

# MAOC and POC

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## Contents

<b>Necessary libraries</b>	<b>1</b>
<b>Data Organisation</b>	<b>2</b>
Read from excel . . . . .	2
Change variable type . . . . .	2
<b>Calculating (g C kg<sup>-1</sup> soil for each fraction)</b>	<b>3</b>
ANOVA and Tukey . . . . .	5
POC Graph . . . . .	7
<b>MAOC</b>	<b>8</b>
ANOVA and Tukey . . . . .	8
MAOC Graph . . . . .	10
<b>SOC</b>	<b>11</b>
ANOVA and Tukey . . . . .	11
SOC Graph . . . . .	13
<b>Combine all into 1 figure</b>	<b>15</b>

## Necessary libraries

```
library(knitr)
library(ggplot2)
theme_set(theme_bw())
library(emmeans)
library(multcomp)
library(PLS205)
library(lme4)
library(lmerTest)
library(multcompView)
library(car)
library(Rmisc)
```

```
library(dplyr) #https://r4ds.had.co.nz/ (Chapter 3, Chapter 5, look at filter and select)
# https://bookdown.org/ansellbr/WEHI_tidyR_course_book/
library(stringr)
library(data.table)
library(GGally)
library(formatR)
library(readxl)
library(ggpubr)
library(xlsx)
```

## Data Organisation

### Read from excel

```
master <- read_excel("MAOC_POC_forR.xlsx", sheet = 2)
str(master)
```

```
## tibble [35 x 10] (S3: tbl_df/tbl/data.frame)
##  $ Sample           : chr [1:35] "101-106 MAOM" "107-112 MAOM" "201-206 MAOM" "207-212 MAOM" ...
##  $ Treatment        : chr [1:35] "RF" "CR" "RF" "CR" ...
##  $ Year              : num [1:35] 2021 2021 2021 2021 2021 ...
##  $ Blk               : num [1:35] 1 1 2 2 3 3 4 4 5 5 ...
##  $ Fraction          : chr [1:35] "MAOM" "MAOM" "MAOM" "MAOM" ...
##  $ Post_shaking_total_weight_g: num [1:35] 9.92 9.92 9.84 9.84 9.9 9.92 9.8 9.8 9.86 9.92 ...
##  $ Fraction_weight_g : num [1:35] 7.88 7.62 7.64 7.56 7.86 7.9 7.24 7.78 7.84 7.56 ...
##  $ Microbalance_Weight_mg : num [1:35] 30.4 30.4 30 30.2 29.9 ...
##  $ Nitrogen_percent    : num [1:35] 0.14 0.15 0.14 0.14 0.14 0.15 0.13 0.13 0.14 0.14 ...
##  $ Carbon_percent     : num [1:35] 1.44 1.58 1.47 1.41 1.35 1.48 1.27 1.2 1.46 1.37 ...
```

### Change variable type

```
master <- mutate_if(master, is.character, as.factor)
master$Blk <- as.factor(master$Blk)
master$Year <- as.factor(master$Year)

str(master)
```

```
## tibble [35 x 10] (S3: tbl_df/tbl/data.frame)
##  $ Sample           : Factor w/ 35 levels "101-106 MAOM",...: 1 3 5 7 9 11 13 15 17 19 ...
##  $ Treatment        : Factor w/ 2 levels "CR","RF": 2 1 2 1 2 1 2 1 2 1 ...
##  $ Year              : Factor w/ 3 levels "2021","2022",...: 1 1 1 1 1 1 2 2 2 2 ...
##  $ Blk               : Factor w/ 9 levels "1","2","3","4",...: 1 1 2 2 3 3 4 4 5 5 ...
##  $ Fraction          : Factor w/ 2 levels "MAOM","POM": 1 1 1 1 1 1 1 1 1 1 ...
##  $ Post_shaking_total_weight_g: num [1:35] 9.92 9.92 9.84 9.84 9.9 9.92 9.8 9.8 9.86 9.92 ...
##  $ Fraction_weight_g : num [1:35] 7.88 7.62 7.64 7.56 7.86 7.9 7.24 7.78 7.84 7.56 ...
##  $ Microbalance_Weight_mg : num [1:35] 30.4 30.4 30 30.2 29.9 ...
##  $ Nitrogen_percent    : num [1:35] 0.14 0.15 0.14 0.14 0.14 0.15 0.13 0.13 0.14 0.14 ...
##  $ Carbon_percent     : num [1:35] 1.44 1.58 1.47 1.41 1.35 1.48 1.27 1.2 1.46 1.37 ...
```

```
head(master)
```

```
## # A tibble: 6 x 10
##   Sample Treatment Year   Blk   Fraction Post_shaking_total_w~1 Fraction_weight_g
##   <fct>   <fct>     <fct> <fct> <fct>                <dbl>                <dbl>
## 1 101-1~ RF       2021   1   MAOM                9.92                7.88
## 2 107-1~ CR       2021   1   MAOM                9.92                7.62
## 3 201-2~ RF       2021   2   MAOM                9.84                7.64
## 4 207-2~ CR       2021   2   MAOM                9.84                7.56
## 5 301-3~ RF       2021   3   MAOM                9.9                7.86
## 6 307-3~ CR       2021   3   MAOM                9.92                7.9
## # i abbreviated name: 1: Post_shaking_total_weight_g
## # i 3 more variables: Microbalance_Weight_mg <dbl>, Nitrogen_percent <dbl>,
## #   Carbon_percent <dbl>
```

