Integrating Genomic and Genetic Approaches to Nutrient Use Efficiency in Plants

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Dec 9, 2004

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Fertilizing the Nitrogen Cycle

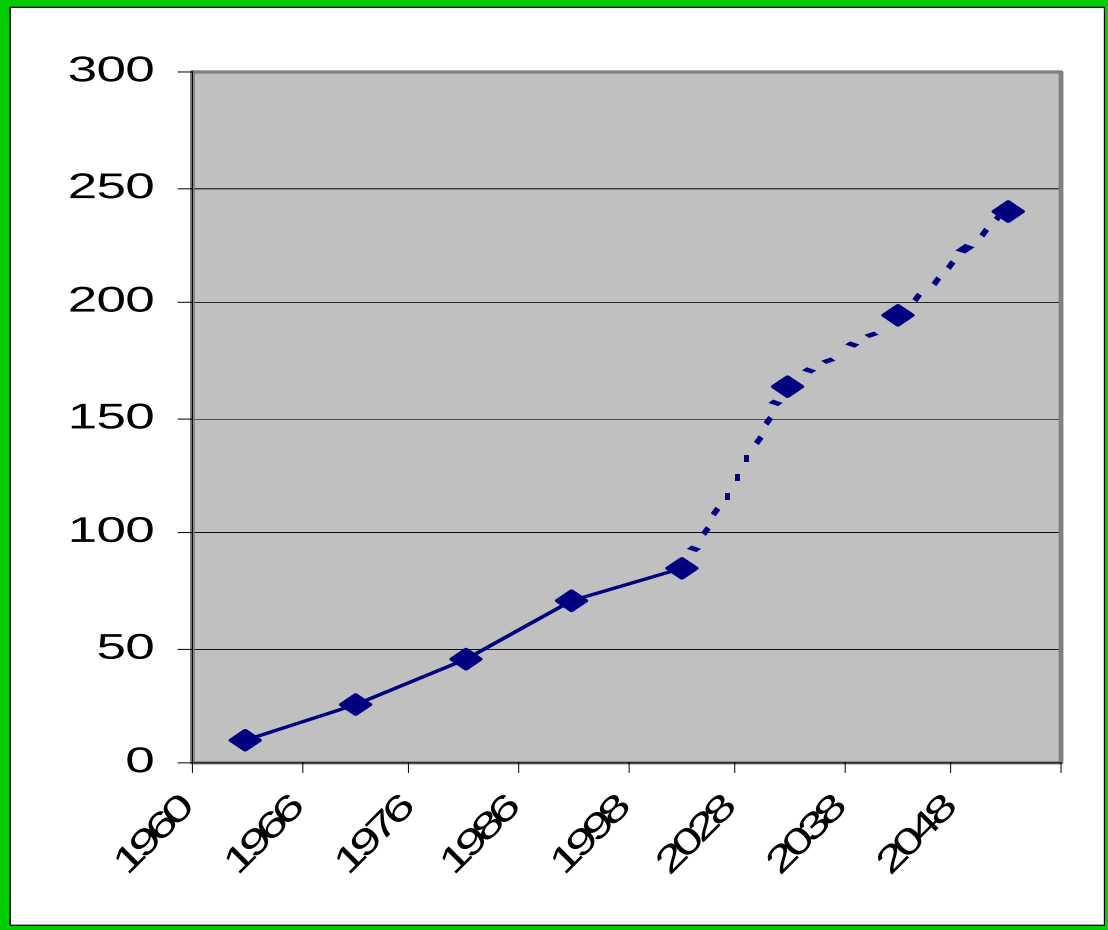
Annual releases of fixed nitrogen caused by human activity

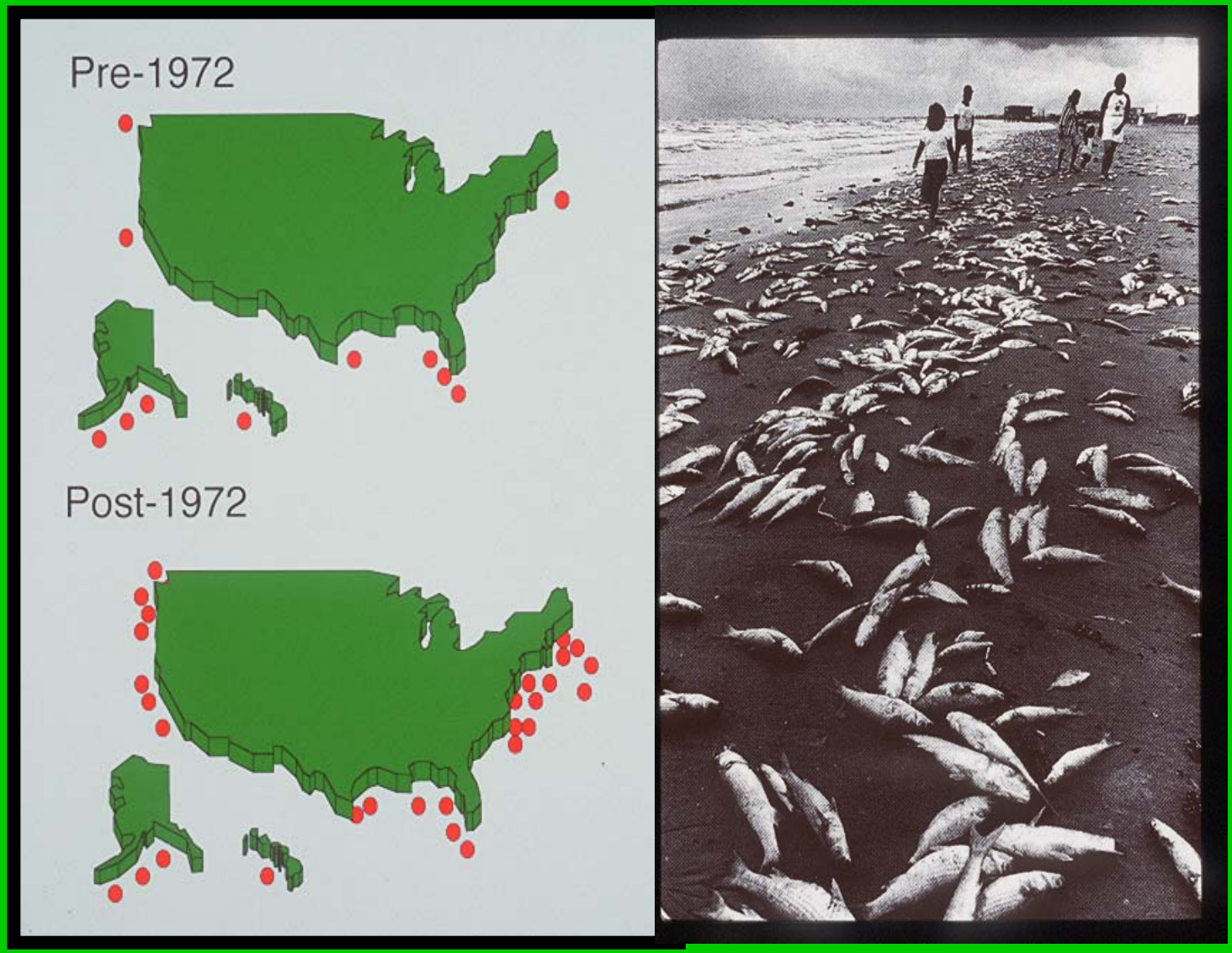
Source	Millions of tons
Fertilizer	**80**
Nitrogen-fixing crops	40
Fossil fuels	20
Biomass burning	40
Wetland drainage	10
Land clearing	20
Total human releases	210
Total natural fixed-nitrogen prod^{n}*	140

