



Efficient Resource Use for Potato Production

Philip J. White

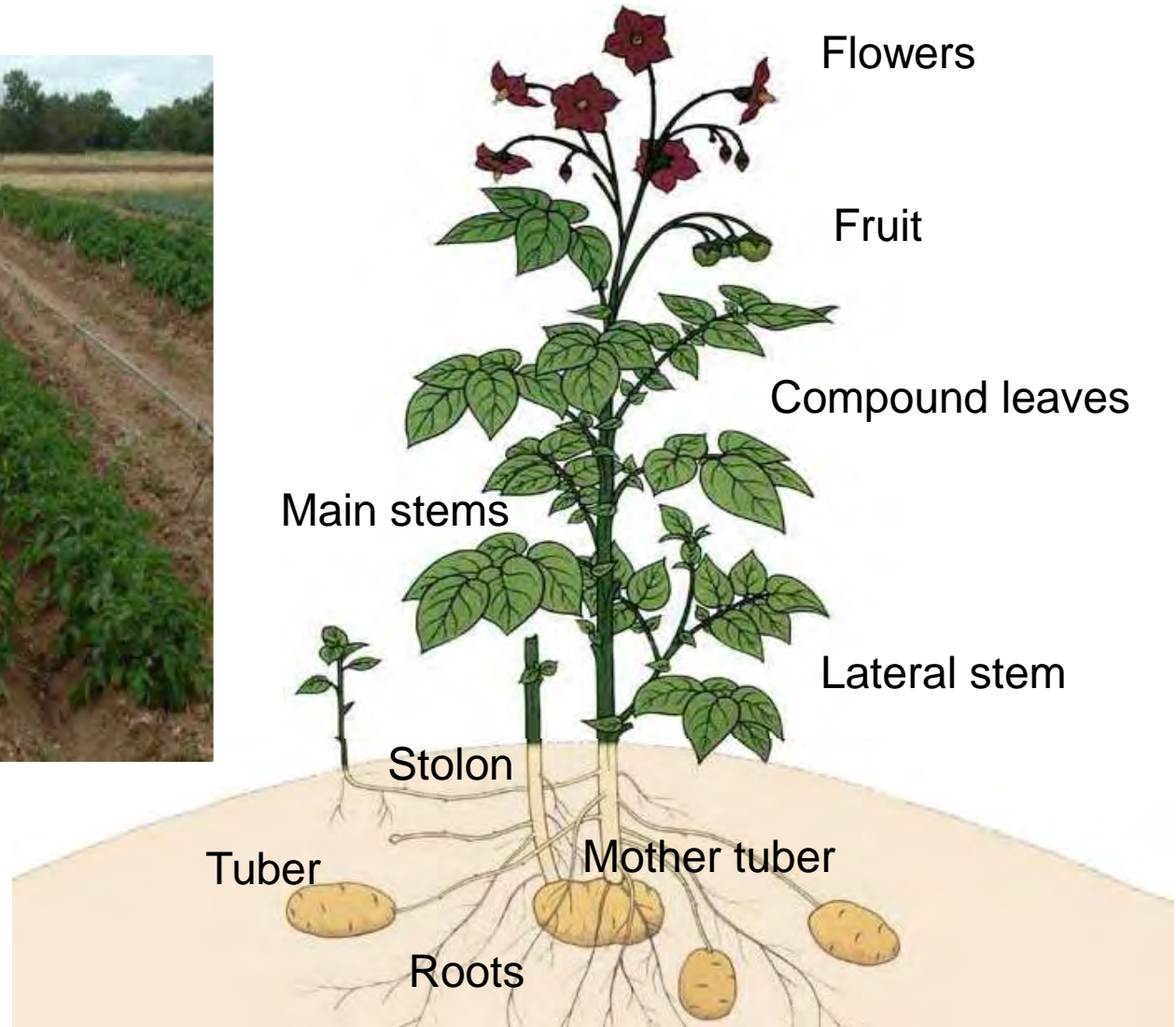
**John Bradshaw, Tim George, Gavin Ramsay (SCRI)
John Hammond, Martin Broadley (Nottingham)
Andrew Thompson (Warwick)**



SSCR, SCRI,
10th February 2011



Air & Sunlight, Clean Water, & Fourteen Essential Mineral Elements



Agronomic Resource Use Efficiency (ARUE)

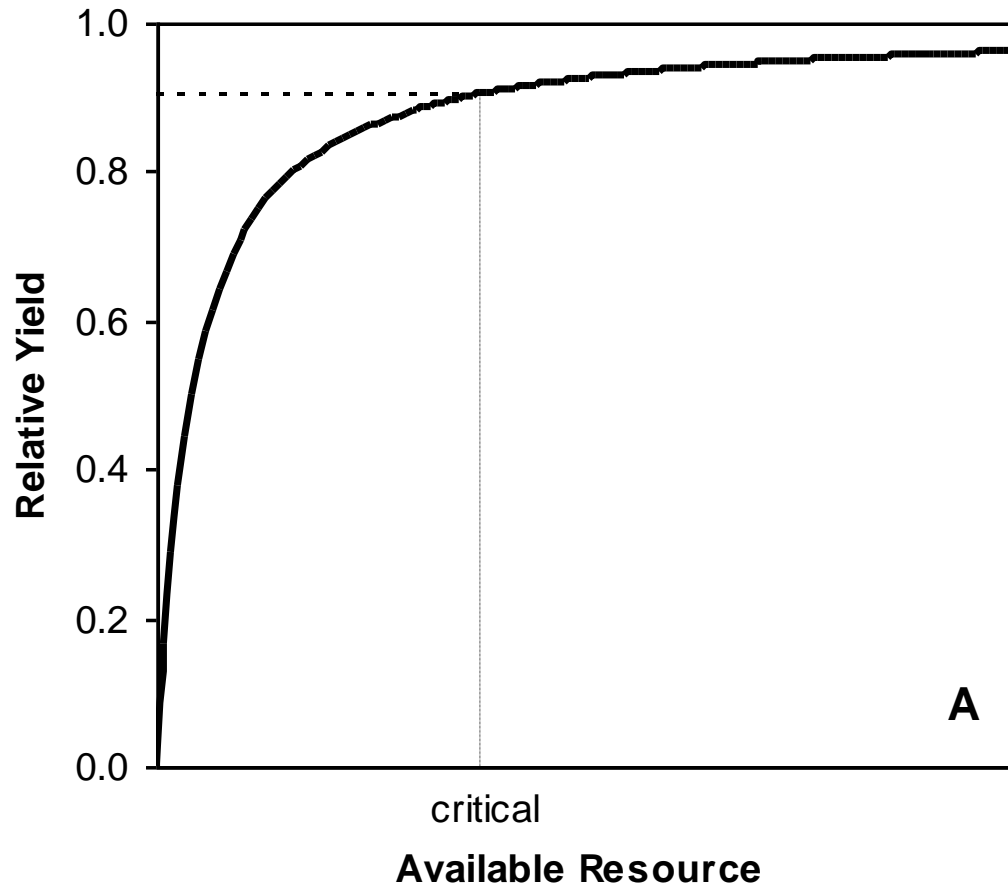


$$\text{ARUE} = \text{RUpE} \times \text{RUtE}$$

$$\begin{aligned} & \text{yield / resource available} = \\ & (\text{acquired / available}) \times (\text{yield / acquired}) \end{aligned}$$

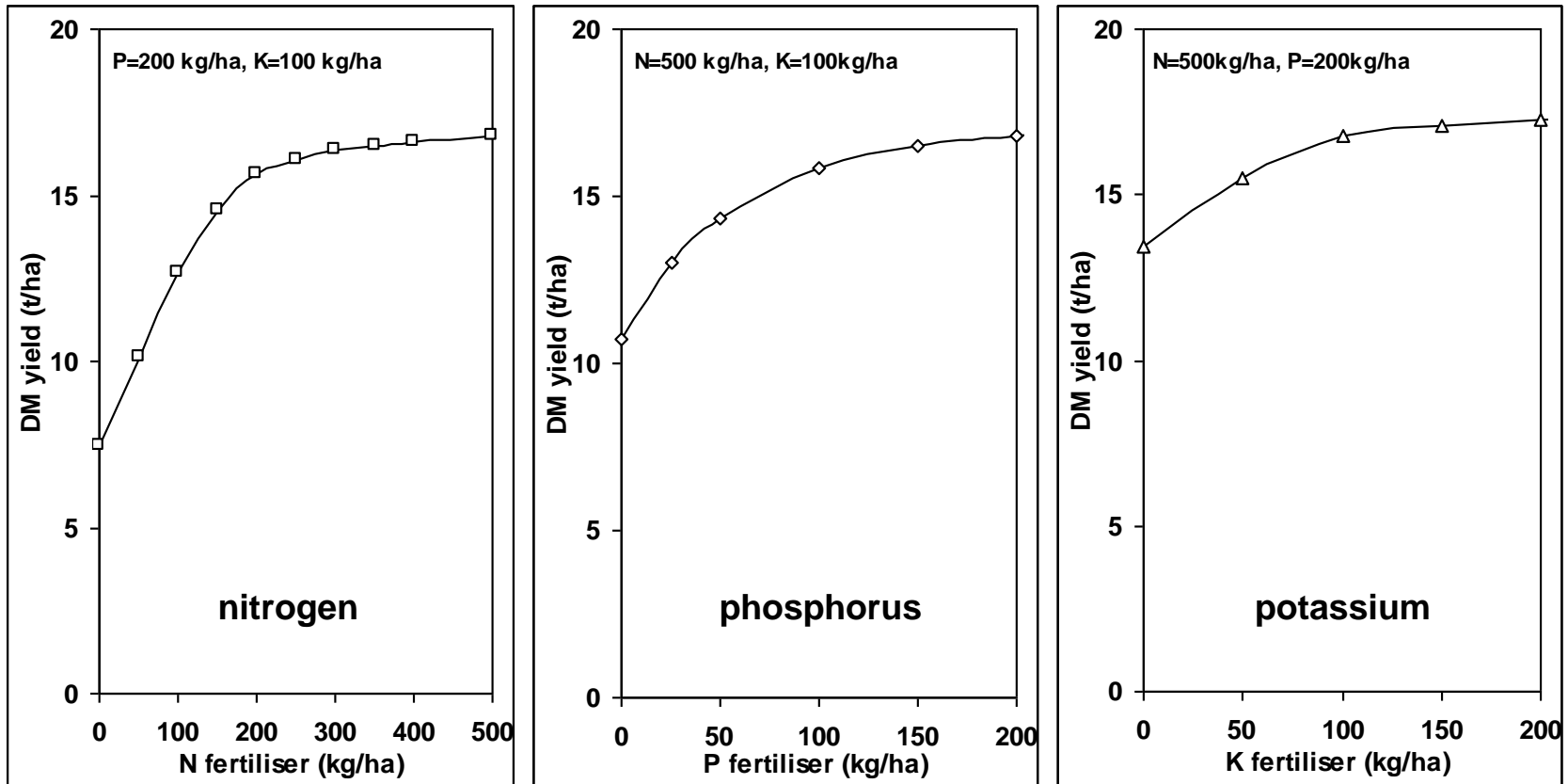
White et al. (2005) Genetic modifications to improve phosphorus acquisition by roots. IFS: York, UK.

