east malling research

Improving systems of crop production: biology, agronomy and engineering

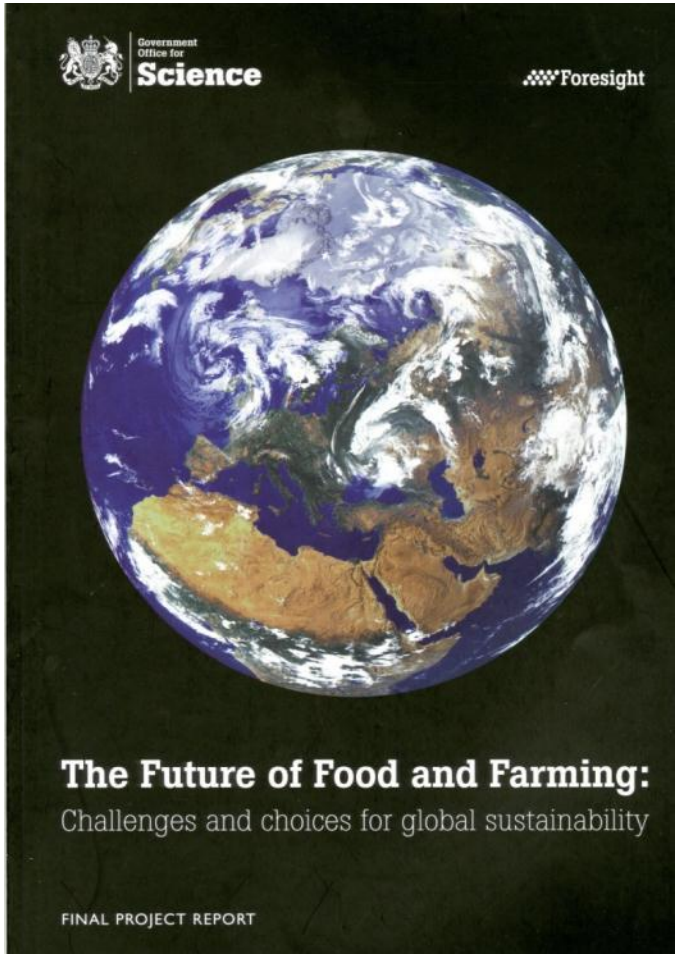
Cranfield Univ 21 May 2014

Professor Peter J. Gregory

University of Reading

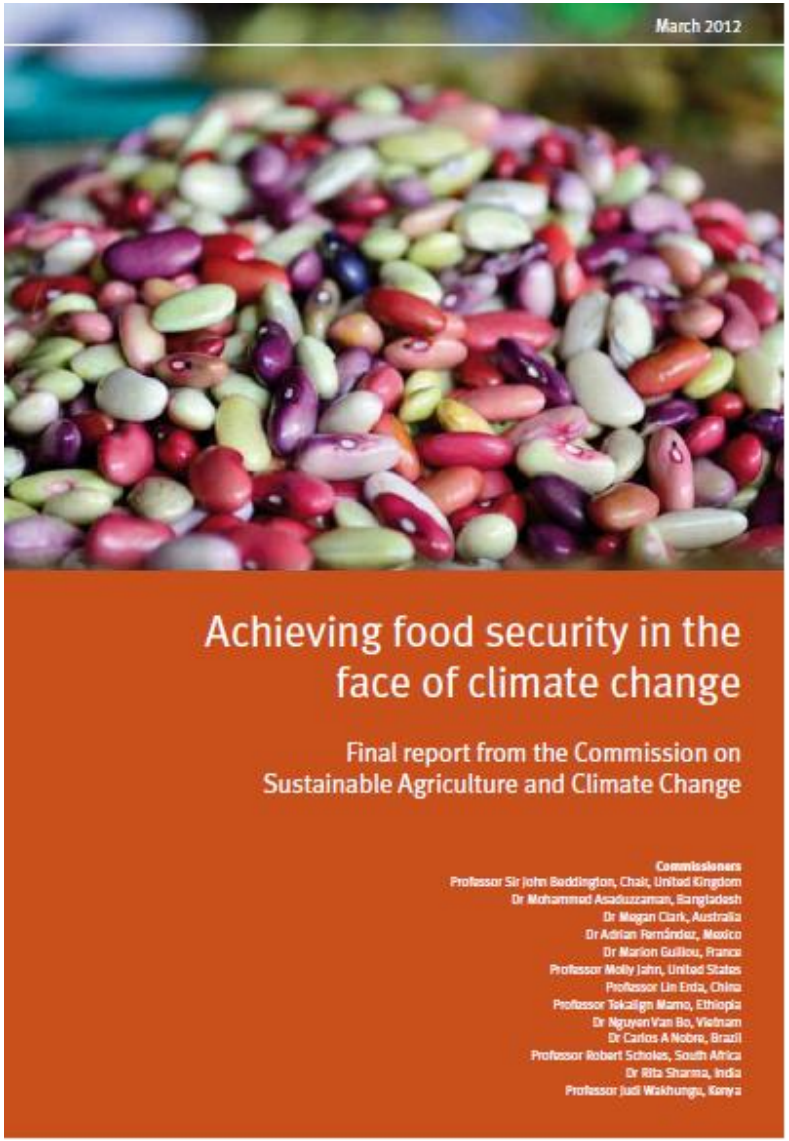
emr

The present – UK focus on food and farming





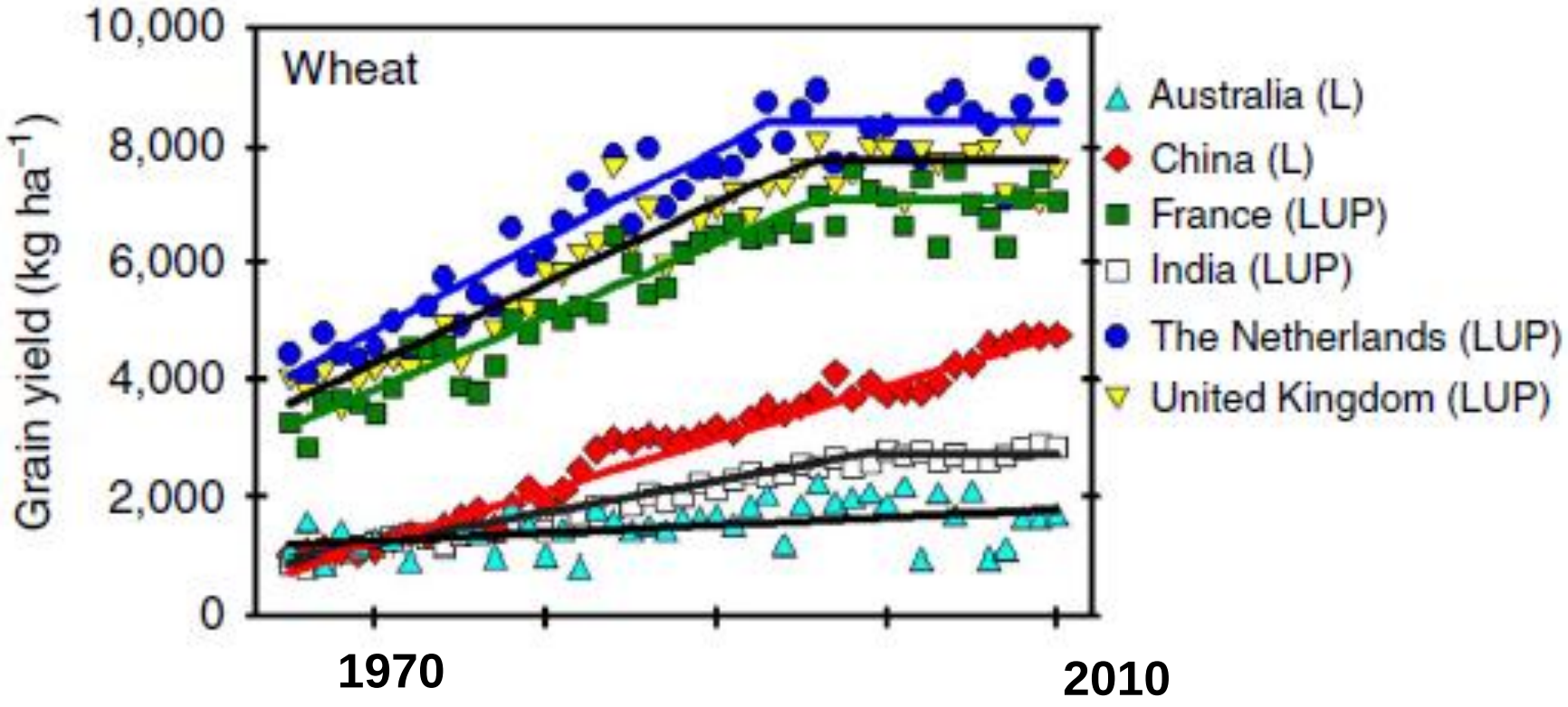
Achieving Food Security in the Face of Climate Change (2012)



Outline of talk

- Factors controlling crop yield
- Managing architecture – shoots and roots
- Engineering the environment
- Concluding remarks

Trends in wheat yields (Grassini et al., 2013)