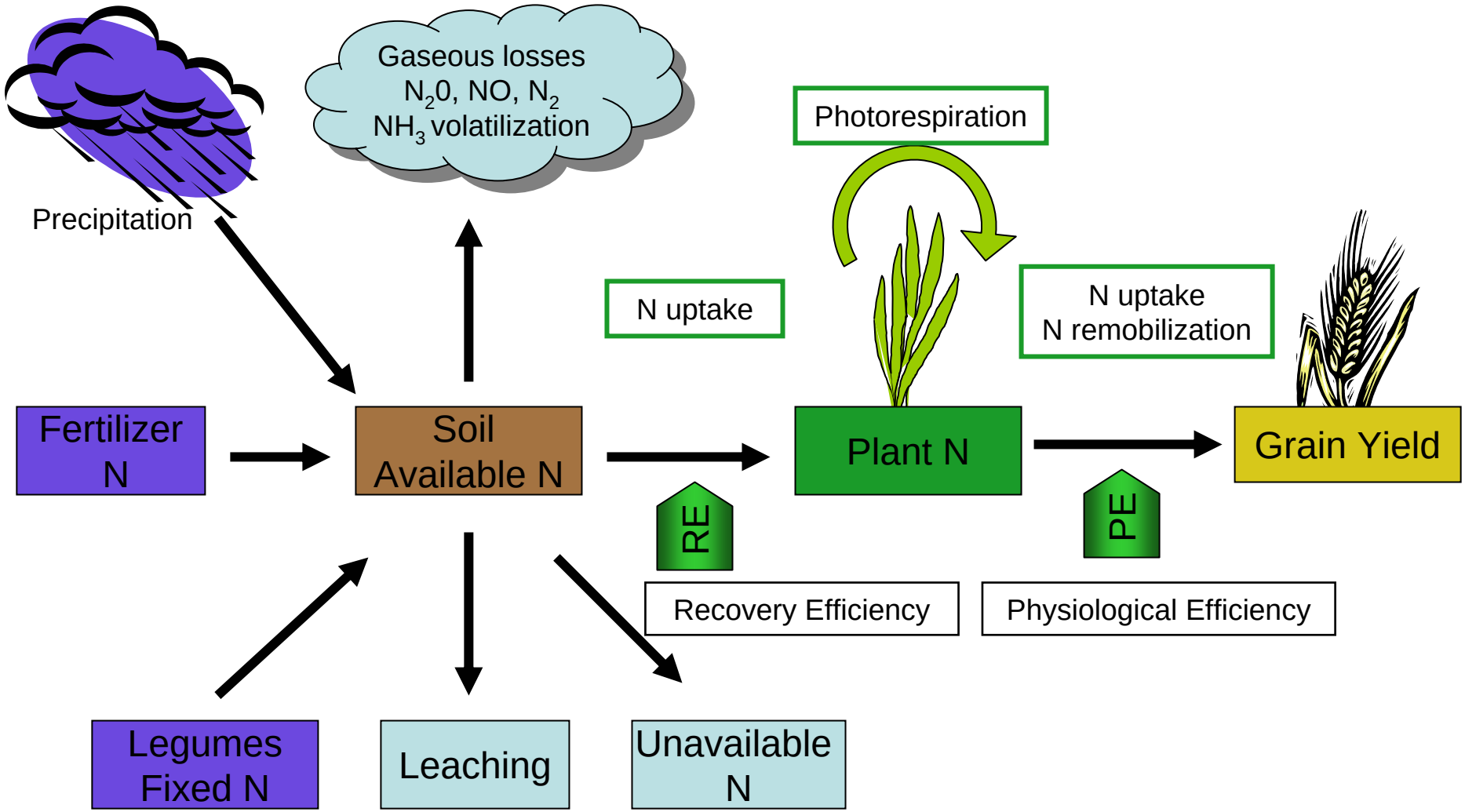
*Terrestrial sources only; marine sources have not yet been reliably estimated.

Source: World Resources Institute, "Global Nitrogen Glut" www.wri.org/wri/wr-98-99/nutrient.htm.