Response of Crop to Resource Availability



The Law of Diminishing Returns

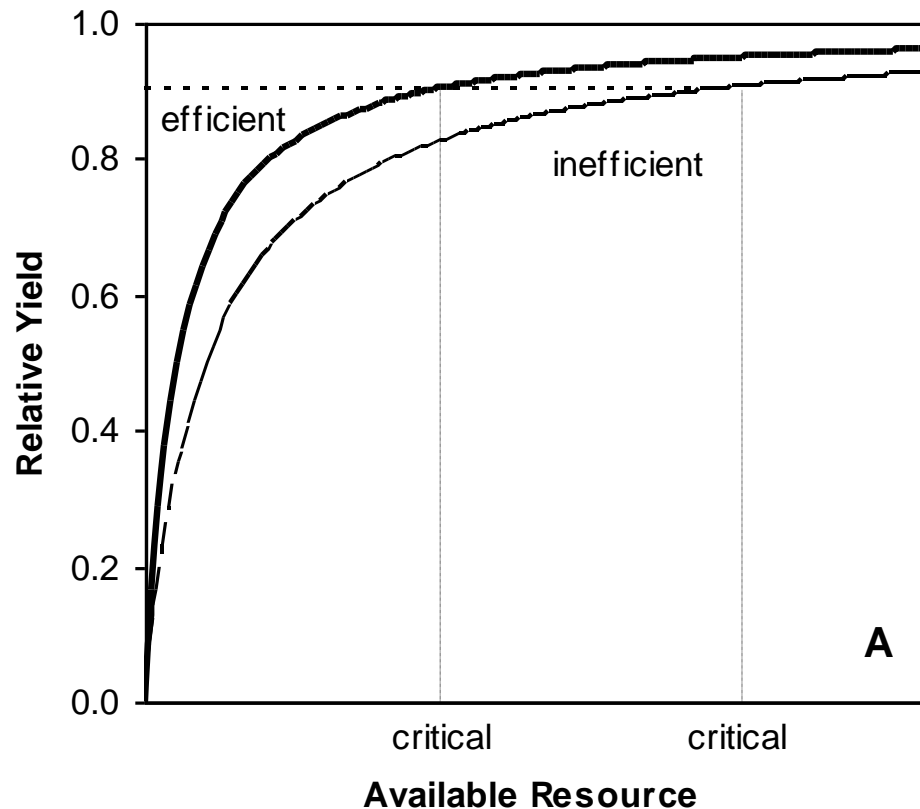
Essential Mineral Elements



Responses in potato yields to N, P and K fertilisation predicted by simulation models (<http://www.qpais.co.uk/>)

White et al. (2007) In: Potato Biology and Biotechnology, Advances and Perspectives, pp.739-752

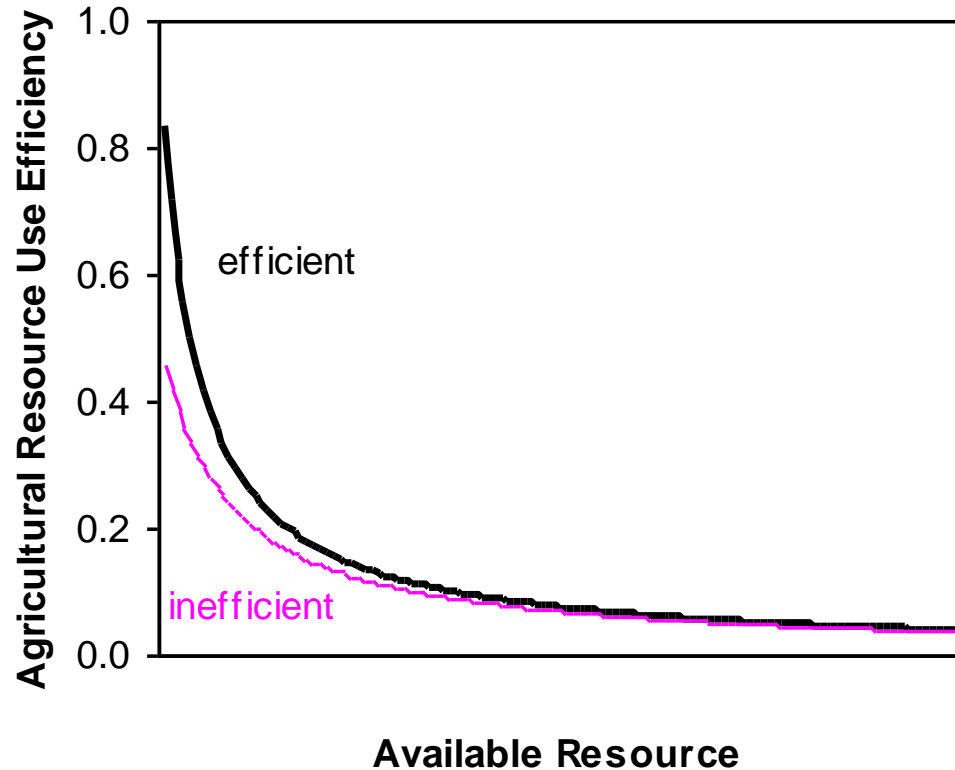
Efficient and Inefficient Varieties



Efficient variety attains 90% maximal yield with less resource than inefficient variety

Agronomic Resource Use Efficiency

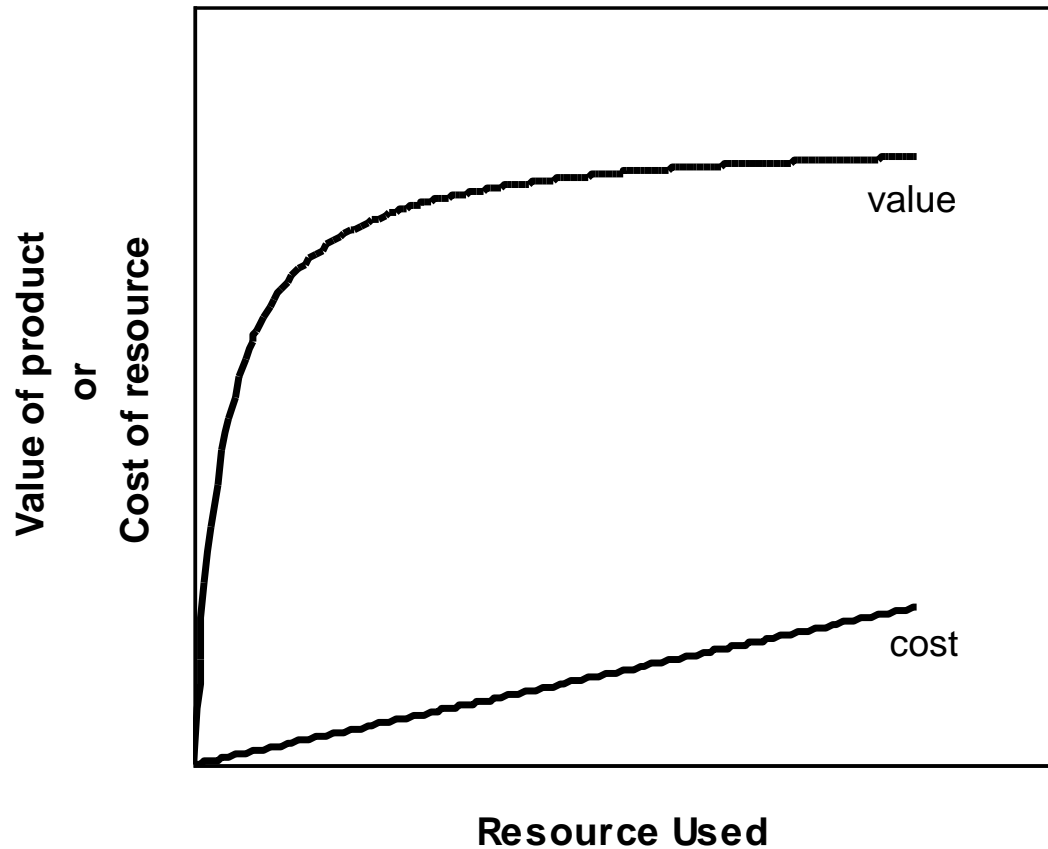
(marketable yield / resource applied)



