Splitting all fluxes into the right seasons, calculation of cumulative fluxes

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Contents

Necessary libraries

```
library(knitr)
library(ggplot2)
theme_set(theme_bw())
library(emmeans)
library(multcomp)
library(PLS205)
library(lme4)
library(lmerTest)
library(multcompView)
```

```r
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(openxlsx)
library(zoo)
library(dplyr)
library(tidyr)
library(zoo)
```

#Load master

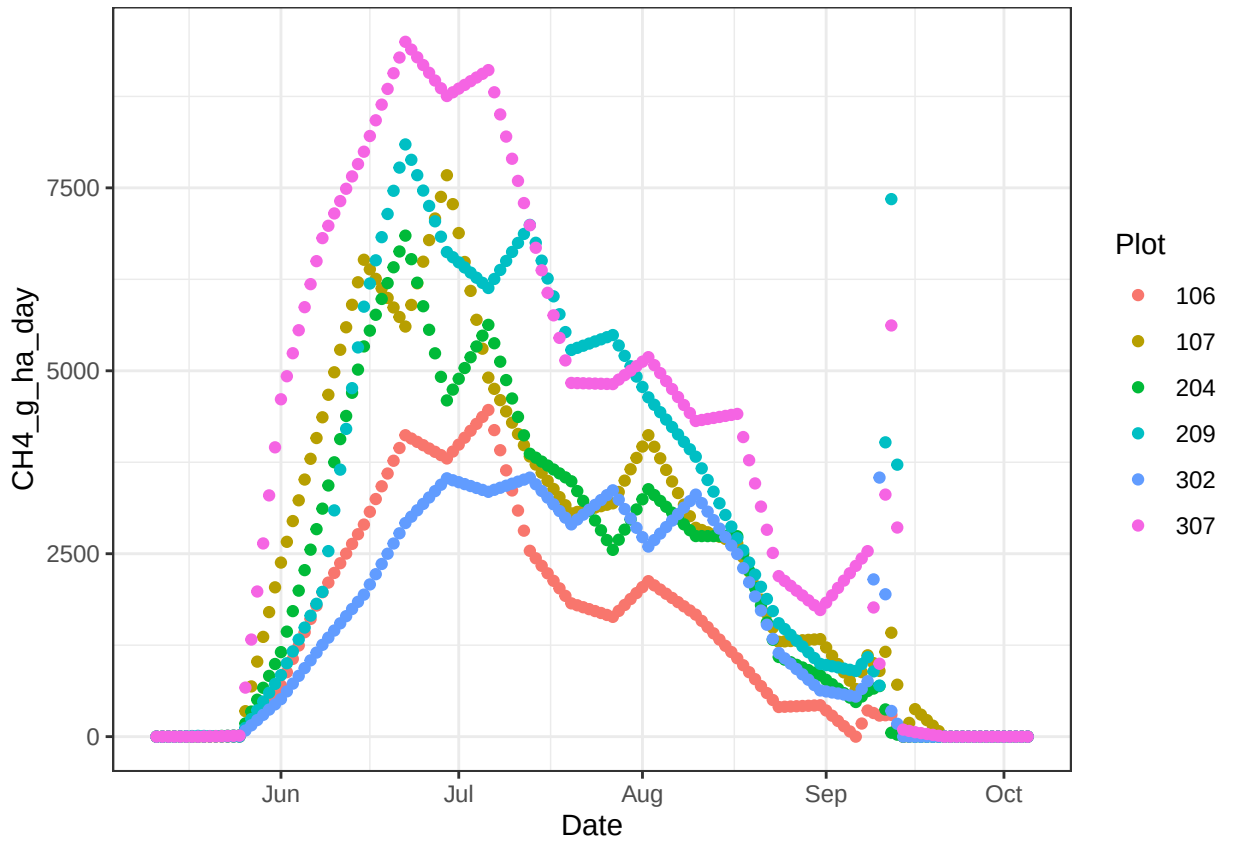
```r
master <- read_excel("D:/Academics/UC Davis/School Work/Linquist Lab/Data/R stats/GHG and MAOM POM/Daily

#checking <- read_excel("Daily_Flux_Mastersheet_Final_DoNotEdit.xlsx", sheet = 1)
#checking$Plot <- as.factor(master$Plot)

master$Plot <- as.factor(master$Plot)

#change from CH4 gha-1day-1 to CH4-C gha-1day-1 and N2O gha-1day-1 to N2O-N gha-1day-1
#master$CH4_C_g_ha_day <- master$CH4_g_ha_day*0.749
#master$N2O_N_g_ha_day <- master$N2O_g_ha_day*0.636

#table(checking$Plot)
table(master$Plot)
```

```
##
## 106 107 204 209 302 307 402 409 505 512 601 608 701 711 805 812 903 909  K1
##  42  42  42  65  42  65  59  40  59  40  60  41  21  21  21  21  21  21  23
```

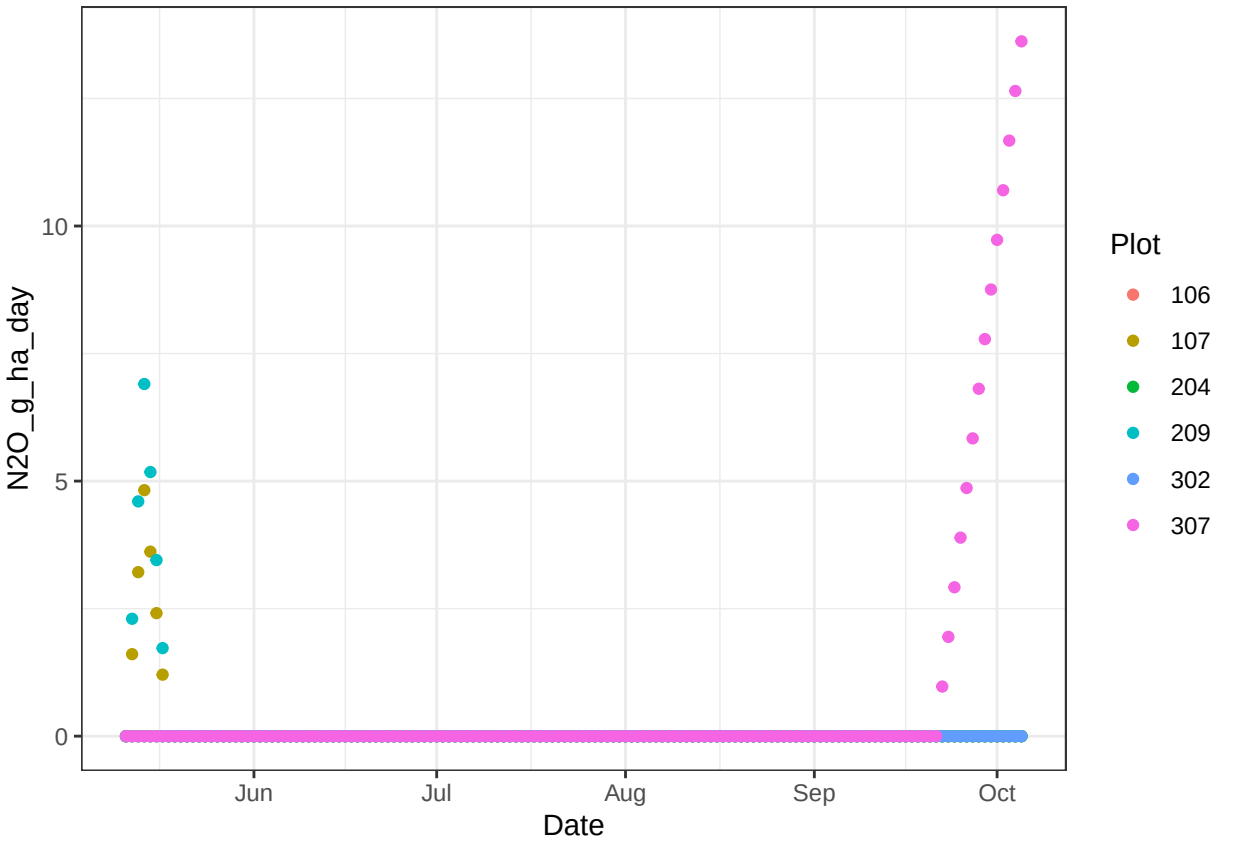
2021 summer rice

```r
summer_2021_rice <- master %>%
  filter(Date >= as.POSIXct("2021-05-10") & Date <= as.POSIXct("2021-10-06"))%>%
  filter (Plot != c(402, 505, 601))

start_date <- as.Date("2021-05-11")
end_date <- as.Date("2021-10-5")
date_seq <- seq.Date(start_date, end_date, by = "day")

summer_2021_rice_interpolated <- summer_2021_rice %>%
  group_by(Plot) %>%
  complete(Date = date_seq) %>%
  ungroup()
```

```r
summer_2021_rice_interpolated <- summer_2021_rice_interpolated %>%
  group_by(Plot) %>%
  mutate(CH4_g_ha_day = na.approx(CH4_g_ha_day, rule = 2)) %>%
  mutate(N2O_g_ha_day = na.approx(N2O_g_ha_day, rule = 2)) %>%
  ungroup()

summer_2021_rice_seasonal_emissions <- summer_2021_rice_interpolated %>%
  group_by(Plot) %>%
  summarize(total_CH4_emissions = sum(CH4_g_ha_day, na.rm = TRUE), total_N2O_emissions = sum(N2O_g_ha_da
  mutate(Period_Year = "Summer_Rice_2021") %>%
  mutate(Period = "Summer_Rice")%>%
  mutate(Treatment = case_when(
    Plot %in% c("106", "204", "302") ~ "FR",
    Plot %in% c("107", "209", "307") ~ "CR",
    TRUE ~ "Other"  # This line handles cases where plot is not listed
  ))

ggplot(summer_2021_rice_interpolated, aes(y=CH4_g_ha_day, x=Date, color = Plot)) + geom_point()
```



