Soil and Plant Nutrition at Wellesbourne

A Flavour of the Research
from the last 70 Years

Ian Burns

18th December 2019 / Celebrating 70 years of research at Wellesbourne

WARWICK
THE UNIVERSITY OF WARWICK

Post-war vegetable production

- largely relied on market garden systems with hand labour and crops fertilised with animal manures

Vegetable production changed

- to mechanised farm-scale systems with nutrients supplied from inorganic NPK fertilisers

Inorganic fertiliser recommendations were urgently needed for vegetable crops

The Problem

- More than 20 different vegetable crops
- Each with specific requirements for N, P and K
- Grown on multiple sites across the country
- on a wide range of soil types

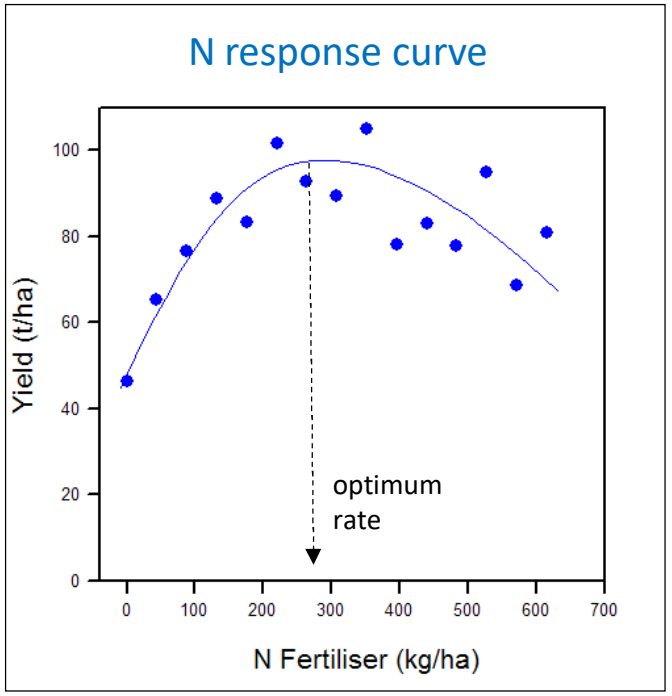
NPK Fertiliser Recommendations for Vegetable Crops

Duncan Greenwood
CBE, FRS

Response equation:

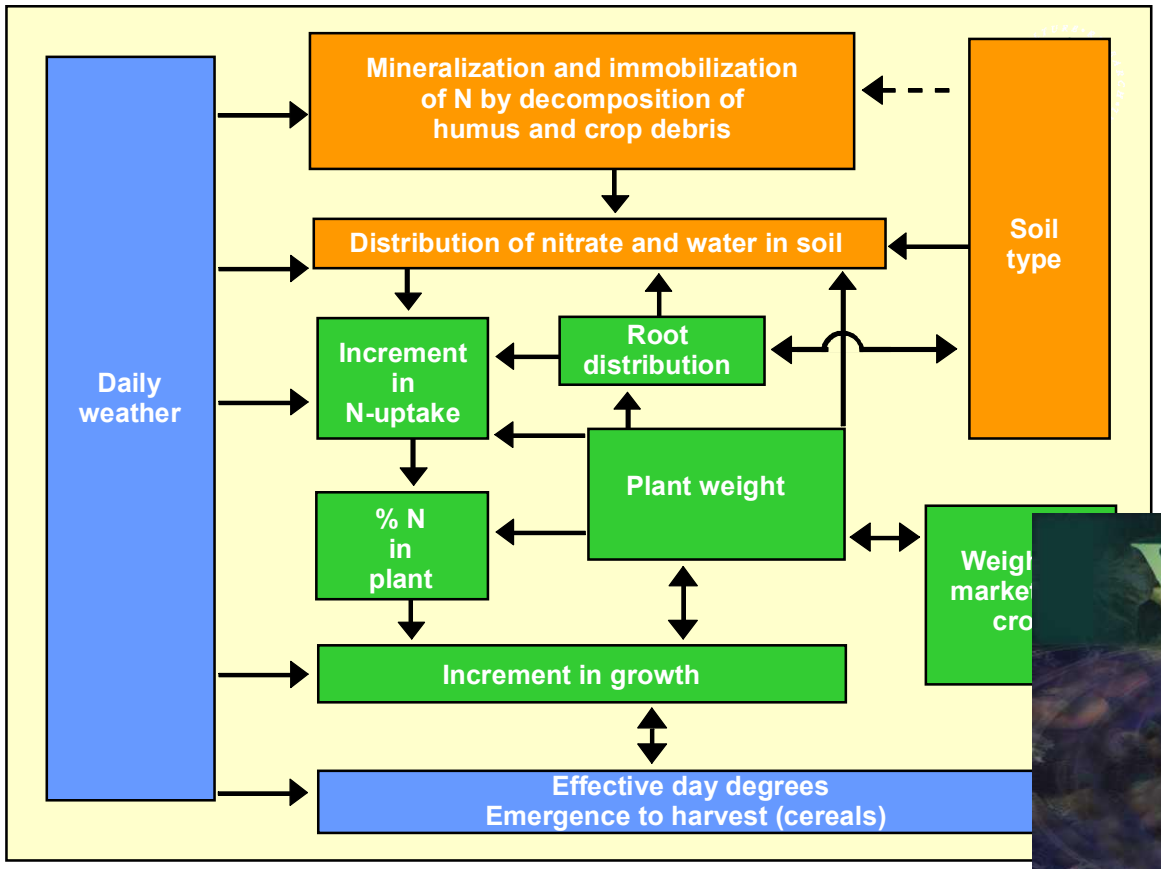
$$\frac{1}{Y} = \frac{1}{1 - (N_S + N_F)/\alpha_N} \left[\frac{1}{A} + \frac{1}{B_N(N_S + N_F)} + \frac{1}{B_P(P_S + P_F)} + \frac{1}{B_K(K_S + K_F)} \right]$$

