SCASI: Wheat

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Load the working packages

```
library(AgroR)
library(tidyverse)
library(agricolae)
library(lme4)
library(emmeans)
library(reshape)
library(reshape2)
library(car)
```

Load the data

```
 setwd("~/Code/R/SCASI")
library(tidyverse)
library(skimr)

df <- readxl::read_excel("./input/SCASI_Field_Trials_Data_2022ALL_20230409_Adama_v2.xlsx",sheet = "MergePart2Part1")
# First rows
#knitr::kable(head(df))

# Convert to factor
df$Rep <- as.factor(df$Rep)
df$Treatment <- as.factor(df$Treatment)
df$Woreda <- as.factor(df$Woreda)
```

Overview of the data

Number of observations and variables:

```
## [1] 709 153
```

Extract data per crops

```
# Wheat
wheat <- df %>% filter(Plot_crop=="Wheat")
```

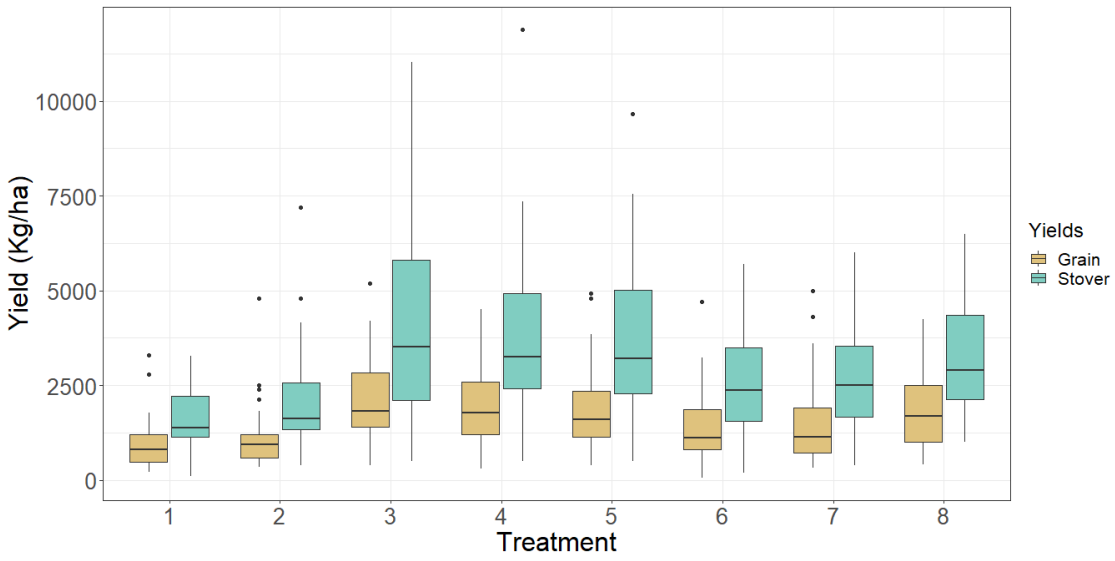
Descriptive statistics

Yield accorss treatments

```
yield_trt_summary<- wheat %>% group_by(Treatment) %>% summarize(across(.cols = c(GY_kg_ha,SY_kg_ha),list(min=min,max=max,mean=mean,sd=sd),na.rm=T,.names = "{.fn}_{.col}"))
knitr::kable(yield_trt_summary)
```