The Law of Diminishing Returns

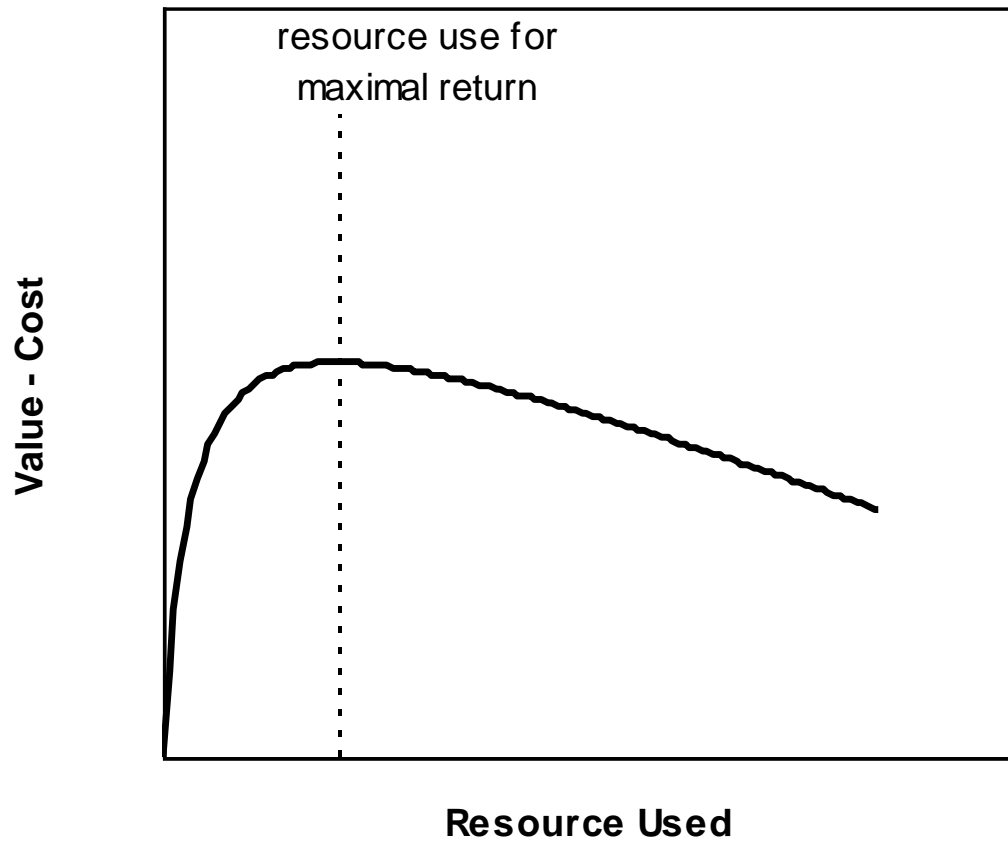
Economic Resource Use Efficiency

(Δ value crop / Δ cost resources)



