

# Phenols for manuscript

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## Necessary libraries

```
library(knitr)
library(rlang)
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(mgcv)
library(openxlsx)
```

## RES

```
RES <- read_excel("RES_25Jan2024.xlsx", sheet = 1)
RES <- mutate_if(RES, is.character, as.factor)
RES$Year <- as.factor(RES$Year)
```

```
str(RES)
```

```
## tibble [12 x 9] (S3: tbl_df/tbl/data.frame)
## $ Field      : Factor w/ 2 levels "CR","RF": 2 2 2 1 1 1 2 2 2 1 ...
## $ Study      : Factor w/ 1 level "RES": 1 1 1 1 1 1 1 1 1 1 ...
## $ Blk        : Factor w/ 6 levels "RES 1","RES 2",...: 1 2 3 1 2 3 4 5 6 4 ...
## $ Year       : Factor w/ 2 levels "2021","2022": 1 1 1 1 1 1 2 2 2 2 ...
## $ TotalP     : num [1:12] 0.212 0.2 0.21 0.233 0.22 ...
## $ TotalV     : num [1:12] 0.5 0.472 0.521 0.64 0.593 ...
## $ TotalC     : num [1:12] 0.464 0.413 0.579 0.739 0.659 ...
## $ TotalS     : num [1:12] 0.667 0.587 0.668 0.774 0.727 ...
## $ Total_phenols: num [1:12] 1.84 1.67 1.98 2.39 2.2 ...
```

```
Total_P_RES <- lmer(TotalP ~ Field*Year+(1|Blk), data=RES)
Total_P_means_RES <- emmeans(Total_P_RES, spec = 'Field')
```

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

```
Total_P_effects_RES <- contrast(Total_P_means_RES, method = 'pairwise', adjust = "tukey")
anova(Total_P_RES)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##           Sum Sq   Mean Sq NumDF DenDF F value    Pr(>F)
## Field      0.0000852 0.0000852     1     4  0.7064 0.447960
## Year       0.0044310 0.0044310     1     4 36.7307 0.003742 **
## Field:Year 0.0003708 0.0003708     1     4  3.0741 0.154419
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
cld(Total_P_means_RES)
```

```
## Field emmean      SE    df lower.CL upper.CL .group
## RF      0.189 0.00513 7.58    0.177    0.201 1
## CR      0.194 0.00513 7.58    0.182    0.206 1
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
## 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.
```

```
summary(Total_P_effects_RES)
```

```
## contrast estimate      SE df t.ratio p.value
## CR - RF    0.00533 0.00634  4    0.840  0.4480
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
```

```
Total_V_RES <- lmer(TotalV ~ Field*Year+(1|Blk), data=RES)
Total_V_means_RES <- emmeans(Total_V_RES, spec = 'Field')
```

