

# Genstat Markdown

## Reproducible Research with Genstat

James M. Curran

Yuxiao Wang

Simon Urbanek

David Baird

2025-12-28

### Reproducible research and Markdown

- **Reproducible research** ensures that scientific findings can be independently verified by others using the same data and methods.
- **Markdown** is a lightweight markup language used to format plain text into styled documents.
- Markdown plays a key role in supporting reproducibility by allowing researchers to combine code, results, and narrative text in a clear, lightweight format.
- Tools like **R Markdown** or **Jupyter Notebooks** use Markdown to embed executable code alongside explanations and outputs, making it easy to document workflows, share analyses, and regenerate results consistently across different environments.
- Neither Simon nor I know much about Jupyter Notebooks, but we do know about R Markdown...

### Why Genstat?



Some of you may know that this happened last November...

## Why Genstat?

- Genstat has a long history in biometrics.
- It has strengths that R does not.
- It still has a large user base who may find this functionality useful.

## Essential prerequisites

- (Access to) a valid Genstat licence.
- [Genstat Messenger](#)
- R and R Studio
- knitr, rmarkdown packages

## Registering a custom language engine for knitr

- Yihui Xie, author of knitr among other things, provides [documentation](#) on how to create a custom *engine* so that knitr can render the input and output of a custom language in a nicely formatted document.
- It is also, perhaps, rather stereotypical in that it is a minimal example that covers the basics and tells you none of the complexities.
- Complexities include:
  1. How do I communicate with the other software?
  2. How do I keep a *session* open with the other software?
  3. How do I handle graphics?
  4. How do I handle default chunk options?
  5. How do I handle custom chunk options?
  6. ...

## Communication and session persistence

Users of R Markdown rely on a couple of features:

1. The R interpreter/server is listening to their commands.
2. The R session remembers previous commands.

This may seem obvious, but a naïve mechanism to pass code and results back and forth is *batch processing*. This process:

1. Starts.
2. Reads commands from a script.
3. Writes results to file.

The script might just be a character string, and so might the outputs. The session in this process has **no persistence**.

---

### What do you mean “session has no persistence”?

It is very common to do something like this in R Markdown:

```
data(mtcars)
fit = lm(mpg ~ disp, data = mtcars)
```

and then later you might embed this in the text:

```
sprintf("%5.2f %%\n", summary(fit)$r.squared * 100)
```

This will not work unless the R session (or in this case the **environment**) containing the variable **fit** **persists** between the two chunks.

---

### Genstat Messenger I

- Most users interact with Genstat through the GUI, which talks to the Genstat Server.
  - It is possible to run Genstat in batch mode, but we lose session persistence.
  - Enter **Genstat Messenger**.
-

## Genstat Messenger Heroes





---

## Genstat Messenger II

Genstat Messenger:

- Keeps a connection to the Genstat Server open.

- Relays commands to the Genstat Server.
- Receives output from the Genstat Server:
  1. Text output is transmitted as either plain text or HTML.
  2. Graphs are returned via Base64 encoding.

## Okay, stop waffling. How do I use it?

1. Start Genstat Messenger
2. Open a new R Markdown (or Quarto) document in RStudio, and set the `knitr_engine` for Genstat:

```
```{r}
knitr::knit_engines$set(gs = gsengine::gs.engine())
```
```

**Note:** The choice of `gs` is arbitrary.

It is just a label we will use to tell `knitr` to use the Genstat engine.

3. Write a Genstat chunk:

```
```{gs}
PRINT 1.0
```
```

4. Compile!

## Does it work?

```
PRINT 1.0
```

Table 1

---

1.000

Yes, but that is not very exciting James! Let us take it up a notch:

```
VARIATE [VALUES=1,2,3] Foo
PRINT Foo
```

Table 2

---

|       |
|-------|
| Foo   |
| 1.000 |
| 2.000 |
| 3.000 |

---

### What else have you got?

As an example we will analyze the built-in Wheat Trials data set. It contains information from a crop trial in New Zealand with four different cultivars.

```
IMPORT [PRINT=*] '%DATA%/WheatTrials.xlsx'; SHEET='Trial A1'
TREATMENTS Cultivar
BLOCKS Rep
ANOVA [PRINT=aov; FPROB=yes; PSE=LSD] Mean_Population_m2
```