New space-saving systematic experimental designs

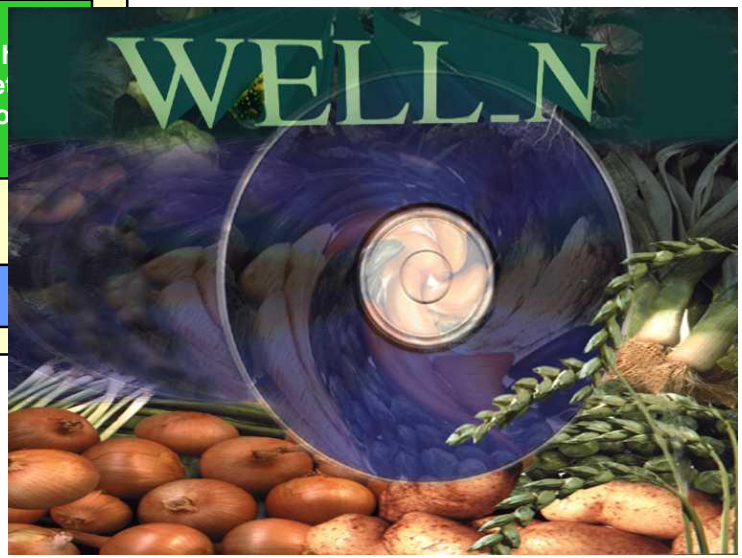


NPK Fertiliser Recommendations for Vegetable Crops

Dynamic model for predicting day-to-day changes of nutrients in the soil-plant system

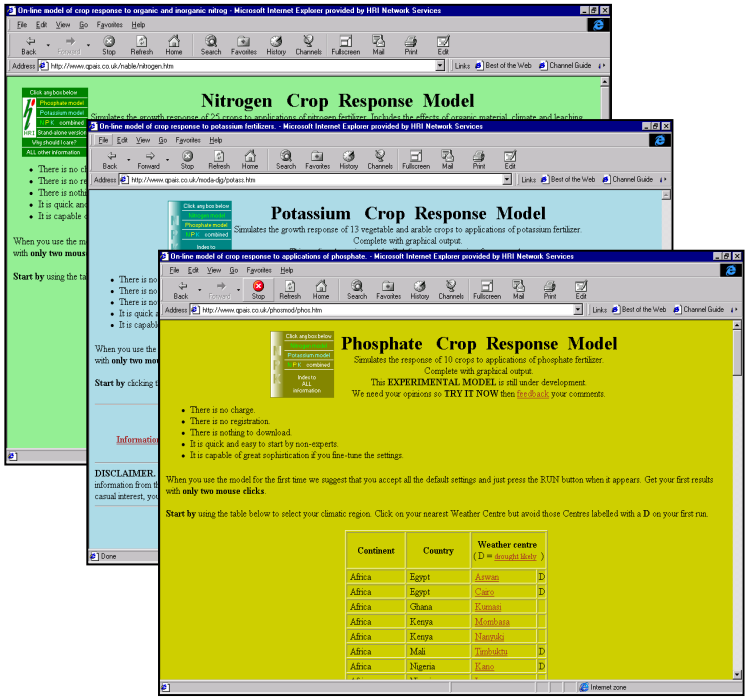


Structure of the N_ABLE model



The model was used to create WELL_N a Decision Support System for site-specific N fertiliser advice for growers