Treatment	min_GY_kg_ha	max_GY_kg_ha	mean_GY_kg_ha	sd_GY_kg_ha	min_SY_kg_ha	max_SY_kg_ha	mean_SY_kg_ha	sd_SY_kg_ha
1	216	3300	931.32	642.21	100	3280	1649.4	830.54
2	352	4800	1108.5	831.25	400	7200	2105.6	1322
3	390	5200	2159.2	1113.9	500	11033	4151.3	2292.4
4	300	4500	2019.2	1037.8	500	11893	3839.6	2108.1
5	380	4920	1933.3	1080.5	500	9666.7	3623.9	1952.6
6	58.416	4700	1396.4	893.81	186.14	5700	2571.4	1398
7	320	5000	1495.4	1067.5	400	6000	2658.7	1523.9
8	420	4235	1842.3	982.31	1000	6500	3338.1	1596.6

```
#yield_trt_summary
#with(wheat, desc(Treatment, GrainYield, ylab = "Grain Yield ", xlab = "Treatment", ylim = NA))

#boxplot
wheat %>% select(GY_kg_ha, SY_kg_ha, Treatment) %>% gather(key = "Yields",value= "Value", -Treatment) %>%
ggplot(aes(x=Treatment,y=Value, fill=Yields)) +
  geom_boxplot() +
  scale_fill_manual(values = c("GY_kg_ha" = "#dfc27d", "SY_kg_ha" = "#80cdc1"), labels=c("Grain", "Stover")) +
  labs(y="Yield (Kg/ha)")+
  theme_bw()+
  theme(legend.title = element_text(size = 18),
        legend.text = element_text(size = 16),
        axis.title = element_text(size = 24),
        axis.text = element_text(size = 20))
```



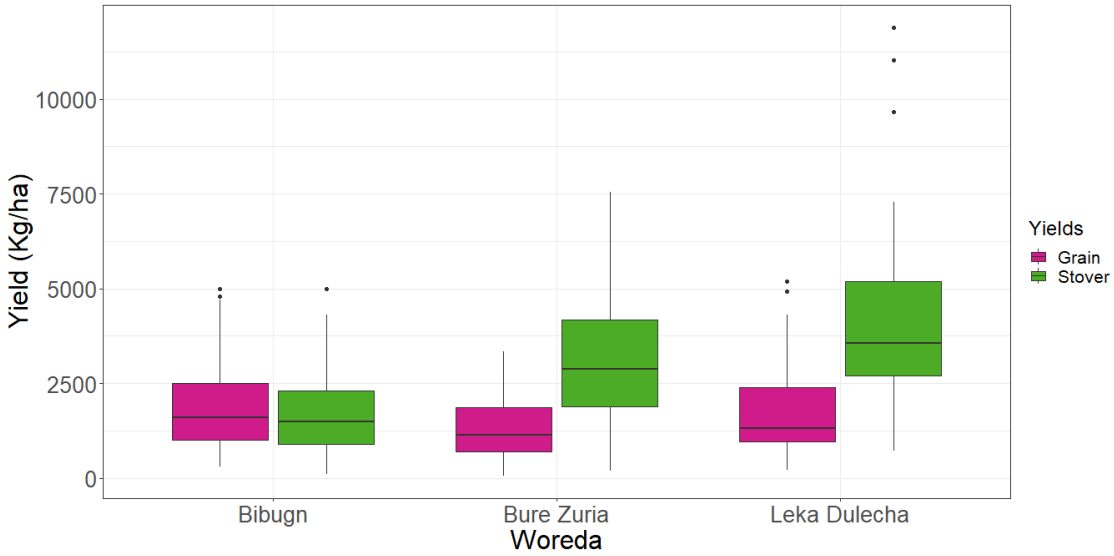
Yield accorss locations

```
yield_location<- wheat %>% group_by(Woreda) %>% summarize(across(.cols = c(GY
_kg_ha,SY_kg_ha),list(min=min,max=max,mean=mean,sd=sd),na.rm=T,.names = "{.fn
}_{.col}"))
knitr::kable(yield_location)
```

Woreda	min_GY_kg_ha	max_GY_kg_ha	mean_GY_kg_ha	sd_GY_kg_ha	min_SY_kg_ha	max_SY_kg_ha	mean_SY_kg_ha	sd_SY_kg_ha
Bibugn	300	5000	1848.3	1113.9	100	5000	1680.9	997.82
Bure Zuria	58.416	3350	1326.3	786.23	186.14	7550	3219.8	1667.6
Leka Dulecha	216	5200	1801.5	1206.5	712	11893	4036	2043.4

```
#yield_trt_summary
#with(wheat, desc(Treatment, GrainYield, ylab = "Grain Yield ", xlab = "Treat
ment", ylim = NA))

#boxplot
wheat %>% select(GY_kg_ha, SY_kg_ha, Woreda) %>% gather(key = "Yields",value=
"Value", -Woreda) %>%
ggplot(aes(x=Woreda,y=Value, fill=Yields)) +
  geom_boxplot() +
  scale_fill_manual(values = c("GY_kg_ha" = "#d01c8b", "SY_kg_ha" = "#4dac26"
), labels=c("Grain", "Stover")) +
  labs(y="Yield (Kg/ha)")+
  theme_bw()+
  theme(legend.title = element_text(size = 18),
        legend.text = element_text(size = 16),
```

```
        axis.title = element_text(size = 24),
        axis.text = element_text(size = 20))
```



