



# Field-based phenotyping of agronomic traits

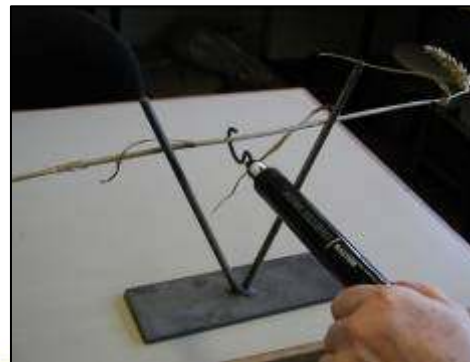
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# ADAS crop research

- Understand how **genetic**, **husbandry** & **environmental** factors affect crop production
- 13,000 field plots per year
- Wide range of environments
- Wide range of measurements
  - Crop
  - Disease & pests
  - Environment



# Crop Physiology Measures

- **Yield**
  - per ha
    - @ traded moisture content
- **Growth**
  - per ha
    - @ 100% dry matter
- **Development**
- **Quality**
  - Grain protein %DM
    - Grain N% x 5.7
  - Specific weight
- **Other agronomic traits**
  - Lodging
  - Rooting
  - Senescence
  - Disease incidence, severity & tolerance
  - N requirement



# Development

## Common framework across cereal crops

- Seedling 11 ... 19 leaves
- Tillering 21 ... 29 tillers
- Stem extension 30 ... 31 internodes
- Booting 41 ... 49
- Ear emergence 51 ... 59
- Flowering 61 ... 69
- Grain Filling 71 ... 79 (milk)
- 81 ... 87 (dough)
- Ripening 91 ... 93