World Fertilizer Consumption

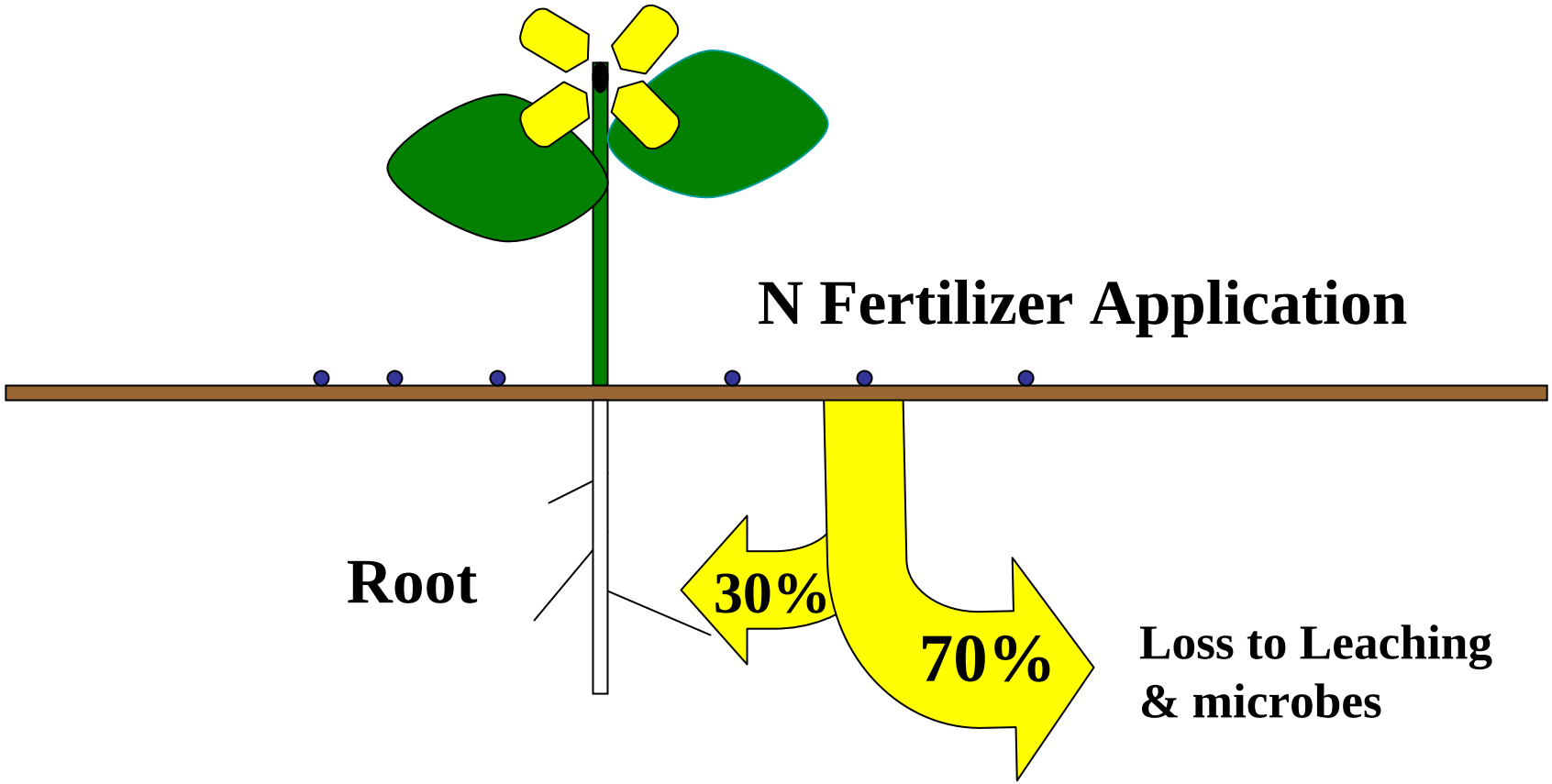






Sources and fates of N in plants and the environment

70% of Nitrogen Fertilizer is Lost



By capturing more N, yield efficiency can be gained

What is Nitrogen Use Efficiency

- Nitrogen efficiency can be measured in different ways
- NUE may be partitioned into different developmental stages
- By understanding this process we should be able to make further improvements in NUE

Agronomic Measures of NUE

Eq	Term	Formula	Definition	Comments
1	Nitrogen Use Efficiency	NUE= Sw/N	Sw = Shoot weight (DW) N = N in shoots (DW)	Does not account for biomass increases
2	Nitrogen Use Efficiency (grain)	NUEg = Gw/Ns[1]	Gw = Grain weight Ns = Nitrogen supply (gm/plant)	Reflects increased yield per unit applied N
3	Uptake Efficiency	UpE = Nt/Ns	Nt = Total Nitrogen in plant Ns = Nitrogen supply (gm/plant)	Measures efficiency of uptake of N into plant
4	Utilization Efficiency	UtE = Gw/Nt	Gw = Grain weight Nt = Total Nitrogen in plant	Fraction of N converted to grain
5	Agronomic Efficiency	$AE = (Gw_F - Gw_C)/ N_F$	N_F = Nitrogen fertilizer applied Gw_F = Grain wt with fertilizer Gw_C = Grain wt, unfertilized control	Measures efficiency of converting applied N to grain yield
6	Apparent nitrogen Rcovery	$AR = (N_F$ uptake – N_C uptake)/ $N_F * 100$	N_F uptake = Plant N (Fertilizer) N_C uptake = Plant N (No fertilizer) N_F = Nitrogen fertilizer applied	Measures efficiency of capture of N from soil
7	Physiological Efficiency	$PE = (Gw_F - Gw_C)/$ (N_F uptake – N_C uptake)	Gw_F = Grain weight (Fertiliser applied) Gw_C = Grain weigh (No fertilizer)	Measures efficiency of capture of plant N in grain yield