Dynamic model for predicting day-to-day changes of nutrients in the environment



Web-based models for N, P and K

Predictions of the models contributed to UK Policy Advice

Fertiliser placement techniques

can increase growth and enhance yields with less fertiliser

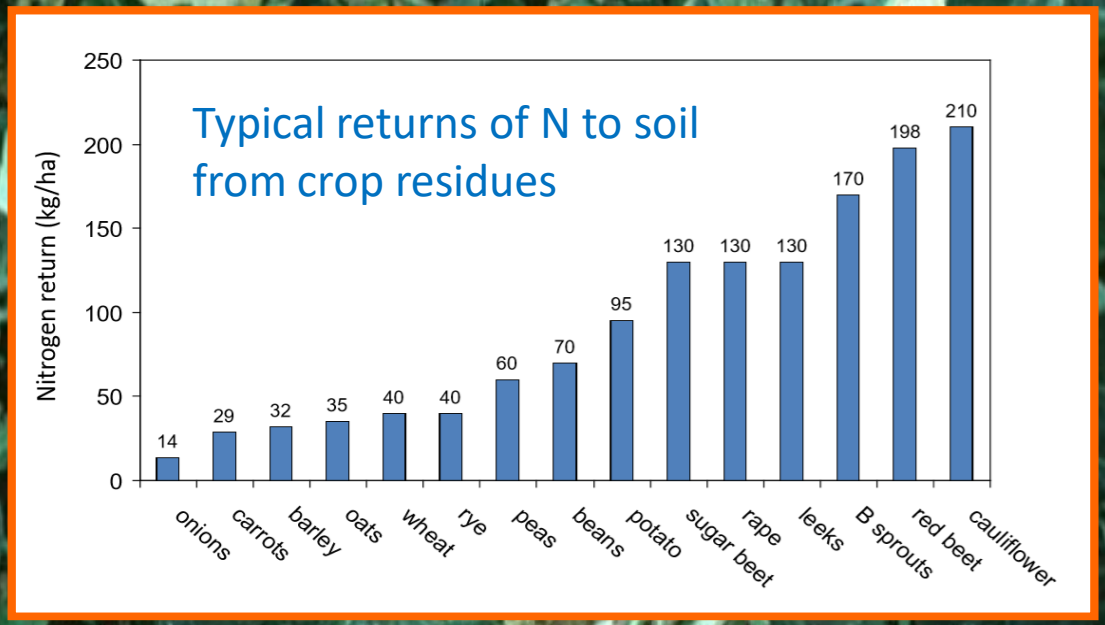
Injection of liquid starter fertilisers into the soil below crop rows

Injection of fertiliser granules into soil beside crop rows

Hugh Rowse and Dave Stone

John Hammond and Mark Meacham

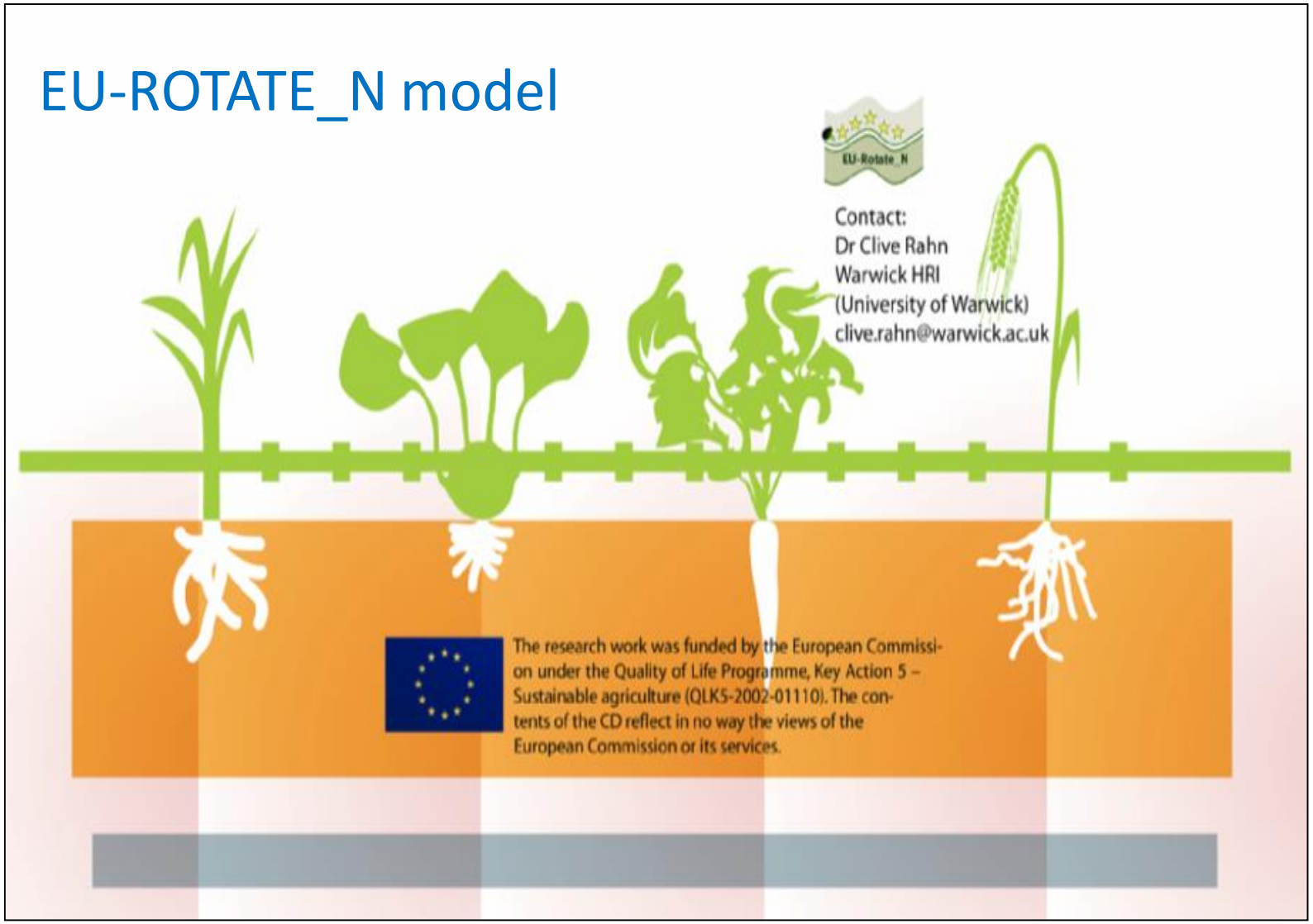
Contribution of crop residues to nutrient supply



