



Basic Nutrition for High Yielding Crops

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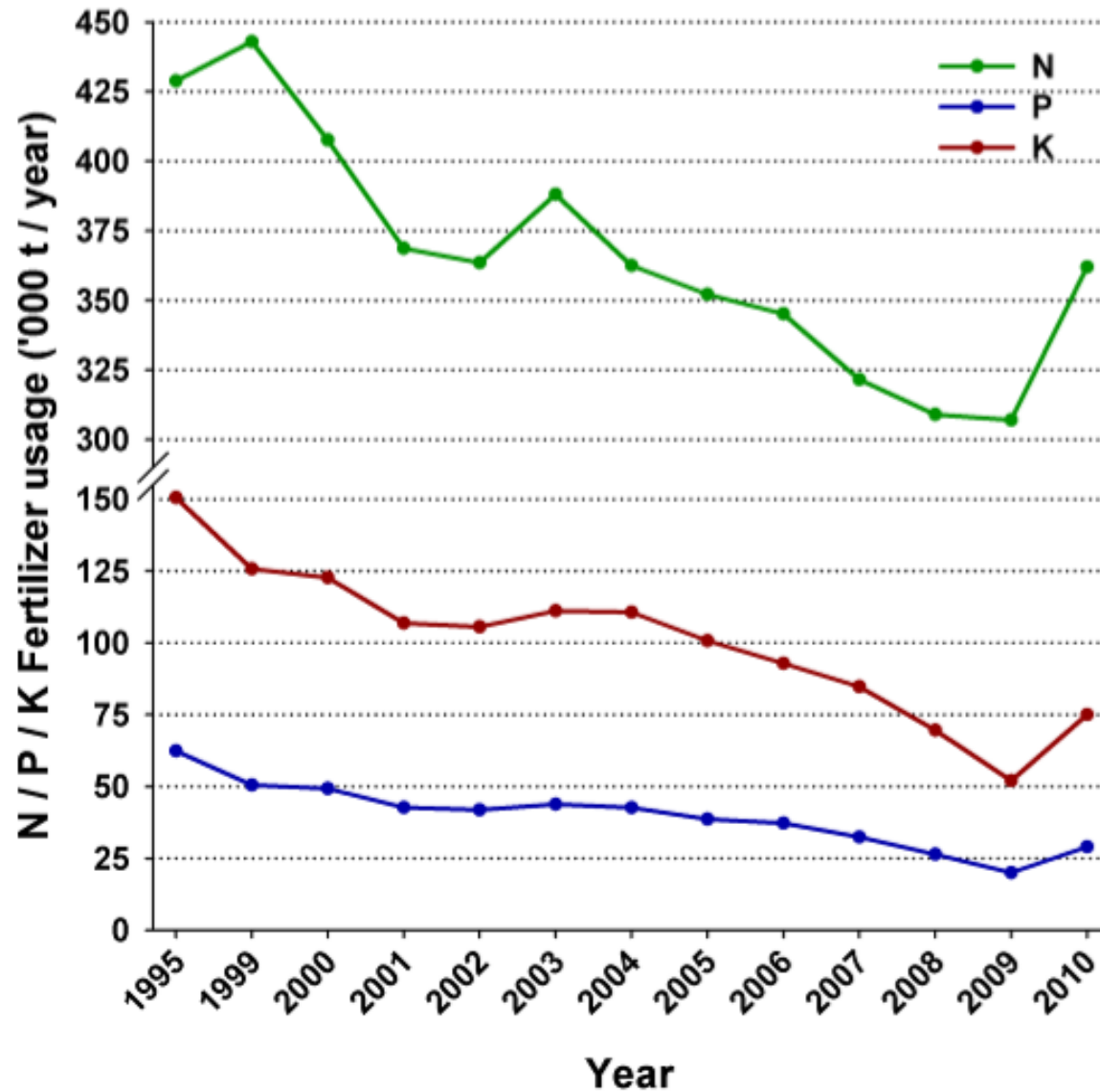
CELUP, Teagasc

ITLUS – 1 December
2011

Outline

- Soil fertility trends
- What are crops taking out of fields - What fertilizer needs to go back?
- Nutrient Balance
- Organic Manure options
- Am I allowed to do it?
- Simple Targets for soil fertility management

