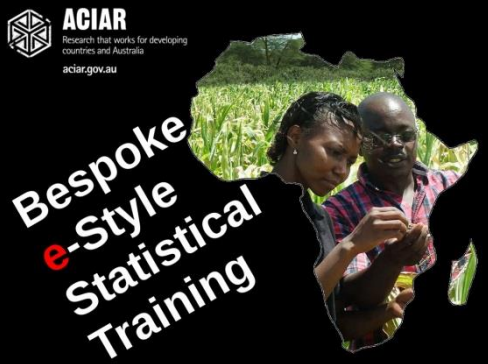
PRINCIPLES OF THE DESIGN OF EXPERIMENTS



Outline for today

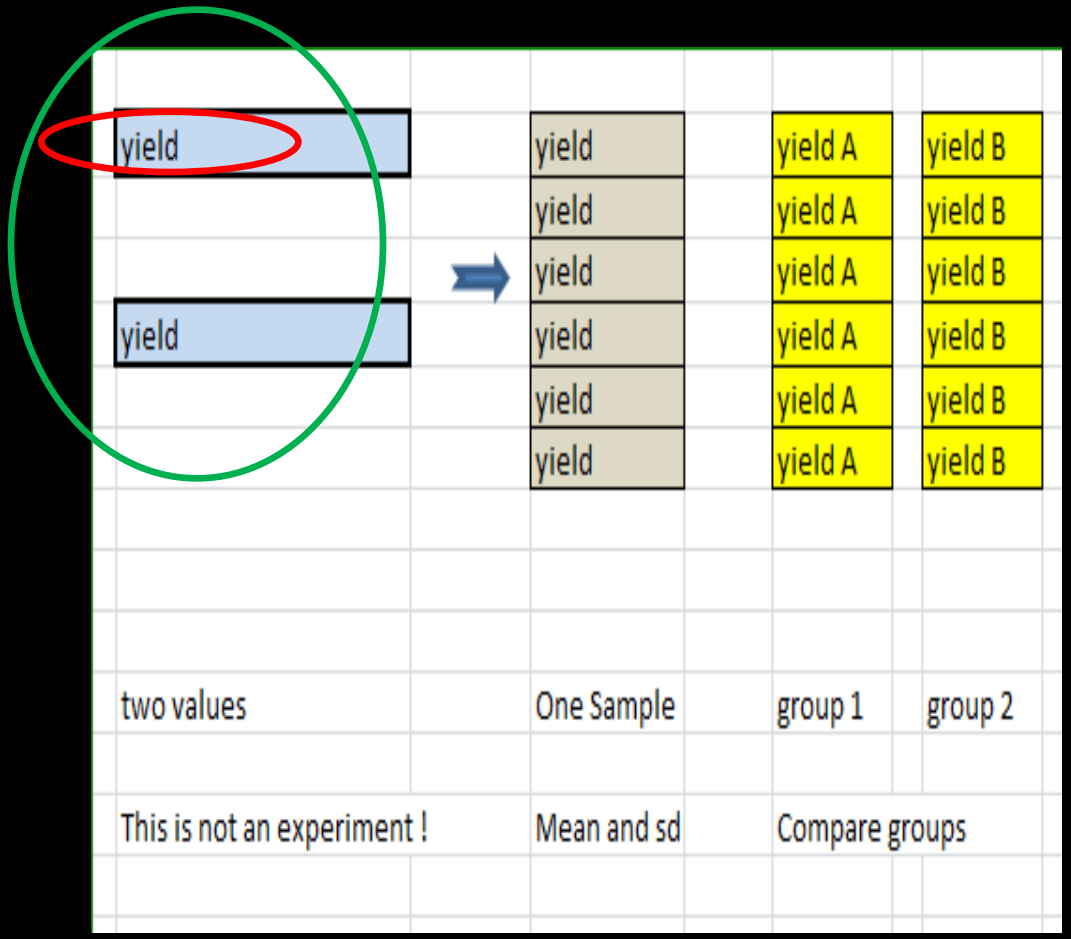
- Planning an experiment
- Treatments – some definitions
- **Randomisation**
- **Replication**
- **Reduction of error/protocols**
- Blocking

Sampling and experimentation

A single measurement is not an experiment

A comparison not an experiment

We need to design an experiment to sample



Thinking about sampling for gaining insight into our sample

- Review of summarising data so far. –mean, variance, sd
- One value is not enough, we need to sample

- Looking at exploring populations and why we sample

- Using the sample to ask questions about the sample mean

  - We generally wish to compare two or more groups

Treatments - defined

- What is a treatment for your particular study?
- Could be breed or variety (simple comparison)
- In a single factor trial, the factor is a categorical variable. Two or more groups would be replicated
- So we can identify the term Factor, and the treatments within a factor are referred to as Levels
- If we had two varieties, the factor is variety and there are two levels.