Yield accorss locations and treatments

- Summary table

```
yield_location_trt<- wheat %>% select(GY_kg_ha, SY_kg_ha, Woreda,Treatment) %
>% group_by(Woreda,Treatment) %>% summarize(across(.cols = c(GY_kg_ha, SY_kg_
ha),list(min=min,max=max,mean=mean,sd=sd),na.rm=T,.names = "{.fn}_{.col}"))

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

knitr::kable(yield_location_trt)
```

Woreda	Treatment	min_GY_kg_ha	max_GY_kg_ha	mean_GY_kg_ha	sd_GY_kg_ha	min_SY_kg_ha	max_SY_kg_ha	mean_SY_kg_ha	sd_SY_kg_ha
Bibugn	1	500	3300	1263.6	924.42	100	2200	954.55	677.29
Bibugn	2	500	4800	1610	1256.5	400	3200	1280	871.52
Bibugn	3	500	4000	2190.9	1021.2	500	5000	2309.1	1176.8
Bibugn	4	300	4500	2309.1	1134.4	500	5000	2263.6	1140.4
Bibugn	5	500	4800	2108.3	1043.1	500	3700	1983.3	854.76
Bibugn	6	700	4700	1645.5	1175	600	4300	1463.6	1085.6
Bibugn	7	500	5000	1616.7	1305.8	400	2500	1316.7	784.9
Bibugn	8	1000	3500	2018.2	917.41	1000	2900	1845.5	612.15

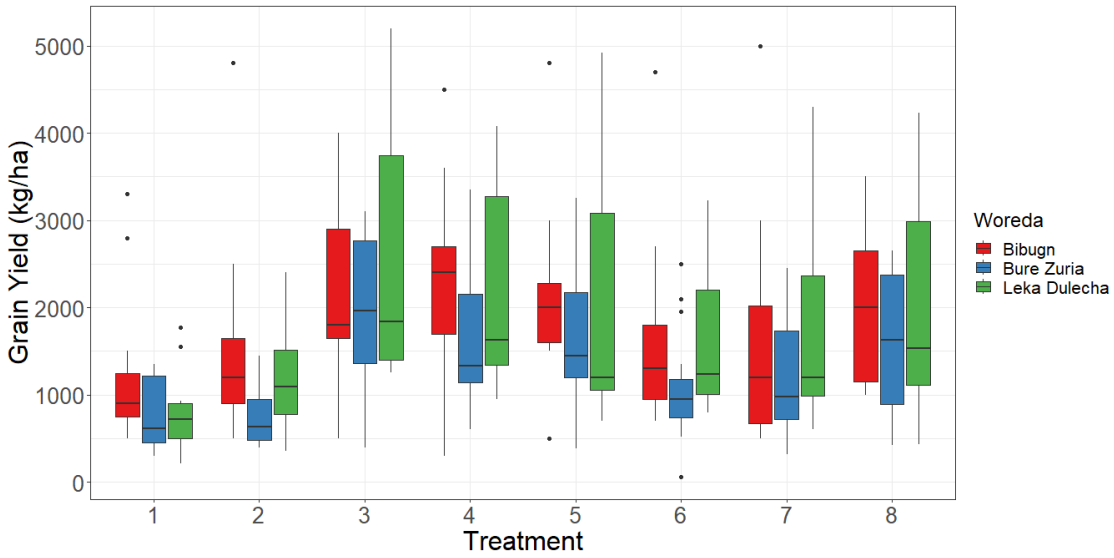
Bure Zuria	1	300	1350	775	396.22	1000	3000	1856.3	679.77
Bure Zuria	2	390	1450	731.88	309.71	1130	4150	2083.1	942.46
Bure Zuria	3	390	3100	1876.9	916.43	1880	6900	4502.5	1878.1
Bure Zuria	4	600	3350	1652.5	788.6	2130	7350	4028.1	1534.6
Bure Zuria	5	380	3250	1676.3	787.55	1500	7550	3962.5	1637.3
Bure Zuria	6	58.416	2500	1080.5	632.66	186.14	5700	2625.4	1362.4
Bure Zuria	7	320	2450	1210.6	672.21	1400	6000	2921.3	1422.6
Bure Zuria	8	420	2650	1606.9	784.57	1500	6200	3779.4	1594.5
Leka Dulecha	1	216	1775	815.9	495.34	712	3280	2082.9	777.37
Leka Dulecha	2	352	2400	1200.4	659.54	1344	7200	2888.8	1708.4
Leka Dulecha	3	1253.3	5200	2538.2	1414.7	1384	11033	5482.5	2624.7
Leka Dulecha	4	946.67	4080	2262.7	1180	2186.7	11893	5141.4	2637.7