Essential data for adjusting fertiliser rates to crops in vegetable rotations

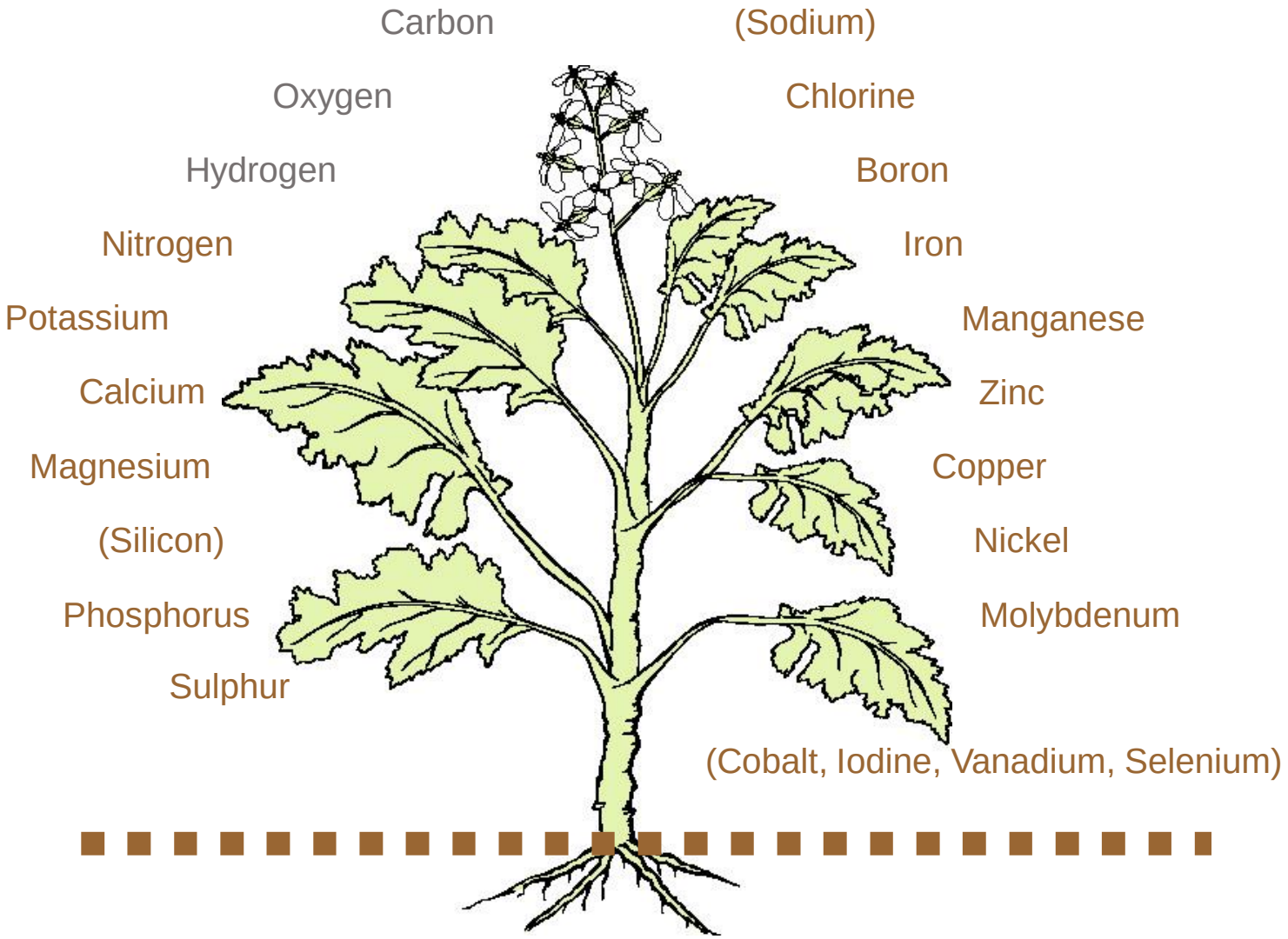
Clive Rahn and Rob Lillywhite

EU-ROTATE_N model



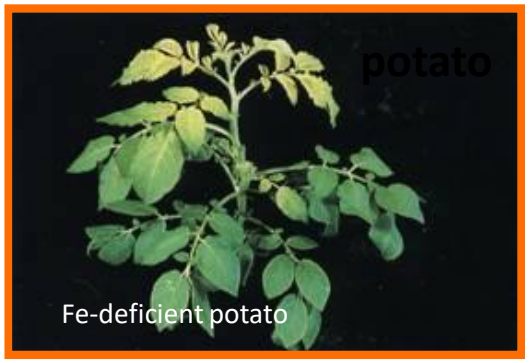
provides N fertiliser advice and assessments of the financial and environmental impacts from whole rotations in both intensive and organic production systems