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

```
Total_V_effects_RES <- contrast(Total_V_means_RES, method = 'pairwise', adjust = "tukey")
anova(Total_V_RES)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##              Sum Sq   Mean Sq NumDF DenDF F value  Pr(>F)
## Field         0.0144138 0.0144138     1     4  9.0905 0.03935 *
## Year          0.0315026 0.0315026     1     4 19.8681 0.01118 *
## Field:Year    0.0038789 0.0038789     1     4  2.4463 0.19285
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
cld(Total_V_means_RES)
```

```
## Field emmean      SE   df lower.CL upper.CL .group
## RF         0.458 0.0173 7.89    0.418    0.498    1
## CR         0.528 0.0173 7.89    0.488    0.568    2
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
## 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.
```

```
summary(Total_V_effects_RES)
```

```
## contrast estimate      SE df t.ratio p.value
## CR - RF    0.0693 0.023  4    3.015  0.0394
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
```

```
Total_C_RES <- lmer(TotalC ~ Field*Year+(1|Blk), data=RES)
```

```
## boundary (singular) fit: see help('isSingular')
```

```

Total_C_means_RES <- emmeans(Total_C_RES, spec = 'Field')

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

Total_C_effects_RES <- contrast(Total_C_means_RES, method = 'pairwise', adjust = "tukey")
anova(Total_C_RES)

## Type III Analysis of Variance Table with Satterthwaite's method
##              Sum Sq  Mean Sq NumDF DenDF F value    Pr(>F)
## Field          0.051635 0.051635     1     8 12.8822 0.007093 **
## Year           0.034450 0.034450     1     8  8.5948 0.018949 *
## Field:Year     0.008735 0.008735     1     8  2.1794 0.178113
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

cld(Total_C_means_RES)

##   Field emmean      SE df lower.CL upper.CL .group
## RF      0.459 0.0258   8    0.399    0.518    1
## CR      0.590 0.0258   8    0.530    0.649    2
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
## 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.

summary(Total_C_effects_RES)

##   contrast estimate      SE df t.ratio p.value
## CR - RF      0.131 0.0366   4   3.589 0.0230
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger

Total_S_RES <- lmer(Totals ~ Field*Year+(1|Blk), data=RES)
Total_S_means_RES <- emmeans(Total_S_RES, spec = 'Field')

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

Total_S_effects_RES <- contrast(Total_S_means_RES, method = 'pairwise', adjust = "tukey")
anova(Total_S_RES)

## Type III Analysis of Variance Table with Satterthwaite's method
##              Sum Sq  Mean Sq NumDF DenDF F value    Pr(>F)
## Field          0.010606 0.010606     1     4  4.3546 0.1052
## Year           0.016718 0.016718     1     4  6.8643 0.0588 .
## Field:Year     0.003826 0.003826     1     4  1.5710 0.2783
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```
cld(Total_S_means_RES)
```

```
## Field emmean SE df lower.CL upper.CL .group
## RF 0.610 0.0235 7.46 0.555 0.665 1
## CR 0.669 0.0235 7.46 0.614 0.724 1
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
## 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.
```

```
summary(Total_S_effects_RES)
```

```
## contrast estimate SE df t.ratio p.value
## CR - RF 0.0595 0.0285 4 2.087 0.1052
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
```

```
Total_phenols_RES <- lmer(Total_phenols ~ Field*Year+(1|Blk), data=RES)
Total_phenols_means_RES <- emmeans(Total_phenols_RES, spec = 'Field')
```

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

```
Total_phenols_effects_RES <- contrast(Total_phenols_means_RES, method = 'pairwise', adjust = "tukey")
anova(Total_phenols_RES)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
## Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## Field 0.21114 0.21114 1 4 7.8280 0.04892 *
## Year 0.37700 0.37700 1 4 13.9770 0.02015 *
## Field:Year 0.05610 0.05610 1 4 2.0799 0.22271
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
cld(Total_phenols_means_RES)
```

```
## Field emmean SE df lower.CL upper.CL .group
## RF 1.72 0.0685 7.99 1.56 1.87 1
## CR 1.98 0.0685 7.99 1.82 2.14 2
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
## 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.
```

```
summary(Total_phenols_effects_RES)
```

```
## contrast estimate      SE df t.ratio p.value
## CR - RF      0.265 0.0948  4    2.798  0.0489
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
```

## Regional Survey

```
Growers <- read_excel("Regional_survey_25Jan2024.xlsx", sheet = 1)
Growers <- mutate_if(Growers, is.character, as.factor)
Growers$Year <- as.factor(Growers$Year)

str(Growers)
```

```
## tibble [18 x 11] (S3: tbl_df/tbl/data.frame)
## $ Field      : Factor w/ 2 levels "CR","RF": 2 2 2 2 1 1 1 1 1 1 ...
## $ Study      : Factor w/ 1 level "Grower": 1 1 1 1 1 1 1 1 1 1 ...
## $ Site       : num [1:18] 3 1 4 2 3 4 2 1 7 5 ...
## $ TotalP     : num [1:18] 0.162 0.14 0.177 0.202 0.182 ...
## $ TotalV     : num [1:18] 0.387 0.313 0.408 0.495 0.443 ...
## $ TotalC     : num [1:18] 0.302 0.161 0.328 0.353 0.648 ...
## $ TotalS     : num [1:18] 0.435 0.402 0.563 0.666 0.609 ...
## $ Total_phenols: num [1:18] 1.29 1.02 1.48 1.72 1.88 ...
## $ Year       : Factor w/ 2 levels "2021","2022": 1 1 1 1 1 1 1 1 2 2 ...
## $ Lat        : num [1:18] 39 38.9 38.8 39.5 39 ...
## $ Long       : num [1:18] -122 -122 -122 -122 -122 ...
```

```
Total_P_Growers <- lmer(TotalP ~ Field*Year+(1|Site), data=Growers)
Total_P_means_Growers <- emmeans(Total_P_Growers, spec = 'Field')
```