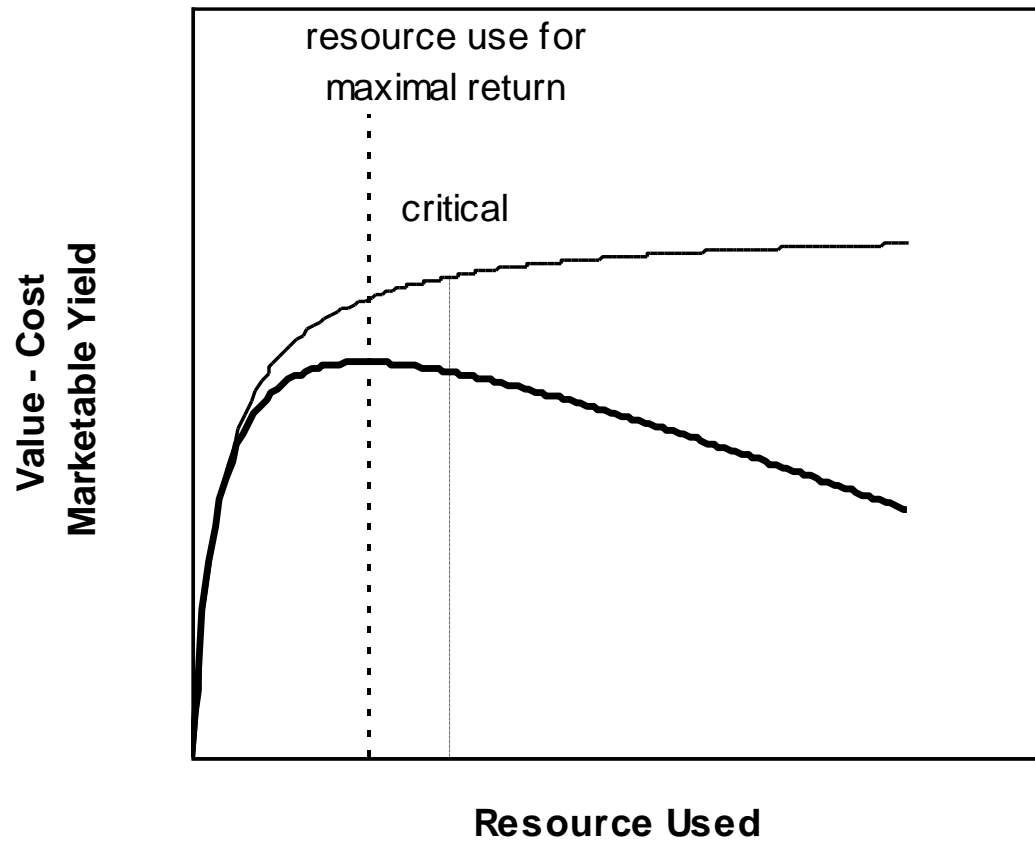
The Law of Diminishing Returns

Economics of Crop Production



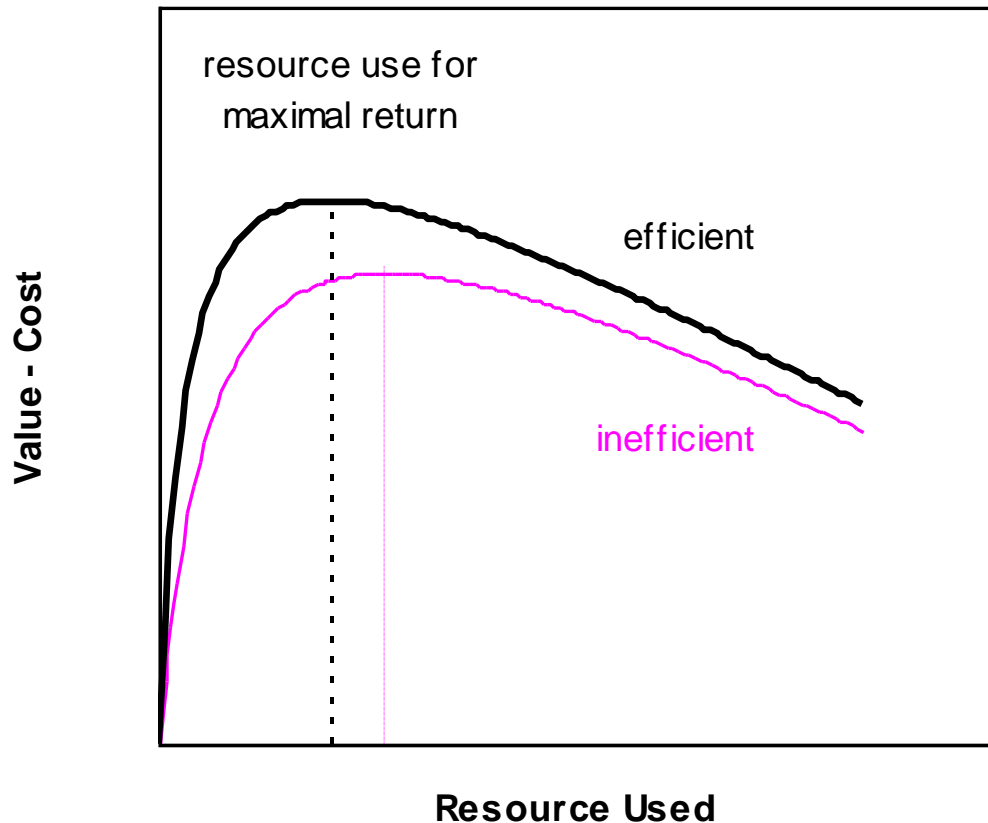
There is a maximum economic return

Economics of Crop Production



*Maximal return often delivers less than
90% maximum yields*

Economics of Crop Production



*Greater profit and less resource used
with an efficient variety*

Improving Resource Use Efficiency



Through Agronomy

soil management,
placement, scheduling,
decision support

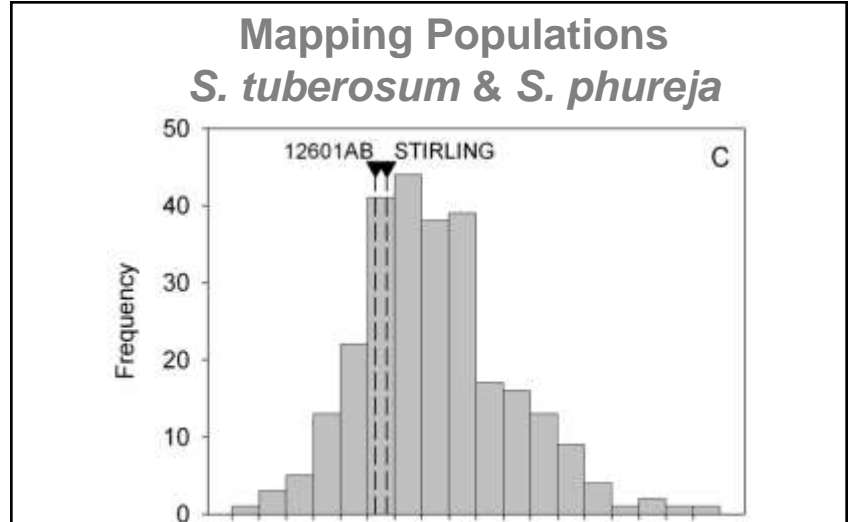


Through Genetics

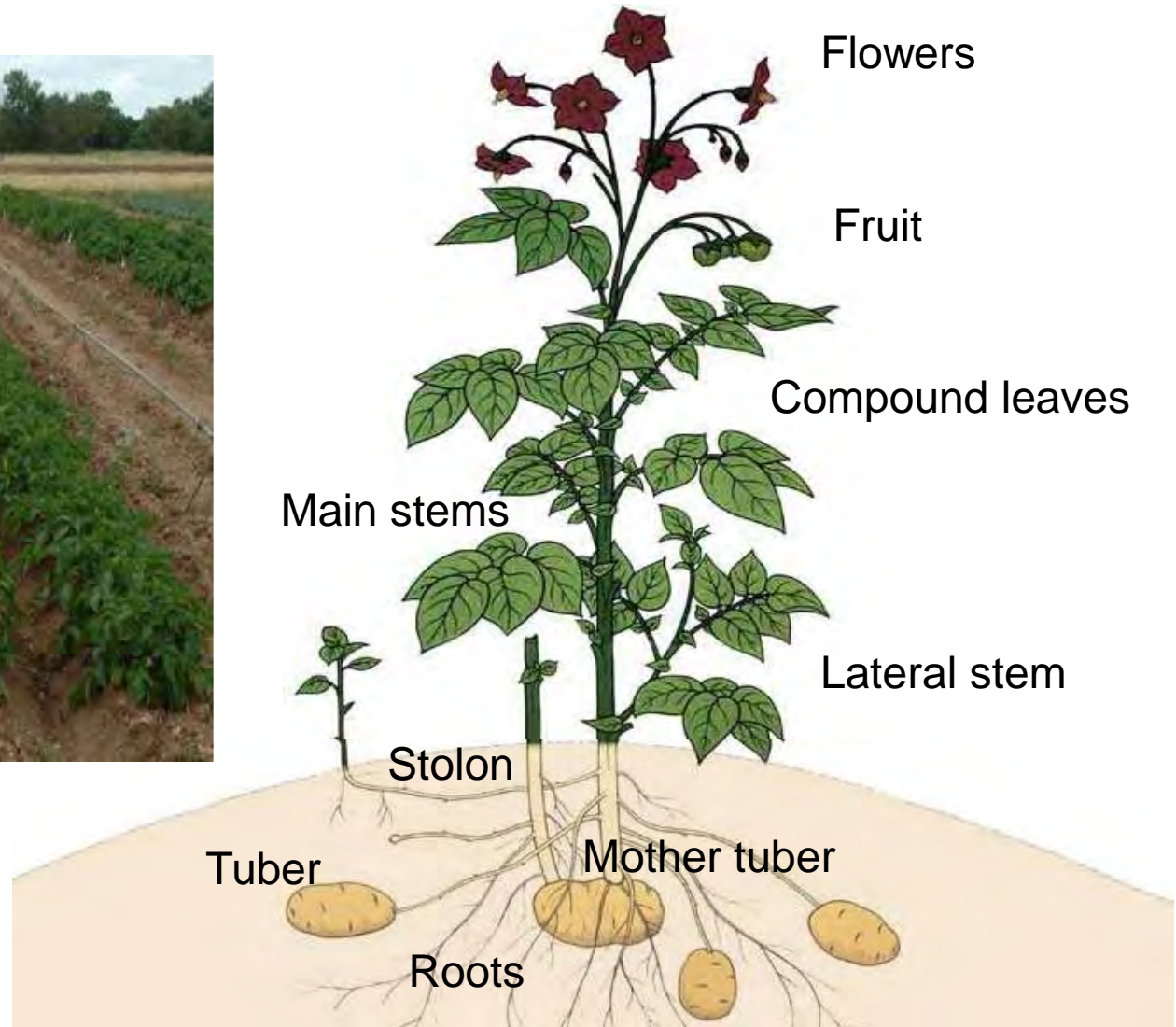
select or breed varieties
that require or consume
less resource



Potato Germplasm Collections at SCRI



Air & Sunlight, Clean Water, & Fourteen Essential Mineral Elements



Carbon Fixation and Accumulation in Tubers

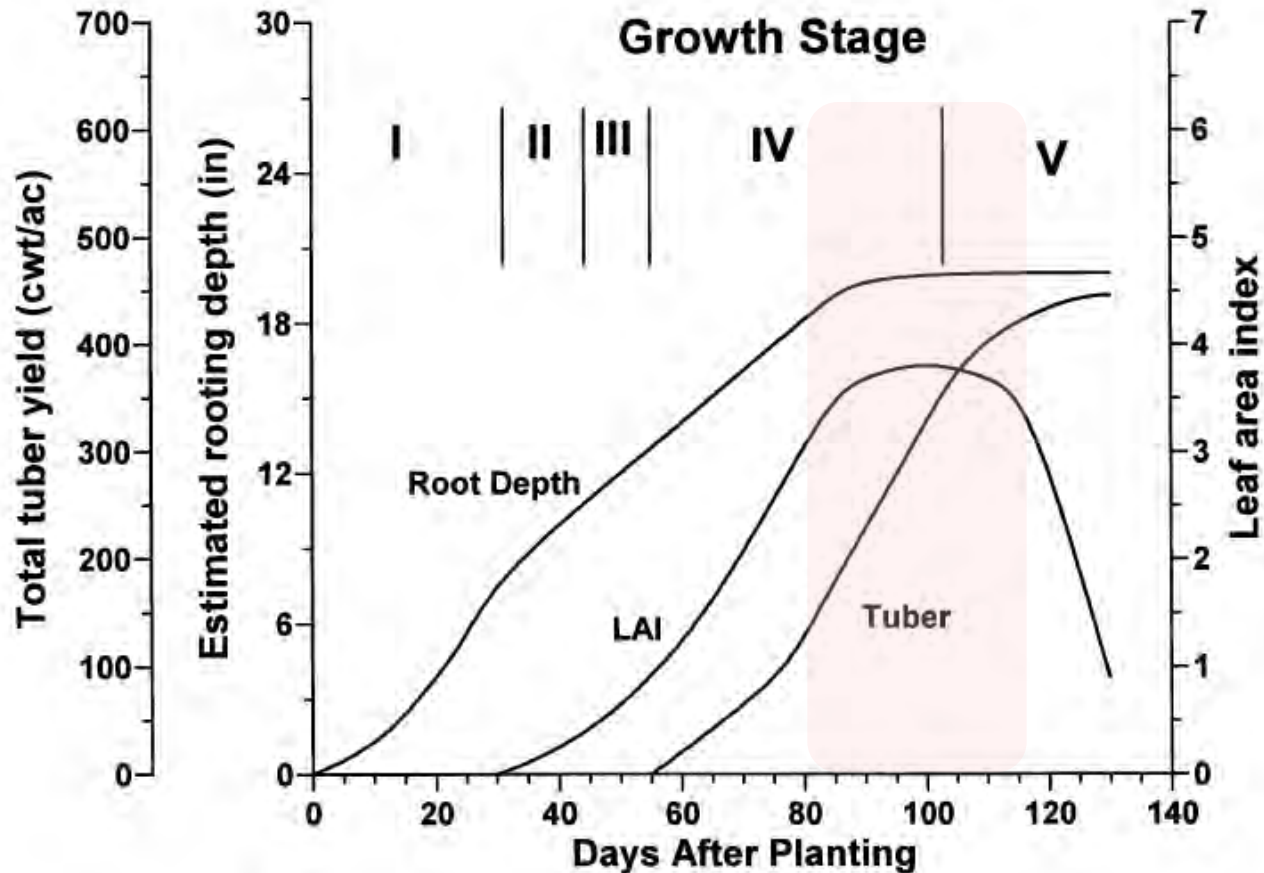
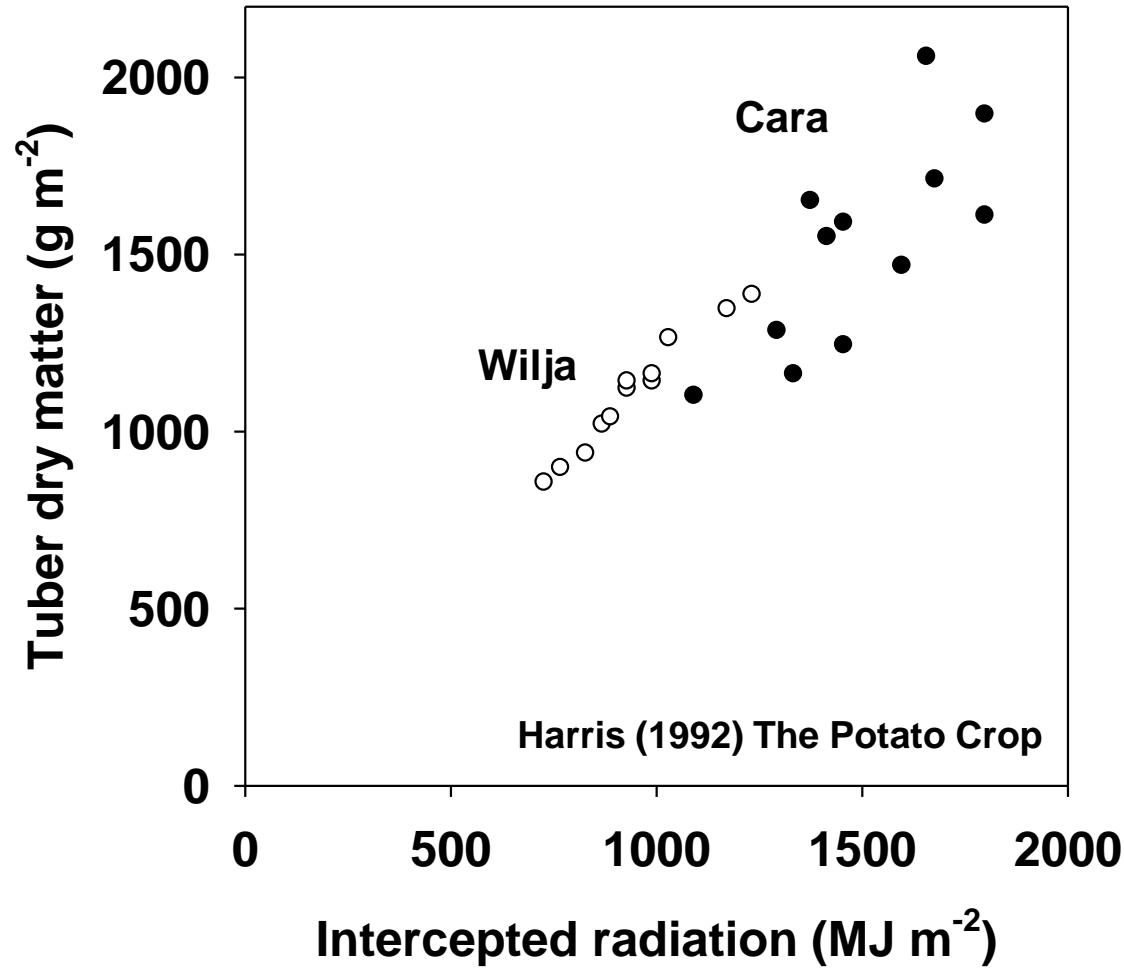


Figure 2. Generalized seasonal progression of rooting depth, leaf area index (LAI), and tuber yield of potato.