Crops require many different nutrients



Nutrient deficiency symptoms in crops


Mn-deficient French bean



Fe-deficient potato


P-deficient cauliflower


Ca-deficient Brussels sprouts

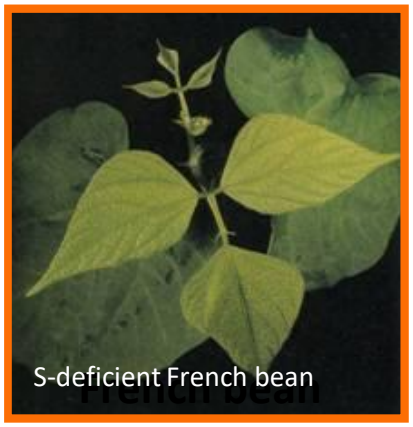

Ca -deficient lettuce


N-deficient cabbage


K-deficient Brussels sprouts


B-deficient cabbage

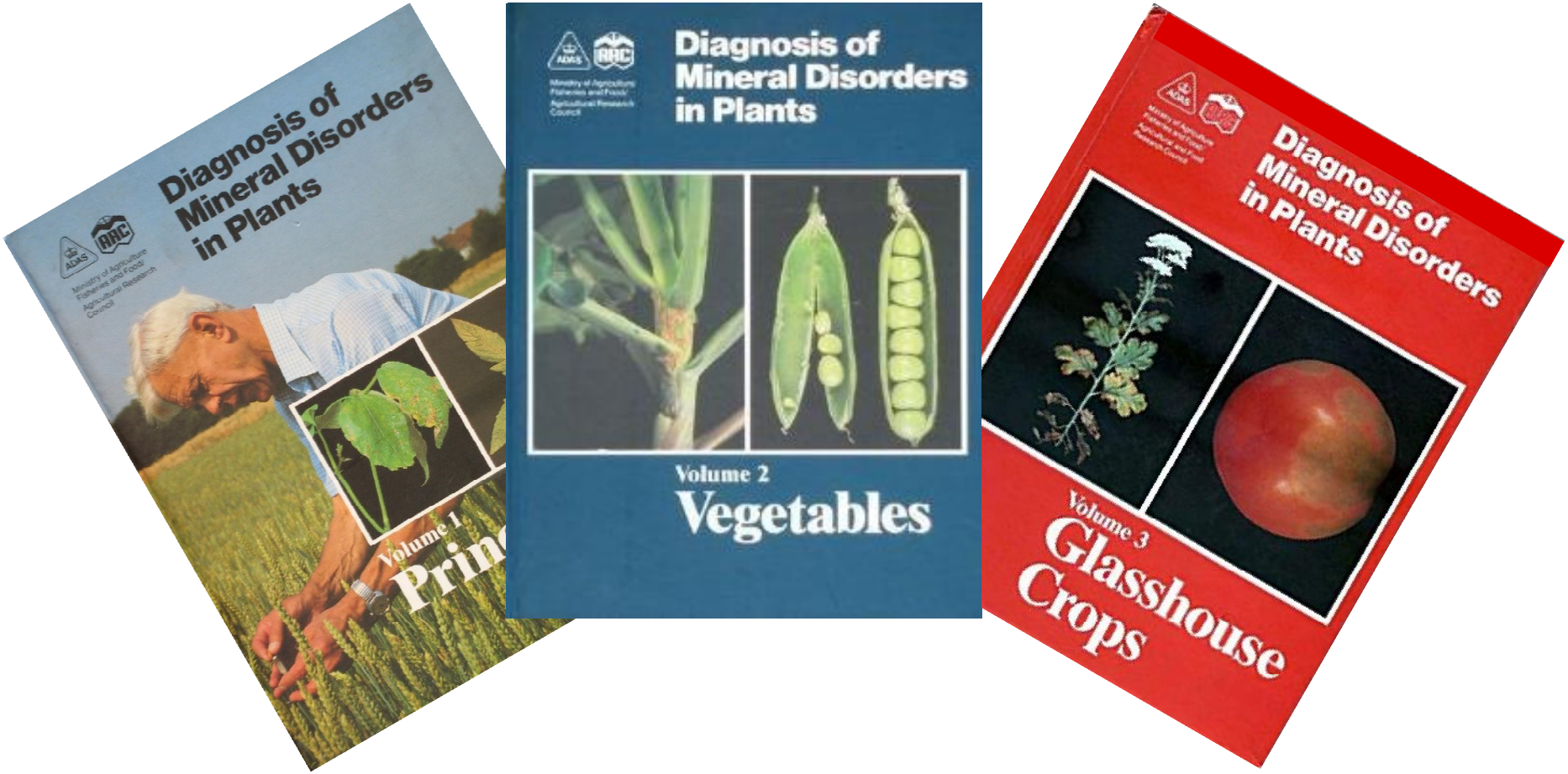

Mo-deficient cauliflower


S-deficient French bean


Ca -deficient celery

Alan Scaife and Mary Turner

Publications on nutrient disorders



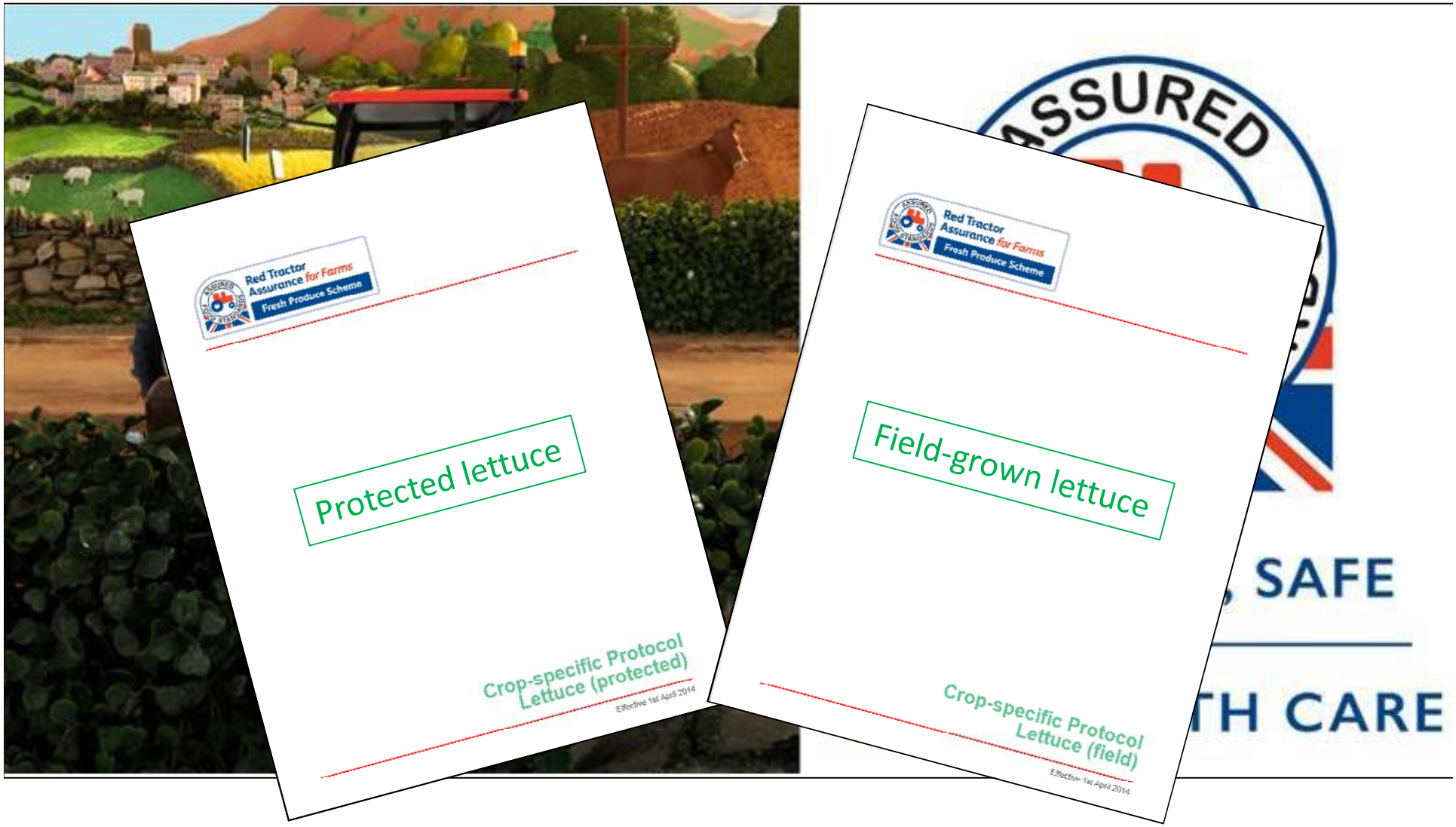
Alan Scaife and Mary Turner

EU Legislation on nitrate accumulation in glasshouse and field-grown lettuce

Ian Burns and Abraham Escobar-Gutierrez