## Calculating (g C kg<sup>-1</sup> soil for each fraction)

```
master$C_soil_g_per_kg <- (master$Fraction_weight_g/master$Post_shaking_total_weight_g)*master$Carbon_p
write.xlsx(master, file = "MAOC_POC_Levels.xlsx", sheetName = "1")
```

```
POC <- master %>% filter(Fraction == "POM")
str(POC)
```

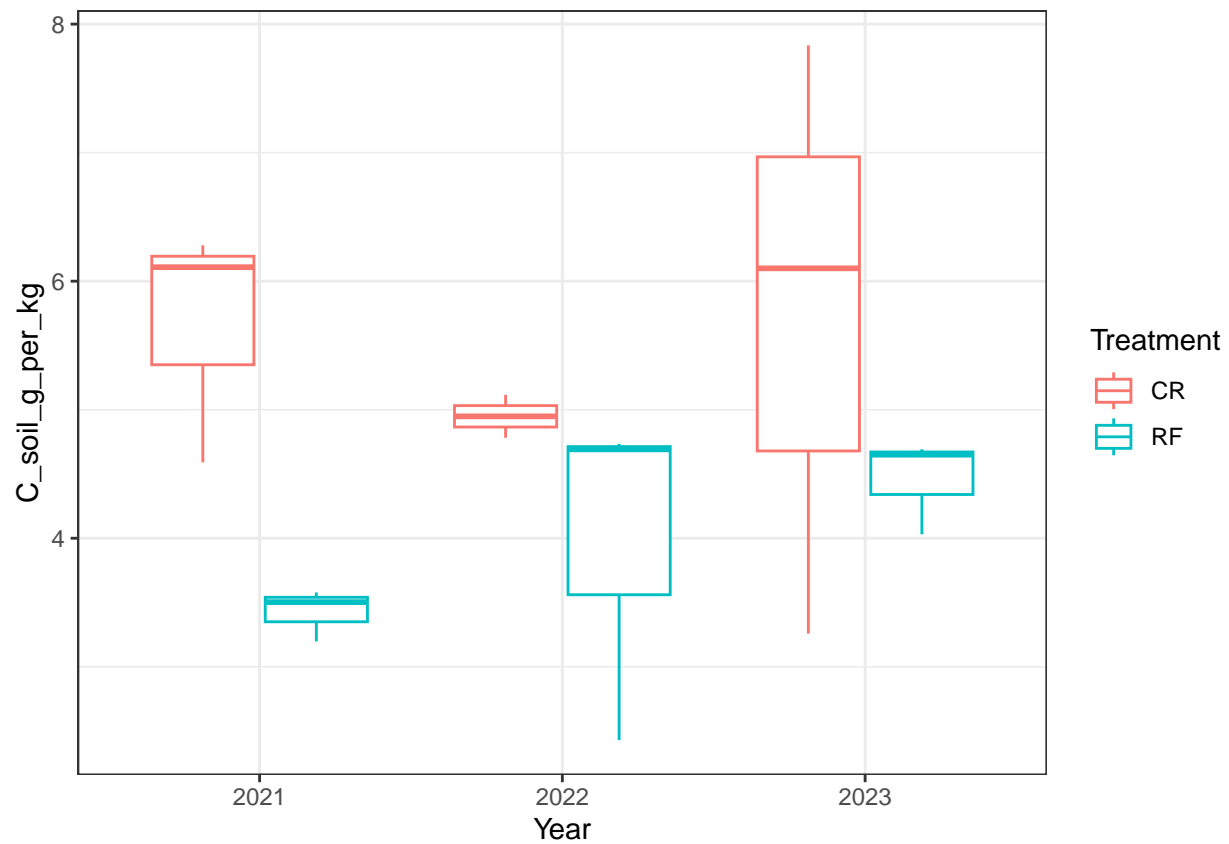
```
## tibble [17 x 11] (S3: tbl_df/tbl/data.frame)
##  $ Sample           : Factor w/ 35 levels "101-106 MAOM",...: 2 4 6 8 10 12 14 16 18 20 ...
##  $ Treatment        : Factor w/ 2 levels "CR","RF": 2 1 2 1 2 1 2 1 2 1 ...
##  $ Year              : Factor w/ 3 levels "2021","2022",...: 1 1 1 1 1 1 2 2 2 2 ...
##  $ Blk              : Factor w/ 9 levels "1","2","3","4",...: 1 1 2 2 3 3 4 4 5 5 ...
##  $ Fraction         : Factor w/ 2 levels "MAOM","POM": 2 2 2 2 2 2 2 2 2 2 ...
##  $ Post_shaking_total_weight_g: num [1:17] 9.92 9.92 9.84 9.84 9.9 9.92 9.8 9.8 9.86 9.92 ...
##  $ Fraction_weight_g : num [1:17] 2.04 2.3 2.2 2.28 2.04 ...
##  $ Microbalance_Weight_mg : num [1:17] 29.5 29.9 29.9 30.2 30.3 ...
##  $ Nitrogen_percent    : num [1:17] 0.1 0.1 0.07 0.12 0.1 0.14 0.05 0.1 0.12 0.1 ...
##  $ Carbon_percent     : num [1:17] 1.74 1.98 1.43 2.71 1.7 3 0.93 2.32 2.29 2.15 ...
##  $ C_soil_g_per_kg    : num [1:17] 3.58 4.59 3.2 6.28 3.5 ...
```

```
MAOC <- master %>% filter(Fraction == "MAOM")
str(MAOC)
```