Photosynthesis drives tuber yield

Increase Light Interception

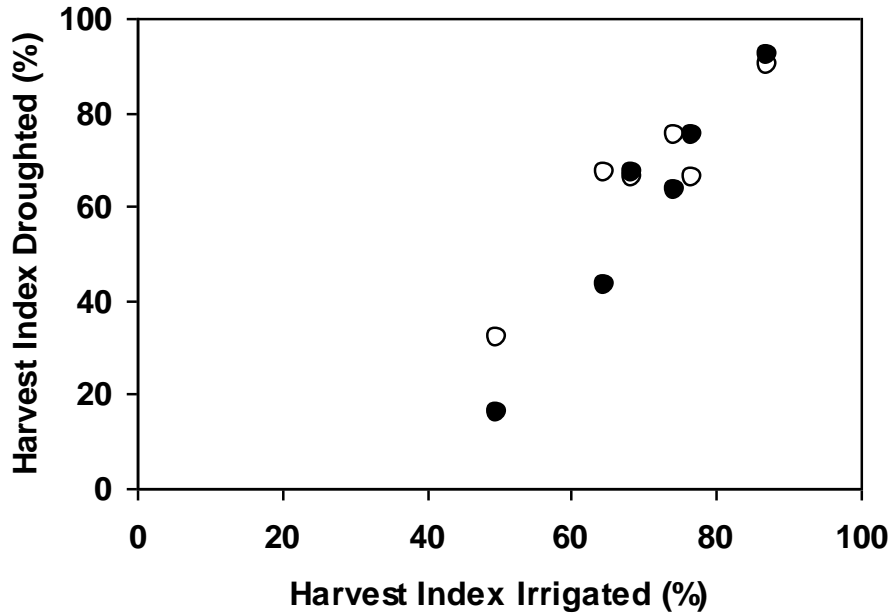


Canopy longevity increases tuber yield

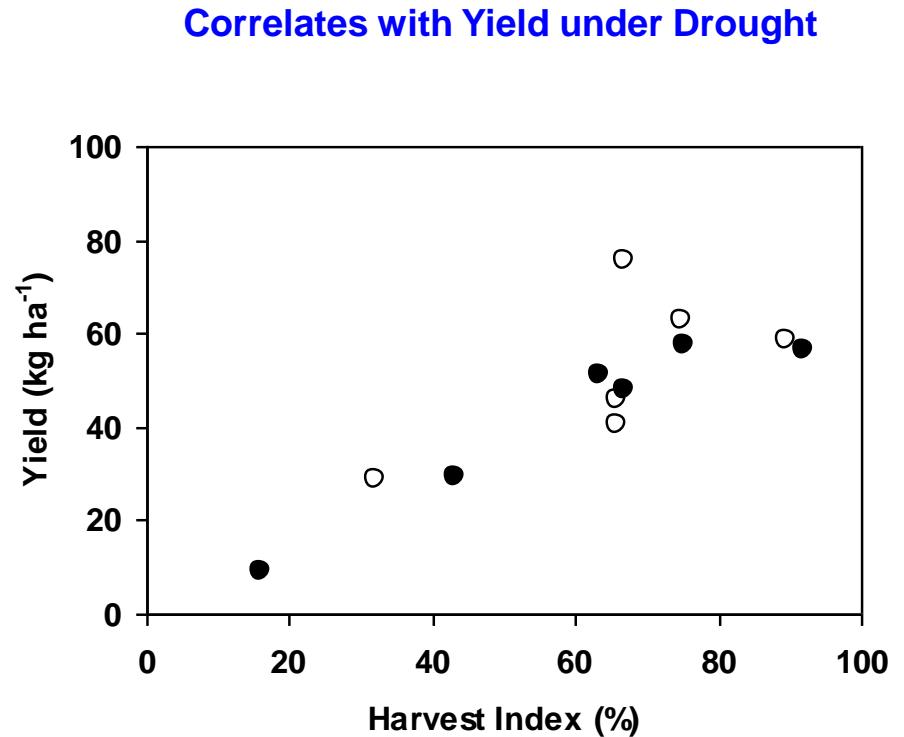
Increase Harvest Index



Effects of water shortage on six potato genotypes in the highlands of Bolivia



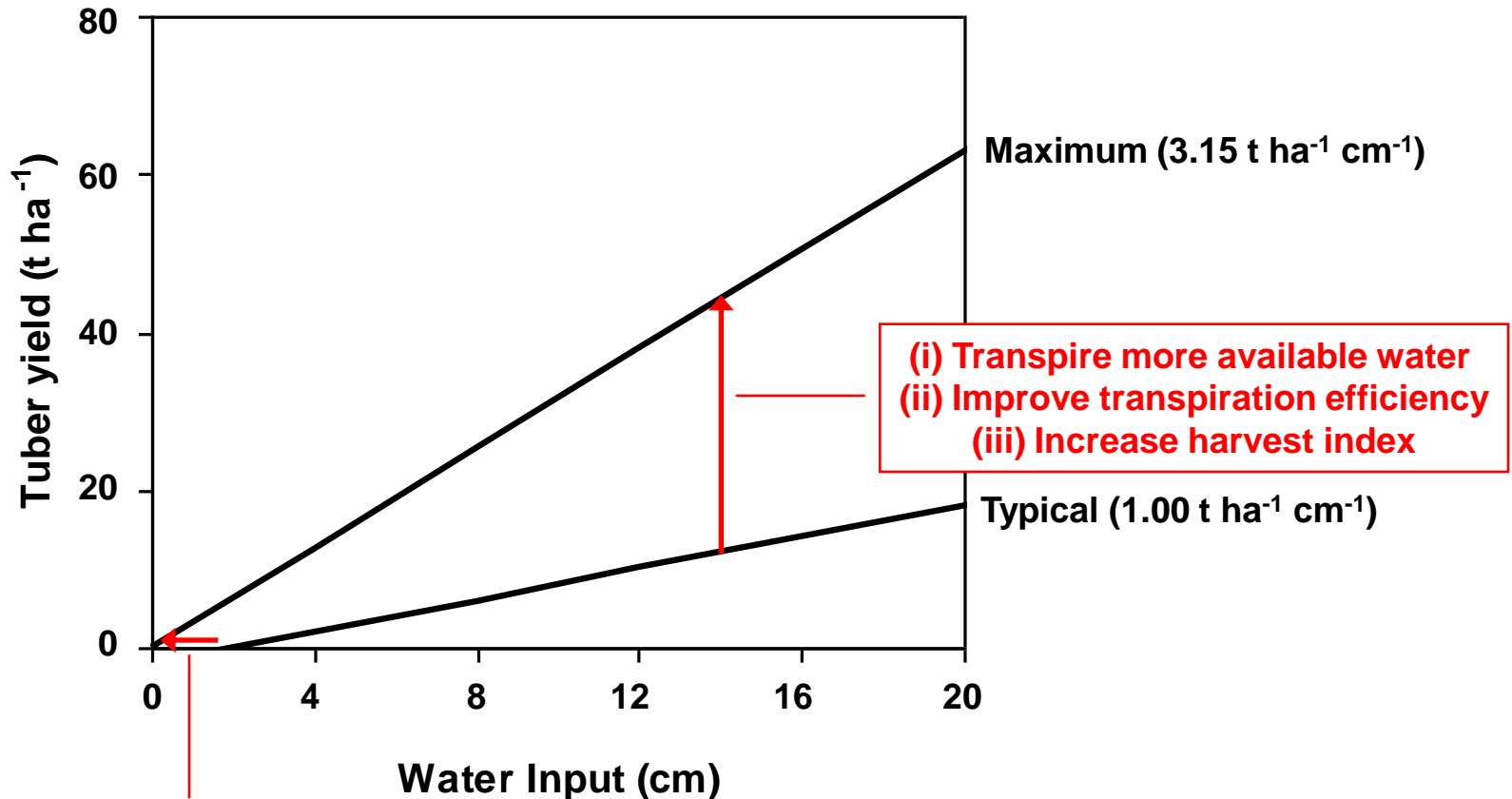
Variation in Harvest Index



Correlates with Yield under Drought

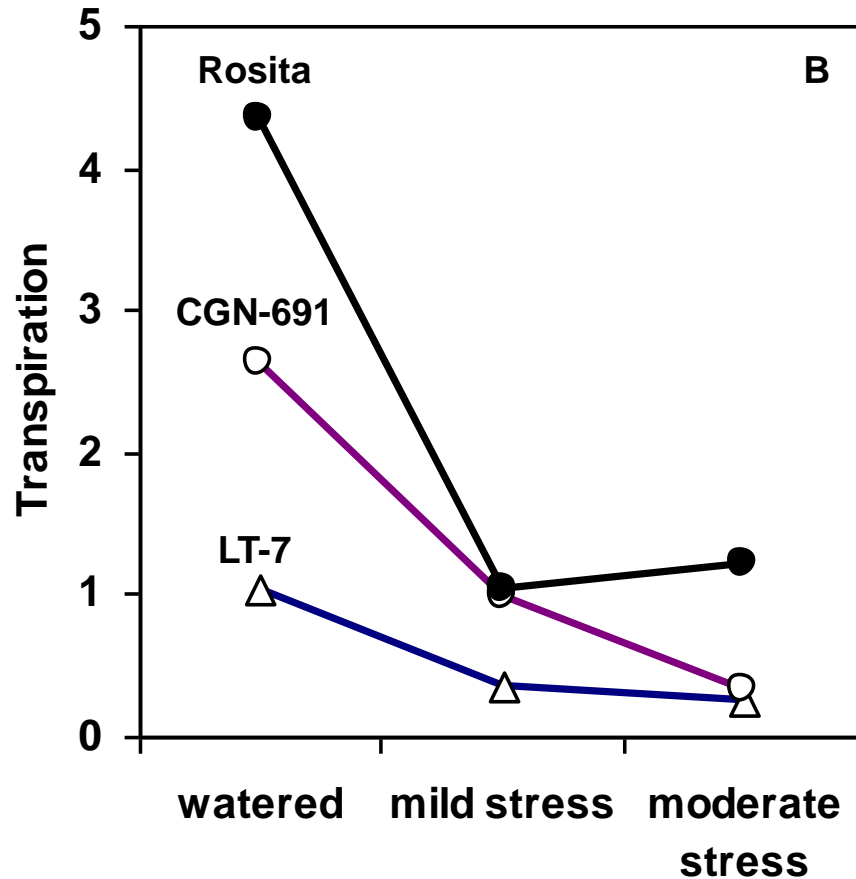
Water-Use Efficiency in Potato

(WUE = Tuber Yield / Water Input)