Leka Dulecha	5	696	4920	2116.2	1459.4	2520	9666.7	4921.1	2097.5
Leka Dulecha	6	800	3225	1606.6	835.65	2200	5600	3600.5	865.61
Leka Dulecha	7	600	4300	1777.2	1241.8	1800	6000	3740.7	1245.5
Leka Dulecha	8	432	4235	2025.3	1313.4	2820	6500	4273.9	1225

```
#yield_trt_summary
#with(wheat, desc(Treatment, GrainYield, ylab = "Grain Yield ", xlab = "Treat
ment", ylim = NA))
```

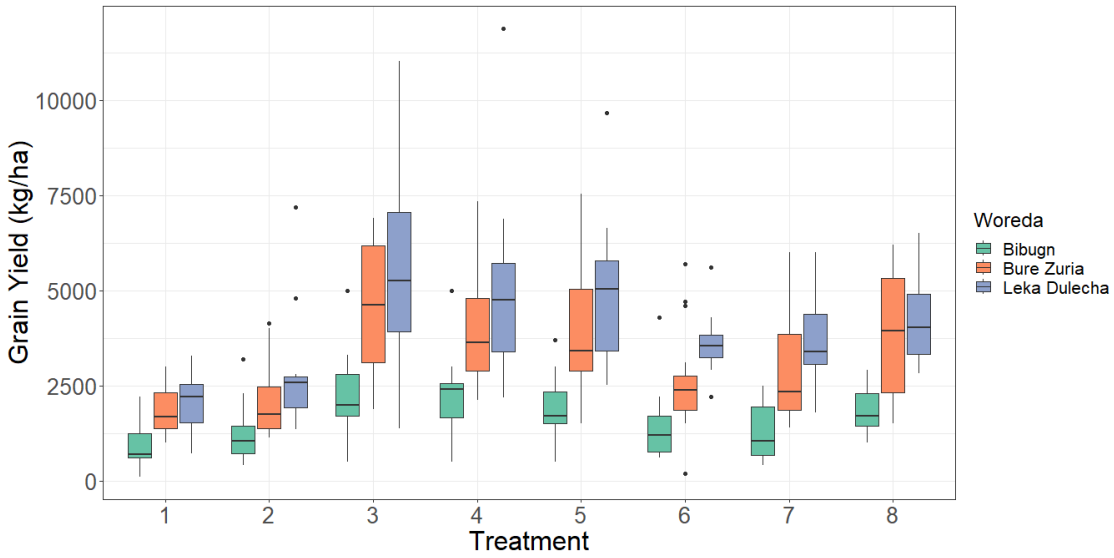
- Grain

```
#boxplot
wheat %>% select(GY_kg_ha, Woreda,Treatment) %>%
ggplot(aes(x=Treatment,y=GY_kg_ha, fill=Woreda)) +
  geom_boxplot() +
  scale_fill_brewer(palette = "Set1") +
  labs(y="Grain Yield (kg/ha)")+
  theme_bw()+
  theme(legend.title = element_text(size = 18),
        legend.text = element_text(size = 16),
        axis.title = element_text(size = 24),
        axis.text = element_text(size = 20))
```