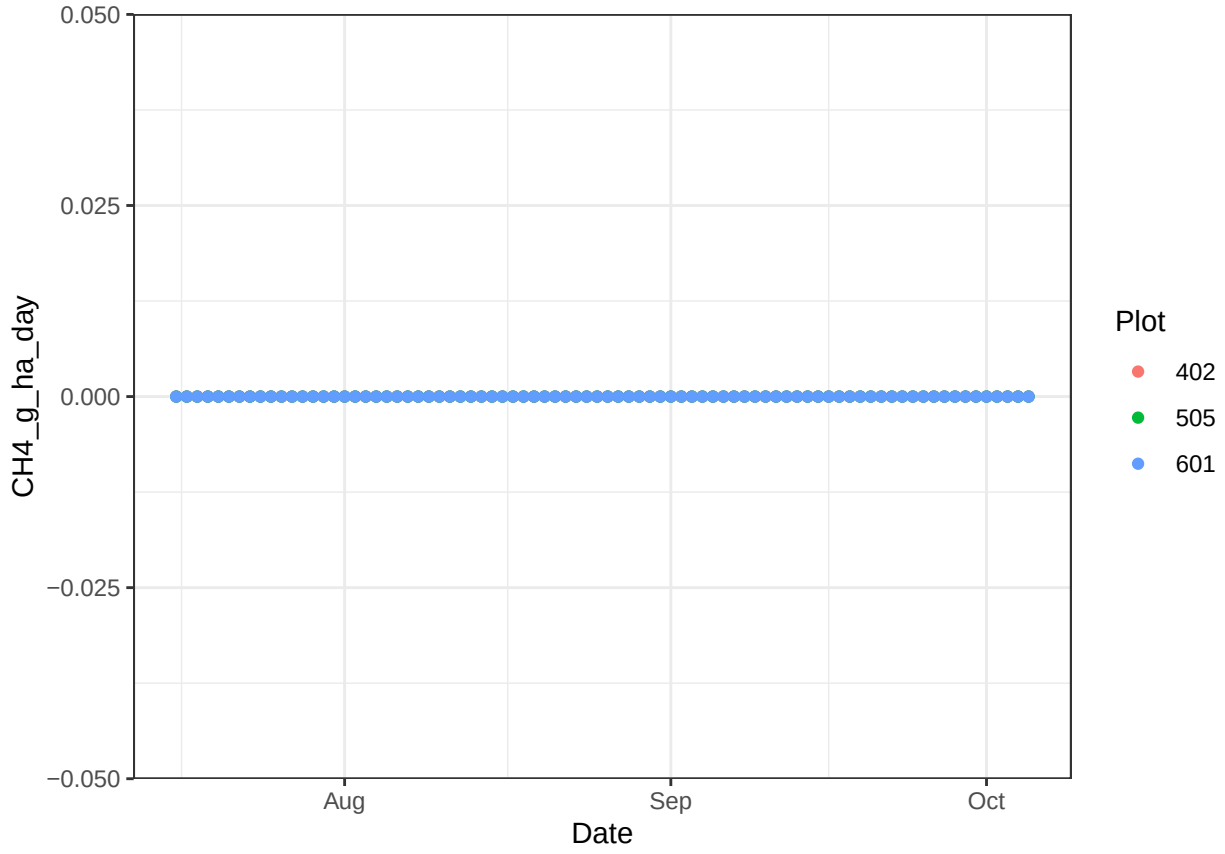

```r
ggplot(summer_2021_rice_interpolated, aes(y=N2O_g_ha_day, x=Date, color = Plot)) + geom_point()
```



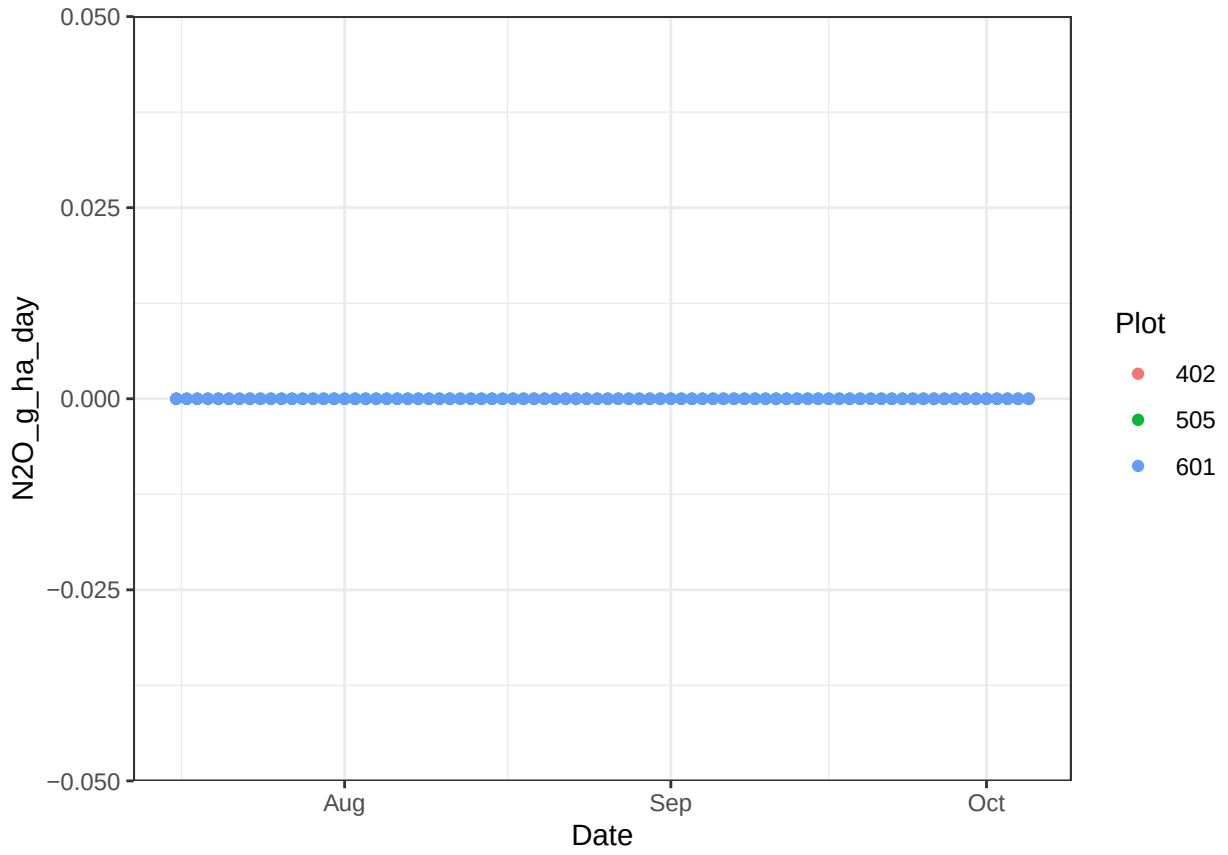
2021 summer fallow

```
summer_2021_fallow <- master %>%
  filter(Date >= as.POSIXct("2021-05-10") & Date <= as.POSIXct("2021-10-06"))%>%
  filter (Plot == c(402, 505, 601))

start_date <- as.Date("2021-07-16")
end_date <- as.Date("2021-10-5")
date_seq <- seq.Date(start_date, end_date, by = "day")

summer_2021_fallow_interpolated <- summer_2021_fallow %>%
  group_by(Plot) %>%
  complete(Date = date_seq) %>%
  ungroup()

summer_2021_fallow_interpolated <- summer_2021_fallow_interpolated %>%
  group_by(Plot) %>%
  mutate(CH4_g_ha_day = na.approx(CH4_g_ha_day, rule = 2)) %>%
  mutate(N2O_g_ha_day = na.approx(N2O_g_ha_day, rule = 2)) %>%
  ungroup()

summer_2021_fallow_seasonal_emissions <- summer_2021_fallow_interpolated %>%
  group_by(Plot) %>%
```

```
  summarize(total_CH4_emissions = sum(CH4_g_ha_day, na.rm = TRUE), total_N2O_emissions = sum(N2O_g_ha_da
  mutate(Period_Year = "Summer_Fallow_2021") %>%
  mutate(Period = "Summer_Fallow")%>%
  mutate(Treatment = case_when(
    Plot %in% c("402", "505", "601") ~ "F",
    TRUE ~ "Other"  # This line handles cases where plot is not listed
  ))

ggplot(summer_2021_fallow_interpolated, aes(y=CH4_g_ha_day, x=Date, color = Plot)) + geom_point()
```



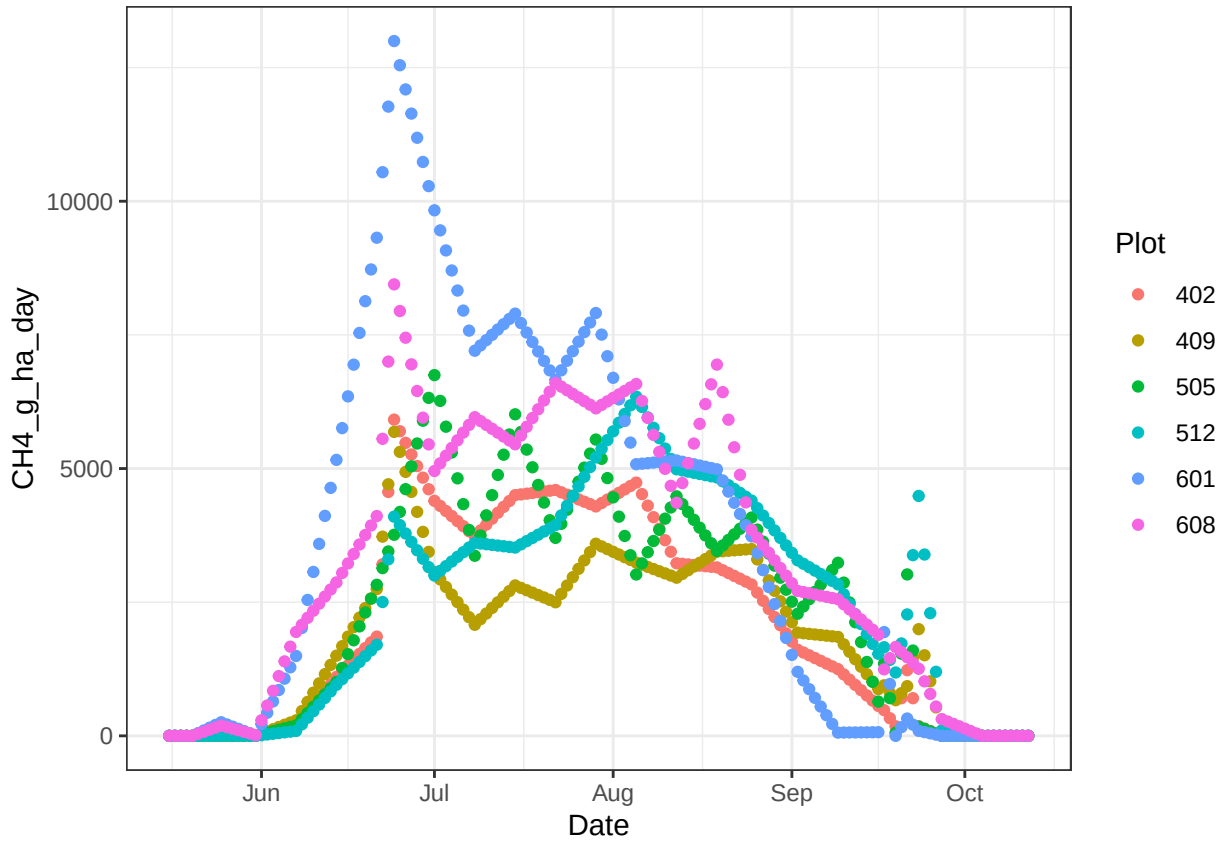

```
ggplot(summer_2021_fallow_interpolated, aes(y=N2O_g_ha_day, x=Date, color = Plot)) + geom_point()
```