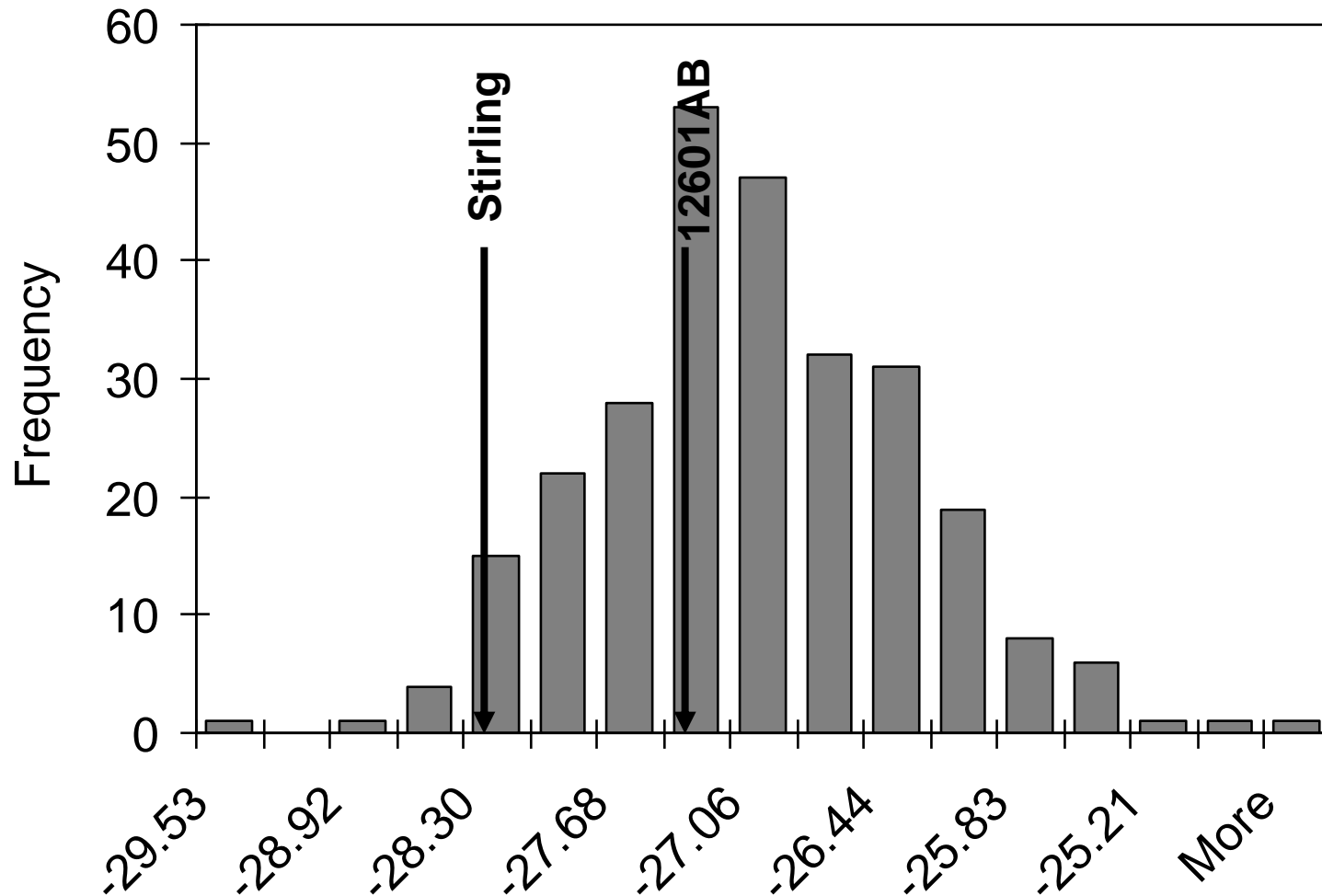


Reduce water losses to environment

Transpire More Available Water

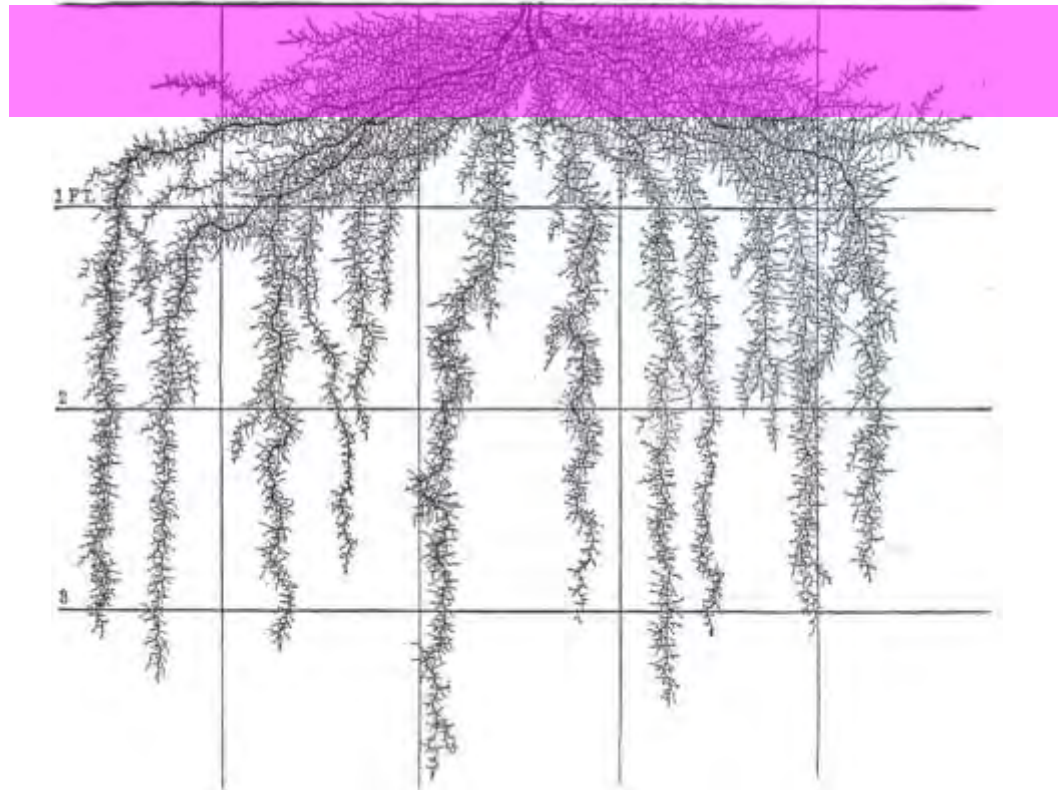


Increase Transpiration Efficiency ($\delta^{13}\text{C}$)



PJ White, AJ Thompson & JE Bradshaw,
unpublished data 2005

Acquire More Available Water



Shallow-rooted phenotypes acquire water (and phosphate) from the topsoil, but deep rooted phenotypes acquire water (and nitrate) at depth

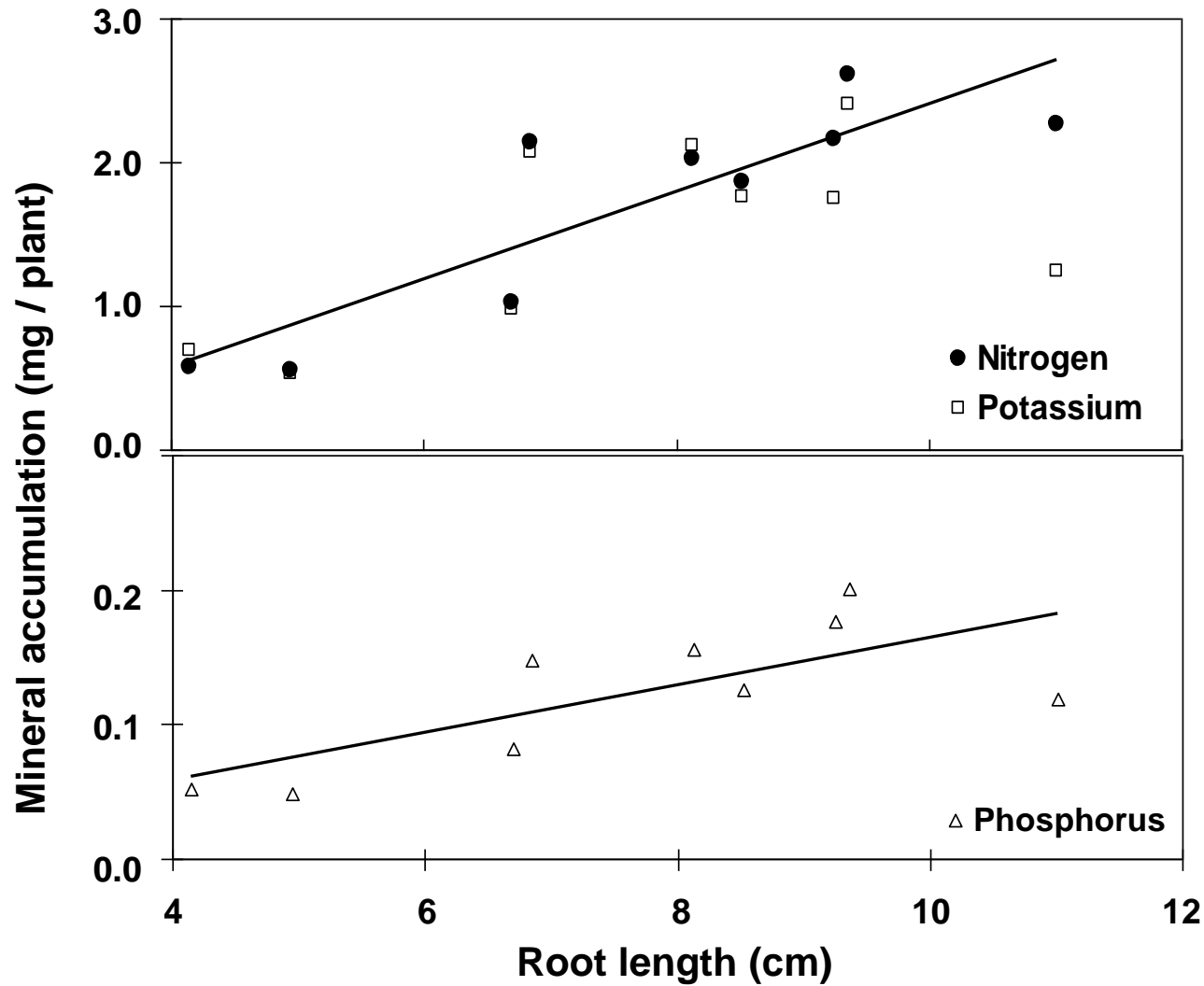
“long roots are like a long rope for a deep well”