- Stover

```
#boxplot
wheat %>% select(SY_kg_ha, Woreda,Treatment) %>%
ggplot(aes(x=Treatment,y=SY_kg_ha, fill=Woreda)) +
  geom_boxplot() +
  scale_fill_brewer(palette = "Set2") +
  labs(y="Grain Yield (kg/ha)")+
  theme_bw()+
  theme(legend.title = element_text(size = 18),
        legend.text = element_text(size = 16),
        axis.title = element_text(size = 24),
        axis.text = element_text(size = 20))
```



Factorial analysis

```
# Analysis of variance
model <- lm(GY_kg_ha~ Treatment + Woreda + (Treatment:Woreda) +
              (Woreda:Rep),data=wheat)
anova(model)

## Analysis of Variance Table
##
## Response: GY_kg_ha
##                    Df    Sum Sq Mean Sq F value    Pr(>F)
## Treatment           7  52485595 7497942  9.5269 1.376e-10 ***
## Woreda              2  18013080 9006540 11.4437 1.688e-05 ***
## Treatment:Woreda   14   3665685  261835  0.3327    0.9893
## Woreda:Rep          6  40905303 6817551  8.6624 1.226e-08 ***
## Residuals         273 214859575  787031
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

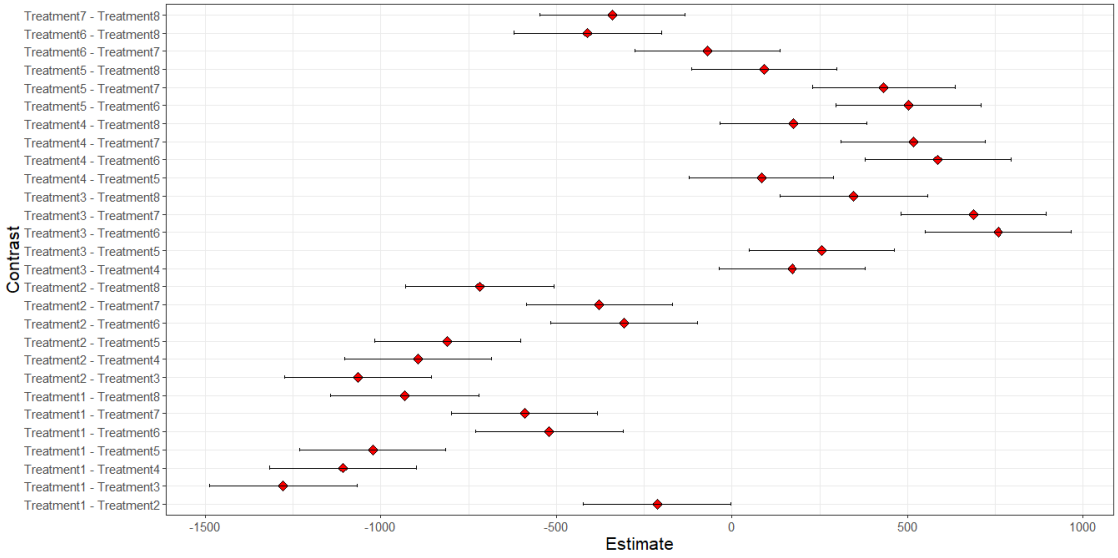
Posthoc test

```
# Compute the estimated marginal means
emmeans_result <- emmeans(model, ~ Treatment)