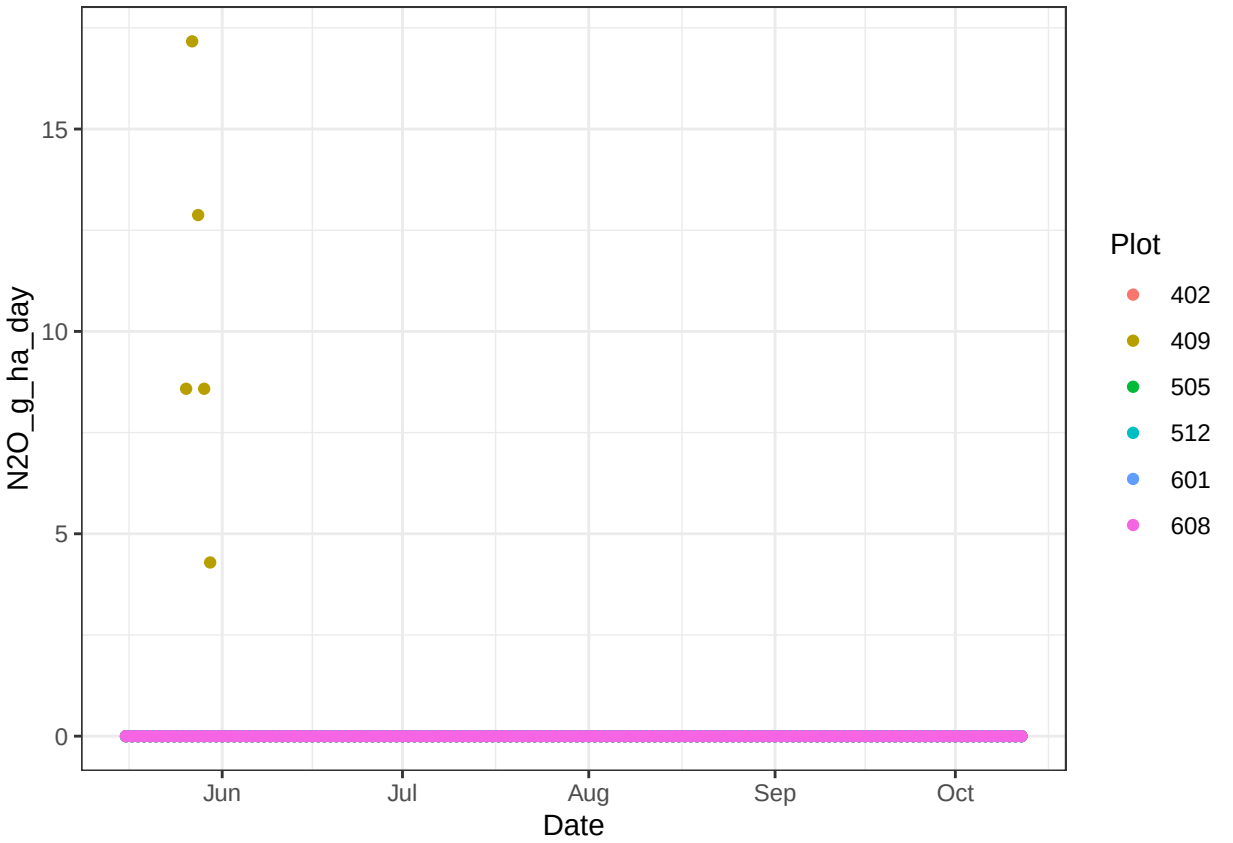
2022 summer rice

```
summer_2022_rice <- master %>%
  filter(Date >= as.POSIXct("2022-05-15") & Date <= as.POSIXct("2022-10-13"))%>%
  filter (Plot %in% c(402, 409, 505, 512, 601, 608))

start_date <- as.Date("2022-05-16")
end_date <- as.Date("2022-10-12")
date_seq <- seq.Date(start_date, end_date, by = "day")

summer_2022_rice_interpolated <- summer_2022_rice %>%
  group_by(Plot) %>%
  complete(Date = date_seq) %>%
  ungroup()

summer_2022_rice_interpolated <- summer_2022_rice_interpolated %>%
  group_by(Plot) %>%
  mutate(CH4_g_ha_day = na.approx(CH4_g_ha_day, rule = 2)) %>%
  mutate(N2O_g_ha_day = na.approx(N2O_g_ha_day, rule = 2)) %>%
  ungroup()

summer_2022_rice_seasonal_emissions <- summer_2022_rice_interpolated %>%
  group_by(Plot) %>%
```

```
  summarize(total_CH4_emissions = sum(CH4_g_ha_day, na.rm = TRUE), total_N2O_emissions = sum(N2O_g_ha_da
  mutate(Period_Year = "Summer_Rice_2022") %>%
  mutate(Period = "Summer_Rice")%>%
  mutate(Treatment = case_when(
    Plot %in% c("402", "505", "601") ~ "FR",
    Plot %in% c("409", "512", "608") ~ "CR",
    TRUE ~ "Other"  # This line handles cases where plot is not listed
  ))

ggplot(summer_2022_rice_interpolated, aes(y=CH4_g_ha_day, x=Date, color = Plot)) + geom_point()
```



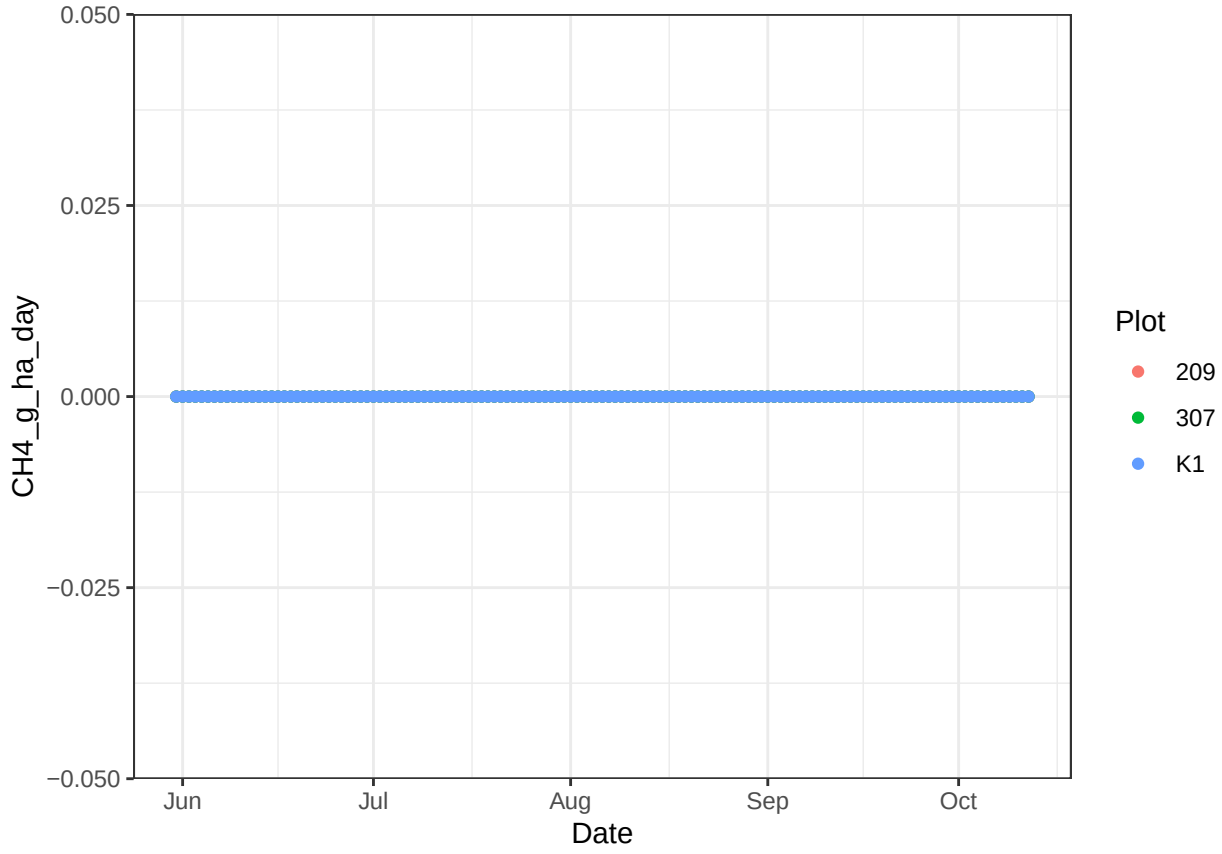

```
ggplot(summer_2022_rice_interpolated, aes(y=N2O_g_ha_day, x=Date, color = Plot)) + geom_point()
```