Improving Nutrient Use Efficiency

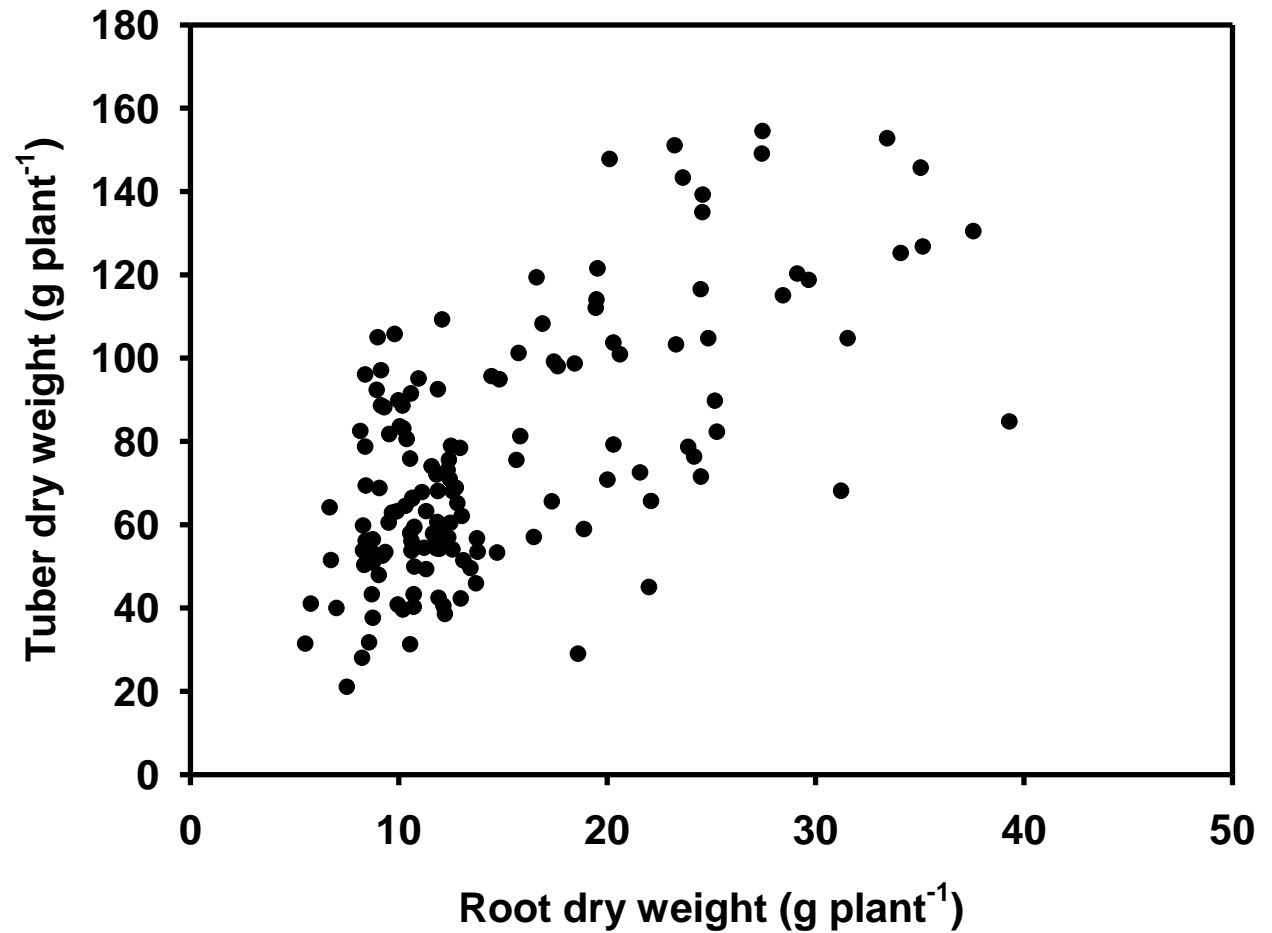


- Varieties that yield well in soils with low available nutrient concentrations
- Varieties that acquire nutrients efficiently (but this should not be 'luxury' consumption and must be converted to yield)
- Varieties that utilise nutrients efficiently in their tissues (and yield well)

Mineral Acquisition is Related to Root Size



Tuber Yield is Related to Root Size

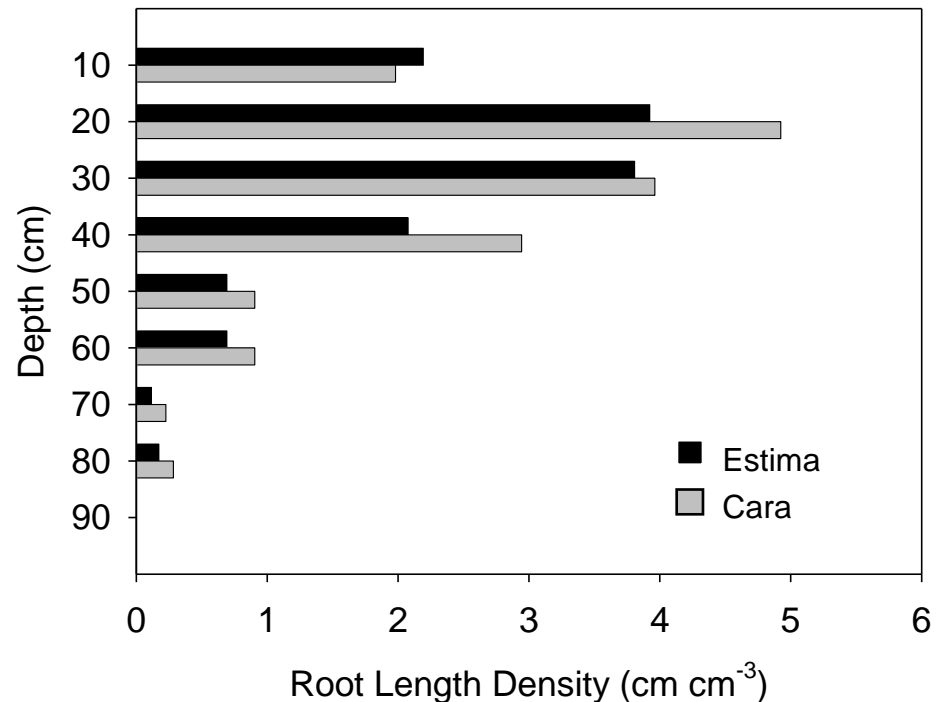
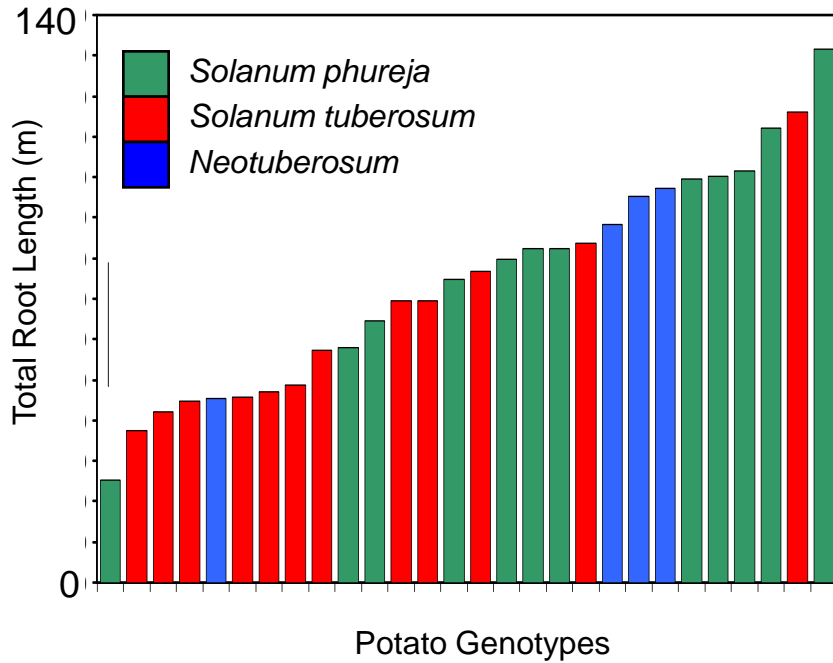