Conceptual framework for crop research

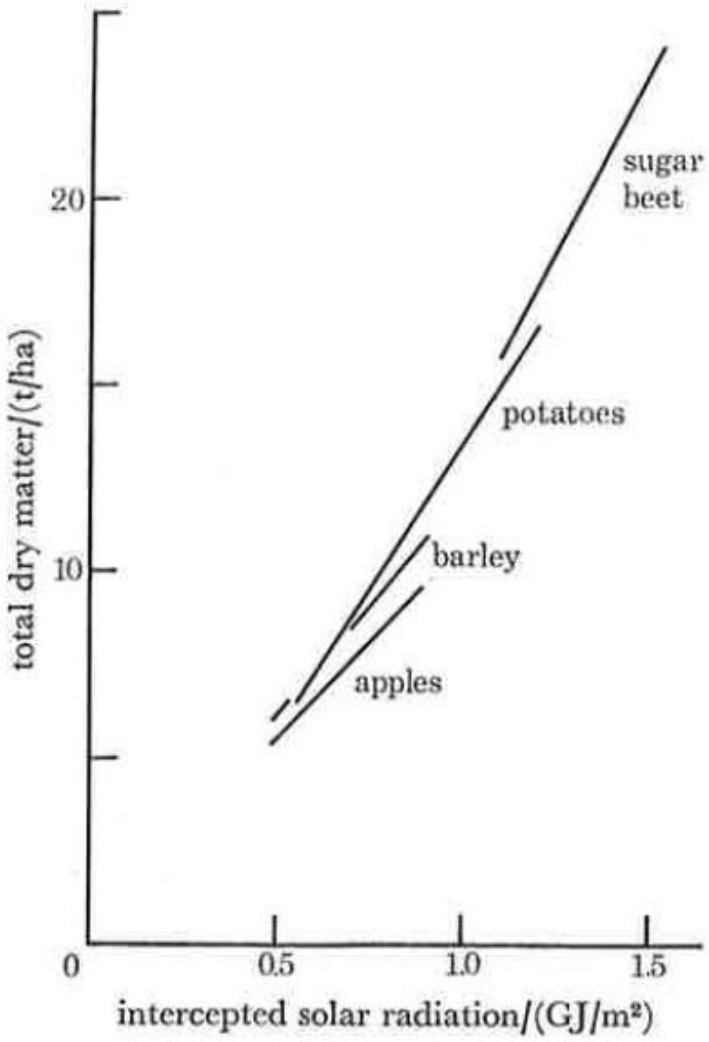
- Production f Genotype x Environment x Management

GEM

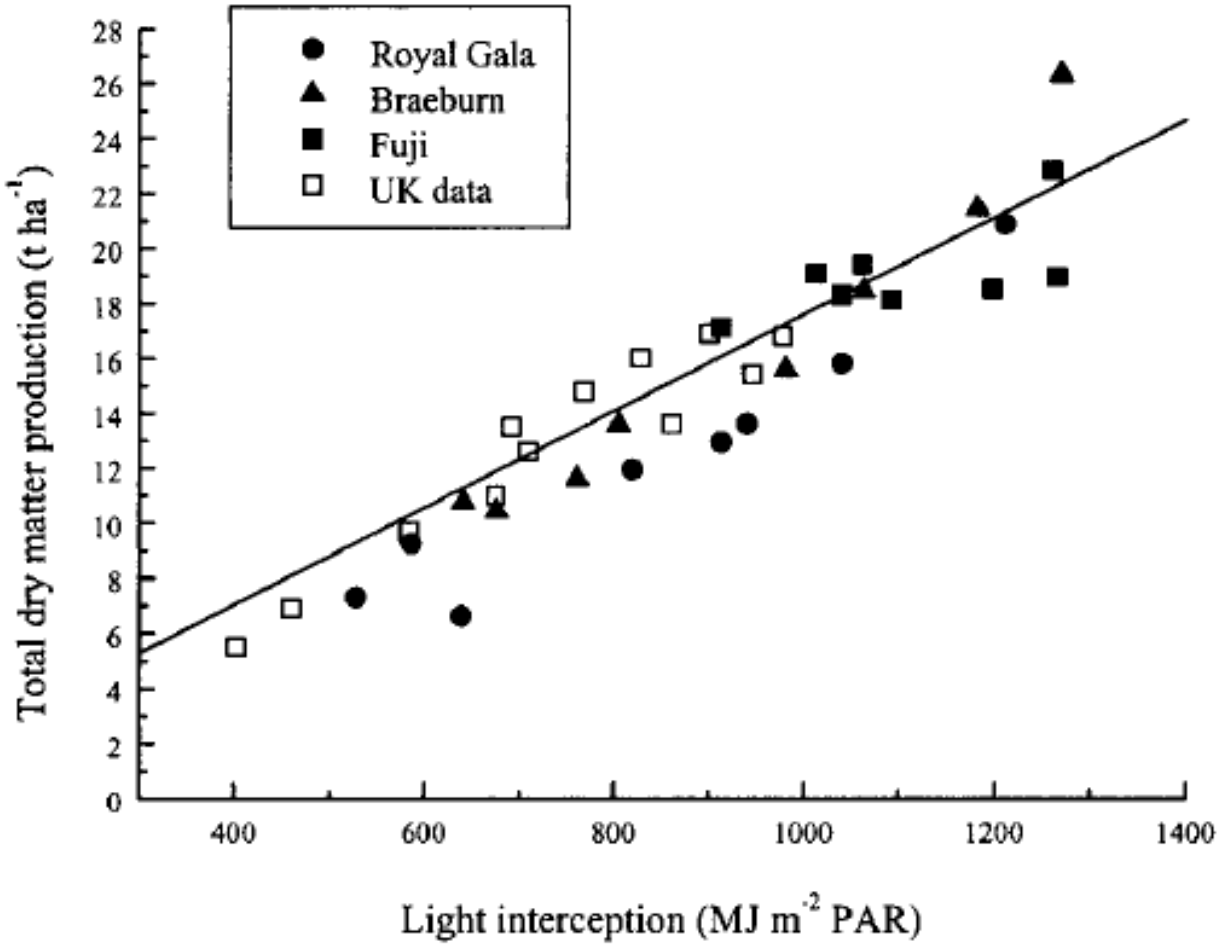
Conceptual frameworks for improving production

- Dry matter per unit area = *f* incoming radiation per unit area x fraction of incoming radiation intercepted x conversion efficiency of radiation to dry matter (integrated over time - Potential Production)
- Harvestable yield = dry matter per unit area x harvest index (x fraction of marketable fruit)

Dry matter production v intercepted radiation (Monteith, 1977) – 1.4 g/MJ

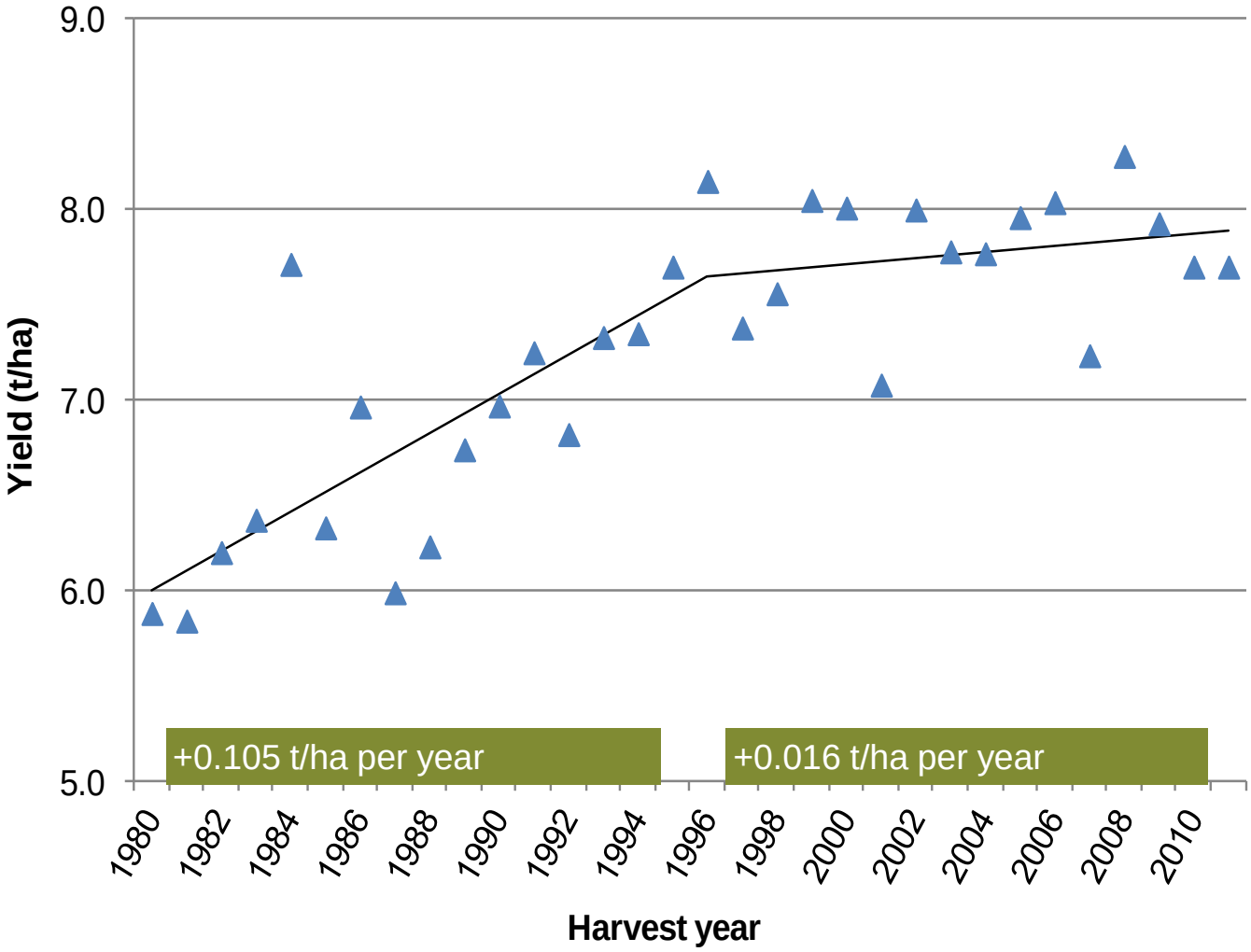


Dry matter production in UK and New Zealand (Palmer, 2002)