Analysis of variance

Table 3

| Source of variation | d.f. | s.s.    | m.s.  | v.r. | F pr. |
|---------------------|------|---------|-------|------|-------|
| Rep stratum         | 3    | 344.2   | 114.7 | 0.40 |       |
| Rep.*Units* stratum |      |         |       |      |       |
| Cultivar            | 12   | 4354.8  | 362.9 | 1.26 | 0.283 |
| Residual            | 36   | 10368.3 | 288.0 |      |       |

|       |    |         |
|-------|----|---------|
| Total | 51 | 15067.3 |
|-------|----|---------|

---

---

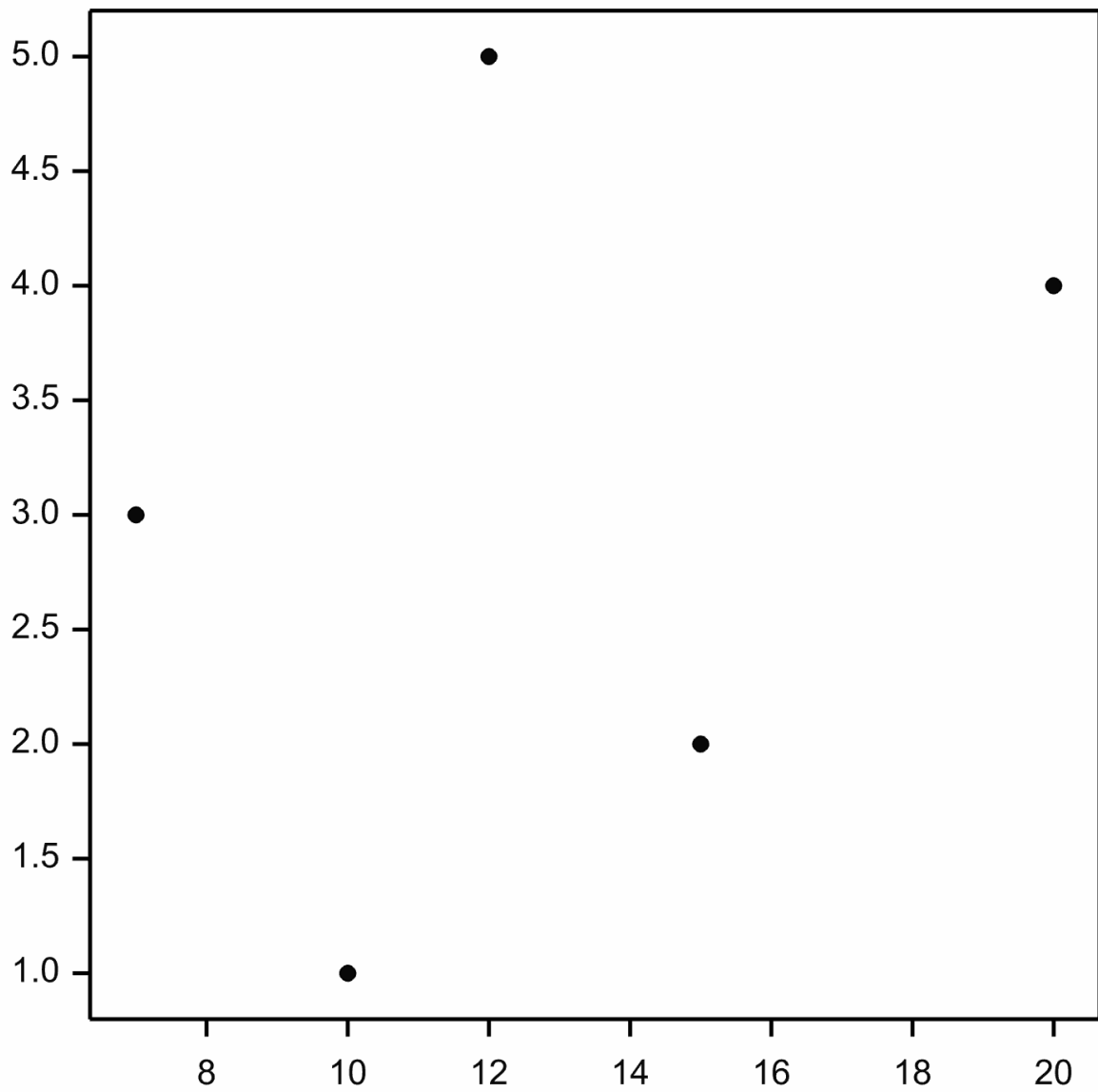
## What about graphics?

