

FNR 15N

Zhang Zhenglin

Contents

Necessary libraries	1
Data Organisation	2
Read from excel	2
Clean up variables	2
Sub dataset for “preplant” and “topdress”	3
Preplant FNR	3
Continuous Rice	3
Fallow Rice	4
Testing for preplant	4
Topdress FNR	7
Continuous Rice	7
Fallow Rice	7
Testing for topdress	7

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(mgcv)
```

Data Organisation

Read from excel

```
FNR <- read_excel("soils_15N_maturity.xlsx", sheet = 1)
str(FNR)
```

```
## tibble [24 x 11] (S3: tbl_df/tbl/data.frame)
## $ Field          : chr [1:24] "CR" "CR" "CR" "RF" ...
## $ Blk            : chr [1:24] "1" "2" "3" "1" ...
## $ Topdress       : chr [1:24] "Y" "Y" "Y" "Y" ...
## $ Stage          : chr [1:24] "Maturity" "Maturity" "Maturity" "Maturity" ...
## $ soil_recovery_fert_N : num [1:24] 4.79 4.76 3.87 6.02 6.3 ...
## $ soil_recovery_fert_N_percent: num [1:24] 16 15.9 12.9 20.1 21 ...
## $ crop_recovery_fert_N : num [1:24] 10.61 9.19 9.48 11.96 11.77 ...
## $ crop_recovery_fert_N_percent: num [1:24] 35.4 30.6 31.6 39.9 39.2 ...
## $ total_fertN_recovery : num [1:24] 15.4 14 13.3 18 18.1 ...
## $ total_fertN_recovery_percent: num [1:24] 51.3 46.5 44.5 59.9 60.2 ...
## $ Year           : num [1:24] 2021 2021 2021 2021 2021 ...
```

Clean up variables

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

str(FNR)
```

```
## tibble [24 x 11] (S3: tbl_df/tbl/data.frame)
## $ 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",...: 1 2 3 1 2 3 1 2 3 1 ...
## $ Topdress       : Factor w/ 2 levels "N","Y": 2 2 2 2 2 2 1 1 1 1 ...
## $ Stage          : Factor w/ 1 level "Maturity": 1 1 1 1 1 1 1 1 1 1 ...
## $ soil_recovery_fert_N : num [1:24] 4.79 4.76 3.87 6.02 6.3 ...
## $ soil_recovery_fert_N_percent: num [1:24] 16 15.9 12.9 20.1 21 ...
## $ crop_recovery_fert_N : num [1:24] 10.61 9.19 9.48 11.96 11.77 ...
## $ crop_recovery_fert_N_percent: num [1:24] 35.4 30.6 31.6 39.9 39.2 ...
## $ total_fertN_recovery : num [1:24] 15.4 14 13.3 18 18.1 ...
## $ total_fertN_recovery_percent: num [1:24] 51.3 46.5 44.5 59.9 60.2 ...
## $ Year           : Factor w/ 2 levels "2021","2022": 1 1 1 1 1 1 1 1 1 1 ...
```

Sub dataset for “preplant” and “topdress”

```
preplant <- FNR %>% filter(Topdress == "N")
str(preplant)
```

```
## tibble [12 x 11] (S3: tbl_df/tbl/data.frame)
##  $ 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",...: 1 2 3 1 2 3 4 5 6 4 ...
##  $ Topdress       : Factor w/ 2 levels "N","Y": 1 1 1 1 1 1 1 1 1 1 ...
##  $ Stage          : Factor w/ 1 level "Maturity": 1 1 1 1 1 1 1 1 1 1 ...
##  $ soil_recovery_fert_N : num [1:12] 30.1 22.6 23.3 32.8 37.6 ...
##  $ soil_recovery_fert_N_percent: num [1:12] 20.1 15.1 15.5 21.8 25.1 ...
##  $ crop_recovery_fert_N : num [1:12] 60.2 44.1 51.2 58.2 52.5 ...
##  $ crop_recovery_fert_N_percent: num [1:12] 40.2 29.4 34.1 38.8 35 ...
##  $ total_fertN_recovery : num [1:12] 90.3 66.8 74.5 91 90.2 ...
##  $ total_fertN_recovery_percent: num [1:12] 60.2 44.5 49.7 60.6 60.1 ...
##  $ Year           : Factor w/ 2 levels "2021","2022": 1 1 1 1 1 1 2 2 2 2 ...
```

```
topdress <- FNR %>% filter(Topdress == "Y")
str(topdress)
```

```
## tibble [12 x 11] (S3: tbl_df/tbl/data.frame)
##  $ 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",...: 1 2 3 1 2 3 4 5 6 4 ...
##  $ Topdress       : Factor w/ 2 levels "N","Y": 2 2 2 2 2 2 2 2 2 2 ...
##  $ Stage          : Factor w/ 1 level "Maturity": 1 1 1 1 1 1 1 1 1 1 ...
##  $ soil_recovery_fert_N : num [1:12] 4.79 4.76 3.87 6.02 6.3 ...
##  $ soil_recovery_fert_N_percent: num [1:12] 16 15.9 12.9 20.1 21 ...
##  $ crop_recovery_fert_N : num [1:12] 10.61 9.19 9.48 11.96 11.77 ...
##  $ crop_recovery_fert_N_percent: num [1:12] 35.4 30.6 31.6 39.9 39.2 ...
##  $ total_fertN_recovery : num [1:12] 15.4 14 13.3 18 18.1 ...
##  $ total_fertN_recovery_percent: num [1:12] 51.3 46.5 44.5 59.9 60.2 ...
##  $ Year           : Factor w/ 2 levels "2021","2022": 1 1 1 1 1 1 2 2 2 2 ...
```

