Policy aspects for use of enhanced-efficiency fertilizers:
Viewpoint of the scientific community

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Challenges to Agriculture

- Increase global food supply
- Avoid loss of natural ecosystems
- Avoid environmental damage
  - Air
  - Water
  - Land degradation
  - Biodiversity

Increase yield per hectare, sustainably

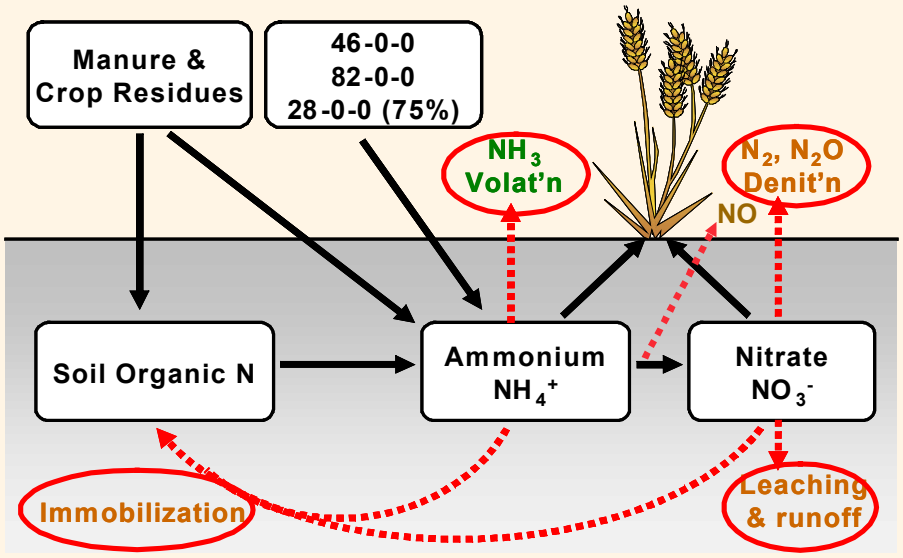
Improved Nitrogen Management Will be Critical for Yield and Sustainability

- Fertilizer N largest single factor in global N balance
- NUE for cereals estimated at 30-50%
- Improvements needed to support yield without risking environment

Policy Framework

- Recognise contribution of improved efficiency to society
- Encourage development and adoption of practices that improve efficiency of resource use throughout production system
- Consider economics, environmental impact, rural sustainability, food security, and food quality