Good *et al.* (2004) Trends Plant Science

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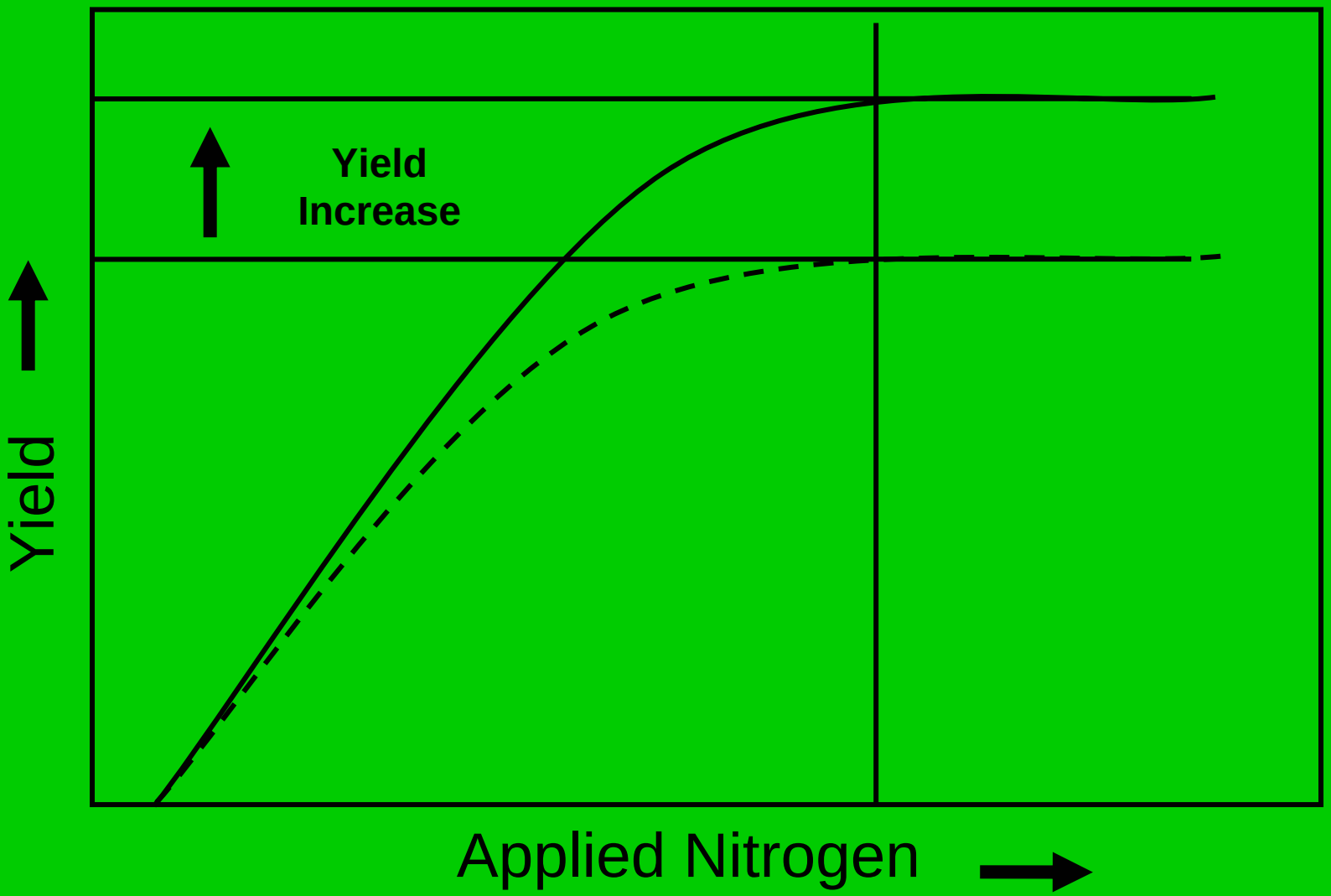
NUE; What are we trying to achieve?



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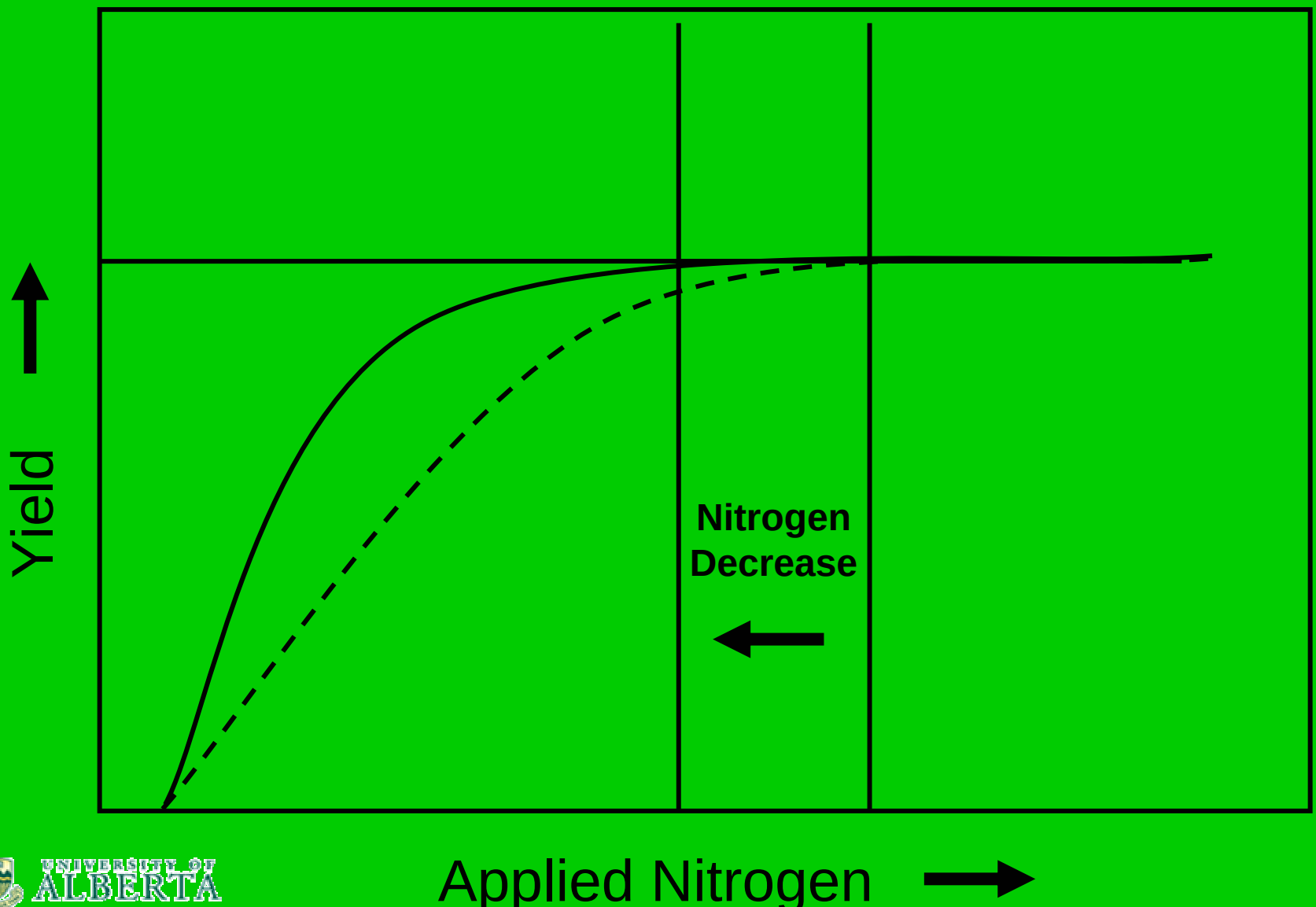