Red Tractor Assurance Scheme

Our research informed the Codes of Practice for Field and Protected Lettuce



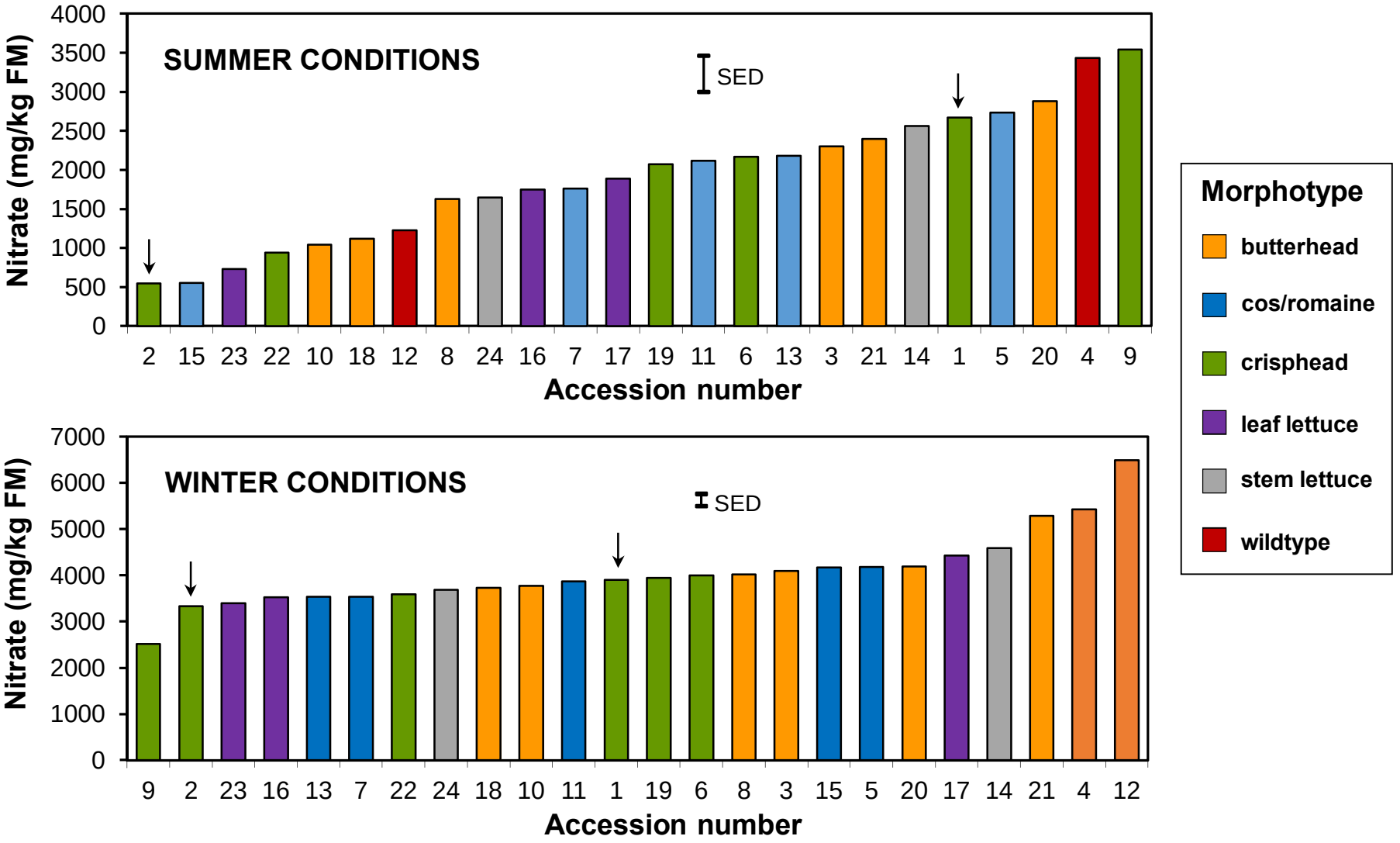
Screening lettuce genotypes for nitrate

Hydroponic - Nutrient Film Technology
N source: nitrate only
for both the RILs and the Diversity Set
under summer and winter conditions

Soil Culture in the field
N source: nitrate and ammonium
for the RILs only
under summer conditions

Ian Burns and Mary Turner, with Dave Pink and Paul Hand

Screening the lettuce diversity set for nitrate



Data for young lettuce from Small Lettuce Diversity Set

Burns et al (2011b)

Variation in ^{137}Cs and ^{90}Sr accumulation in brassica

Up to 70 *Brassica oleracea* cultivars screened in glasshouse and field experiments