Braeburn and Fuji both allocated 70% of seasonal dry matter to fruit; at 90% light interception. In NZ, apple yields of about 160 t/ha would be obtained; 110 t/ha in UK

UK wheat yields 1980 - 2011

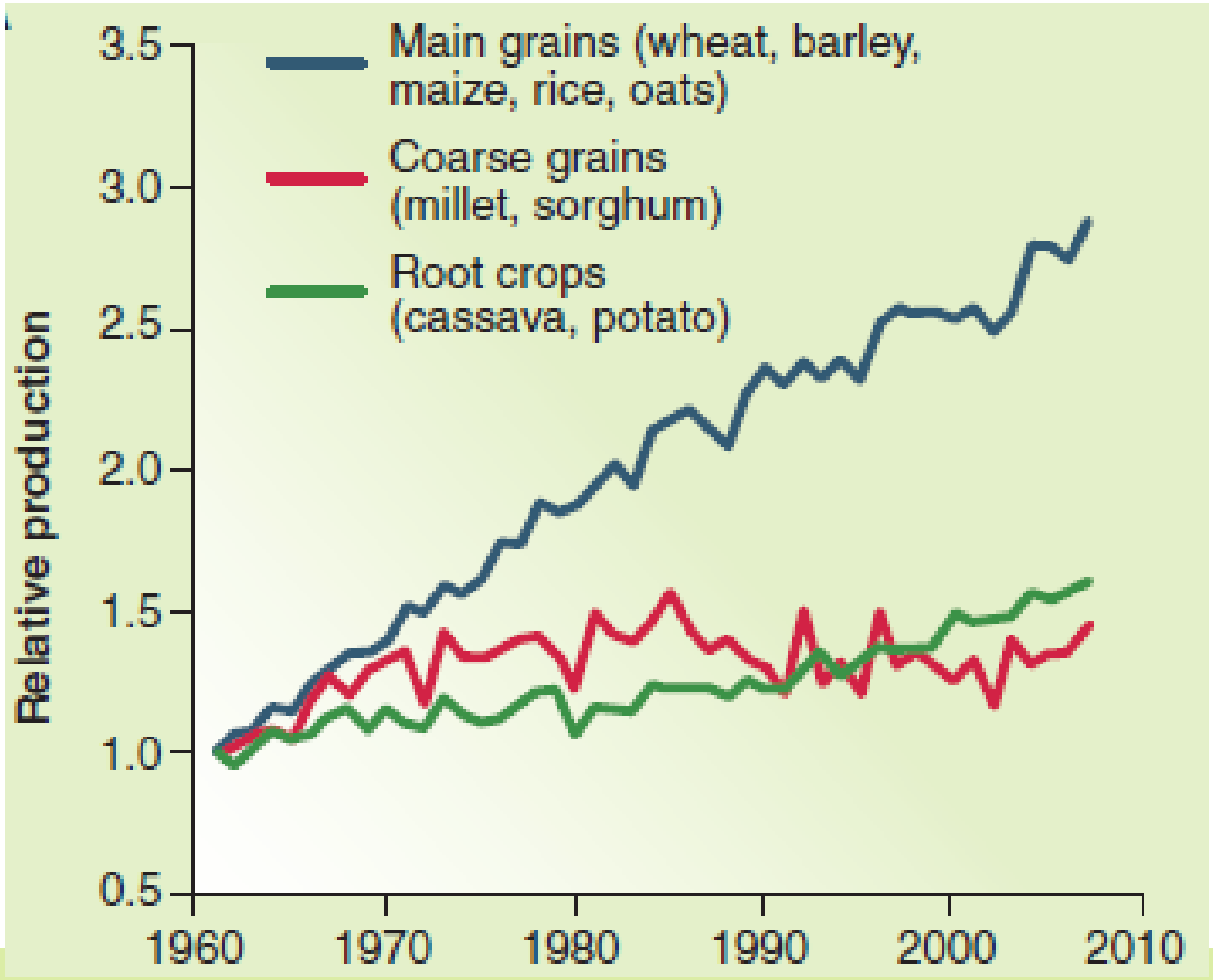


Source: Cereal Production Surveys (Defra)

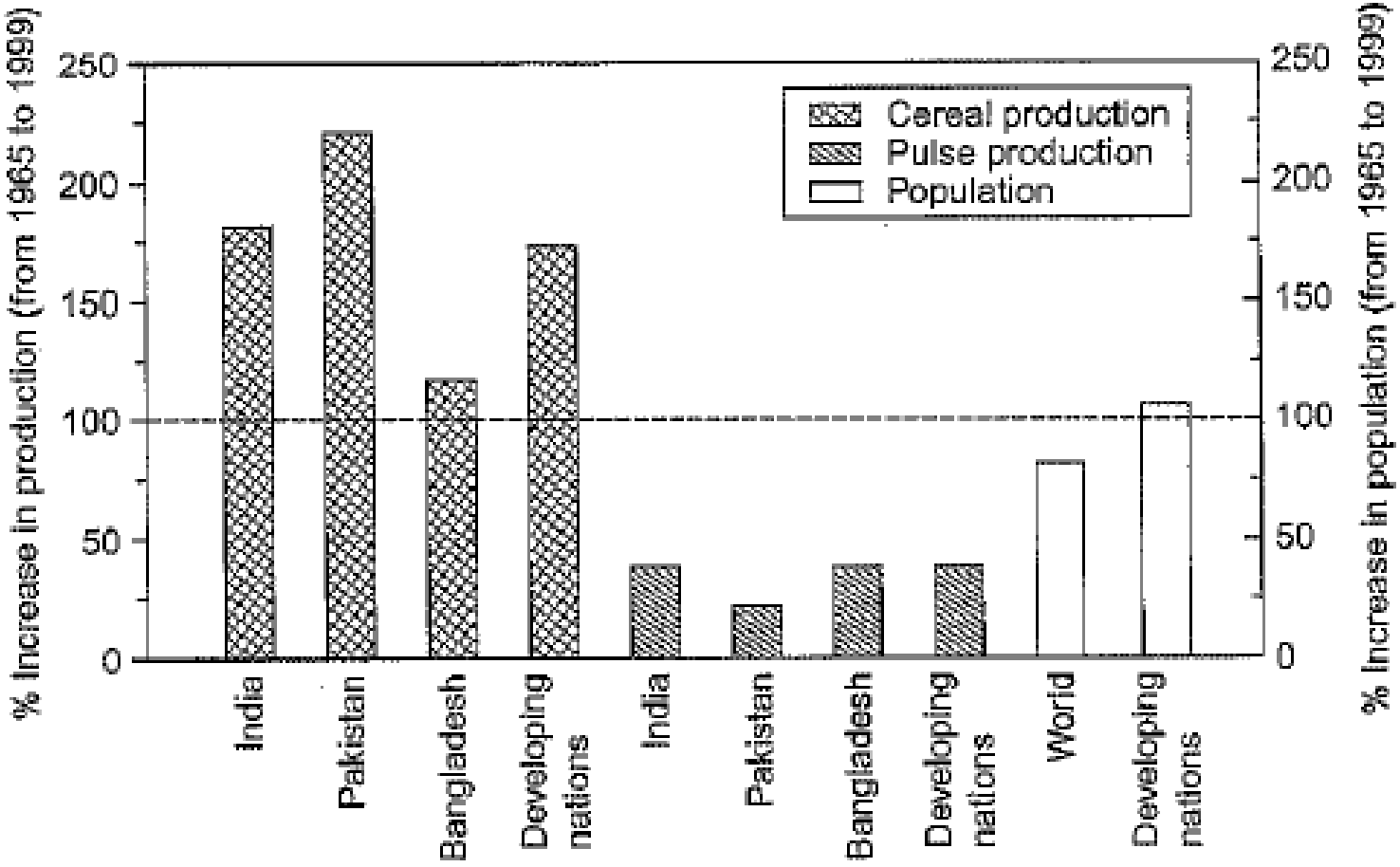
Some consequences of focussing on converting radiation to food

- Increased yields
- Focus on cereals relative to other crops
- Less diverse diets
- Poorer nutrition
- Focus on arable crops – dimunition of perennial and mixed crop systems

Changes in the relative global production of crops since 1961 (from Godfray et al. 2010)



Relative changes in cereal and pulse production (Graham et al., 2012)



Global mineral deficiencies (% of population)