## NOTE: A nesting structure was detected in the fitted model:
##     Rep %in% Woreda

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

# Perform pairwise comparisons using Tukey's adjustment
pairwise_result <- pairs(emmeans_result, adjust = "tukey")

# Display the pairwise comparisons
knitr::kable(pairwise_result)
```

contrast	estimate	SE	df	t.ratio	p.value
Treatment1 - Treatment2	-213.20143	210.9984	273	-1.0104408	0.9726136
Treatment1 - Treatment3	-1278.38325	210.0544	273	-6.0859625	0.0000001
Treatment1 - Treatment4	-1107.18754	209.1061	273	-5.2948600	0.0000068
Treatment1 - Treatment5	-1022.99090	207.0419	273	-4.9409858	0.0000369
Treatment1 - Treatment6	-520.58005	210.0544	273	-2.4783105	0.2092149
Treatment1 - Treatment7	-590.91388	207.0419	273	-2.8540792	0.0863763
Treatment1 - Treatment8	-931.95126	210.5236	273	-4.4268248	0.0003656
Treatment2 - Treatment3	-1065.18182	209.5775	273	-5.0825208	0.0000189
Treatment2 - Treatment4	-893.98611	208.6270	273	-4.2850932	0.0006612
Treatment2 - Treatment5	-809.78947	207.4344	273	-3.9038333	0.0029737
Treatment2 - Treatment6	-307.37861	209.5775	273	-1.4666587	0.8244636
Treatment2 - Treatment7	-377.71245	207.4344	273	-1.8208763	0.6064152
Treatment2 - Treatment8	-718.74983	210.9984	273	-3.4064224	0.0170737
Treatment3 - Treatment4	171.19571	207.6722	273	0.8243555	0.9916272
Treatment3 - Treatment5	255.39235	206.4741	273	1.2369220	0.9201884
Treatment3 - Treatment6	757.80321	206.7129	273	3.6659688	0.0070801
Treatment3 - Treatment7	687.46937	206.4741	273	3.3295671	0.0218515
Treatment3 - Treatment8	346.43199	210.0544	273	1.6492488	0.7197609
Treatment4 - Treatment5	84.19664	205.5093	273	0.4096975	0.9999091
Treatment4 - Treatment6	586.60750	207.6722	273	2.8246803	0.0931896
Treatment4 - Treatment7	516.27367	205.5093	273	2.5121671	0.1947069
Treatment4 - Treatment8	175.23628	209.1061	273	0.8380257	0.9907561
Treatment5 - Treatment6	502.41085	206.4741	273	2.4332875	0.2296232
Treatment5 - Treatment7	432.07702	203.4829	273	2.1234075	0.4025162

Treatment5 - Treatment8	91.03964	207.0419	273	0.4397161	0.9998537
Treatment6 - Treatment7	-70.33383	206.4741	273	-0.3406424	0.9999741
Treatment6 - Treatment8	-411.37122	210.0544	273	-1.9584032	0.5120470
Treatment7 - Treatment8	-341.03738	207.0419	273	-1.6471905	0.7210522

```
#plot(pairwise_result, pch = "*", cex = 1.5)
as_tibble(pairwise_result) %>%
ggplot(aes(x=estimate,y=contrast)) +
  geom_point(shape=23, size = 3, fill = "red") +
  geom_errorbar(aes(xmin = estimate - SE, xmax = estimate + SE),
                width = 0.2) +
  labs(x = "Estimate", y = "Contrast")+
  theme_bw()+
  theme(axis.title = element_text(size = 16),
        axis.text = element_text(size = 11))
```



Best treatment per location

For every woreda, what are the 3 best treatment?

- Grain

```
best_comb<-yield_location_trt %>% select(Woreda, Treatment, mean_GY_kg_ha) %>
%
  group_by(Woreda) %>%
  slice_max(mean_GY_kg_ha, n=3)
knitr::kable(best_comb)
```

Woreda	Treatment	mean_GY_kg_ha
Bibugn	4	2309.091
Bibugn	3	2190.909
Bibugn	5	2108.333

Bure Zuria	3	1876.875
Bure Zuria	5	1676.250
Bure Zuria	4	1652.500
Leka Dulecha	3	2538.242
Leka Dulecha	4	2262.667
Leka Dulecha	5	2116.182

- Stover

```
best_comb<-yield_location_trt %>% select(Woreda, Treatment, mean_SY_kg_ha) %>%
%
  group_by(Woreda) %>%
  slice_max(mean_SY_kg_ha, n=3)
knitr::kable(best_comb)
```

Woreda	Treatment	mean_SY_kg_ha
Bibugn	3	2309.091
Bibugn	4	2263.636
Bibugn	5	1983.333
Bure Zuria	3	4502.500
Bure Zuria	4	4028.125
Bure Zuria	5	3962.500
Leka Dulecha	3	5482.545
Leka Dulecha	4	5141.364
Leka Dulecha	5	4921.061