

IPM of Date Palm Insect Pests and Diseases

Training Course

Statistical Designs and Analysis of IPM data of Date Palm Pests
(Basics, RCBD and Incomplete Block Designs)

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Venue: Muscat, Oman

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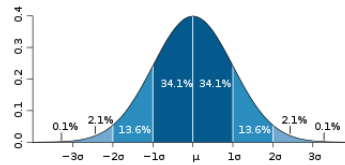
Fisher's Principles of Experimentation

The 3 “R’s”

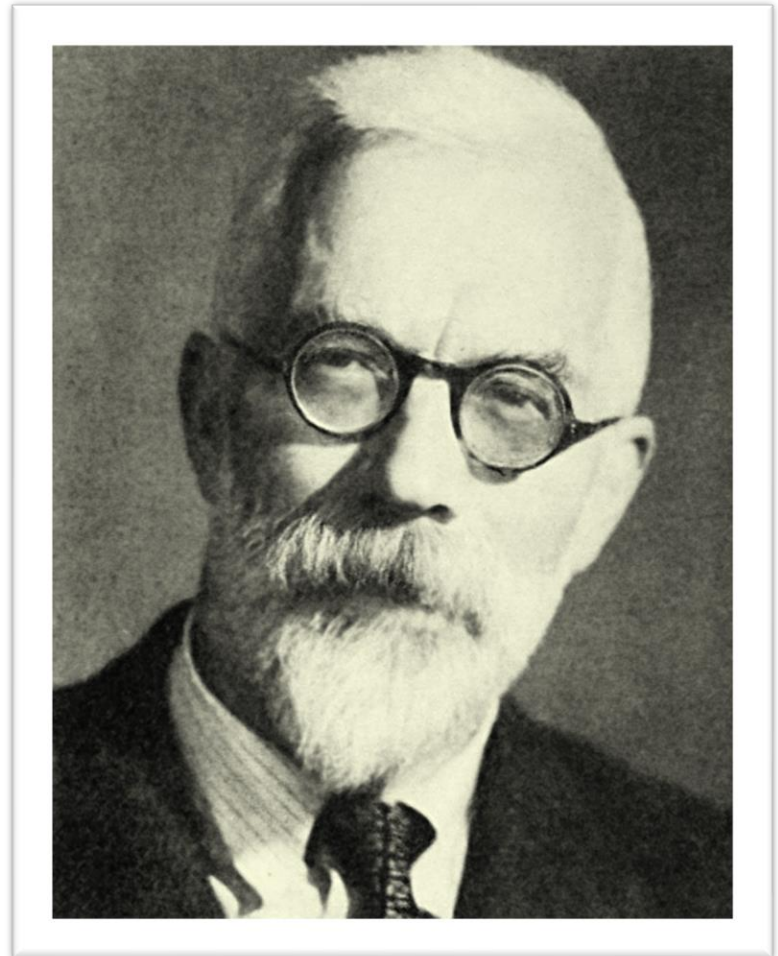
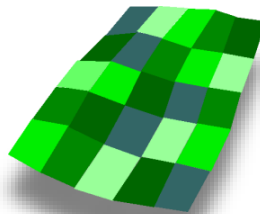
- Randomization



- Replication



- Local Control
(Reduce noise)



Sir Ronald Fisher

Randomized Complete Block Design (RCBD)

- **Randomization**

Representative unbiased responses.

- **Replication**

No replication, no estimation of experimental error.

$$SE(\text{mean}) = \frac{\sigma}{\sqrt{r}}$$

- **Local Control**

Homogeneity at design stage.



Randomization Test

List numbers from 1 to 12 in random order!