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

```
Total_P_effects_Growers <- contrast(Total_P_means_Growers, method = 'pairwise', adjust = "tukey")
anova(Total_P_Growers)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##           Sum Sq   Mean Sq NumDF DenDF F value    Pr(>F)
## Field      0.0044961 0.0044961     1     7 12.8844 0.008863 **
## Year       0.0004444 0.0004444     1     7  1.2735 0.296301
## Field:Year 0.0003220 0.0003220     1     7  0.9227 0.368754
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
cld(Total_P_means_Growers)
```

```
## Field emmean      SE   df lower.CL upper.CL .group
## RF      0.180 0.0131 8.77    0.150    0.210    1
## CR      0.212 0.0131 8.77    0.182    0.241    2
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
## 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.
```

```
summary(Total_P_effects_Growers)
```

```
## contrast estimate      SE df t.ratio p.value
## CR - RF      0.0318 0.00886 7    3.589 0.0089
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
```

```
Total_V_Growers <- lmer(TotalV ~ Field*Year+(1|Site), data=Growers)
Total_V_means_Growers <- emmeans(Total_V_Growers, spec = 'Field')
```

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

```
Total_V_effects_Growers <- contrast(Total_V_means_Growers, method = 'pairwise', adjust = "tukey")
anova(Total_V_Growers)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##              Sum Sq Mean Sq NumDF DenDF F value    Pr(>F)
## Field          0.058331 0.058331      1      7 12.4968 0.009533 **
## Year            0.014030 0.014030      1      7  3.0057 0.126568
## Field:Year      0.000293 0.000293      1      7  0.0628 0.809272
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
cld(Total_V_means_Growers)
```

```
## Field emmean      SE   df lower.CL upper.CL .group
## RF      0.461 0.0403 9.6    0.371    0.551    1
## CR      0.575 0.0403 9.6    0.485    0.666    2
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
## 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.
```

```
summary(Total_V_effects_Growers)
```

```
## contrast estimate      SE df t.ratio p.value
## CR - RF      0.115 0.0324  7   3.535  0.0095
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
```

```
Total_C_Growers <- lmer(TotalC ~ Field*Year+(1|Site), data=Growers)
Total_C_means_Growers <- emmeans(Total_C_Growers, spec = 'Field')
```

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

```
Total_C_effects_Growers <- contrast(Total_C_means_Growers, method = 'pairwise', adjust = "tukey")
anova(Total_C_Growers)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##              Sum Sq Mean Sq NumDF DenDF F value    Pr(>F)
## Field         0.247896 0.247896     1     7 16.2315 0.005003 **
## Year          0.032279 0.032279     1     7  2.1135 0.189320
## Field:Year    0.074047 0.074047     1     7  4.8484 0.063552 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
cld(Total_C_means_Growers)
```

```
## Field emmean      SE    df lower.CL upper.CL .group
## RF      0.428 0.0606 10.9    0.294    0.561    1
## CR      0.664 0.0606 10.9    0.530    0.797    2
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
## 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.
```

```
summary(Total_C_effects_Growers)
```

```
## contrast estimate      SE df t.ratio p.value
## CR - RF      0.236 0.0586  7   4.029  0.0050
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
```

```
Total_S_Growers <- lmer(TotalS ~ Field*Year+(1|Site), data=Growers)
Total_S_means_Growers <- emmeans(Total_S_Growers, spec = 'Field')
```

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



```
Total_S_effects_Growers <- contrast(Total_S_means_Growers, method = 'pairwise', adjust = "tukey")
anova(Total_S_Growers)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##           Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## Field      0.122354 0.122354      1      7 14.7325 0.006389 **
## Year        0.038270 0.038270      1      7  4.6081 0.068955 .
## Field:Year  0.001097 0.001097      1      7  0.1321 0.726970
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
cld(Total_S_means_Growers)
```

```
## Field emmean      SE    df lower.CL upper.CL .group
## RF      0.653 0.0641 8.77    0.508    0.799 1
## CR      0.819 0.0641 8.77    0.674    0.965 2
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
## 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.
```

```
summary(Total_S_effects_Growers)
```

```
## contrast estimate      SE df t.ratio p.value
## CR - RF      0.166 0.0432 7    3.838 0.0064
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
```

```
Total_phenols_Growers <- lmer(Total_phenols ~ Field*Year+(1|Site), data=Growers)
Total_phenols_means_Growers <- emmeans(Total_phenols_Growers, spec = 'Field')
```