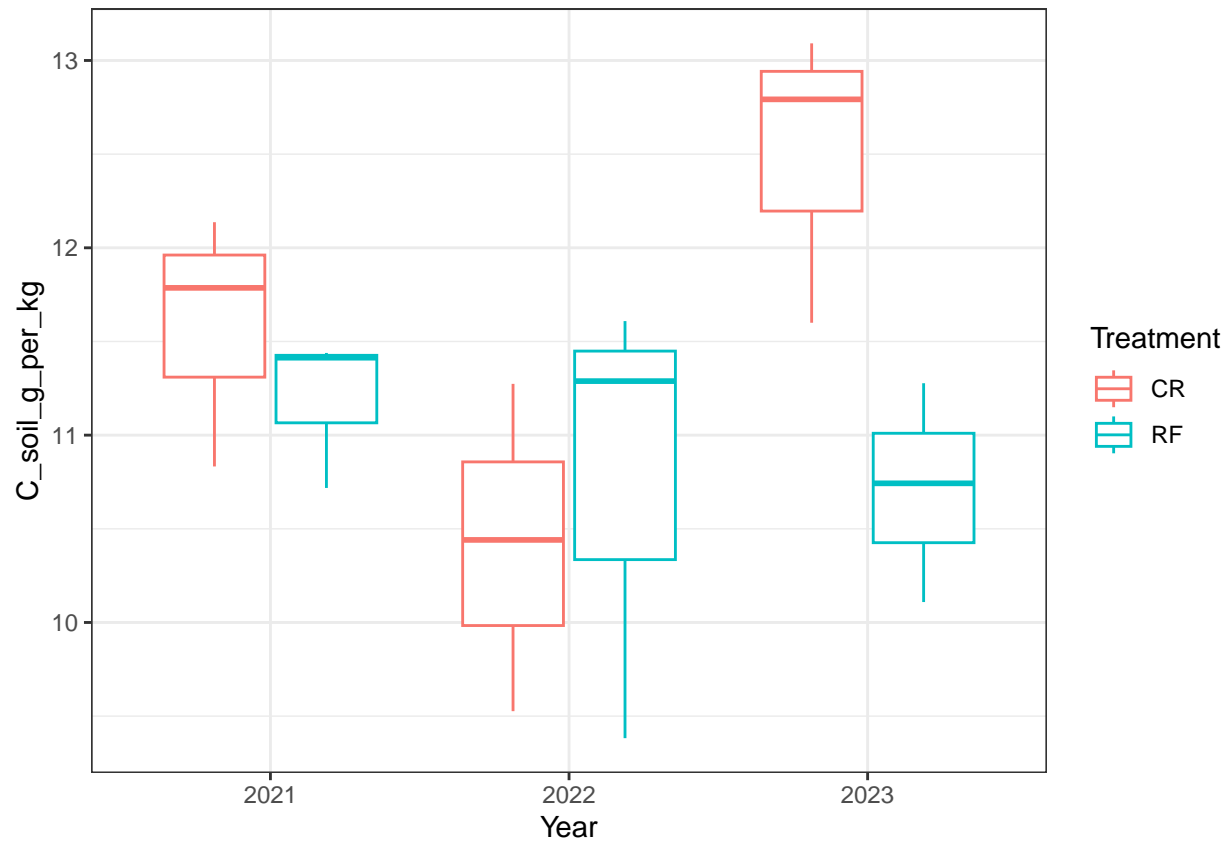
```
## tibble [18 x 11] (S3: tbl_df/tbl/data.frame)
##  $ Sample           : Factor w/ 35 levels "101-106 MAOM",...: 1 3 5 7 9 11 13 15 17 19 ...
##  $ Treatment        : Factor w/ 2 levels "CR","RF": 2 1 2 1 2 1 2 1 2 1 ...
##  $ Year              : Factor w/ 3 levels "2021","2022",...: 1 1 1 1 1 1 2 2 2 2 ...
##  $ Blk              : Factor w/ 9 levels "1","2","3","4",...: 1 1 2 2 3 3 4 4 5 5 ...
##  $ Fraction         : Factor w/ 2 levels "MAOM","POM": 1 1 1 1 1 1 1 1 1 1 ...
##  $ Post_shaking_total_weight_g: num [1:18] 9.92 9.92 9.84 9.84 9.9 9.92 9.8 9.8 9.86 9.92 ...
##  $ Fraction_weight_g : num [1:18] 7.88 7.62 7.64 7.56 7.86 7.9 7.24 7.78 7.84 7.56 ...
##  $ Microbalance_Weight_mg : num [1:18] 30.4 30.4 30 30.2 29.9 ...
```

```
## $ Nitrogen_percent      : num [1:18] 0.14 0.15 0.14 0.14 0.14 0.15 0.13 0.13 0.14 0.14 ...
## $ Carbon_percent        : num [1:18] 1.44 1.58 1.47 1.41 1.35 1.48 1.27 1.2 1.46 1.37 ...
## $ C_soil_g_per_kg       : num [1:18] 11.4 12.1 11.4 10.8 10.7 ...
```

```
ggplot(POC, aes(y=C_soil_g_per_kg, x=Year, color=Treatment)) + geom_boxplot()
```



```
ggplot(MAOC, aes(y=C_soil_g_per_kg, x=Year, color=Treatment)) + geom_boxplot()
```



