

Yield Analysis

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Contents

Necessary libraries	1
Data Organisation	2
Read from excel	2
Change variable type	2
Sub dataset for “preplant” and “topdress”	2
Initial Visualisation	3
Preplant	5
Comparision by treatment and year	5
Graphing	6
TopDress	8
Comparison by treatment	8
Graphing	9

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)
```

Data Organisation

Read from excel

```
yield <- read_excel("Yield_15N.xlsx", sheet = 1)
str(yield)
```

```
## tibble [24 x 7] (S3: tbl_df/tbl/data.frame)
## $ Plot      : chr [1:24] "407 412 plus MG" "507 512 plus MG" "607 612 plus MG" "401 406 plus MG" ...
## $ Field     : chr [1:24] "CR" "CR" "CR" "RF" ...
## $ Blk       : num [1:24] 4 5 6 4 5 6 4 5 6 4 ...
## $ TopDress  : chr [1:24] "Y" "Y" "Y" "Y" ...
## $ Yield     : num [1:24] 5.69 8.62 4.98 10.08 10.06 ...
## $ Year      : num [1:24] 2022 2022 2022 2022 2022 ...
## $ TopDress_graph: chr [1:24] "Topdress" "Topdress" "Topdress" "Topdress" ...
```

Change variable type

```
yield$Plot <- as.factor(yield$Plot)
yield$Field <- as.factor(yield$Field)
yield$Blk <- as.factor(yield$Blk)
yield$TopDress <- as.factor(yield$TopDress)
yield$Year <- as.factor(yield$Year)

str(yield)
```

```
## tibble [24 x 7] (S3: tbl_df/tbl/data.frame)
## $ Plot      : Factor w/ 24 levels "101 106 minus M",...: 16 20 24 14 18 22 15 19 23 13 ...
## $ Field     : Factor w/ 2 levels "CR","RF": 1 1 1 2 2 2 1 1 1 2 ...
## $ Blk       : Factor w/ 6 levels "1","2","3","4",...: 4 5 6 4 5 6 4 5 6 4 ...
## $ TopDress  : Factor w/ 2 levels "N","Y": 2 2 2 2 2 2 1 1 1 1 ...
## $ Yield     : num [1:24] 5.69 8.62 4.98 10.08 10.06 ...
## $ Year      : Factor w/ 2 levels "2021","2022": 2 2 2 2 2 2 2 2 2 2 ...
## $ TopDress_graph: chr [1:24] "Topdress" "Topdress" "Topdress" "Topdress" ...
```

Sub dataset for “preplant” and “topdress”