Mineral	% population
Iron	60
Zinc	30
Iodine	30
Selenium	15

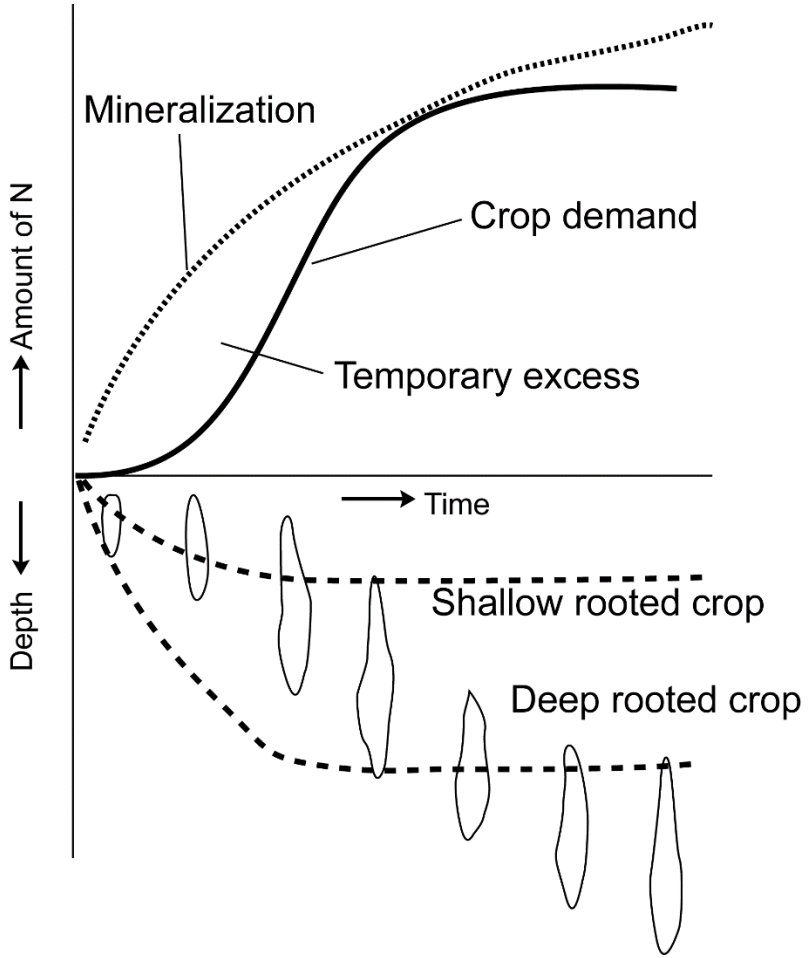
Managing architecture



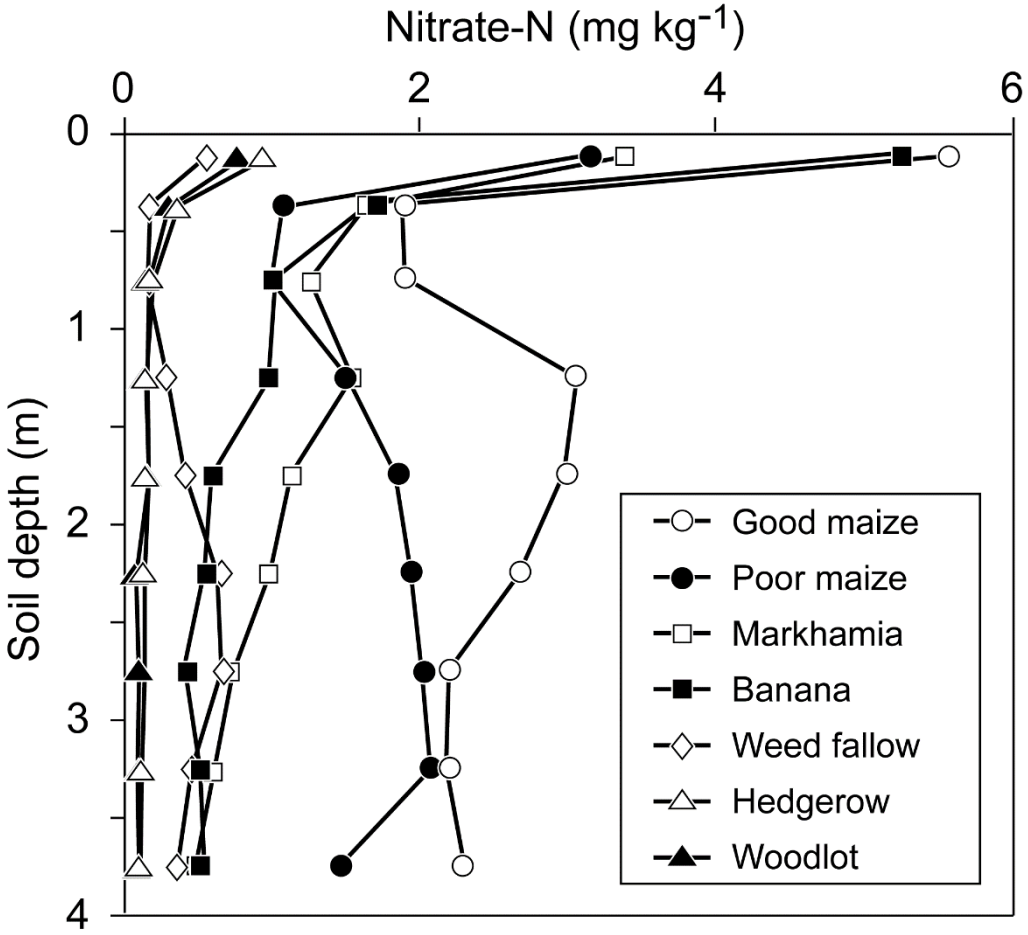
Typical mixed cropping in central Kenya



The synchrony hypothesis – mixing shallow and deep rooting species



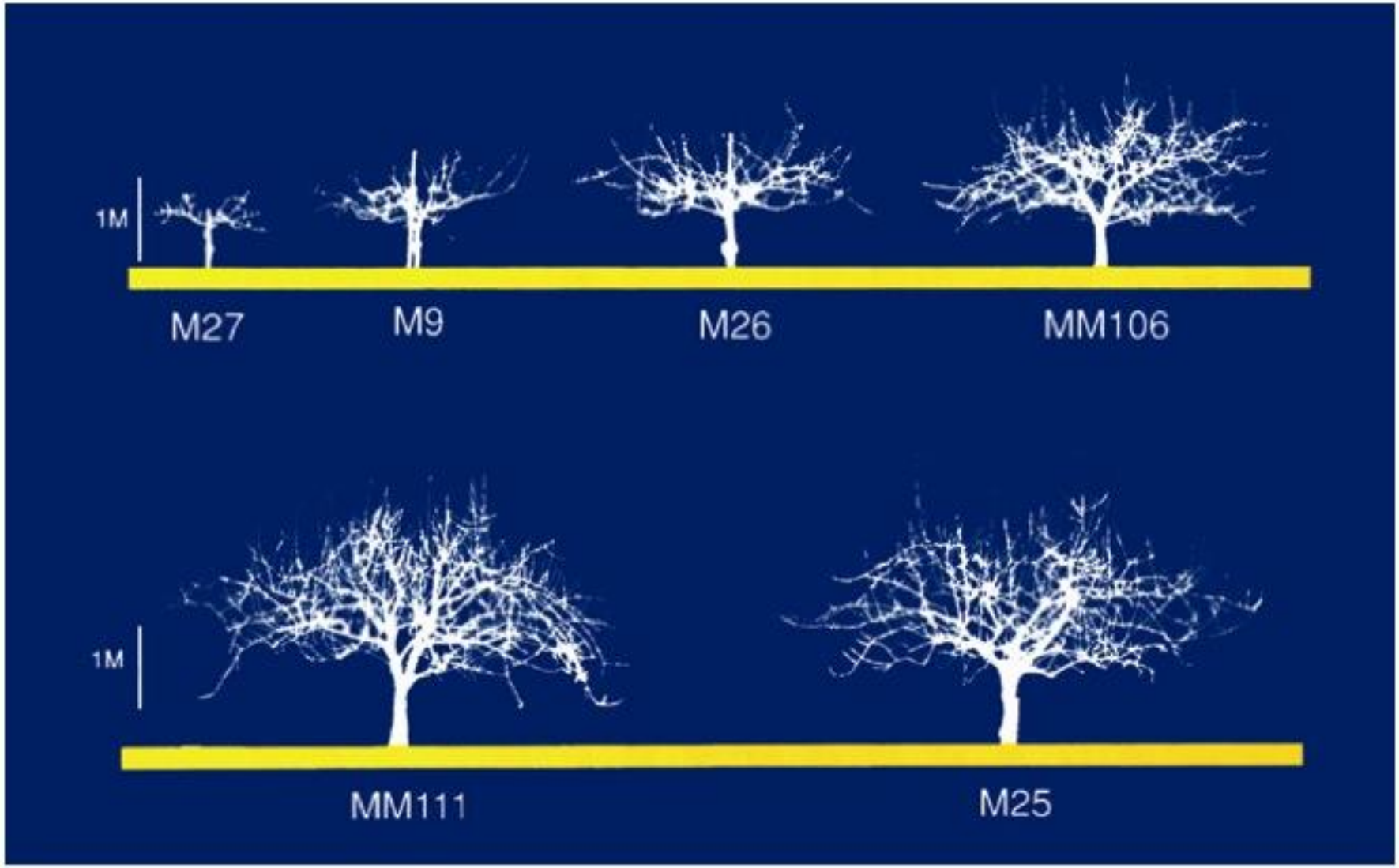
Nitrate concentrations at the time of maize harvesting under seven different vegetation types on smallholder farms in western Kenya (Shepherd et al., 2000)