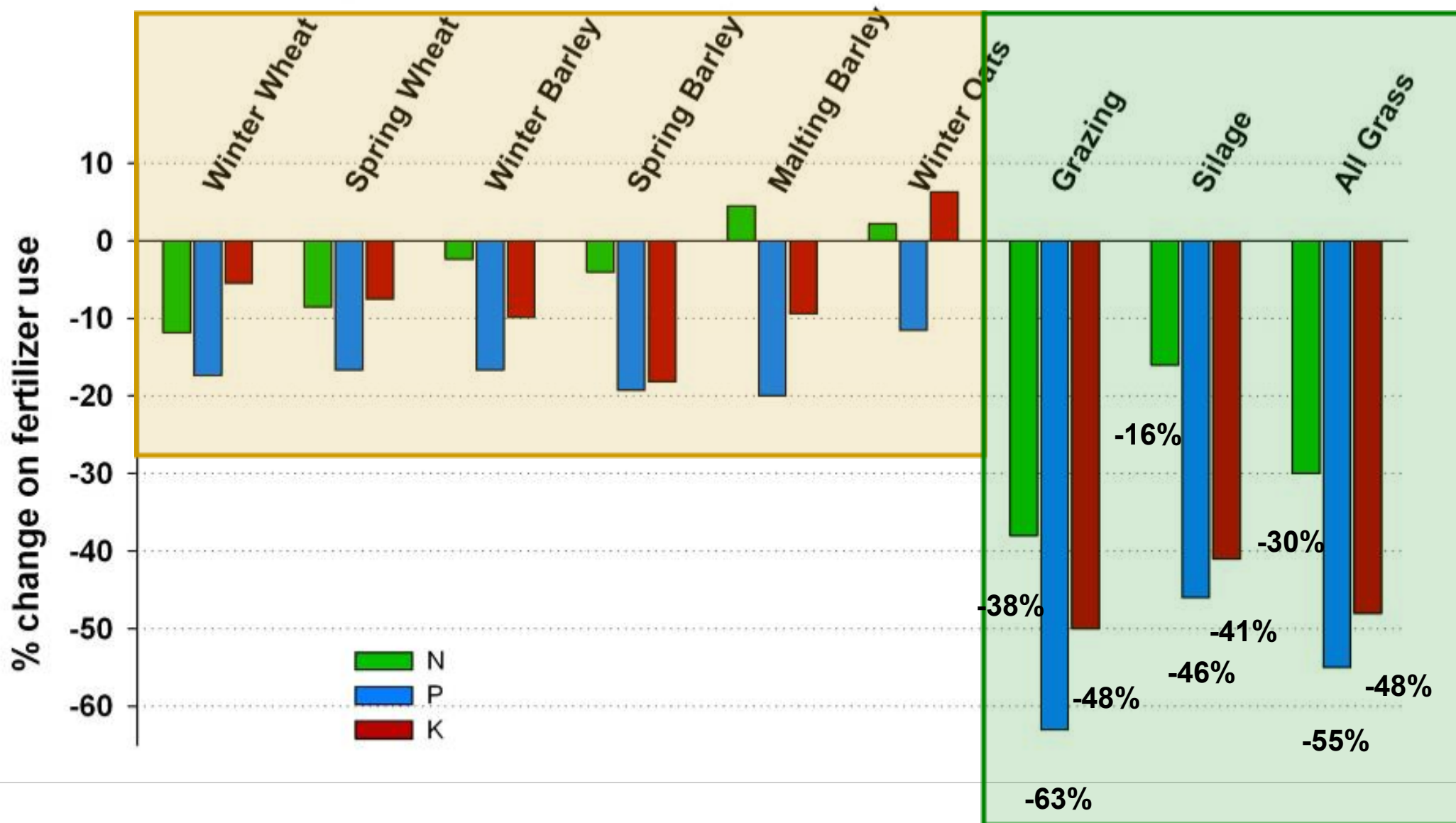
National Fertilizer Usage 1995-2010



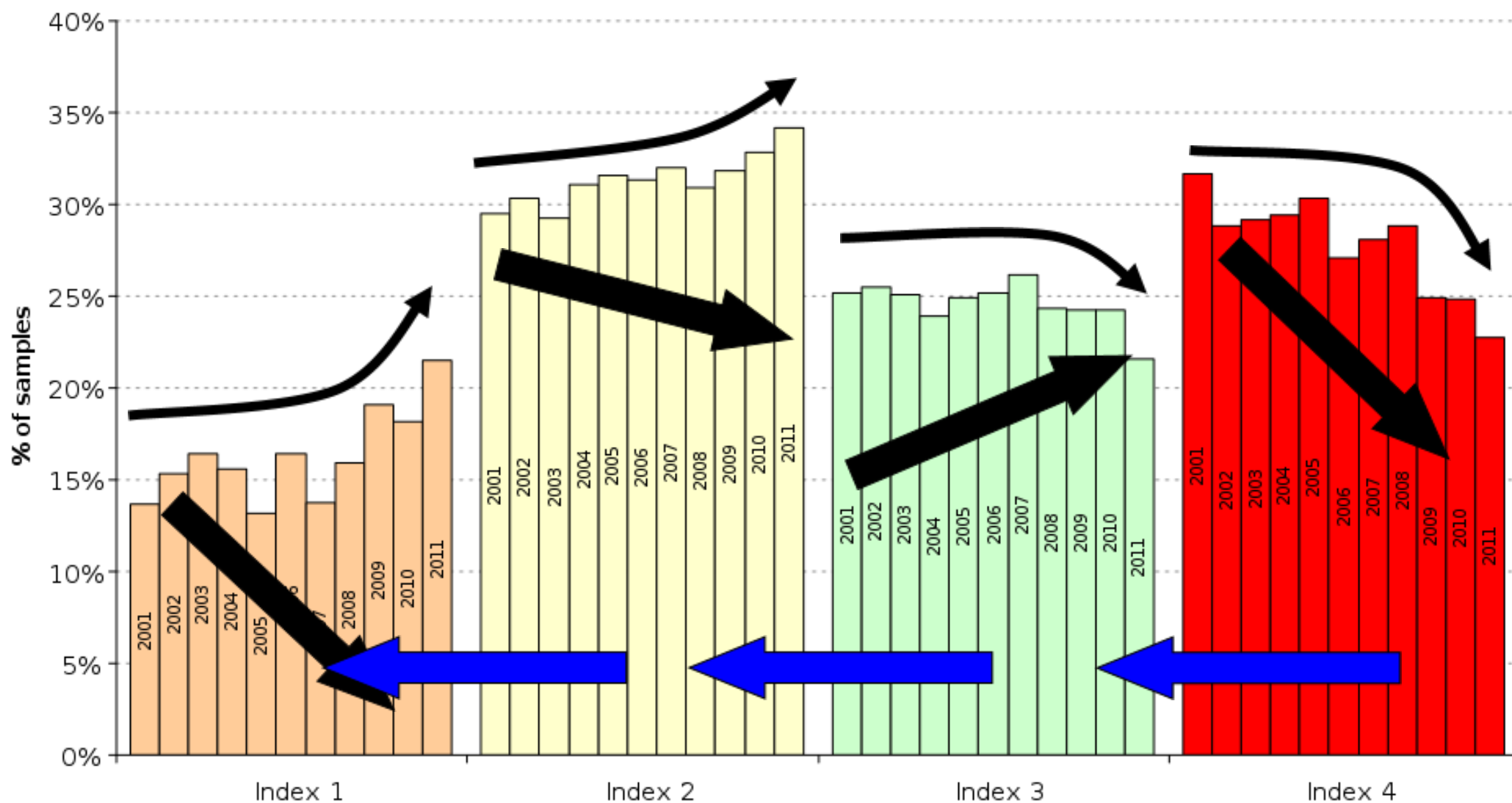
Source: DAFM

% Change in usage 2003-2008

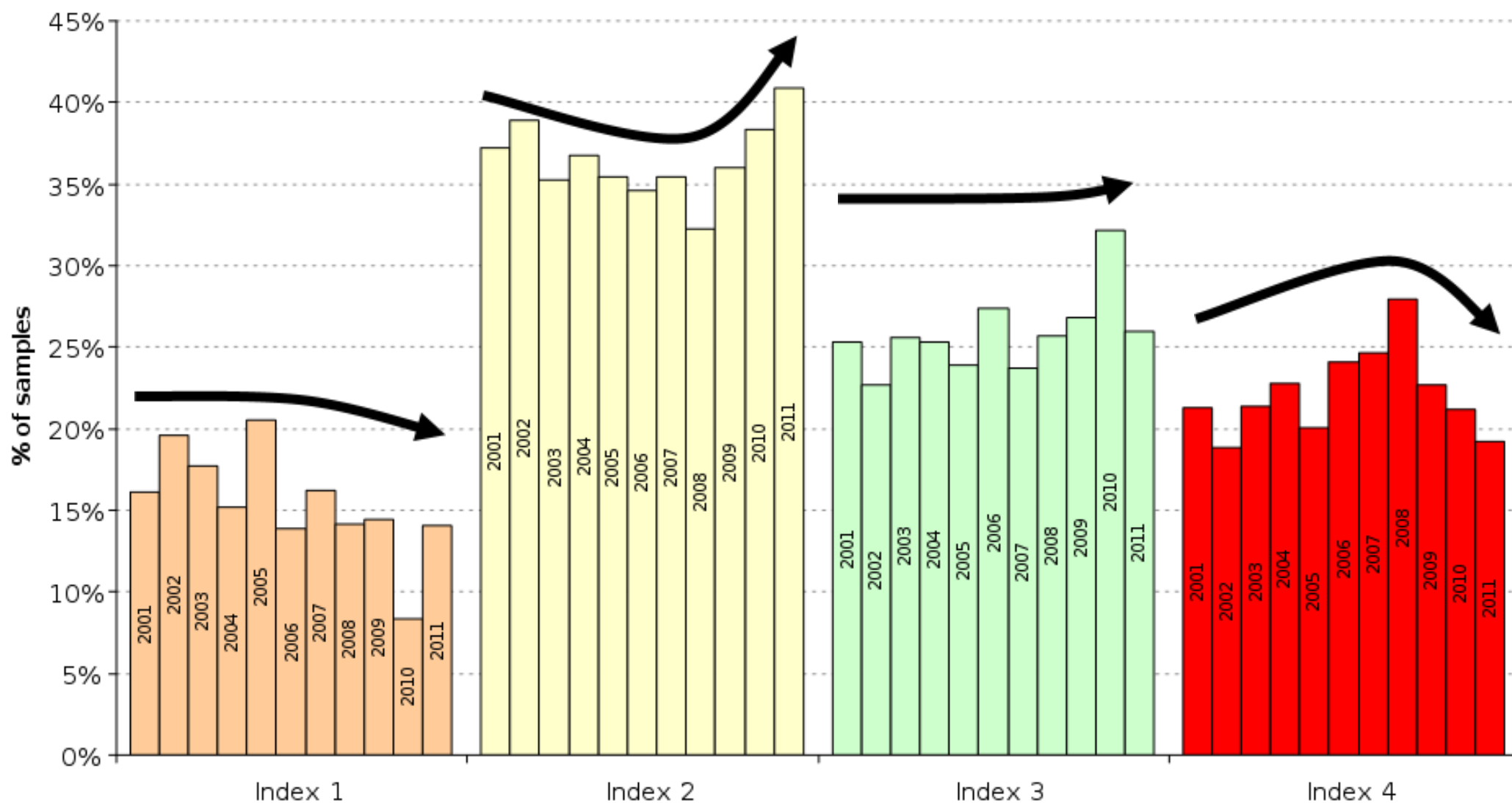
% change in fertilizer N P and K usage between 2003 and 2008



Tillage Farms P Indices in Teagasc Soil Samples 2



Tillage Farms K Indices in Teagasc Soil Samples 2



Regional Variation 2007-2011 (Counties > 1000 samples)

% Tillage Soils with Low Index (1 or 2)

P		K	
Carlow (1750)	33%	Wexford (5350)	32%
Cork (3155)	42%	Carlow (1750)	32%
Kilkenny (1655)	43%	Wicklow (1010)	36%
Dublin (1130)	45%	Cork (3155)	36%
Tipperary (2160)	48%	Kilkenny (1655)	54%
Kildare (2830)	50%	Louth (1670)	57%
Louth (1670)	51%	Tipperary (2160)	58%
Wexford (5350)	62%	Meath (1015)	72%
Wicklow (1010)	63%	Dublin (1130)	73%
Meath (1015)	64%	Kildare (2830)	73%

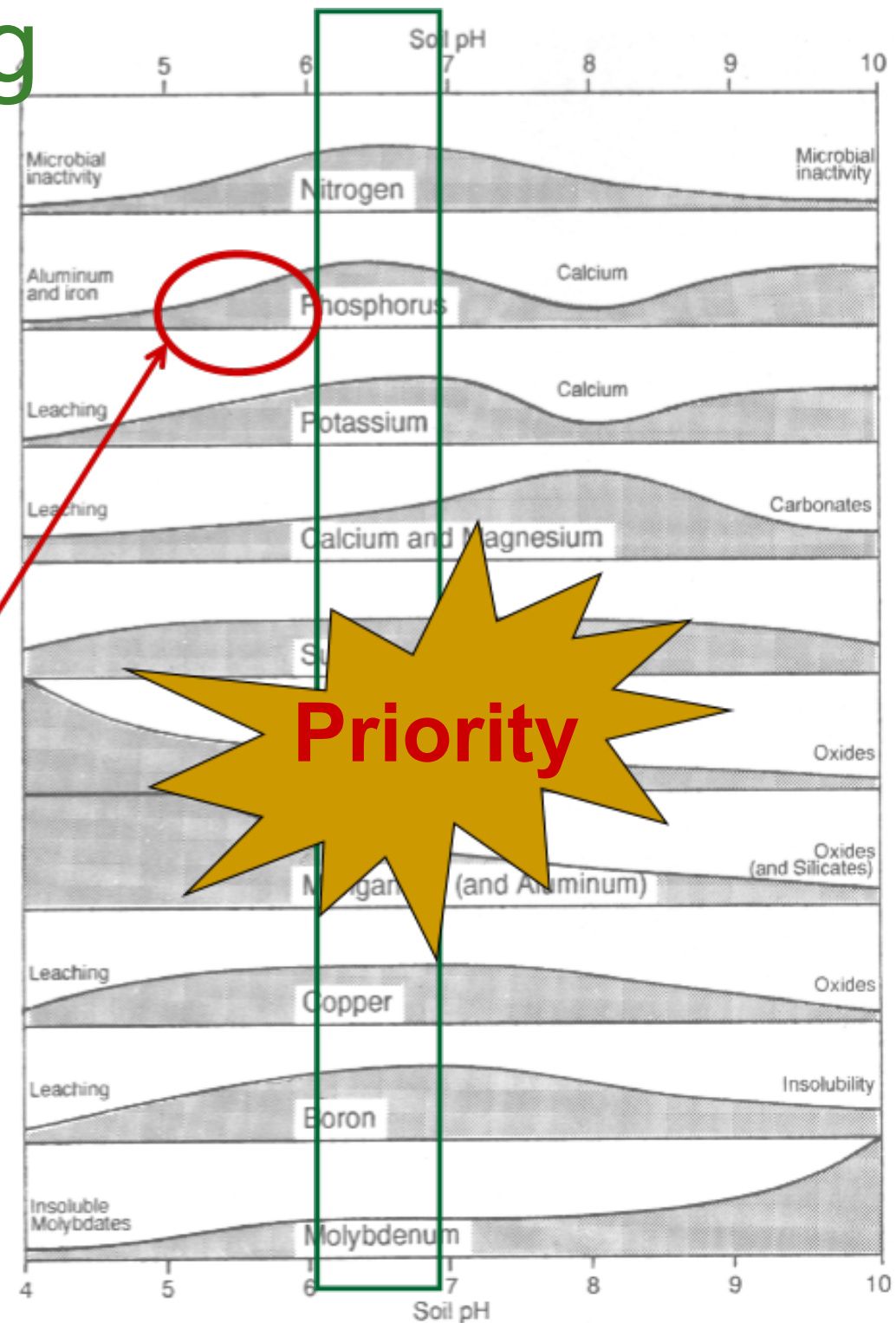
Soil pH and Liming

- Optimum pH for most crops = 6.0-7.0

- Maximum nutrient release from soils
- Break-down release of nutrients from organic manures
- Reduced P fixation by iron (Fe) and Aluminium (Al)