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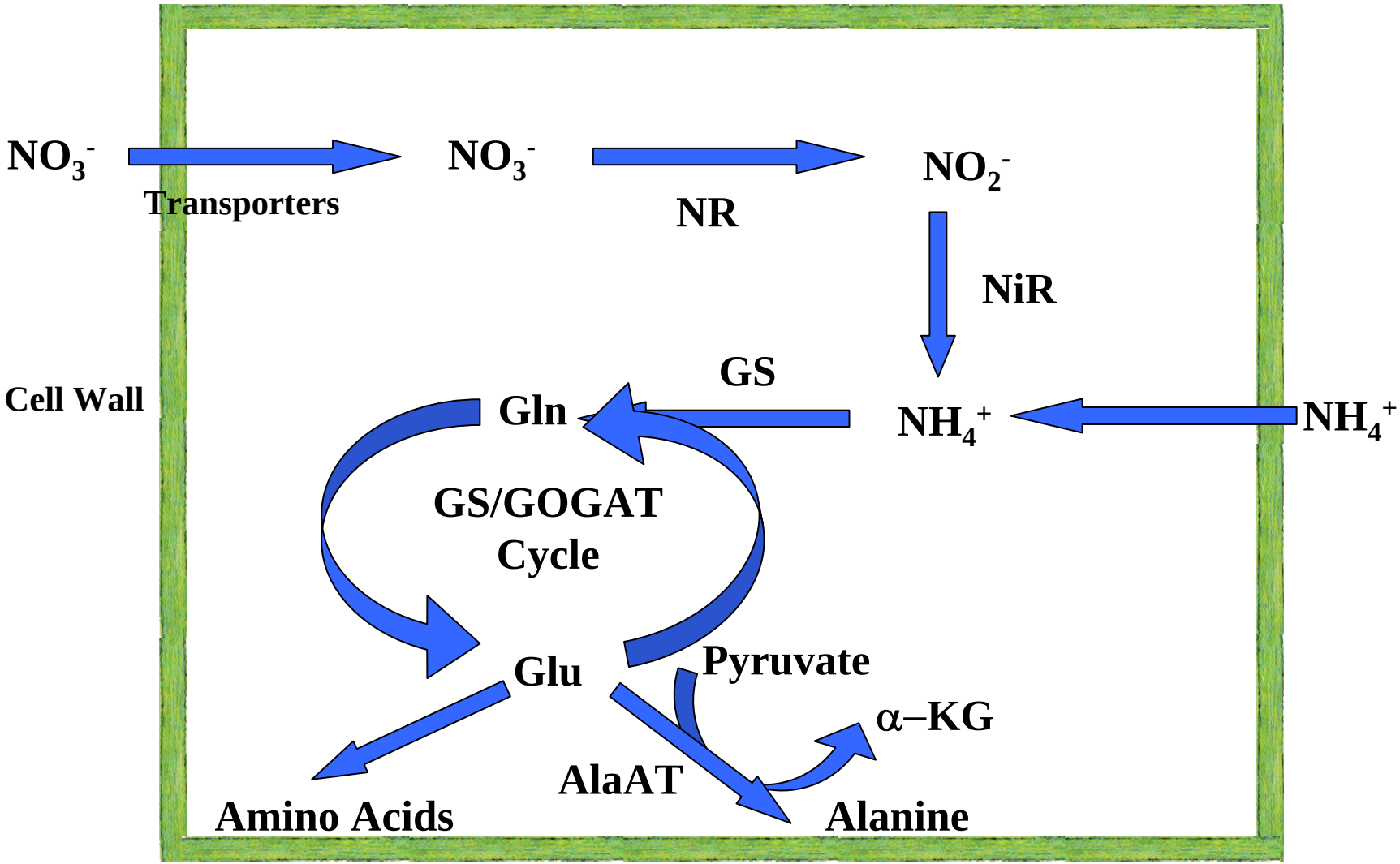
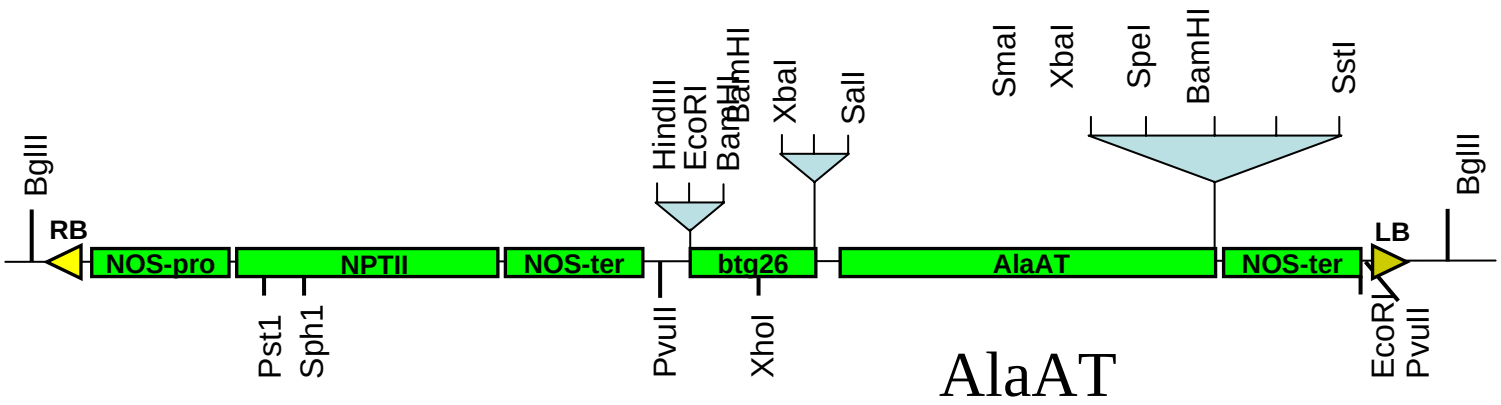
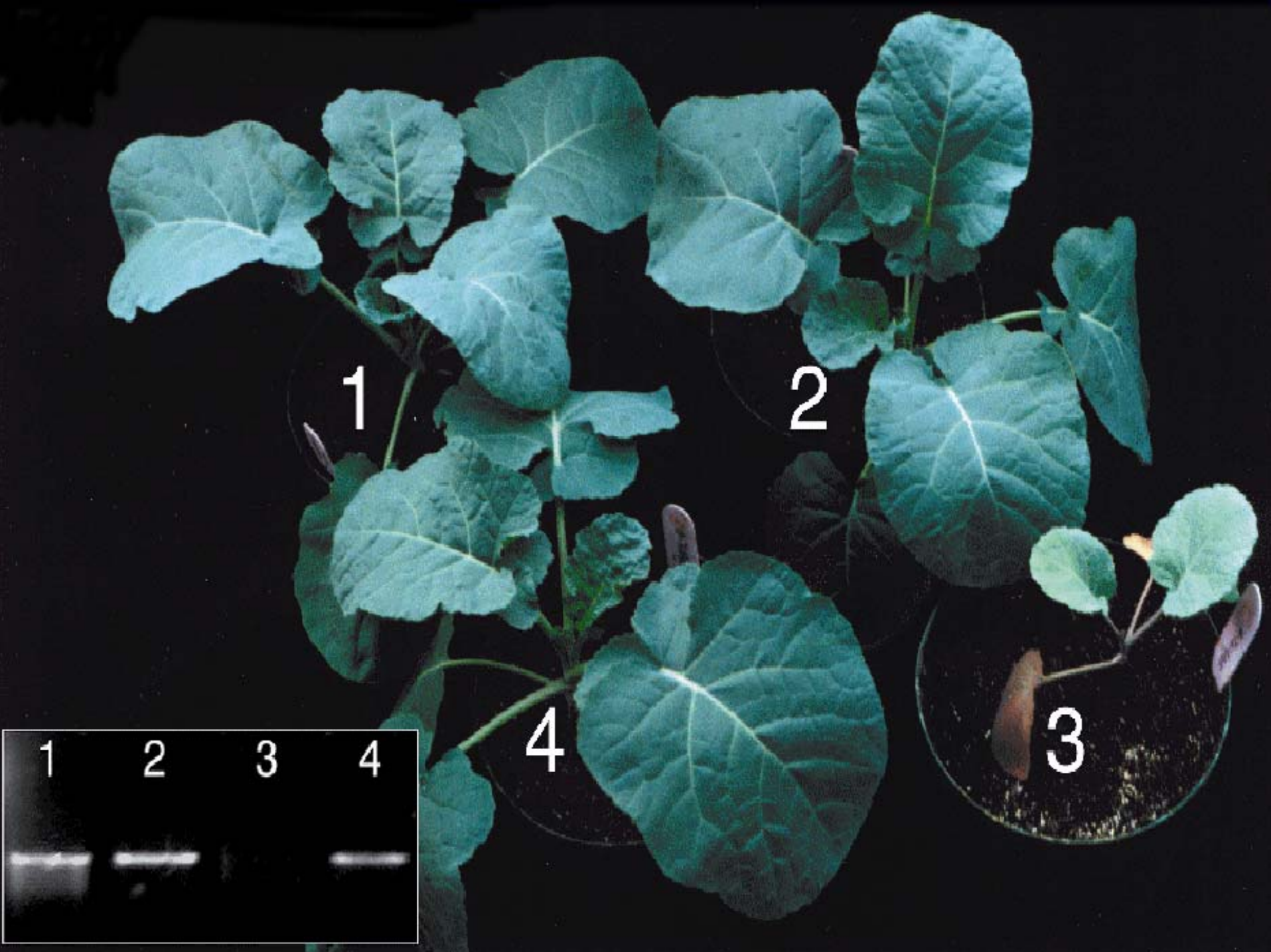
Influencing Key Steps in the Nitrogen Pathway