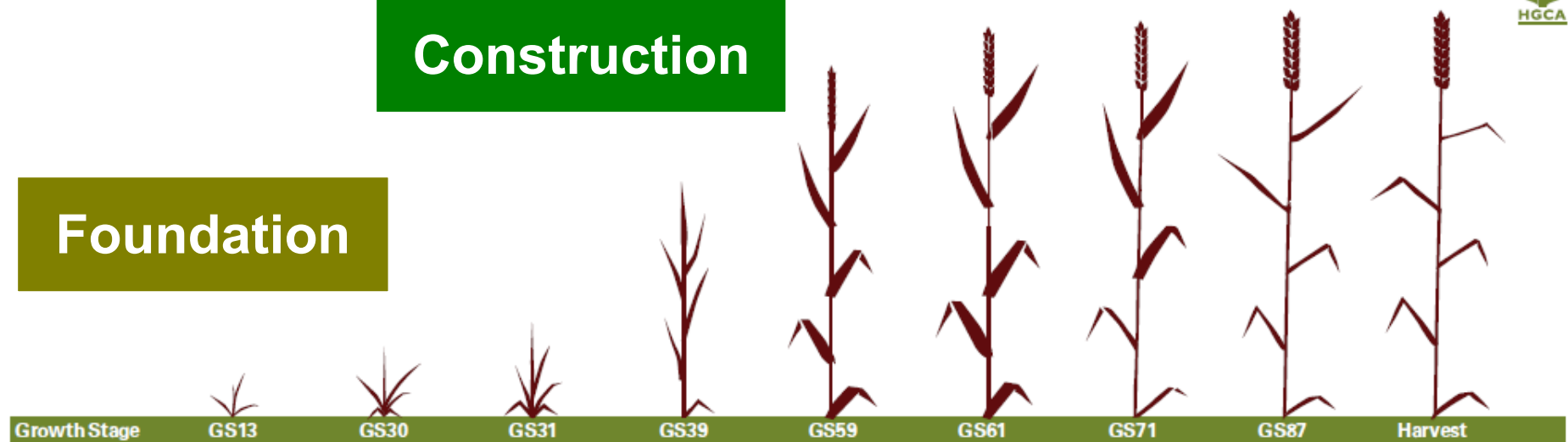
Foundation

Construction

Production

Construction

Foundation



# Wheat growth stages



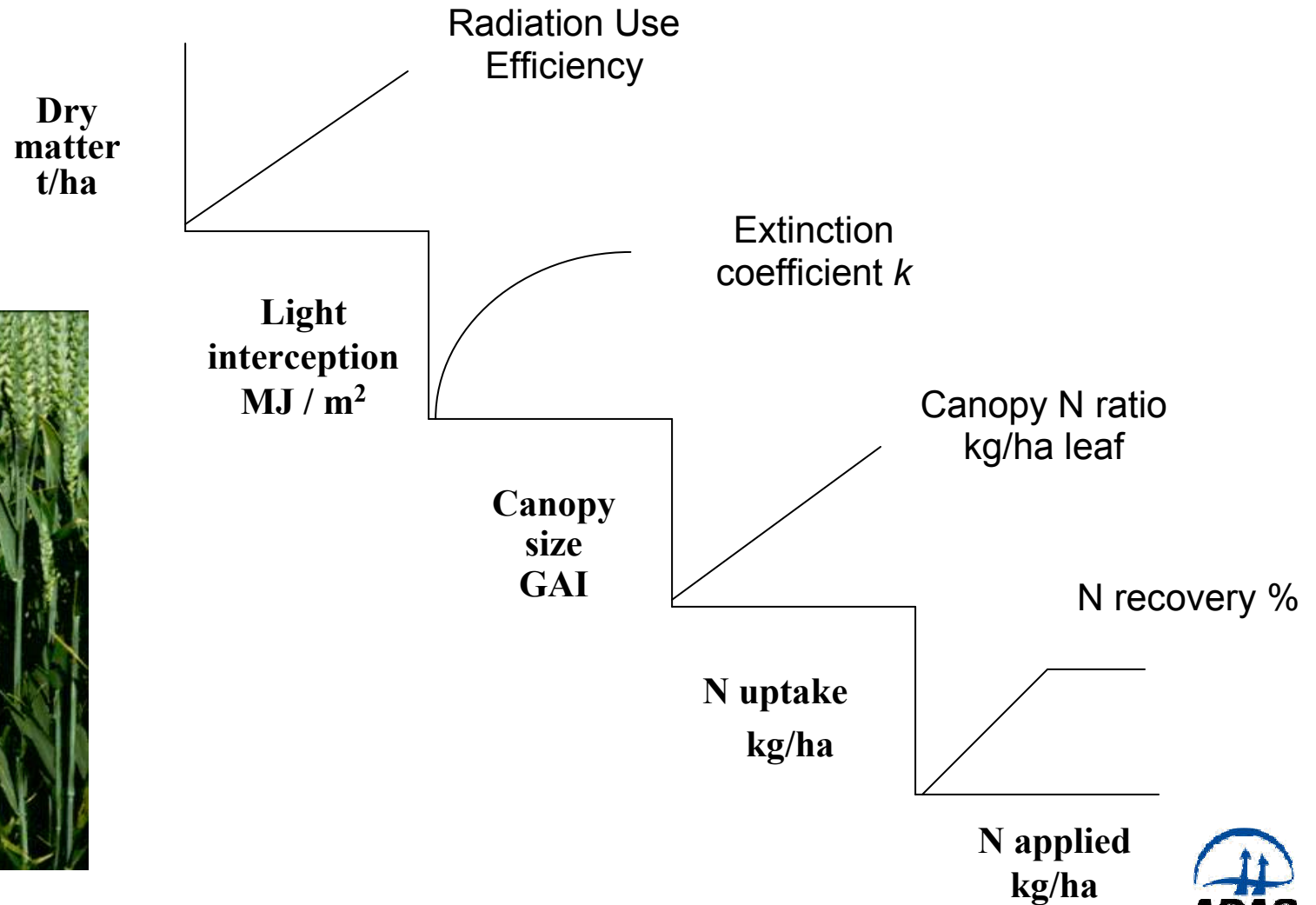
Growth Stage	Description of stage	Growth Stage	Description of stage	Growth Stage	Description of stage	Growth Stage	Description of stage
	<b>Seedling growth</b>		<b>Stem elongation</b>		<b>Ear emergence</b>		<b>Dough development</b>
GS10	First leaf through <i>coleoptile</i>	GS30	Ear at 1 cm (pseudostem erect)	GS51	First spikelet of ear just visible above flag leaf ligule	GS83	Early dough
GS11	First leaf unfolded ( <i>ligule</i> visible)	GS31	First node detectable	GS55	Half of ear emerged above flag leaf ligule	GS85	Soft dough
GS13	3 leaves unfolded	GS32	Second node detectable	GS59	Ear completely emerged above flag leaf ligule	GS87	Hard dough (thumbnail impression held)
GS15	5 leaves unfolded	GS33	Third node detectable		<b>Flowering</b>		<b>Ripening</b>
GS19	9 or more leaves unfolded	GS37	Flag leaf just visible	GS61	Start of flowering	GS91	Grain hard (difficult to divide)
	<b>Tillering</b>	GS39	Flag leaf blade all visible	GS65	Flowering half-way	GS92	Grain hard (not dented by thumbnail)
GS20	Main shoot only		<b>Booting</b>	GS69	Flowering complete	GS93	Grain loosening in daytime
GS21	Main shoot and 1 tiller	GS41	Flag leaf sheath extending		<b>Milk development</b>		
GS23	Main shoot and 3 tillers	GS43	Flag leaf sheath just visibly swollen	GS71	Grain watery ripe		
GS25	Main shoot and 5 tillers	GS45	Flag leaf sheath swollen	GS73	Early milk		
GS29	Main shoot and 9 or more tillers	GS47	Flag leaf sheath opening	GS75	Medium milk		
				GS77	Late milk		