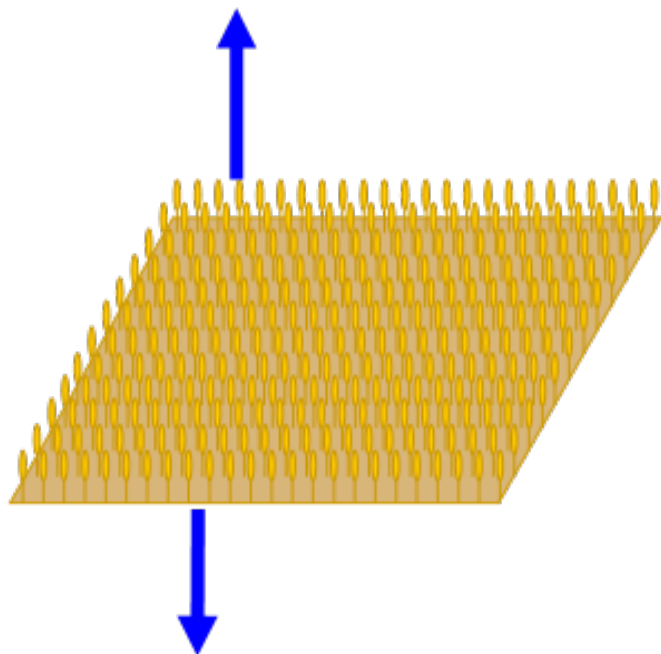
- Response to fertilizer P on acid soils ????

- Soil P reserve less available
- Fertilizers less available



What are crops taking out of fields?

Gaseous losses (N)



Leaching / Runoff losses
Mainly N (up to 100 kg/ha)
Some K, Ca, Mg
Little P

Nutrients removed (kg/t of grain yield)

Straw removed

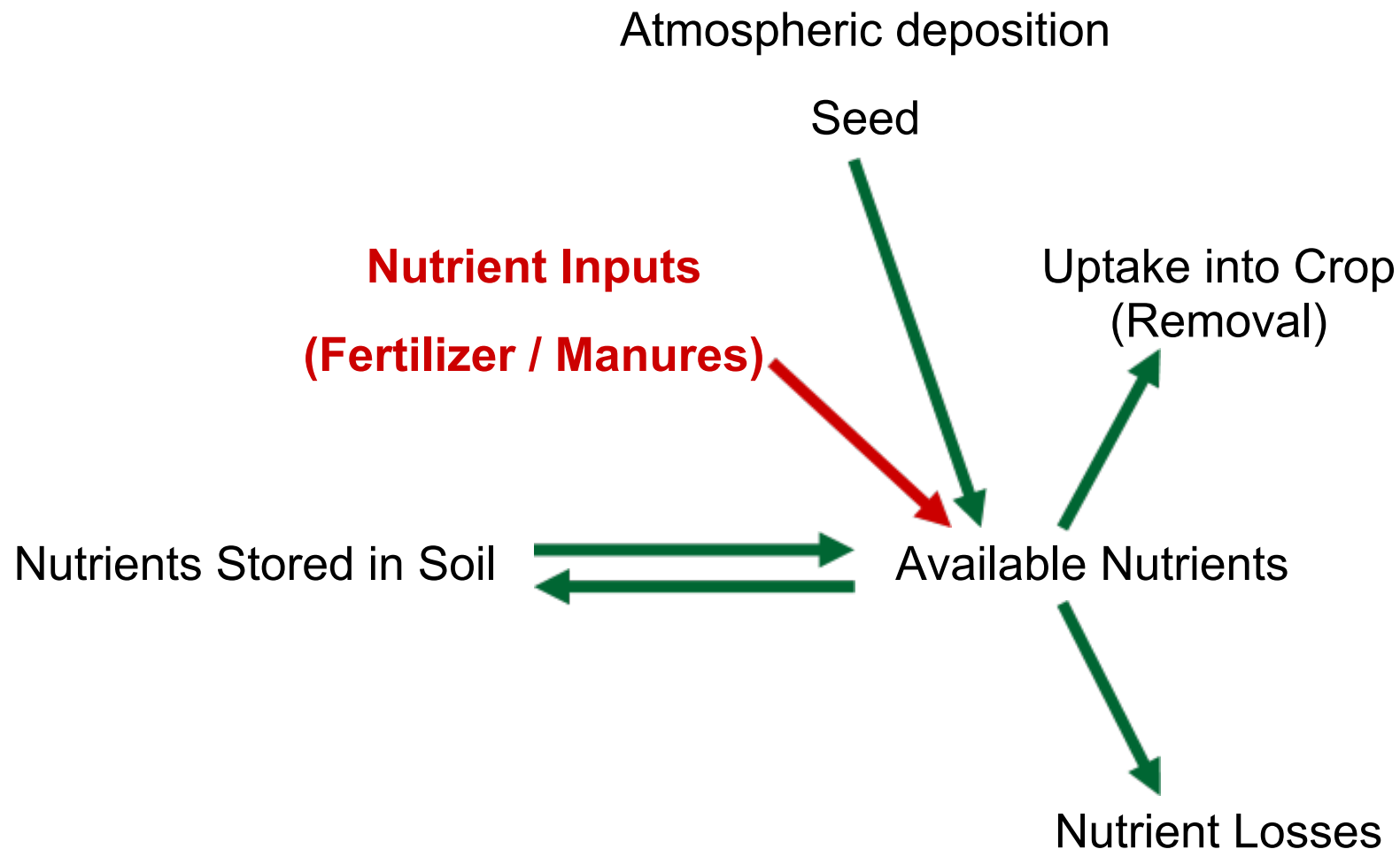
Source: DEFRA RB 209

	N	P	K
Wheat	20	3.7	9
Barley	20	3.7	10
Oats	20	3.8	15

Typical crop offtakes

		Nutrient Offtake (incl. Straw) (kg/ha)		
		N	P	K
Winter Wheat	Yield (t/ha) 11	220	41	99
Spring Wheat	8	160	30	72
Winter Barley	9	180	33	90
Spring Barley	7.5	150	28	75
Winter Oats	7.5	150	29	113

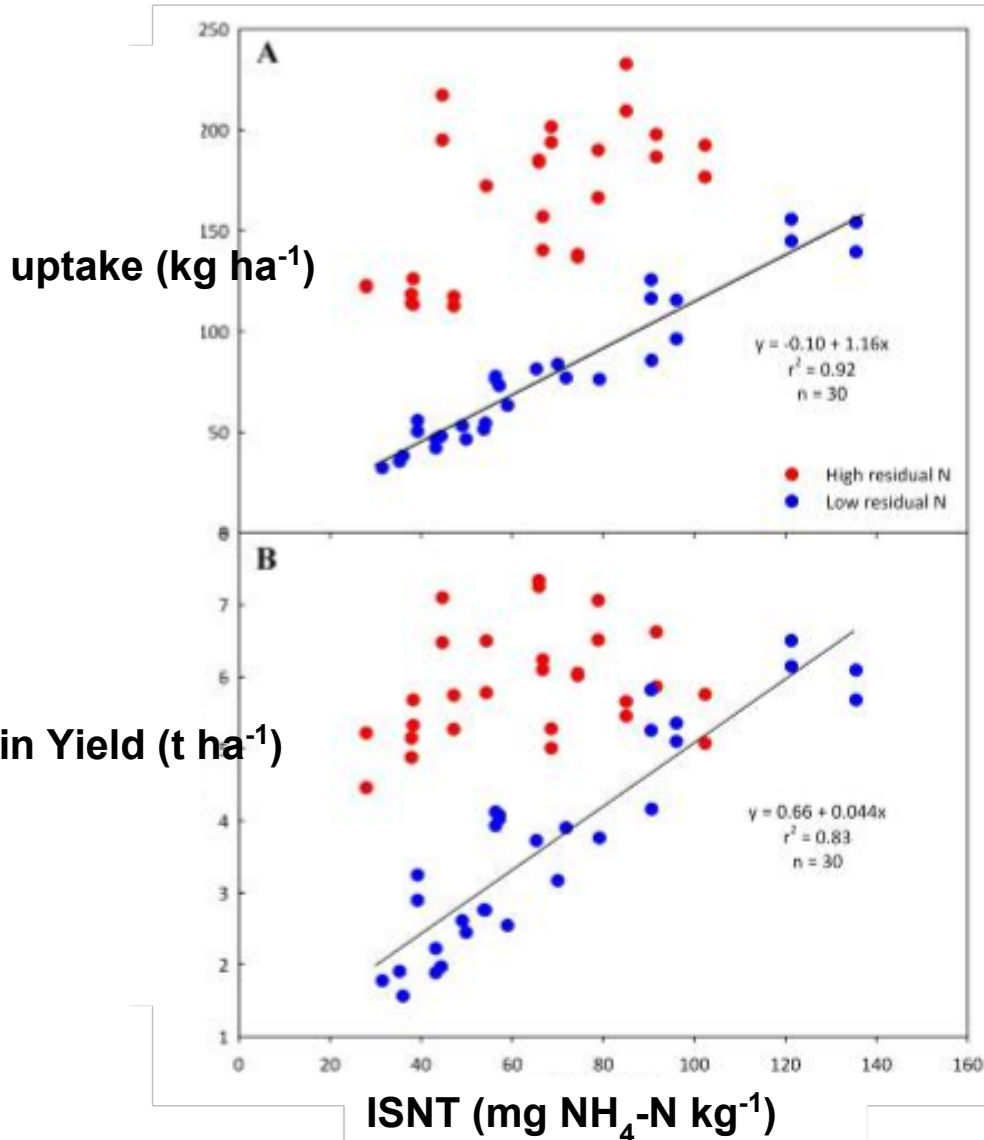
What fertilizer needs to go back?



