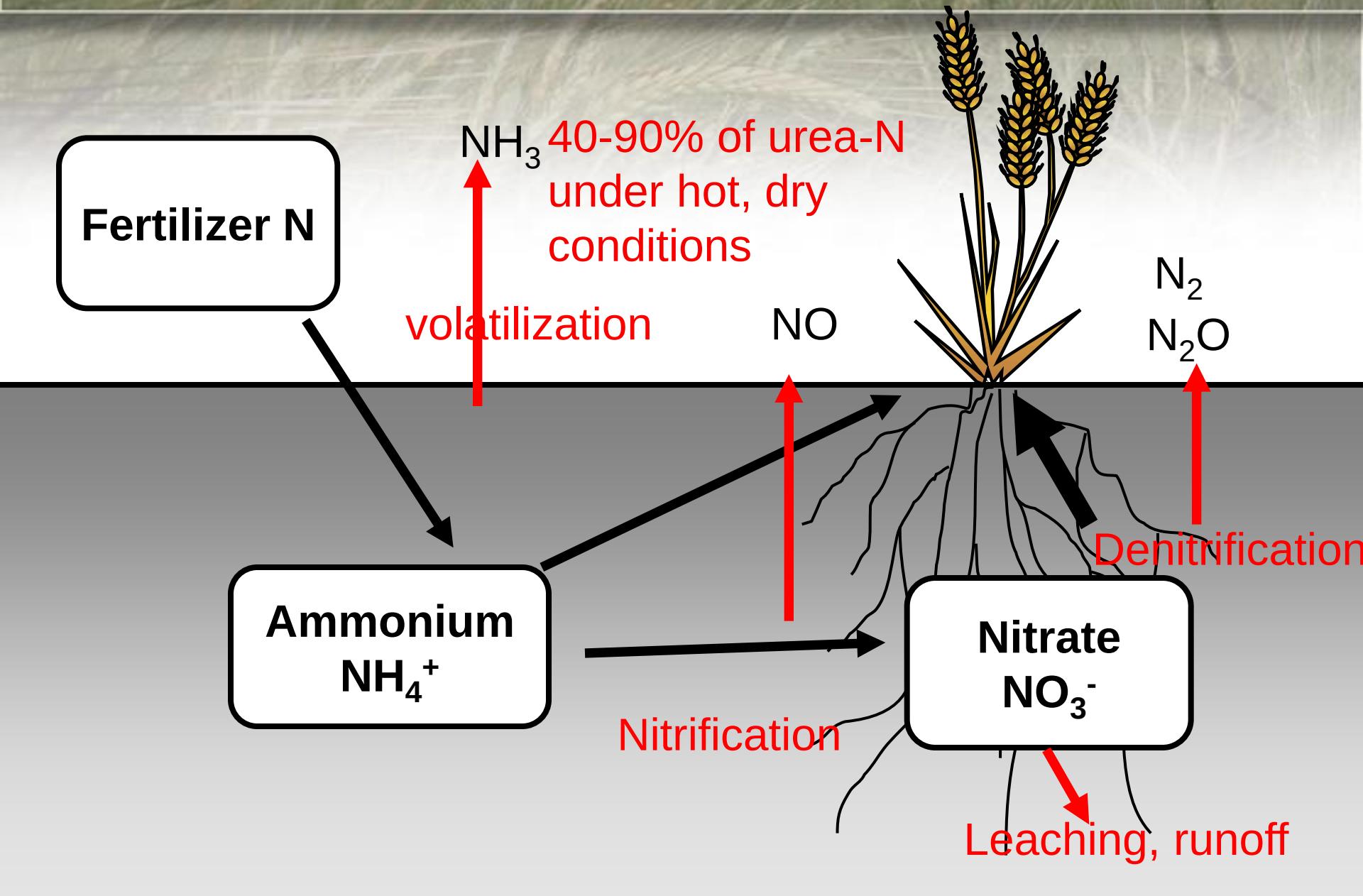
What Happens to That "Other 50%"?

- Is it gone forever?
- Do we get it back?
- Are our fertilization systems really that poor?
- How can we improve our nutrient use efficiency?

Where Does the Nitrogen Go?



Volatilization Can be High with Broadcast Urea if Not Incorporated



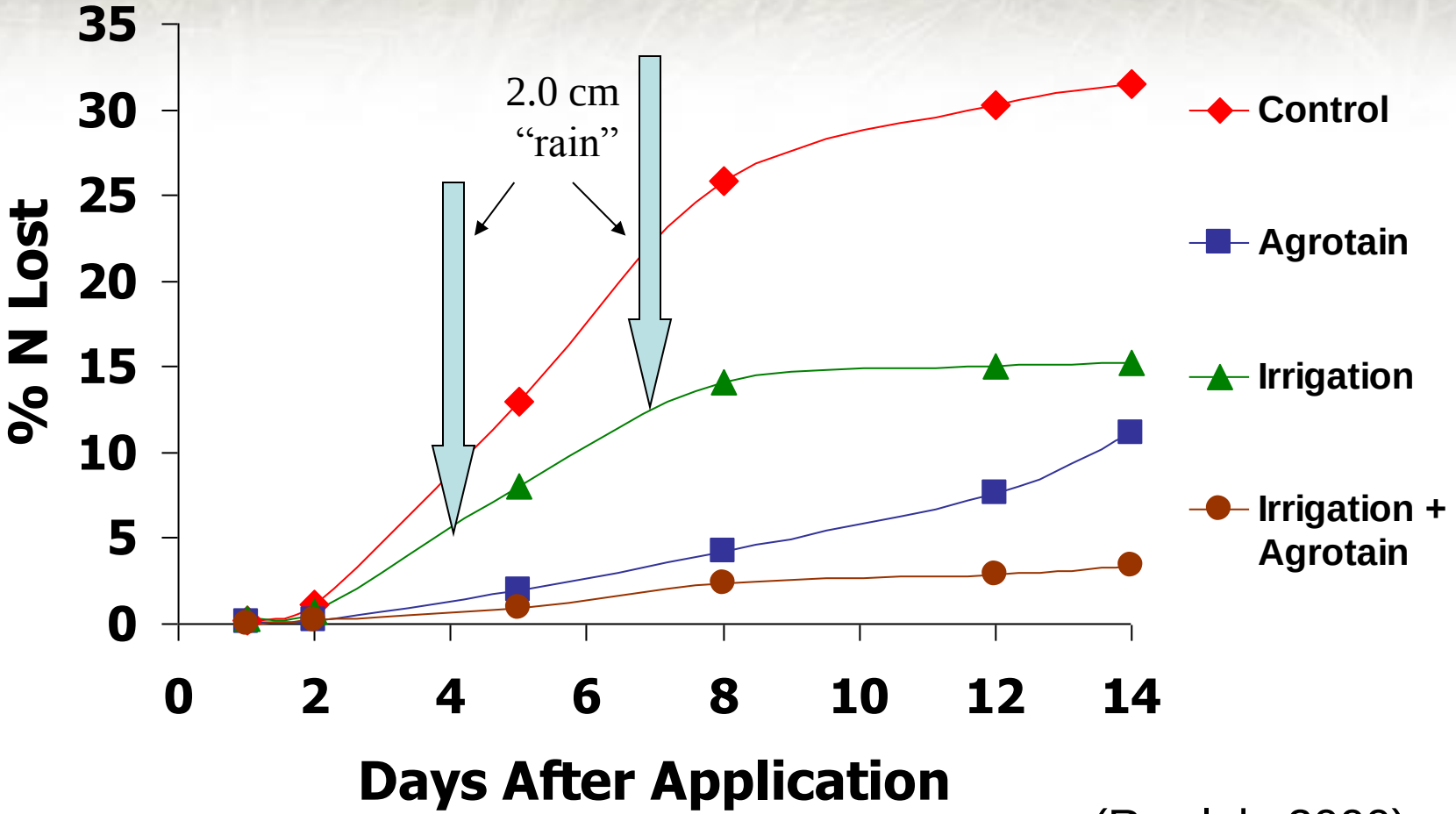
Risk Factors for Volatilization

- High concentration of ammonia near soil surface
- High pH soils
- Free lime near surface
- Coarse soil texture
- Low organic matter
- Surface residues
- High air and soil temperature
- Wind
- Lack of rain after application
- Use of urea or ammonium sulphate fertilizer

Reducing Volatilization Loss

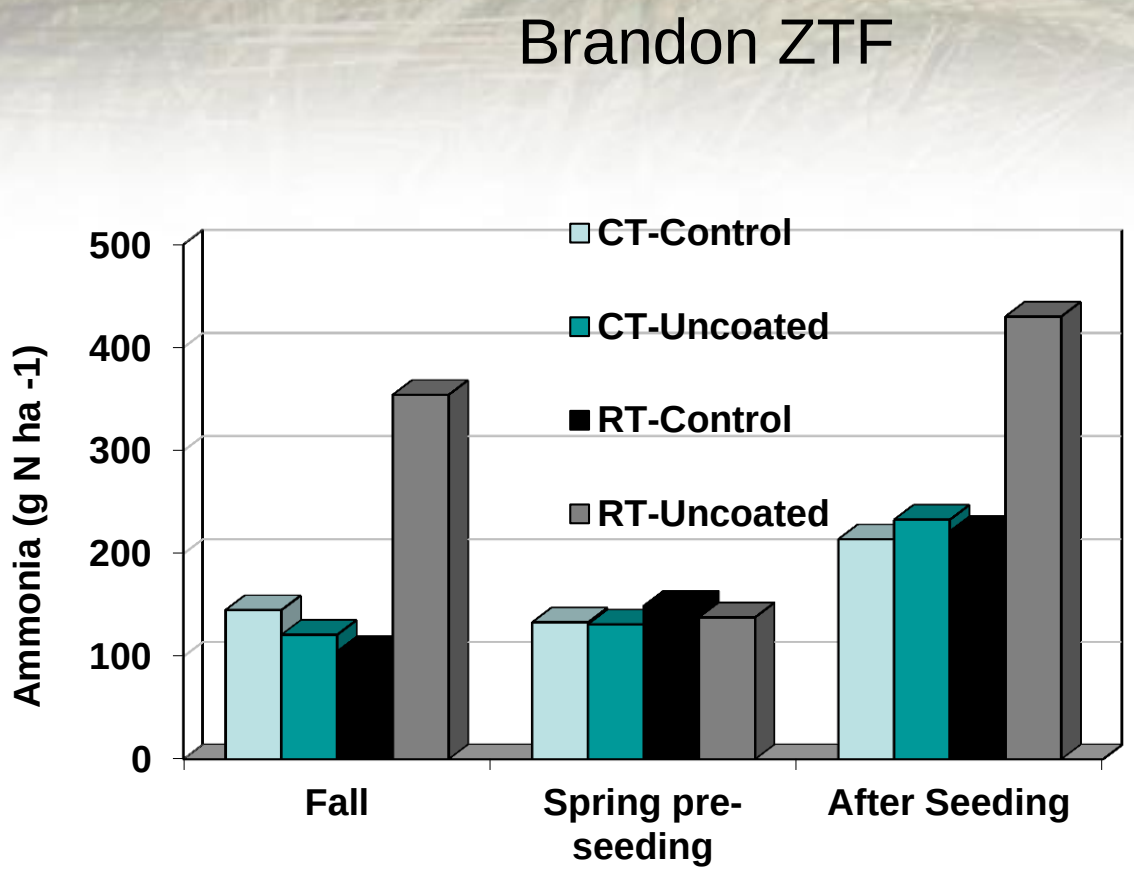
- Avoid use of urea fertilizer for surface application
  - Losses lower with UAN or ammonium nitrate
- Incorporate broadcast fertilizer immediately
  - Or apply irrigation water
  - Or apply just before a rain
- Avoid broadcast urea applications under warm, windy conditions
- Place fertilizer below the soil surface
  - Band application usually reduces volatilization losses under prairie conditions
  - Shallow bands may not be effective
  - Wide bands on soils with low CEC may increase losses if ability of the soil to adsorb ammonium ion is exceeded

Urease Inhibitor such as Agrotain can Reduce Volatilization from Surface Applications of Urea



(Rawluk, 2000)

Ammonia Losses from Fall and Spring Banded Urea

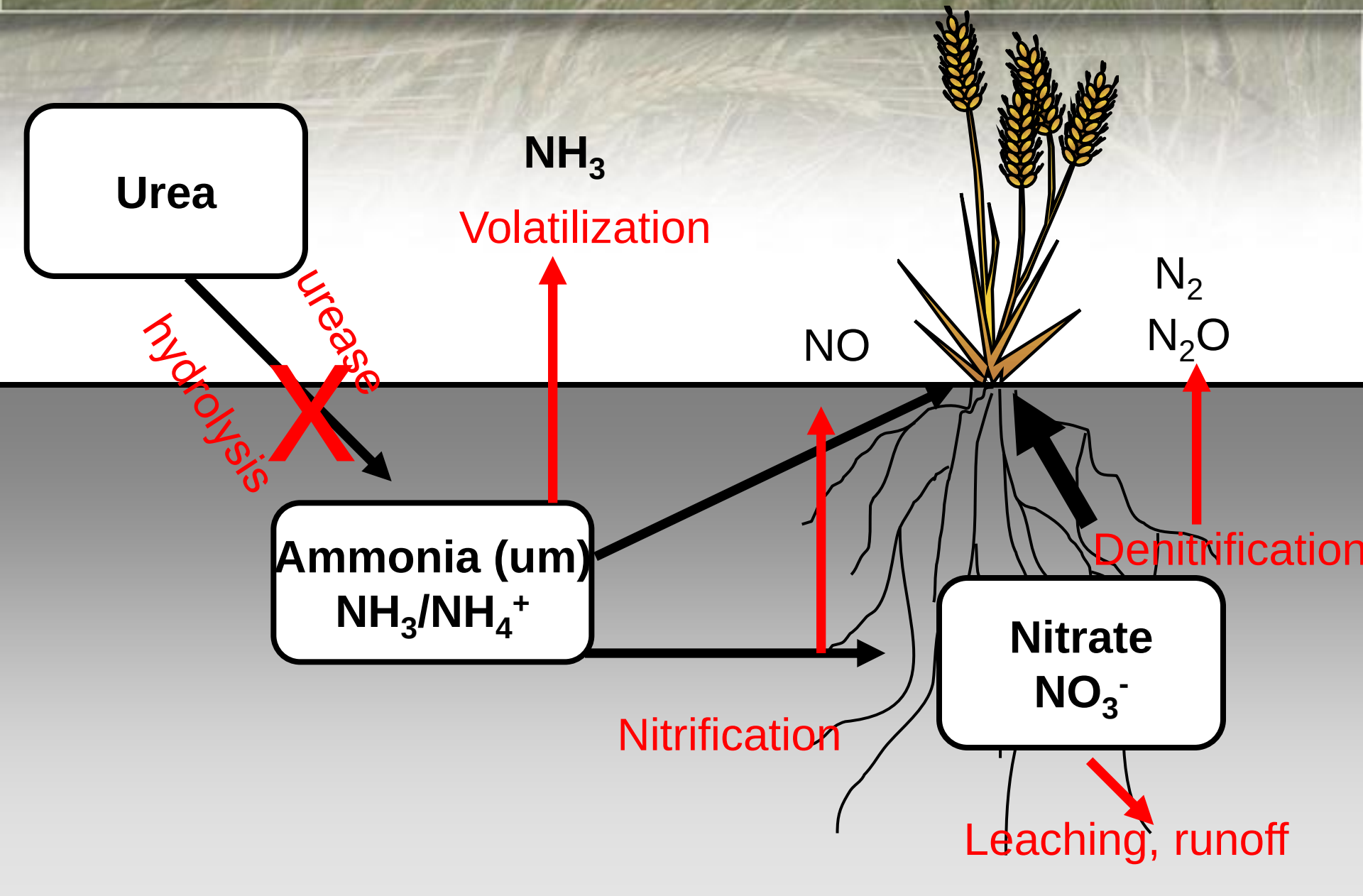


- Ammonia emissions were very low with banded N and under conventional tillage (CT)
- Some losses occurred under reduced tillage (RT) when band did not seal

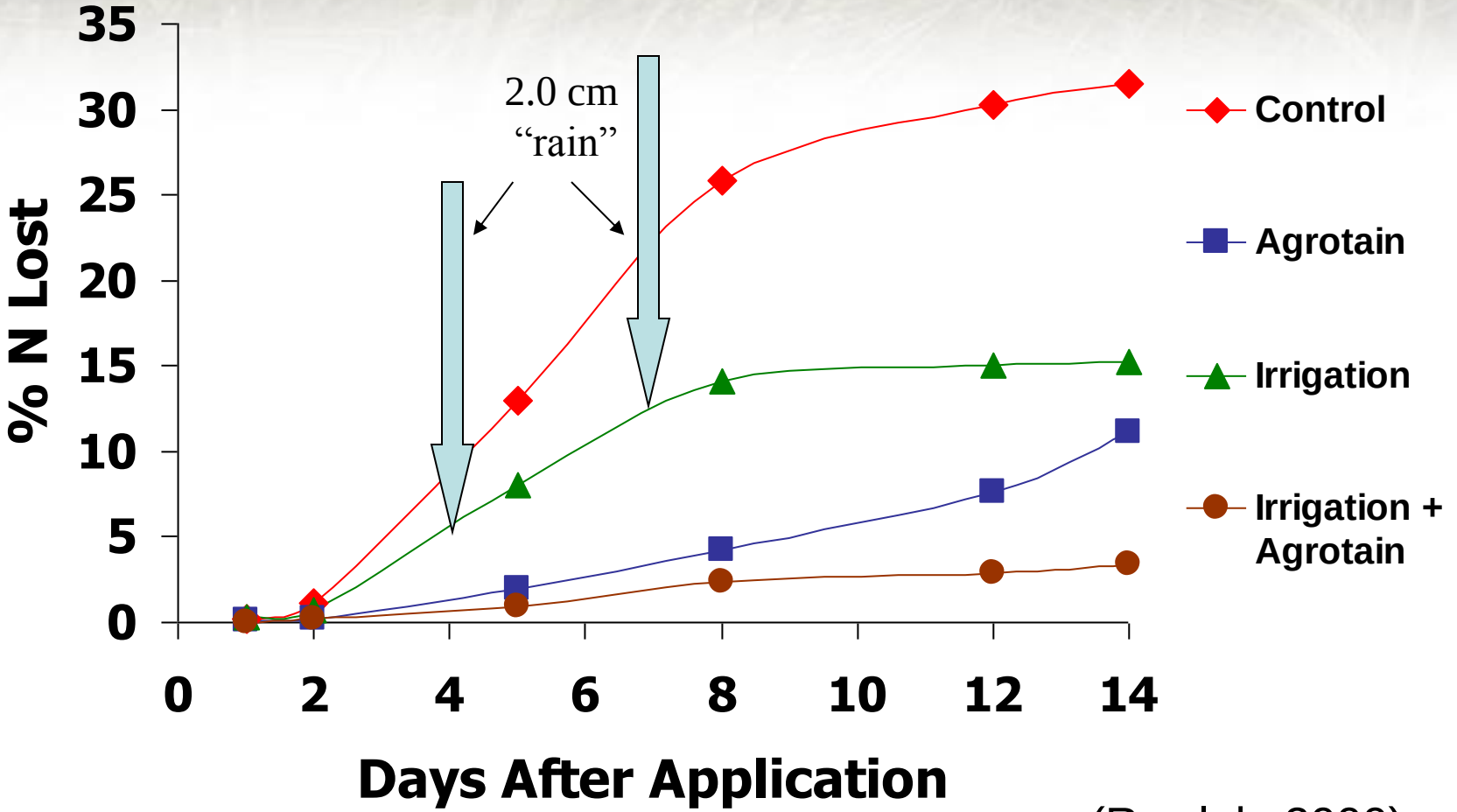
Enhanced Efficiency Fertilizers can Reduce Volatilization Loss

- Controlled release urea may reduce loses
  - Urea is released gradually from the prill through a polyurethane membrane
  - Lowers concentration near the soil surface
  - Volatilization in concentration dependant
- Urease inhibitors can reduce volatilization
  - Inhibitor slows the conversion of urea to ammonia
  - Allows time for urea to move into the soil
  - Lowers the concentratnio of ammonia near the soil surface

Urease Inhibitors Delay Conversion of Urea to Ammonia



Urease Inhibitors Reduce Volatilization from Surface Urea

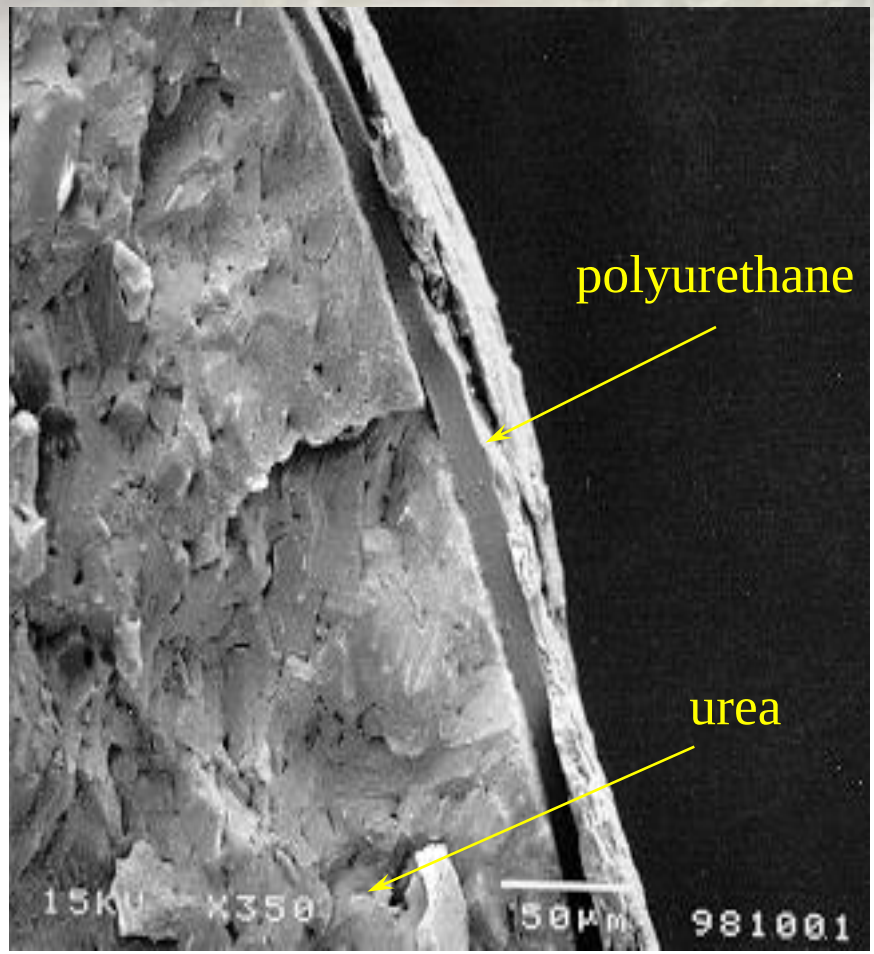


(Rawluk, 2000)

Polymer Coated Urea Controls N Release

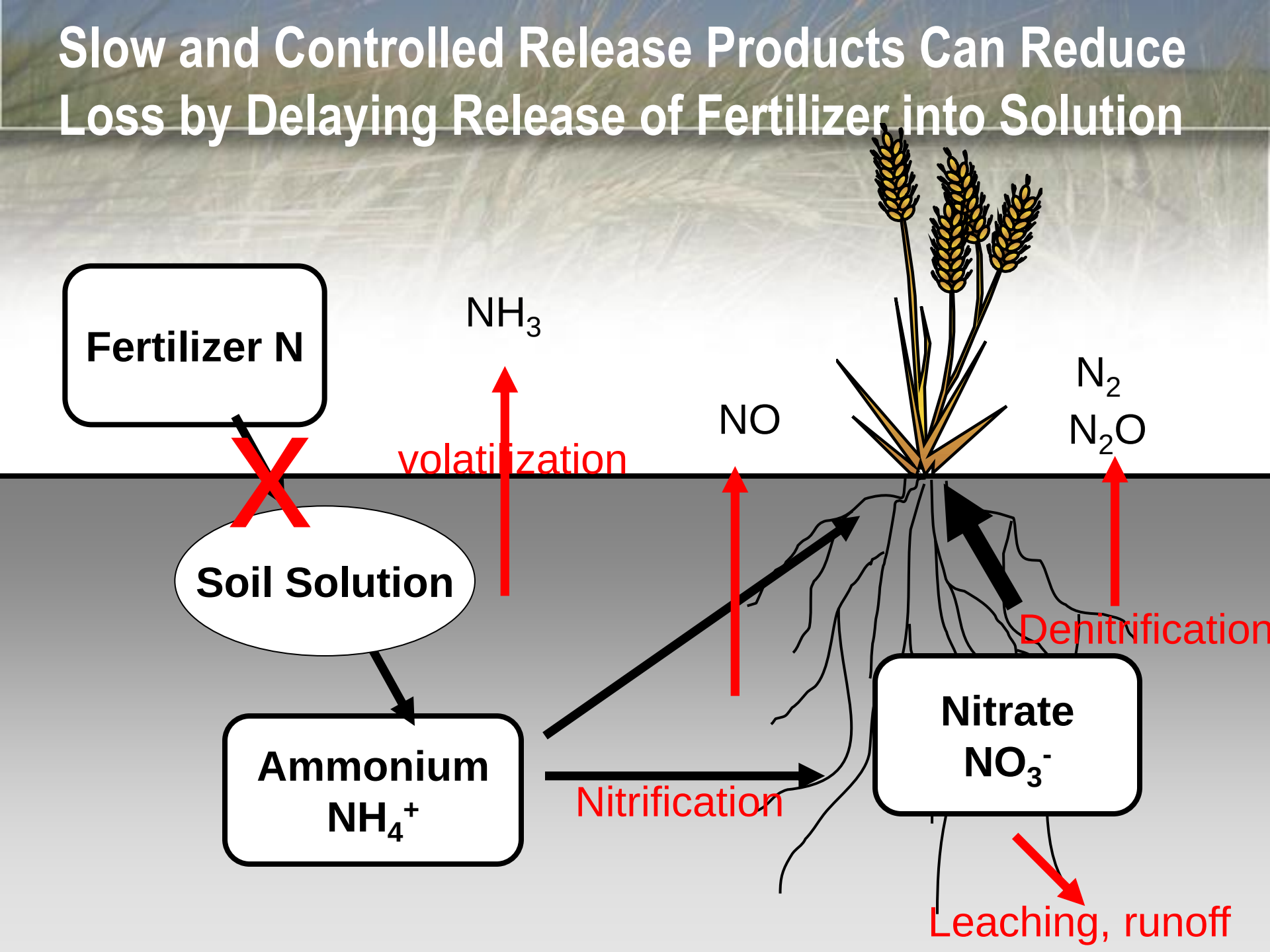
Polyurethane or polyolefin coating applied to soluble fertilizer