# POC

## ANOVA and Tukey

```
POC_model <- lm(C_soil_g_per_kg ~ Treatment * Year, data = POC)
anova(POC_model)
```

```
## Analysis of Variance Table
##
## Response: C_soil_g_per_kg
##           Df Sum Sq Mean Sq F value Pr(>F)
## Treatment    1  10.3512   10.3512   6.9877 0.02285 *
## Year          2   1.2586    0.6293   0.4248 0.66418
## Treatment:Year 2   1.1824    0.5912   0.3991 0.68026
## Residuals    11  16.2948    1.4813
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

*#all pooled*

```
POC_means_all <- emmeans(POC_model, spec = 'Treatment')
```

## NOTE: Results may be misleading due to involvement in interactions

```
POC_effects_all <- contrast(POC_means_all, method = 'pairwise', adjust = "tukey")
summary(POC_effects_all)
```

```
## contrast estimate      SE df t.ratio p.value
## CR - RF              1.5 0.597 11    2.514  0.0288
##
## Results are averaged over the levels of: Year
```

```
cld(POC_means_all)
```

```
## Treatment emmean      SE df lower.CL upper.CL .group
## RF          3.95 0.406 11     3.05     4.84  1
## CR          5.45 0.438 11     4.48     6.41  2
##
## Results are averaged over the levels of: Year
## Confidence level used: 0.95
## significance level used: alpha = 0.05
## NOTE: If two or more means share the same grouping symbol,
##       then we cannot show them to be different.
##       But we also did not show them to be the same.
```

```
#by year
POC_means <- emmeans(POC_model, spec = 'Treatment', by = 'Year')
POC_effects <- contrast(POC_means, method = 'pairwise', adjust = "tukey")
summary(POC_effects)
```

```
## Year = 2021:
## contrast estimate      SE df t.ratio p.value
## CR - RF              2.233 0.994 11    2.248  0.0461
##
## Year = 2022:
## contrast estimate      SE df t.ratio p.value
## CR - RF              0.997 1.111 11    0.897  0.3889
##
## Year = 2023:
## contrast estimate      SE df t.ratio p.value
## CR - RF              1.273 0.994 11    1.281  0.2265
```

```
cld(POC_means)
```

```
## Year = 2021:
## Treatment emmean      SE df lower.CL upper.CL .group
## RF          3.43 0.703 11     1.88     4.97  1
## CR          5.66 0.703 11     4.11     7.21  2
##
## Year = 2022:
## Treatment emmean      SE df lower.CL upper.CL .group
## RF          3.95 0.703 11     2.41     5.50  1
## CR          4.95 0.861 11     3.05     6.84  1
##
## Year = 2023:
```

```
## Treatment emmean SE df lower.CL upper.CL .group
## RF 4.46 0.703 11 2.91 6.00 1
## CR 5.73 0.703 11 4.18 7.28 1
##
## Confidence level used: 0.95
## significance level used: alpha = 0.05
## NOTE: If two or more means share the same grouping symbol,
## then we cannot show them to be different.
## But we also did not show them to be the same.
```

## POC Graph

```
POC_graphing <- POC %>% group_by(Treatment) %>%
mutate(C_soil_g_per_kg_se = sd(C_soil_g_per_kg)/sqrt(3)) %>%
  summarise(C_soil_g_per_kg = mean(C_soil_g_per_kg),
            C_soil_g_per_kg_se = mean(C_soil_g_per_kg_se))
```

```
## 'summarise()' has grouped output by 'Treatment'. You can override using the
## '.groups' argument.
```

```
POC_all <- POC %>% group_by(Treatment) %>%
mutate(C_soil_g_per_kg_se = sd(C_soil_g_per_kg)/sqrt(9)) %>%
  summarise(C_soil_g_per_kg = mean(C_soil_g_per_kg),
            C_soil_g_per_kg_se = mean(C_soil_g_per_kg_se)) %>%
  mutate(Year = "Average")
```

```
POC_graphing <- rbind(POC_graphing, POC_all)
```

```
POC_graph <-
ggplot(POC_graphing, aes(x= Year, y = C_soil_g_per_kg, fill = Treatment))+
  geom_bar(stat = "identity", position = "dodge", width = 0.7) +
  labs(x = "Year", y = "C_soil_g_per_kg", fill = "Treatment") +
  scale_fill_manual(values = c("#0072B2", "#FFCC66"), labels = c("Continuous rice (CR)", "Fallow rice (FR)")) +
  geom_errorbar(aes(ymin=C_soil_g_per_kg-C_soil_g_per_kg_se, ymax=C_soil_g_per_kg+C_soil_g_per_kg_se), width = 0.5) +
  scale_y_continuous(name=expression("POC (g kg-1*)"), limits = c(0, 22), expand = c(0, 0)) +
  scale_x_discrete(name="")+
  theme_classic()+
  theme(axis.text = element_text(size = 12), axis.title = element_text(size=14))+
  theme(legend.position = "bottom", legend.text = element_text(size = 12))+
  theme(legend.title = element_blank(),
        legend.text = element_text(size = 16),
        axis.text.x = element_text(size = 14), # Increase size of x-axis text
        axis.text.y = element_text(size = 14), # Increase size of y-axis text
        axis.title.y = element_text(size = 14), # Increase size of y-axis title
        ) +
  annotate(
    "text",
    x = c(1,4), # X-axis positions for annotations
    y = c(6.5,7), # Y-axis positions for annotations
    label = "*",
    size = 10,
```