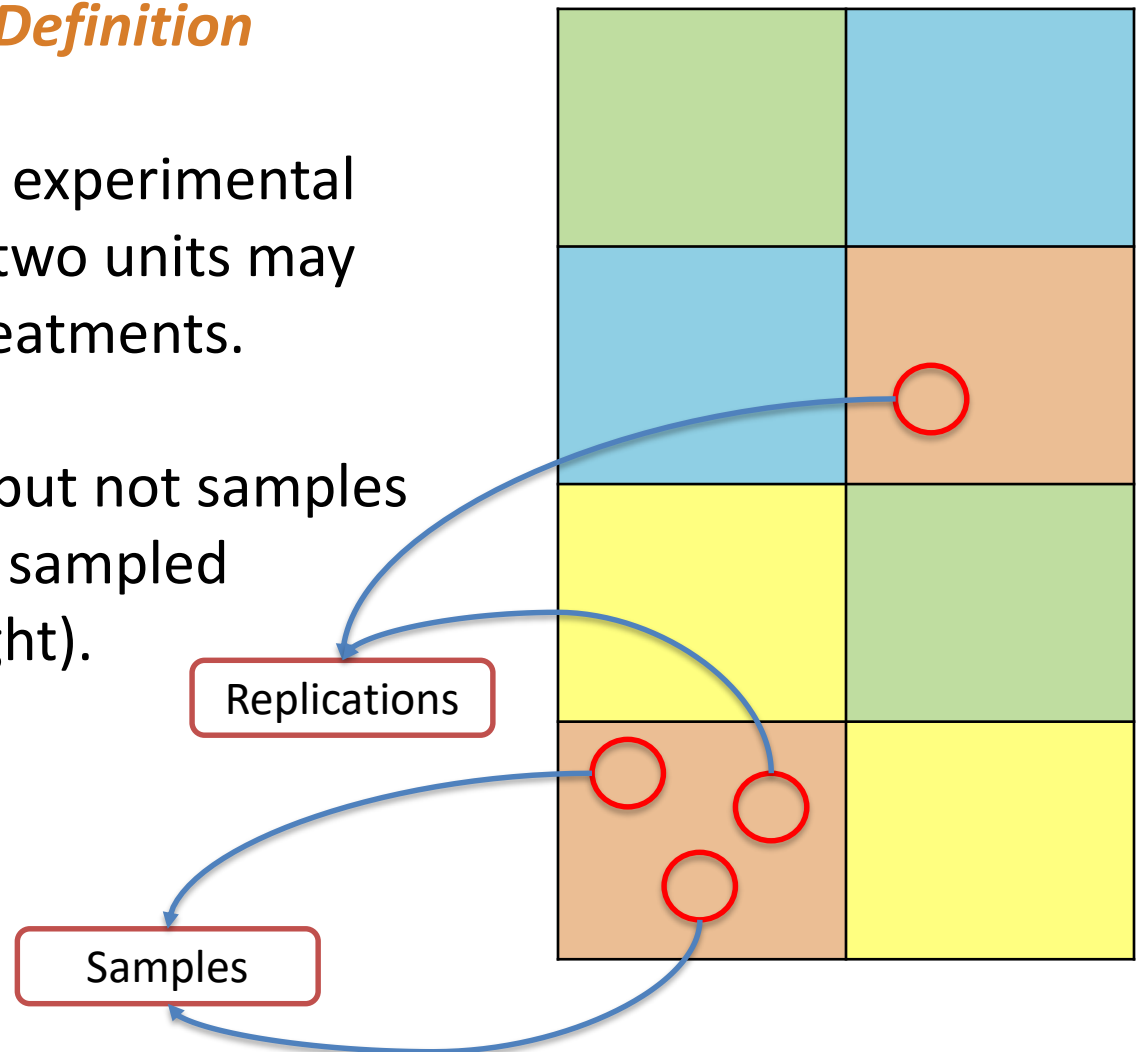


Sample vs. Replication

- *Experimental Unit Definition*

Smallest division of experimental area such that any two units may receive different treatments.

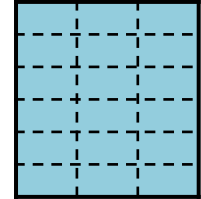
For example, plots but not samples in a plot (e.g. dates sampled to get average weight).