Controlled Release Urea



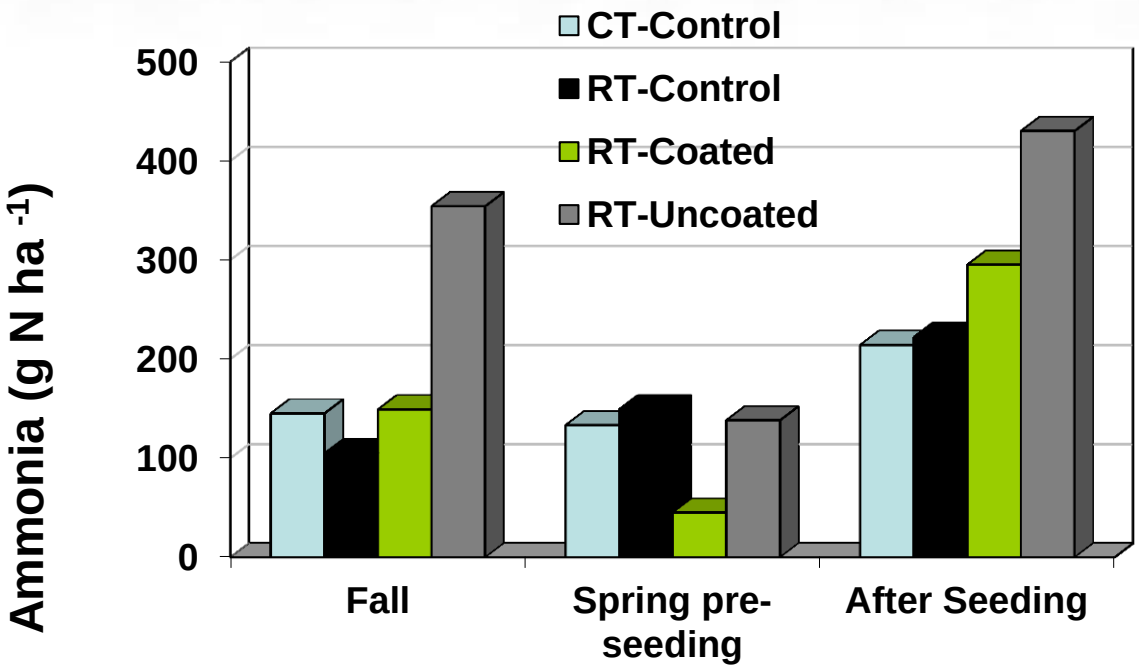
- A polyurethane membrane is applied to urea
- This membrane allows for diffusion of urea solution at a controlled rate
- The diffusion rate of urea from the granule is limited by moisture, and controlled by temperature

Slow and Controlled Release Products Can Reduce Loss by Delaying Release of Fertilizer into Solution



Ammonia Losses from Fall and Spring Banded ESN and Urea under Reduced Tillage

Brandon ZTF

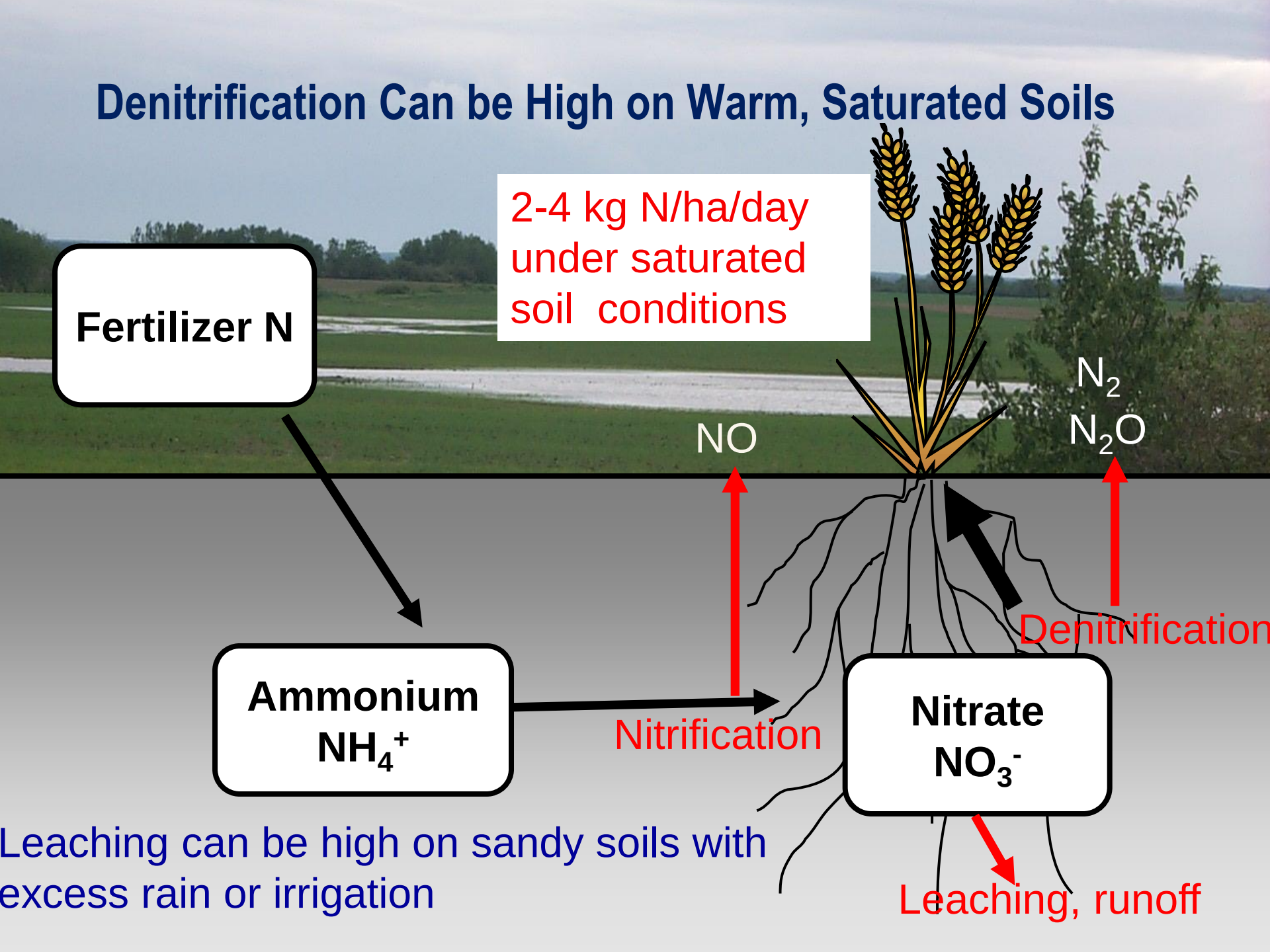


- Some losses occurred under reduced tillage (RT) when band did not seal
- Coating reduced losses

Leaching and Denitrification

- The longer the fertilizer is in the soil before crop uptake, the greater the risk of loss
- Wet conditions increase risk of denitrification and leaching
  - Leaching needs water moving through the soil
  - Denitrification needs anaerobic conditions
    - High moisture and/or compaction
- Ammonium must convert to nitrate before it is subject to denitrification or leaching
  - Warm conditions increase conversion rate

Denitrification Can be High on Warm, Saturated Soils



Leaching can be high on sandy soils with excess rain or irrigation

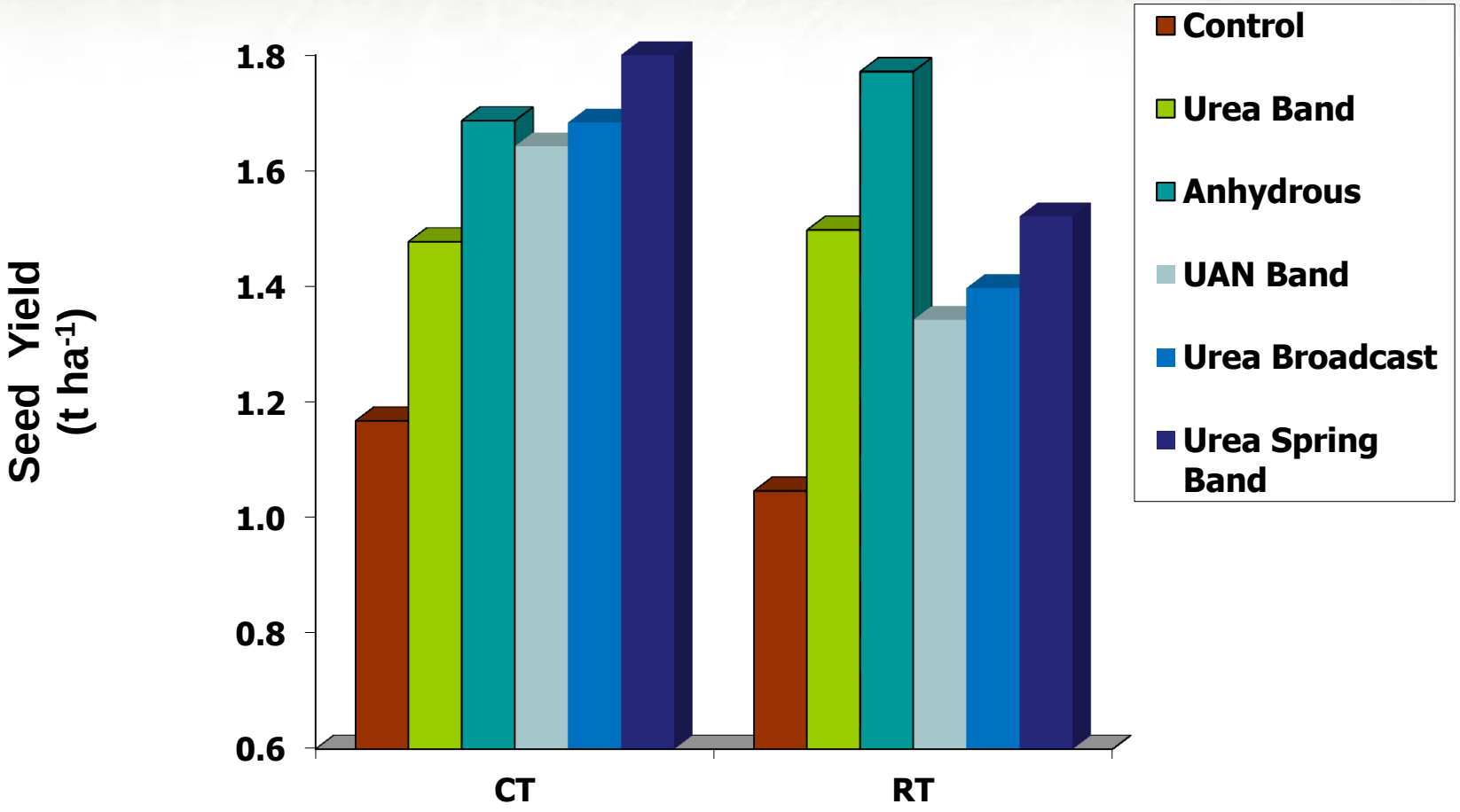
Banding an Ammonium-Producing Fertilizer Can Reduce Leaching and Denitrification

- Band reduces contact with microbes
- Slows conversion of ammonium to nitrate
- Keeps fertilizer in ammonium form for longer
- Reduces nitrate in soil solution and risk of loss by denitrification and leaching

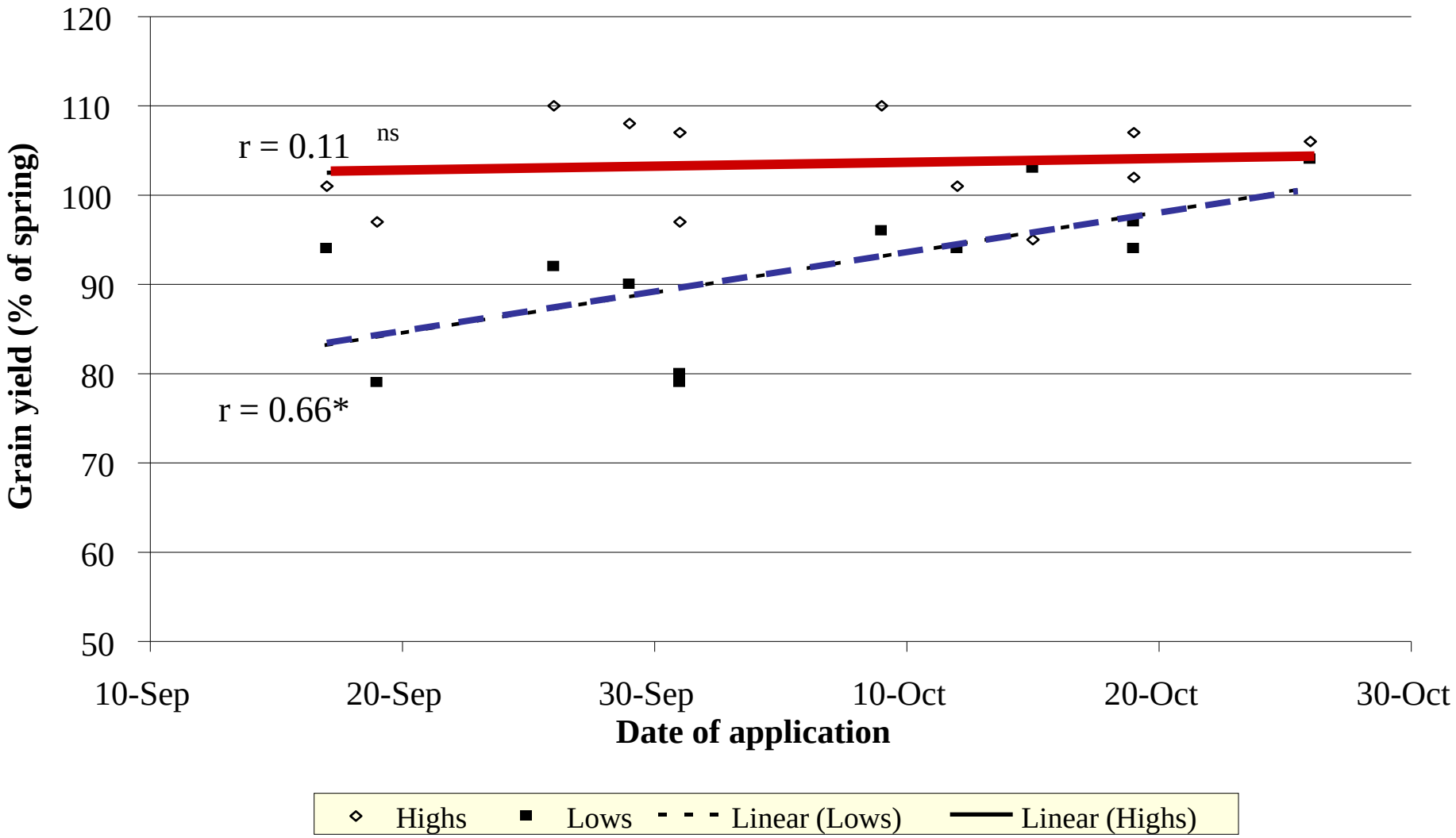
Fall Banding is Popular in Western Canada, Mainly in Conventional Tillage

- Soils are frozen from November to March
- Fall banding N in late October when soils are cold can be efficient
  - Usually less efficient than spring bands
  - Efficiency decreases with increasing moisture
- Spreads workload
  - Allows earlier seeding in spring
- May improve seed-bed
- Fertilizer cost may be lower in fall than spring
- UAN is not the best source - nitrate losses
  - Anhydrous ammonia is most popular source for fall-banding
    - Low cost and high efficiency

Fall Banding Can Perform Well Under Prairie Conditions

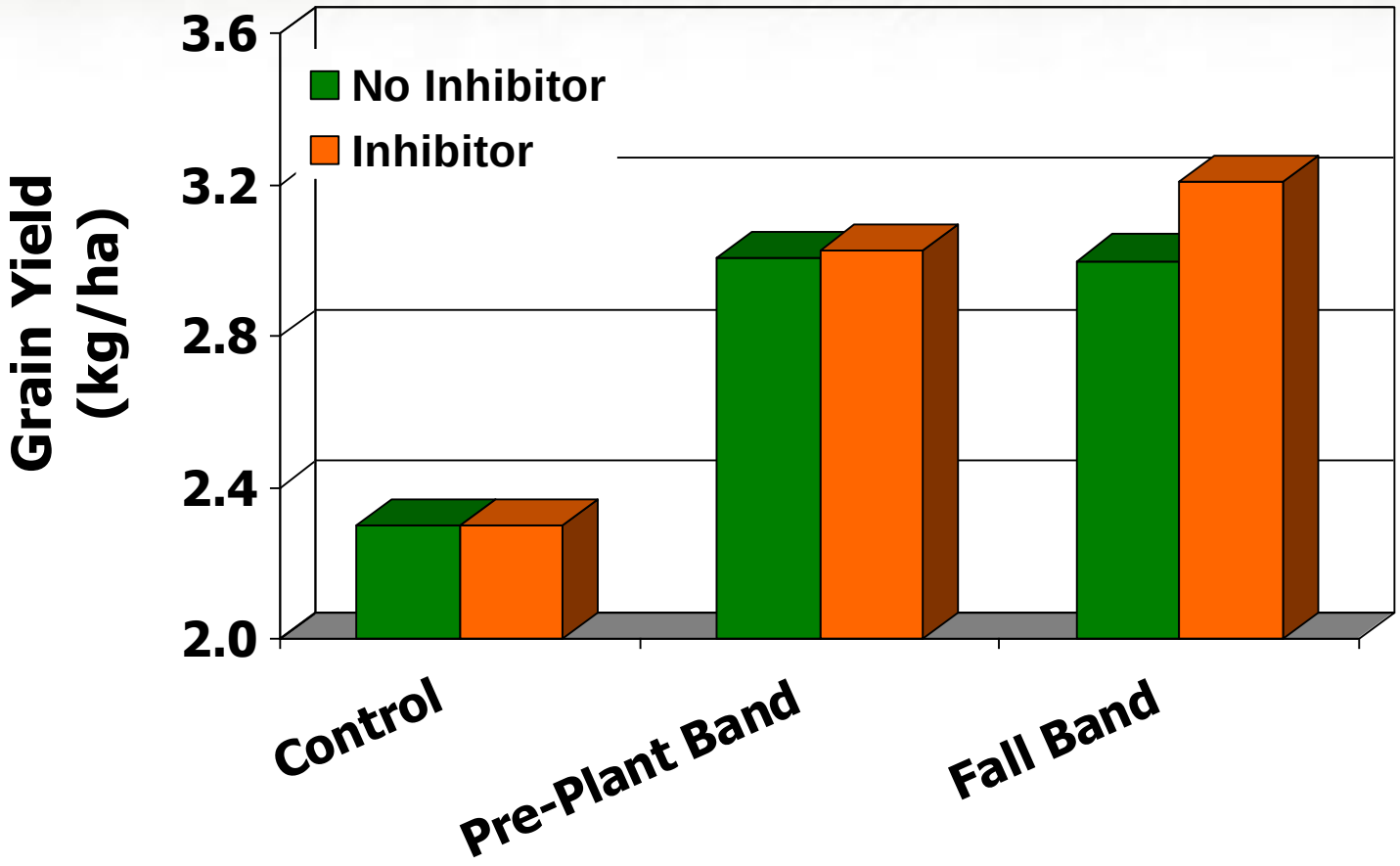


Losses Can be Minor on Well-Drained Soils



Thiessen et al. – U. of Manitoba

Urease Inhibitor Can Also Improve Efficiency of Fall Banded Application



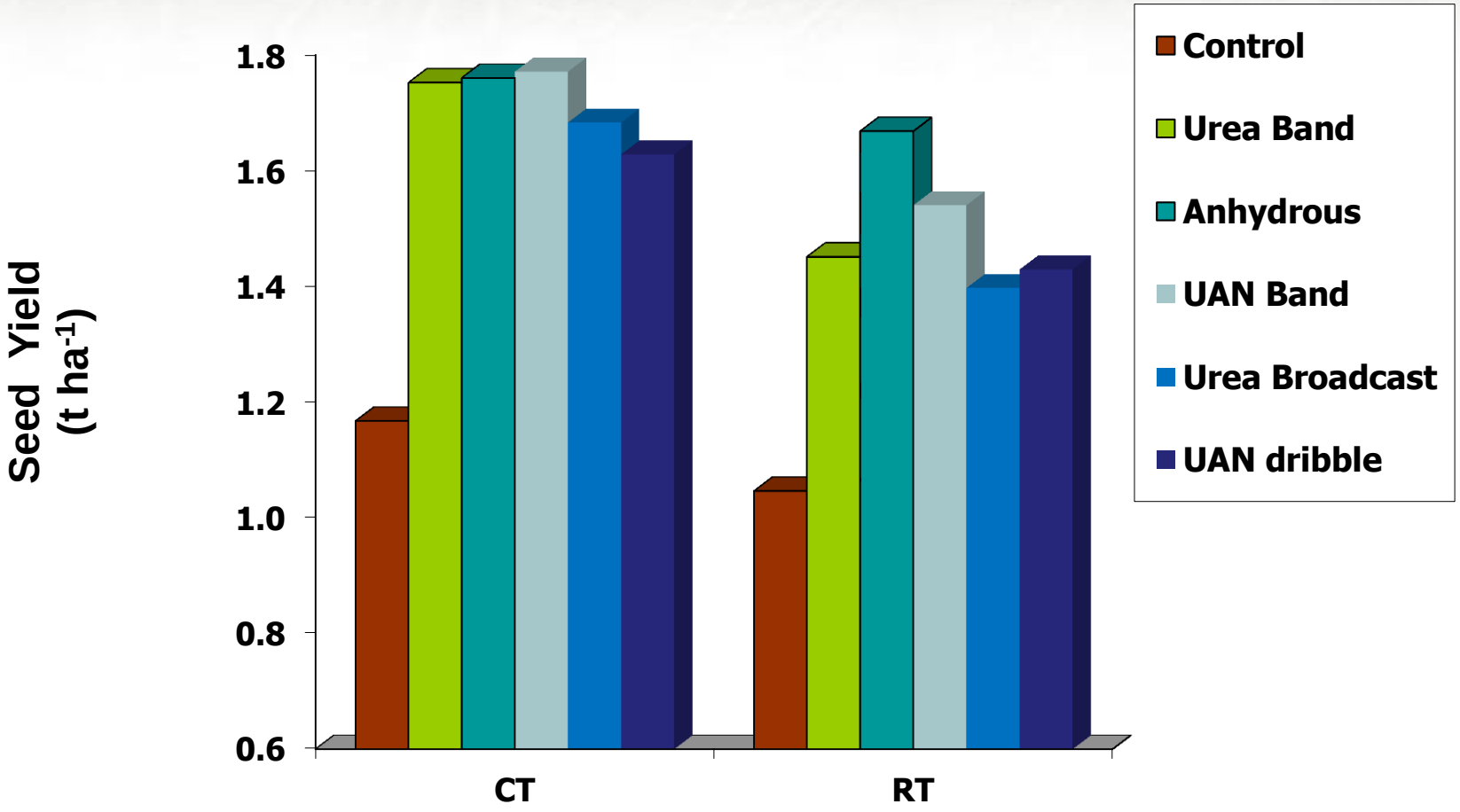
Major Losses Are Site Specific

- On well-drained sites, losses may be low
- On warm, poorly drained sites, losses can be high and more intensive management can be beneficial
- Need good site-specific assessment of loss potentials and pathways
  - Research trials on well-drained sites may be under-estimating field-scale losses

Banding at Time of Seeding is an Efficient Base Practice

- Avoids over-winter and early spring losses from fall applications
- Reduced volatilization and immobilization
  - By placing the fertilizer below the soil surface and crop residue
- Reduces denitrification and leaching
  - Slows conversion of ammonium to nitrate
  - Lowers nitrate concentration in the solution
  - Reduces the risk of loss
- More than 70% of fertilizer N on the prairies is banded to improve efficiency
  - Exceptions are winter wheat, fall rye and perennial forages and a few no-till fields

Spring Banding Improved Canola Seed Yield Under Both Conventional and Reduced Tillage Management

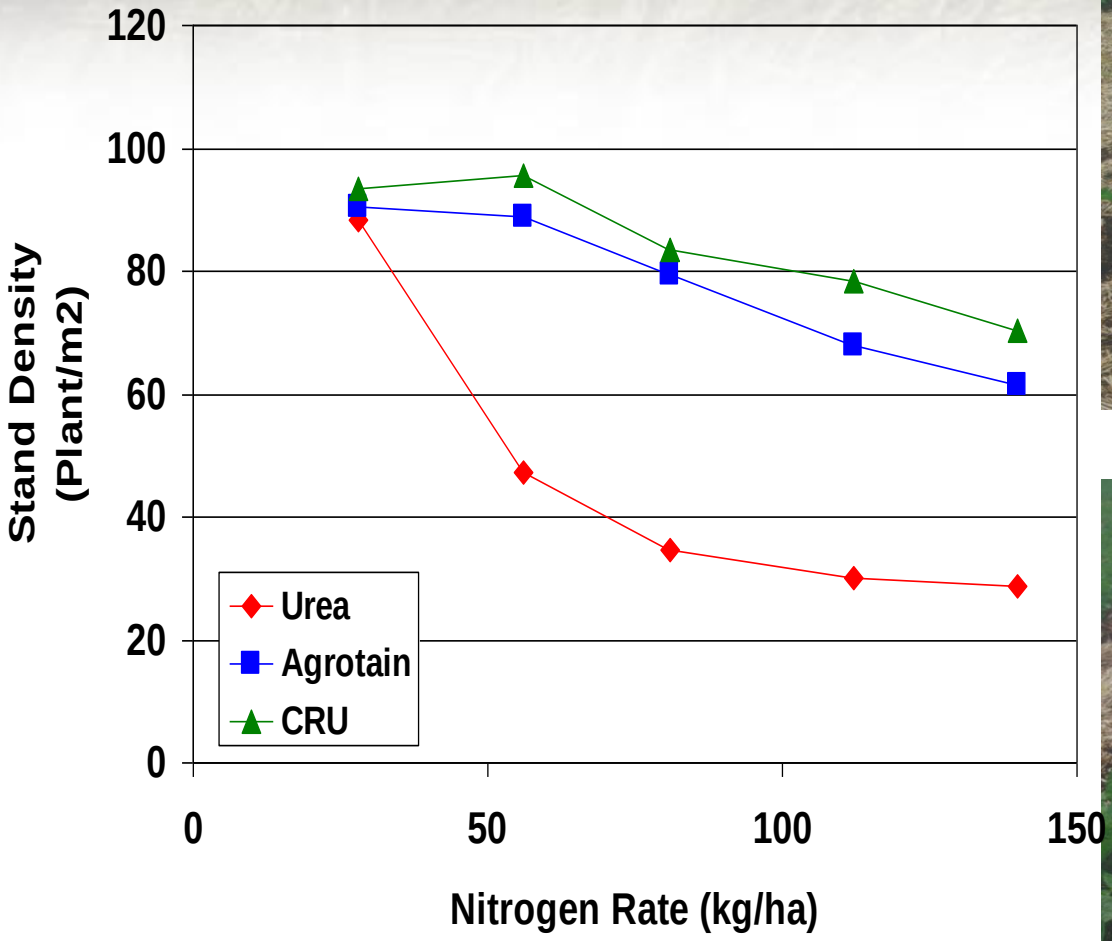


Seed-placement is an efficient application method

- One-pass
  - Reduces time and labour
- Specialized injection
  - Reduces N losses
- Close to seed
  - Gives crop advantage over weeds
- Seedling damage is problem at higher rates
  - Canola is very sensitive to seedling damage