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

```
Total_phenols_effects_Growers <- contrast(Total_phenols_means_Growers, method = 'pairwise', adjust = "tukey")
anova(Total_phenols_Growers)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##           Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## Field      1.33692 1.33692      1      7 16.5548 0.004757 **
## Year        0.25938 0.25938      1      7  3.2118 0.116212
## Field:Year  0.07299 0.07299      1      7  0.9039 0.373413
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
cld(Total_phenols_means_Growers)
```

```
## Field emmean SE df lower.CL upper.CL .group
## RF 1.72 0.172 9.45 1.33 2.11 1
## CR 2.27 0.172 9.45 1.88 2.66 2
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
## 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.
```

```
summary(Total_phenols_effects_Growers)
```

```
## contrast estimate SE df t.ratio p.value
## CR - RF 0.548 0.135 7 4.069 0.0048
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
```

## Import graphing data

```
manuscript_graphing <- read_excel("Phenols_graphing_manuscript_25Jan2024.xlsx", sheet = 1)
```

```
RES_graphing <- manuscript_graphing %>% filter(Study == "RES")
str(RES_graphing)
```

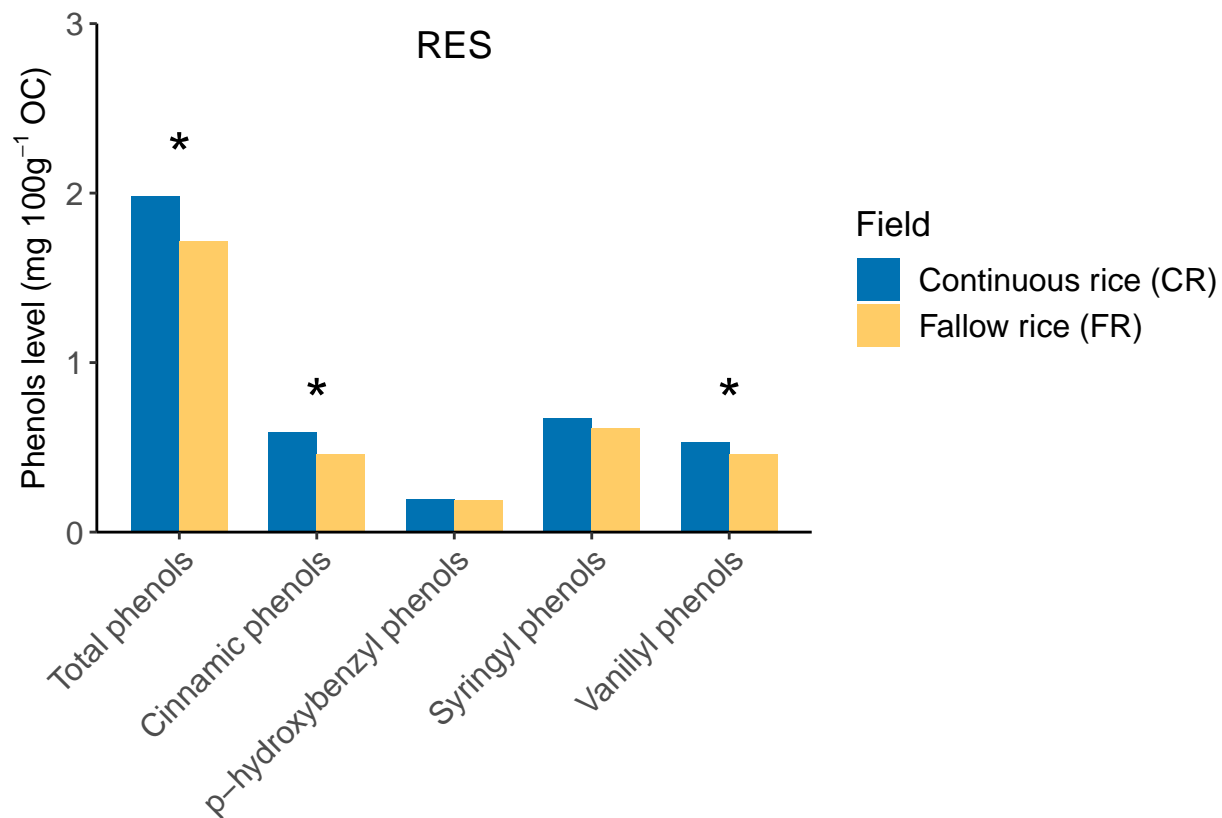
```
## tibble [10 x 5] (S3: tbl_df/tbl/data.frame)
## $ Type      : chr [1:10] "Total_phenols" "Total_phenols" "TotalP" "TotalP" ...
## $ Field      : chr [1:10] "CR" "RF" "CR" "RF" ...
## $ Study      : chr [1:10] "RES" "RES" "RES" "RES" ...
## $ Phenols_level: num [1:10] 1.981 1.716 0.194 0.189 0.528 ...
## $ SD         : num [1:10] 0.3312 0.2754 0.0346 0.0285 0.0891 ...
```

```
Growers_Graphing <- manuscript_graphing %>% filter(Study == "Grower")
str(Growers_Graphing)
```

```
## tibble [10 x 5] (S3: tbl_df/tbl/data.frame)
## $ Type      : chr [1:10] "Total_phenols" "Total_phenols" "TotalP" "TotalP" ...
## $ Field      : chr [1:10] "CR" "RF" "CR" "RF" ...
## $ Study      : chr [1:10] "Grower" "Grower" "Grower" "Grower" ...
## $ Phenols_level: num [1:10] 2.295 1.761 0.214 0.181 0.583 ...
## $ SD         : num [1:10] 0.6355 0.4976 0.0472 0.0303 0.1536 ...
```