btg26/AlaAT Analysis

Goal: Determine whether the alanine aminotransferase gene can show effectiveness in improving nitrogen use efficiency (NUE)




1
2
3
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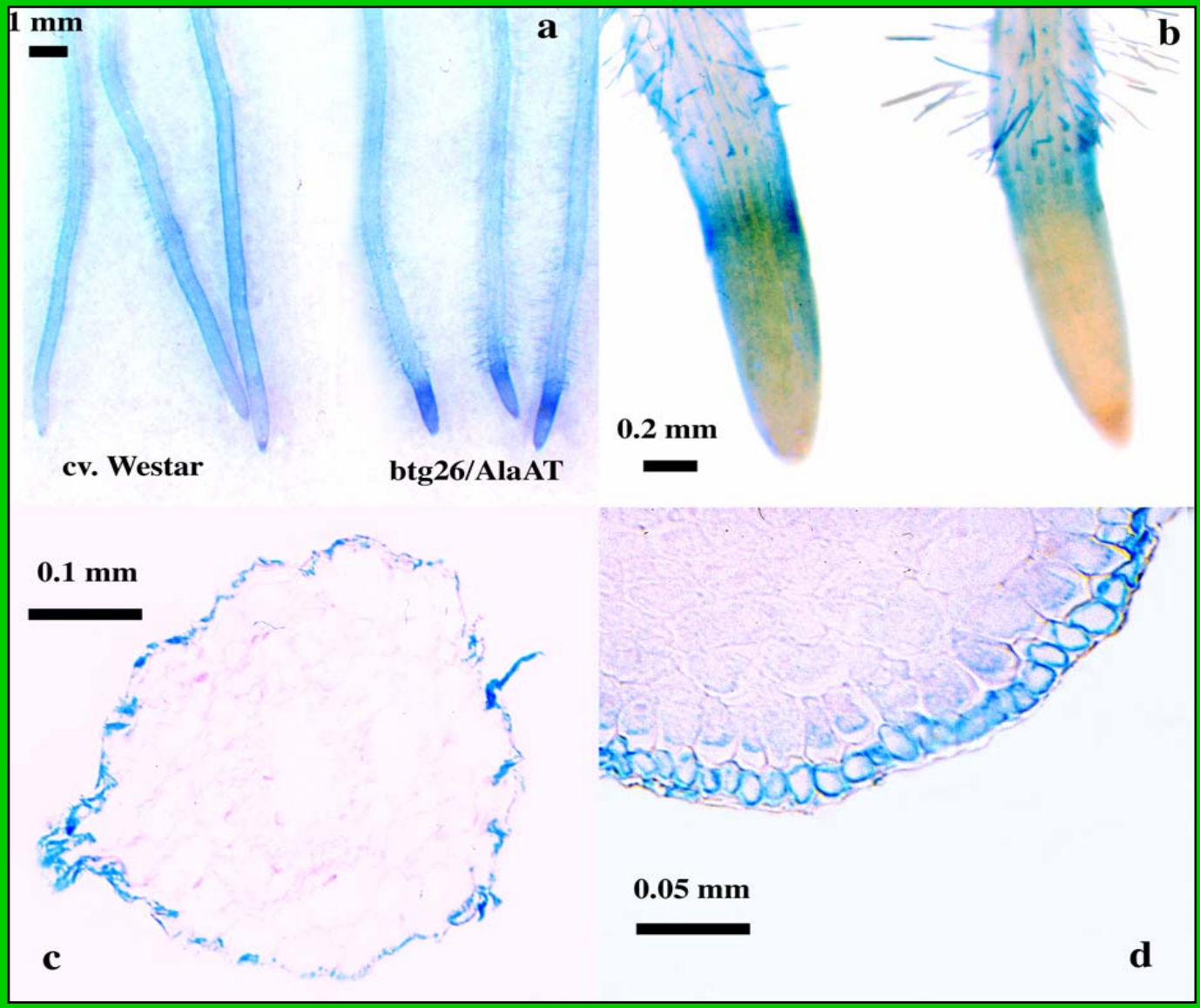
1 2 3 4