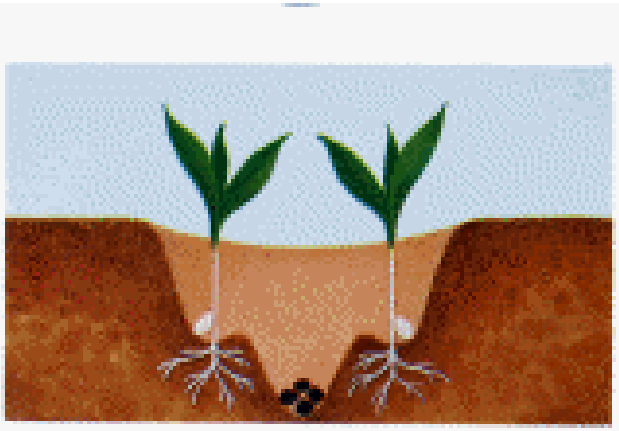
Damage in canola from seed-placed urea

Both Urease Inhibitors and Coated Products Can Reduce Seedling Damage



Reduce Risk by Placing N Away from Seed-row

- Separates seed and fertilizer
- Reduces concentration of fertilizer near seed-row
- Higher effective seed-bed utilization
- Side-band or mid-row band
  - Still have injection efficiency
  - Improved safety



Side-Banding Nitrogen May Have Risks

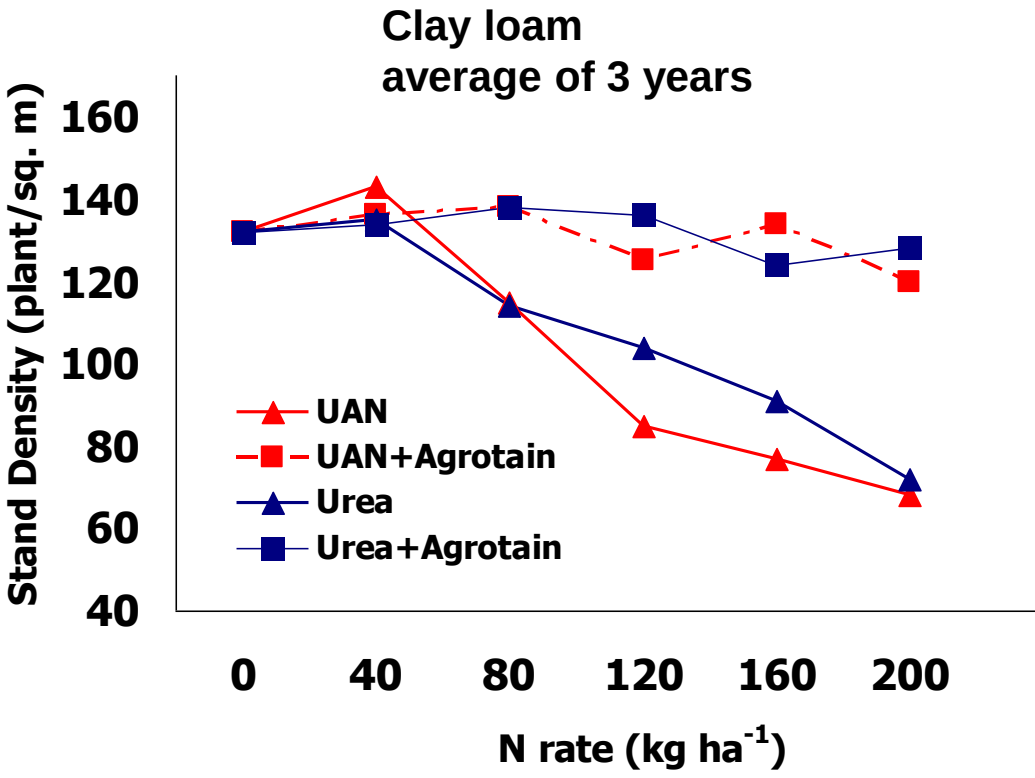
- Loss of separation of seed and fertilizer
  - Seed and fertilizer “bounce”
  - Soil movement during seeding operation
  - Equipment wear
- Placement of fertilizer too near seed
  - Wide row-spacing with high rates
  - Increase horizontal separation to reduce risk
- UAN safer than urea for cereals
  - Not necessarily safer for canola

Seedling Damage from Excess Side-banded N Fertilizer

Agrotain Can Reduce Seedling Damage from Side-banded Urea and UAN

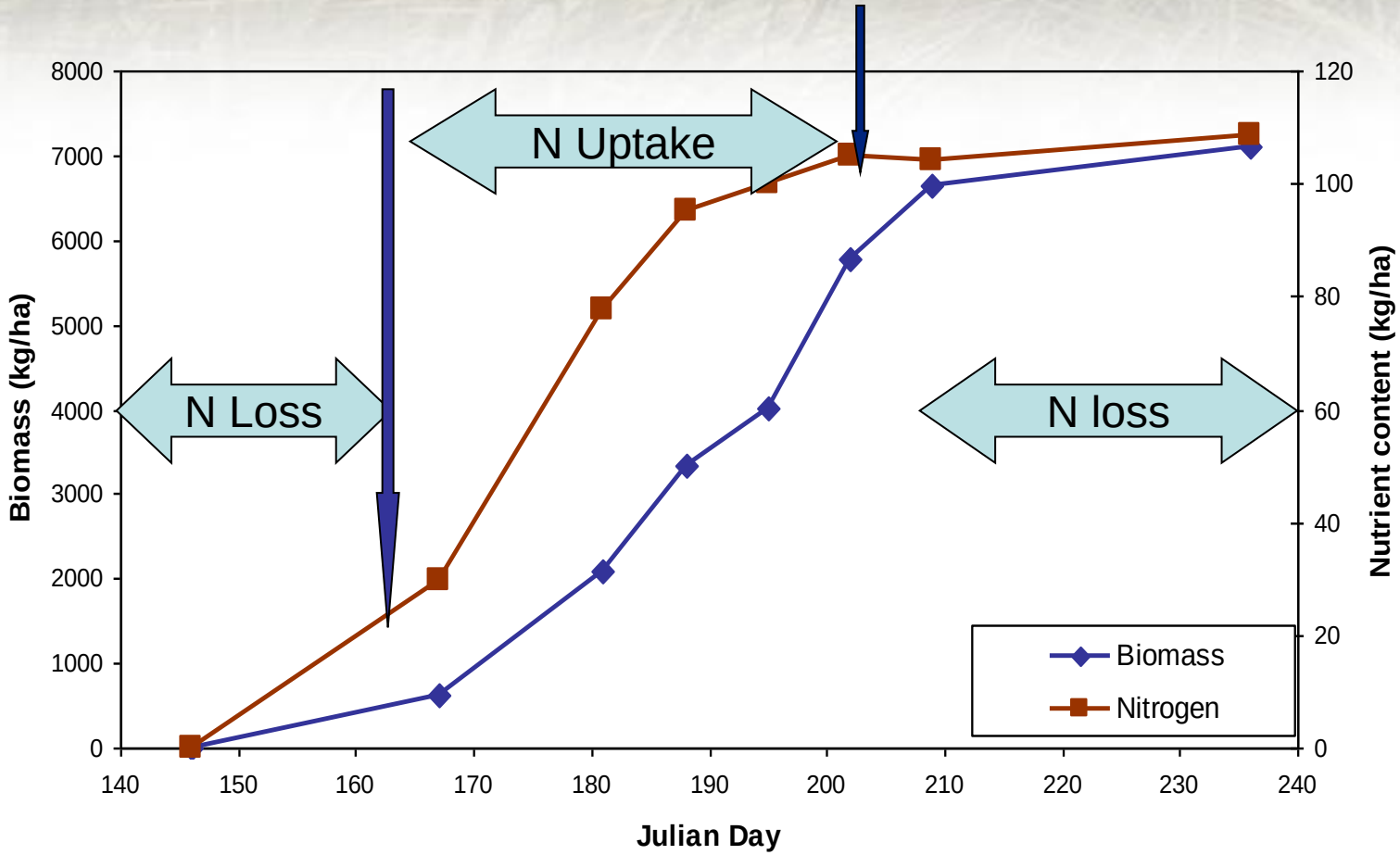
- Urease inhibitor slows conversion of urea to ammonia/ammonium
- More time for uncharged urea to move away from seedling
- More time for rain to dilute fertilizer
- Gradual conversion reduces concentration near seedling
  - Lower concentration reduces damage

Side-banded N rate and source effects on canola stand

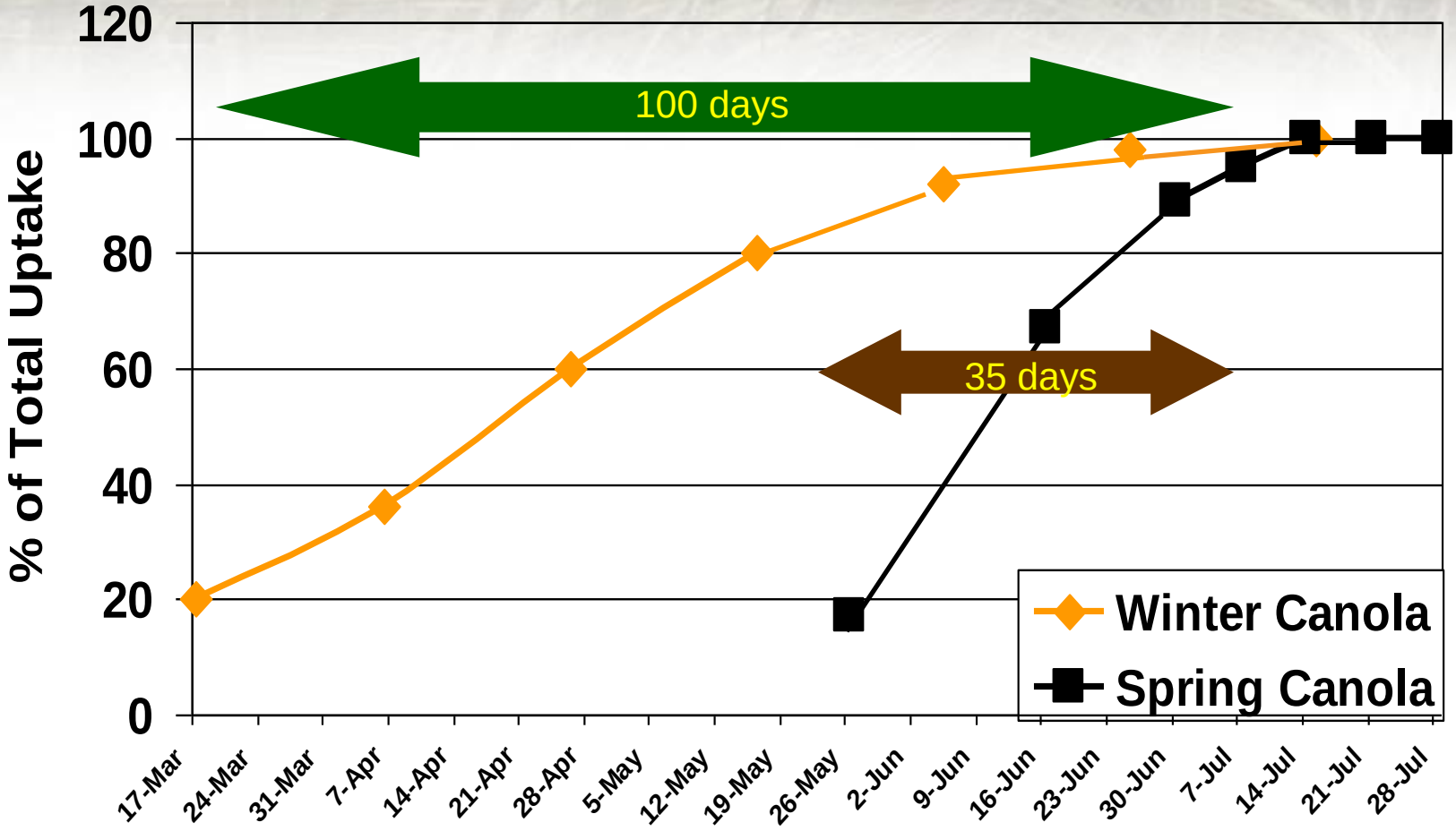


Matching Supply to Crop Uptake

Synchrony of N Supply and Uptake Can Improve NUE



Length of Period of N Uptake affects need for Precision N Timing



Split Applications Attempt to Match N Supply with Crop Demand

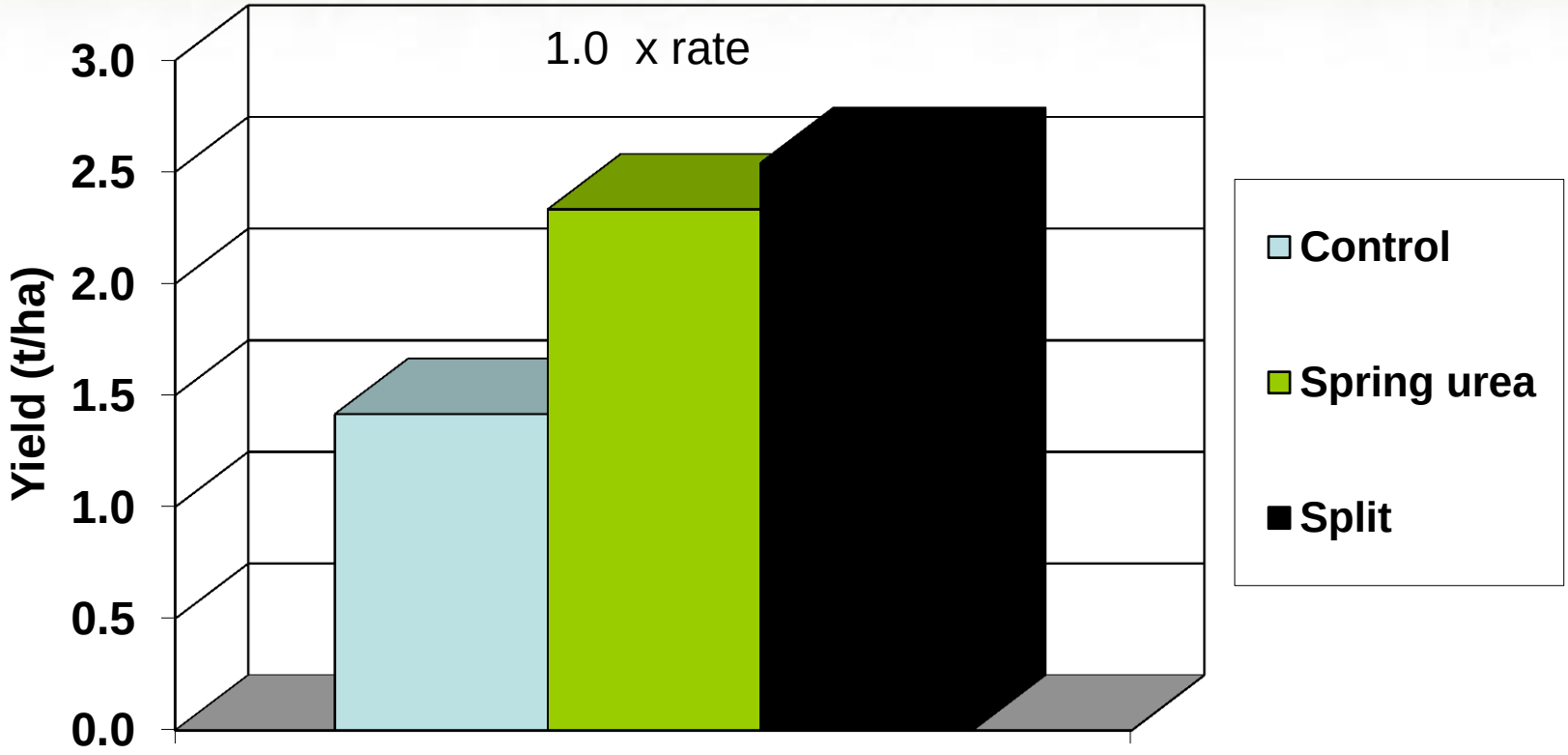
- Minimise inorganic N in solution before crop uptake
- Reduce the risk of N losses and increase NUE
- Allow rate to be changed if yield potential changes
  - Minimise investment in low-yielding crop
- Potential agronomic benefits
  - Reduced lodging
  - Less disease
  - Improved crop quality

Potential Benefits of Split Application Increase with Length of Growing Season

- More time for N loss
- More time for changes in yield
  - Drought
  - Rainfall
  - Frost
  - Pests
- Wider window for N application

Have been more widely adopted in regions with long, wet growing seasons than in the prairies

Under Wet Conditions Split Application Increased Canola Yield Compared to Spring Banded Urea



Melfort 2005

P<0.02

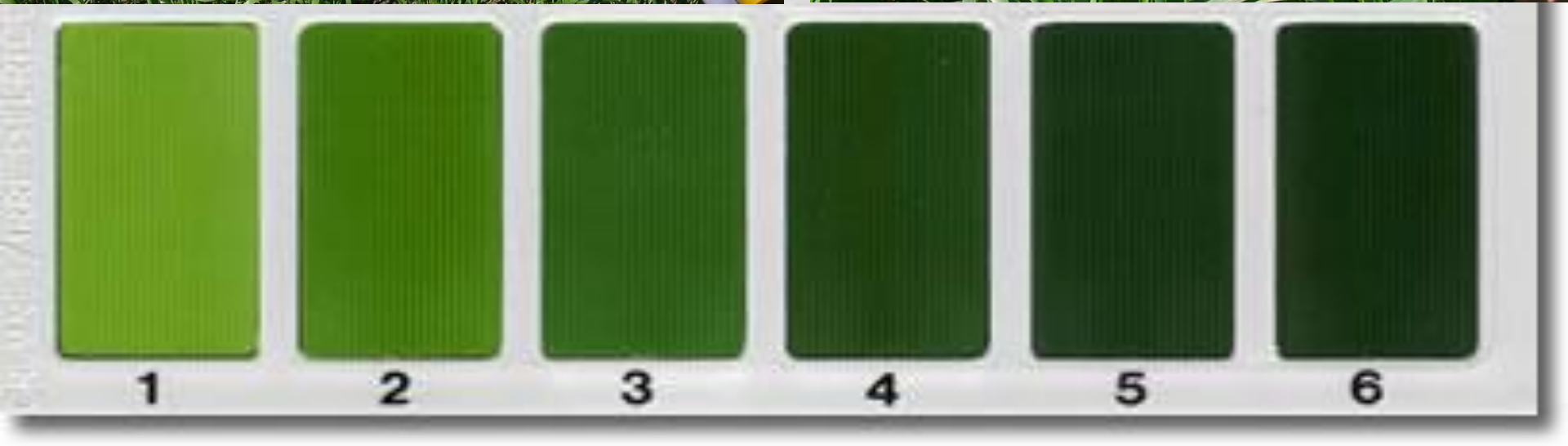
Post-emergence Fertilizer Placement Options

- Broadcast
- Nesting
- Coulter
- Dribble
- Foliar
- Pressure injection
- Fertigation





In-Crop Assessment of Deficiency Can Identify if Extra N is Needed – May Reduce Total N Applied



Drawbacks of Split Applications

- Multiple passes increase cost, fuel consumption, traffic, and labour
- Surface applications may increase volatilization, immobilization and risk of stranding in dry soil
- In-soil applications may damage crop
- Risk of missing window of application
- Controlled release products may be a good substitute for split applications
  - Single application releases N over season

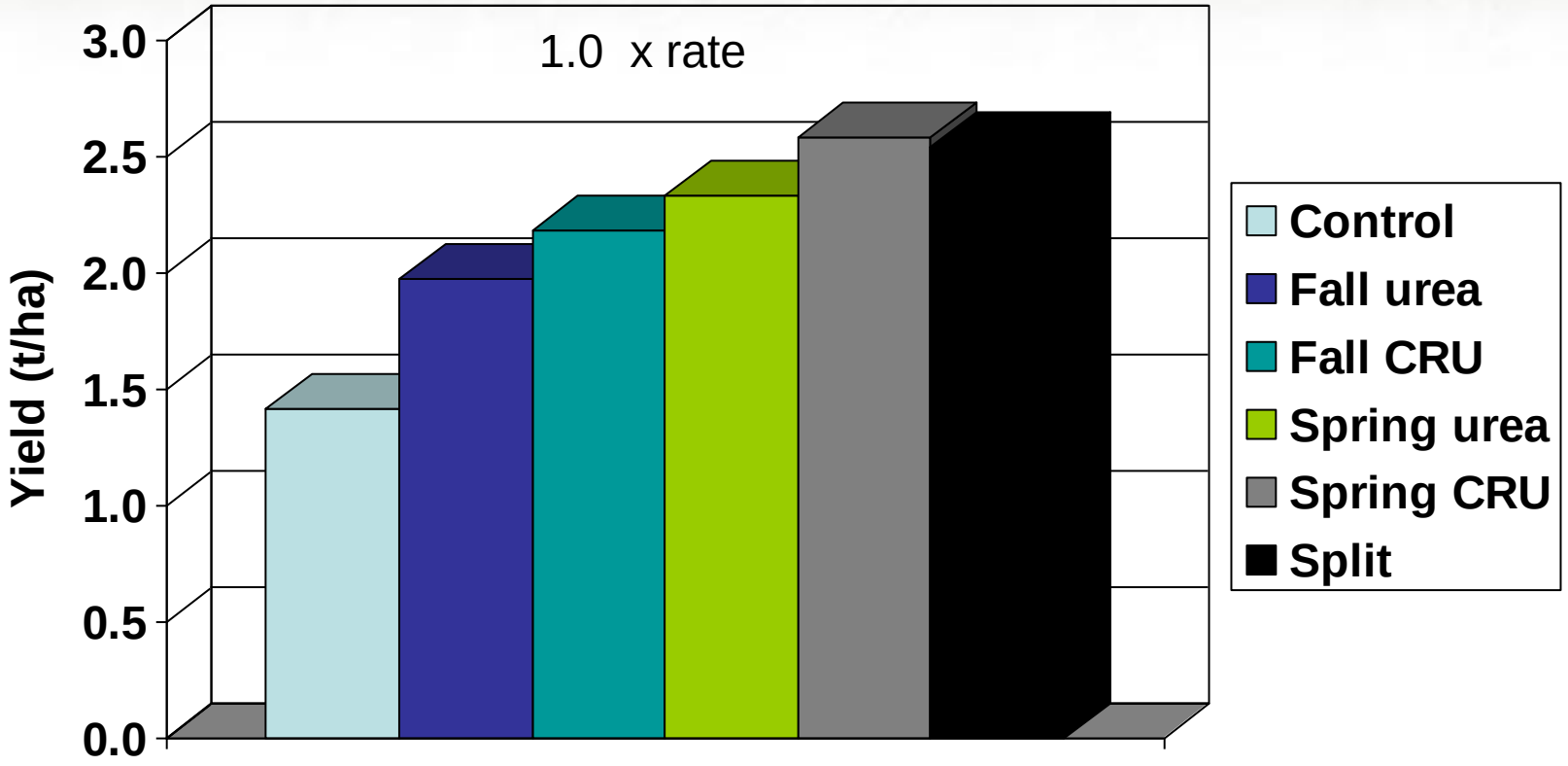
Controlled Release Fertilizers Can Substitute for Split Applications

- Single application released at controlled rate over season
- Reduces time, fuel and labour
- Minimises risk of N loss
- Rate cannot be modified with changing conditions
  - Based on yield potential assessed at start of season

Under dry conditions on the prairies, there was no yield advantage to ESN

Site	Crop	N rate (kg ha^{-1})	Yield (t ha^{-1}) Coated	Uncoated	Inc.%
Lacombe	Canola	30	3.22	3.24	-0.62
		60	3.22	3.21	0.31
Swift Current	Wheat	20	2.42	2.46	-1.63
		40	2.6	2.55	1.96
		60	2.58	2.62	-1.53
Lacombe	Barley	30	5.64	5.67	-0.53
		60	6.44	6.46	-0.31
Swift Current	Wheat	15	2.14	2.32	-7.76
		30	2.31	2.32	-0.43
		45	2.3	2.36	-2.54

At Melfort, use of CRU, fall or spring, increased canola yield compared to urea



Melfort 2005

P<0.02 for CRU vs urea

Environment Drives Response to ESN and Other Enhanced Efficiency Fertilizers

- Yield potential and crop nutrient demand
- Pathways and amount of nutrient loss
- Using enhanced efficiency fertilizers in the proper environment can minimise N losses and maximize return
  - Provides both economic and environmental benefits
- Benefits will not occur where losses are low

How to Improve Nitrogen Management for Canola?