Kennebec potatoes grown in Wharf Ground, HRI-Wellesbourne
in 2004, 2005 & 2006

Genetic Variation in Root Length and Distribution in the Soil

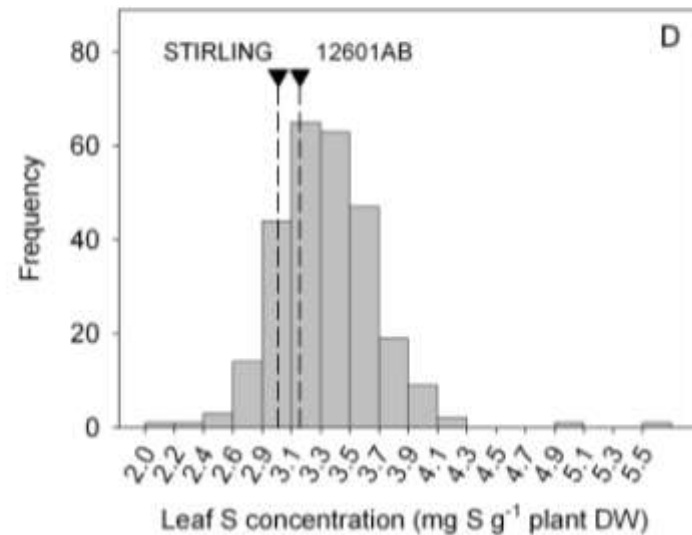
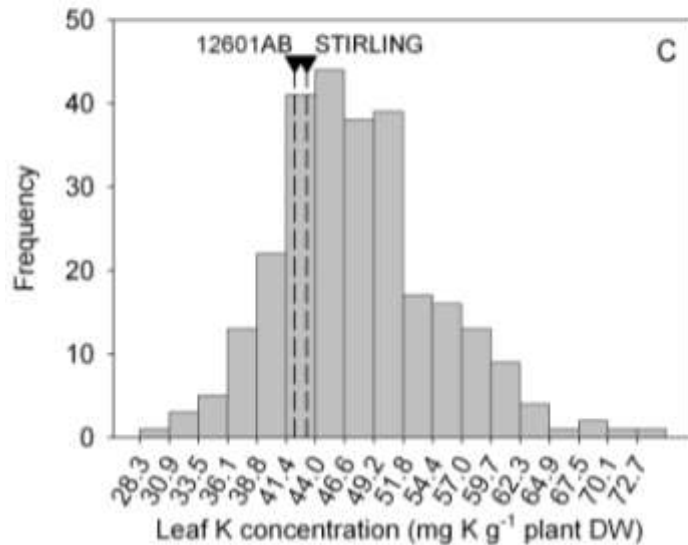
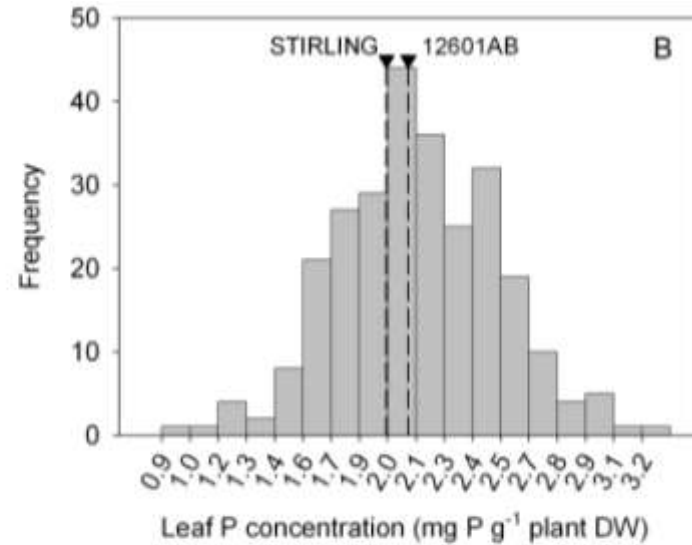
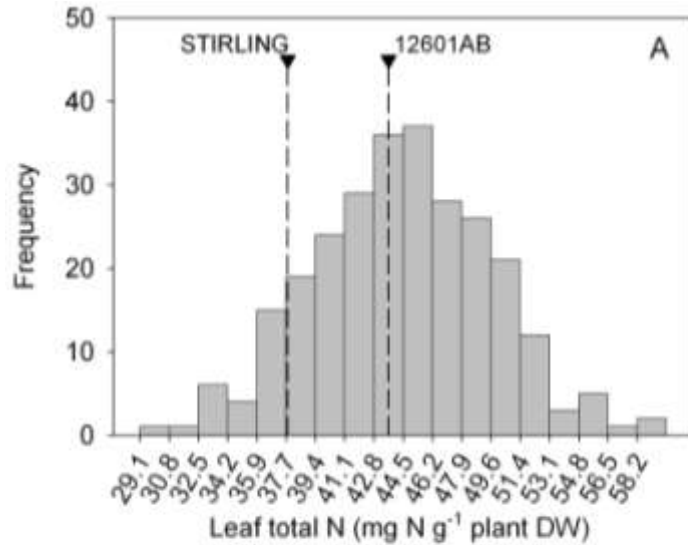


~5-fold variation in root length

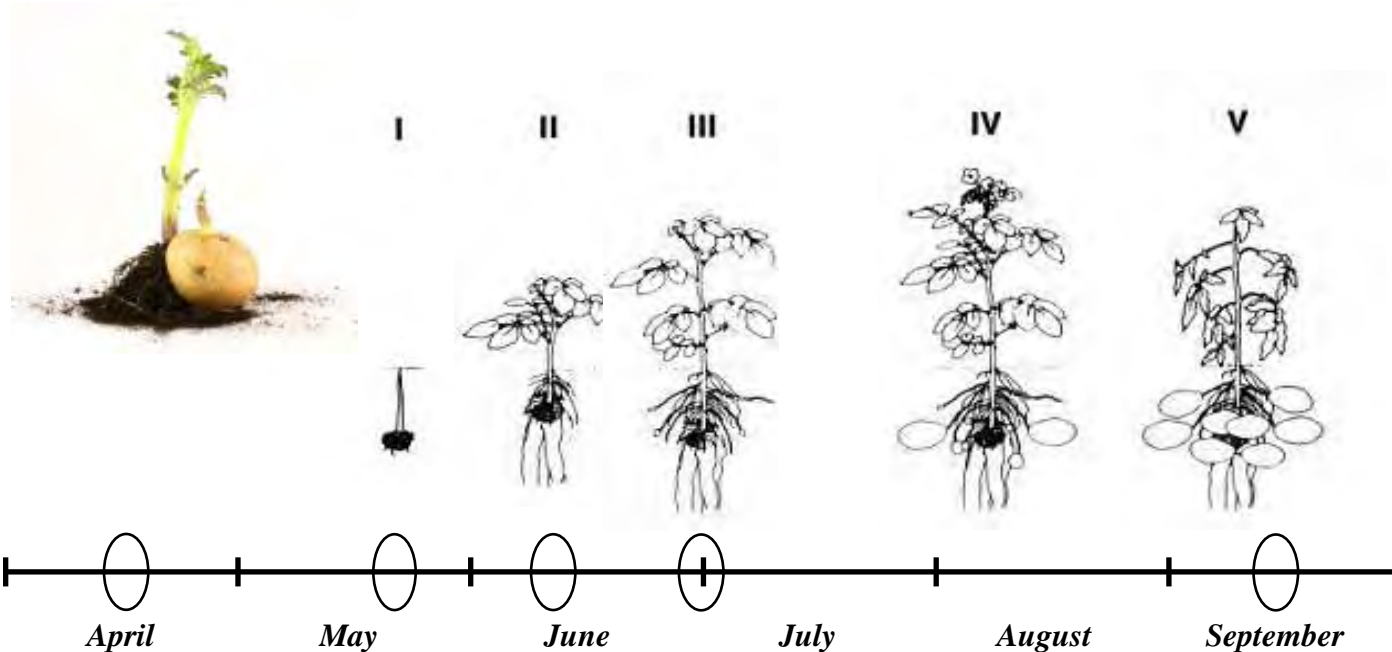


Wishart et al. (2011) unpublished data
 Stalham & Allen (2001) J. Agric. Sci. 137, 251-270

Genetic Variation in Tissue Mineral Concentrations



Select for Yield with Low Fertiliser Input and High Physiological Nutrient Use Efficiency



QTL for Agronomic PUE, PUpE & PUEt
All associated with QTL for maturity on Chromosome V

Defra 2003-2010; RERAD 2006-2011
NUE_Crops 2009-2014

Summary

Traits that Increase Resource Use Efficiencies



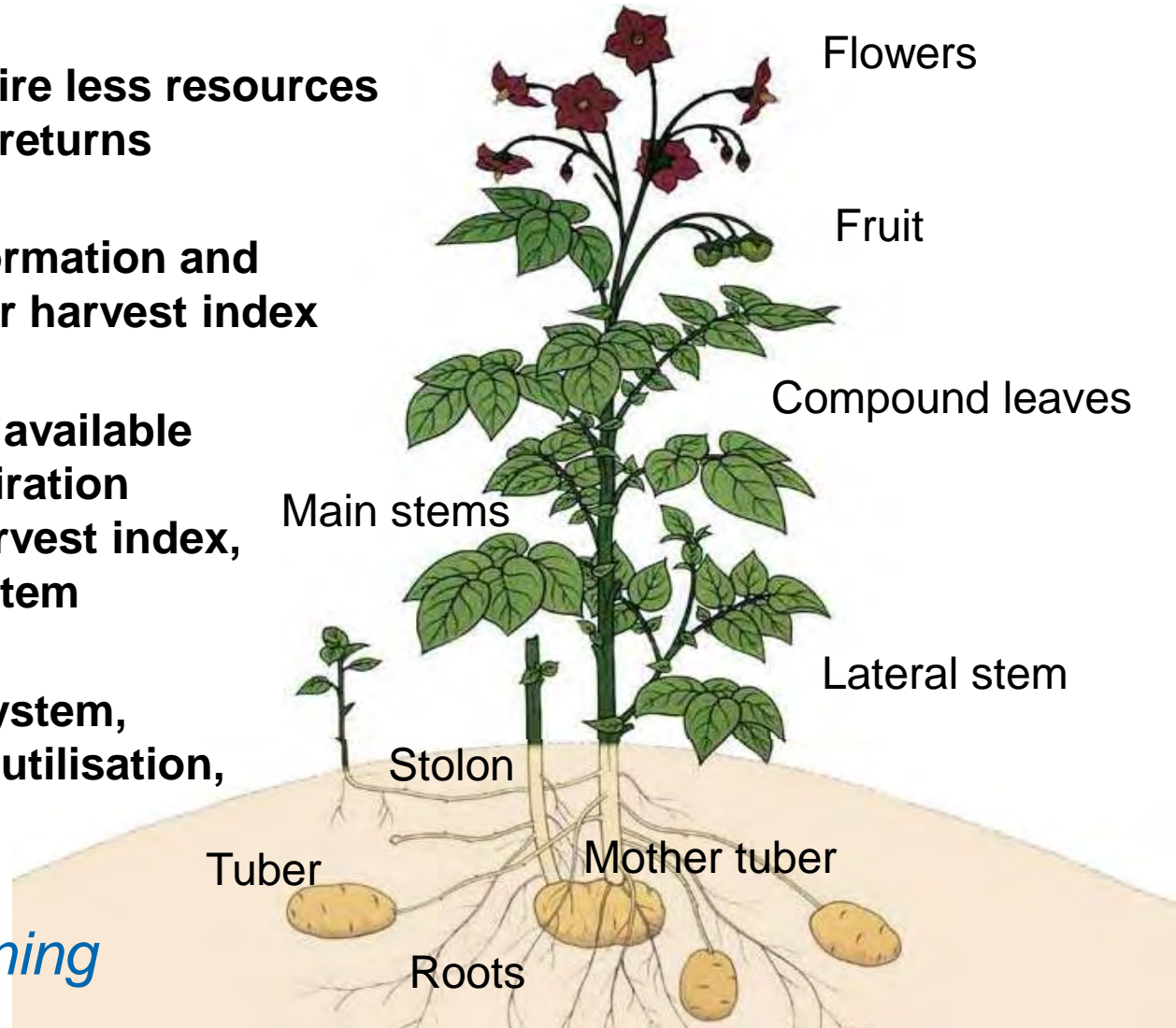
Efficient varieties require less resources and increase financial returns

Light: Rapid canopy formation and longevity, and a greater harvest index

Water: Transpire more available water, improve transpiration efficiency, increase harvest index, produce large root system

Minerals: Large root system, efficient physiological utilisation, greater harvest index

Thankyou for listening



Summary

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Thankyou for listening