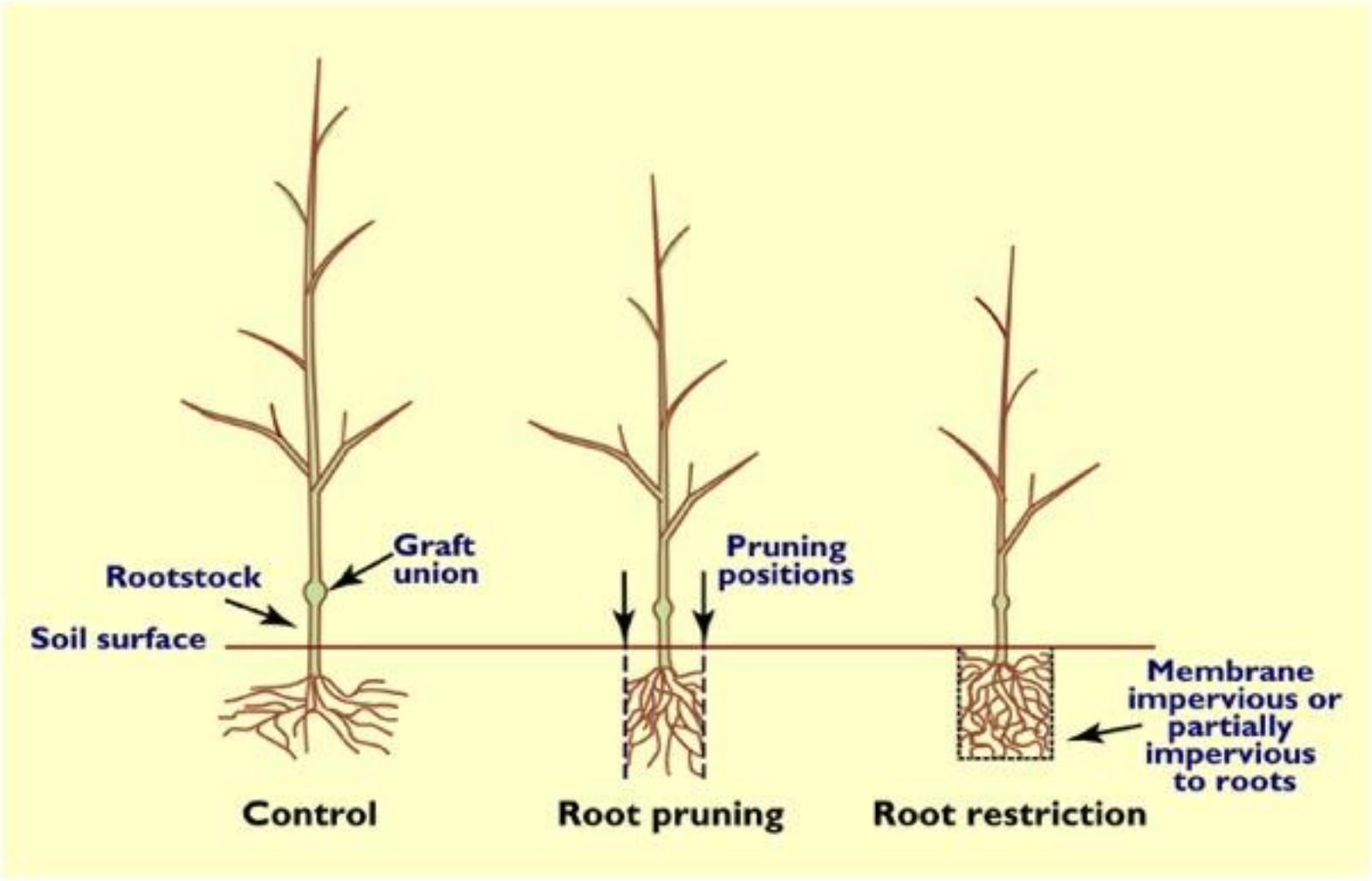
Research on Growing Systems is essential