Treatments

- What is a treatment for your particular study?
- In agronomy we can often look at two factors. i.e we want to look at 3 varieties at 4 fertilizer rates.
  - The 3 varieties are said to be the 3 levels of Factor 1
  - The 4 fertiliser rates are said to be the 4 levels of Factor 2
  - In this case we have a 3 by 4 study and it gives us 3×4=12 treatment combinations

Three Principles of Design

- Randomisation
- Replication
- Reduction of Experimental Error

Randomisation

- In week 2 we looked at the importance of a simple random sample to avoid bias.
- We would like to give each animal an equal chance of being represented in our study.
- If we are doing comparisons we have to select two groups. Experimental units (plots, households, animals) need to be selected

- Avoid bias.
- Important step and it must be undertaken
- This requires practical knowledge of the context
- (Animals that are allowed to enter pens may be following a pecking order!)

Methods to Randomise

There are several ways to randomise:

1)Use Excel to calculate the random numbers (CLA3)

2)Use the random number tables (available on BB)

3) Use a package (R Studio)

4) Place all items in a hat, pull out at random

Note: you should all be able to randomise without using a statistical package.

Replication

- We need to replicate within each group.

- Choice of the number of replicates can be assisted by examining the literature, or sample size calculations with a biometrician
- Size of study is dictated by resources, cost, and collection of data within a reasonable time frame.

- Environments vary, application of the treatment (fertilizer may vary).
- Several independent plots will give us our individual values of yield, milk production, disease resistance,

Replications can be blocked

- When a study involves producing a crop- the replicates are set out in plots.
- A block of land adjacent to another will be more similar to one farther away. This has given rise to the use of blocking.
- More later under the Module for ANOVA

Reduction of Experimental error

- Have well defined descriptions of the measurements
- Have well defined protocols (times, temperatures) under which the study is conducted
- Make sure all treatments are applied in a consistent way (same day, same rate)
- Calibrate equipment and be aware of any measurement drift
- Scales – such as rating scales need have a standard for all assistants and researchers to be made aware of (and training)
- Monitoring of the environment is also useful
- Make notes of pests, anything that may affect results.

Ways to set up an experiment

yield		yield	yield A	yield B	yield a	yield B	yield C	yield D
		yield	yield A	yield B	yield a	yield B	yield C	yield D
	⇒	yield	yield A	yield B	yield a	yield B	yield C	yield D
yield		yield	yield A	yield B	yield a	yield B	yield C	yield D
		yield	yield A	yield B	yield a	yield B	yield C	yield D
		yield	yield A	yield B	yield a	yield B	yield C	yield D
two values		One Sample	group 1	group 2	group 1	group 2	Group3	Group4
This is not an experiment !		Mean and sd	Compare groups		This is an experiment- but not laid out well			

Blocking and gradients

- Blocking
- Experimental unit

- Plots or pots closer to each other experience the environment that is more similar.
- Plots or pots

Gradients to consider in all facilities we use

Ovens, incubators, refrigerators, even storage rooms

- Gradients exist
- Time of day matters
- Equipment may need to warm up
- The operator may matter (experience v less experienced)