# Yield determination :

- Harvest components
  - $\text{Ears/m}^2 \times \text{Grains/ear} \times \text{TGW}$
- Biomass  $\times$  Harvest Index
- Nitrogen components
  - $\text{N capture} \times \text{N harvest index} \div \text{grain N\%}$
- Phases
  - Construction
    - $\text{Duration} \times \text{Rate} \times \text{Redistribution} (\% \text{WSC})$
  - Production
    - $\text{Duration} \times \text{Rate}$ .

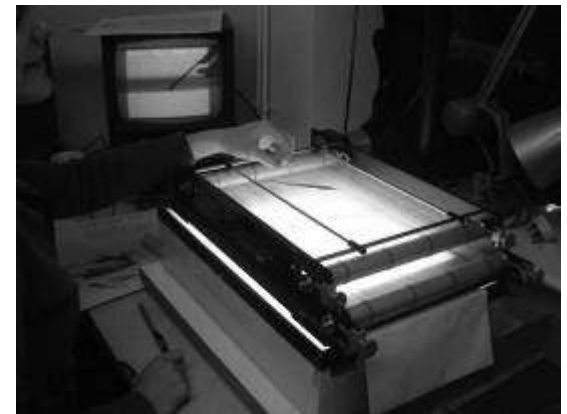


# Resource capture & yield



# Measuring Crop Growth

- Germination (% seeds sown)
- Emergence (% seeds sown)
- Establishment (% seeds sown)
- Plant population (plants m<sup>-2</sup>)
- Shoots m<sup>-2</sup> (main shoots & tillers)
- Biomass (t/ha)
- Green Area Index (m<sup>2</sup>/m<sup>2</sup>)
  - (ground cover %)
  - Light interception (% , MJ)
- N uptake (kg/ha)
- Canopy N ratio (kg N /ha leaf)
- Shoots/plant
- Height (cm)
- Partitioning (DM & N) stems leaves (roots)
- Stem water soluble carbohydrates (WSC)
- Ears m<sup>-2</sup>
- Florets per spikelet
- Spikelets per ear
- Grains per ear
- Grain weight (mg grain<sup>-1</sup>)