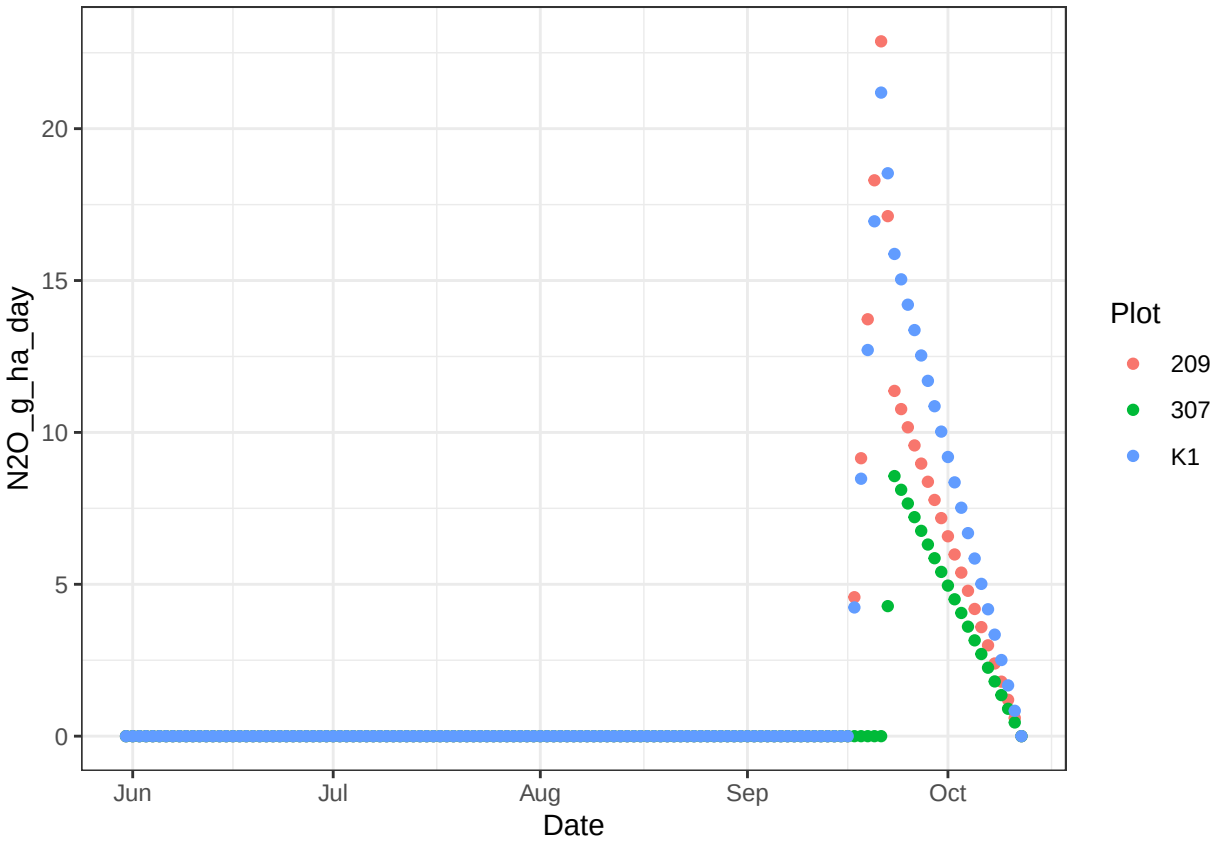
2022 summer fallow

```
summer_2022_fallow <- master %>%
  filter(Date >= as.POSIXct("2022-05-15") & Date <= as.POSIXct("2022-10-13"))%>%
  filter (Plot %in% c(209, 307, "K1"))

start_date <- as.Date("2022-05-31")
end_date <- as.Date("2022-10-12")
date_seq <- seq.Date(start_date, end_date, by = "day")

summer_2022_fallow_interpolated <- summer_2022_fallow %>%
  group_by(Plot) %>%
  complete(Date = date_seq) %>%
  ungroup()

summer_2022_fallow_interpolated <- summer_2022_fallow_interpolated %>%
  group_by(Plot) %>%
  mutate(CH4_g_ha_day = na.approx(CH4_g_ha_day, rule = 2)) %>%
  mutate(N2O_g_ha_day = na.approx(N2O_g_ha_day, rule = 2)) %>%
  ungroup()

summer_2022_fallow_seasonal_emissions <- summer_2022_fallow_interpolated %>%
  group_by(Plot) %>%
```

```
  summarize(total_CH4_emissions = sum(CH4_g_ha_day, na.rm = TRUE), total_N2O_emissions = sum(N2O_g_ha_da
  mutate(Period_Year = "Summer_Fallow_2022") %>%
  mutate(Period = "Summer_Fallow")%>%
  mutate(Treatment = case_when(
    Plot %in% c("209", "307", "K1") ~ "F",
    TRUE ~ "Other"  # This line handles cases where plot is not listed
  ))

ggplot(summer_2022_fallow_interpolated, aes(y=CH4_g_ha_day, x=Date, color = Plot)) + geom_point()
```



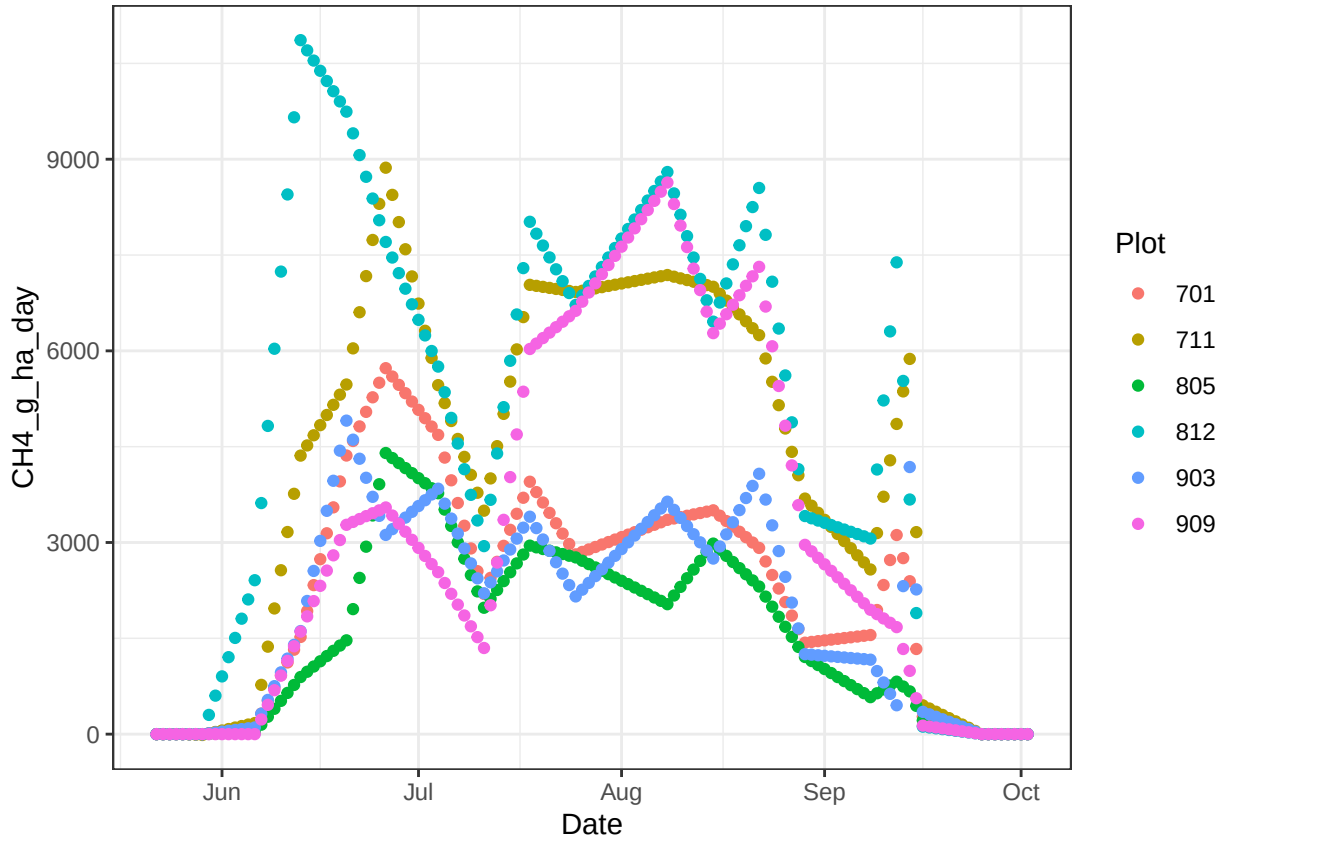

```
ggplot(summer_2022_fallow_interpolated, aes(y=N2O_g_ha_day, x=Date, color = Plot)) + geom_point()
```