## Graphing RES

```
RES_phenols_graph <-
ggplot(RES_graphing, aes(x = Type, y = Phenols_level, fill = Field)) +
  geom_bar(stat = "identity", position = "dodge", width = 0.7) +
  labs(x = "Type", y = "Phenols_level", fill = "Field") +
  scale_fill_manual(values = c("#0072B2", "#FFCC66"), labels = c("Continuous rice (CR)", "Fallow rice (FR)", "Rice fallow (RF)")) +
  scale_y_continuous(name=expression("Phenols level (mg 100g"^{-1}* " OC)"), limits = c(0,3), expand = c(0.05, 0.05)) +
  scale_x_discrete(name="", labels = c("Total phenols", "Cinnamic phenols", "p-hydroxybenzyl phenols", "p-coumaric phenols", "p-hydroxybenzoic phenols", "p-coumaric phenols")) +
  theme_classic() +
  theme(axis.text.x = element_text(angle = 45, hjust = 1, size= 12))+
  theme(axis.text.y = element_text(size= 12),axis.title = element_text(size=12))+
  theme(legend.text = element_text(size = 12),legend.title = element_text(size = 13))+
  annotate(
    "text",
    x = c(1,2,5), # X-axis positions for annotations
    y = c(2.1,0.65,0.65), # Y-axis positions for annotations
    label = "*",
    size = 8,
    vjust = 0 # Adjust vertical position of asterisks
  )+
  annotate(
    "text",
    x = c(3), # X-axis positions for annotations
    y = c(2.8), # Y-axis positions for annotations
    label = "RES",
    size = 5,
    vjust = 0
  )
RES_phenols_graph
```



```
ggsave(RES_phenols_graph, filename = "RES_phenols_graph_22Jan2024.png", height = 15, width = 20, units = "cm")
```