```
preplant <- yield %>% filter(TopDress == "N")
str(preplant)
```

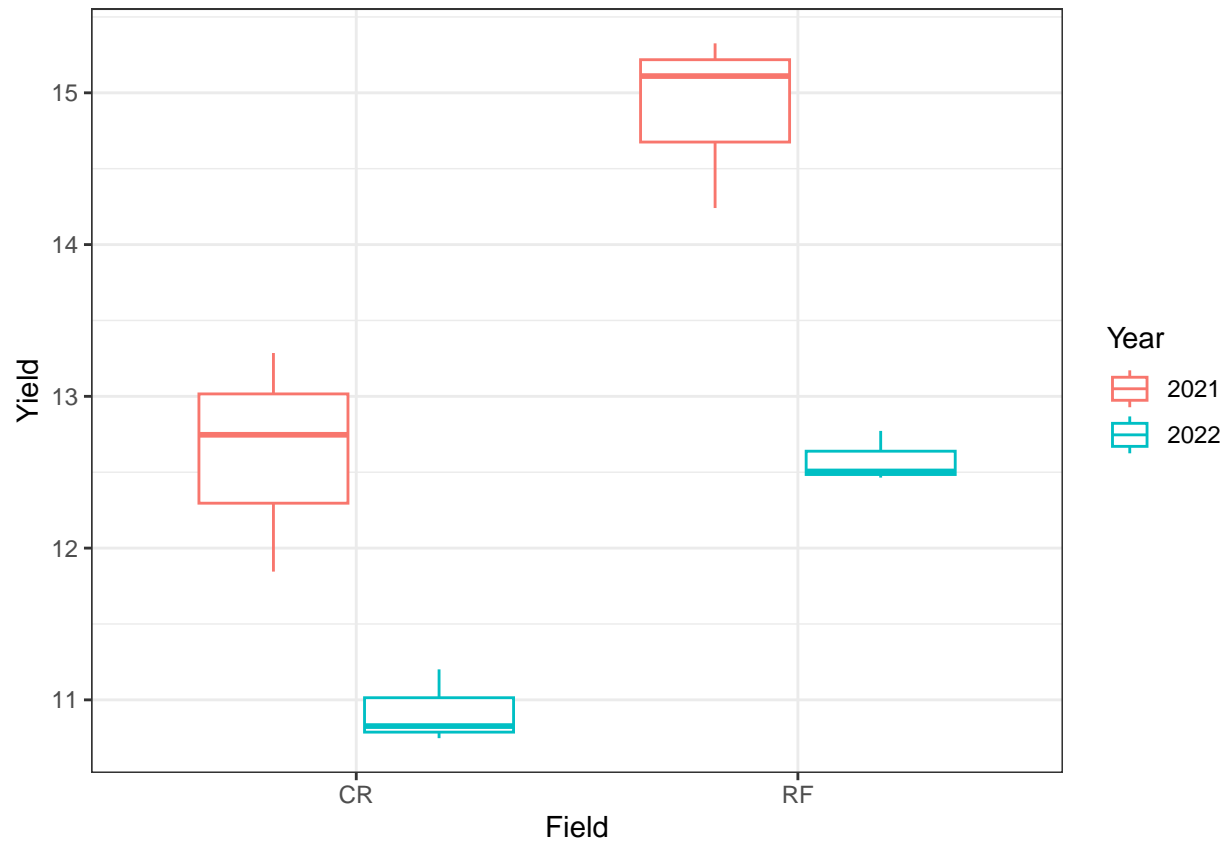
```
## tibble [12 x 7] (S3: tbl_df/tbl/data.frame)
## $ Plot      : Factor w/ 24 levels "101 106 minus M",...: 15 19 23 13 17 21 3 7 11 1 ...
## $ Field     : Factor w/ 2 levels "CR","RF": 1 1 1 2 2 2 1 1 1 2 ...
## $ Blk       : Factor w/ 6 levels "1","2","3","4",...: 4 5 6 4 5 6 1 2 3 1 ...
## $ TopDress  : Factor w/ 2 levels "N","Y": 1 1 1 1 1 1 1 1 1 1 ...
## $ Yield     : num [1:12] 11.2 10.7 10.8 12.8 12.5 ...
## $ Year      : Factor w/ 2 levels "2021","2022": 2 2 2 2 2 2 1 1 1 1 ...
## $ TopDress_graph: chr [1:12] "Preplant" "Preplant" "Preplant" "Preplant" ...
```

