Yield Analysis

Zhang Zhenglin

Contents

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)
```

```r
library(GGally)
library(formatR)
library(readxl)
```

Data Organisation

Read from excel

```r
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

```r
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”

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

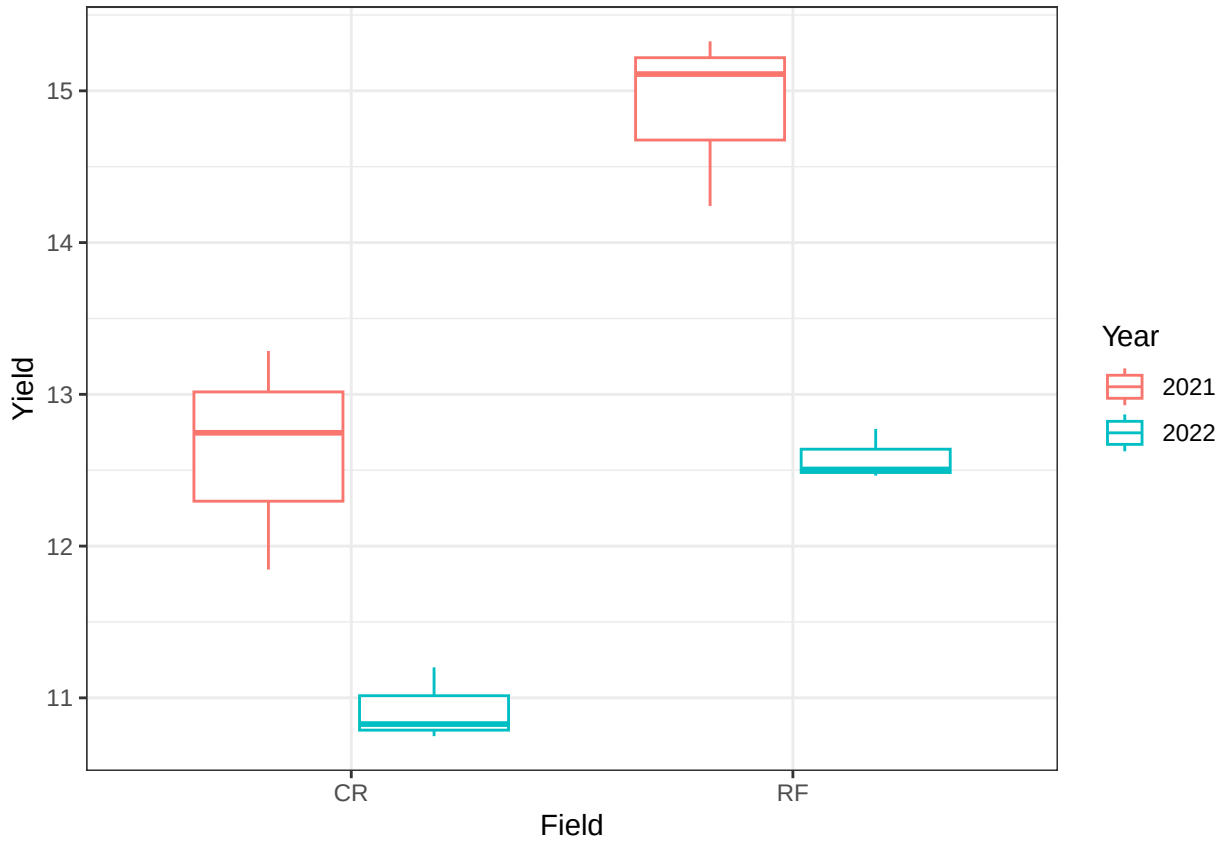
```
## tibble [12 x 7] (S3: tbl_df/tbl/data.frame)
##  $ Plot          : Factor w/ 24 levels "101 106 minus M",..: 15 19 23 13 17 21 3 7 11 1 ...
##  $ Field         : Factor w/ 2 levels "CR","RF": 1 1 1 2 2 2 1 1 1 2 ...
##  $ Blk           : Factor w/ 6 levels "1","2","3","4",..: 4 5 6 4 5 6 1 2 3 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)
```

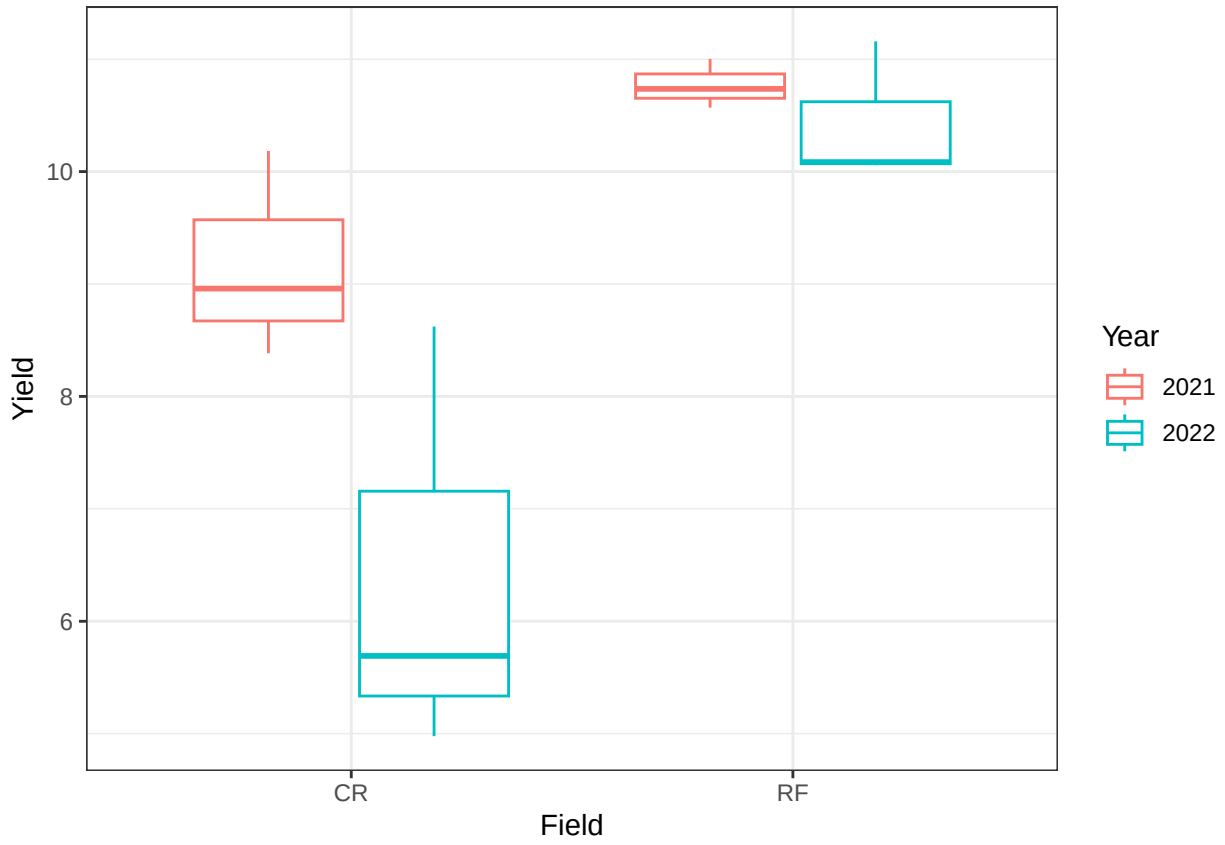
```
## tibble [12 x 7] (S3: tbl_df/tbl/data.frame)
##  $ Plot          : Factor w/ 24 levels "101 106 minus M",..: 16 20 24 14 18 22 4 8 12 2 ...
##  $ Field         : Factor w/ 2 levels "CR","RF": 1 1 1 2 2 2 1 1 1 2 ...
##  $ Blk           : Factor w/ 6 levels "1","2","3","4",..: 4 5 6 4 5 6 1 2 3 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