Required Inputs =

Removal + Losses - Atm. dep. & Seed – Net release from soil

30 Winter Wheat Sites (USA) (Wall et al. 2008)

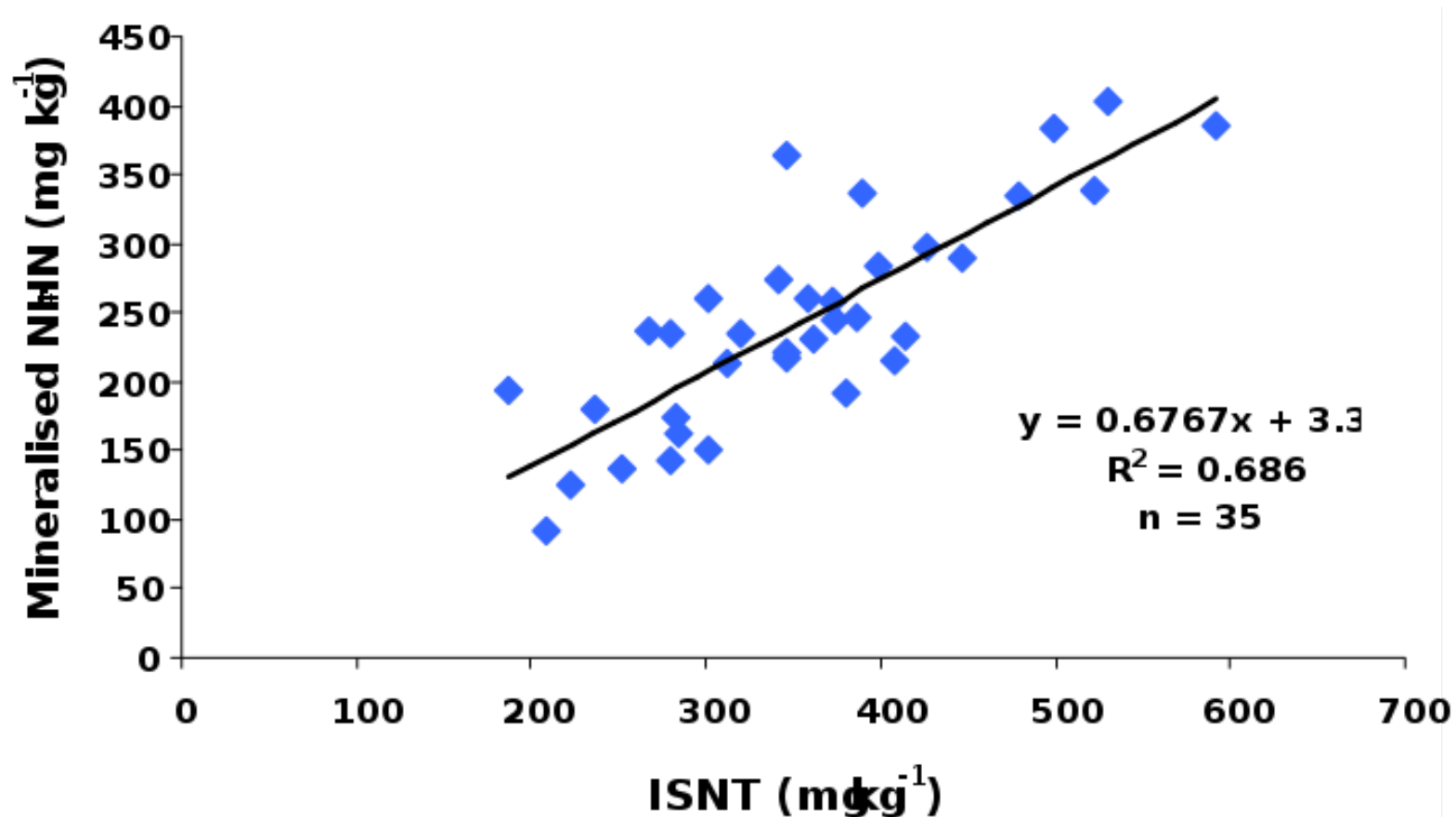


- ISNT test – good predictor of both baseline N uptake and grain yield (without fertilizer) on low residual N sites

- Soil
- Organic matter
- Place in Rotation
- Seasonal variation

Developing a soil N test for predicting soil N-supply

- 6 chemical N tests validated against a standard biological N test
- The Illinois Soil N test (ISNT) was the best predictor of N mineralisation



Controlled Microcosm Study at Johnstown Castle



- Objective: To validate soil N tests for predicting soil N-supply and grass DM production on 30 mineral soil types kept under controlled environmental conditions;
- 15°C, 80% Relative Humidity, 16 h daylight, atmospheric CO₂ levels

Soil release of P & K

- Easier to work with / predict than N
 - More stable in the soil than N
 - Interchange between soluble the readily available pools
- Soil test
 - Estimates potential of soil to supply nutrient
 - Extracted amounts 2-3% of total (labile nutrient)
 - Solution concentration
 - < 1mg P/l
 - 1-10 mg K/l

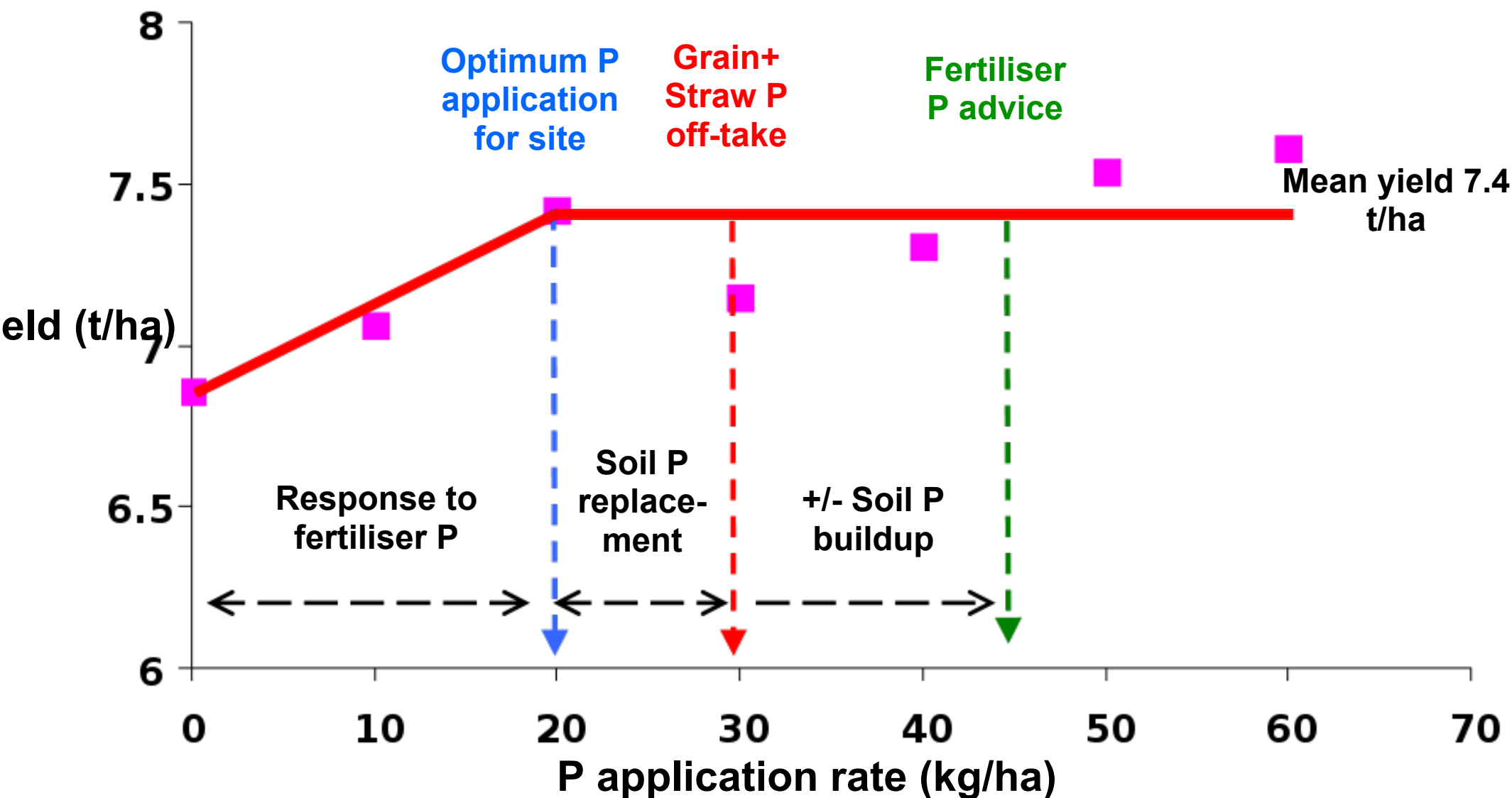
Predicting P & K – Soil testing

- Convert test result into soil Index
- Target = All soils in Index 3 for P and K !
 - Only ~ 25% at present

Soil Index	Description	Soil test P (mg L ⁻¹)	Soil test K (mg L ⁻¹)
1	Very low	0 – 3.0	0 – 50
2	Low	3.1 – 6.0	51 – 100
3	Medium	6.1 – 10.0	101 – 150
4	High	≥ 10.1	≥ 151