```

  vjust = 0 # Adjust vertical position of asterisks
)+
  annotate(
    "text",
    x = c(1), # X-axis positions for annotations
    y = c(20), # Y-axis positions for annotations
    label = "POC",
    size = 8,
    vjust = 0
  )+
  geom_segment(aes(x = 3.5, xend = 3.5, y = 0, yend = 20.5), color = "black", linetype = "dashed", size=

```

```

## Warning: Using 'size' aesthetic for lines was deprecated in ggplot2 3.4.0.
## i Please use 'linewidth' instead.
## This warning is displayed once every 8 hours.
## Call 'lifecycle::last_lifecycle_warnings()' to see where this warning was
## generated.

```

```

ggsave(POC_graph, filename = "POC_graph.png", height = 15, width = 20, units = "cm", dpi=1000)

```

## MAOC

### ANOVA and Tukey

```

MAOC_model <-lm(C_soil_g_per_kg~Treatment*Year, data = MAOC)
anova(MAOC_model)

```

```

## Analysis of Variance Table
##
## Response: C_soil_g_per_kg
##           Df Sum Sq Mean Sq F value Pr(>F)
## Treatment    1  1.6816   1.68158    2.6553 0.1292
## Year          2  3.4368   1.71839    2.7135 0.1066
## Treatment:Year 2  3.5116   1.75580    2.7725 0.1024
## Residuals    12  7.5994   0.63329

```

```

#all pooled

```

```

MAOC_means_all <- emmeans(MAOC_model, spec = 'Treatment')

```

```

## NOTE: Results may be misleading due to involvement in interactions

```

```

MAOC_effects_all <- contrast(MAOC_means_all, method = 'pairwise', adjust = "tukey")
summary(MAOC_effects_all)

```

```

## contrast estimate    SE df t.ratio p.value
## CR - RF          0.611 0.375 12    1.630  0.1292
##
## Results are averaged over the levels of: Year

```



```
cld(MAOC_means_all)
```

```
## Treatment emmean SE df lower.CL upper.CL .group
## RF 10.9 0.265 12 10.3 11.5 1
## CR 11.5 0.265 12 10.9 12.1 1
##
## Results are averaged over the levels of: Year
## Confidence level used: 0.95
## significance level used: alpha = 0.05
## NOTE: If two or more means share the same grouping symbol,
## then we cannot show them to be different.
## But we also did not show them to be the same.
```

```
#by year
```

```
MAOC_means <- emmeans(MAOC_model, spec = 'Treatment', by = 'Year')
MAOC_effects <- contrast(MAOC_means, method = 'pairwise', adjust = "tukey")
summary(MAOC_effects)
```

```
## Year = 2021:
## contrast estimate SE df t.ratio p.value
## CR - RF 0.395 0.65 12 0.608 0.5544
##
## Year = 2022:
## contrast estimate SE df t.ratio p.value
## CR - RF -0.346 0.65 12 -0.533 0.6038
##
## Year = 2023:
## contrast estimate SE df t.ratio p.value
## CR - RF 1.785 0.65 12 2.747 0.0177
```

```
cld(MAOC_means)
```

```
## Year = 2021:
## Treatment emmean SE df lower.CL upper.CL .group
## RF 11.2 0.459 12 10.19 12.2 1
## CR 11.6 0.459 12 10.58 12.6 1
##
## Year = 2022:
## Treatment emmean SE df lower.CL upper.CL .group
## CR 10.4 0.459 12 9.41 11.4 1
## RF 10.8 0.459 12 9.76 11.8 1
##
## Year = 2023:
## Treatment emmean SE df lower.CL upper.CL .group
## RF 10.7 0.459 12 9.71 11.7 1
## CR 12.5 0.459 12 11.49 13.5 2
##
## Confidence level used: 0.95
## significance level used: alpha = 0.05
## NOTE: If two or more means share the same grouping symbol,
## then we cannot show them to be different.
## But we also did not show them to be the same.
```

## MAOC Graph