```
topdress <- yield %>% filter(TopDress == "Y")
str(topdress)
```

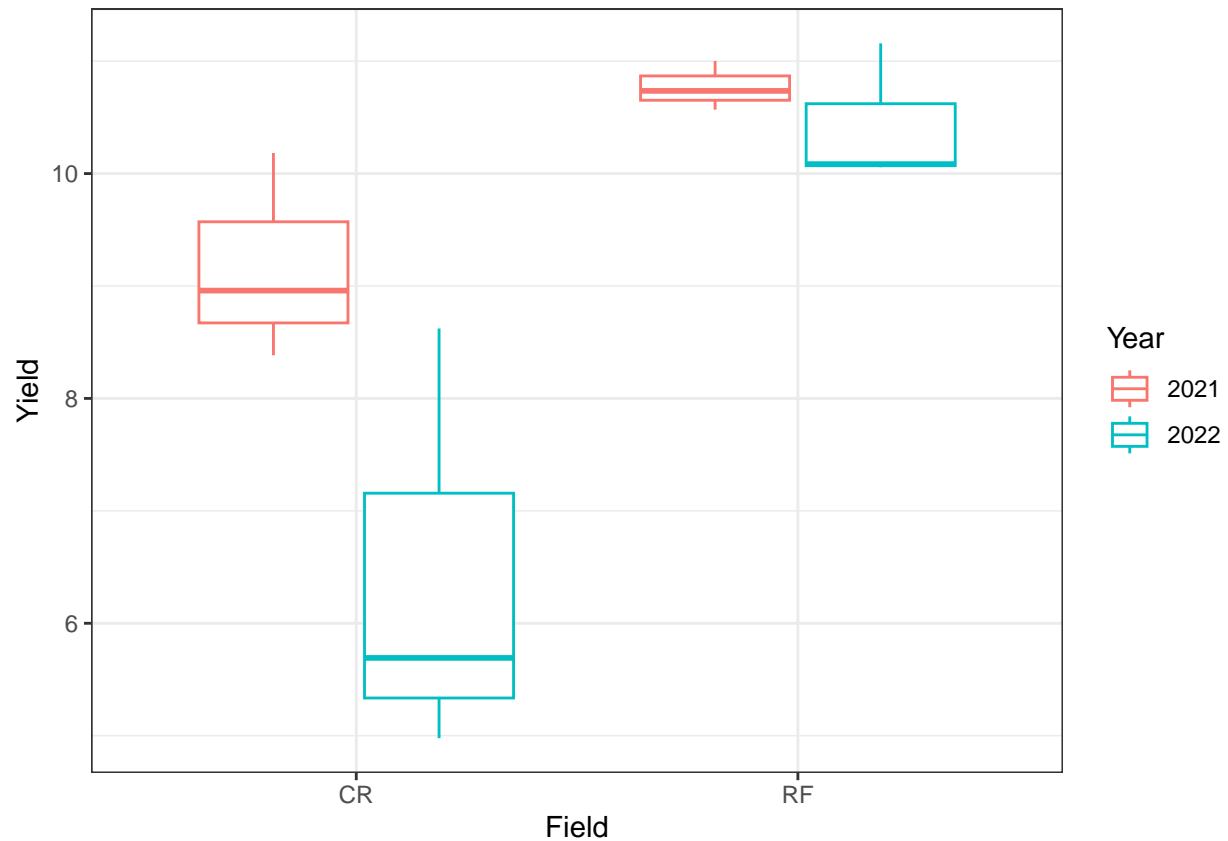
```
## tibble [12 x 7] (S3: tbl_df/tbl/data.frame)
## $ Plot      : Factor w/ 24 levels "101 106 minus M",...: 16 20 24 14 18 22 4 8 12 2 ...
## $ Field     : Factor w/ 2 levels "CR","RF": 1 1 1 2 2 2 1 1 1 2 ...
## $ Blk       : Factor w/ 6 levels "1","2","3","4",...: 4 5 6 4 5 6 1 2 3 1 ...
## $ TopDress  : Factor w/ 2 levels "N","Y": 2 2 2 2 2 2 2 2 2 2 ...
## $ Yield     : num [1:12] 5.69 8.62 4.98 10.08 10.06 ...
## $ Year      : Factor w/ 2 levels "2021","2022": 2 2 2 2 2 2 1 1 1 1 ...
## $ TopDress_graph: chr [1:12] "Topdress" "Topdress" "Topdress" "Topdress" ...
```

Initial Visualisation

```
#preplant
ggplot(preplant, aes(y=Yield, x=Field, color=Year)) + geom_boxplot()
```



```
#topdress  
ggplot(topdress, aes(y=Yield, x=Field, color=Year)) + geom_boxplot()
```



Preplant

Comparison by treatment and year

```
preplant_model <- lmer(Yield~Field*Year+(1|Blk), data=preplant)
anova(preplant_model)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##           Sum Sq Mean Sq NumDF DenDF F value    Pr(>F)
## Field      11.5371  11.5371     1     4  971.430 6.315e-06 ***
## Year         0.3110   0.3110     1     4   26.185 0.006900 **
## Field:Year   0.2803   0.2803     1     4   23.601 0.008291 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