Comparision 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

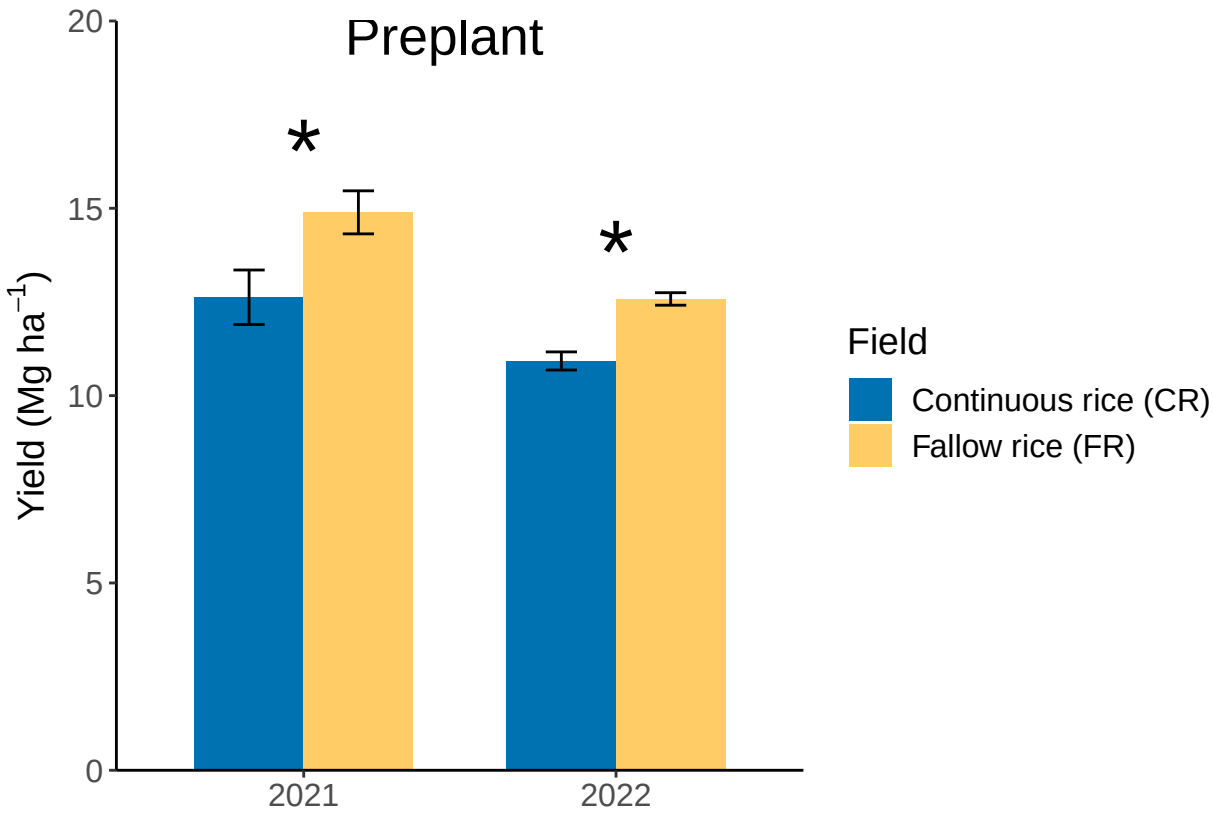
```
preplant_graphing <- preplant %>% group_by(Field, Year) %>%
   mutate(yield_sd = sd(Yield)) %>%
  summarise(Yield = mean(Yield),
            yield_sd = mean(yield_sd))
```

```
## `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_sd, ymax=Yield+yield_sd), 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 interation.