- Canola is a high N user
  - Ensure an adequate N supply to support high yield
- Encourage vigorous early season crop growth to compete with N loss pathways
  - Good seedling establishment
  - Avoid seedling damage
  - Control weeds, insects and diseases
- Assess soil N supply to fine-tune application rates
- Match management practices to environment
  - Site-specific management targeted to loss pathways
- Enhanced efficiency fertilizers and split applications may have role where environmental conditions promote losses

Phosphorus is Among the Most Limiting Nutrients for Canola

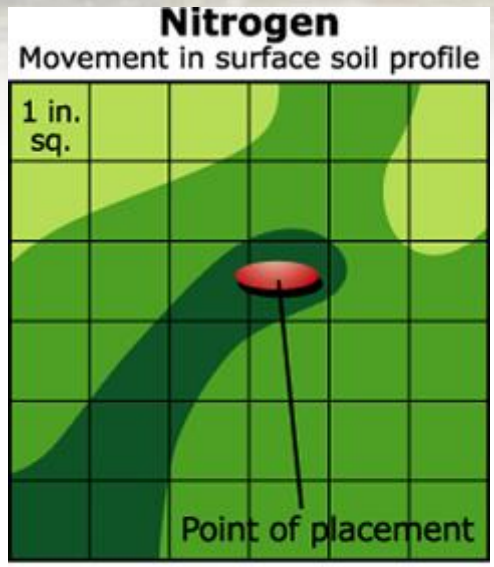
Phosphorus

- Phosphorus is critical for crop growth
  - Structural component of nucleotides, nucleic acids and phospholipids.
  - Essential for all energy reactions
  - Needed for all growth processes
  - promotes root development, tillering, early flowering, seed production, and uniform ripening.
- P fertilizer is a major input for crop production
- Low P recovery is a major economic and environmental concern

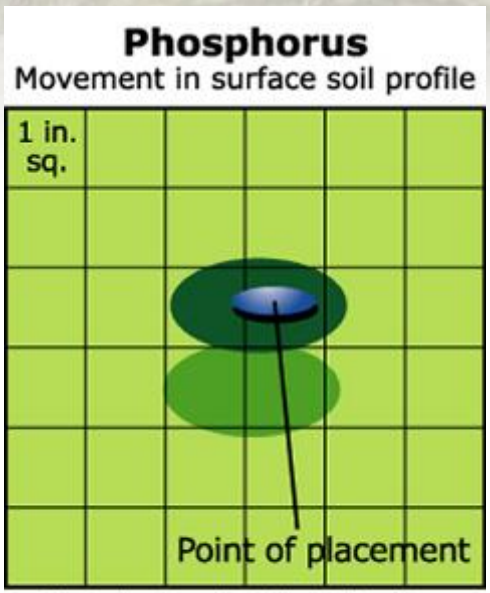
Principles of Phosphorus Nutrition that Affect Fertilizer Management Choices

- P is not very mobile
  - Ties up with Ca, Mg, Al and Fe
  - Will not normally leach on most soils
  - Roots must intercept P since P won't move to roots
- P is needed early in growth
  - Plants must have adequate supply in first 3-6 weeks
  - Soil supply is reduced under wet, cold conditions
- Adequate P needs to be near the seed-row so the plants can access it early in the season
  - May need to apply starter near the seed-row unless the soil level is high

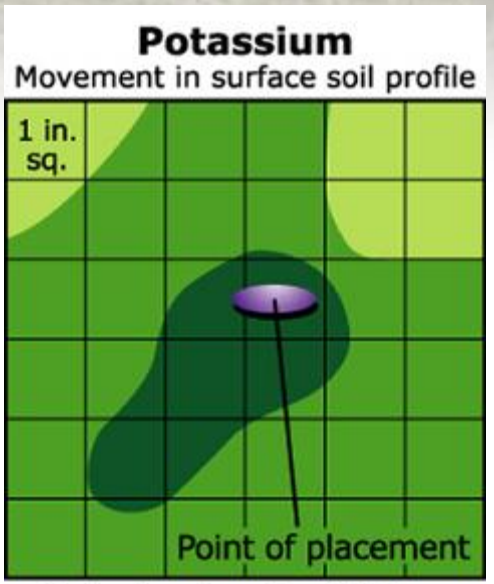
Phosphorus is Relatively Immobile in the Soil



Nitrogen location 17 days after application



Phosphorus location 17 days after application

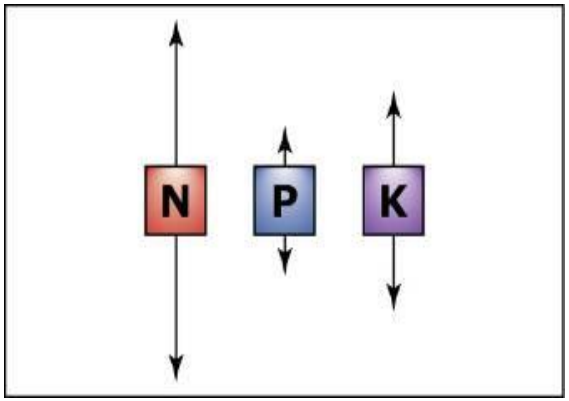


Potassium location 17 days after application

High concentration

Medium concentration

No effect



Has important effect on P management decisions

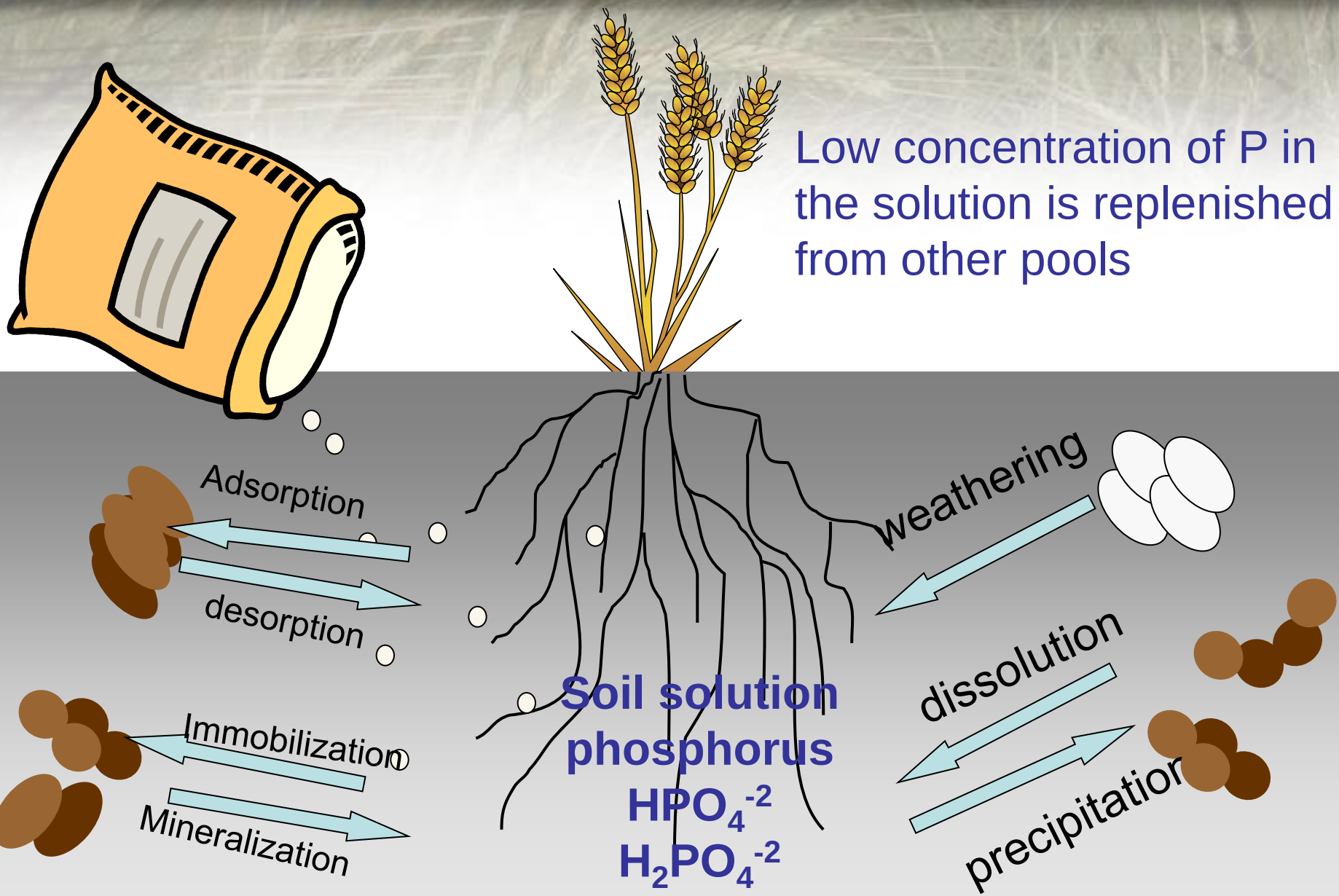
How Much Phosphorus is Needed by a Canola Crop?

- A 2.2 t ha^{-1} canola removes about 20 kg P ha^{-1} in the seed
  - About 10 kg more taken up but recycled in residue
  - Total of about 30 kg P ha^{-1} needed for growth

Without an adequate P supply, crop yield will be reduced

But not all crop requirement has to come from fertilizer

Plants Access P from Soil Solution



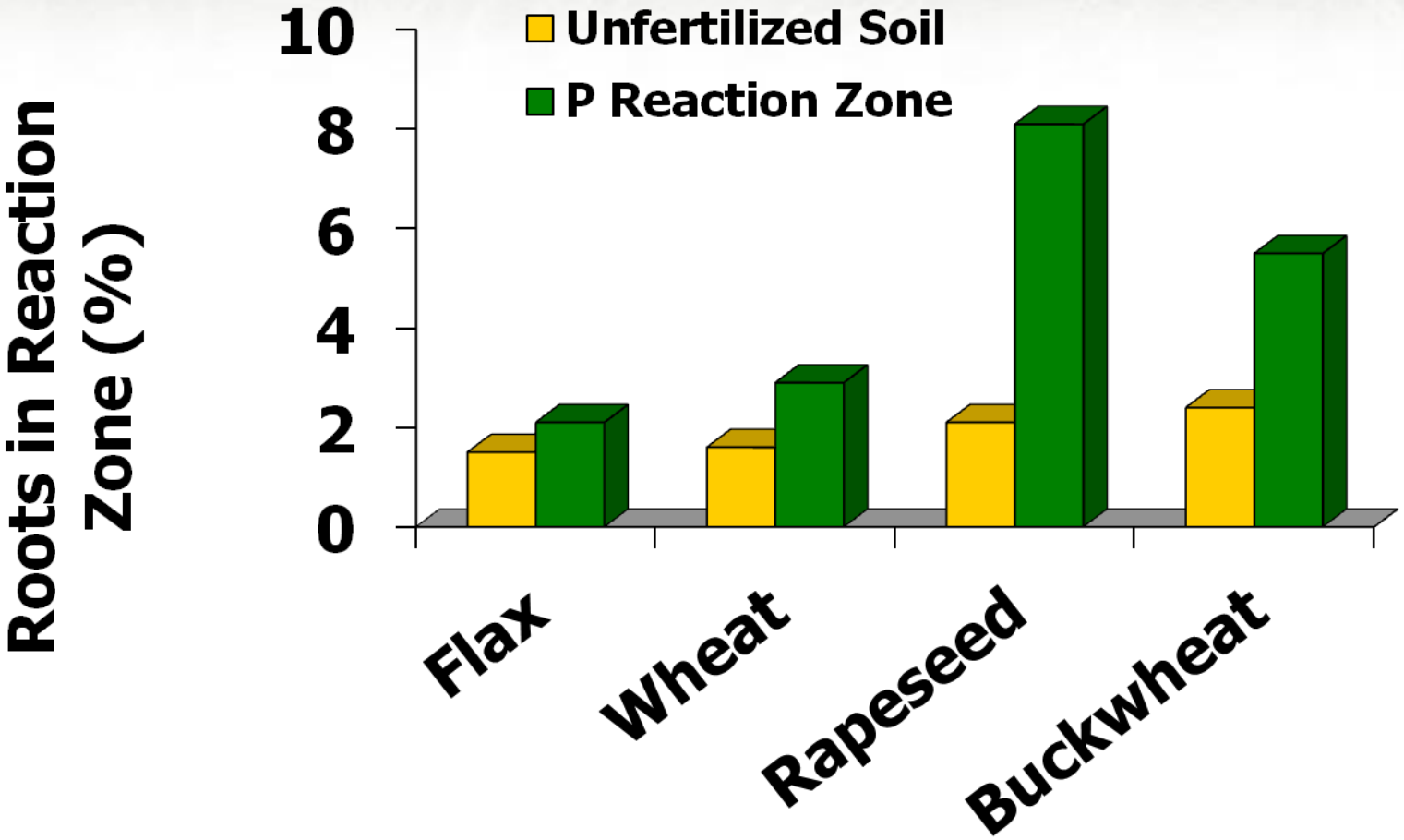
Crops Differ in Ability to Access Soil and Fertilizer P

(Flax Council of Canada)

(Canola Council of Canada)

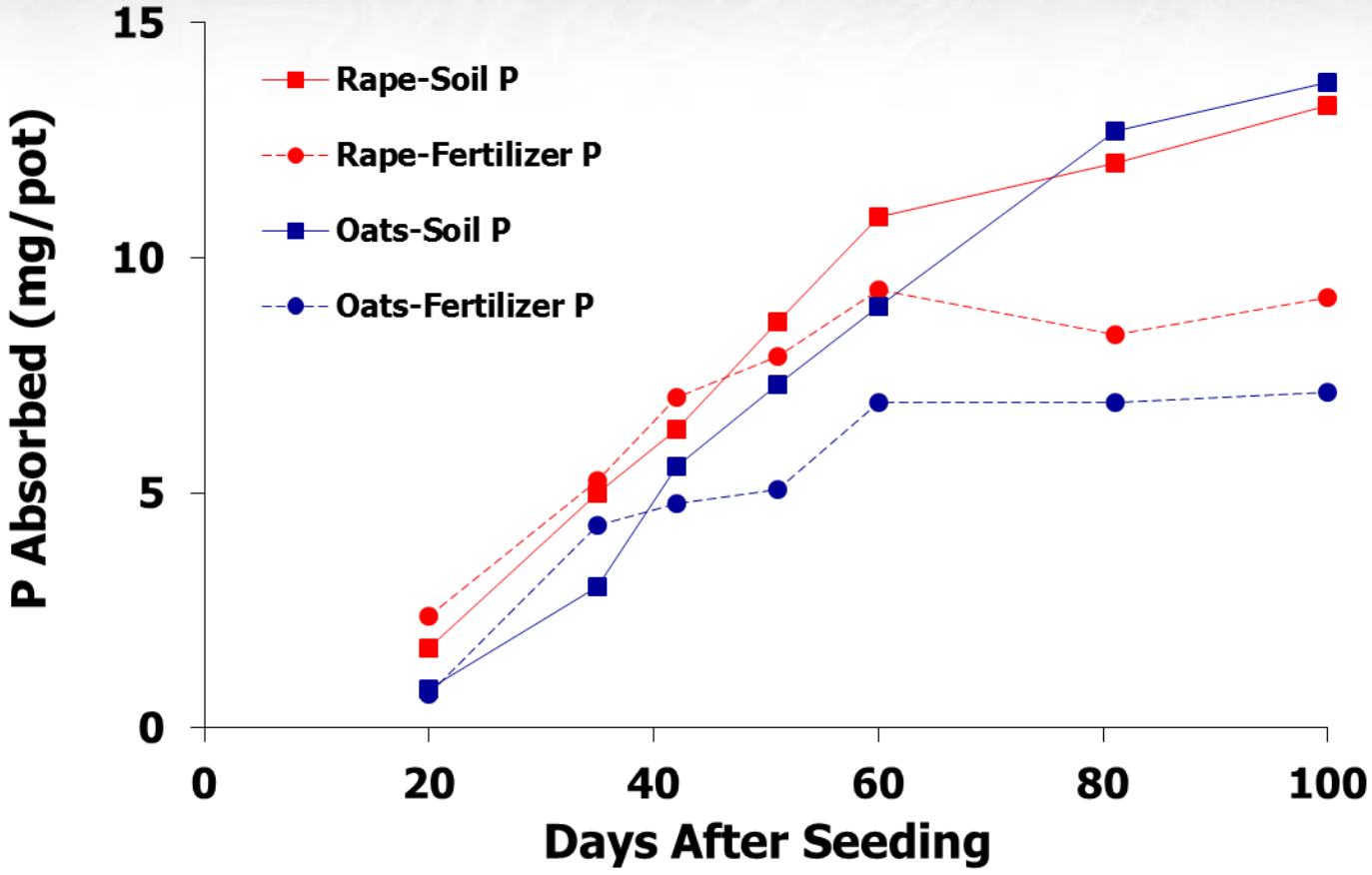
- Flax has poor ability to take up fertilizer P
  - relies more strongly on soil P
  - poor response to fertilizer P
- Cereals moderate in their ability to use soil and fertilizer P
- Canola effective at feeding from both fertilizer and soil P
  - modification of rhizosphere
  - Proliferation of roots in fertilizer reaction zone

Canola Can Increase Rooting in High P Fertilizer Reaction Zone



Canola is Efficient at Accessing Starter P Early With Greater Soil P Uptake Later in the Season

Uptake from the soil increases as root system grows

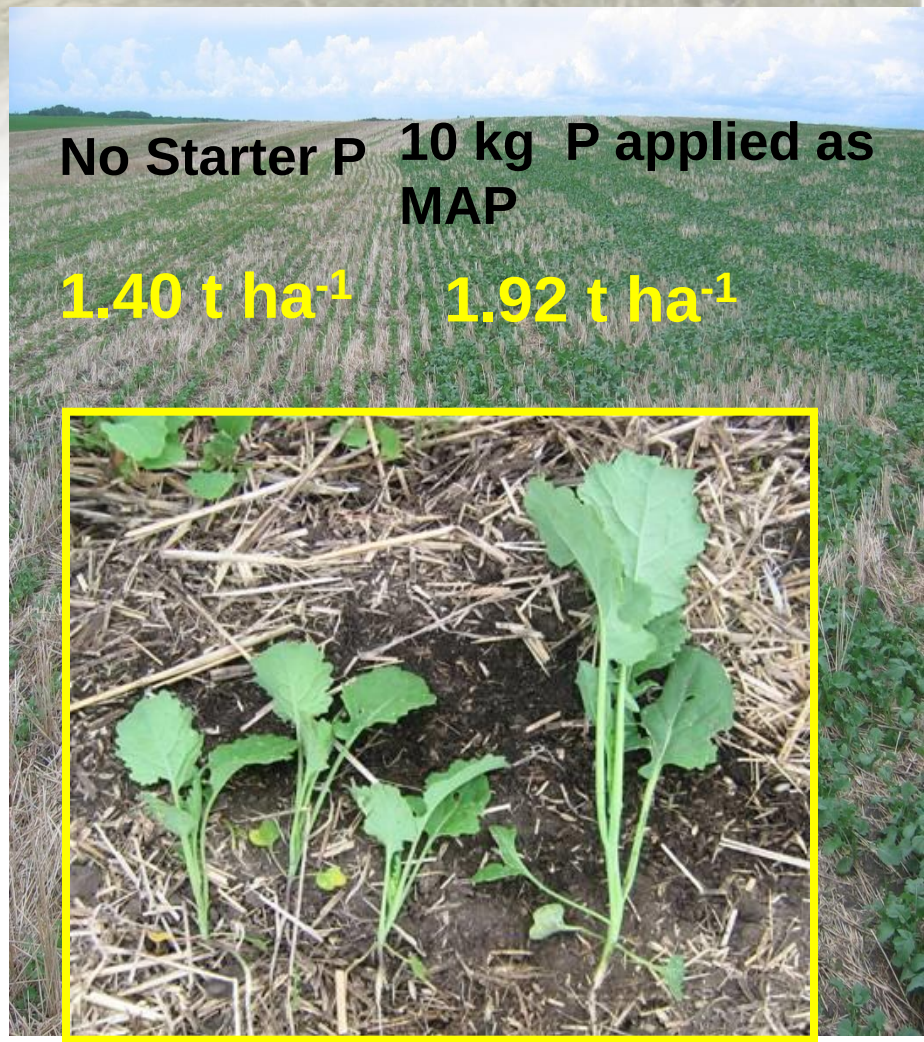


Kalra and Soper (1968)

Kalra and Soper

Canola Responds Well to P on Low P Soils

- Canola is highly responsive to P on very low P soils
  - Can use soil P well if soil test P is moderate to high
- Yield will usually be optimized with 7 to 10 kg P ha^{-1}
- Place as starter near or in the seed-row
- Response to starter more likely on cold soils, with early seeding



90

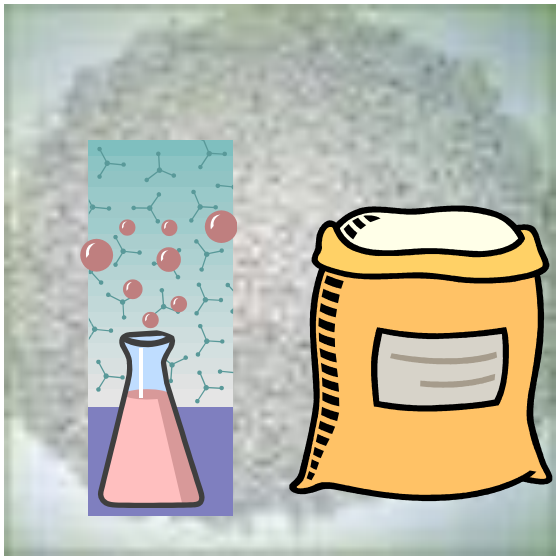
15 lb NW MKP per ac, equiv. to ~ 7 ppm Olsen P

Products and Practices that Attempt to Improve P use Efficiency

- Banding P near the seed
- Use of more crop available forms
  - Fluids versus dry
  - Orthophosphates versus polyphosphates
- Reduce soil reactions
  - Avail
- Release P gradually to match plant uptake
  - Coated MAP
- Fungi that mobilize P in rhizosphere
  - Provide *Penicillium bilaii*
- Fungi that improve plant access to P
  - Mycorrhizae

Can Different Fertilizer Formulations Improve P Availability?

- Monoammonium phosphate is the standard fertilizer source for the prairies
  - Ammonium in formulation enhances efficiency
- Ammonium polyphosphate is standard fluid form
- Other novel formulations include:
  - Fluid orthophosphates such as Alpine
  - Avail additive
  - Polymer coated MAP

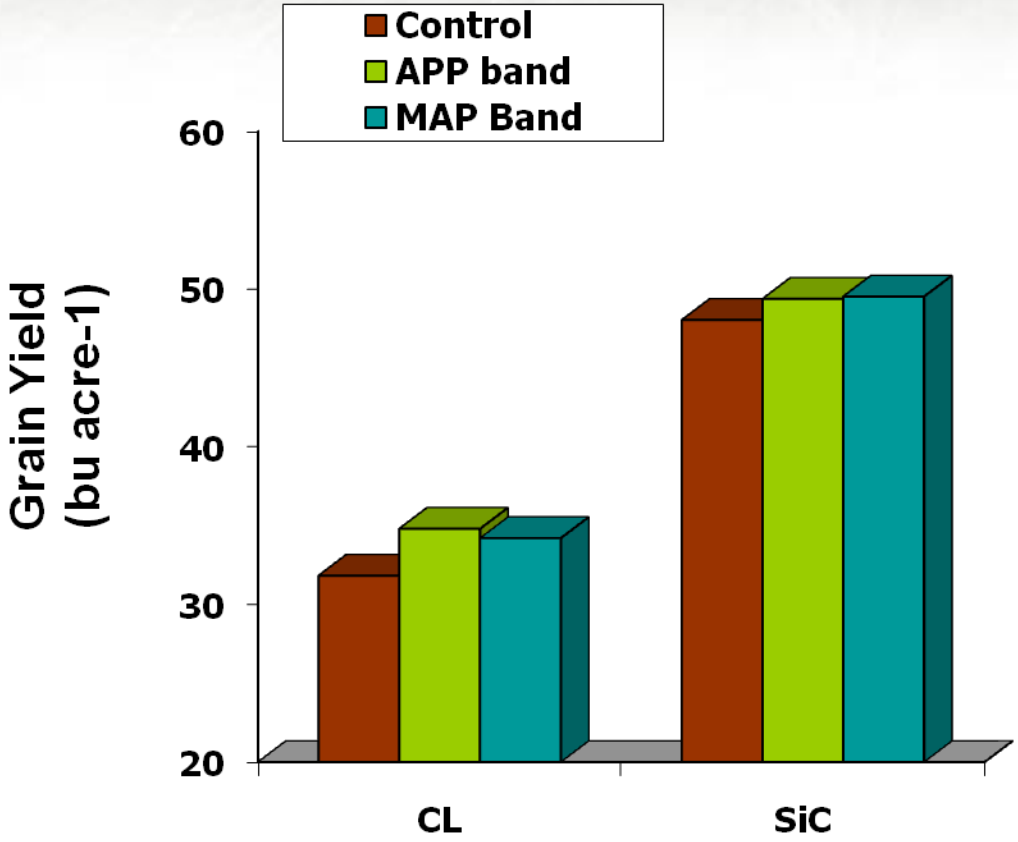


Fluids Versus Dry

- Under arid, highly calcareous conditions in Australia, fluid forms of P are more available than dry
  - Water moving toward granule carries Ca
  - Ca precipitates P and leads to small reaction zone
  - Fluid forms increase reaction zone and allow greater root uptake
- Similar benefit has not shown up in tests in Manitoba and is unlikely in humid areas

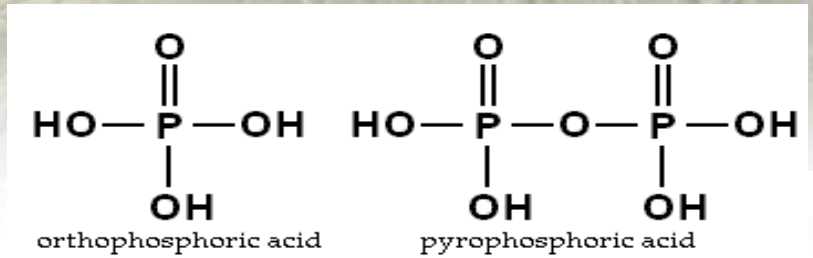
There was no difference between dry MAP and fluid APP in wheat yield over three years at two sites near Brandon

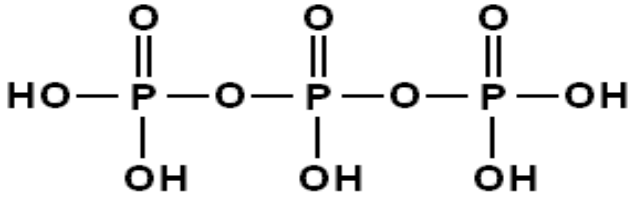
- Similar results in previous studies by Racz and in later studies on canola
- Soils are much less calcareous than the 70% calcium carbonate in the Australian trials

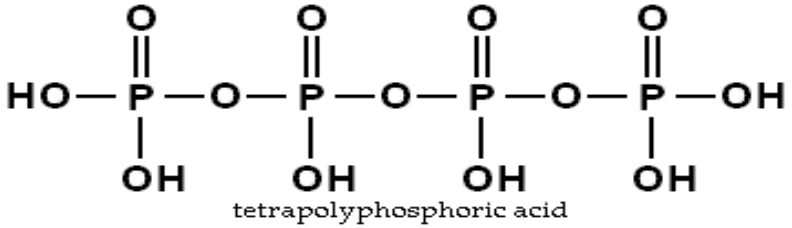


Orthophosphates versus Polyphosphates

- Polyphosphates are chains of orthophosphates
- Most polyphosphate fertilizers still have 40-60% of the phosphate in the orthophosphate form
- Polyphosphate converts to orthophosphate in soils rapidly
  - Half usually is converted within a week,
  - Conversion may be slower if soils are cool and dry
- Generally no difference in effectiveness under field conditions