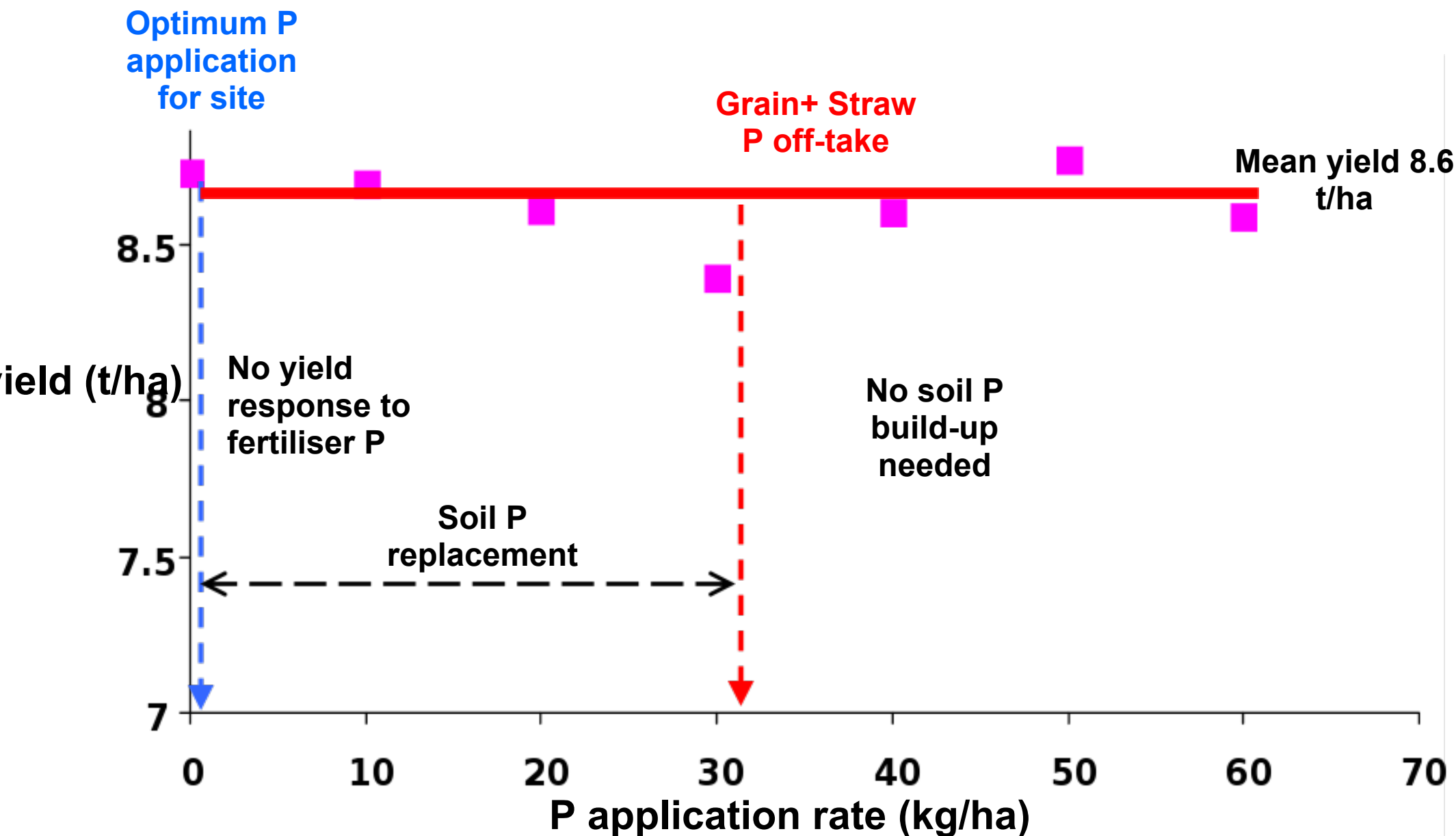
Spring Barley – P response

Low P-index (1) Site 2010

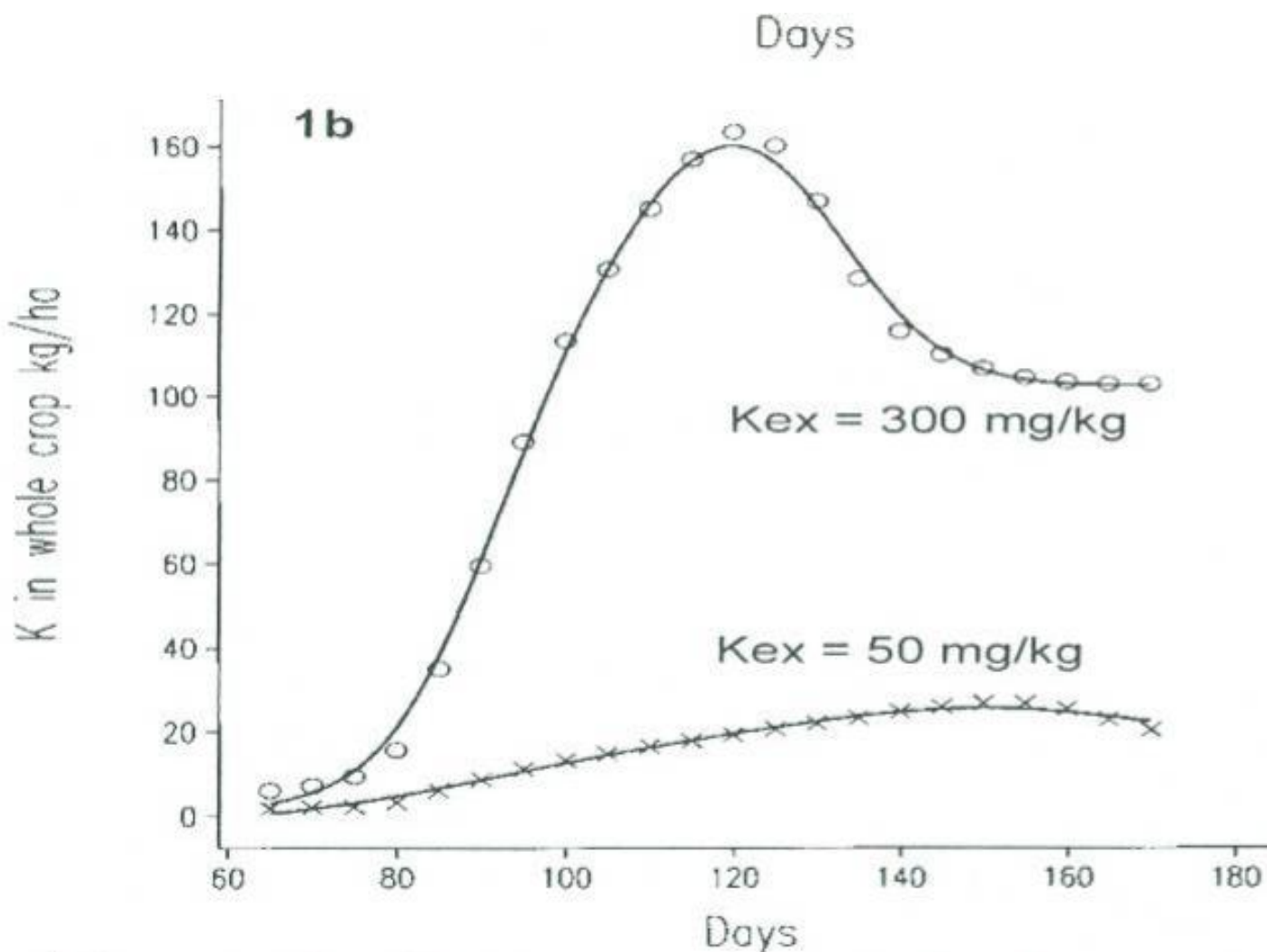


Spring Barley – P response

High P-index (3) Site 2010



Effect of soil K on K uptake



Spring Barley
(Rothamsted, UK)