CRD, RCBD, and Alpha Designs

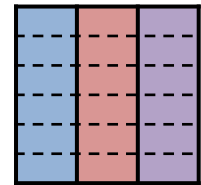
$$\text{Response} = \mu + \tau + \xi$$

(CRD)



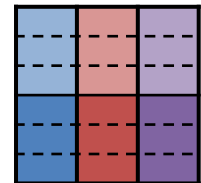
$$\text{Response} = \mu + \tau + \pi + \xi$$

(RCBD)



$$\text{Response} = \mu + \tau + \pi + \beta + \xi$$

(Alpha)



μ) grand mean

τ) effect of treatments

π) effect of replicates

β) effect of blocks

ξ) experimental error

Replication vs. Block

- **Replication:**
“Experimental units represents all treatment levels”
- **Block:**
“Homogeneous group of experimental units”

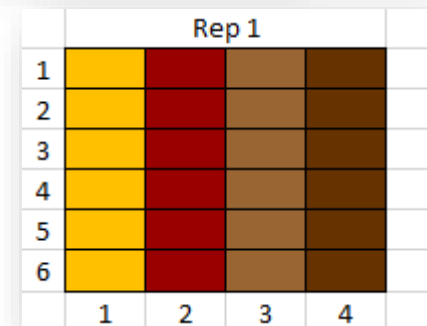
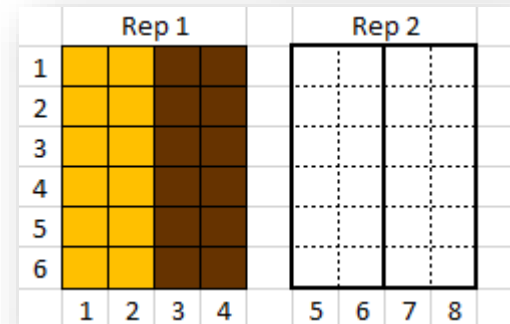
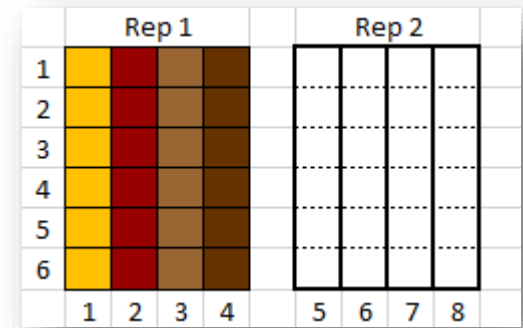
In RCB Design, Replication = Block

In Alpha Design, Replication > Block

What is the Right Block Size?

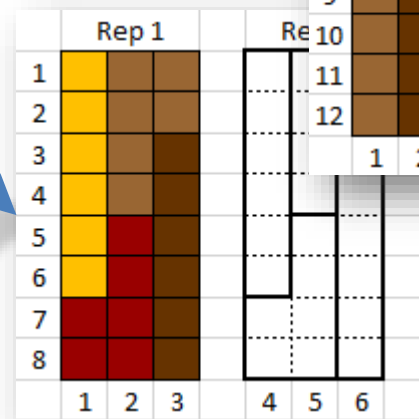
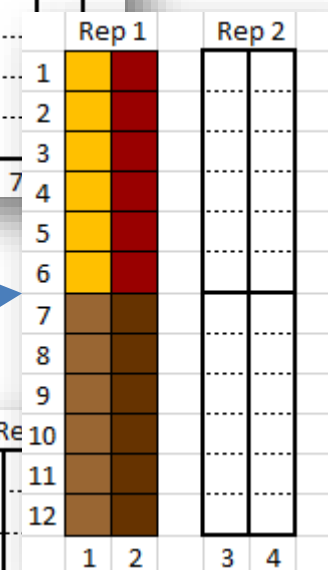
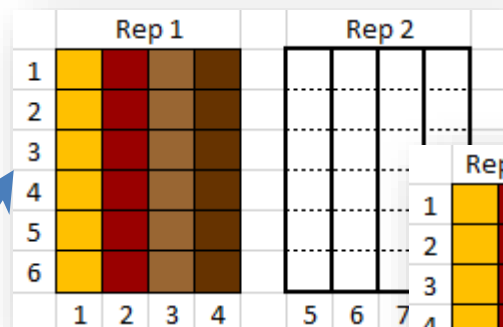
Do **NOT** ask biometrician that question! It is constrained by the physical arrangement of plots in the field, for example:

- Total number of treatments
- Field homogeneity
- Plot size
- Field layout (*i.e. rows & columns*)



Alpha Design Implementation (1)

<i>Rep</i>	<i>Block</i>	<i>Plot</i>
1	1	1
1	1	:
1	1	6
1	2	7
1	2	:
1	2	12
1	3	13
1	3	:
1	3	18
1	4	19
1	4	:
1	4	24

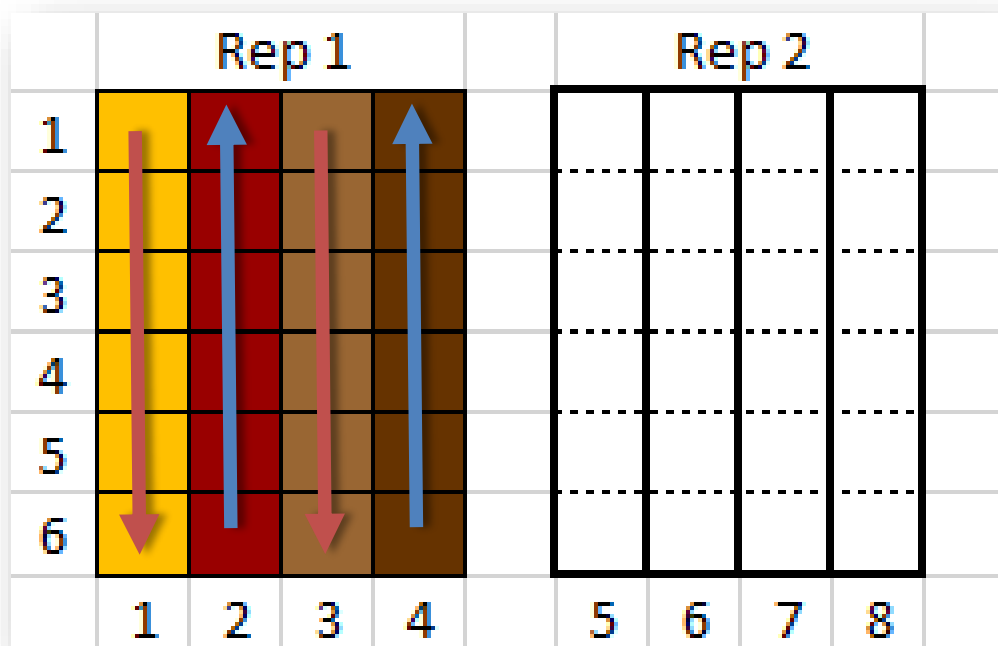


Alpha Design Implementation (2)

	Rep 1			
1	Yellow	Red	Brown	
2	Yellow	Red	Brown	
3	Yellow	Red	Brown	
4	Yellow	Red	Brown	
5	Yellow	Brown	Brown	
6	Yellow	Brown	Brown	
7	Red	Brown	Brown	
8	Red	Brown	Brown	
	1	2	3	

	Rep 1			Rep 2		
1	Yellow	Brown	Brown			
2	Yellow	Brown	Brown			
3	Yellow	Brown	Brown			
4	Yellow	Brown	Brown			
5	Yellow	Red	Brown			
6	Yellow	Red	Brown			
7	Red	Red	Brown			
8	Red	Red	Brown			
	1	2	3	4	5	6

Layout Information (1)



<i>Rep</i>	<i>Block</i>	<i>Col</i>	<i>Row</i>	<i>Plot</i>
1	1	1	1	1
1	1	1	:	:
1	1	1	6	6
1	2	2	6	7
1	2	2	:	:
1	2	2	1	12
1	3	3	1	13
1	3	3	:	:
1	3	3	6	18
1	4	4	6	19
1	4	4	:	:
1	4	4	1	24

Layout Information (2)

	Rep 1		Rep 2	
1	Yellow	Red		
2	Yellow	Red		
3	Yellow	Red		
4	Yellow	Red		
5	Yellow	Red		
6	Yellow	Red		
7	Brown	Brown		
8	Brown	Brown		
9	Brown	Brown		
10	Brown	Brown		
11	Brown	Brown		
12	Brown	Brown		
	1	2	3	4