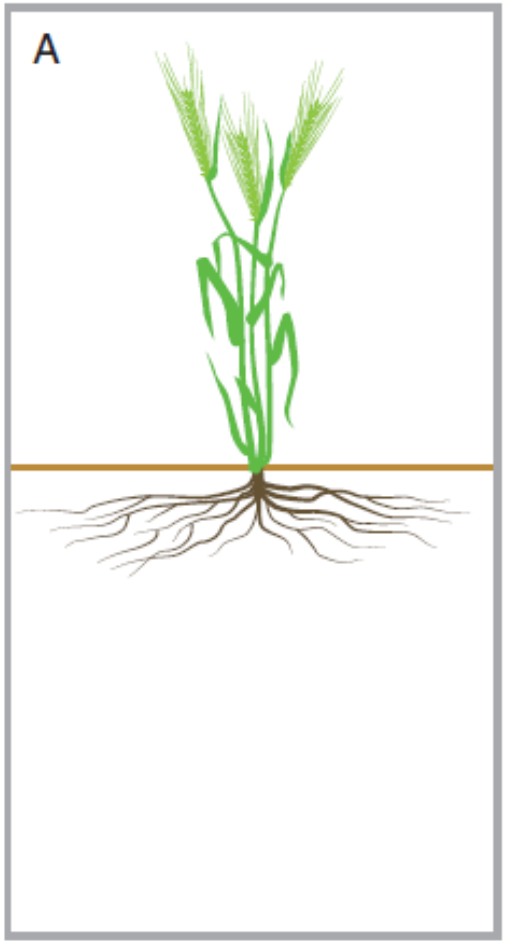
Scion size control in apple



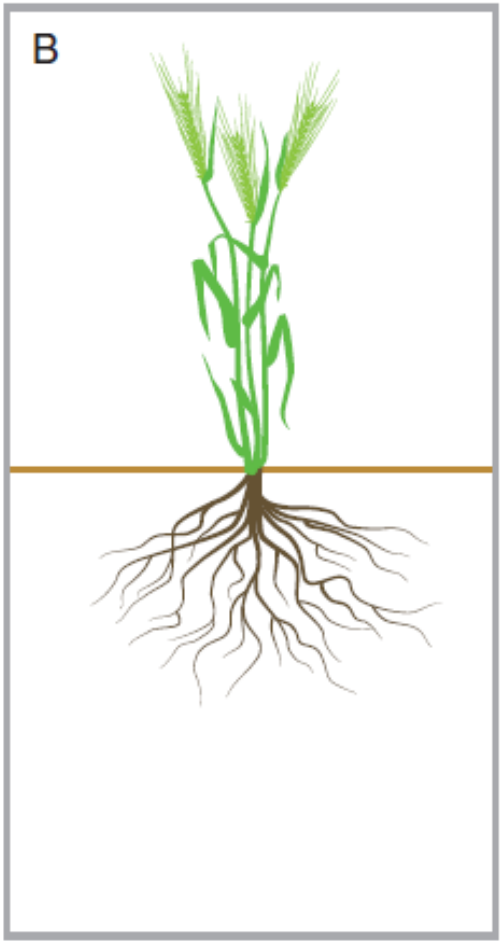
Managing tree size



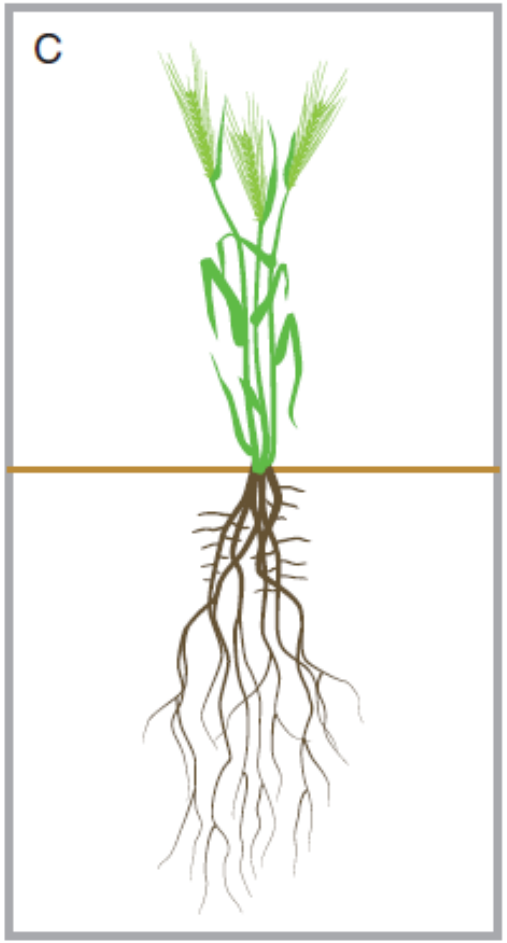
Adapting root architecture



Topsoil foraging for P

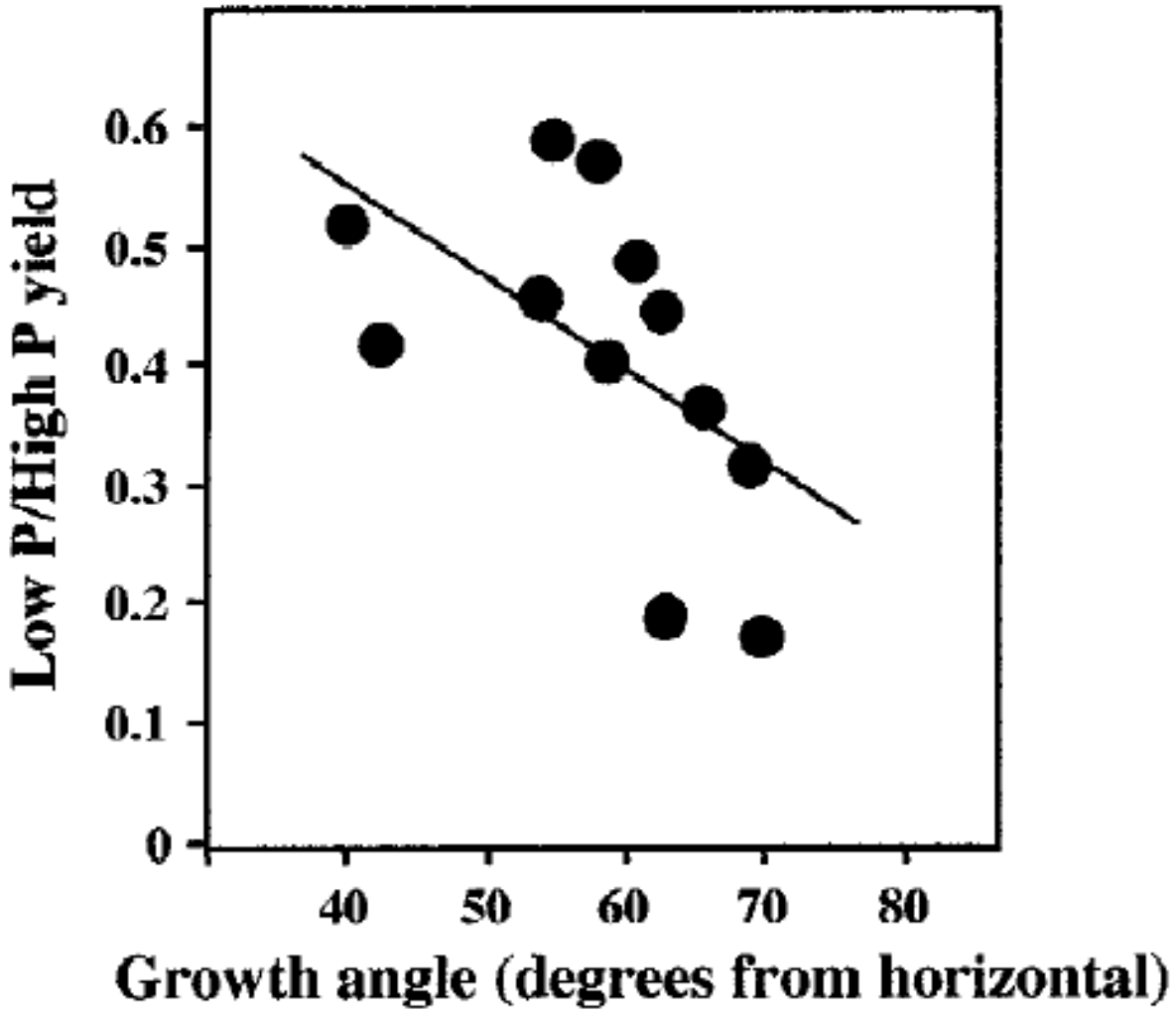


Intermediate response for K

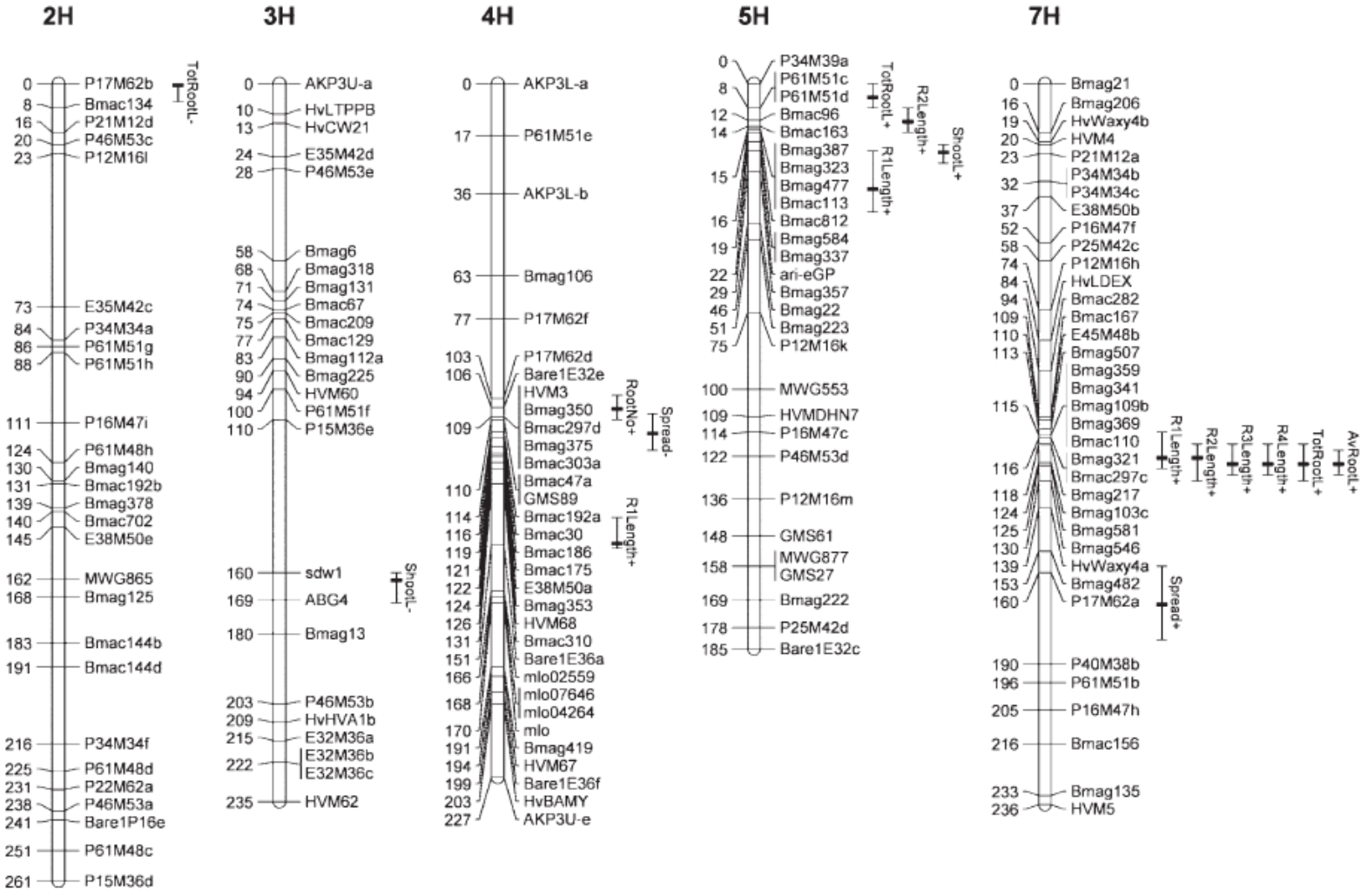


Steep, cheap and deep for N

Relative yield and root growth angle of common bean (from Lynch & Brown, 2001)