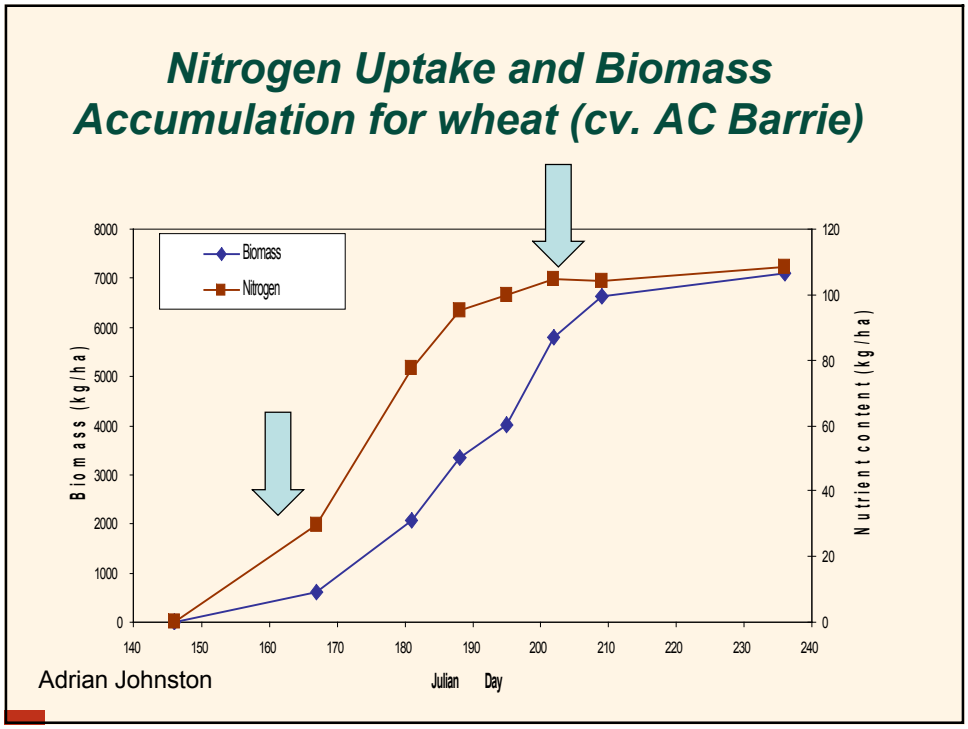
Manage Nutrients to Minimize Losses



Traditional Nutrient Management Practices

- Soil testing to determine rate of application
  - Avoid over- or under-fertilization
- Selection of source to optimise efficiency
- Split applications to synchronise supply with crop demand
- Timing of application to minimise losses
- In-soil application or incorporation to reduce volatilization
- Banding or injection to reduce immobilization, denitrification, leaching


Matching Supply to Crop Uptake


Nitrogen Uptake and Biomass Accumulation for wheat (cv. AC Barrie)
Biomass
Nitrogen
Biomass (kg/ha)
Nutrient content (kg/ha)
Julian Day
Adrian Johnston

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

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

Drawbacks of Split Applications

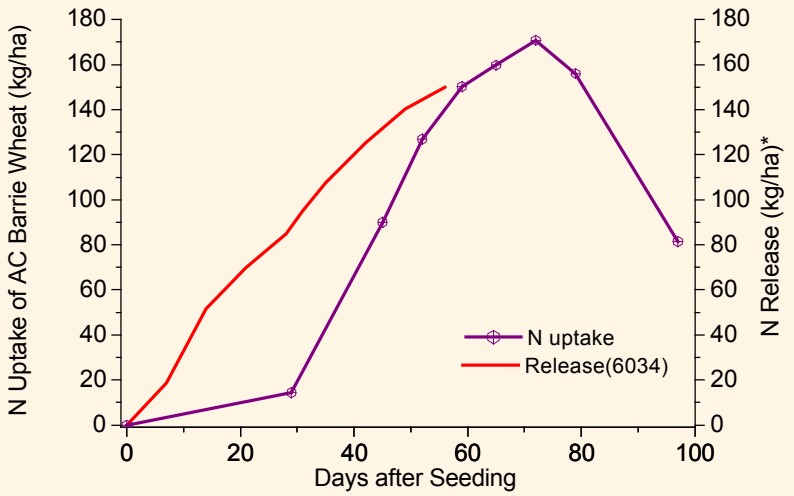
- Multiple passes increase cost, fuel consumption, traffic, and labour
  - Economic, environmental and societal effects
- Surface application may be inefficient
  - Volatilization and immobilization
  - Stranding on soil surface
  - Lack of foliar uptake
- In-soil applications may damage crop
- Risk of missing window of application

Wet Conditions may Hamper Field Operations

Enhanced Efficiency Fertilizers Can Substitute for Split Applications

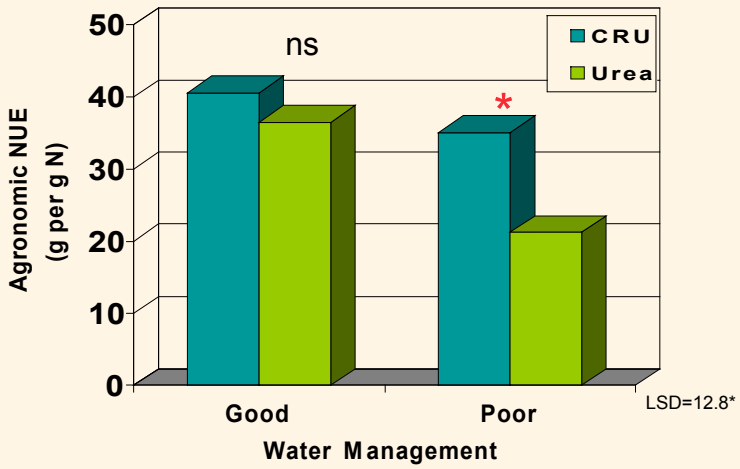
- Single basal application released at controlled rate over season
- Reduces time, fuel and labour
- Minimises risk of losses from applied N
- Fertilizer is on so won't miss application due to poor conditions
- Does not allow for fertilizer rate to be modified with changing conditions
  - Application based on yield potential assessed at start of season