```
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

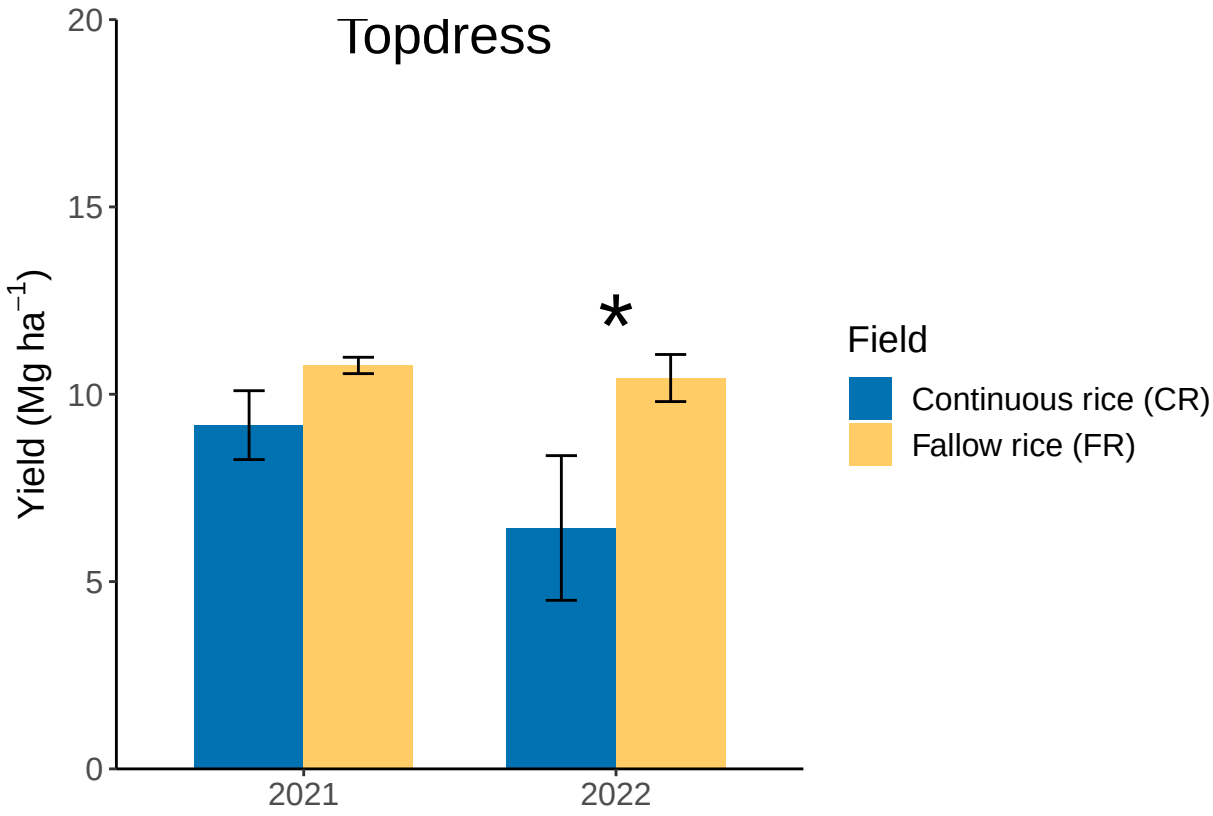
Create graphing dataframe

```
topdress_graphing <- topdress %>% group_by(Field, Year) %>%
   mutate(yield_sd = sd(Yield)) %>%
  summarise(Yield = mean(Yield),
            yield_sd = mean(yield_sd))
```

```
## `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_sd, ymax=Yield+yield_sd), 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
```