Cost and resources require us to do the best design we can for the conditions

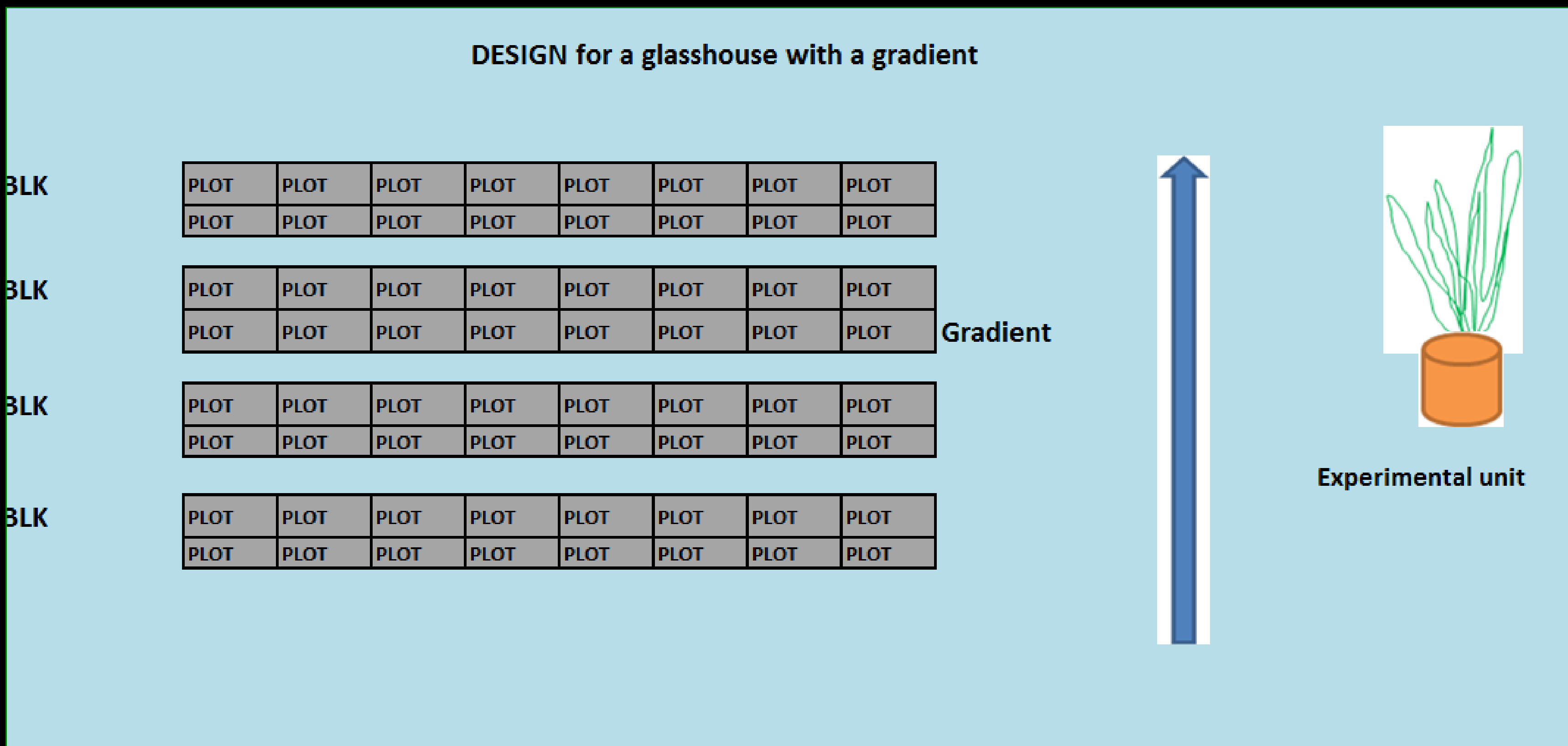
A large glasshouse trial

Gradients in glasshouses

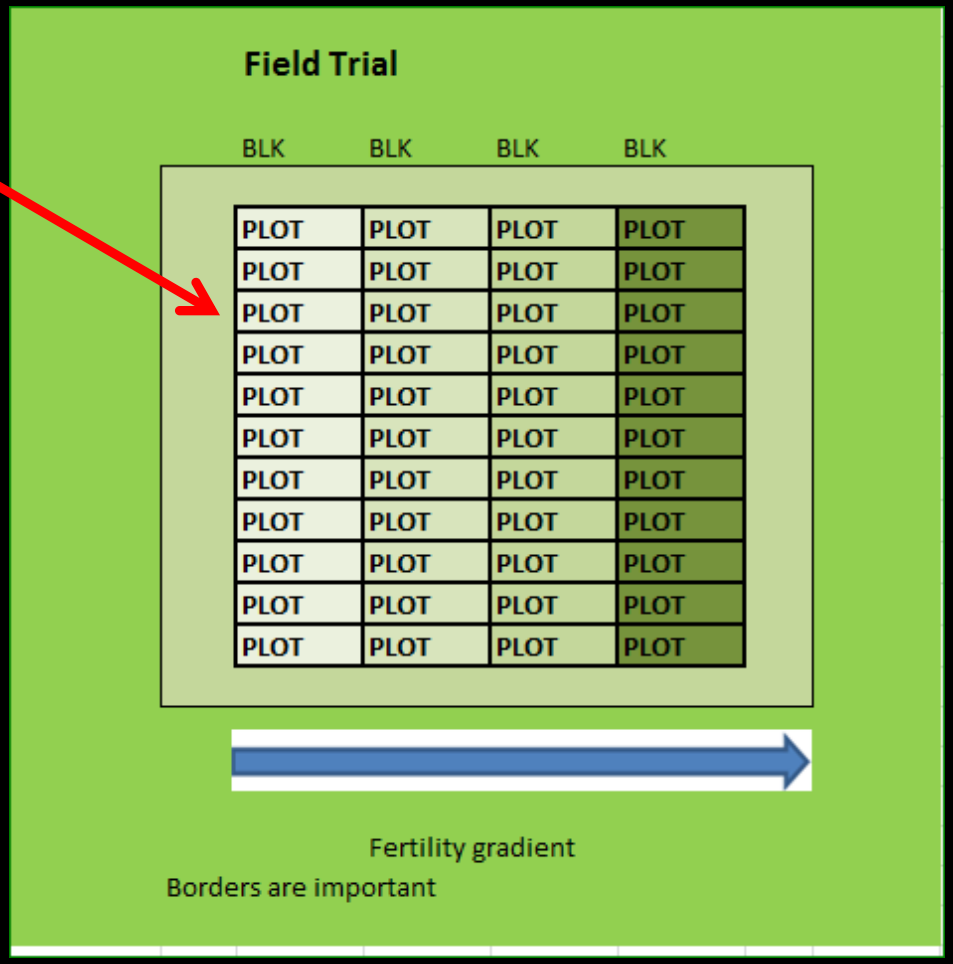
- Where are the fans?
- How is it cooled?
- What is the Humidity
- What is the light level
- Temperature
- Shade

- Here we are interested in a known and measurable gradient. Versus a Random variation which we can't plan for

Glasshouse trials are often arranged in blocks



Crop trials are often arranged in blocks Of land, and we need borders



Summary

- Three principles of design
- Assumptions for statistical testing
- Use of our sampling knowledge in research planning