Btg26 promoter is root, epidermal specific



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Field Trials Winter 2003, 2004
Brawley, California

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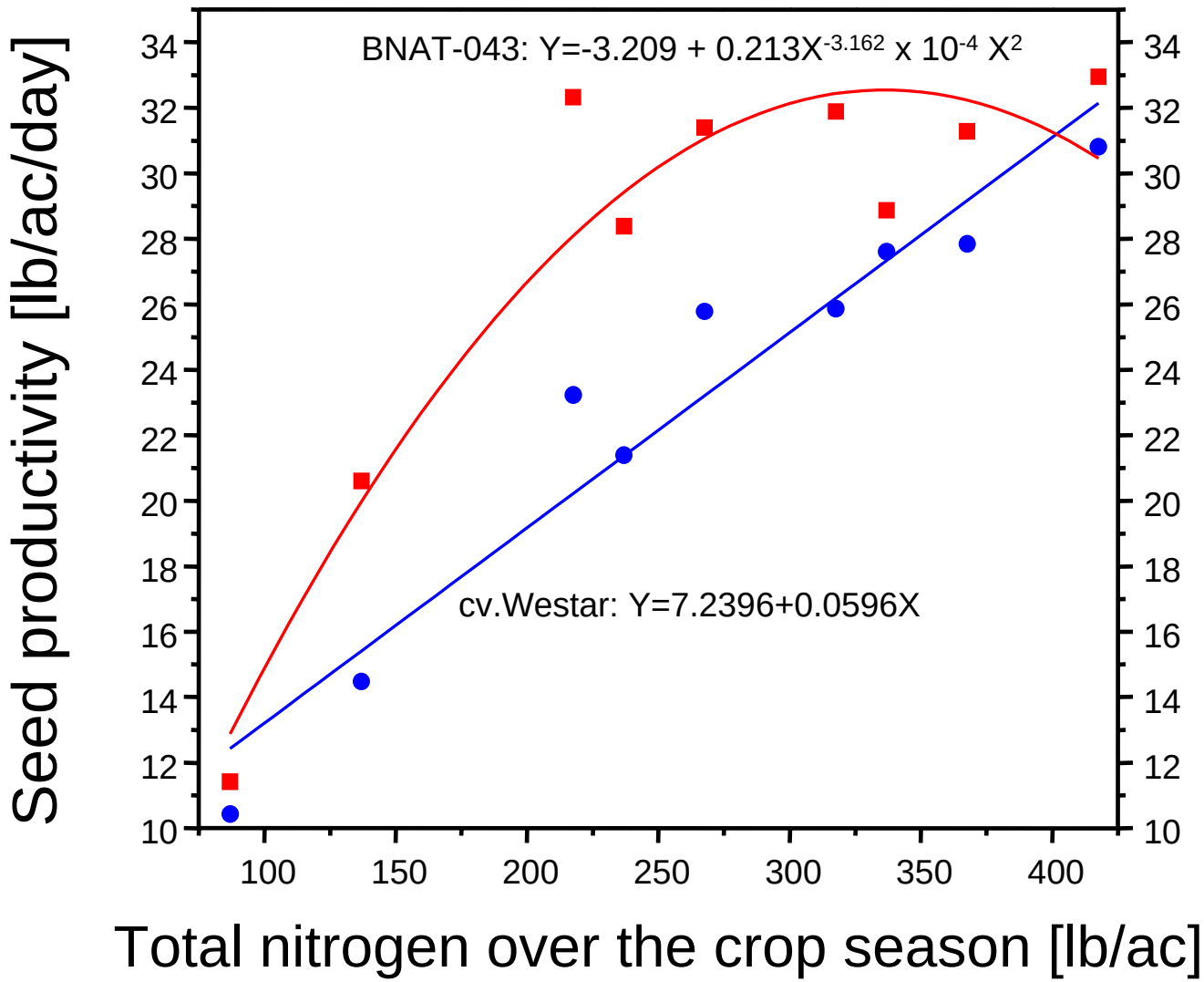
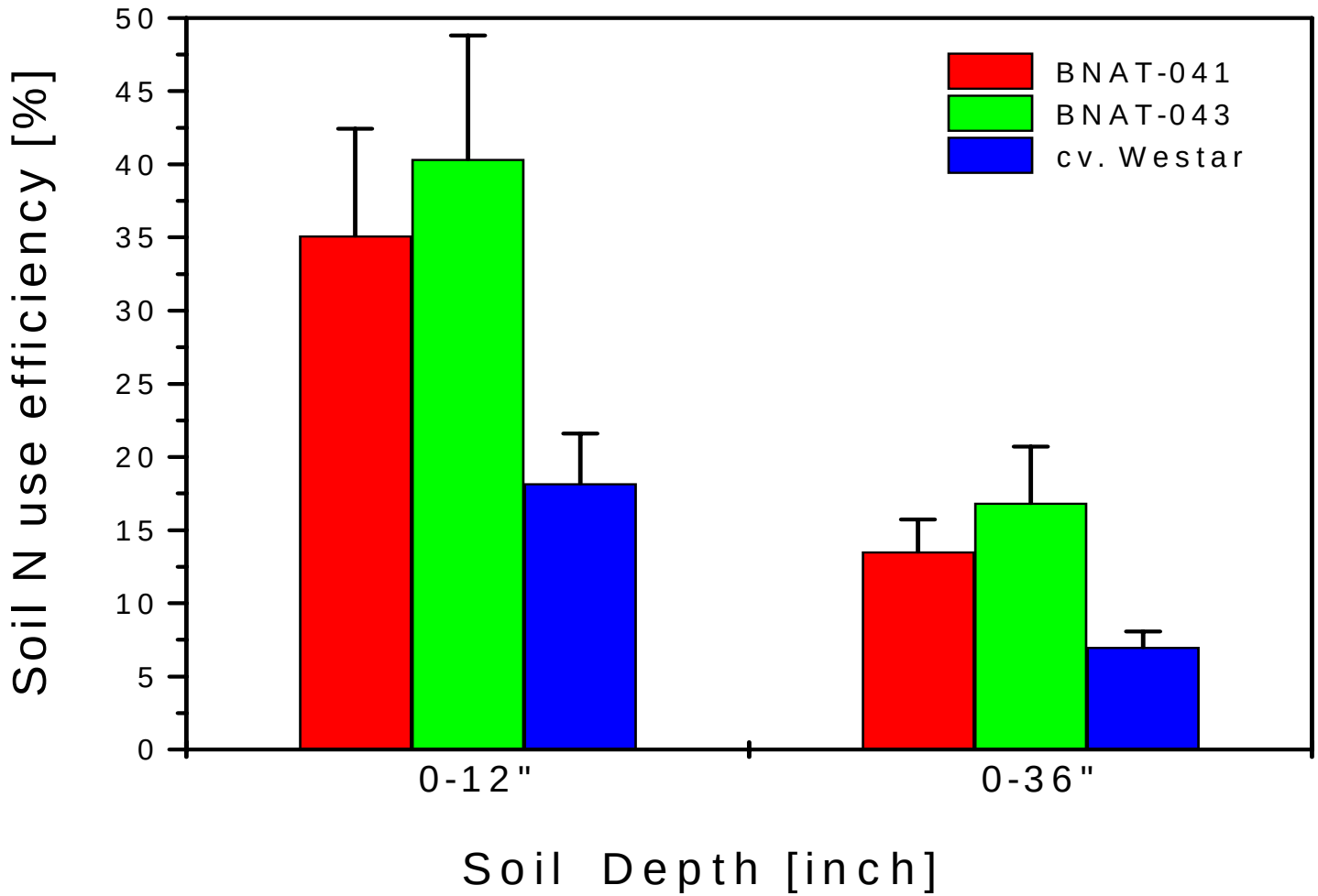
Integrated responses to nitrogen fertility