```
MAOC_graphing <- MAOC %>% group_by(Treatment, Year) %>%
mutate(C_soil_g_per_kg_se = sd(C_soil_g_per_kg)/sqrt(3)) %>%
  summarise(C_soil_g_per_kg = mean(C_soil_g_per_kg),
            C_soil_g_per_kg_se = mean(C_soil_g_per_kg_se))
```

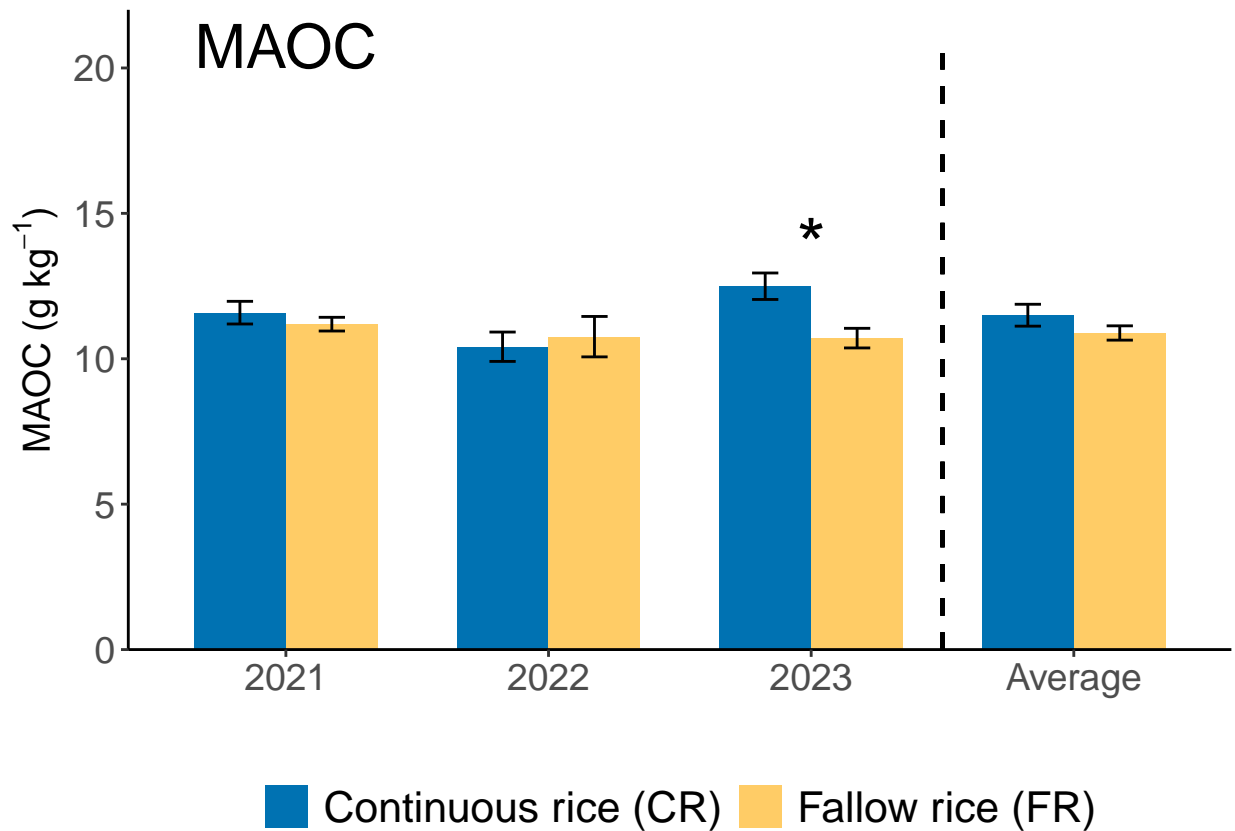
## 'summarise()' has grouped output by 'Treatment'. You can override using the  
## '.groups' argument.

```
MAOC_all <- MAOC %>% group_by(Treatment) %>%
mutate(C_soil_g_per_kg_se = sd(C_soil_g_per_kg)/sqrt(9)) %>%
  summarise(C_soil_g_per_kg = mean(C_soil_g_per_kg),
            C_soil_g_per_kg_se = mean(C_soil_g_per_kg_se)) %>%
  mutate(Year = "Average")
```

```
MAOC_graphing <- rbind(MAOC_graphing, MAOC_all)
```

```
MAOC_graph <-
ggplot(MAOC_graphing, aes(x= Year, y = C_soil_g_per_kg, fill = Treatment))+
  geom_bar(stat = "identity", position = "dodge", width = 0.7) +
  labs(x = "Year", y = "C_soil_g_per_kg", fill = "Treatment") +
  scale_fill_manual(values = c("#0072B2", "#FFCC66"), labels = c("Continuous rice (CR)", "Fallow rice (FR)")) +
  geom_errorbar(aes(ymin=C_soil_g_per_kg-C_soil_g_per_kg_se, ymax=C_soil_g_per_kg+C_soil_g_per_kg_se), width = 0.2) +
  scale_y_continuous(name=expression("MAOC (g kg"-1)*"), limits = c(0, 22), expand = c(0, 0))+
  scale_x_discrete(name="")+
  theme_classic()+
  theme(axis.text = element_text(size = 12), axis.title = element_text(size=14))+
  theme(legend.position = "bottom", legend.text = element_text(size = 12))+
  theme(legend.title = element_blank(),
        legend.text = element_text(size = 16),
        axis.text.x = element_text(size = 14), # Increase size of x-axis text
        axis.text.y = element_text(size = 14), # Increase size of y-axis text
        axis.title.y = element_text(size = 14), # Increase size of y-axis title
        ) +
  annotate(
    "text",
    x = c(3), # X-axis positions for annotations
    y = c(13), # Y-axis positions for annotations
    label = "*",
    size = 10,
    vjust = 0 # Adjust vertical position of asterisks
  )+
  annotate(
    "text",
    x = c(1), # X-axis positions for annotations
    y = c(20), # Y-axis positions for annotations
    label = "MAOC",
    size = 8,
    vjust = 0
  )+
  geom_segment(aes(x = 3.5, xend = 3.5, y = 0, yend = 20.5), color = "black", linetype = "dashed", size = 1)
```

MAOC\_graph