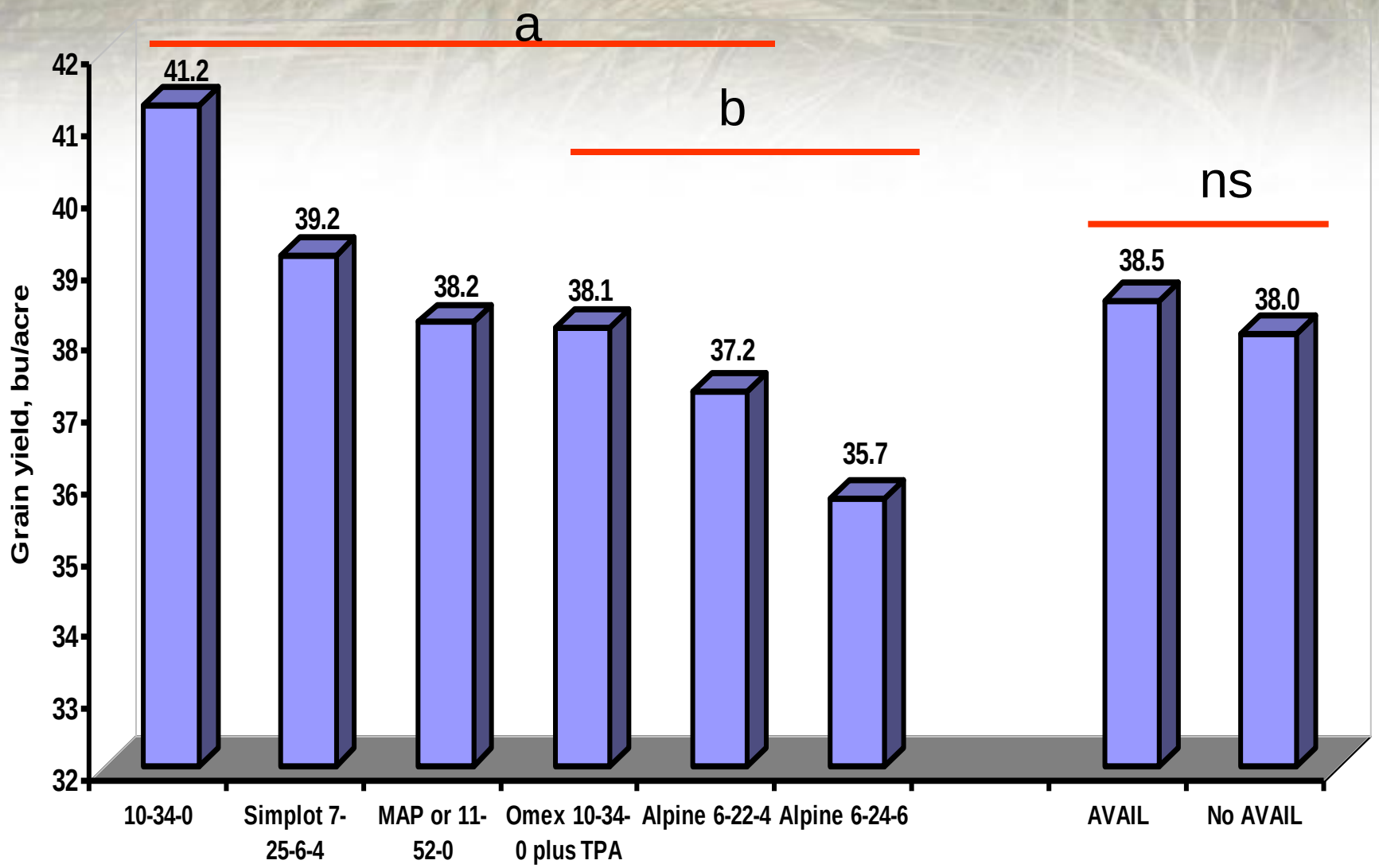




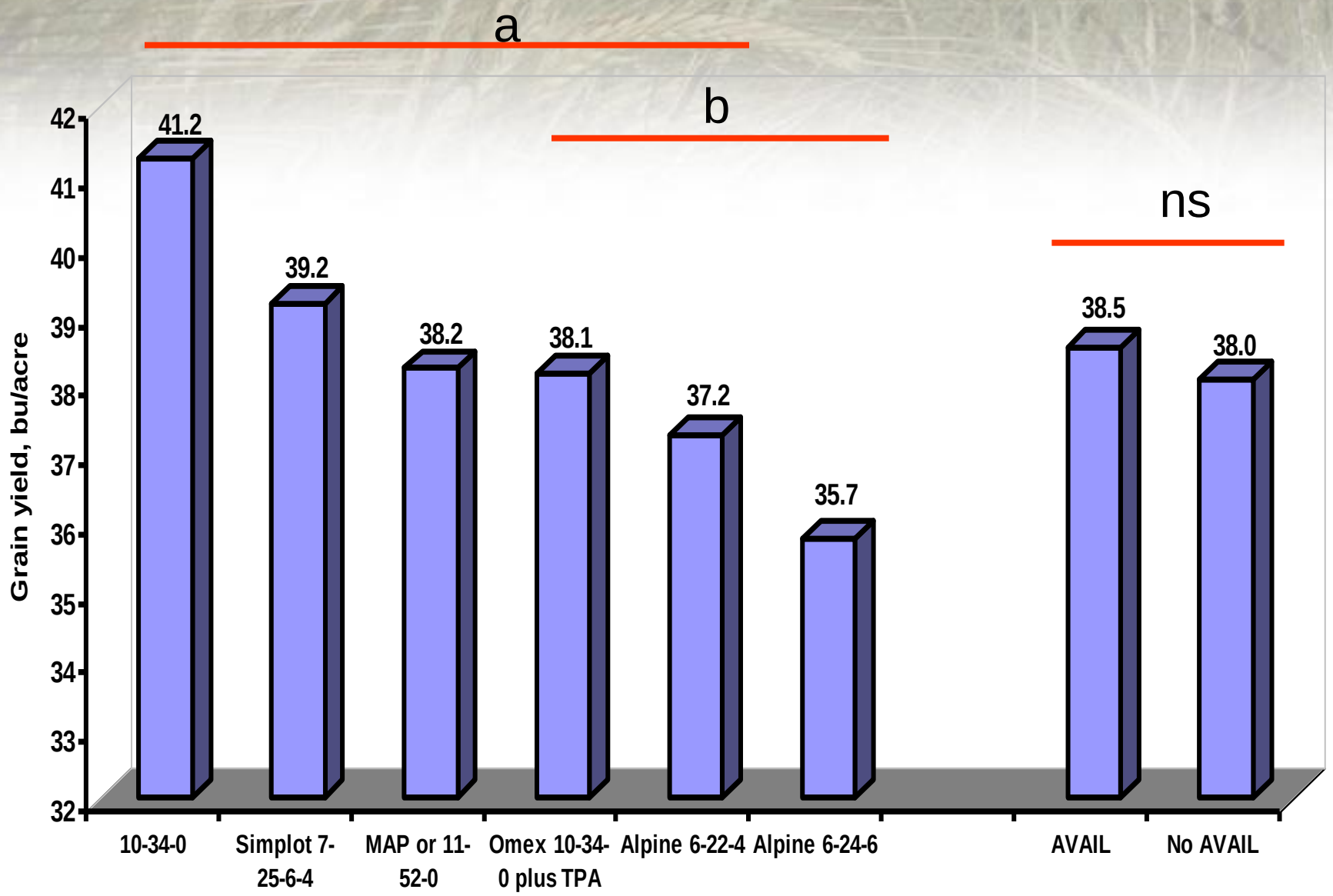


  - http://www.extension.umn.edu/distribution/cropsystems/DC6288.html

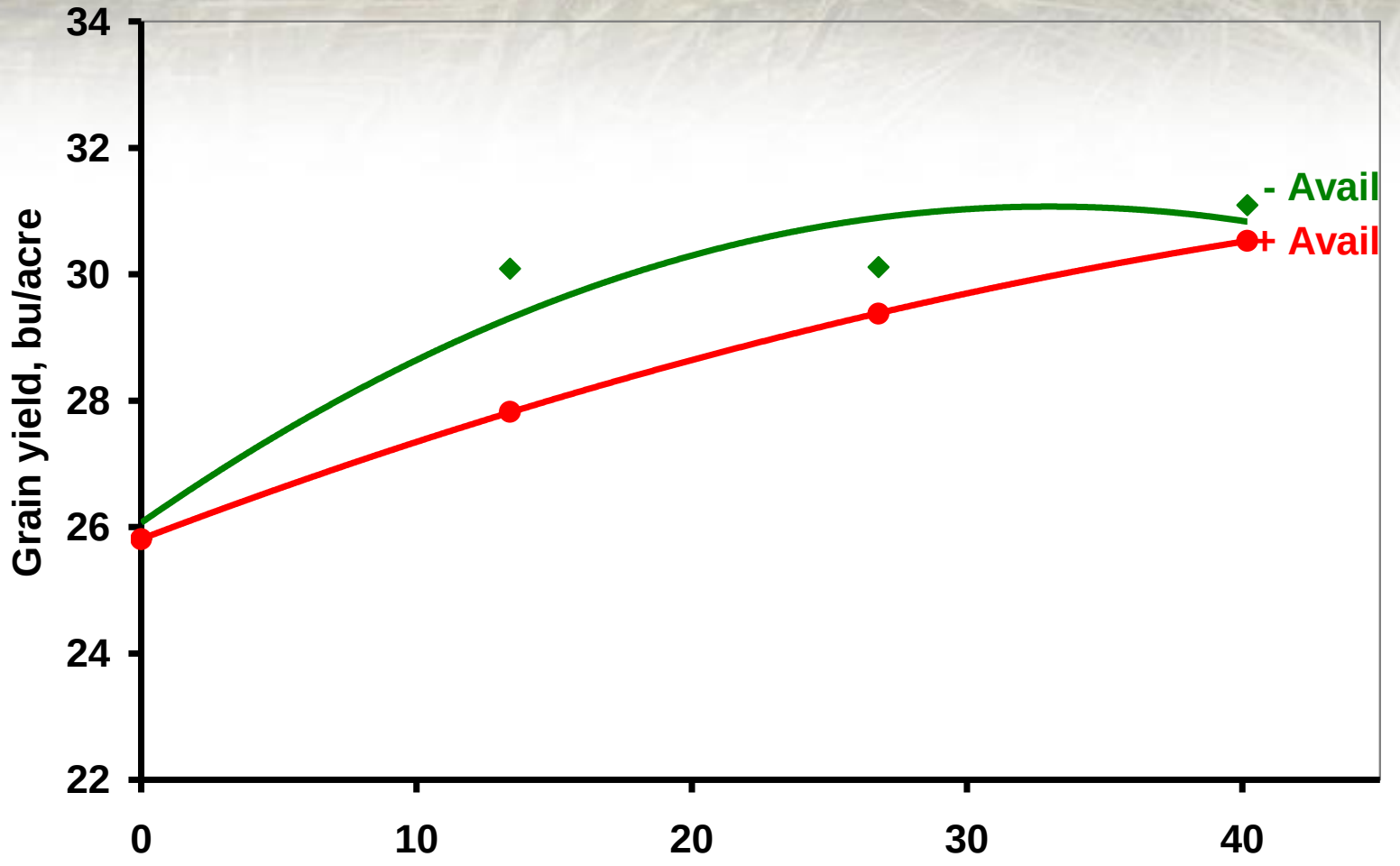
In studies by Tom Jensen at Brandon, 10-34-0 and MAP performed as well or better than enhanced P products (Average of 8, 16 and 32 kg ha^{-1} phosphate rates)



Yield was also similar with MAP alone or treated with Avail



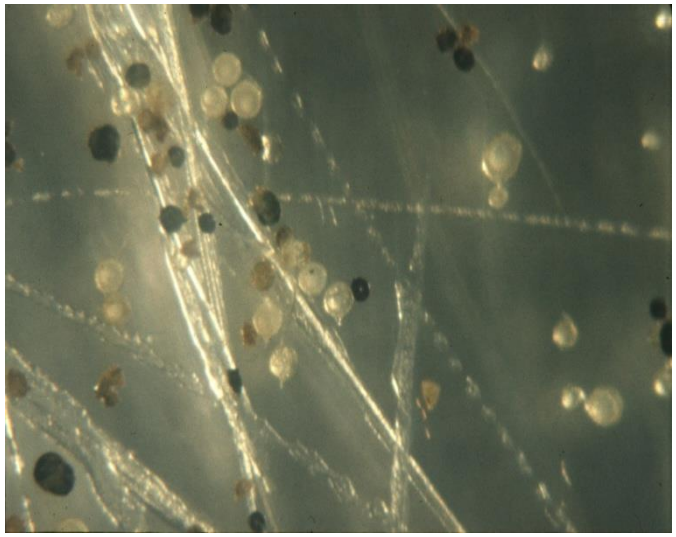
In wheat on the prairies, yield was similar if MAP was applied with or without Avail

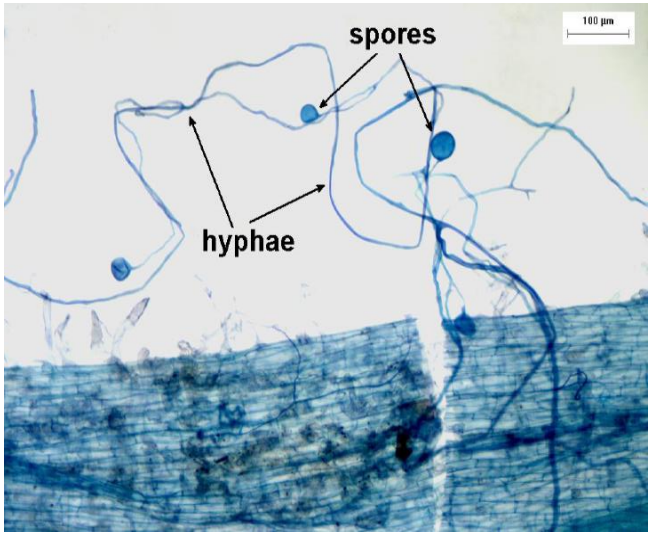


Karamanos

What about the microbial products?

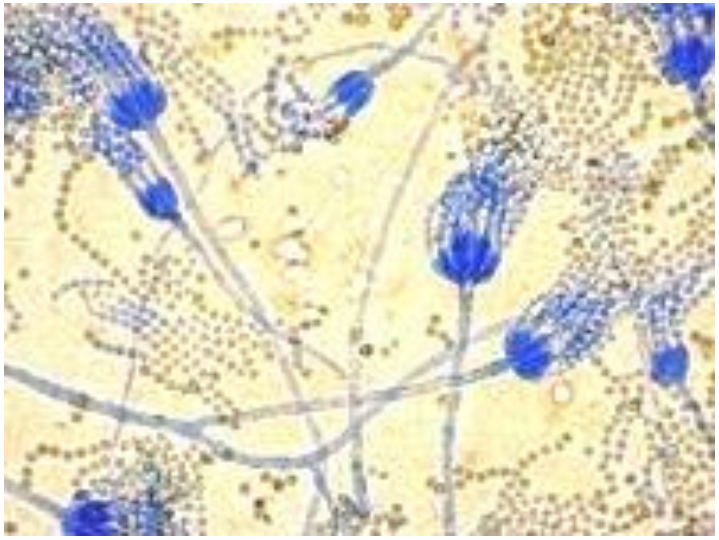
- Two major products sold in western Canada
- Provide (Jumpstart and part of Tagteam)
- Mycorrhizal inoculants – not for use with canola since canola does not form mycorrhizal associations
  - Watch for P problems in mycorrhizal-dependent crops such as corn or flax grown after canola



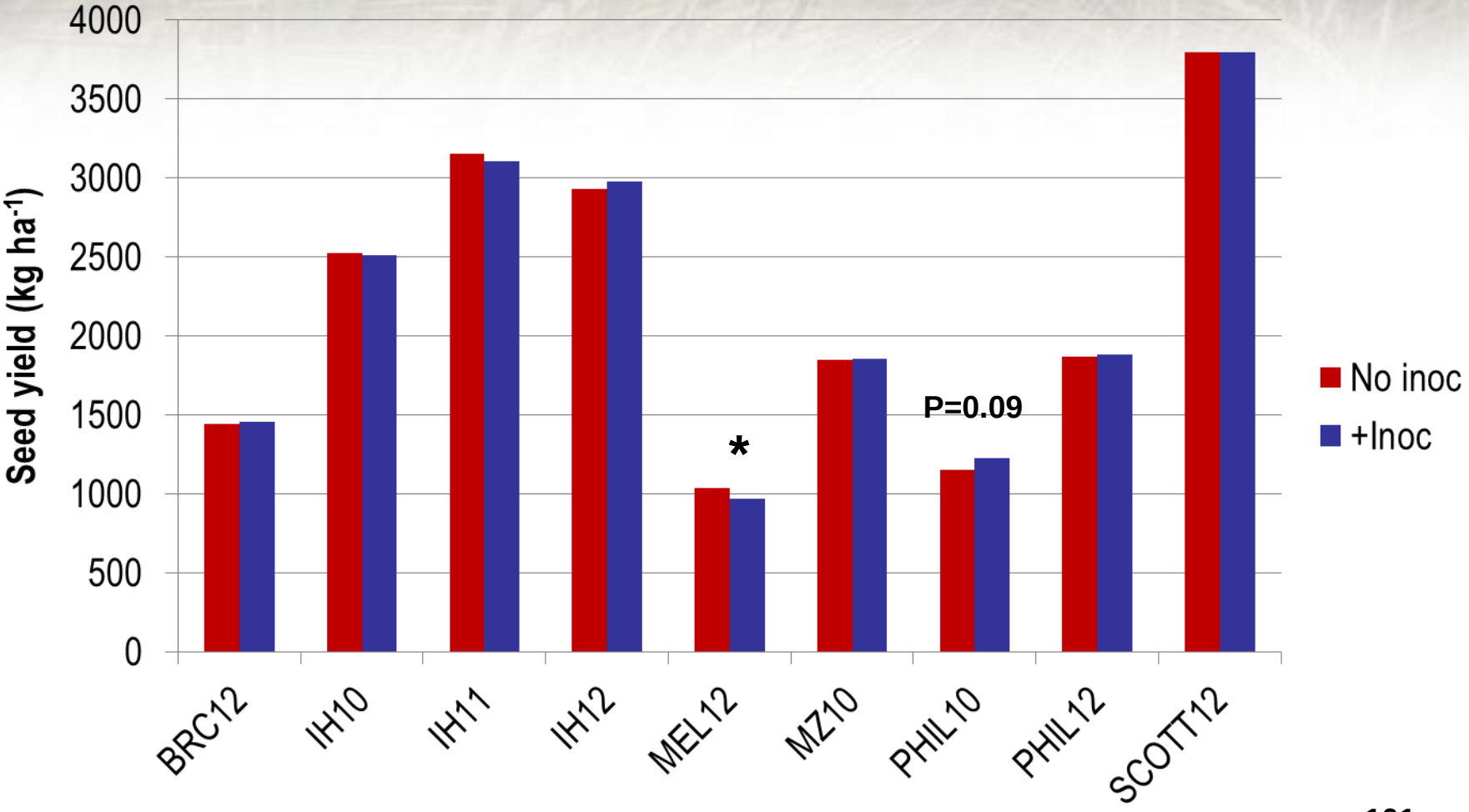


Provide is a microbial inoculant

- *Penicillium bilaii* (also classified as *P. bilaji* and *P. bilaiae*) is a fungi that colonizes the rhizosphere
- Effective in solubilizing phosphorus (P) under controlled conditions
- Under field conditions, results have been inconsistent



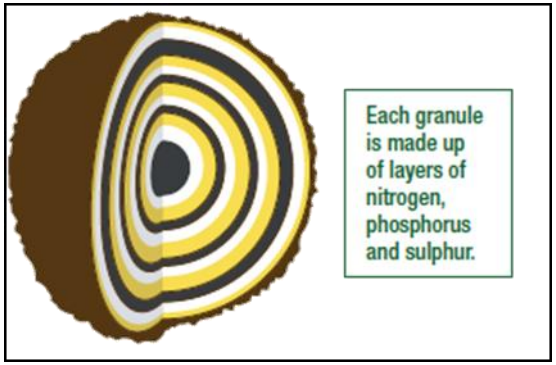
Provide did not benefit canola yield in studies in Manitoba and Saskatchewan



Ramona Mohr

MicroEssentials S-15

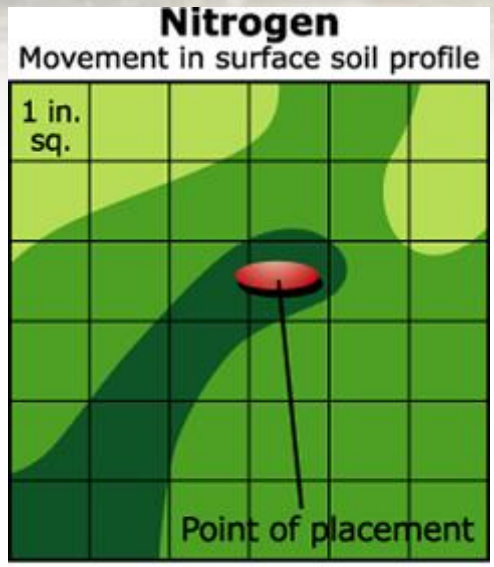
- Blend of monoammonium phosphate, ammonium sulphate and elemental sulphate (13-33-0-15)
- “Onion-skin” layers of sulphur
- Mosaic product
- Good product for seed-placement
  - Good distribution and seed safety
  - P availability is as good as MAP



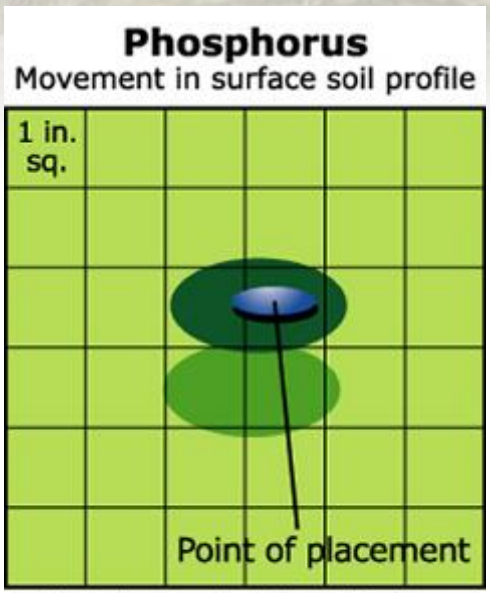
Banding Is the Main Way of Improving P Availability

- Slows tie-up of P in soil
  - Having some N in the band is beneficial
- Bands must be placed where roots will contact them early in season
  - Seed-placed
  - Side-banded
- Some plant roots proliferate in bands
- Uptake increases with P concentration and rooting
  - Fertilizer bands provide high concentration
  - More roots in the band increase uptake

Phosphorus is Relatively Immobile in the Soil



Nitrogen location 17 days after application



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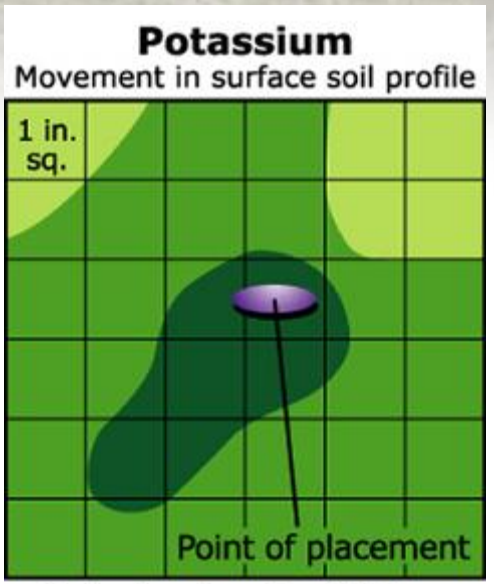
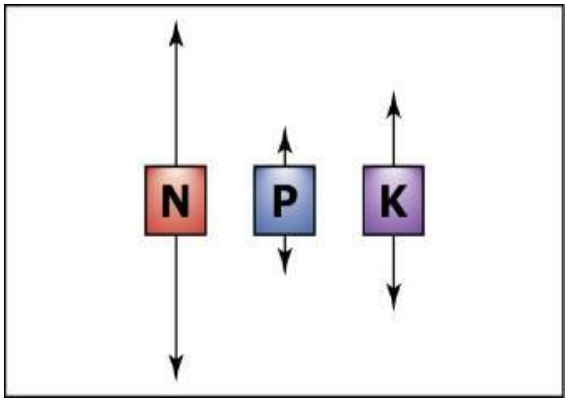


Potassium location 17 days after application

High concentration

Medium concentration

No effect



Has important effect on P management decisions

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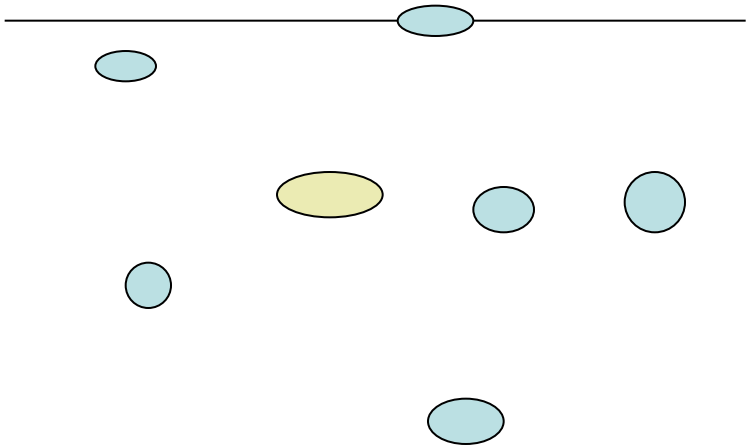
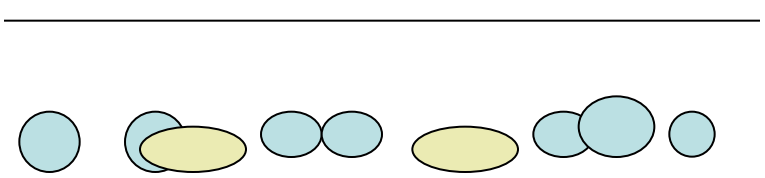
  - Seed-placed
  - Side-banded
- Canola roots proliferate in bands
- Uptake increases with P concentration and rooting
  - Fertilizer bands provide high concentration
  - More roots in the band increase uptake

Banding P Near the Seed-Row Ensures that Roots Will Contact the P Granule Early in Growth

Broadcast



Banded



At 25 Kg P_2O_5/Ha and 18 cm row spacing have a granule every 2.3 cm (11-55-0)

The large difference between banded and broadcast applications is POSITION

Courtesy Geza Racz

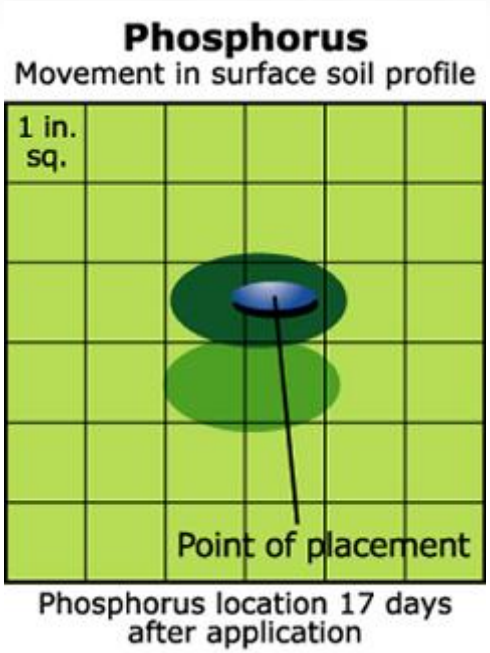

Both sides received fall-banded 70-30-10-10
9 kg of P with seed
No starter P
Courtesy of Aaron Baldwin

Banding P Near Seed is Most Important With

- Low soil P levels
- Restricted rooting
  - Compaction
  - Tillage pans
- Cool soil conditions
  - Solubility, mobility, rooting
  - Early seeding

Low P Mobility Limits How Much You Can Reduce P Application Rates

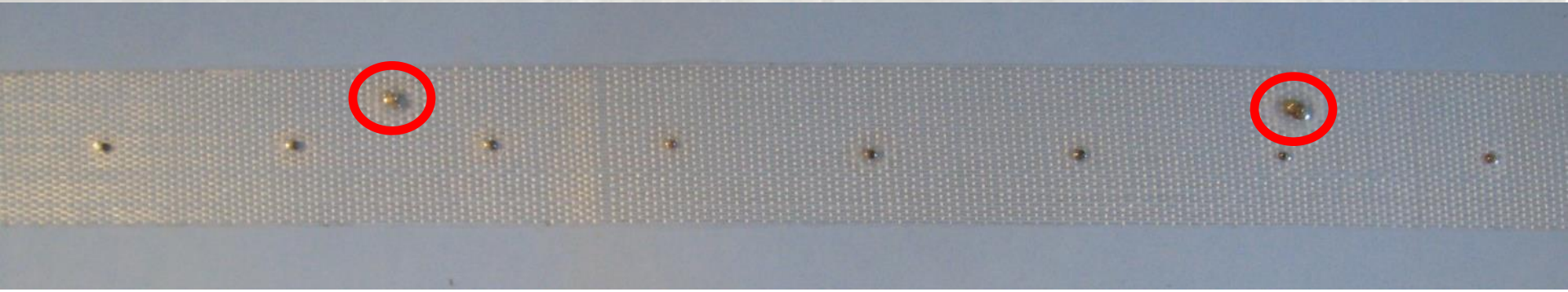
- Must have a high enough rate that each seedling can reach granule (or droplet) during early growth
- Reducing rate below about 15-20 kg/ha may restrict availability
- Distribution is affected by row spacing and band width
  - Greater the seed-bed utilization, the wider apart the granules are spaced
  - May need higher rate with higher seed-bed utilization