All terms significant.

```
preplant_means <- emmeans(preplant_model, spec='Field', by='Year')
preplant_effects <- contrast(preplant_means, method='pairwise', adjust="tukey")
summary(preplant_effects)
```

```
## Year = 2021:
## contrast estimate SE df t.ratio p.value
## CR - RF -2.27 0.089 4 -25.474 <.0001
##
## Year = 2022:
## contrast estimate SE df t.ratio p.value
## CR - RF -1.66 0.089 4 -18.604 <.0001
##
## Degrees-of-freedom method: kenward-roger
```

```
cld(preplant_means)
```

```
## Year = 2021:
## Field emmean SE df lower.CL upper.CL .group
## CR 12.6 0.281 4.21 11.9 13.4 1
## RF 14.9 0.281 4.21 14.1 15.7 2
##
## Year = 2022:
## Field emmean SE df lower.CL upper.CL .group
## CR 10.9 0.281 4.21 10.2 11.7 1
## RF 12.6 0.281 4.21 11.8 13.3 2
##
## 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.
```

Yield higher for fallow rice in both 2021 and 2022

Graphing

Create dataframe for error bars

```
preplant_graphing <- preplant %>% group_by(Field, Year) %>%
  mutate(yield_se = sd(Yield)/sqrt(3)) %>%
  summarise(Yield = mean(Yield),
            yield_se = mean(yield_se))
```

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

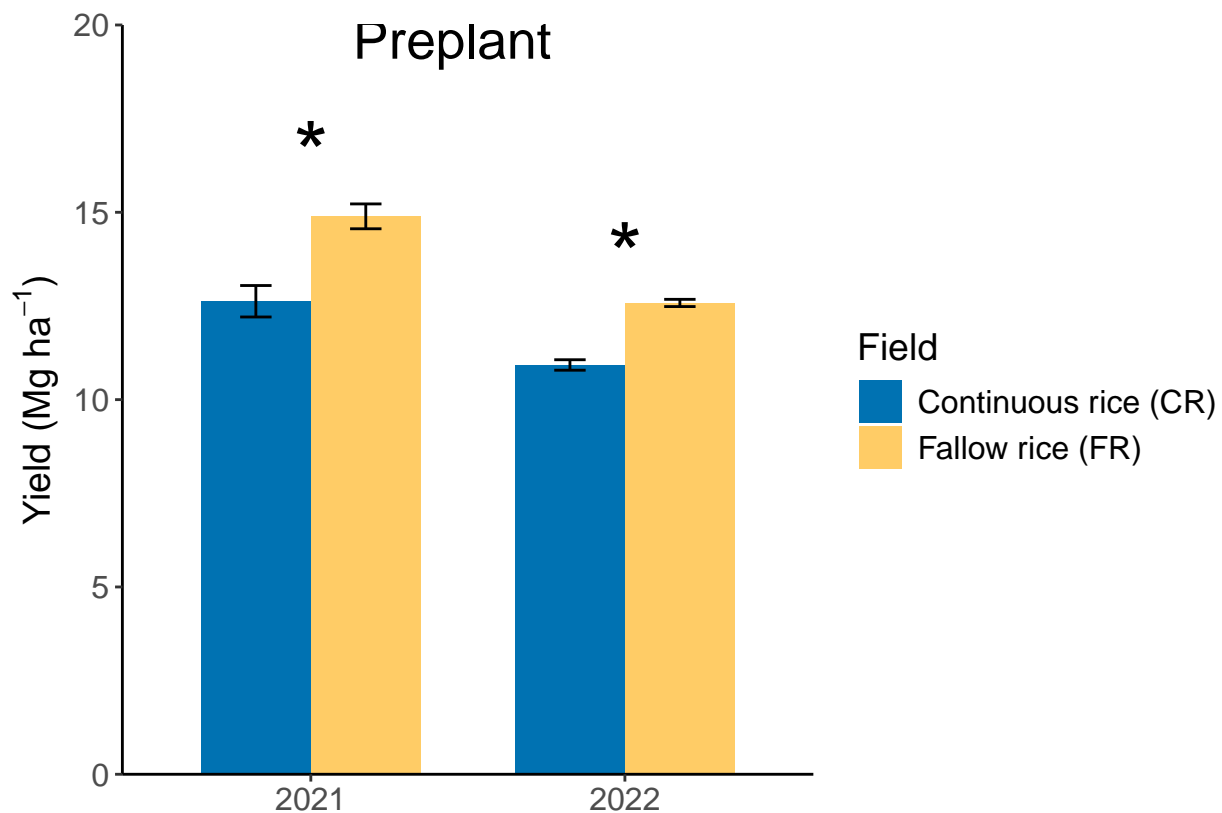
```
preplant_yield_graph <-
  ggplot(preplant_graphing, aes(x = Year, y = Yield, fill = Field)) +
  geom_bar(stat = "identity", position = "dodge", width = 0.7) +
  labs(x = "Year", y = "Yield", fill = "Field") +
  scale_fill_manual(values = c("#0072B2", "#FFCC66"), labels = c("Continuous rice (CR)", "Fallow rice (FR)")) +
  geom_errorbar(aes(ymin=Yield-yield_se, ymax=Yield+yield_se), width=.2, position=position_dodge(0.7)) +
  scale_y_continuous(name=expression("Yield (Mg ha"^-1*"")"), limits = c(0, 20), 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.text = element_text(size = 12), legend.title = element_text(size = 14))+
annotate(
  "text",
  x = c(1,2), # X-axis positions for annotations
  y = c(15.7,13), # Y-axis positions for annotations
  label = "*",
  size = 12,
  vjust = 0 # Adjust vertical position of asterisks
)+
annotate(
  "text",
  x = c(1.45), # X-axis positions for annotations
  y = c(19.1), # Y-axis positions for annotations
  label = "Preplant",
  size = 7,
  vjust = 0
)