N Release from CRU compared to the N uptake of spring wheat



* Estimated based on 150 kg/ha N application

NUE of a single application of coated urea was superior to a split application of uncoated urea under poor water management

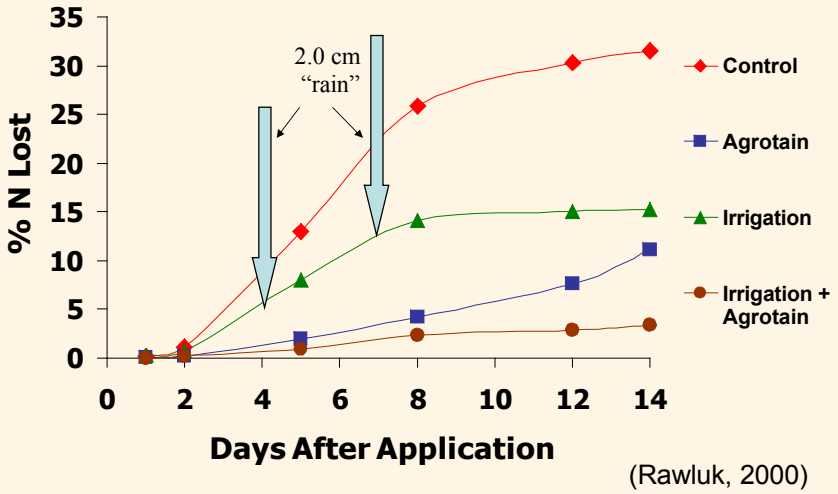


(Fashola et al., 2002)

Enhanced Efficiency Fertilizers Can Work with Split Applications

- Improve efficiency of surface application
  - Urease inhibitors or controlled release products can reduce volatilization and immobilization
- Stacking technology
  - Assess deficiency
  - Apply in-crop N if needed
  - Use enhanced efficiency fertilizer to reduce losses

Urease inhibitor can reduce volatilization from surface applications of urea



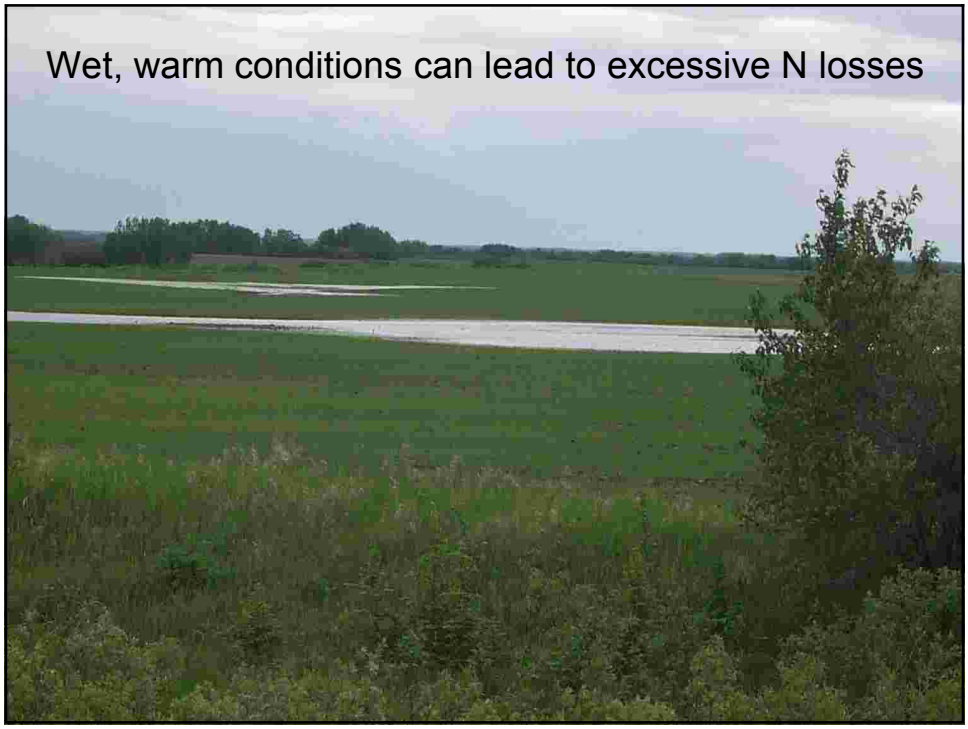
(Rawluk, 2000)