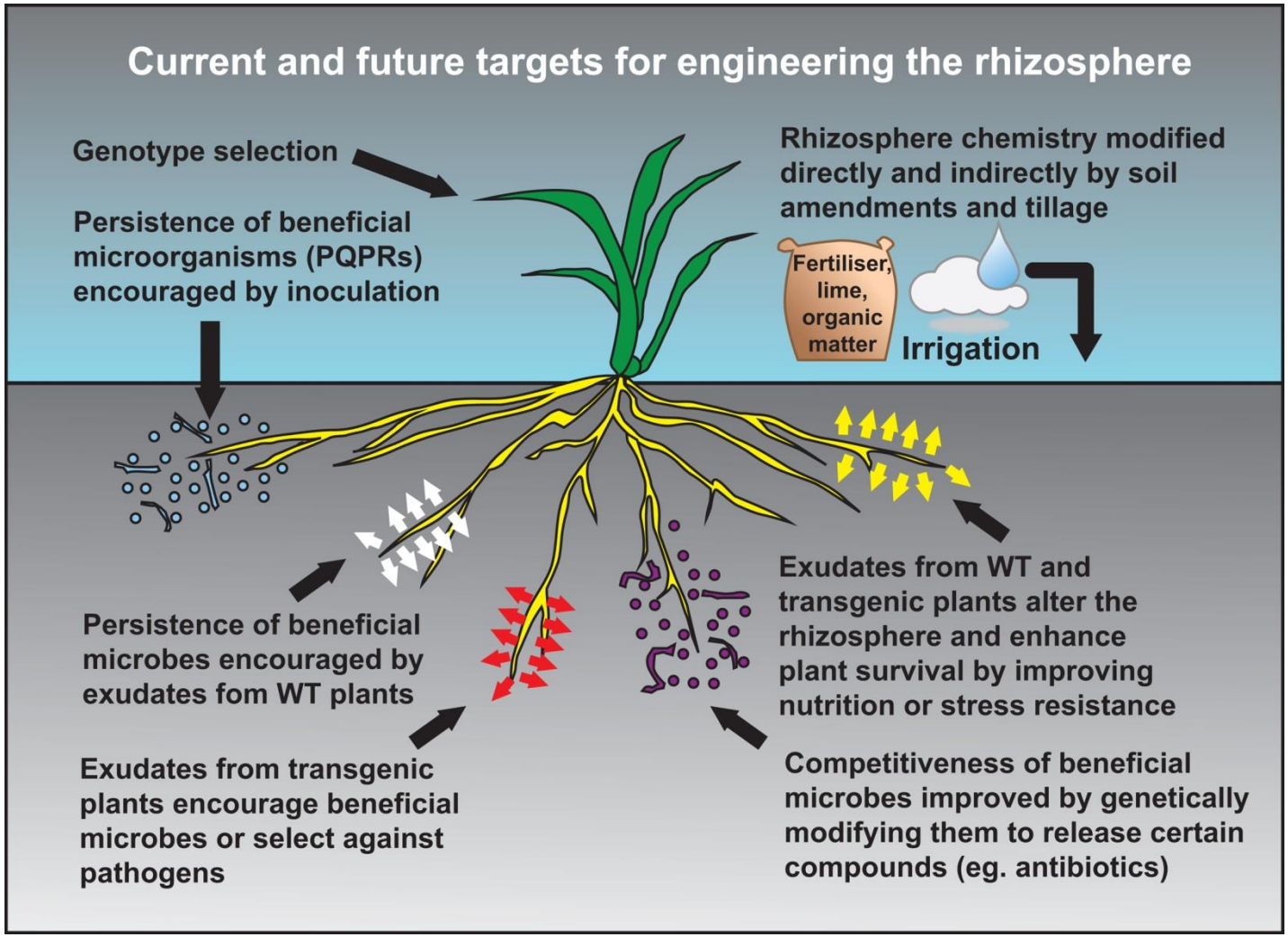


QTL for barley root properties (from Gregory et al., 2009)



Engineering the environment

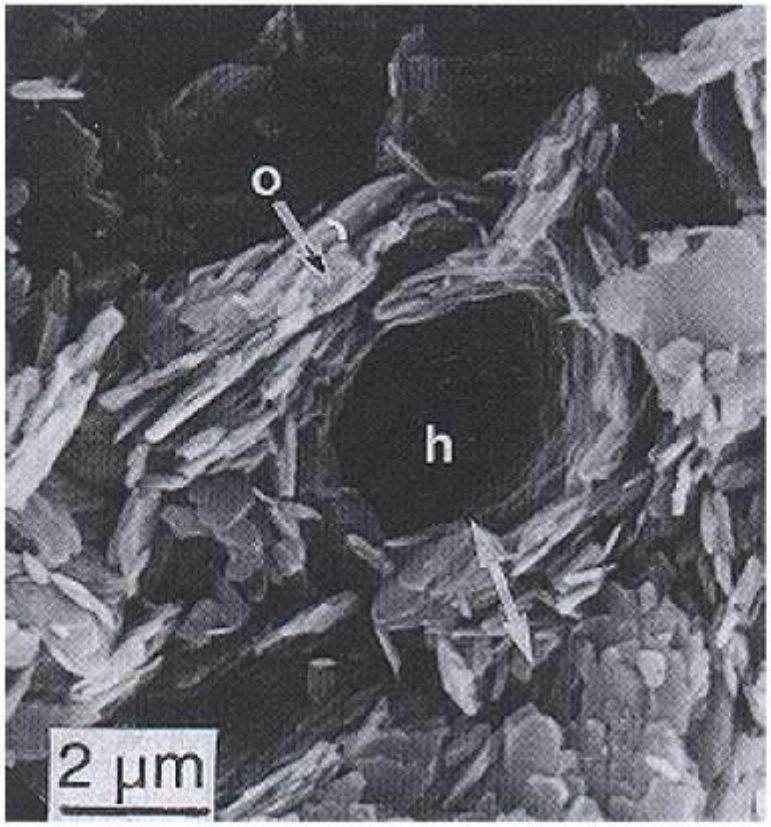
Rhizosphere engineering (from Ryan et al., 2009)