Genstat users are likely to want to include graphics in their reports. We can do that too.

Calls to Genstat's graphing procedures result in a PNG image, which are be displayed directly in the output document. These images are saved locally with filenames like 'graph\_1.png', 'graph\_2.png', etc.

Example:

```
DGRAPH !(1,2,3,4,5); !(10,15,7,20,12)
```



●  $!(1, \dots, 5) \vee !(10, \dots, 12)$

## Got anything else?

### Saving Genstat tables for further manipulation

A lot of Genstat output is in tabular format. Equally, it is a very common in reproducible research to want to include figures from tables. For example, a sum-of-squares value or an  $F$ -statistic. The current implementation in `gsengine` allows for three different modes of table retrieval. The package can:

1. Automatically assign all tables to a list to a name like `gs_tables_<chunklabel>`.
2. Assign a single table (if there is only one) or a list to a given name.
3. Return the first  $k$  tables to a list of  $k$  names.

We implement this through a chunk option `saveTables`.

- Option one is accessed through `saveTables=TRUE`.
- Option two might be something like `saveTables="aovTbls"`.
- Option three might be something like `saveTables=c("aovTbl", "meanTbl")`.

### A little bit of magic

We will run this chunk with `label="wheat_anova"`, `saveTables=TRUE`

```
IMPORT [PRINT=*] '%DATA%/WheatTrials.xlsx'; SHEET='Trial A1'
TREATMENTS Cultivar
BLOCKS Rep
ANOVA [FPROB=yes; PSE=LSD] Mean_Population_m2
```

This means that the ANOVA table will be stored in a list called `gs_tables_wheat_anova`. The first element of this list is the ANOVA table, and it is pretty unusable

```
str(gs_tables_wheat_anova[[1]])
```

```
'data.frame':  10 obs. of  6 variables:
 $ X1: chr  "Source of variation" "" "Rep stratum" "" ...
 $ X2: chr  "d.f." "" "3" "" ...
 $ X3: chr  "s.s." "" "344.2" "" ...
 $ X4: chr  "m.s." "" "114.7" "" ...
 $ X5: chr  "v.r." "" "0.40" "" ...
 $ X6: chr  "F pr." "" "" "" ...
- attr(*, "gen_head_major")= chr "Analysis of variance"
- attr(*, "gen_head_minor")= logi NA
- attr(*, "gen_table_id")= chr "gs-table-4"
```

## A little bit of magic

However, we can help...

```
anovatbl = gsengine::genstatAnovaToAnova(gs_tables_wheat_anova[[1]])
anovatbl
```

### Analysis of Variance Table

|             | Df | Sum Sq  | Mean Sq | F value | Pr(>F) |
|-------------|----|---------|---------|---------|--------|
| Rep stratum | 3  | 344.2   | 114.7   | 0.40    |        |
| Cultivar    | 12 | 4354.8  | 362.9   | 1.26    | 0.283  |
| Residual    | 36 | 10368.3 | 288.0   |         |        |
| Total       | 51 | 15067.3 |         |         |        |

```
class(anovatbl)
```

```
[1] "anova"      "data.frame"
```

- This is, in some sense quite unusual behaviour, in that R Markdown was not really built to facilitate transport of objects between languages.
- However, given that all output comes back from Genstat as tables, it does offer a way to access information for reports.

## Some caveats

- Currently all of our work is with HTML output from Genstat.
  1. PDF production is handled through **pandoc**—specifically converting HTML to LaTeX.
  2. This works okay for a report, but not so well for Beamer.
- There has **not** been extensive testing.
- There are some bugs in the save table code I have to fix.

## Acknowledgements

- David Baird and VSNi
- Simon Urbanek
- Yuxiao Wang for taking this project on
- ChatGPT
- Emi Tanaka