Nitrogen Still Commonly Applied in Single Basal Application

- Prior to or at time of seeding
- Minimize time and labour
- Cannot adjust rate for changing conditions
  - Over or under-application
- May cause agronomic problems
  - Lodging, disease, weediness

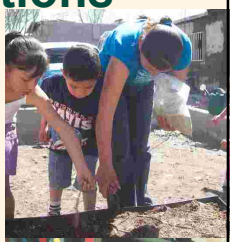
Basal Applications Can Be Inefficient

- In soil for extended period before crop uptake
- Losses may cause environmental concerns
  - NO_x, nitrate, ammonia
- Losses increase with time before uptake and with wetness



Basal Fertilizer Placement Options

- Pre-plant
  - Band
  - Injection
  - Broadcast
  - Dribble band
- At Seeding
  - Seed-placed
  - Side-banded
  - Mid-row band



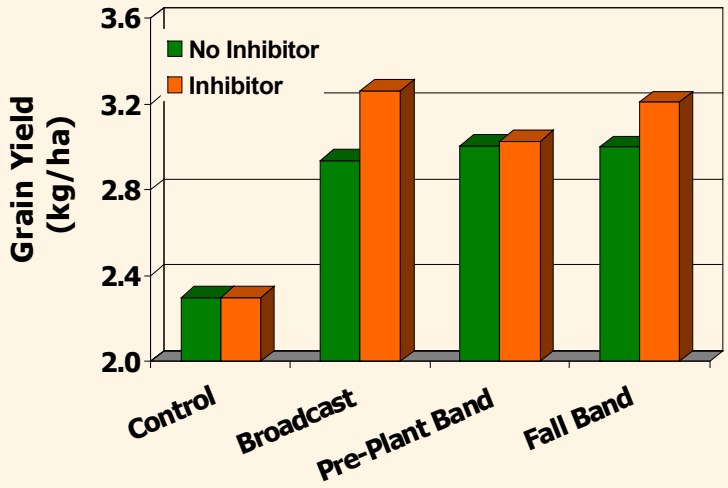
In-Soil Banding Can Reduce Losses and Improves NUE

- Soil disturbance
  - Seed bed quality
  - Moisture
  - Residue loss
- Increased application costs
  - Possible extra pass
  - Extra equipment complexity, draft
  - Risk of seedling damage with one-pass systems

Enhanced Efficiency Fertilizers

- Reduce volatilization and immobilization from broadcast fertilizers
- Reduce losses from in-soil banded applications
  - Urease inhibitors, nitrification inhibitors, coated products
- Slow release products can help match uptake with demand