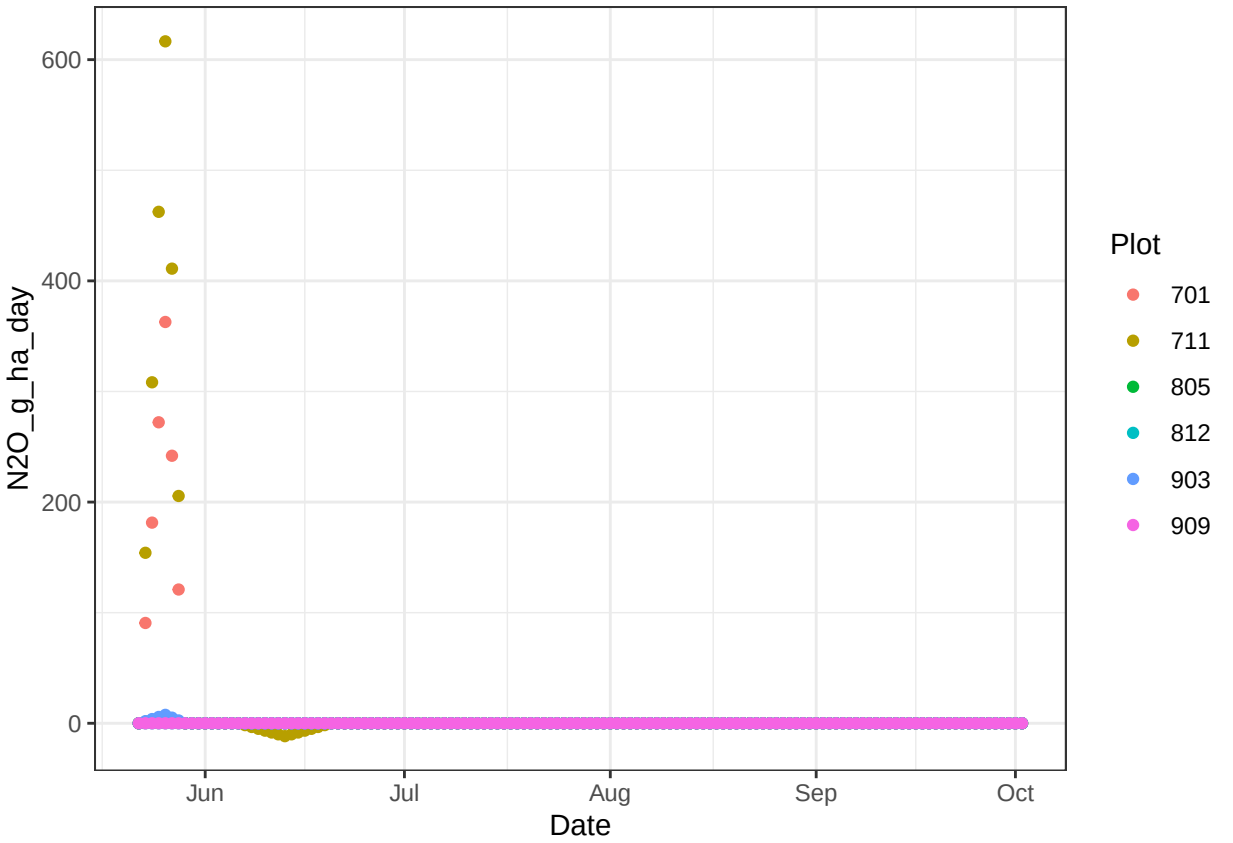
2023 summer rice

```
summer_2023_rice <- master %>%
  filter(Date >= as.POSIXct("2023-05-21") & Date <= as.POSIXct("2023-10-2"))

start_date <- as.Date("2023-05-22")
end_date <- as.Date("2023-10-2")
date_seq <- seq.Date(start_date, end_date, by = "day")

summer_2023_rice_interpolated <- summer_2023_rice %>%
  group_by(Plot) %>%
  complete(Date = date_seq) %>%
  ungroup()

summer_2023_rice_interpolated <- summer_2023_rice_interpolated %>%
  group_by(Plot) %>%
  mutate(CH4_g_ha_day = na.approx(CH4_g_ha_day, rule = 2)) %>%
  mutate(N2O_g_ha_day = na.approx(N2O_g_ha_day, rule = 2)) %>%
  ungroup()

summer_2023_rice_seasonal_emissions <- summer_2023_rice_interpolated %>%
  group_by(Plot) %>%
  summarize(total_CH4_emissions = sum(CH4_g_ha_day, na.rm = TRUE), total_N2O_emissions = sum(N2O_g_ha_da
```

```
  mutate(Period_Year = "Summer_Rice_2023") %>%
  mutate(Period = "Summer_Rice")%>%
  mutate(Treatment = case_when(
    Plot %in% c("701", "805", "903") ~ "FR",
    Plot %in% c("711", "812", "909") ~ "CR",
    TRUE ~ "Other"  # This line handles cases where plot is not listed
  ))

ggplot(summer_2023_rice_interpolated, aes(y=CH4_g_ha_day, x=Date, color = Plot)) + geom_point()
```



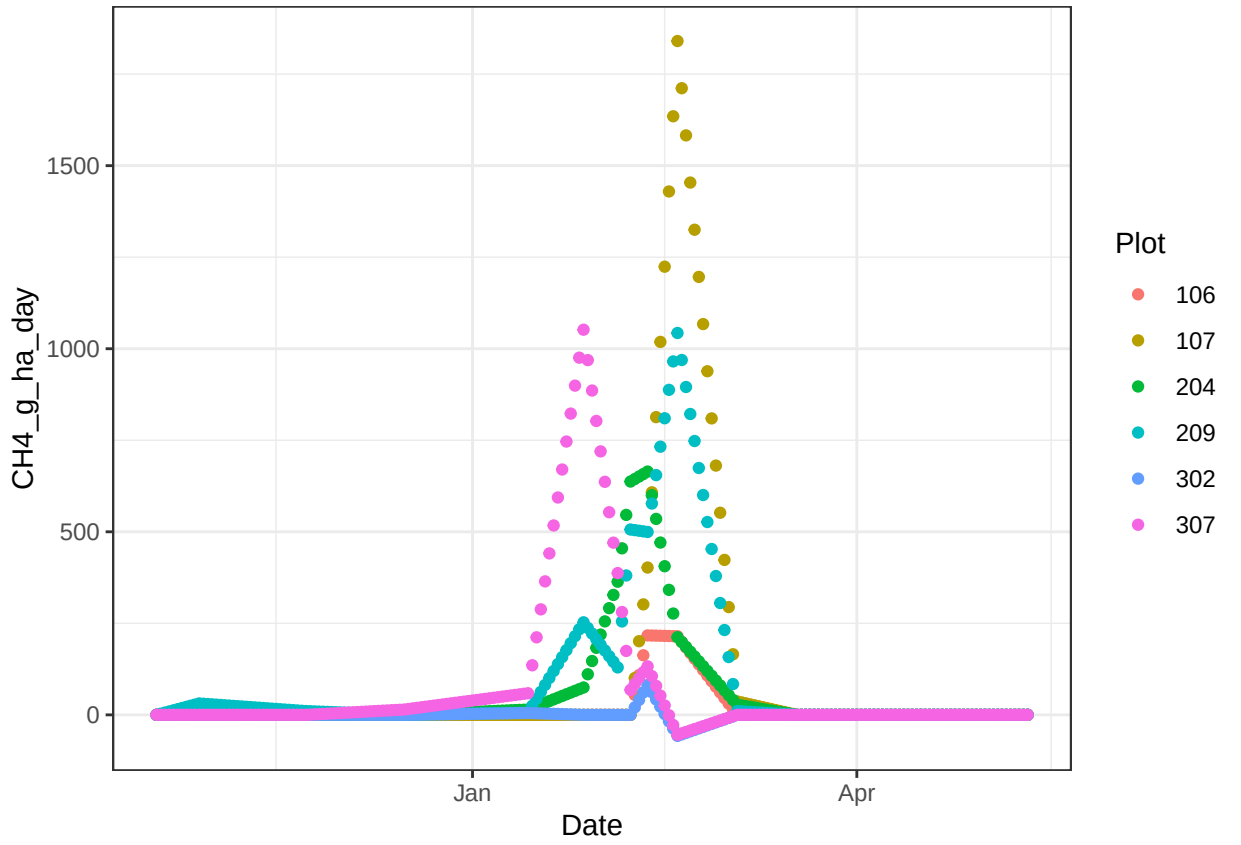

```
ggplot(summer_2023_rice_interpolated, aes(y=N2O_g_ha_day, x=Date, color = Plot)) + geom_point()
```



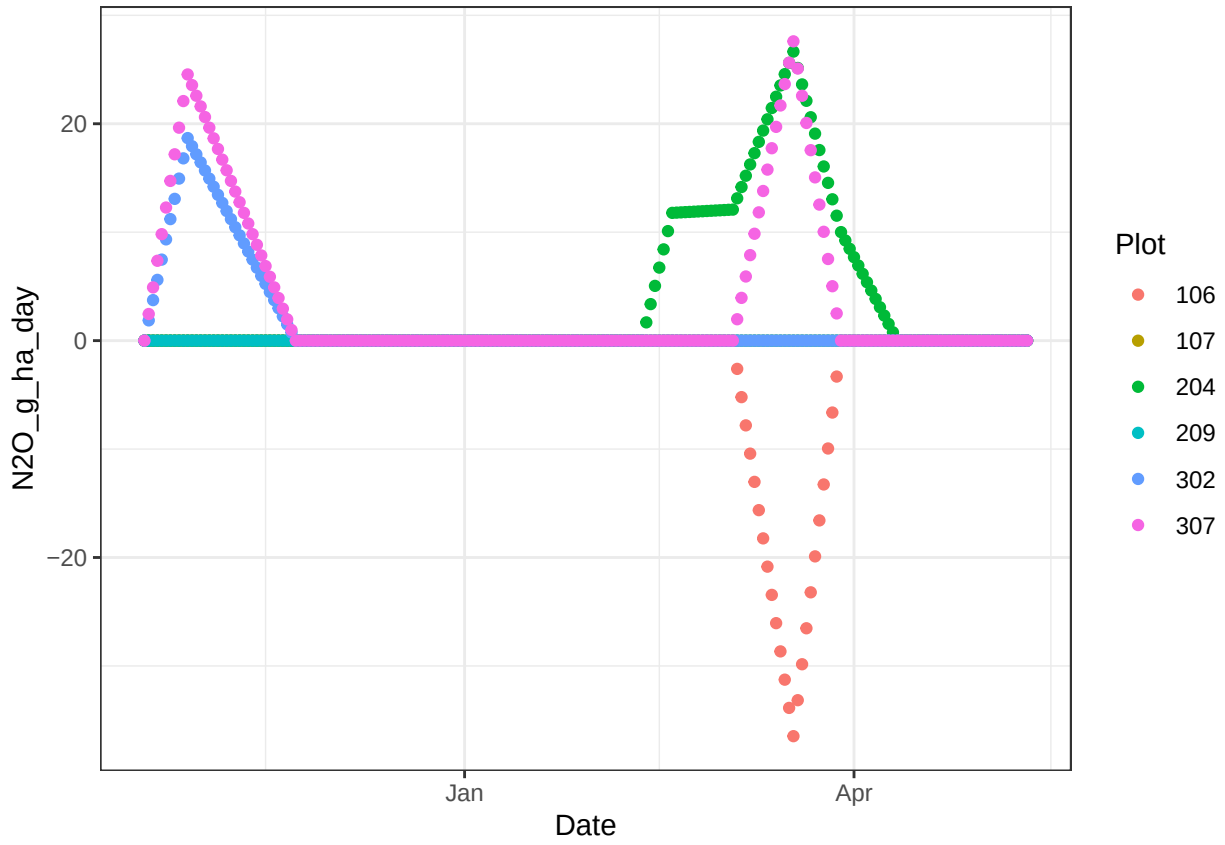
2021/2022 rice winter

```
winter_rice_2021_2022 <- master %>%
  filter(Date >= as.POSIXct("2021-10-18") & Date <= as.POSIXct("2022-05-12"))%>%
  filter (Plot != c(402, 505, 601))

start_date <- as.Date("2021-10-19")
end_date <- as.Date("2022-05-11")
date_seq <- seq.Date(start_date, end_date, by = "day")

winter_rice_2021_2022_interpolated <- winter_rice_2021_2022 %>%
  group_by(Plot) %>%
  complete(Date = date_seq) %>%
  ungroup()

winter_rice_2021_2022_interpolated <- winter_rice_2021_2022_interpolated %>%
  group_by(Plot) %>%
  mutate(CH4_g_ha_day = na.approx(CH4_g_ha_day, rule = 2)) %>%
  mutate(N2O_g_ha_day = na.approx(N2O_g_ha_day, rule = 2)) %>%
  ungroup()

winter_rice_2021_2022_seasonal_emissions <- winter_rice_2021_2022_interpolated %>%
  group_by(Plot) %>%
```

```
  summarize(total_CH4_emissions = sum(CH4_g_ha_day, na.rm = TRUE), total_N2O_emissions = sum(N2O_g_ha_da
  mutate(Period_Year = "Winter_Rice_2021_2022") %>%
  mutate(Period = "Winter_Rice")%>%
  mutate(Treatment = case_when(
    Plot %in% c("106", "204", "302") ~ "FR",
    Plot %in% c("107", "209", "307") ~ "CR",
    TRUE ~ "Other"  # This line handles cases where plot is not listed
  ))

ggplot(winter_rice_2021_2022_interpolated, aes(y=CH4_g_ha_day, x=Date, color = Plot)) + geom_point()
```