Phosphorus location 17 days after application

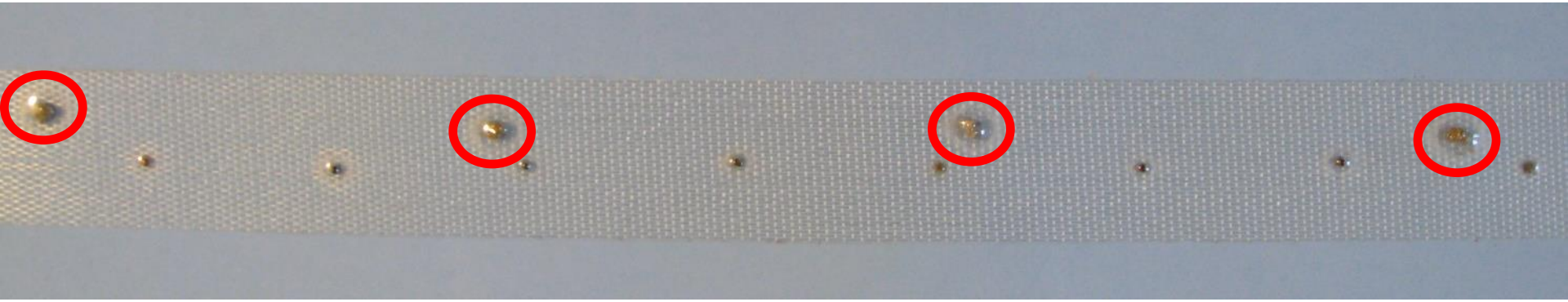
Dry Fertilizer Material

Canola – 17.5 cm rows, 2.5 kg/ha P
5 kg/ha MAP fertilizer
19 cm between MAP particles



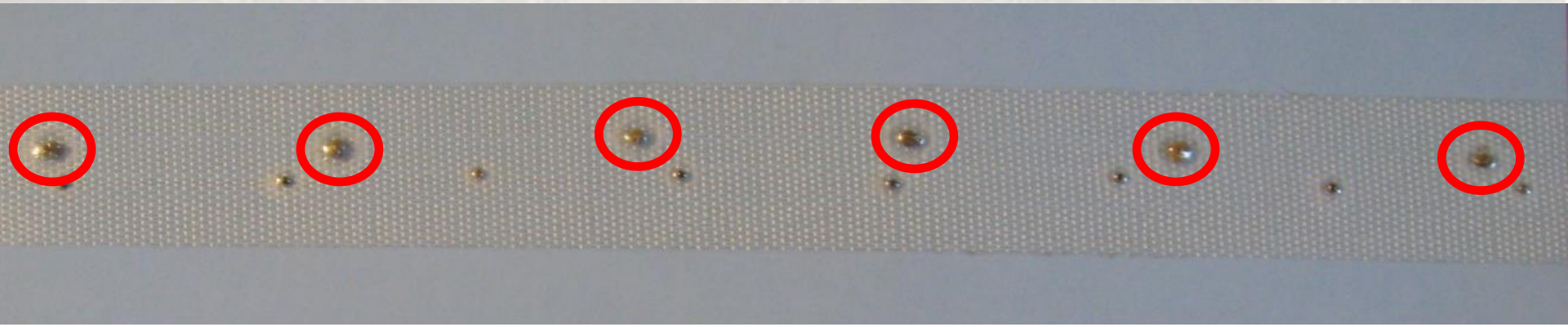
Canola – 17.5 cm rows 5 kg/ha P
10 kg/ha MAP fertilizer
9.5 cm between MAP particles

AGVISE LABORATORIES



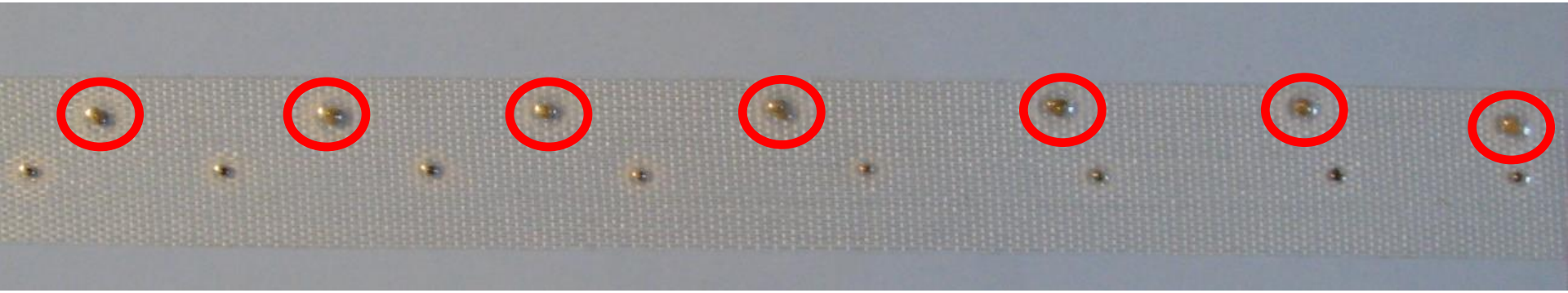
Dry Fertilizer Material

Canola – 17.5 cm row 7.5 kg P/ha
15 kg/ha MAP fertilizer
6.4 cm between MAP particles



Canola - 17.5 cm row 10 kg P/ha
20 kg/ha MAP fertilizer
4.8 cm between MAP particles

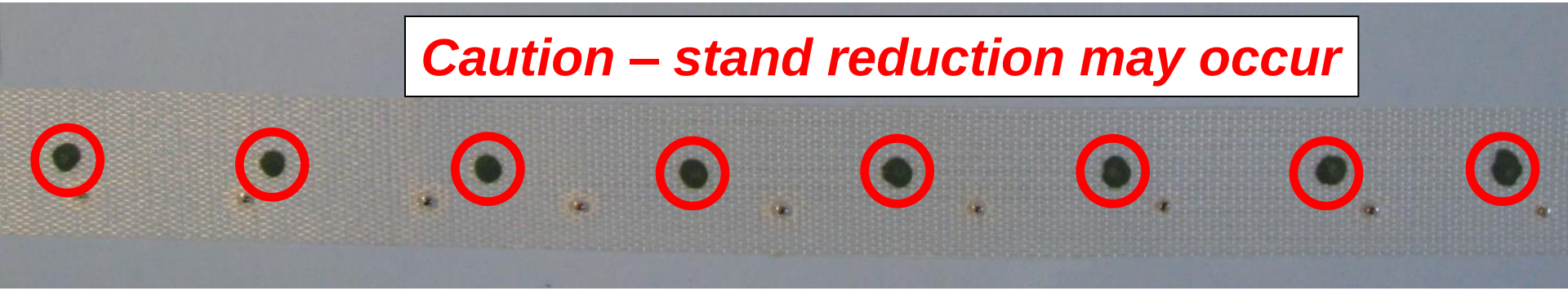
AGVISE LABORATORIES



Liquid Fertilizer Material

Canola – 7” rows, 30 lb/a P_2O_5
7.5 gallons/acre 10-34-0
1.9” between drops of fertilizer

Caution – stand reduction may occur



AGVISE LABORATORIES

Effect of Band Width on Response to P fertilizer

Treatment	Yield (g) 11 Days after Emergence
Control	0.52
MAP- 1 inch	0.85
MAP- 2 inch	0.79
MAP- 6 inch	0.75

- As band width increases, fertilizer granules are spread over larger area
- Higher seed bed utilization and granules less likely to be near each seedling
- Greater early-season response to P when band is narrow

Courtesy of Geza Racz

Effect of Band Width on Response to P fertilizer

Treatment	Yield (g) 23 Days After Emergence
Control	2.73
MAP- 1 inch	5.55
MAP- 2 inch	5.49
MAP- 6 inch	5.25

- Effect of band-width persisted when MAP was seed-placed
- May need to increase P rate with wide band

Courtesy of Geza Racz

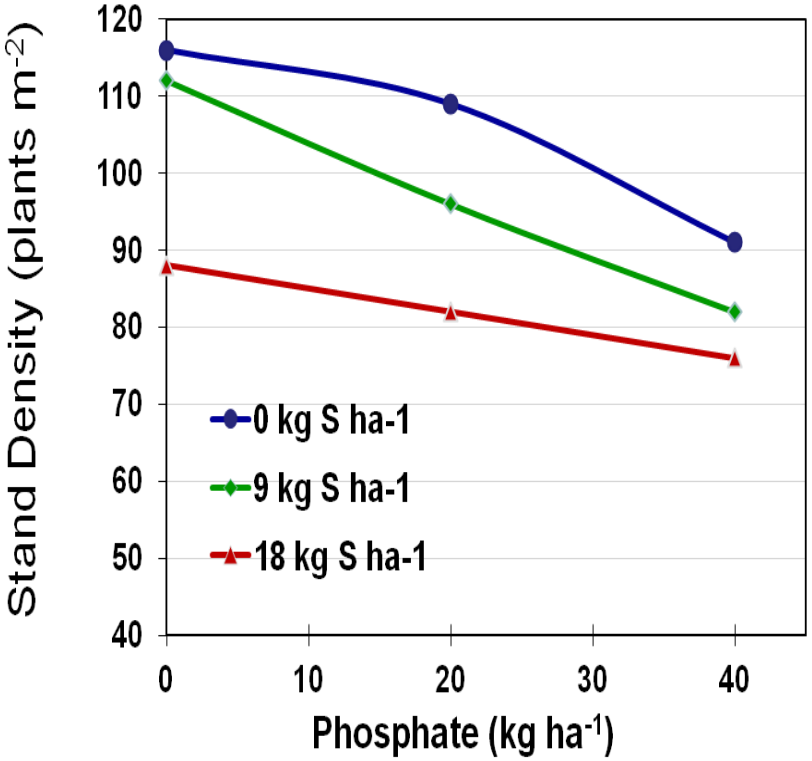
Excess Seed-placed Monoammonium Phosphate can Cause Seedling Damage in Canola

- Toxicity is mainly related to salt effect from N portion of MAP fertilizer
- Toxicity will be affect by soil characteristics and weather
- Seed-bed utilization affects concentration and therefore toxicity
- Reducing concentration in soil solution will reduce toxicity
  - Controlled release fertilizers?
- Toxicity due to salt dessication, so blends may produce additive effect

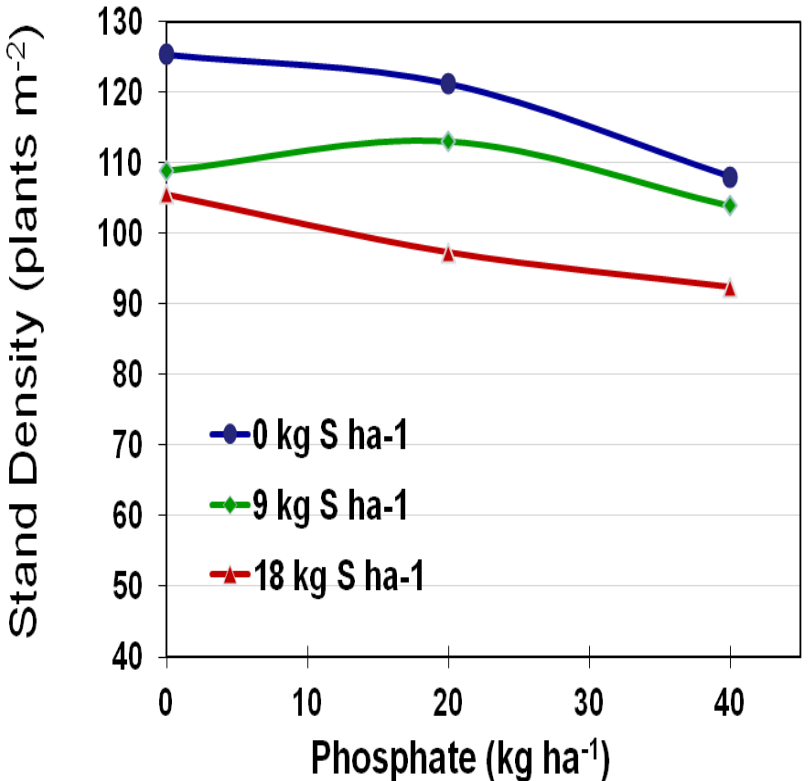
Excess seed-placed monoammonium phosphate can cause seedling damage in canola

- Stand density decreased with increasing rates of seed-placed MAP
- Most damage occurred with highest rates of MAP and ammonium sulphate

Quebec 2010

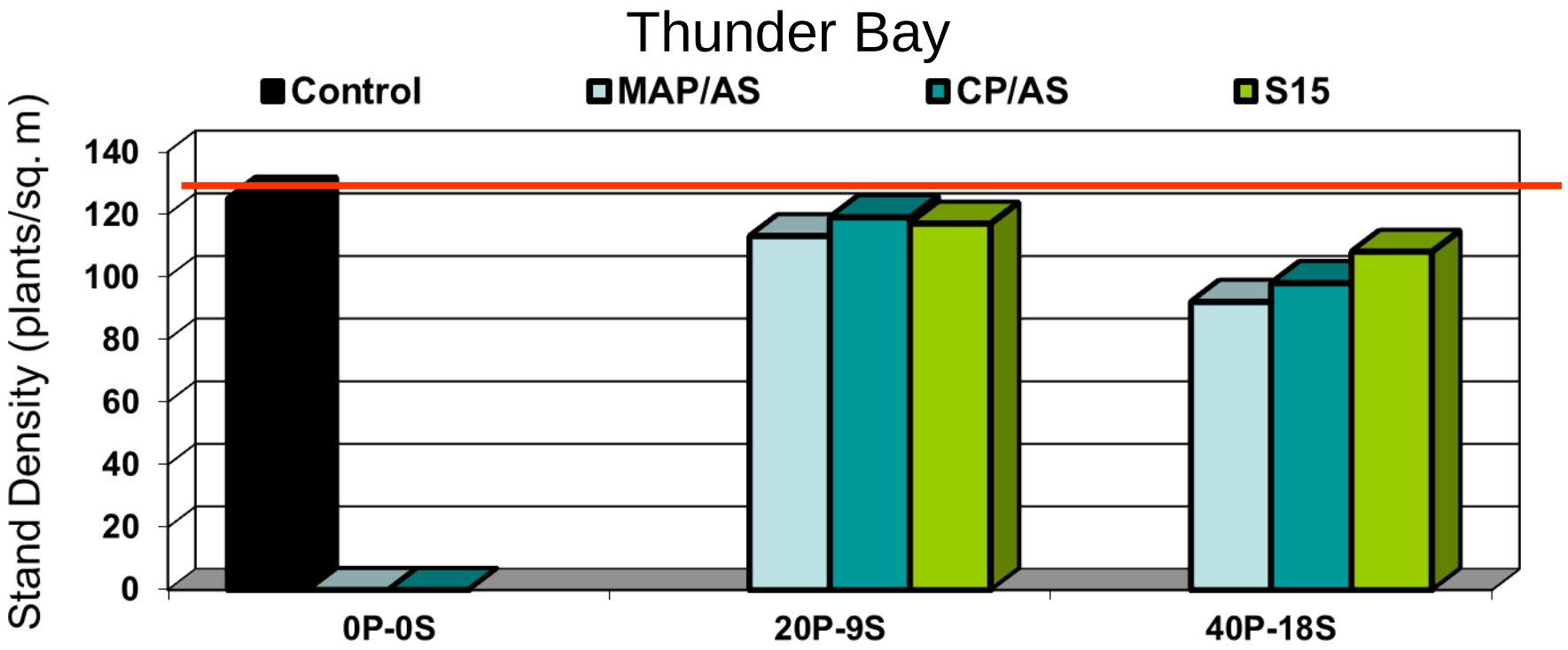


Thunder Bay 2011



Damage Occurred with both P and S

- Most damage occurred with highest rates of MAP and AS
- MicroEssentials was slightly less damaging

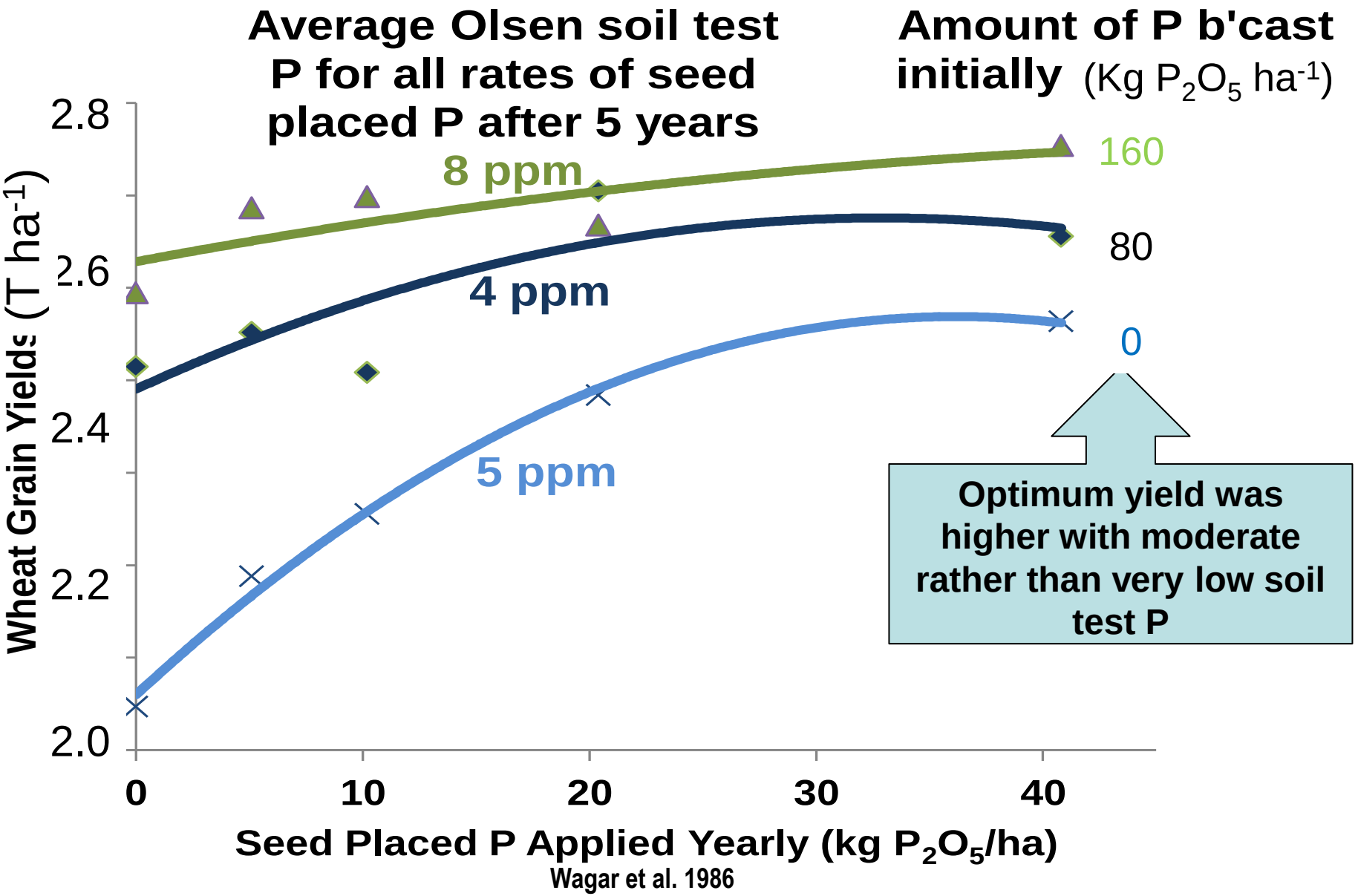


Relying on only the "safe" rate of seed-placed MAP can lead to depletion in canola and soybean crops

Crop	Yield	P Removal	Seed Limit	Difference
	t/ha	----------	kg P ha^{-1}	----------
Wheat	2.7	14	24	+10
Canola	2.2	20	10	-10
Soybeans	2.7	16	5	-11
Barley	4.3	19	24	+5
Oats	3.5	14	24	+10

*Rates are based on disk or knife openers with a 1 in. spread, 6 to 7 in. row spacing and good to excellent soil moisture

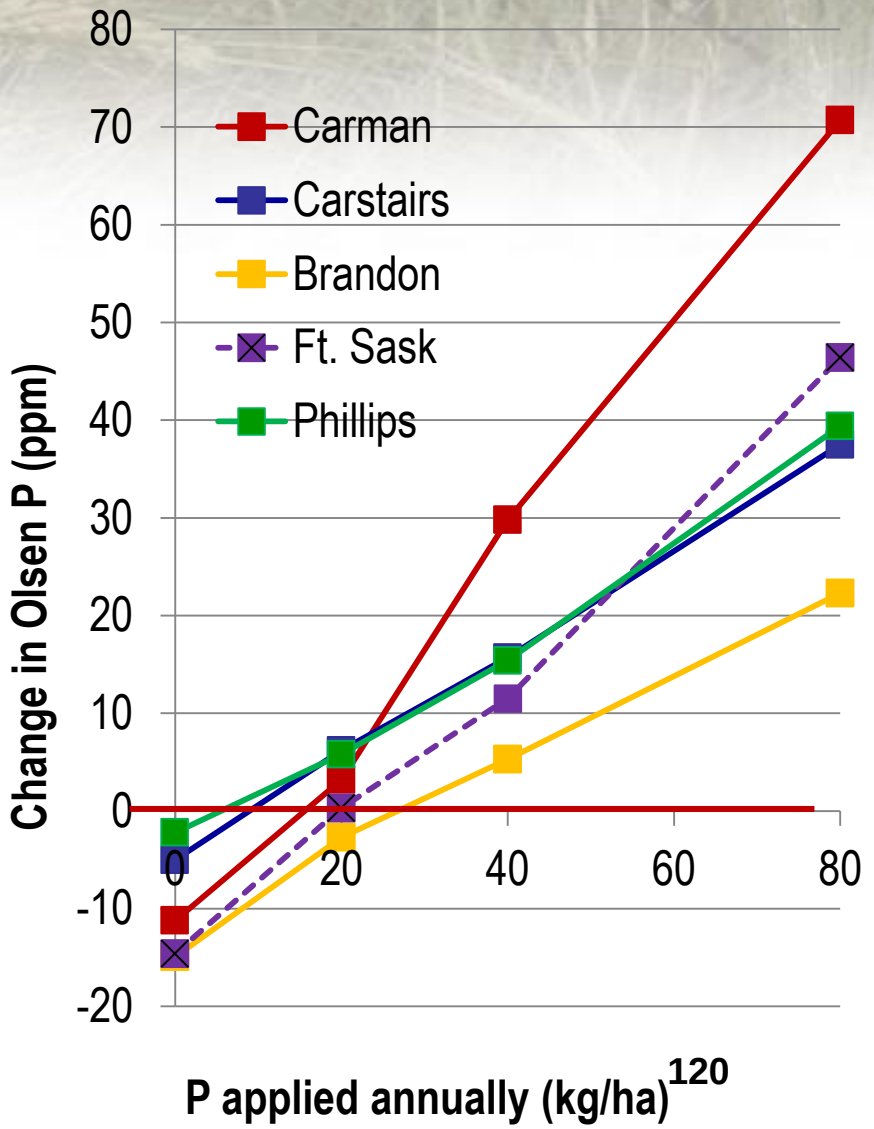
Crops respond to P fertilizer and P fertility, so depleted soil P can decrease crop yield potential



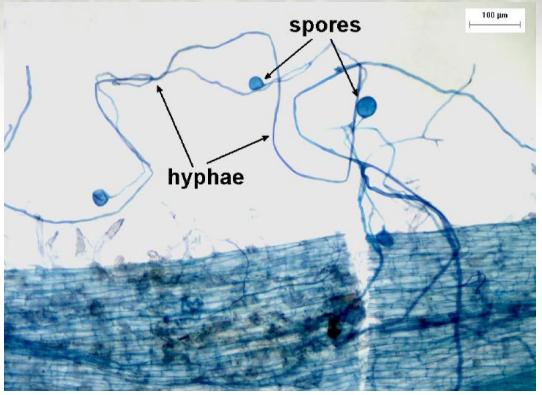
Wagar et al. 1986

Soil P Changes Reflect Balance Between P Input and Offtake

- Olsen P declined when no P was applied
- At 20 kg P per ha, Olsen P was maintained at most sites
  - However flax was grown half of the time with full rate of P which would give less deficit than with canola or soybean
- Large increases in Olsen P occurred with high P rates



Treatments that Increase P Uptake From the Soil Relative to P Input Will Hasten Depletion



- Provide (Jumpstart)
- Mycorrhizae
- Ultra low application rates based on claims of enhanced P availability

If application rates are reduced when these products are used, it will increase the imbalance between crop removal and P applied

Need to Maintain Soil P at Reasonable Levels

- Excesses can cause environmental problems
- Deficits can reduce potential crop yield
  - Especially if seed-placed P is reduced in sensitive crops
- Target Olsen P levels of around 15 ppm
  - Build levels in cereal years, with large broadcast applications, or with manure
- Consider replacement strategy when target soil levels are attained

Phosphorus Summary

- P fertilization is an essential part of a sustainable crop production system
- Canola will respond well to starter P at low rates
  - 8 to 12 kg P ha^{-1}
  - Response can occur even with moderate to high soil test P
- Both the likelihood and the size of P response are greater with low soil test P
- Enhanced efficiency fertilizers do not seem to be more effective than standard MAP or APP

Phosphorus Summary

- Under standard soil conditions, MAP and ammonium polyphosphate are effective sources
  - Benefits of having some ammonium in product
- No benefits of fluids versus MAP
  - Except on dry, highly calcareous conditions as occur in Australia
- No benefit of orthophosphate versus polyphosphate
- No evidence of consistent benefits from enhanced efficiency products

Phosphorus Summary

- Band placement is generally the most reliable applicati method
  - Plant roots must “find” fertilizer granule early in season
  - Band in or near seed row where roots intercept early
- Rate must be high enough that granules or droplets are near each seedling
  - Below 5 to 7 kg P ha^{-1} the fertilizer is spread too thin
  - Consider Seed Bed Utilization when thinking of rate
    - Higher seed bed utilization means fertilizer is spread more thinly
    - Good for seedling toxicity – poorer for P availability
- Risk of seedling damage from seed-placed MAP or APP
  - With high rates and/or if combined with ammonium sulphate

Sulphur is an important nutrient for Canola

Sulphur Deficiency Are More Common in Canola than Other Crops

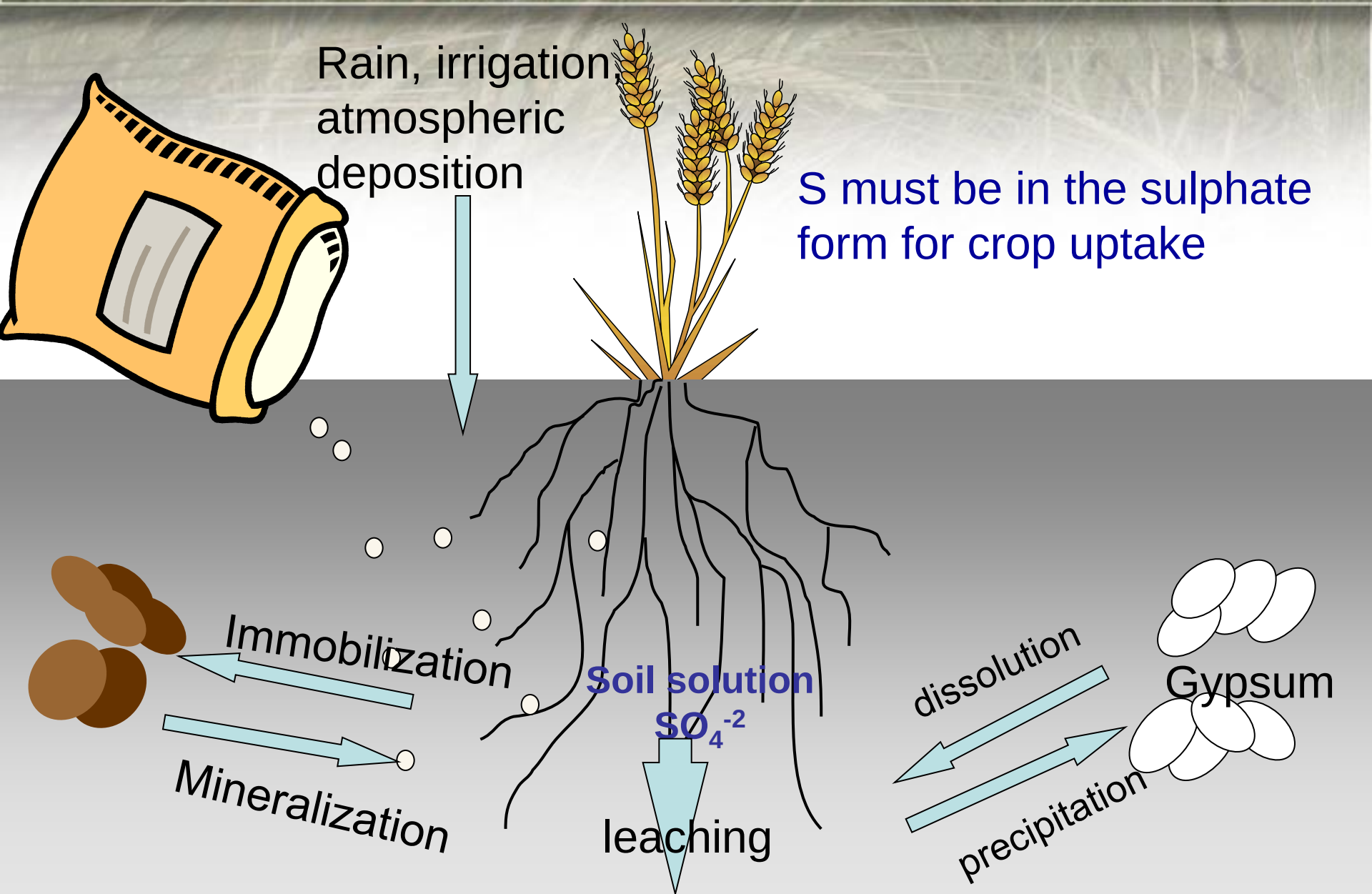
	Wheat	Canola	Peas	Alfalfa	Corn	Soybeans
Yield (t/ha)	2.7	2.2	3.4	11	9.4	2.7
Sulphur removal (kg/ha)	4	13	7	34	9	5

- Canola requires more S than most cereal and pulse crops.