```
ggsave(MAOC_graph, filename = "MAOC_graph.png", height = 15, width = 20, units = "cm", dpi=1000)
```

## SOC

### ANOVA and Tukey

```
SOC <- read_excel("MAOC_POC_Levels_total_carbon_summed.xlsx", sheet = 1) %>% filter(Fraction=="All")

## New names:
## * ' ' -> '...1'

SOC <- mutate_if(SOC, is.character, as.factor)
SOC$Blk <- as.factor(SOC$Blk)
SOC$Year <- as.factor(SOC$Year)

SOC_model <- lm(C_soil_g_per_kg~Treatment*Year, data = SOC)
anova(SOC_model)
```

```
## Analysis of Variance Table
##
## Response: C_soil_g_per_kg
##           Df Sum Sq Mean Sq F value Pr(>F)
## Treatment    1 14.7572  14.7572   5.9311 0.03142 *
## Year          2 13.7162   6.8581   2.7563 0.10351
## Treatment:Year 2  9.7326   4.8663   1.9558 0.18399
## Residuals    12 29.8575   2.4881
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#all pooled
```

```
SOC_means_all <- emmeans(SOC_model, spec = 'Treatment')
```

```
## NOTE: Results may be misleading due to involvement in interactions
```

```
SOC_effects_all <- contrast(SOC_means_all, method = 'pairwise', adjust = "tukey")
summary(SOC_effects_all)
```

```
## contrast estimate    SE df t.ratio p.value
## CR - RF           1.81 0.744 12   2.435  0.0314
##
## Results are averaged over the levels of: Year
```

```
cld(SOC_means_all)
```

```
## Treatment emmean    SE df lower.CL upper.CL .group
## RF         14.8 0.526 12    13.7    16.0    1
## CR         16.6 0.526 12    15.5    17.8    2
##
## Results are averaged over the levels of: Year
## Confidence level used: 0.95
## significance level used: alpha = 0.05
## NOTE: If two or more means share the same grouping symbol,
##       then we cannot show them to be different.
##       But we also did not show them to be the same.
```

```
#by year
```

```
SOC_means <- emmeans(SOC_model, spec = 'Treatment', by = 'Year')
SOC_effects <- contrast(SOC_means, method = 'pairwise', adjust = "tukey")
summary(SOC_effects)
```

```
## Year = 2021:
## contrast estimate    SE df t.ratio p.value
## CR - RF           2.629 1.29 12   2.041  0.0639
##
## Year = 2022:
## contrast estimate    SE df t.ratio p.value
## CR - RF          -0.254 1.29 12  -0.197  0.8469
```

```
##
## Year = 2023:
## contrast estimate SE df t.ratio p.value
## CR - RF 3.058 1.29 12 2.374 0.0351

cld(SOC_means)

## Year = 2021:
## Treatment emmean SE df lower.CL upper.CL .group
## RF 14.6 0.911 12 12.6 16.6 1
## CR 17.2 0.911 12 15.3 19.2 1
##
## Year = 2022:
## Treatment emmean SE df lower.CL upper.CL .group
## CR 14.5 0.911 12 12.5 16.4 1
## RF 14.7 0.911 12 12.7 16.7 1
##
## Year = 2023:
## Treatment emmean SE df lower.CL upper.CL .group
## RF 15.2 0.911 12 13.2 17.2 1
## CR 18.2 0.911 12 16.2 20.2 2
##
## Confidence level used: 0.95
## significance level used: alpha = 0.05
## NOTE: If two or more means share the same grouping symbol,
## then we cannot show them to be different.
## But we also did not show them to be the same.
```

## SOC Graph

```
SOC_graphing <- SOC %>% group_by(Treatment, Year) %>%
mutate(C_soil_g_per_kg_se = sd(C_soil_g_per_kg)/sqrt(3)) %>%
summarise(C_soil_g_per_kg = mean(C_soil_g_per_kg),
C_soil_g_per_kg_se = mean(C_soil_g_per_kg_se))
```

```
## 'summarise()' has grouped output by 'Treatment'. You can override using the
## '.groups' argument.
```