<i>Rep</i>	<i>Block</i>	<i>Col</i>	<i>Row</i>	<i>Plot</i>
1	1	1	1	1
1	1	1	:	:
1	1	1	6	6
1	2	1	7	7
1	2	1	:	:
1	2	1	12	12
1	3	2	12	13
1	3	2	:	:
1	3	2	7	18
1	4	2	6	19
1	4	2	:	:
1	4	2	1	24

Meta Data

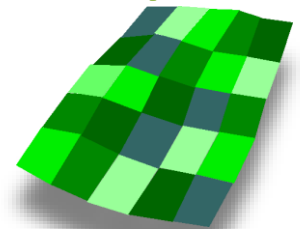
- **Experiment name**
- **Description**
- **Coordinator name**
- **Coordinator institute**
- **Coordinator contact information**



- **Location**
- **Province (state)**
- **Country**
- **Latitude**
- **Longitude**



- **Crop / genotypes**
- **List of treatments**
- **Season and cycle**
- **Experiment design**
- **Total number of entries**
- **Total number of plots**
- **Number of replications**
- **Block size (plots per block)**
- **Number of rows**
- **Number of columns**



Excel - Generate RCB Design

The screenshot illustrates the process of generating a Randomized Complete Block (RCB) design in Excel. It shows a data table with treatments and their corresponding random order values, the Sort menu set to 'Smallest to Largest', and a 'Sort Warning' dialog box that has appeared because the data is not contiguous.

	A	B
1	Treatment	Order
2	Pesticides A	=RAND()
3	Pesticides B	
4	Pesticides C	
5	Pesticides D	
6	Pesticides E	
7	Pesticides F	
8	Pesticides G	
9	Pesticides H	

	A	B	C
1	Treatment	Order	
2	Pesticides A	0.88311	
3	Pesticides B	0.89088	
4	Pesticides C	0.58081	
5	Pesticides D	0.23668	
6	Pesticides E	0.10171	
7	Pesticides F	0.79184	
8	Pesticides G	0.41665	
9	Pesticides H	0.79723	
10			

Sort & Filter
Sort Smallest to Largest
Lowest to highest.
[Tell me more](#)

Sort Warning
Microsoft Excel found data next to your selection. Since you have not selected this data, it will not be sorted.
What do you want to do?
 Expand the selection
 Continue with the current selection
Sort **Cancel**

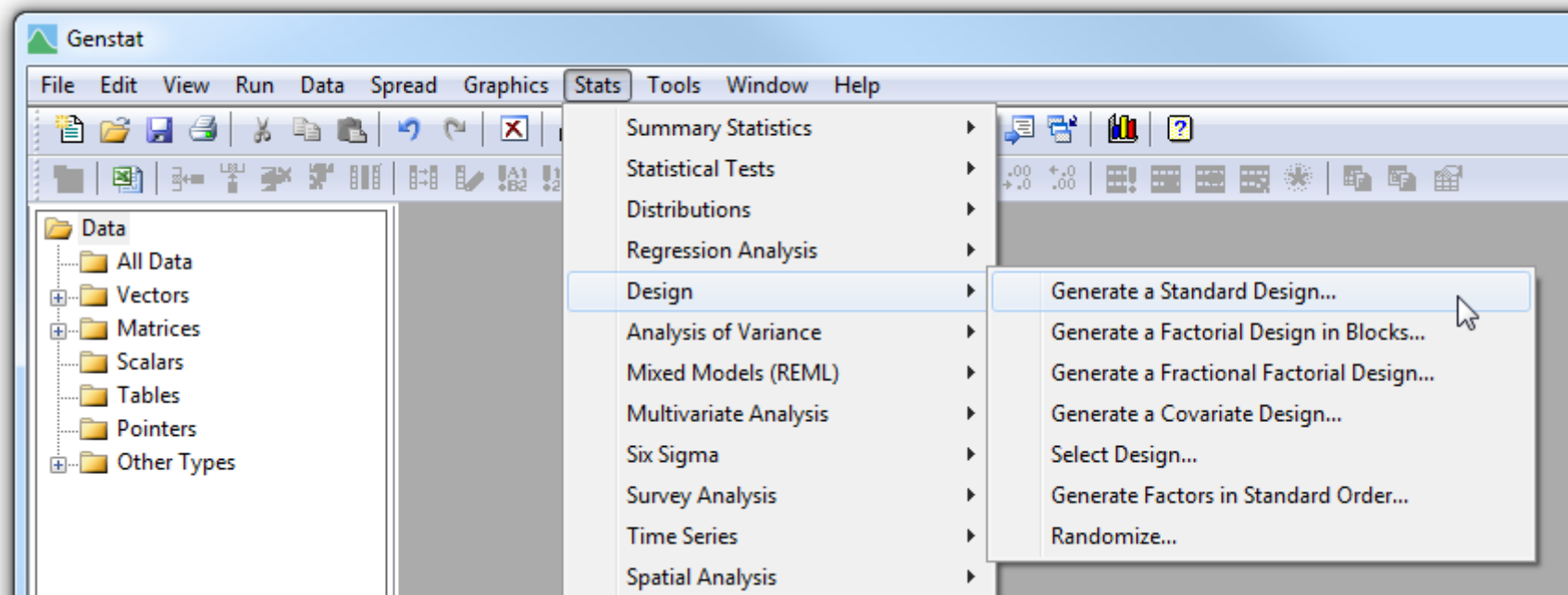
Excel - Generate RCB Design (*continue*)