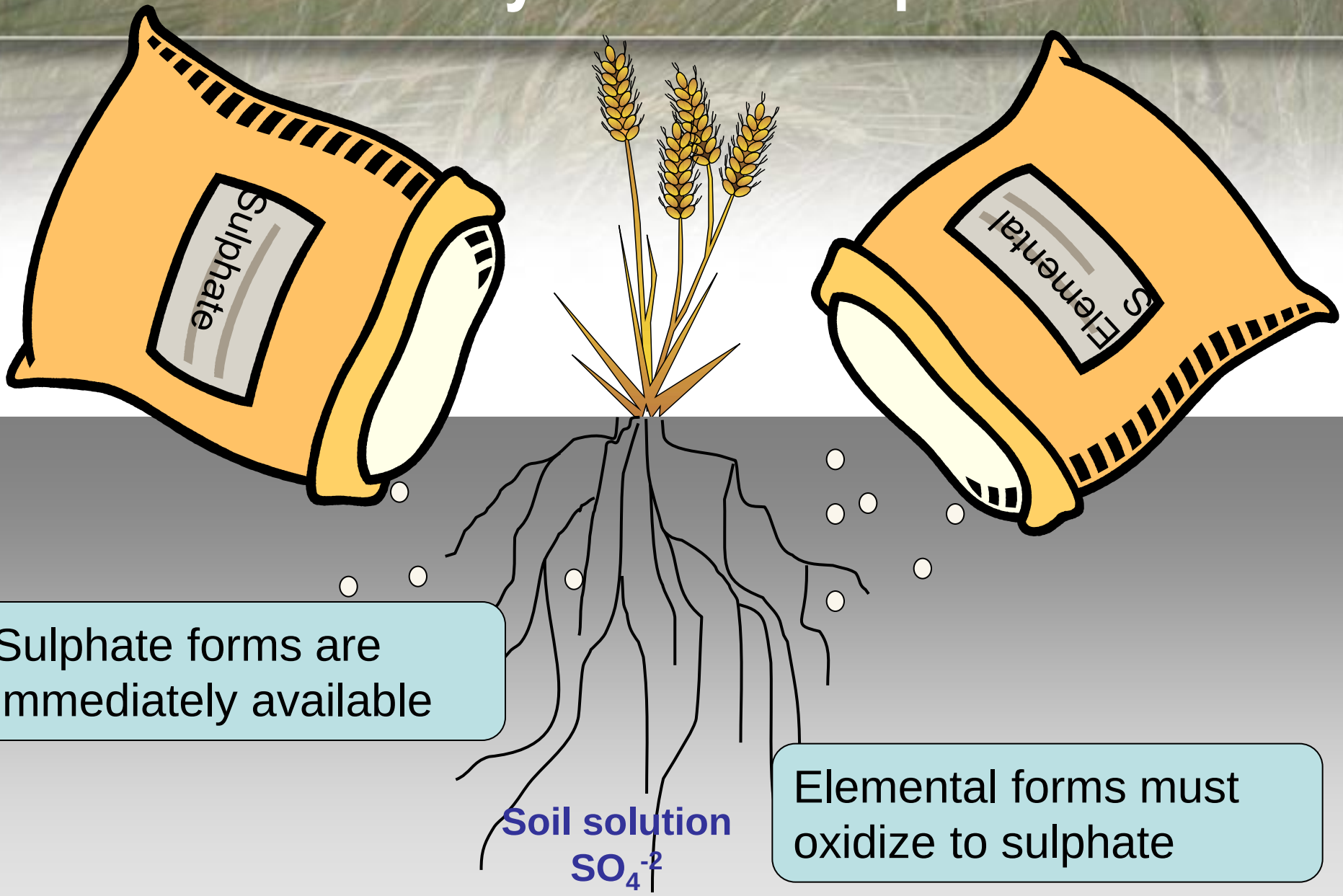
How Much Sulphur is Needed by a Canola Crop?

- A 2.2 t ha^{-1} canola removes about 13 kg S ha^{-1} in the seed
  - About 10 kg more taken up but recycled in residue
  - Total of about 24 kg needed for growth

Plants Access Sulphate from Soil Solution



Plants Only Absorb Sulphate-S



Sulphate forms are immediately available

Elemental forms must oxidize to sulphate

A Range of Sulphur Sources Are Available

Sulphate Sources

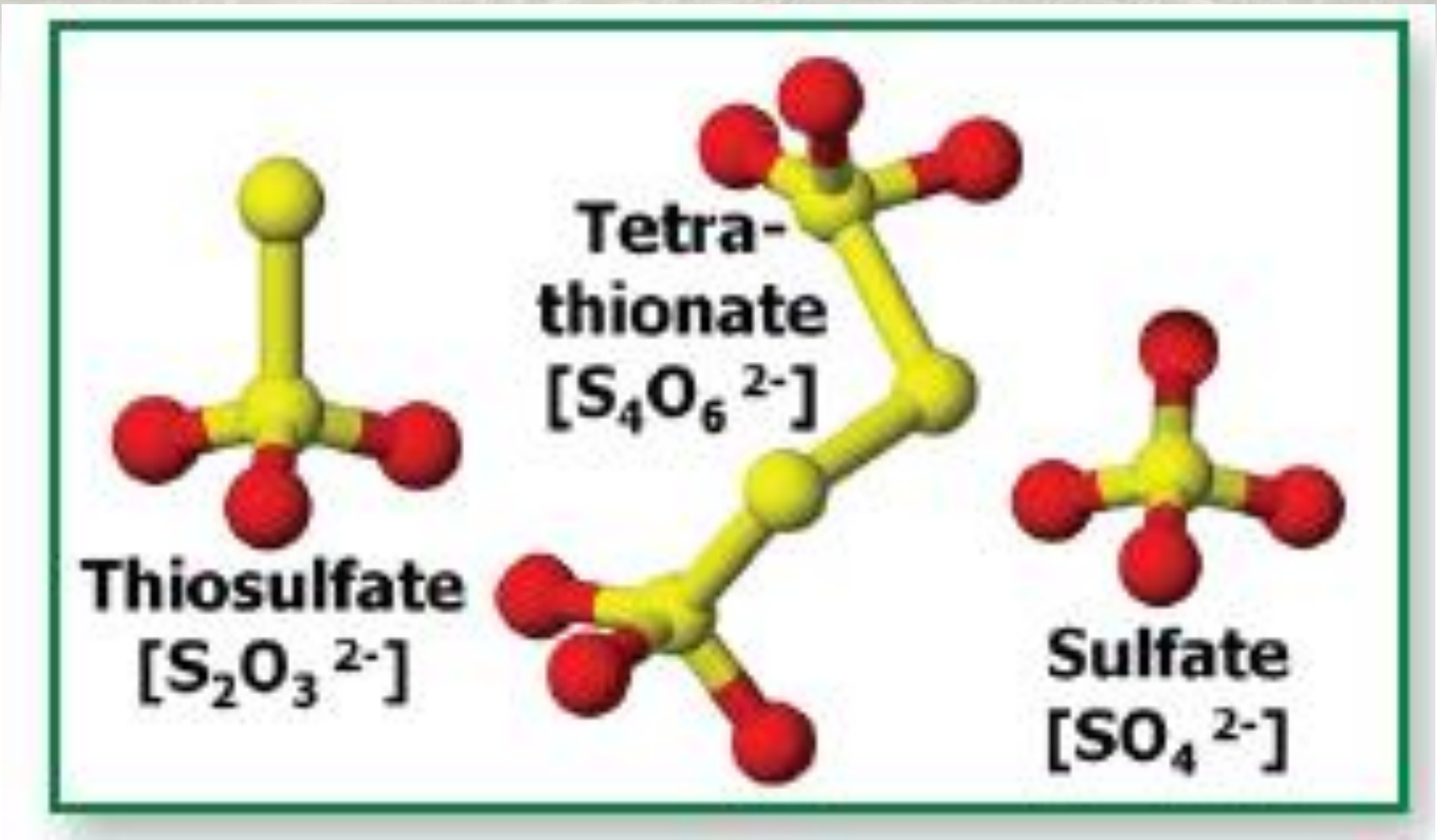
- Ammonium sulphate
- Ammonium thiosulphate
- Gypsum
- Microessentials S-15

Elemental Sources

- Elemental S
- Bentonite blends
- Rapid Release Sulphur
- Microessentials S-15

Manage sulphate and elemental sources differently

Ammonium Thiosulphate Converts Rapidly to Sulphate



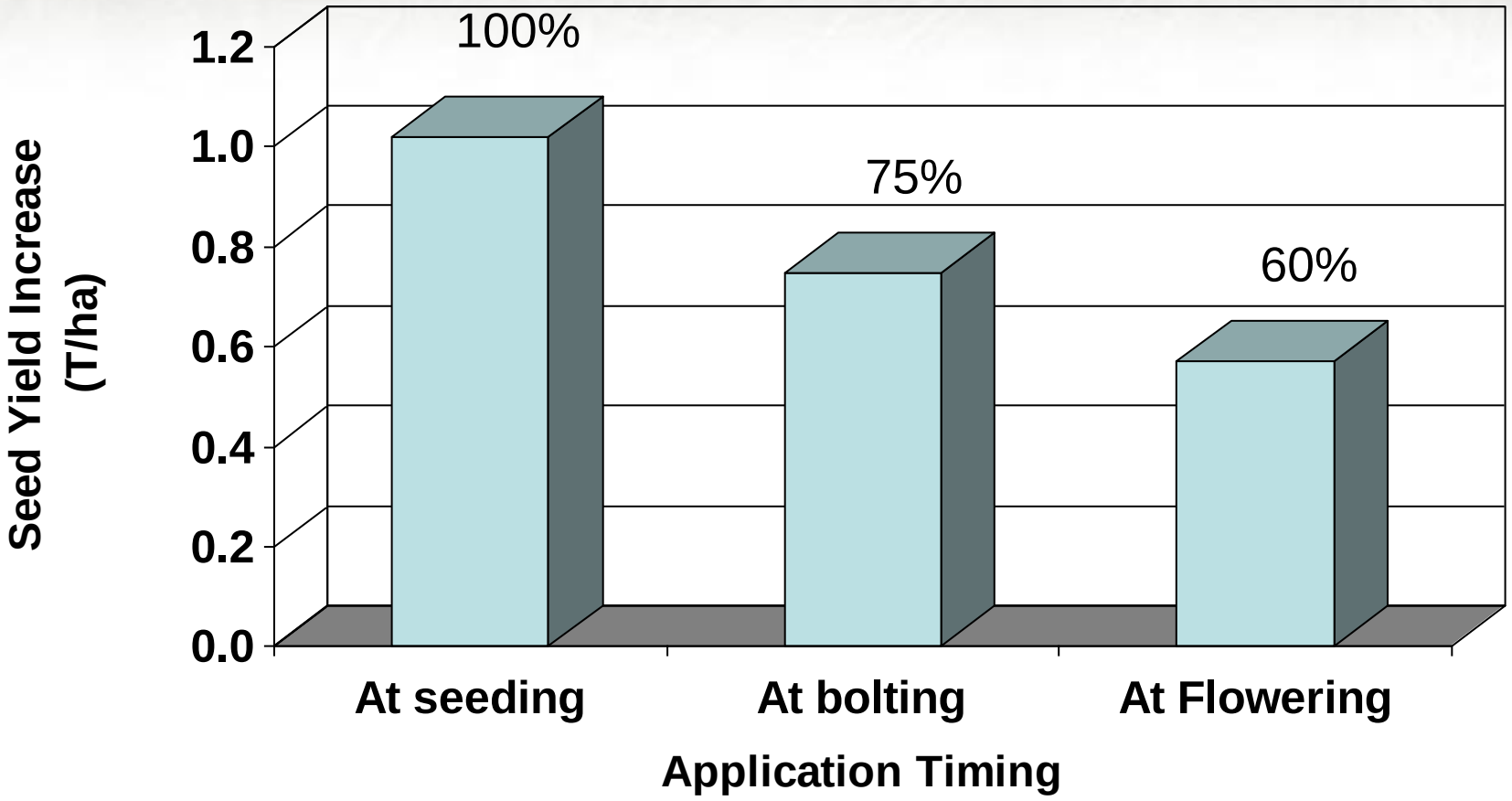
Gypsum is a Traditional S Source in Many Areas

- Calcium sulphate ($CaSO_4 \cdot 2H_2O$)
- Lowers pH if soil pH is greater than 8.5 and increases it if soil is less than 4.5
  - Not common on Canadian soils
- Can be used as a sulphate source
  - Solubility is low relative to ammonium sulphate
  - Solubility reduced on soils with high Ca in soil solution
  - Tends to be difficult to handle and apply
  - Strongly marketed because it is a waste product for disposal

Sulphate Sources Are Immediately Available so Timing of Application is Flexible

- Ahead of seeding
  - S portion will not volatilize
  - May possibly immobilize or leach but to lesser extent than nitrate
- Near seeding
  - Readily available
  - Reduces risk of leaching below rooting zone
- Post-seeding
  - Can be effective, even when delayed
  - Option where deficiencies are noticed late

Canola Response is Still Greatest When Sulphate is Supplied Near Seeding



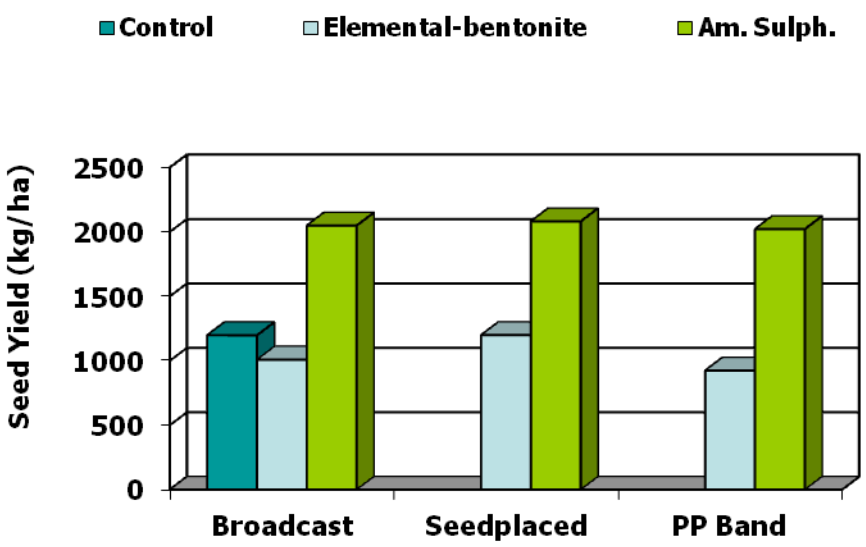
Malhi and Leach, 2002

Managing Post-Emergence Sulphur

- Watch for deficiencies early – spraying time.
- Act quickly when you see a problem and use sulphate sulphur.
- Understand the deficiencies may “disappear” with crop rooting into gypsum, salts or leached S
  - Need to assess sulphate supply below the plough layer

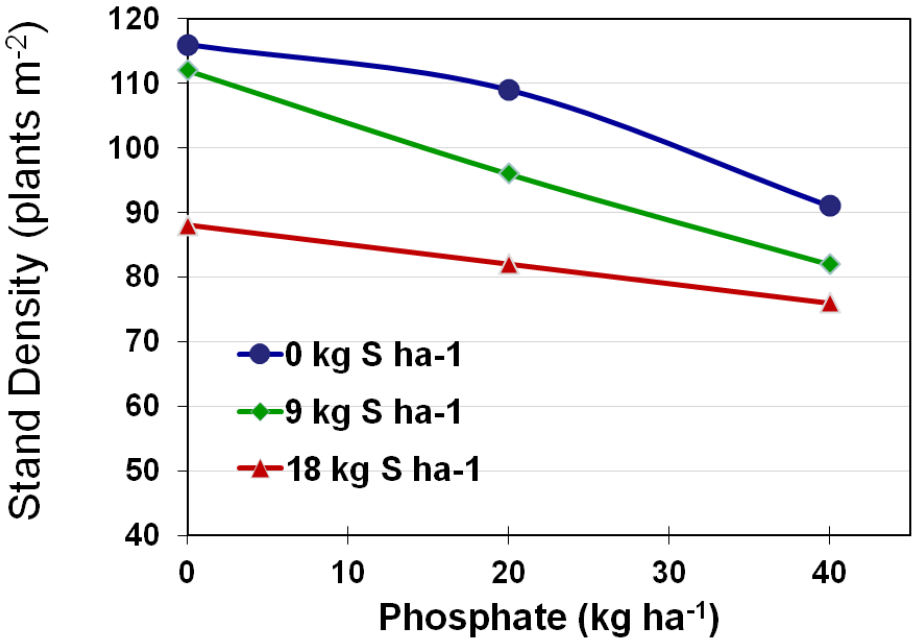
Sulphate Sources Are Mobile in the Soil so Placement Options Are Flexible

- Banding – pre-plant, mid-row or side-banding
- Broadcast
- Dribble-band
- Seed-placement
  - Avoid excesses that could cause toxicity



Excess Seed-placed Ammonium Sulphate can Cause Seedling Damage in Canola

- Stand density decreased with increasing rates of ammonium sulphate
- Most damage occurred with highest rates of MAP and AS



Greater risk on calcareous soils

Soil from a Hilltop

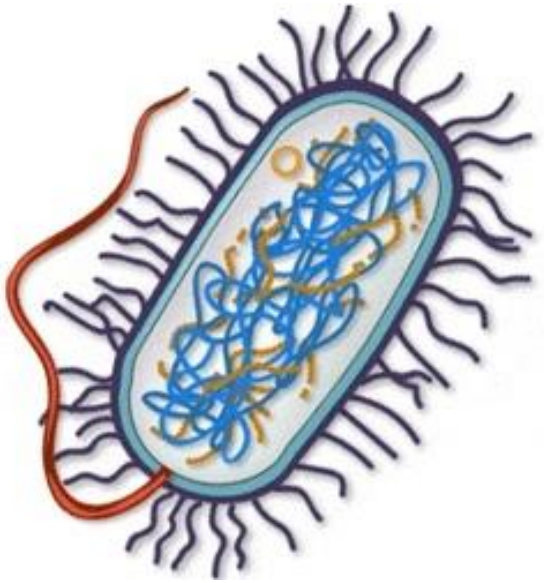
Soil from a Hollow

0 9 18 kg

<u>Figure 2</u>: Effect of AS on canola seedling emergence in soils from Brandon Grenkow

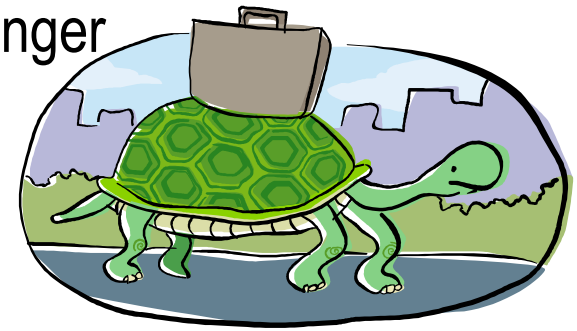
Elemental Sources Must Oxidize to Sulphate

- Requires time and conditions for microbial activity
- Apply far before crop requirement
- Use finely divided product
- Broadcast rather than band
  - Want to maximize contact with microbes
- Leave on surface to “weather”
- Incorporate after weathering
  - Conversion may be slower if left on surface under reduced tillage



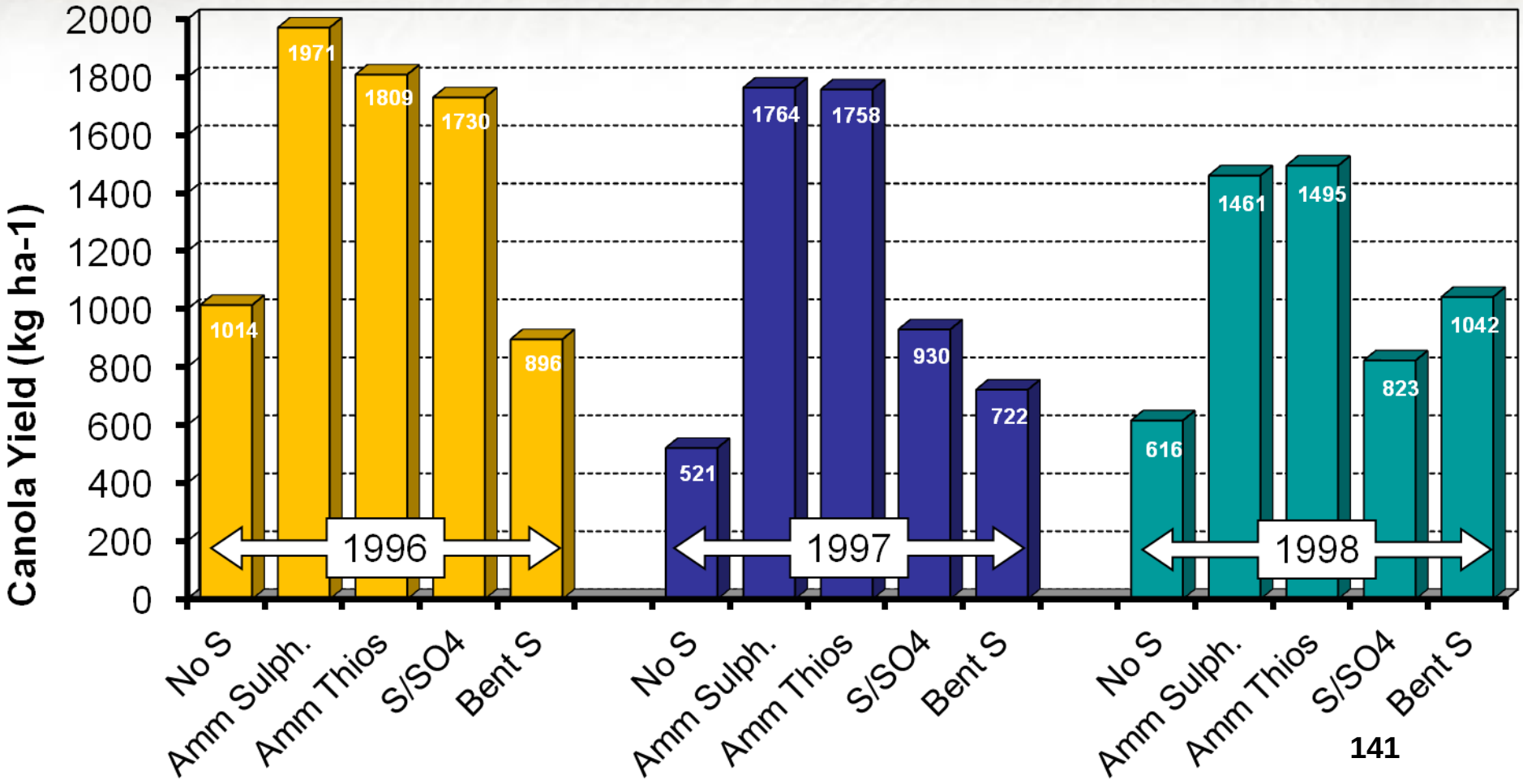
Environmental Conditions Affect Oxidation to Sulphate

- Conversion for elemental S to available sulphate is mainly by microorganisms
- More rapid conversion when soils are warm and moist
  - Slower under very wet or very dry conditions
  - Slower under cold conditions
- Under Canadian conditions, we cannot rely on elemental sources to provide enough available sulphate on deficient soils during the following crop year
  - Oxidation may be faster under warmer, moister, longer growing season conditions as in Brazil
  - May be beneficial in long-term planning