## Graphing growers' fields

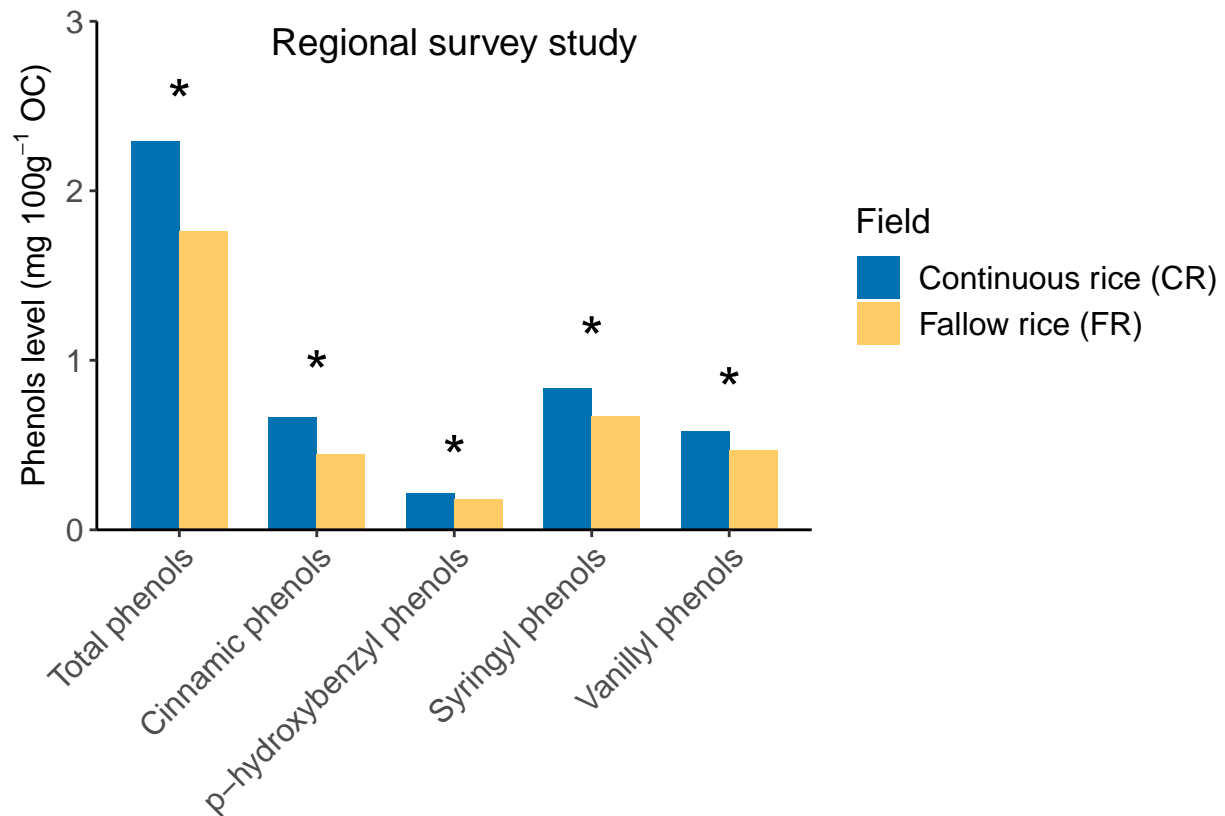
```
Grower_phenols_graph<-
ggplot(Growers_Graphing, aes(x = Type, y = Phenols_level, fill = Field)) +
  geom_bar(stat = "identity", position = "dodge", width = 0.7) +
  labs(x = "Type", y = "Phenols_level", fill = "Field") +
  scale_fill_manual(values = c("#0072B2", "#FFCC66"), labels = c("Continuous rice (CR)", "Fallow rice (FR)")) +
  scale_y_continuous(name=expression("Phenols level (mg 100g"^-1)*" OC"), limits = c(0,3), expand = c(0,0.1)) +
  scale_x_discrete(name="", labels = c("Total phenols", "Cinnamic phenols", "p-hydroxybenzyl phenols", "Syringyl phenols", "Vanillyl phenols")) +
  theme_classic() +
  theme(axis.text.x = element_text(angle = 45, hjust = 1, size = 12)) +
  theme(axis.text.y = element_text(size = 12), axis.title = element_text(size = 12)) +
  theme(legend.text = element_text(size = 12), legend.title = element_text(size = 13)) +
  annotate(
    "text",
    x = c(1,2,3,4,5), # X-axis positions for annotations
    y = c(2.4,0.8,0.3,1,0.7), # Y-axis positions for annotations
    label = "*",
    size = 8,
    vjust = 0 # Adjust vertical position of asterisks
  ) +
```

```

annotate(
  "text",
  x = c(3), # X-axis positions for annotations
  y = c(2.8), # Y-axis positions for annotations
  label = "Regional survey study",
  size = 5,
  vjust = 0
)

```

Grower\_phenols\_graph



```

ggsave(Grower_phenols_graph, filename = "Growers_phenols_graph_22Jan2024.png", height = 15, width = 20,

```