	A	B	C
1	Treatment	Order	Plot
2	Pesticides E	0.07183	1
3	Pesticides A	0.27052	2
4	Pesticides F	0.35682	3
5	Pesticides H	0.61784	4
6	Pesticides B	0.63138	5
7	Pesticides G	0.87106	6
8	Pesticides C	0.87696	7
9	Pesticides D	0.89878	8



	A	B	C
1	Treatment	Rep	Plot
2	Pesticides E	1	1
3	Pesticides A	1	2
4	Pesticides F	1	3
5	Pesticides H	1	4
6	Pesticides B	1	5
7	Pesticides G	1	6
8	Pesticides C	1	7
9	Pesticides D	1	8

GenStat – Generate RCB Design



GenStat – Generate RCB Design (continue)

Generate a Standard Design

Design: One-way Design (in Randomized Blocks)

Design Factor _____ Name _____ Number of Levels _____

Blocks: Rep 3

Units within blocks: Plot

Treatment factor: Treatment 8

Options

Randomize design Number of Units: 24

Display design in a spreadsheet Randomization Seed: 8575

Replications required... Check Power...

Run Cancel Options... Defaults



Spreadsheet [Book:1]

Row	PlotNo	Rep	Plot	Treatment
1	11	1	1	1
2	12	1	2	5
3	13	1	3	3
4	14	1	4	8
5	15	1	5	4
6	16	1	6	6
7	17	1	7	7
8	18	1	8	2
9	21	2	1	6
10	22	2	2	5
11	23	2	3	3
12	24	2	4	8
13	25	2	5	4
14	26	2	6	2
15	27	2	7	1
16	28	2	8	7
17	31	3	1	3
18	32	3	2	5

GenStat – Generate Alpha Design

The screenshot shows the GenStat software interface. The main window is titled 'Genstat' and has a menu bar with 'File', 'Edit', 'View', 'Run', 'Data', 'Spread', 'Graphics', 'Stats', 'Tools', 'Window', and 'Help'. The 'Stats' menu is open, showing 'Summary Statistics' and 'Statistical Tests'. A dialog box titled 'Which type of design would you like to generate?' is displayed. It contains a list of design types with radio buttons. The 'alpha designs' option is selected. A mouse cursor is pointing at the 'alpha designs' option. Below the list are 'OK', 'Help', and 'Exit' buttons. In the foreground, a smaller dialog box asks 'How many treatments are there (20 to 100)?' with a text input field containing '24' and 'OK', 'Help', and 'Exit' buttons.