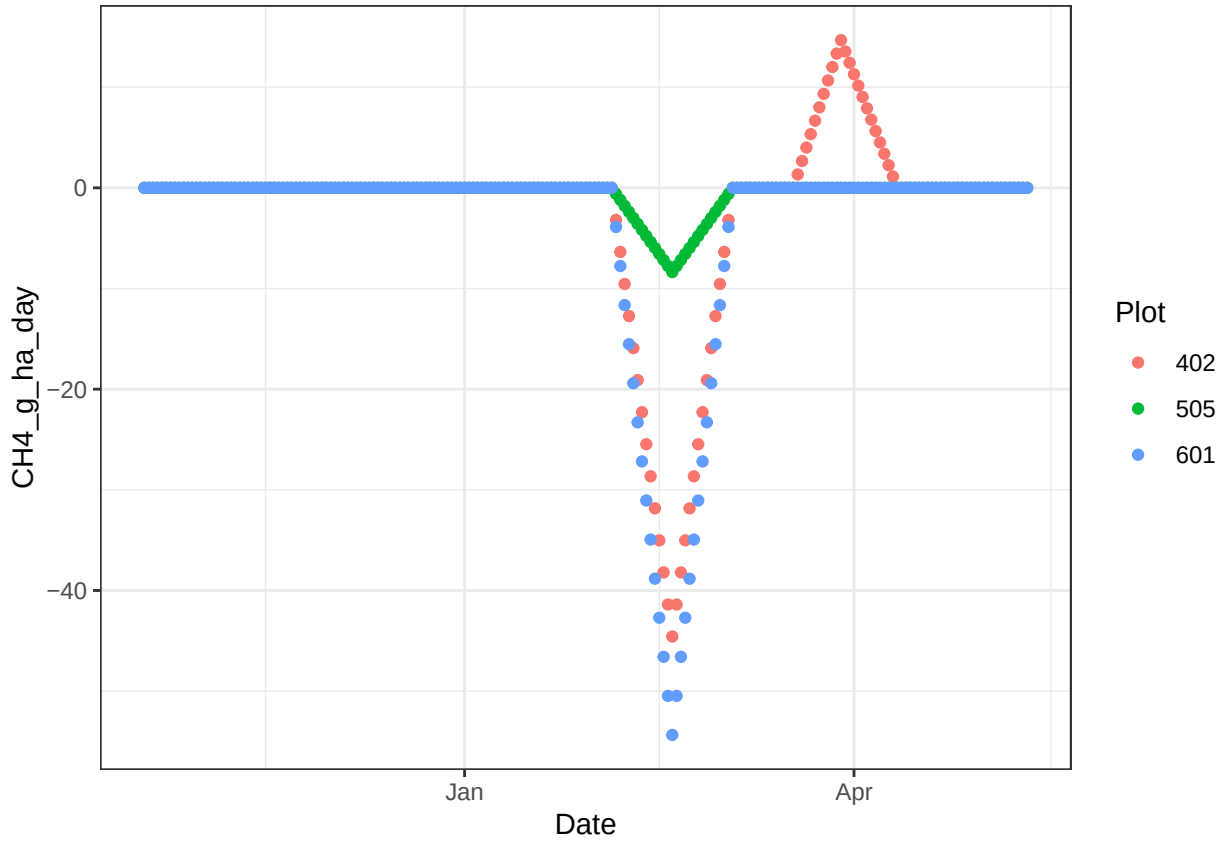

```
ggplot(winter_rice_2021_2022_interpolated, aes(y=N2O_g_ha_day, x=Date, color = Plot)) + geom_point()
```



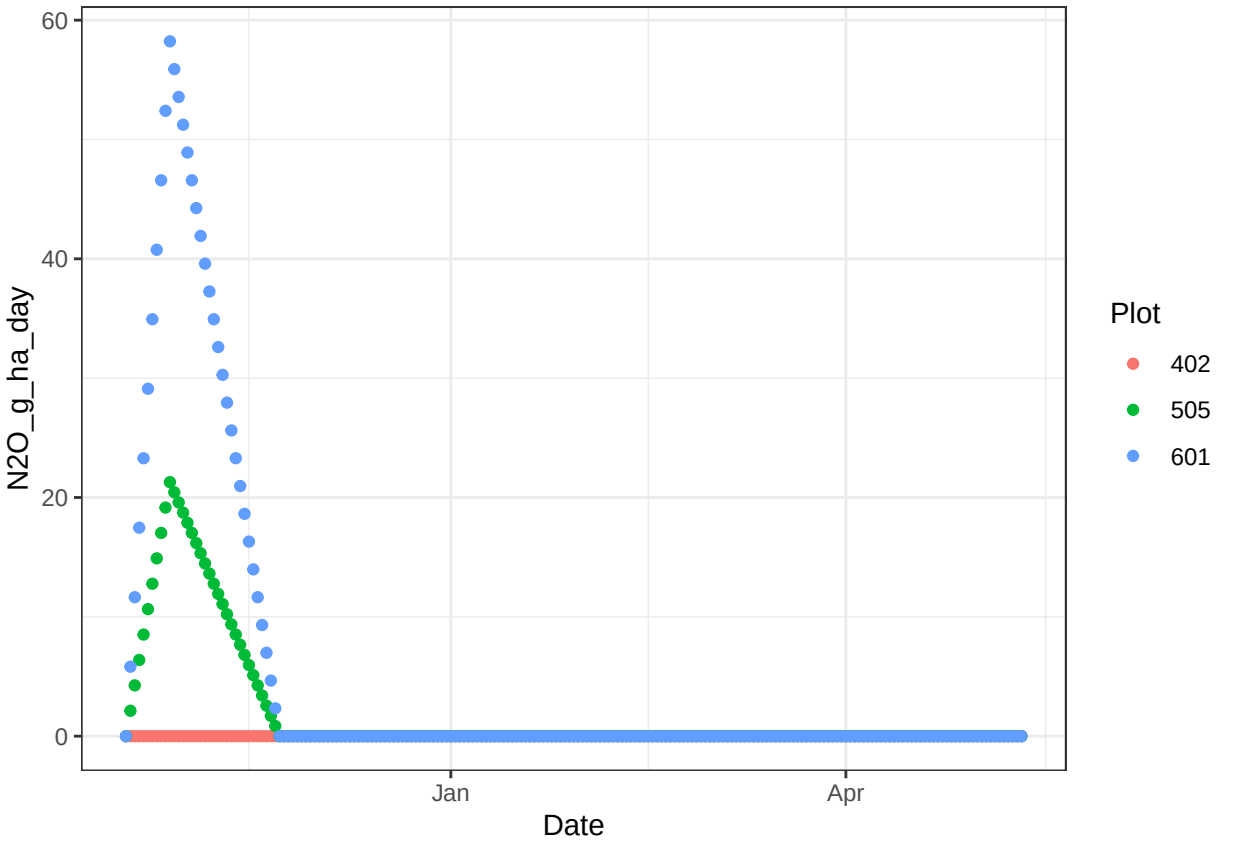
2021/2022 fallow winter

```
winter_fallow_2021_2022 <- master %>%
  filter(Date >= as.POSIXct("2021-10-18") & Date <= as.POSIXct("2022-05-12"))%>%
  filter (Plot == c(402, 505, 601))

start_date <- as.Date("2021-10-19")
end_date <- as.Date("2022-05-11")
date_seq <- seq.Date(start_date, end_date, by = "day")

winter_fallow_2021_2022_interpolated <- winter_fallow_2021_2022 %>%
  group_by(Plot) %>%
  complete(Date = date_seq) %>%
  ungroup()

winter_fallow_2021_2022_interpolated <- winter_fallow_2021_2022_interpolated %>%
  group_by(Plot) %>%
  mutate(CH4_g_ha_day = na.approx(CH4_g_ha_day, rule = 2)) %>%
  mutate(N2O_g_ha_day = na.approx(N2O_g_ha_day, rule = 2)) %>%
  ungroup()

winter_fallow_2021_2022_seasonal_emissions <- winter_fallow_2021_2022_interpolated %>%
  group_by(Plot) %>%
```

```
  summarize(total_CH4_emissions = sum(CH4_g_ha_day, na.rm = TRUE), total_N2O_emissions = sum(N2O_g_ha_da
  mutate(Period_Year = "Winter_Fallow_2021_2022") %>%
  mutate(Period = "Winter_Fallow")%>%
  mutate(Treatment = case_when(
    Plot %in% c("402", "505", "601") ~ "F",
    TRUE ~ "Other"  # This line handles cases where plot is not listed
  ))

ggplot(winter_fallow_2021_2022_interpolated, aes(y=CH4_g_ha_day, x=Date, color = Plot)) + geom_point()
```