```
SOC_all <- SOC %>% group_by(Treatment) %>%
mutate(C_soil_g_per_kg_se = sd(C_soil_g_per_kg)/sqrt(9)) %>%
summarise(C_soil_g_per_kg = mean(C_soil_g_per_kg),
C_soil_g_per_kg_se = mean(C_soil_g_per_kg_se)) %>%
mutate(Year = "Average")
```

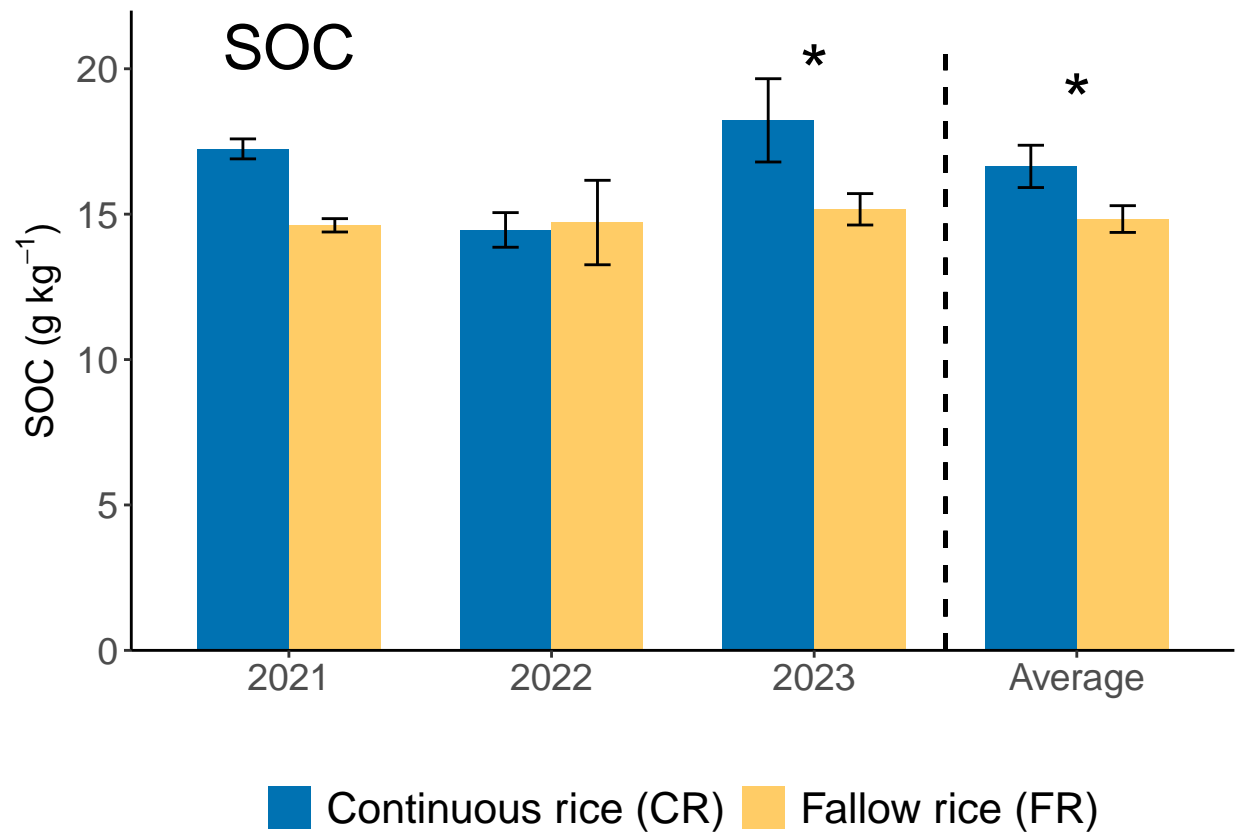
```
SOC_graphing <- rbind(SOC_graphing, SOC_all)
```

```
SOC_graph <-
ggplot(SOC_graphing, aes(x= Year, y = C_soil_g_per_kg, fill = Treatment))+
geom_bar(stat = "identity", position = "dodge", width = 0.7) +
labs(x = "Year", y = "C_soil_g_per_kg", fill = "Treatment") +
```

```

scale_fill_manual(values = c("#0072B2", "#FFCC66"), labels = c("Continuous rice (CR)", "Fallow rice (FR)", "Fallow rice (FR)"),
geom_errorbar(aes(ymin=C_soil_g_per_kg-C_soil_g_per_kg_se, ymax=C_soil_g_per_kg+C_soil_g_per_kg_se),
scale_y_continuous(name=expression("SOC (g kg"-1)*")), limits = c(0, 22), expand = c(0, 0))+
scale_x_discrete(name="")+
theme_classic()+
theme(axis.text = element_text(size = 12), axis.title = element_text(size=14))+
theme(legend.position = "bottom", legend.text = element_text(size = 12))+
theme(legend.title = element_blank(),
      legend.text = element_text(size = 16),
      axis.text.x = element_text(size = 14), # Increase size of x-axis text
      axis.text.y = element_text(size = 14), # Increase size of y-axis text
      axis.title.y = element_text(size = 14), # Increase size of y-axis title
    ) +
annotate(
  "text",
  x = c(3, 4), # X-axis positions for annotations
  y = c(19, 18), # Y-axis positions for annotations
  label = "*",
  size = 10,
  vjust = 0 # Adjust vertical position of asterisks
)+
annotate(
  "text",
  x = c(1), # X-axis positions for annotations
  y = c(20), # Y-axis positions for annotations
  label = "SOC",
  size = 8,
  vjust = 0
)+
geom_segment(aes(x = 3.5, xend = 3.5, y = 0, yend = 20.5), color = "black", linetype = "dashed", size=
SOC_graph

```



```
ggsave(SOC_graph, filename = "SOC_graph.png", height = 15, width = 20, units = "cm", dpi=1000)
```

Combine all into 1 figure

```
c_fractions_horizontal <- ggarrange(SOC_graph, POC_graph, MAOC_graph,
  #labels = c("2021", "2022", "2023"),
  ncol = 3,
  common.legend = TRUE,
  legend = "bottom")
ggsave(c_fractions_horizontal, filename = "c_fractions_horizontal.jpg", height = 15, width = 50, units = "cm", dpi=1000)
```