Genstat

File Edit View Run Data Spread Graphics Stats Tools Window Help

Summary Statistics
Statistical Tests

Data

- All Data
- Vectors
- Matrices
- Scalars
- Tables
- Pointers
- Other Types

Which type of design would you like to generate?

- orthogonal designs (randomized blocks, split-plots etc)
- complete or fractional factorials (with confounded interactions)
- factorial designs from a repertoire (with confounded interactions)
- fractional factorial designs from a repertoire (with blocking)
- square lattice designs
- lattice square designs
- complete and quasi-complete Latin squares
- alpha designs
- cyclic designs
- balanced-incomplete-blocks
- neighbour designs
- central composite designs
- Box-Behnken designs
- Plackett Burman (main effect) designs

OK Help Exit

How many treatments are there (20 to 100)?

24

OK Help Exit

GenStat – Generate Alpha Design *(continue)*

- How many blocks in each replicate? **6**
- How many replicates? **3**
- What would you like to call the treatment factor? **Treatments**
- What would you like to call the replicates factor? **Replicates**
- What would you like to call the block factor? **Blocks**
- What would you like to call the unit-within-block factor? **Plots**
- Seed for randomization (-1 for none)? **25185**
- Do you want to print the generator for the design? **No**
- Do you want to print the design? **Yes**

GenStat – Generate Alpha Design (*continue*)

Window Help

- Close All
- Cascade
- Tile Horizontally Alt+Shift+F4
- Tile Vertically Shift+F4
- Attach to Frame Ctrl+Shift+J
- Hide
- Next Ctrl+F6
- Previous Ctrl+Shift+F6
- Graphics Alt+0
- 1 Output
- 2 Input Log
- 3 Event Log
- 4 Start Page
- Windows...

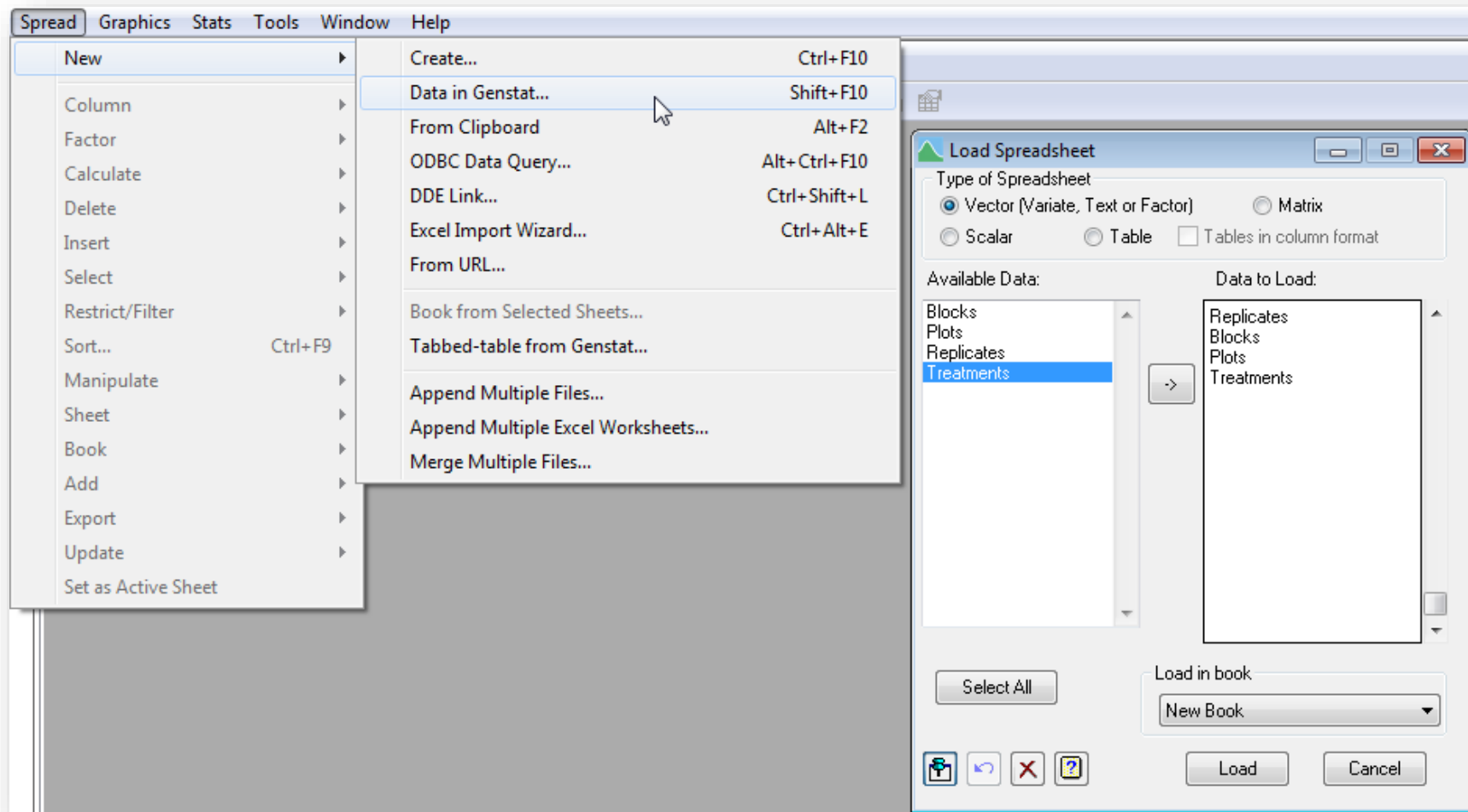
Output

```
80 DELETE [REDEFINE=yes] _statement
81 DESIGN [STATEMENT=_statement]
```