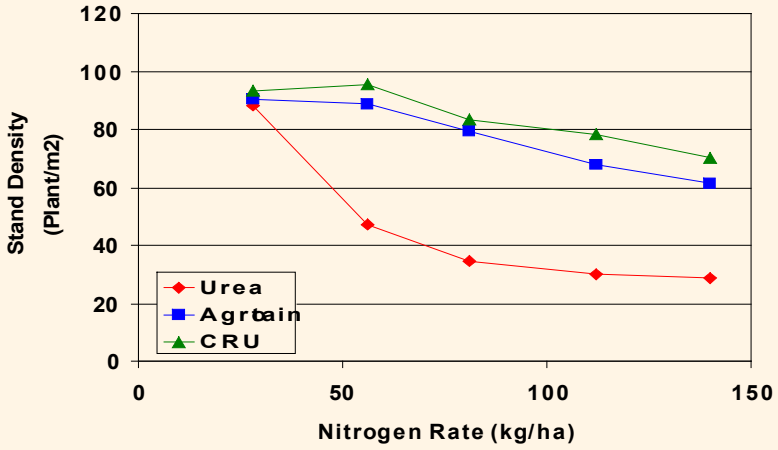
Agrotain Can Improve Efficiency of Broadcast and Fall Banded Application



Reduction of Seedling Damage

- Excess N too near the seedling
- Osmotic effects or ammonia toxicity
- Urease inhibitors or controlled release can reduce damage

Effect of seed placed urea, urea with Agrotain, or polymer coated urea (CRU) on stand density of durum wheat



Malhi et al. 2003

Advantages of Enhanced Efficiency Fertilizers Over Traditional Methods

- Substitute for capital investment in equipment
  - Can be used with current or more simplified equipment
- Reduce on-farm labour
  - Replace extra applications
- Increase flexibility in timing of applications
- Avoid potential to miss window of application

Advantages of Enhanced Efficiency Fertilizers

- No need for specialized knowledge
  - Technology substitutes for timing
    - Assessment of crop N level in season
    - Physiological timing of applications
- Minimise inorganic N in solution
  - Reduced environmental risk
- May be able to select NH_4^+ or NO_3^- ratio for improved nutrition
- Can be used in combination with other management techniques for improved effectiveness

Further Research Needs

- Improved product performance
  - Premature loss of effectiveness
  - Release too rapid or too slow
- Development of new fertilizer forms
  - Nanomaterials, microcapsules, enzymes
  - Release triggered by solution concentration?

Future Research Needs

- Determine pattern of release required for different crops in different environments
- Fundamental understanding of paths and magnitude of losses in varying environments
  - Use of enhanced efficiency fertilizers with site-specific management
  - Apply only where risk of losses are high

Future Research Needs

- Quantification of environmental benefits
- Quantify possible reductions in application rate
- Identification of other benefits
  - Reduced lodging
  - Reduced disease incidence
  - Controlled maturity
  - Enhanced protein content
  - Oil content and oil quality
  - Trace element content of the crop

Major Constraint is Cost of Product

- Cost of products is high relative to perceived benefits
  - Particularly in low value crops
- Current trends may increase relative value
  - Increasing energy costs,
  - Increased cost of fertilizer N
  - Scarcity and cost of agricultural labour
  - Improved site-specific technology

Environmental benefits to society are not always given economic value

- Life cycle analysis could more clearly define value
- Define the costs and benefits throughout the system
  - including manufacturing, emissions on and off farm, transport, off-site impacts

Clarification of Value to Society

- Current costs are borne by agricultural industry
- Benefits are to both agriculture and society in general
  - Environmental benefits, security of food supply, reduced food prices, improved food quality, maintenance of natural ecosystems, strong rural economy
- If benefit to society is substantial, should some costs be shifted to society?
  - Subsidies or incentives for adoption
  - Support for developmental and adaptive research

Policies for Use of Enhanced Efficiency Fertilizers

- Optimise whole cropping system
  - Tillage management, crop genetics, pest control, water management and soil tilth and nutrient management
    - All resources will be used more effectively
- Consider resource use and impacts throughout system
  - Value of enhanced efficiency fertilizers relative to alternative technologies will vary with scarcity of conserved resources

Policies for Optimizing Use Of Enhanced Efficiency Fertilizers

- Policies should attempt to distribute the cost of technology among those that benefit
- Quantification of relative agronomic, environmental and social benefits of enhanced efficiency fertilizers needed to guide policy direction