```

preplant_yield_graph



```

ggsave(preplant_yield_graph, filename = "preplant_yield_graph.png", height = 15, width = 20, units = "cm")

```

TopDress

Comparison by treatment

```
topdress_model <- lmer(Yield~Field*Year+(1|Blk), data=topdress)
```

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

```
anova(topdress_model)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##           Sum Sq Mean Sq NumDF DenDF F value    Pr(>F)
## Field      23.4820  23.4820     1     8 18.7256 0.002521 **
## Year        7.1170   7.1170     1     8  5.6754 0.044386 *
## Field:Year  4.3529   4.3529     1     8  3.4712 0.099455 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Field effect strongest. Year effect present. Likely some Field:Year interaction.

```
topdress_means <- emmeans(topdress_model, spec='Field', by='Year')
topdress_effects <- contrast(topdress_means, method='pairwise', adjust="tukey")
summary(topdress_effects)
```

```
## Year = 2021:
## contrast estimate    SE df t.ratio p.value
## CR - RF      -1.59 0.914  4  -1.742  0.1564
##
## Year = 2022:
## contrast estimate    SE df t.ratio p.value
## CR - RF      -4.00 0.914  4  -4.377  0.0119
##
## Degrees-of-freedom method: kenward-roger
```

```
cld(topdress_means)
```

```
## Year = 2021:
## Field emmean    SE df lower.CL upper.CL .group
## CR      9.18 0.647  8    7.68   10.67  1
## RF     10.77 0.647  8    9.28   12.26  1
##
## Year = 2022:
## Field emmean    SE df lower.CL upper.CL .group
## CR      6.43 0.647  8    4.94    7.92  1
## RF     10.43 0.647  8    8.94   11.92  2
##
## 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.
```