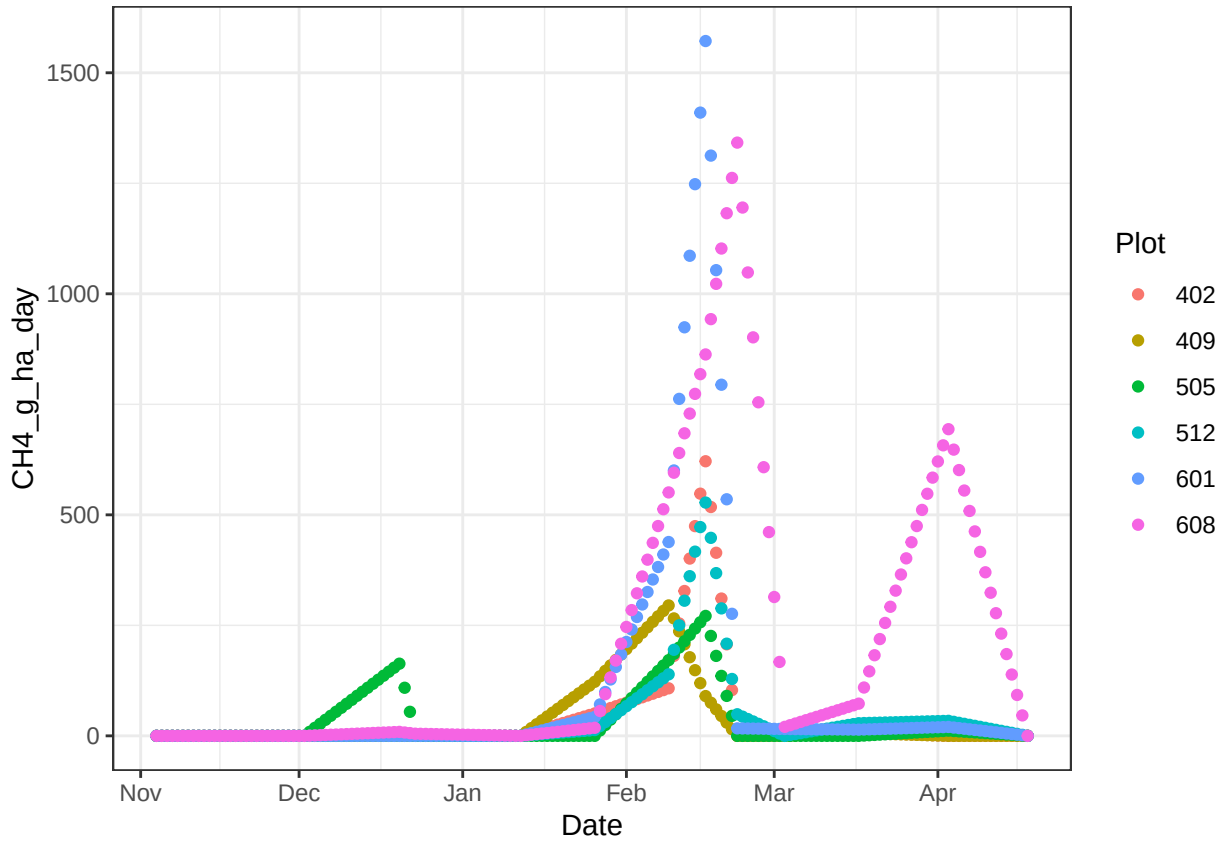

```
ggplot(winter_fallow_2021_2022_interpolated, aes(y=N2O_g_ha_day, x=Date, color = Plot)) + geom_point()
```



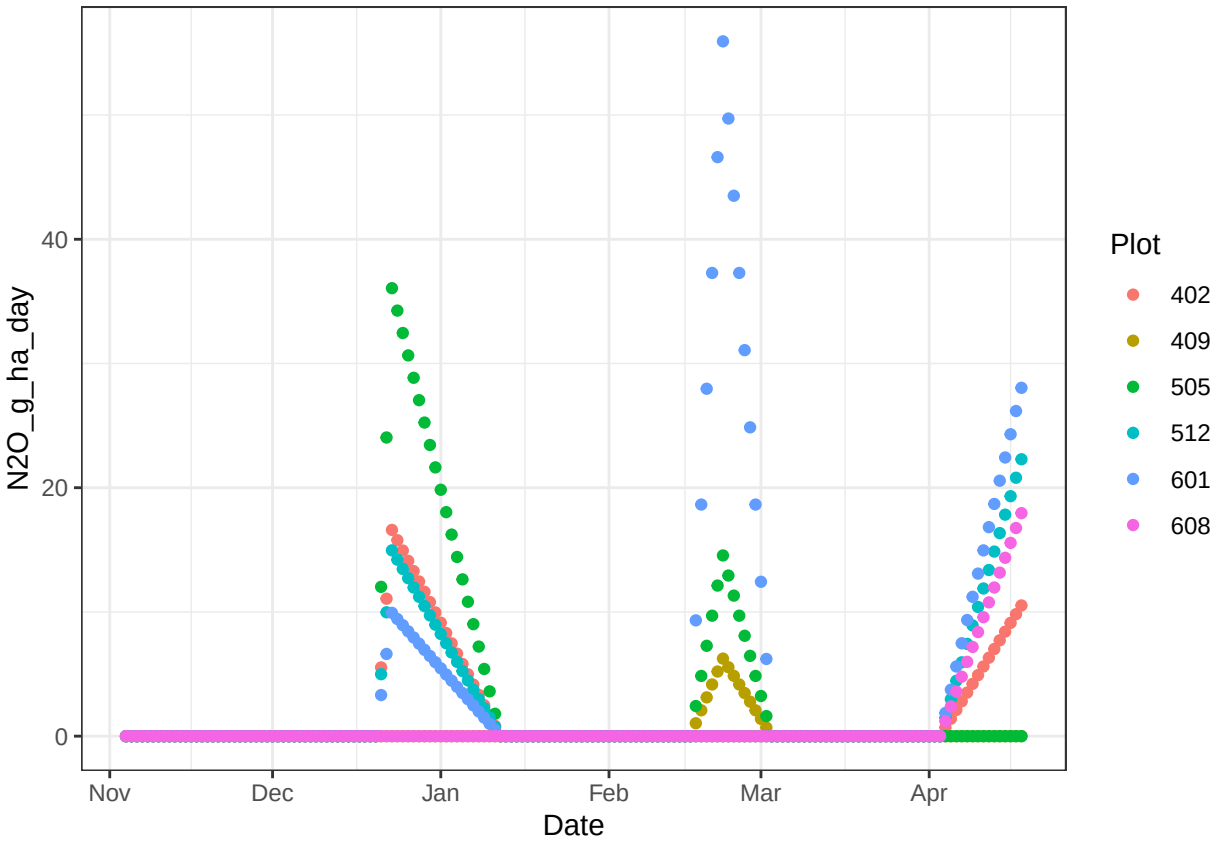
2022/2023 rice winter

```
winter_rice_2022_2023 <- master %>%
  filter(Date >= as.POSIXct("2022-11-3") & Date <= as.POSIXct("2023-4-19"))%>%
  filter (Plot %in% c(402, 409, 505, 512, 601, 608))

start_date <- as.Date("2022-11-4")
end_date <- as.Date("2023-04-18")
date_seq <- seq.Date(start_date, end_date, by = "day")

winter_rice_2022_2023_interpolated <- winter_rice_2022_2023 %>%
  group_by(Plot) %>%
  complete(Date = date_seq) %>%
  ungroup()

winter_rice_2022_2023_interpolated <- winter_rice_2022_2023_interpolated %>%
  group_by(Plot) %>%
  mutate(CH4_g_ha_day = na.approx(CH4_g_ha_day, rule = 2)) %>%
  mutate(N2O_g_ha_day = na.approx(N2O_g_ha_day, rule = 2)) %>%
  ungroup()

winter_rice_2022_2023_seasonal_emissions <- winter_rice_2022_2023_interpolated %>%
  group_by(Plot) %>%
```

```
  summarize(total_CH4_emissions = sum(CH4_g_ha_day, na.rm = TRUE), total_N2O_emissions = sum(N2O_g_ha_da
  mutate(Period_Year = "Winter_Rice_2022_2023") %>%
  mutate(Period = "Winter_Rice")%>%
  mutate(Treatment = case_when(
    Plot %in% c("402", "505", "601") ~ "FR",
    Plot %in% c("409", "512", "608") ~ "CR",
    TRUE ~ "Other"  # This line handles cases where plot is not listed
  ))

ggplot(winter_rice_2022_2023_interpolated, aes(y=CH4_g_ha_day, x=Date, color = Plot)) + geom_point()
```