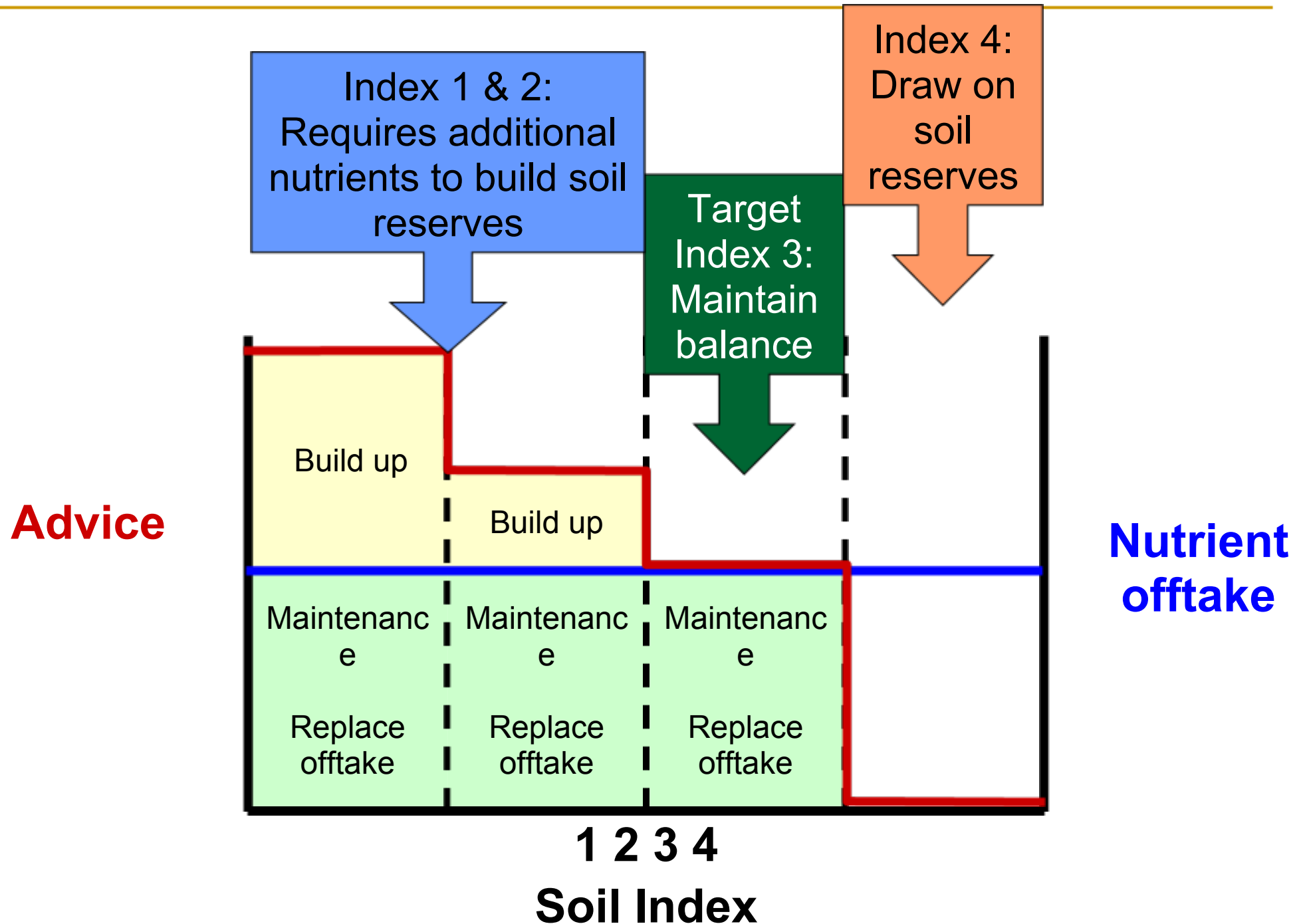
Cumulative uptake of K

Figure 1: *Potassium uptake by spring barley in a field experiment.*

Rationale for fertilizing

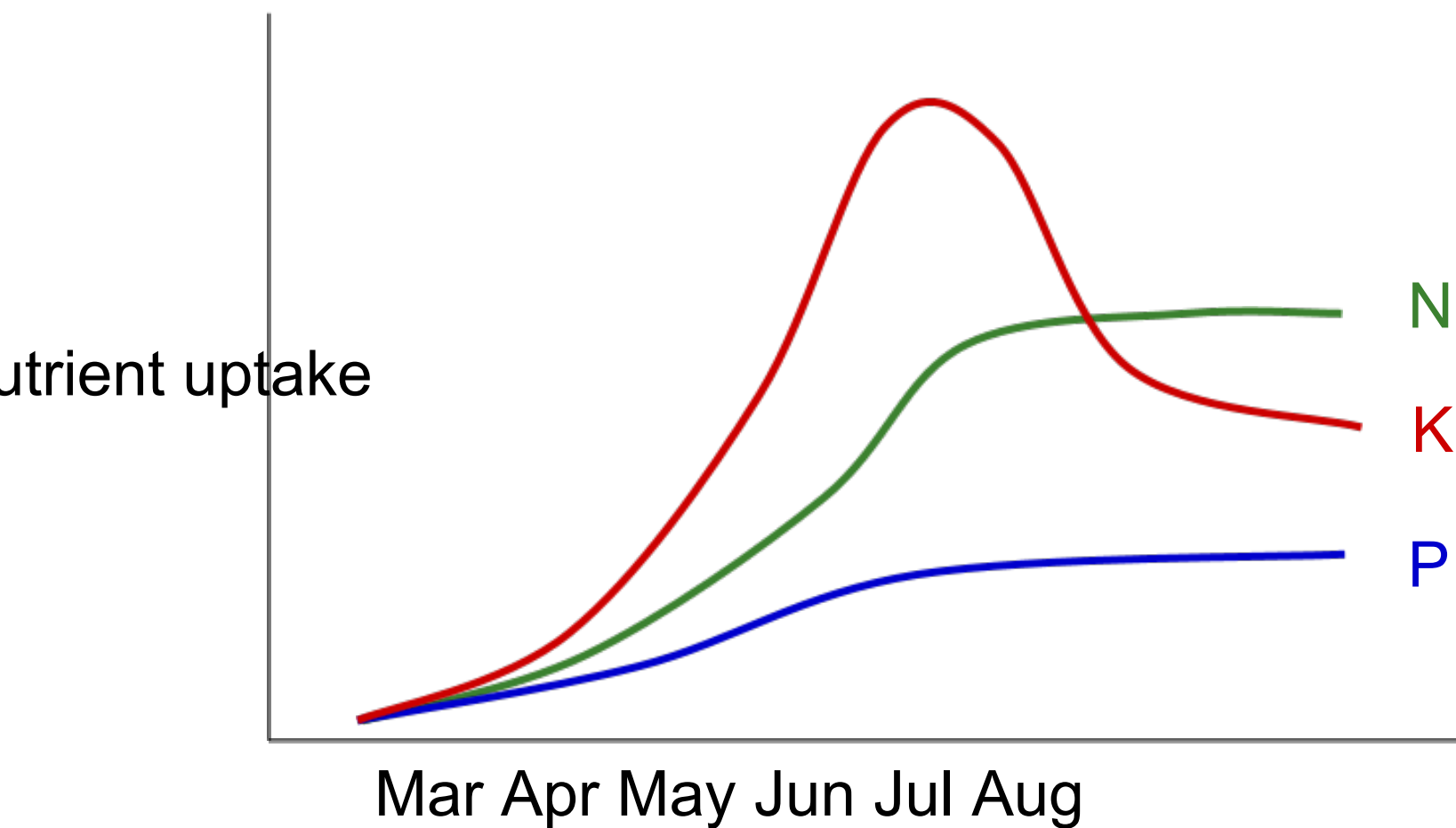
- Maintaining critical P and K level (Index 3 range) is important for yield
- Build up P & K level such that soils remain just above critical P level
 - Index 3
 - Soil variability
- Therefore once at critical level replace what is removed
- Use periodic soil analysis to check that soil P is not deviating from critical value
- FEED THE SOIL and LET THE SOIL FEED THE PLANT

Soil Index & Advice



Pattern of nutrient uptake

General Pattern for cereal crops



Timing of P & K

- P

- Nitrates Regs more or less preclude autumn application
- Work on low P soils (index 1) indicated little difference between autumn and spring application of P

- K

- Where soil levels are high autumn application for winter crops not required (except K fixing soils)
- At low soil K levels some autumn K should be considered
- Main requirement is in late spring - spring application best but autumn application ok
- Risk of leaching is relatively low (estimated at 1 kg for every 100mm drainage), except for sandy soils

How long does it take to change Index ?

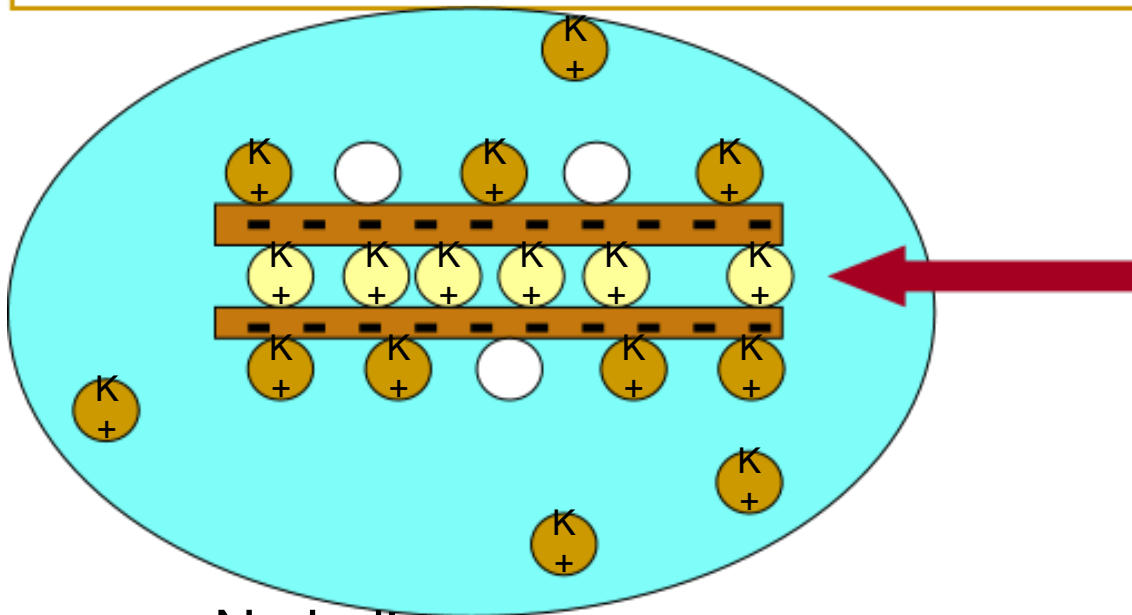
- P

- Will take a number of years
- Lighter soils tend to move faster
 - Lower organic matter and clay content
- Advice
 - Soil test valid for number of years
 - Re-test every 3-5 years to monitor what is happening