There was

- a 35-fold variation in radio-caesium
- a 23-fold variation in radio-stronthium

- 5 cultivars had consistently lower ^{137}Cs concentration
- 3 cultivars had consistently lower ^{90}Sr concentration
- 1 cultivar was consistently lower in both ^{137}Cs and ^{90}Sr concentrations

Martin Broadley, Phil White and Mark Meacham with collaborators in Ukraine

Phosphorus use effciency in *Brassica oleracea*

Glasshouse experimental design:

2 levels of P

3 replicates per DFS line (376 accessions)

9 replicates per F_1 (74 accessions)

Field experimental design:

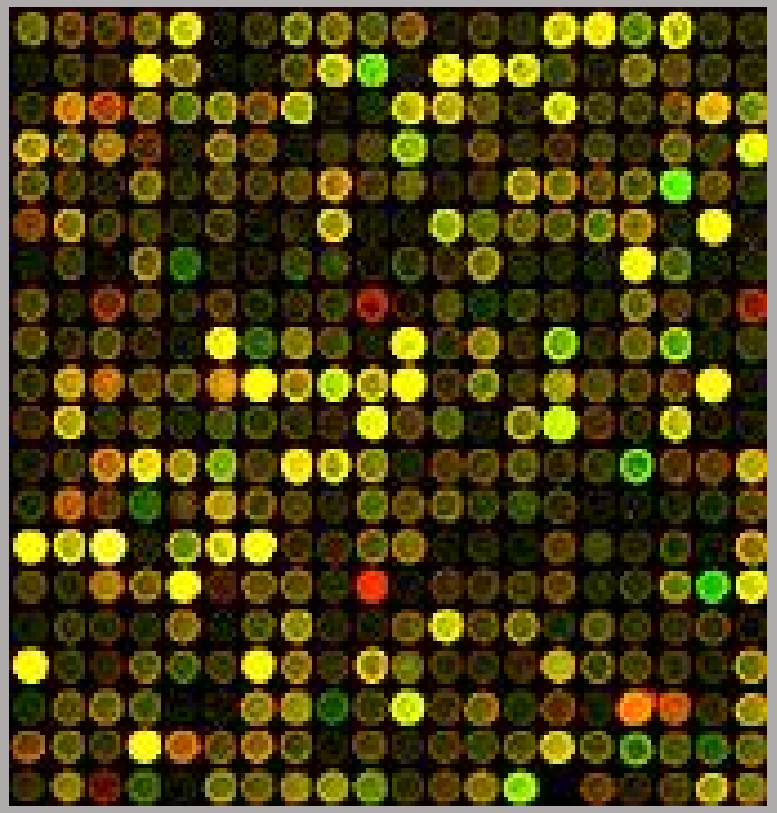
4 levels of P

3 replicates per F_1 (74 accessions)