Preplant FNR

Continuous Rice

```
preplant_CR <- preplant %>% filter(Field == "CR")
mean(preplant_CR$crop_recovery_fert_N_percent)
```

```
## [1] 30.05688
```

```
mean(preplant_CR$soil_recovery_fert_N_percent)
```

```
## [1] 21.25597
```

```
mean(preplant_CR$total_fertN_recovery_percent)
```

```
## [1] 51.31285
```

Fallow Rice

```
preplant_RF <- preplant %>% filter(Field == "RF")  
mean(preplant_RF$crop_recovery_fert_N_percent)
```

```
## [1] 31.81622
```

```
mean(preplant_RF$soil_recovery_fert_N_percent)
```

```
## [1] 24.5583
```

```
mean(preplant_RF$total_fertN_recovery_percent)
```

```
## [1] 56.37452
```

Testing for preplant

```
#total FNR  
preplant_total_model <- lmer(total_fertN_recovery_percent~Field*Year+(1|Blk), data = preplant)
```

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

```
anova(preplant_total_model)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method  
##           Sum Sq Mean Sq NumDF DenDF F value Pr(>F)  
## Field      76.861   76.861     1     8  1.9872 0.1963  
## Year       34.377   34.377     1     8  0.8888 0.3734  
## Field:Year  28.746   28.746     1     8  0.7432 0.4137
```

```
preplant_total_means <- emmeans(preplant_total_model, spec = 'Field')
```

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

```
preplant_total_effects <- contrast(preplant_total_means, method = 'pairwise', adjust = "tukey")  
cld(preplant_total_means)
```

```
## Field emmean SE df lower.CL upper.CL .group
## CR 51.3 2.54 8 45.5 57.2 1
## RF 56.4 2.54 8 50.5 62.2 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(preplant_total_effects)
```

```
## contrast estimate SE df t.ratio p.value
## CR - RF -5.06 3.59 4 -1.410 0.2314
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
```

```
#crop FNR
```

```
preplant_crop_model <- lmer(crop_recovery_fert_N_percent~Field*Year+(1|Blk), data = preplant)
```

```
anova(preplant_crop_model)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
## Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## Field 9.286 9.286 1 4 0.9972 0.37450
## Year 117.154 117.154 1 4 12.5811 0.02386 *
## Field:Year 1.980 1.980 1 4 0.2126 0.66869
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
preplant_crop_means <- emmeans(preplant_crop_model, spec = 'Field')
```

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

```
preplant_crop_effects <- contrast(preplant_crop_means, method = 'pairwise', adjust = "tukey")
cld(preplant_crop_means)
```

```
## Field emmean SE df lower.CL upper.CL .group
## CR 30.1 1.46 7.47 26.7 33.5 1
## RF 31.8 1.46 7.47 28.4 35.2 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(preplant_crop_effects)
```

```
## contrast estimate SE df t.ratio p.value
## CR - RF -1.76 1.76 4 -0.999 0.3745
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
```

```
#soil FNR
```

```
preplant_soil_model <- lmer(soil_recovery_fert_N_percent~Field*Year+(1|Blk), data = preplant)
```

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

```
anova(preplant_soil_model)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
## Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## Field 32.716 32.716 1 8 1.4153 0.2683
## Year 70.061 70.061 1 8 3.0308 0.1199
## Field:Year 45.813 45.813 1 8 1.9819 0.1968
```

```
preplant_soil_means <- emmeans(preplant_soil_model, spec = 'Field')
```