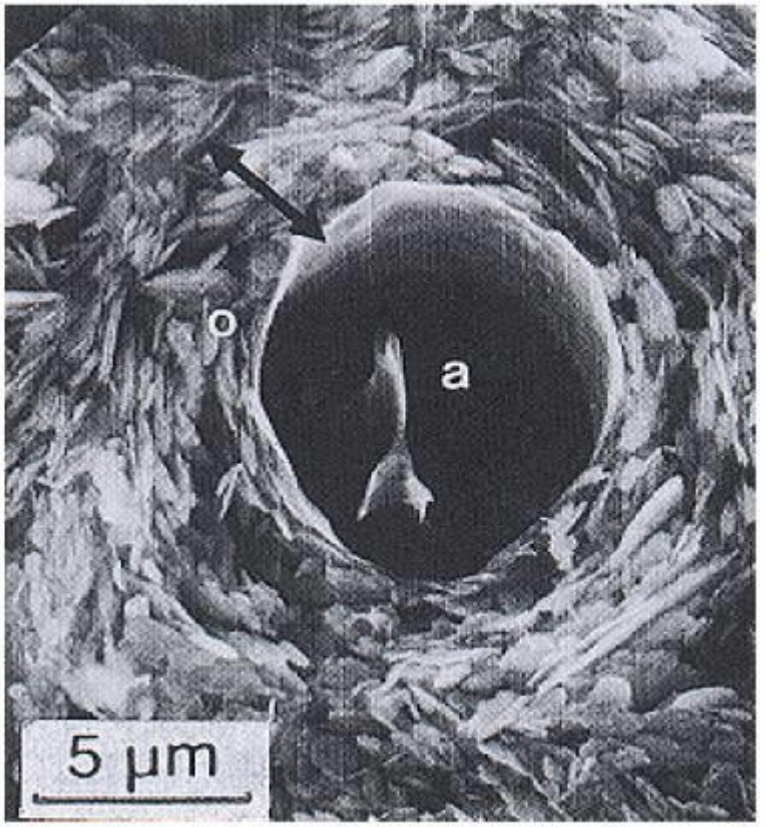


Particle re-orrientation by roots and fungi

Fungal hyphae

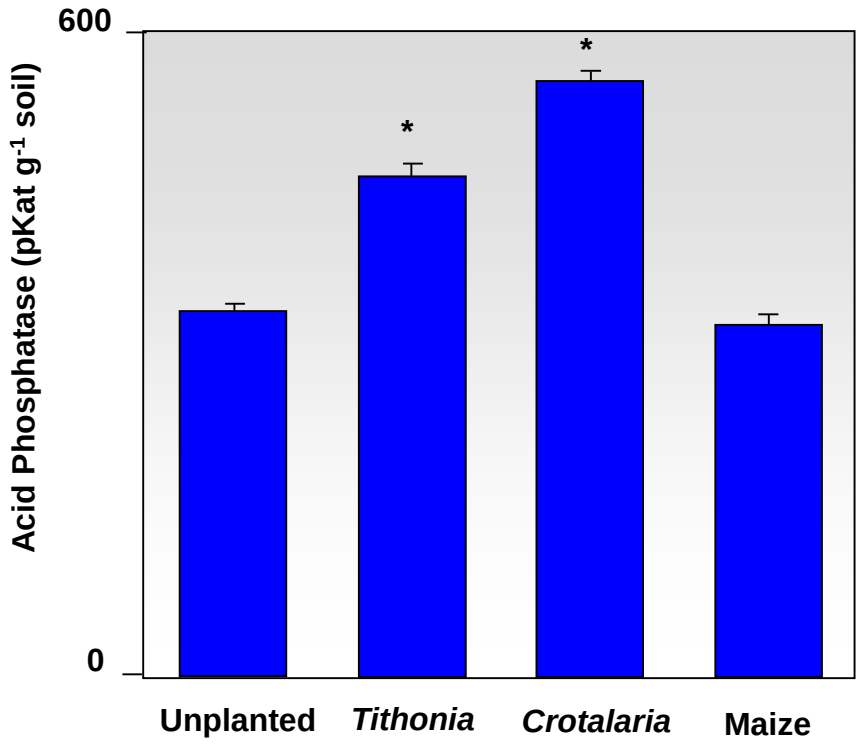
Plant root

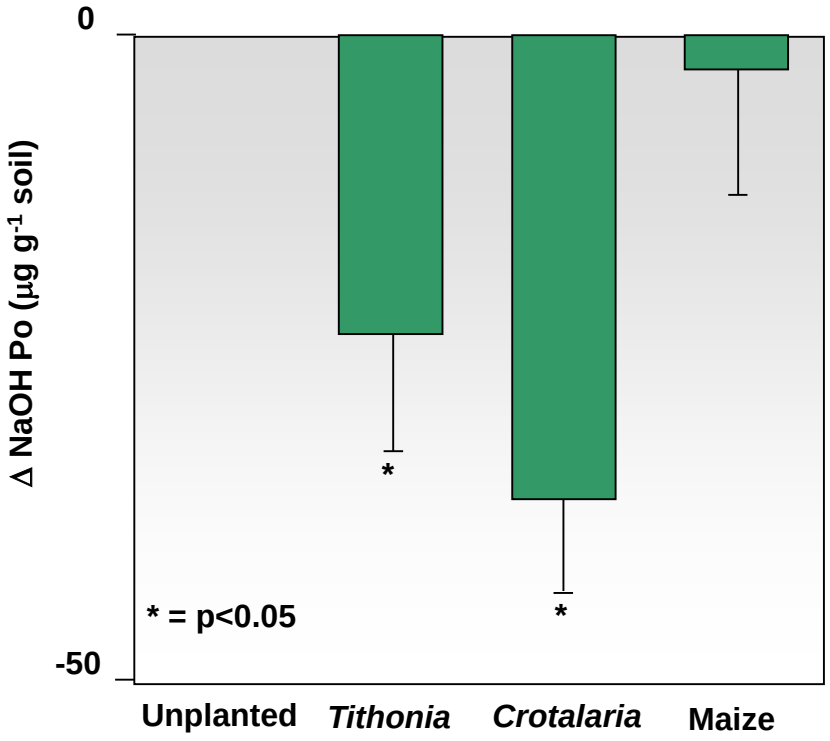




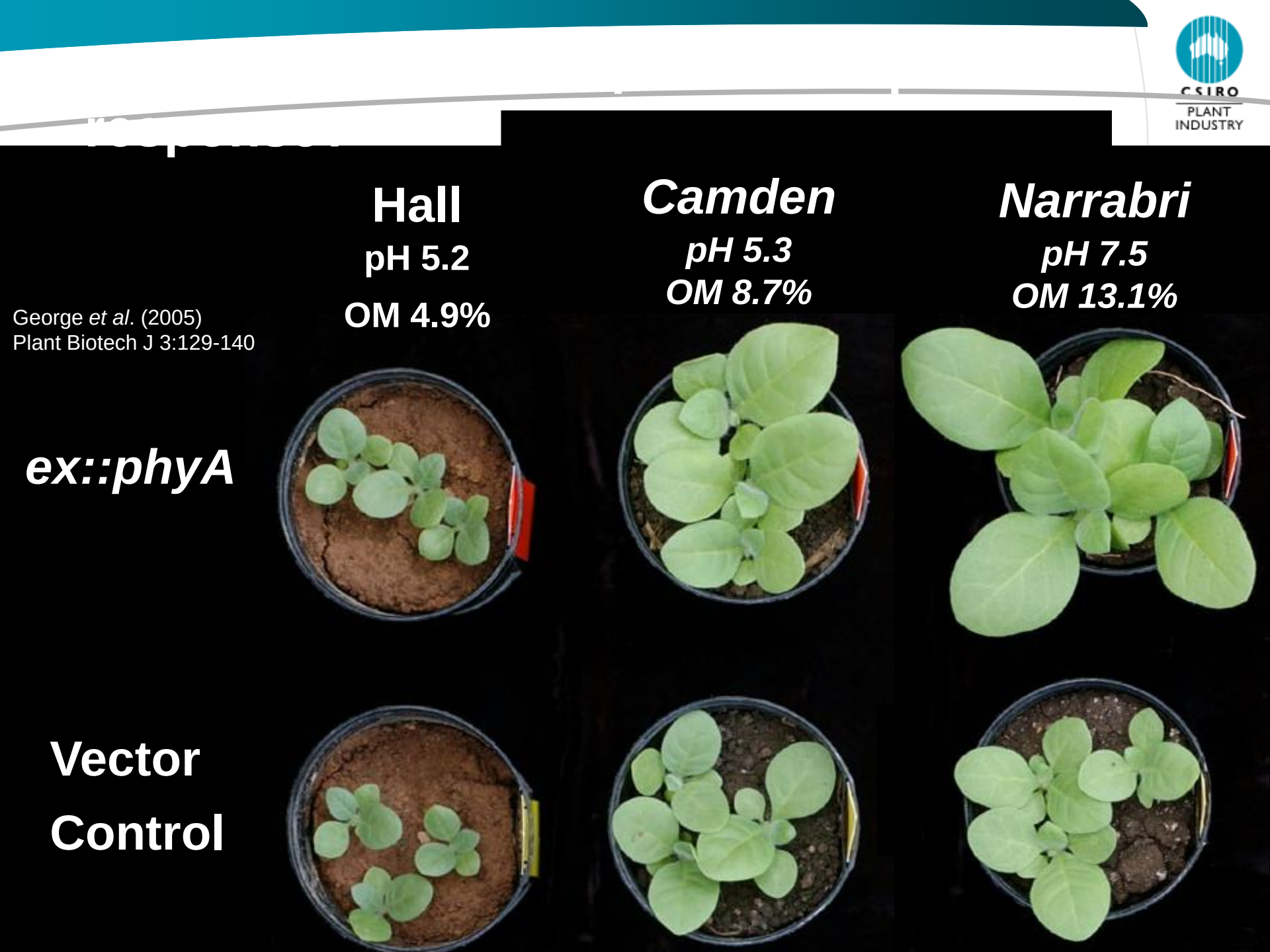
Dorioz et al. 1993

Enhanced rhizosphere phosphatase is related to depletion of P from within 2mm of roots



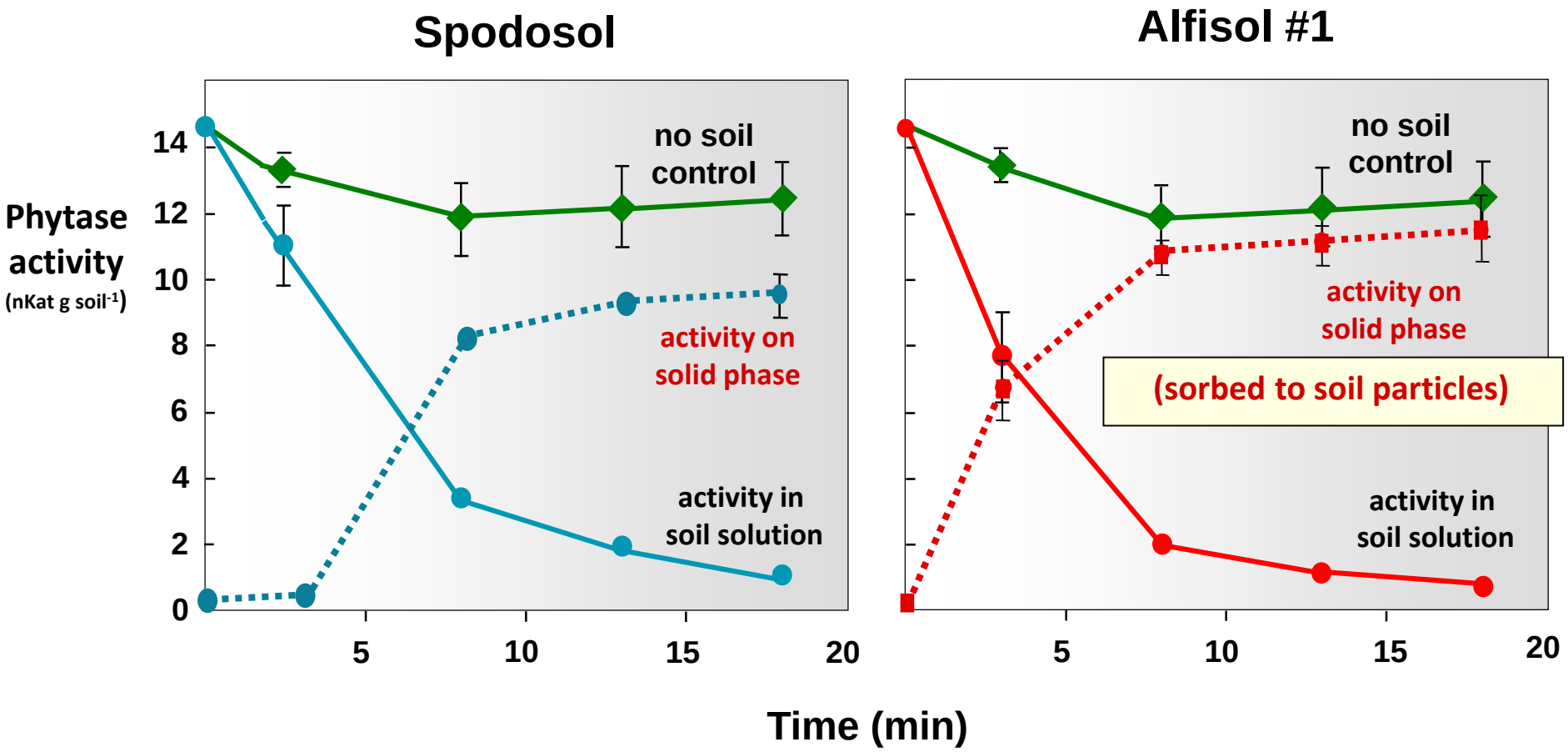


George *et al*., (2006) *Euro J Soil Sci 57:47-57*


Hall
pH 5.2
OM 4.9%
Camden
pH 5.3
OM 8.7%
Narrabri
pH 7.5
OM 13.1%
George et al. (2005)
Plant Biotech J 3:129-140
ex::phyA
Vector
Control

Phytase is rapidly adsorbed to soil solid surfaces

- addition of root-exuded phytase from transgenic plants



George *et al*., (2005) *Soil Biol Biochem 37:977-988*

Raspberries in polytunnels and coir



Raspberries in coir



Strawberries on tabletops in plastic tunnels





Cherries in tunnels



Hail nets



Investment in controlled nutrition systems



Concluding remarks

- Food security is a political concern internationally and in UK
- New approaches to increasing crop yield are required
- Greater focus on nutritional aspects of food security and human health is required
- Integrating the "Engineering" of systems via architecture, biological processes and control of environments and resource applications is an essential requirement for progress