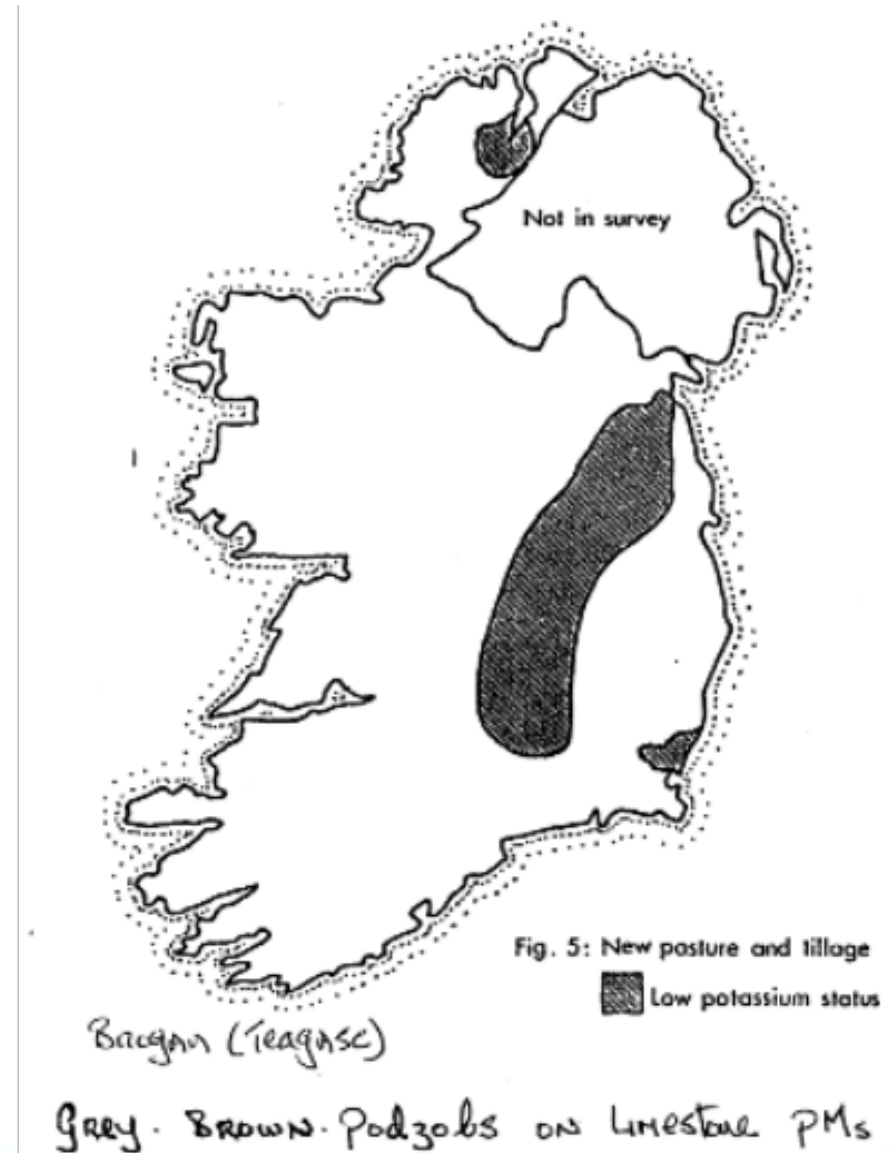
- K

- Will react more quickly than P
- Index 1 & 2
 - Apply maintenance plus build-up until next soil test
- Index 4
 - Skip application for one year, then revert to maintenance (unless very high)

K Fixing soils

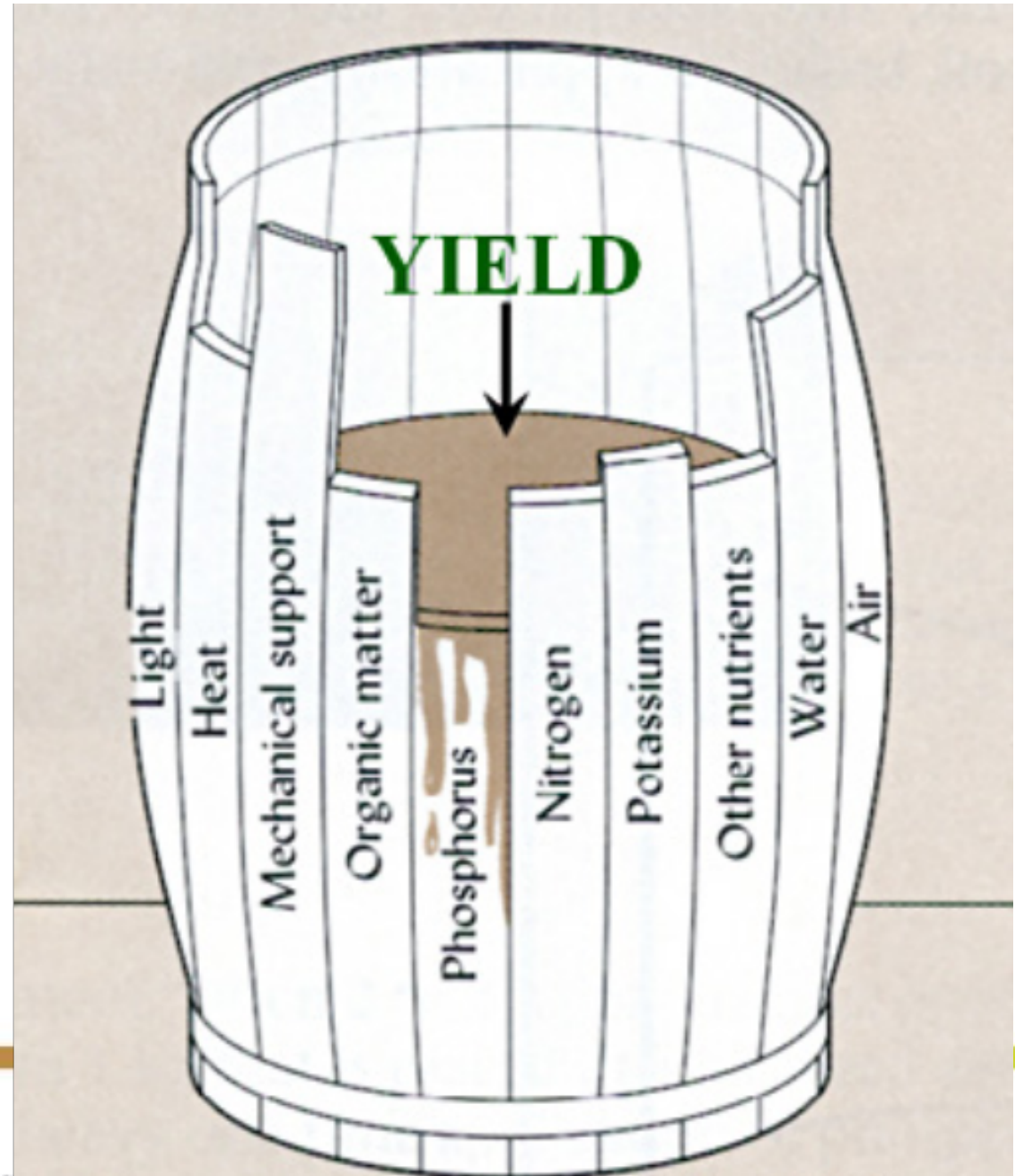


- No build up
- Little and often
- Dry weather



Soil Fertility and Nutrient Balance

- Law of the minimum:
 - Nutrient in shortest supply determines yield



Effect of K on N efficiency

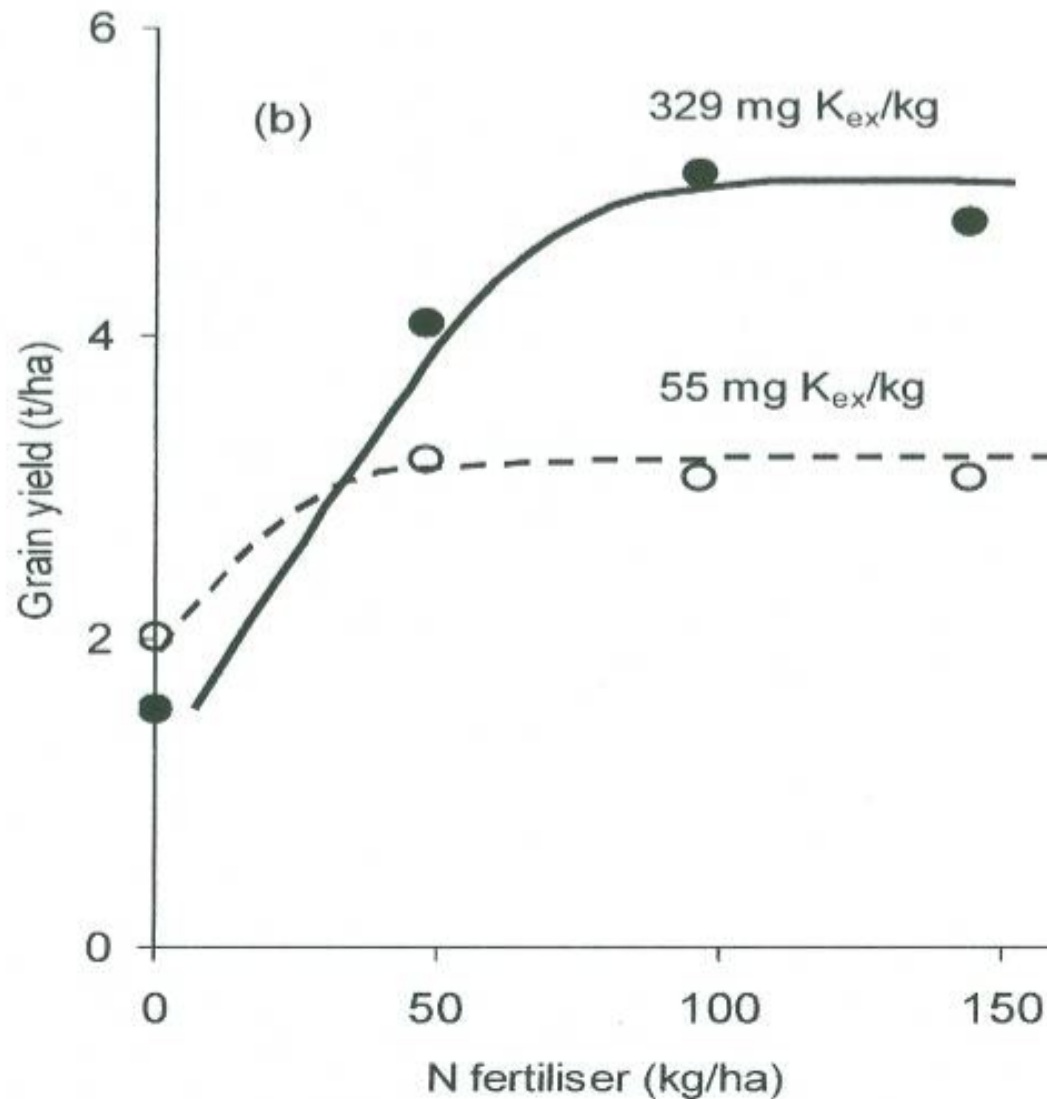


Figure 1: Response of spring barley to N fertiliser on soils with different levels of exchangeable soil K (K_{ex}), Hoosfield, Rothamsted.