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

```
preplant_soil_effects <- contrast(preplant_soil_means, method = 'pairwise', adjust = "tukey")
cld(preplant_soil_means)
```

```
## Field emmean SE df lower.CL upper.CL .group
## CR 21.3 1.96 8 16.7 25.8 1
## RF 24.6 1.96 8 20.0 29.1 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(preplant_soil_effects)
```

```
## contrast estimate SE df t.ratio p.value
## CR - RF -3.3 2.78 4 -1.190 0.3000
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
```

Topdress FNR

Continuous Rice

```
topdress_CR <- topdress %>% filter(Field == "CR")
mean(topdress_CR$crop_recovery_fert_N_percent)
```

```
## [1] 29.30806
```

```
mean(topdress_CR$soil_recovery_fert_N_percent)
```

```
## [1] 16.98183
```

```
mean(topdress_CR$total_fertN_recovery_percent)
```

```
## [1] 46.28989
```

Fallow Rice

```
topdress_RF <- topdress %>% filter(Field == "RF")
mean(topdress_RF$crop_recovery_fert_N_percent)
```

```
## [1] 39.03669
```

```
mean(topdress_RF$soil_recovery_fert_N_percent)
```

```
## [1] 19.73554
```

```
mean(topdress_RF$total_fertN_recovery_percent)
```

```
## [1] 58.77223
```

Testing for topdress

```
#total FNR
topdress_total_model <- lmer(total_fertN_recovery_percent~Field*Year+(1|Blk), data = topdress)
anova(topdress_total_model)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##           Sum Sq Mean Sq NumDF DenDF F value  Pr(>F)
## Field      467.43   467.43     1     4   9.7124 0.03565 *
## Year        44.07    44.07     1     4   0.9157 0.39280
## Field:Year  186.71   186.71     1     4   3.8795 0.12022
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```

topdress_total_means <- emmeans(topdress_total_model, spec = 'Field')

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

topdress_total_effects <- contrast(topdress_total_means, method = 'pairwise', adjust = "tukey")
cld(topdress_total_means)

## Field emmean SE df lower.CL upper.CL .group
## CR 46.3 3.53 7.1 38.0 54.6 1
## RF 58.8 3.53 7.1 50.4 67.1 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(topdress_total_effects)

## contrast estimate SE df t.ratio p.value
## CR - RF -12.5 4.01 4 -3.116 0.0356
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger

#crop FNR
topdress_crop_model <- lmer(crop_recovery_fert_N_percent~Field*Year+(1|Blk), data = topdress)

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

anova(topdress_crop_model)

## Type III Analysis of Variance Table with Satterthwaite's method
## Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## Field 283.94 283.94 1 8 8.0294 0.02203 *
## Year 1.32 1.32 1 8 0.0373 0.85159
## Field:Year 152.19 152.19 1 8 4.3038 0.07172 .
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

topdress_crop_means <- emmeans(topdress_crop_model, spec = 'Field')

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

topdress_crop_effects <- contrast(topdress_crop_means, method = 'pairwise', adjust = "tukey")
cld(topdress_crop_means)

```



```
## Field emmean SE df lower.CL upper.CL .group
## CR 29.3 2.43 8 23.7 34.9 1
## RF 39.0 2.43 8 33.4 44.6 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(topdress_crop_effects)
```

```
## contrast estimate SE df t.ratio p.value
## CR - RF -9.73 3.43 4 -2.834 0.0472
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
```

```
#soil FNR
```

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

```
anova(topdress_soil_model)
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
## Sum Sq Mean Sq NumDF DenDF F value Pr(>F)
## Field 22.749 22.749 1 4 1.7558 0.2558
## Year 36.375 36.375 1 4 2.8074 0.1691
## Field:Year 1.762 1.762 1 4 0.1360 0.7310
```

```
topdress_soil_means <- emmeans(topdress_soil_model, spec = 'Field')
```

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

```
topdress_soil_effects <- contrast(topdress_soil_means, method = 'pairwise', adjust = "tukey")
cld(topdress_soil_means)
```

```
## Field emmean SE df lower.CL upper.CL .group
## CR 17.0 1.79 7.22 12.8 21.2 1
## RF 19.7 1.79 7.22 15.5 24.0 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(topdress_soil_effects)
```

```
## contrast estimate SE df t.ratio p.value
## CR - RF          -2.75 2.08 4  -1.325  0.2558
##
## Results are averaged over the levels of: Year
## Degrees-of-freedom method: kenward-roger
```