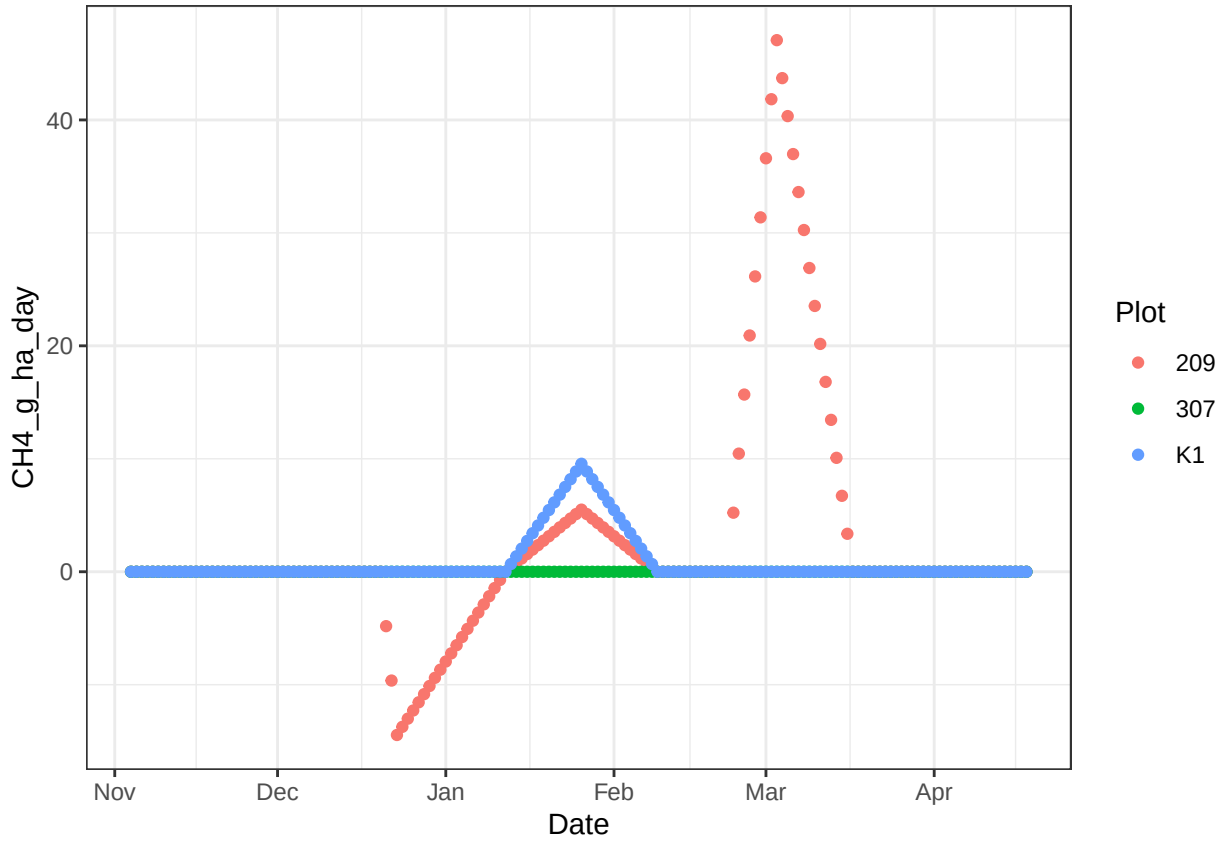

```
ggplot(winter_rice_2022_2023_interpolated, aes(y=N2O_g_ha_day, x=Date, color = Plot)) + geom_point()
```



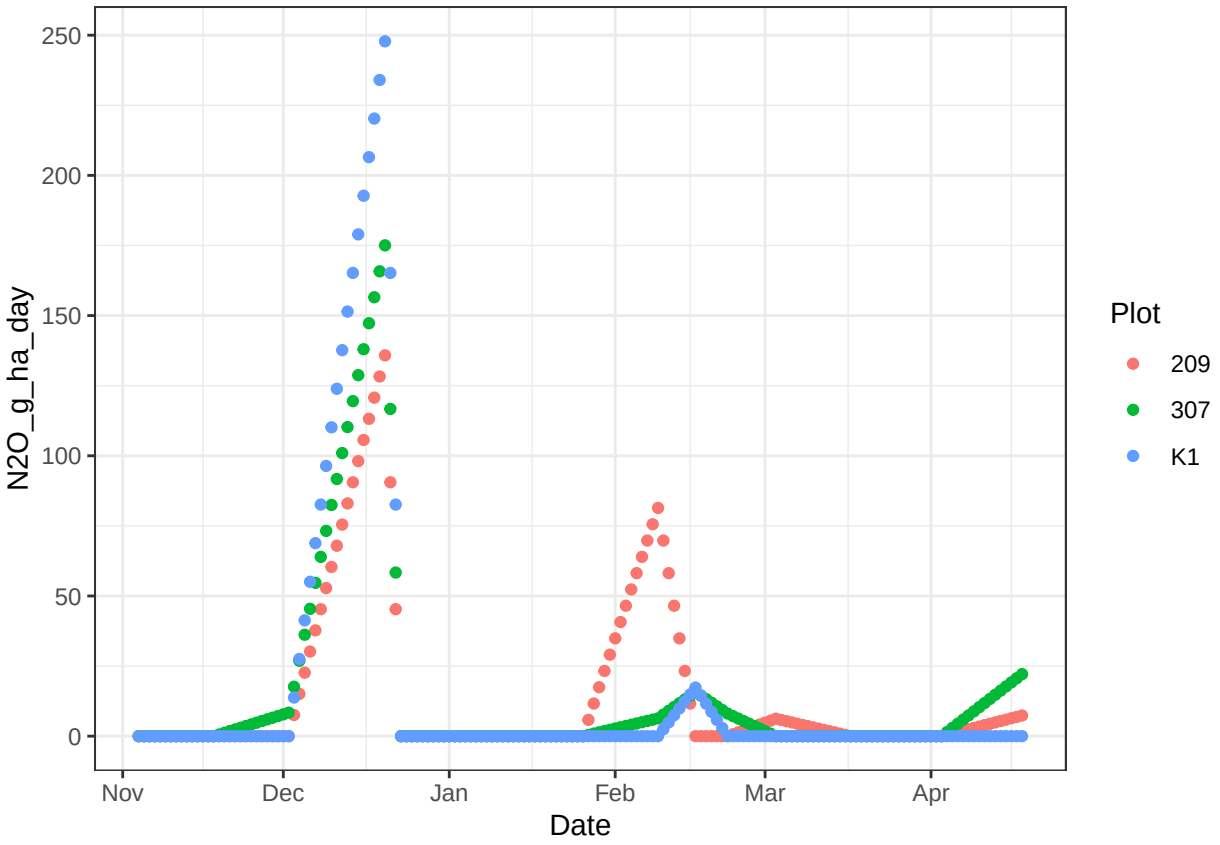
2022/2023 fallow winter

```
winter_fallow_2022_2023 <- master %>%
  filter(Date >= as.POSIXct("2022-11-3") & Date <= as.POSIXct("2023-4-19"))%>%
  filter (Plot %in% c(209, 307, "K1"))

start_date <- as.Date("2022-11-4")
end_date <- as.Date("2023-04-18")
date_seq <- seq.Date(start_date, end_date, by = "day")

winter_fallow_2022_2023_interpolated <- winter_fallow_2022_2023 %>%
  group_by(Plot) %>%
  complete(Date = date_seq) %>%
  ungroup()

winter_fallow_2022_2023_interpolated <- winter_fallow_2022_2023_interpolated %>%
  group_by(Plot) %>%
  mutate(CH4_g_ha_day = na.approx(CH4_g_ha_day, rule = 2)) %>%
  mutate(N2O_g_ha_day = na.approx(N2O_g_ha_day, rule = 2)) %>%
  ungroup()

winter_fallow_2022_2023_seasonal_emissions <- winter_fallow_2022_2023_interpolated %>%
  group_by(Plot) %>%
```

```
  summarize(total_CH4_emissions = sum(CH4_g_ha_day, na.rm = TRUE), total_N2O_emissions = sum(N2O_g_ha_da
  mutate(Period_Year = "Winter_Fallow_2022_2023") %>%
  mutate(Period = "Winter_Fallow") %>%
  mutate(Treatment = case_when(
    Plot %in% c("209","307", "K1") ~ "F",
    TRUE ~ "Other"  # This line handles cases where plot is not listed
  ))

ggplot(winter_fallow_2022_2023_interpolated, aes(y=CH4_g_ha_day, x=Date, color = Plot)) + geom_point()
```




```
ggplot(winter_fallow_2022_2023_interpolated, aes(y=N2O_g_ha_day, x=Date, color = Plot)) + geom_point()
```



Put all seasonal emissions together

```
all_seasonal_cumulative <- rbind(summer_2021_rice_seasonal_emissions,
                                 summer_2022_rice_seasonal_emissions,
                                 summer_2023_rice_seasonal_emissions,
                                 summer_2021_fallow_seasonal_emissions,
                                 summer_2022_fallow_seasonal_emissions,
                                 winter_rice_2021_2022_seasonal_emissions,
                                 winter_rice_2022_2023_seasonal_emissions,
                                 winter_fallow_2021_2022_seasonal_emissions,
                                 winter_fallow_2022_2023_seasonal_emissions
                                 )

#compute GWP using CH4 (28) and N2O (265)
all_seasonal_cumulative$GWP <- all_seasonal_cumulative$total_CH4_emissions*28+ all_seasonal_cumulative$

all_seasonal_cumulative$GWP_kg_CO2 <- all_seasonal_cumulative$GWP/1000
all_seasonal_cumulative$total_CH4_emissions_kg <- all_seasonal_cumulative$total_CH4_emissions/1000
all_seasonal_cumulative$total_N2O_emissions_kg <- all_seasonal_cumulative$total_N2O_emissions/1000

table(all_seasonal_cumulative$Period_Year)
```

```
##
```

```
##      Summer_Fallow_2021      Summer_Fallow_2022        Summer_Rice_2021
##                       3                       3                       6
##        Summer_Rice_2022        Summer_Rice_2023 Winter_Fallow_2021_2022
##                       6                       6                       3
## Winter_Fallow_2022_2023   Winter_Rice_2021_2022   Winter_Rice_2022_2023
##                       3                       6                       6
```

```r
table(all_seasonal_cumulative$Period)
```

```
##
## Summer_Fallow   Summer_Rice Winter_Fallow   Winter_Rice
##             6            18             6            12
```

```r
write.xlsx(all_seasonal_cumulative, file = "all_seasonal_cumulative.xlsx", sheetName = "1", rowNames = F
```