Phil White, John Hammond and Martin Broadley

Engineering a smart plant for P nutrition

DNA microarray
to identify P-sensitive genes



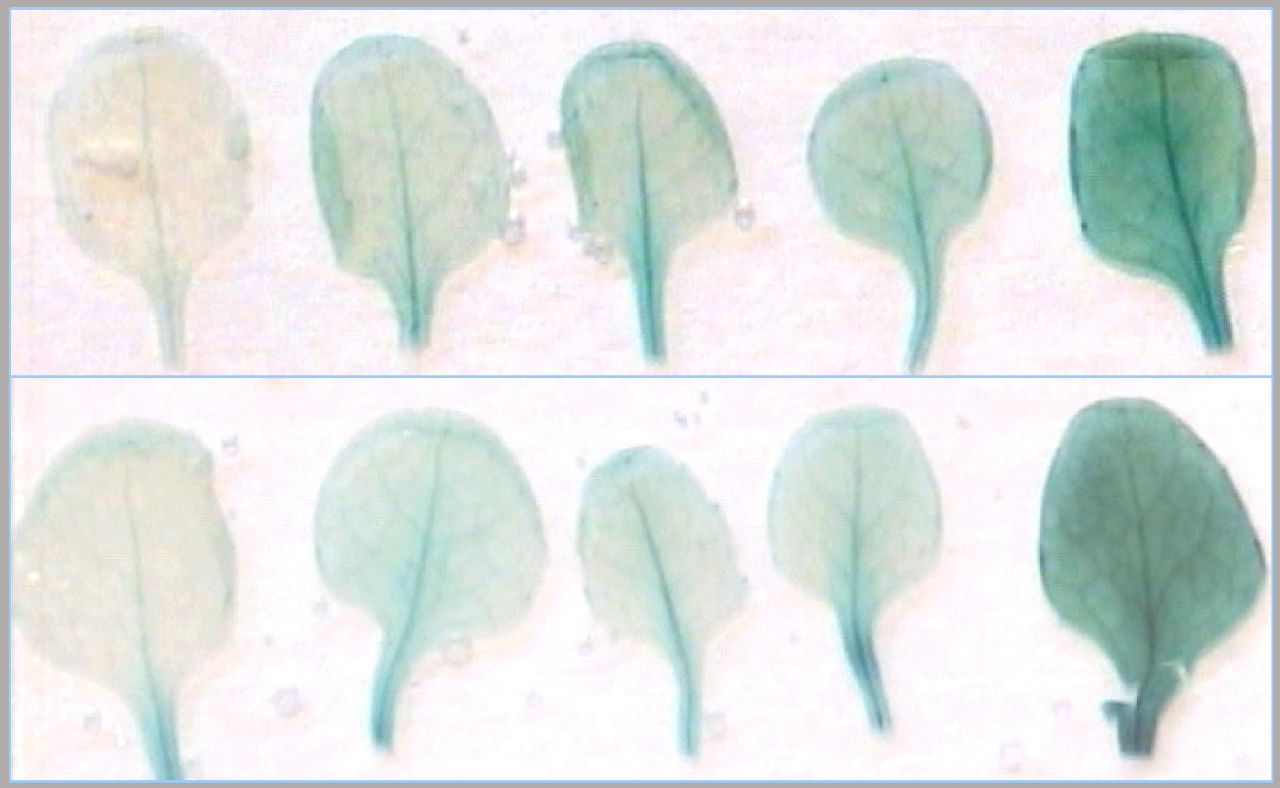
Expression of SQD1
increases in shoots
of P-deficient plants

Phil White, John Hammond and Martin Broadley

GUS expression in smart arabidopsis

GUS 22 / 1

GUS 13 / 4



-20 4 28 100 220

Time (hours) after phosphate withdrawal

Phil White, John Hammond and Martin Broadley

Summary of Agronomic and Environmental Achievements

- Developed the first inorganic NPK recommendations for vegetable crops
- Devised dynamic models of processes controlling crop response to NPK fertilisers and their impact on the environment for improving fertiliser practice and advising policy makers on environmentally benign strategies
- Created the first computer-based Decision Support system giving site-specific N fertiliser advice for vegetable crops directly to growers
- Developed techniques and advice for improving fertiliser use efficiency
- Devised protocols and identified cultivars for producing 'safe' crops under adverse climatic and soil conditions
- Produced guides for identifying nutrient disorders in vegetable crops
- Identified sources of genetic control of nitrate accumulation in lettuce and P deficiency in Brassica

In future our preliminary research on developing functional foods byimproving the micronutrient content of crops (work that I have not had time to describe here) should be continued with the aim of helping to meet human dietary requirements

Key Contributors to Soil and Plant Nutrition Research

Chris Bell
Gary Bending
Helen Bowen
Martin Broadley
Ian Burns
Trevor Cleaver
Carol Coleman
Ann Draycott
Simon Elliott
Abraham Escobar-Gutierrez
Tony Gerwitz
David Goodman
Duncan Greenwood
John Hammond
Fred Haworth
John Hunt
David Jones
Andy Jukes
Rob Lillywhite
Mike McKee
Mark Meacham
Barry Mulholland
Kim Niendorf
Ron Page
Clive Rahn
Hugh Rowse
Alan Scaife
Dave Stone
Mary Turner
Phil White
Kefeng Zhang

WARWICK
THE UNIVERSITY OF WARWICK