No difference in 2021, but different in 2022.

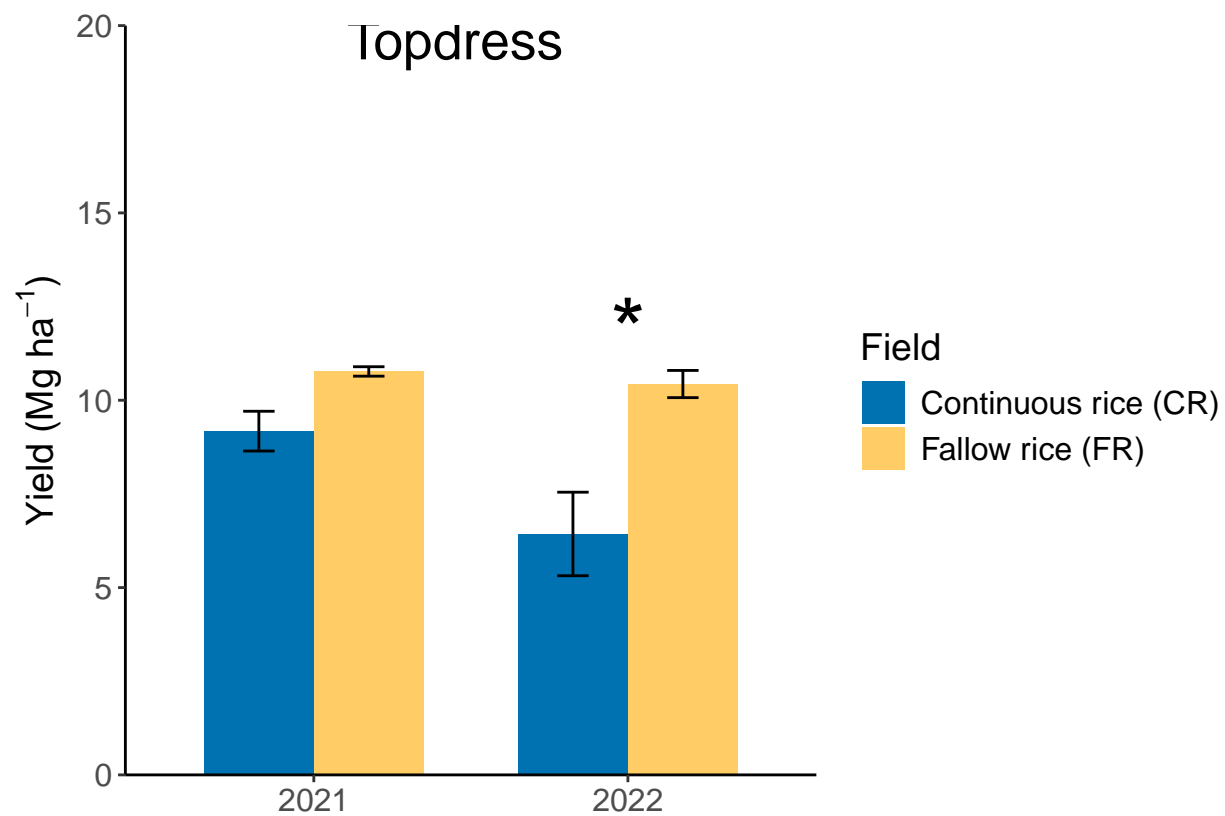
Graphing

Create graphing dataframe

```
topdress_graphing <- topdress %>% group_by(Field, Year) %>%
  mutate(yield_se = sd(Yield)/sqrt(3)) %>%
  summarise(Yield = mean(Yield),
            yield_se = mean(yield_se))
```

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

```
topdress_yield_graph <-
  ggplot(topdress_graphing, aes(x = Year, y = Yield, fill = Field)) +
  geom_bar(stat = "identity", position = "dodge", width = 0.7) +
  labs(x = "Year", y = "Yield", fill = "Field") +
  scale_fill_manual(values = c("#0072B2", "#FFCC66"), labels = c("Continuous rice (CR)", "Fallow rice (FR)")) +
  geom_errorbar(aes(ymin=Yield-yield_se, ymax=Yield+yield_se), width=.2, position=position_dodge(0.7)) +
  scale_y_continuous(name=expression("Yield (Mg ha"^-1)*"), limits = c(0, 20), 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.text = element_text(size = 12), legend.title = element_text(size = 14)) +
  annotate(
    "text",
    x = c(2), # X-axis positions for annotations
    y = c(11), # Y-axis positions for annotations
    label = "*",
    size = 12,
    vjust = 0 # Adjust vertical position of asterisks
  ) +
  annotate(
    "text",
    x = c(1.45), # X-axis positions for annotations
    y = c(19.1), # Y-axis positions for annotations
    label = "Topdress",
    size = 7,
    vjust = 0
  )
topdress_yield_graph
```



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