Soil nitrogen use efficiency



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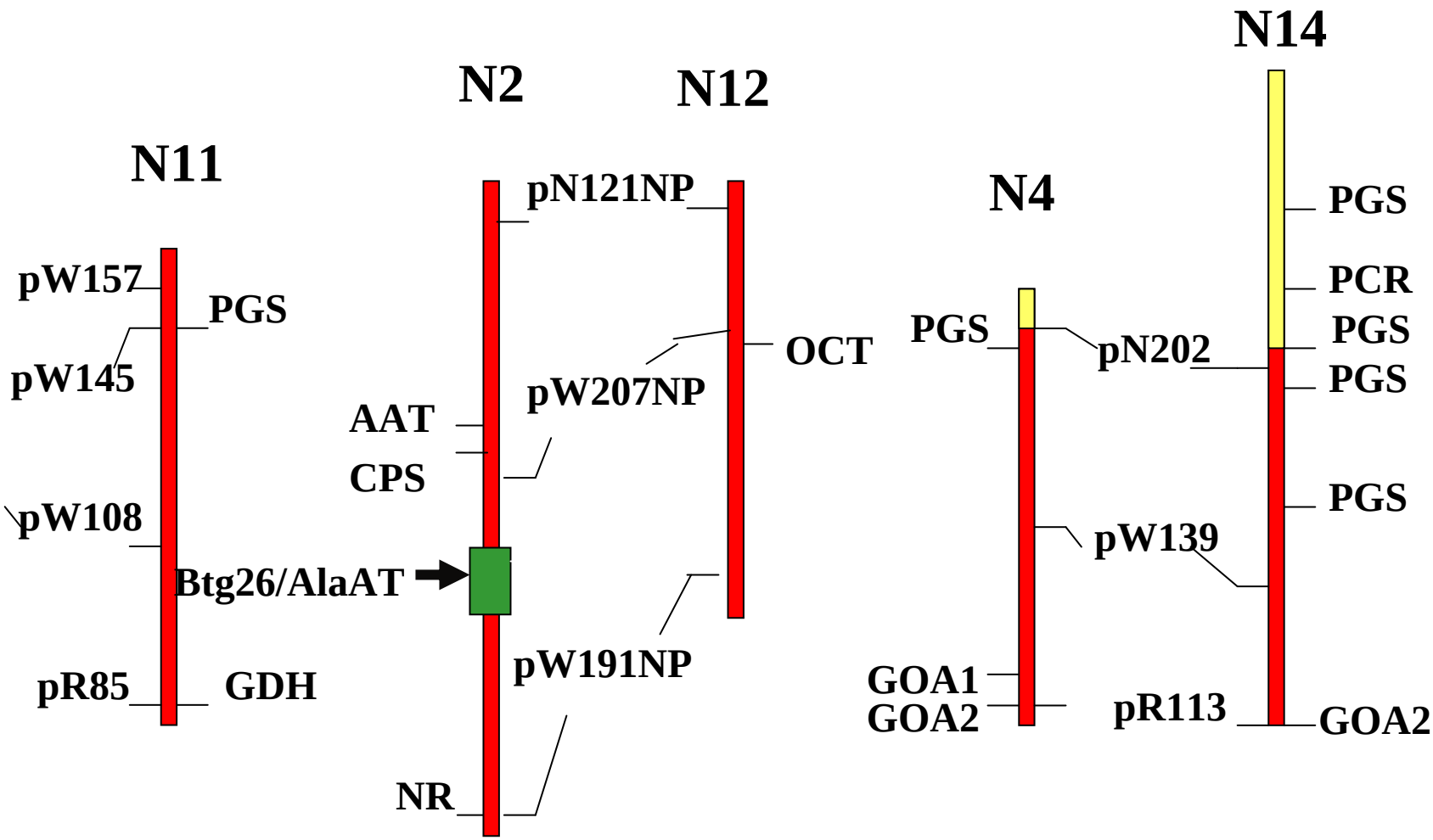
Metabolic fine tuning



Transgenes need to be evaluated in different genetic backgrounds to ensure optimal efficiency

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Questions and Challenges

- How well do specific transgenic constructs in different genetic backgrounds
- What is the impact of the genetic architecture of the plant on the efficacy of the trait (ie: do transgenes work better in combination with specific alleles of other nitrogen metabolism genes?)
- What are the key considerations that will be required to make it work efficiently in monocots (C3 versus C4)

Questions and Challenges

- Can we use genomics to dissect the effect of the btg26/AlaAT transgene in plants
- How can the use of transgenics be integrated with proper nutrient management on the farm