Treatments on each unit of the design

Replicates	Plots	1	2	3	4
1	Blocks				
	1	10	16	12	8
	2	1	7	6	19
	3	21	22	4	11
	4	18	24	2	14
	5	3	15	23	13
2	1	8	7	13	17
	2	2	16	1	21
	3	18	20	3	10
	4	19	12	23	11
	5	4	24	5	6
	6	14	15	9	22
3	1	7	3	4	16
	2	11	8	14	6
	3	24	12	15	17
	4	5	18	21	13
	5	23	1	9	10

GenStat – Generate Alpha Design (continue)



GenStat – Generate Alpha Design (continue)

Spreadsheet [Book1]

Row	Replicates	Blocks	Plots	Treatments
1	1	1	1	10
2	1	1	2	16
3	1	1	3	12
4	1	1	4	8
5	1	2	1	1
6	1	2	2	7
7	1	2	3	6
8	1	2	4	19
9	1	3	1	21
10	1	3	2	22
11	1	3	3	4
12	1	3	4	11
13	1	4	1	18
14	1	4	2	24
15	1	4	3	2
16	1	4	4	14
17	1	5	1	3

Output

Treatments on each unit of the design

Replicates	Plots	1	2	3	4
1	Blocks				
	1	10	16	12	8
	2	1	7	6	19
	3	21	22	4	11
	4	18	24	2	14
	5	3	15	23	13
2	6	5	20	17	9
	1	8	7	13	17
	2	2	16	1	21
	3	18	20	3	10
	4	19	12	23	11
	5	4	24	5	6
3	6	14	15	9	22
	1	7	3	4	16
	2	11	8	14	6
	3	24	12	15	17
	4	5	18	21	13
	5	23	1	9	10
	6	2	20	22	19

Thank You

Questions?



Japanese attitude for work:

If one can do it, I can do it. If no one can do it, I must do it.

Middle Eastern attitude for work:

Wallahi... if one can do it, let him do it.

If no one can do it, ya-habibi how can I do it?

Statistical Details (Skip if you'd like)

$$x_1, x_2, \dots, x_n \sim N(\mu, \sigma^2)$$

$$\bar{x} = \frac{\sum x_i}{n}$$

$$Var(x) = \frac{\sum (x_i - \bar{x})^2}{n}$$

$$SD(x) = \sigma = \sqrt{Var(x)}$$

$$Z_i = \frac{x_i - \bar{x}}{SD(x)} \sim N(0, 1)$$

$$t = \frac{\bar{x} - \mu}{SD(x)/\sqrt{n}} \sim t(n - 1)$$