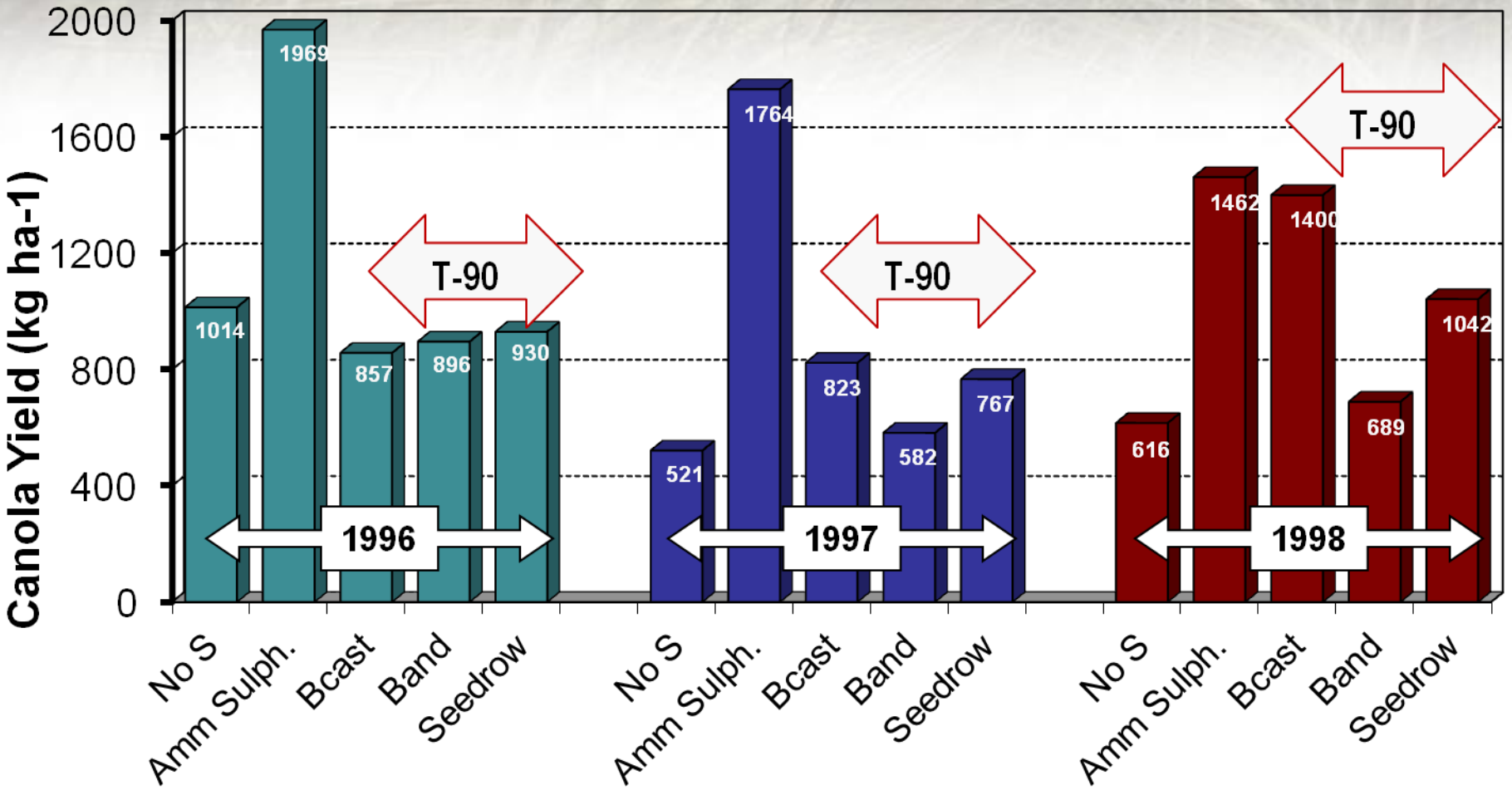


Sulphur Source Study at Melfort from 1996 to 1998

One application of 20 kg S ha^{-1} in 1996

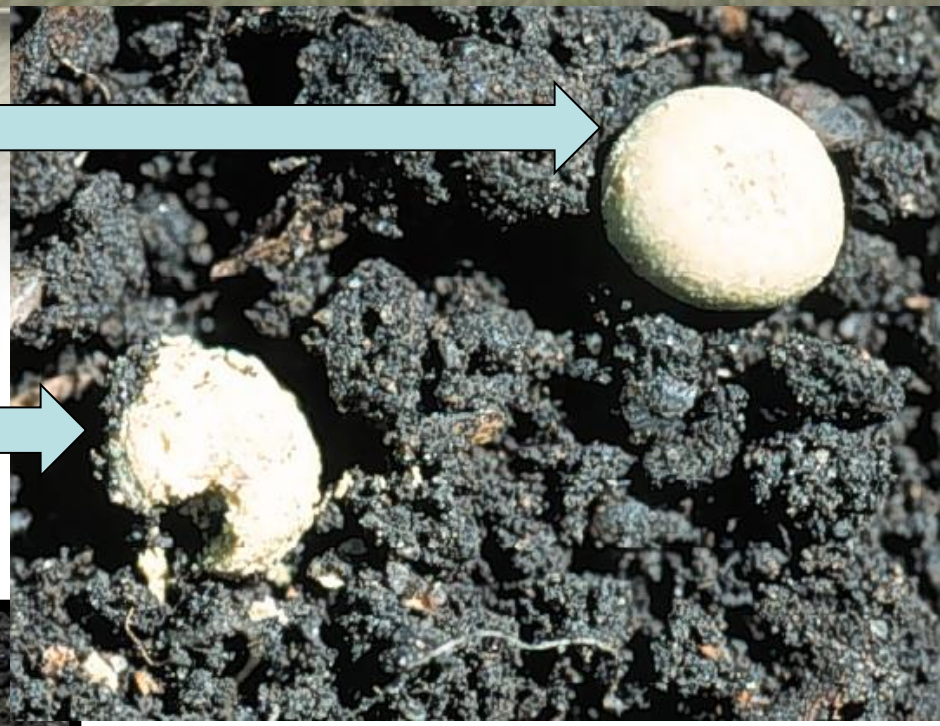


In-Soil Banding Delays the Availability of Elemental S



Weathering on the soil surface speeds breakdown, while band-placement restricts it

Freshly applied T-90 pellet

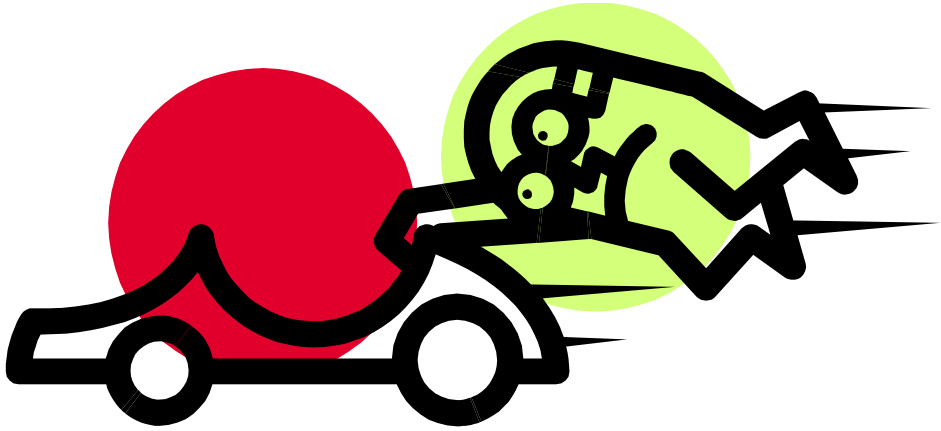


T-90 pellet after 90 days in seed-row

Pellet after weathering on soil surface

New Products Aim to Hasten Conversion of Elemental S

- MicroEssentials S15
  - Onionskin
- Vitasul , sulphur95
  - Greater dispersion
  - Smaller particles

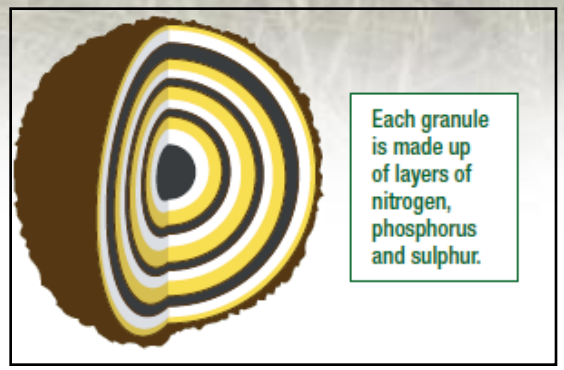


Greater dispersion and contact with microorganisms should hasten oxidation

MicroEssentials S15 by Mosaic

13 – 33 – 0 + 15

- Ammonium Phosphate
- Ammonium Sulphate
- Elemental S



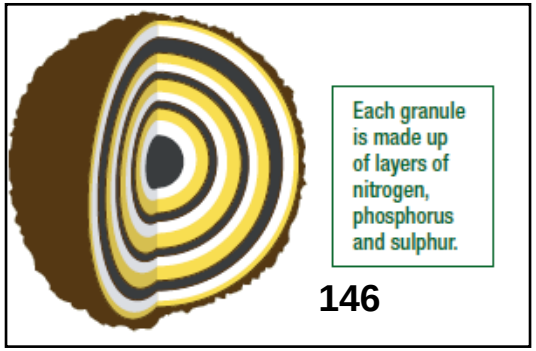
- **½ S in sulphate form (plant available)**
- **½ S in elemental form (requires conversion)**

Advantages of MicroEssentials S15

- Lower salt index than a blend of MAP and AS
  - Improved seed safety
- Better distribution of P and sulphate in the seed-row
- Co-granulation of AS and MAP may improve P uptake
- Conversion of elemental to sulphate does not appear to be hastened

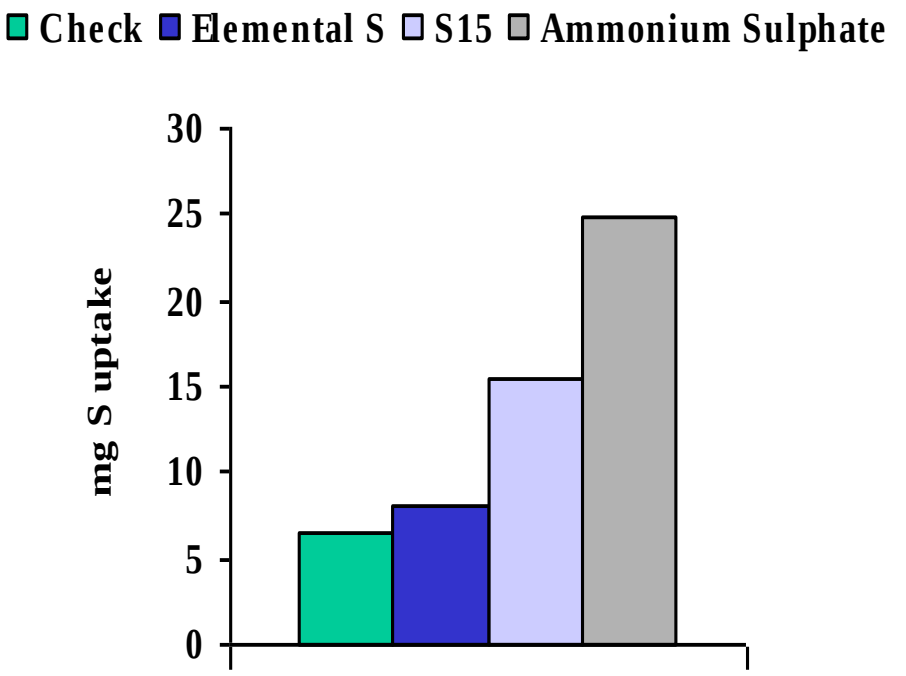
-Under Canadian conditions we can only count on ½ of the S being available since elemental S will not convert rapidly

-May be more rapid in warmer, moister areas with a longer growing season

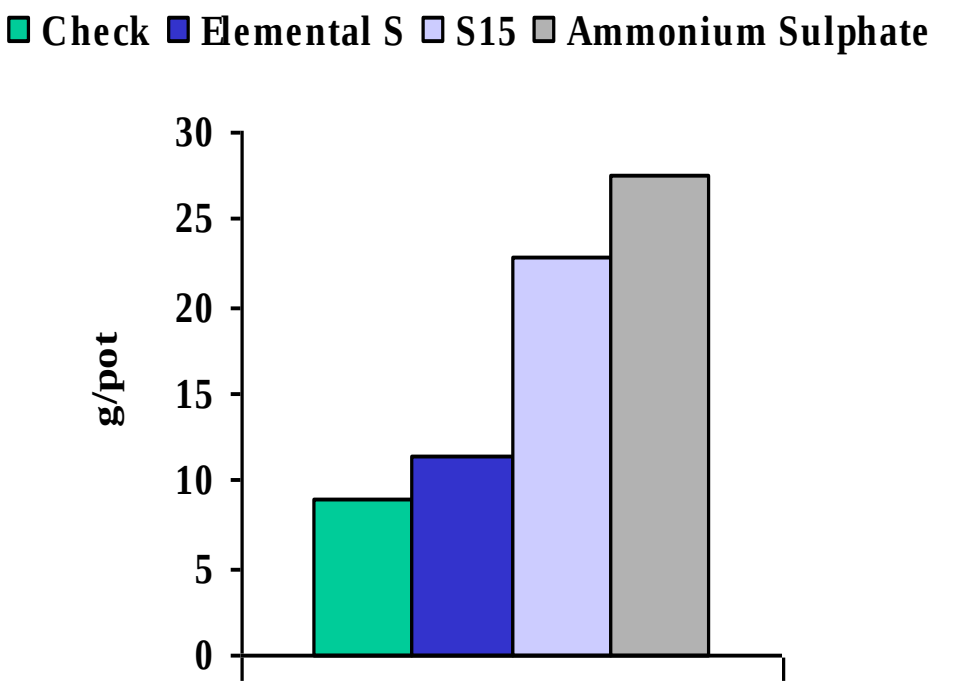


Availability of S15 was Intermediate Between Elemental and Sulphate Source

S Uptake

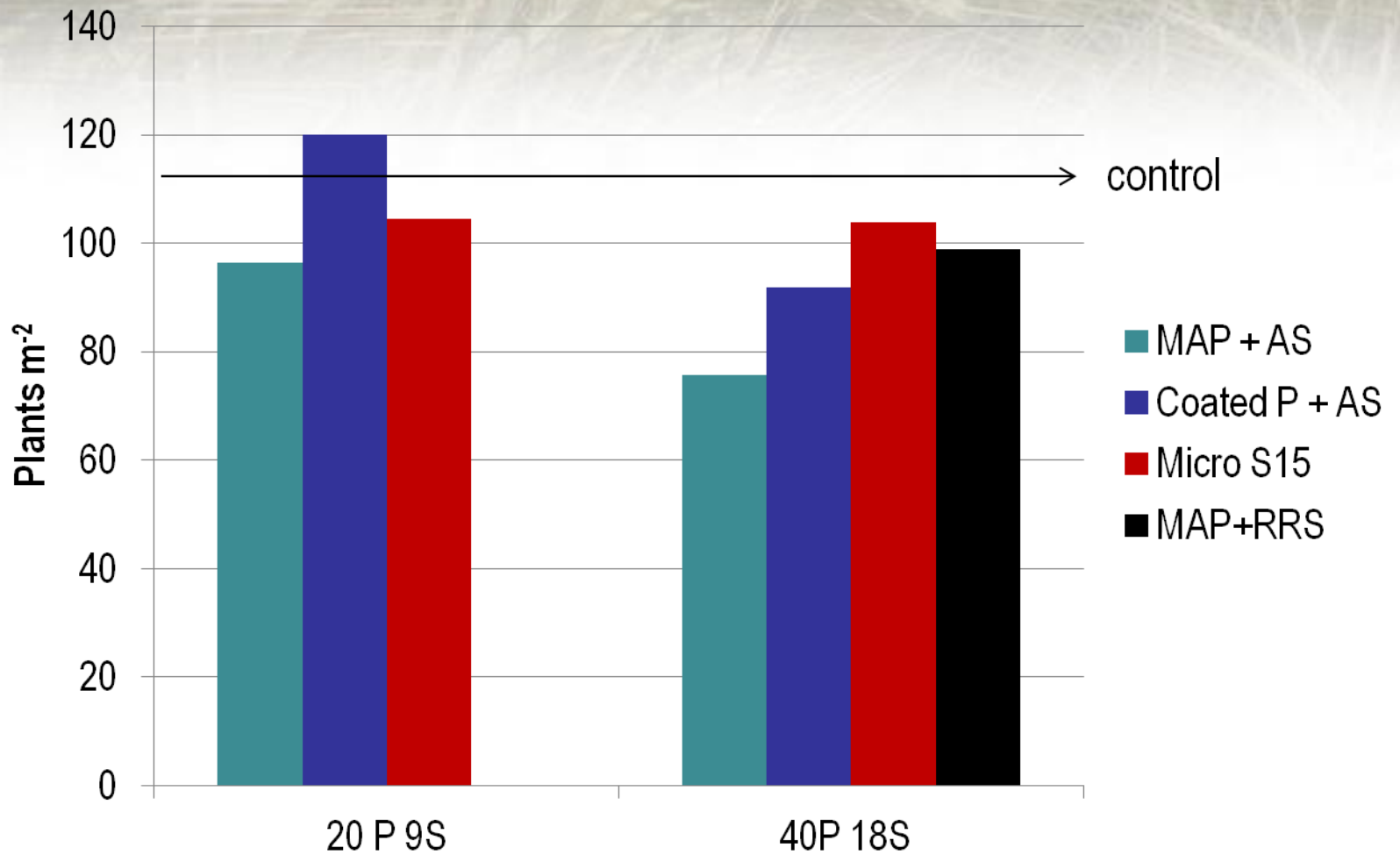


Plant Yield



(U of M thesis by Kroeker 2005)

MicroEssentials S15 and Vitasul had lower seedling toxicity than ammonium sulphate



Weather Can Affect S Deficiency

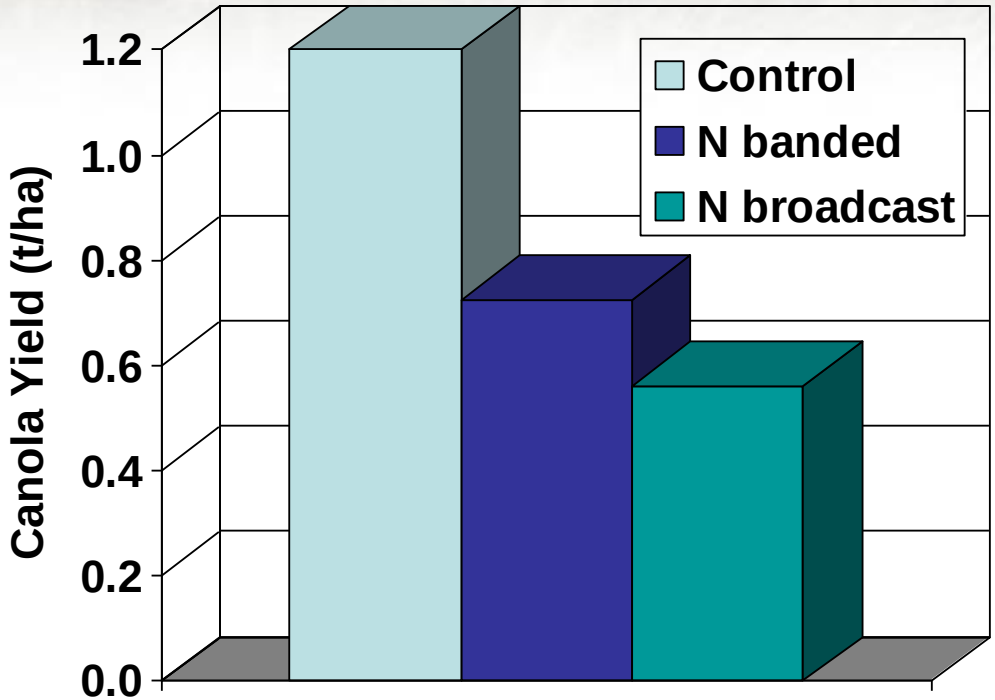
Sulphur Deficiencies in Canola are More Frequent After Wet Years - 1999, 2010 and 2011

Leaching in Wet Years or Field Areas Increases Risk of Deficiency

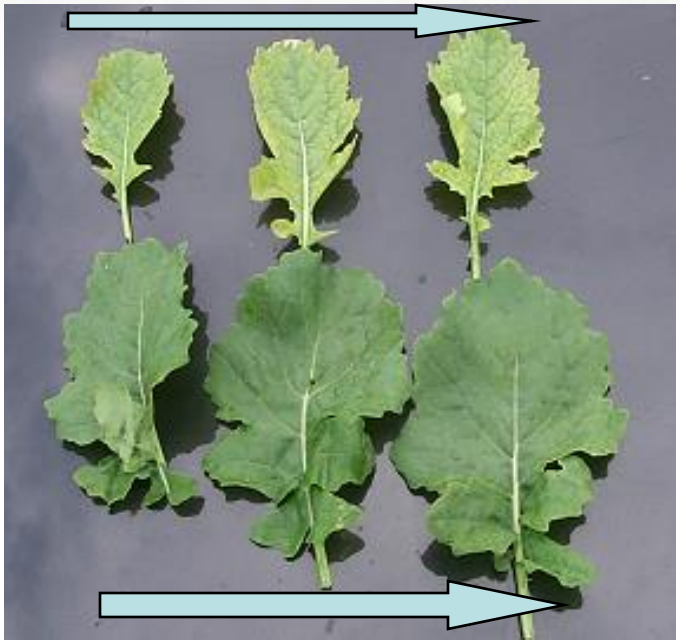
Strong S Response Occurred after a Wet Season

Be particularly alert for S deficiencies after a wet year that promoted leaching

Adding N without S Can Depress Canola Yield on an S-deficient soil



Increasing N with No S



Increasing N with S

Led to the idea that a specific N:S ratio was needed
– between 5 and 7 N to 1 S

Adequate S is Needed, But Specific N:S Ratio May Not Be That Important

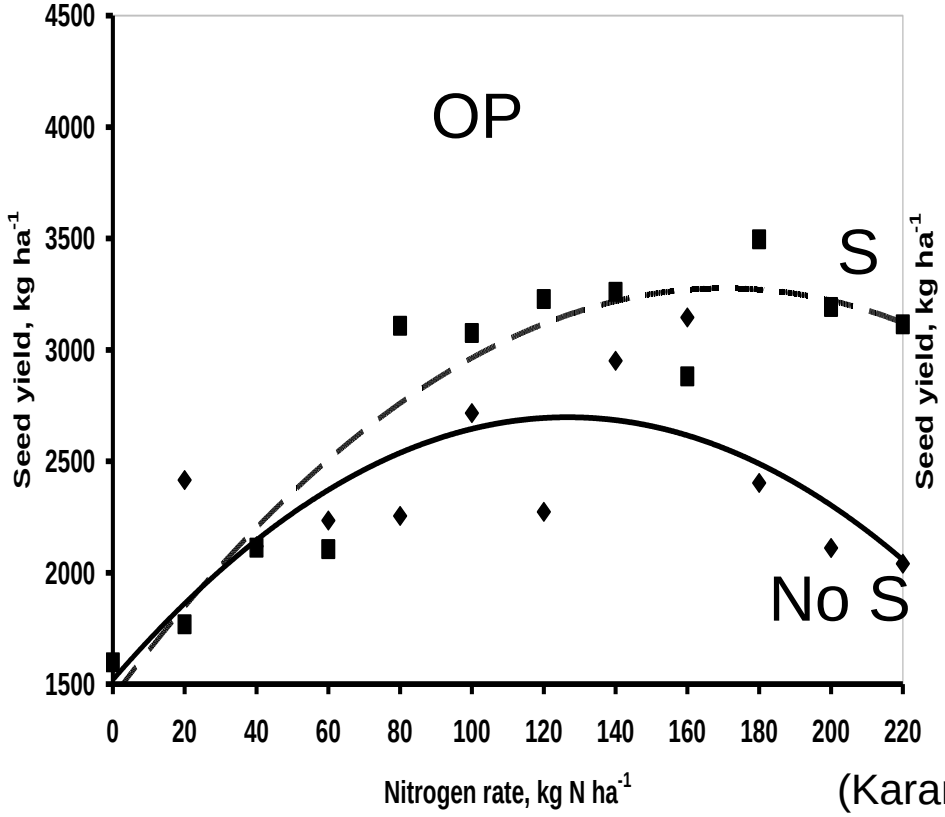
- High N:S ratio can indicate an S deficiency
- However, once a S deficiency is corrected there is little or no response to adding more S with increasing N rate.
- Worry about supplying the required S rather than about a precise N:S ratio

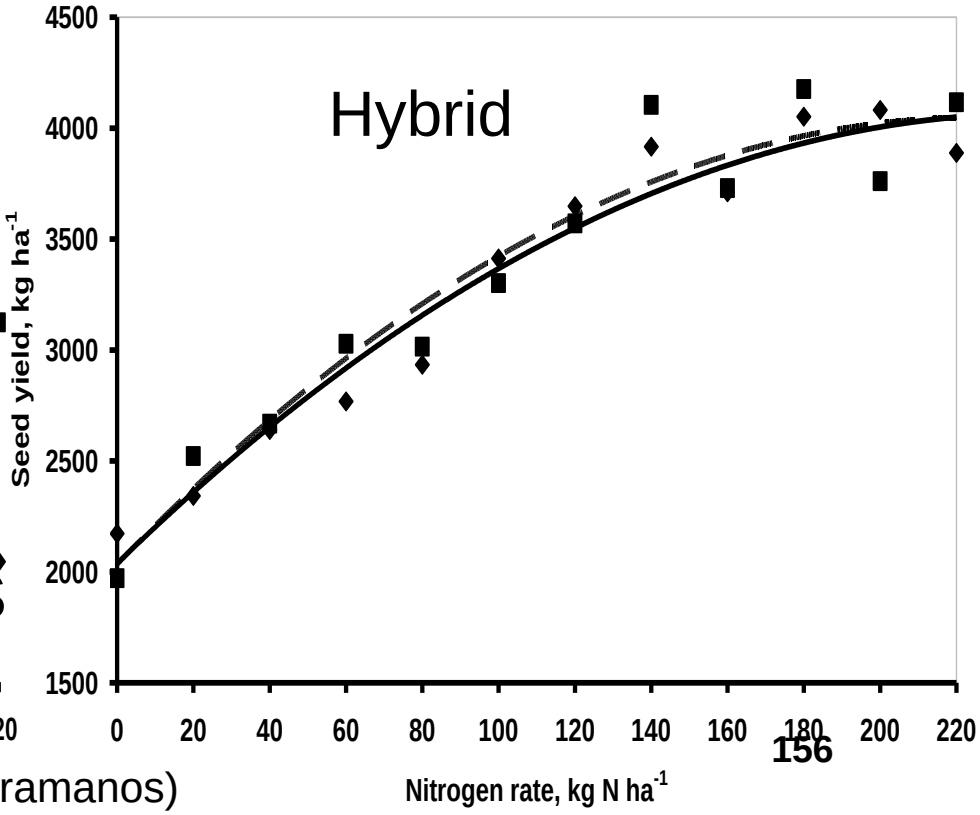
Do Hybrid Cultivars need More Sulphur?

- Most cultivars grown in Canada are hybrids
- Yield potential is substantially higher than older OP varieties
- Removal of S over time will be greater with higher yield
- Hybrids appear to have higher root activity and greater ability to extract S from the soil than OP cultivars
- Hybrids produce more yield at a given S level than OP

Yield of OP or Hybrid Canola as a function of N application with or without 40 kg S ha^{-1}

- Hybrid cultivars produced higher seed yield than OP lines but did not require additional S
  - Decrease in OP yield at high N without S may reflect lower rooting and poorer access to soil S





(Karamanos)

Sulphur Summary

- Principles of S fertilization apply
  - Plants take up sulphate
  - Elemental must convert to sulphate
  - Conversion of elemental is slow in Canadian soils
- Conversion of elemental in new products isn't rapid enough to supply S in year of application
  - May be other benefits in seed safety or distribution
- Hybrids extract S efficiently from soil and may not initially need more S than OP
  - May increase depletion on poorly buffered soils

Sulphur Summary

- Recognise S variability across field and within soil profile
- Don't worry too much about specific N:S ratios
  - High N:S ratio can indicate an S deficiency
  - Correct the S deficiency
- Very wet conditions can lead to leaching and increase the risk of S deficiencies
  - Keep alert for S problems in wet years


Thank You for Your Attention