# Measurement issues

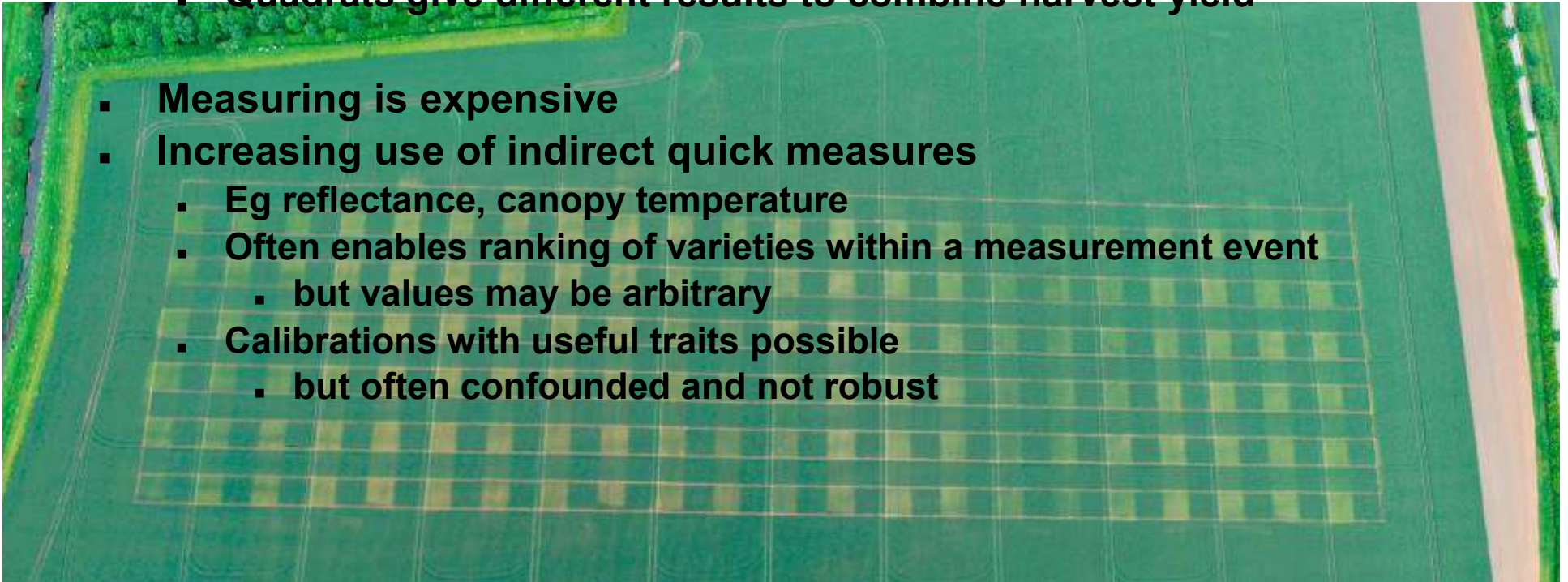
- Agronomically important crop traits are high level, complex & quantitative
- Crops are populations of plants
  - Very different to individual plants
  - Compensatory growth gives interactions between traits and limits effects of individual traits on yield t/ha
    - Eg  $\uparrow$  ears  $m^{-2}$   $\downarrow$  grains  $ear^{-1}$



# Measurement issues

- Large effects of environment
  - Extreme variability
    - spatially & year to year
  - Interacts with genetic variation
    - Variation often reduced with high plant populations
- So Crucially Important to define the environment
- Large errors on area based measures
  - Quadrats give different results to combine harvest yield

- Measuring is expensive
- Increasing use of indirect quick measures
  - Eg reflectance, canopy temperature
  - Often enables ranking of varieties within a measurement event
    - but values may be arbitrary
  - Calibrations with useful traits possible
    - but often confounded and not robust



Thank you