P:K Ratios

Winter Wheat 11 t/ha

N advice 250 kg/ha

			K			
			1	2	3	4
			140	125	110	0
P	Index	Advice (kg/ha)				
	1	62	2.3	2.0	1.8	P
	2	52	2.7	2.4	2.1	P
	3	42	3.3	3.0	2.6	P
	4	0	K	K	K	-

**18-6-12 or 10-10-20
not always ideal.**

**1:2 product plus
MOP.**

**Complement
organic fertilizers.**

Spring Barley 7.5 t/ha

N advice 155 kg/ha (Feed)

			K			
			1	2	3	4
			115	100	85	0
P	Index	Advice (kg/ha)				
	1	49	2.3	2.0	1.7	P
	2	39	2.9	2.6	2.2	P
	3	29	4.0	3.4	2.9	P
	4	0	K	K	K	-

Minimising Costs

- Organic Manures

- Increasing value as fertilizer increases

- Straw incorporation

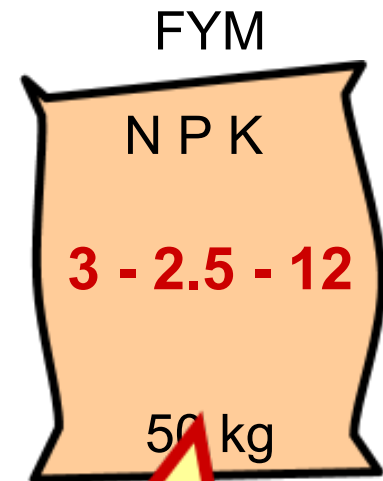
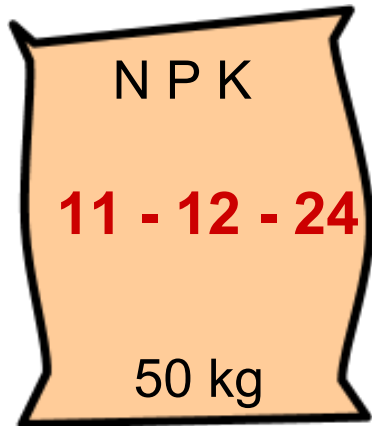
- 50-60 kg/ha of K
- Even spread of chopped straw
- Value of straw & Baling costs
- Chopping
 - Combine Fuel & Speed



Fertilizer Value

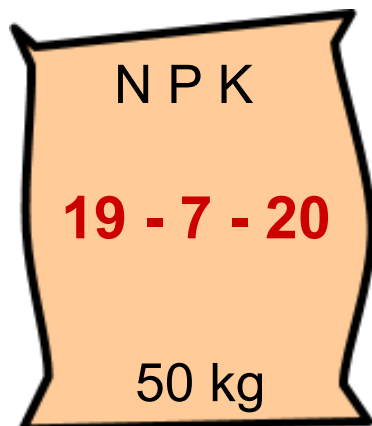
Solid Manures (1 ton)

Poultry Litter (Broiler)

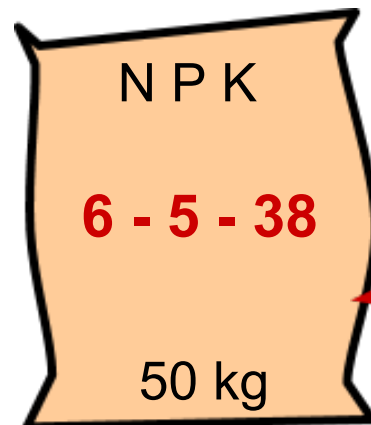


Slurry (1000 gallons)

Pig Slurry



Cattle Slurry



Beware of Variability

Beware of Variability

Nutrient	Poultry	K
Protein	100%	100%
Calcium	20%	20%

Organic Manures – Speed of Incorporation

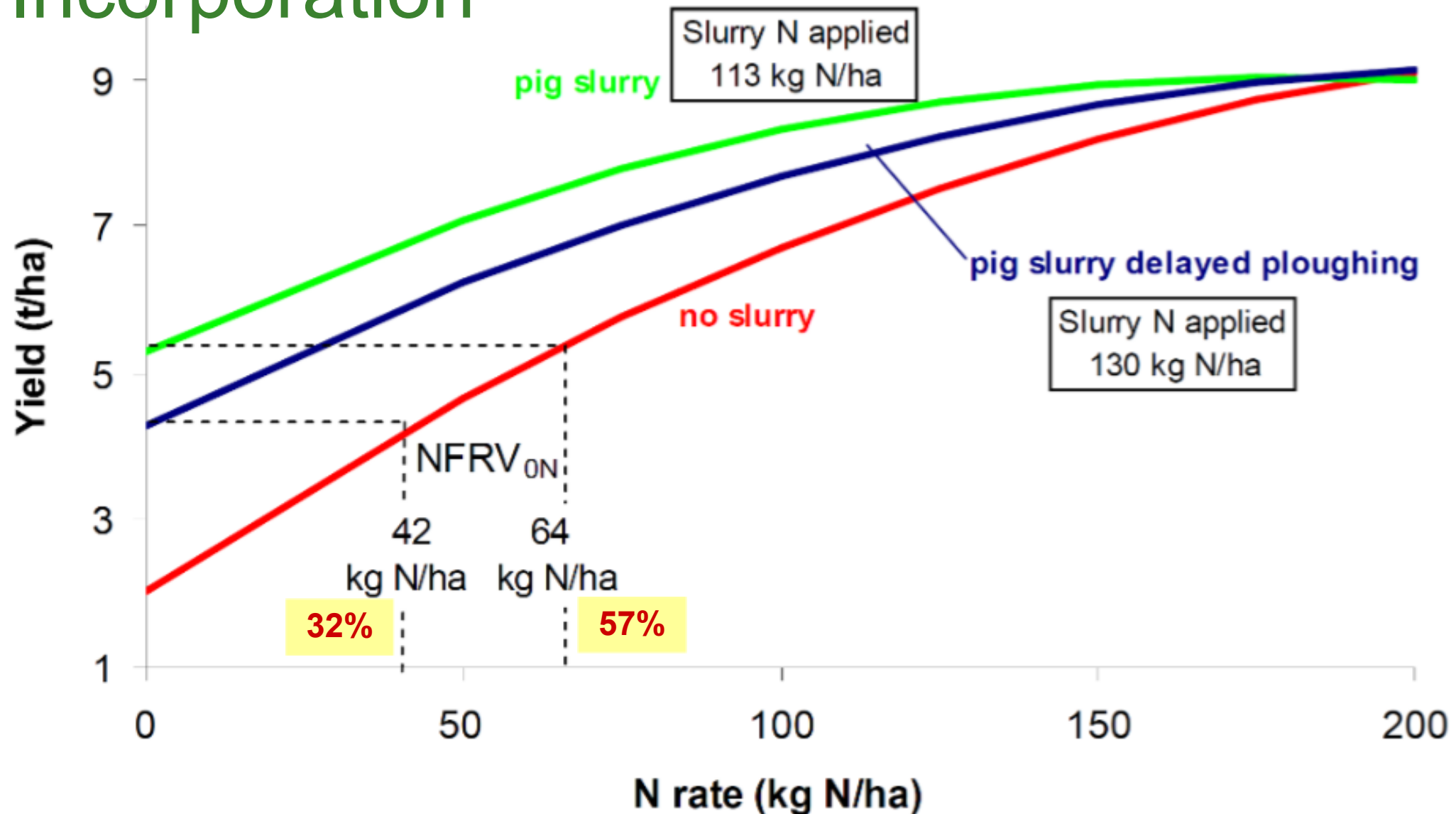


Figure 2. Comparison of pig slurry ploughed in immediately after application with pig slurry ploughed in three days after application on the nitrogen fertiliser replacement value of pig slurry for spring barley (cv. Wicket) at Oak Park in 2009.

Am I allowed to do it?

- Changes in Nitrates rules
- Winter Wheat N rates
 - Increased by 20 kg/ha
- Spring Barley
 - Increased N
 - Reference Yield now 6.5 t/ha
 - Additional 20 kg/ha on Malting Barley
- Additional P allowance
 - 3.8 kg/ha for yields > 6.5 t/ha
- Organic manures
 - Change in N Index
 - N & P allowances
 - N availability of SMC now 20%
 - Surplus P (pig, poultry and SMC) extended to end 2016
- K has never been restricted! – K advice revised upwards in 2008

P and K holiday

- Be careful
- Maybe okay on Index 3 in short term ??
- But.....
 - Removals must be replaced at some stage if fertility to be maintained
 - Rules may cause problems (P)
 - Annual based allowances
- Main savings to be made on Index 4 soils – identify and focus on those

What targets can be set for soil fertility management?

- Have soil analysis for whole farm
 - Take samples
 - Use the results
- Soil pH between 6 and 7 in all fields
 - Apply lime in rotation to more pH sensitive crops
 - OSR, Beet, Peas, Beans > Cereals > Potatoes
- P and K Index 3 in all fields
 - Index 4 is a resource □ Exploit it
 - Index 1 & 2 should be increased to Index 3
- Use organic fertilizers where possible / practical
 - Cost
 - Organic Matter □ Structure, Biology, Residual nutrients
- Nutrient inputs in proper balance

