Global Crop Yield

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For a different project, I'm in need of a dataset to use to work through some inferential linear model ideas. Seems like maybe the crop yield dataset could be used?

Not sure how easy it is to create an inferential claim, but I'm going to try!

The Data

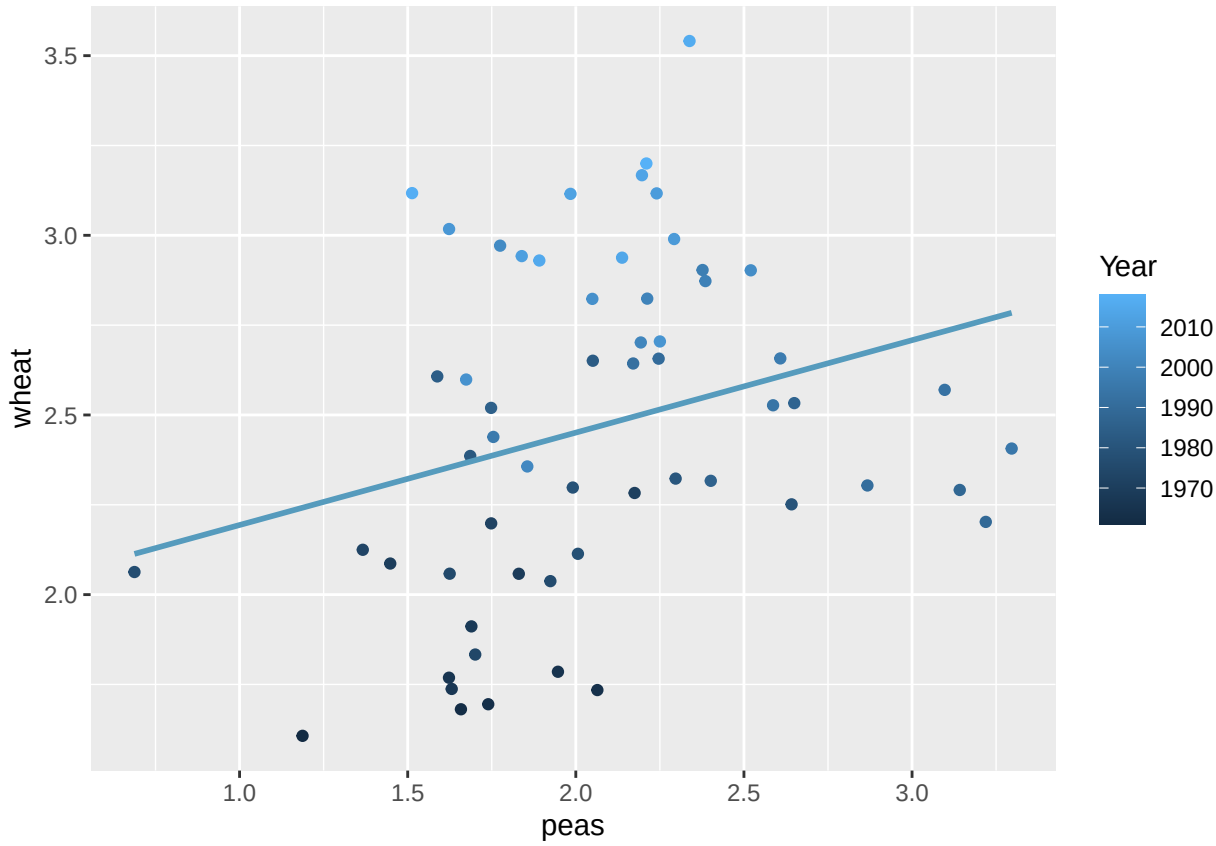
```
fertilizer <- readr::read_csv('cereal_crop_yield_vs_fertilizer_application.csv')
tractors <- readr::read_csv('cereal_yields_vs_tractor_inputs_in_agriculture.csv')
land_use <- readr::read_csv('land_use_vs_yield_change_in_cereal_production.csv')
arable_land <- readr::read_csv('arable_land_pin.csv')

key_crop_yields <- readr::read_csv('key_crop_yields.csv') %>%
  rename(wheat = `Wheat (tonnes per hectare)`,
         rice = `Rice (tonnes per hectare)`,
         maize = `Maize (tonnes per hectare)`,
         soybeans = `Soybeans (tonnes per hectare)`,
         potatoes = `Potatoes (tonnes per hectare)`,
         beans = `Beans (tonnes per hectare)`,
         peas = `Peas (tonnes per hectare)`,
         cassava = `Cassava (tonnes per hectare)`,
         barley = `Barley (tonnes per hectare)`,
         cocoa = `Cocoa beans (tonnes per hectare)`,
         bananas = `Bananas (tonnes per hectare)`)

crops_USA <- key_crop_yields %>%
  filter(Code == "USA")
```

Goals for inference in linear regression:

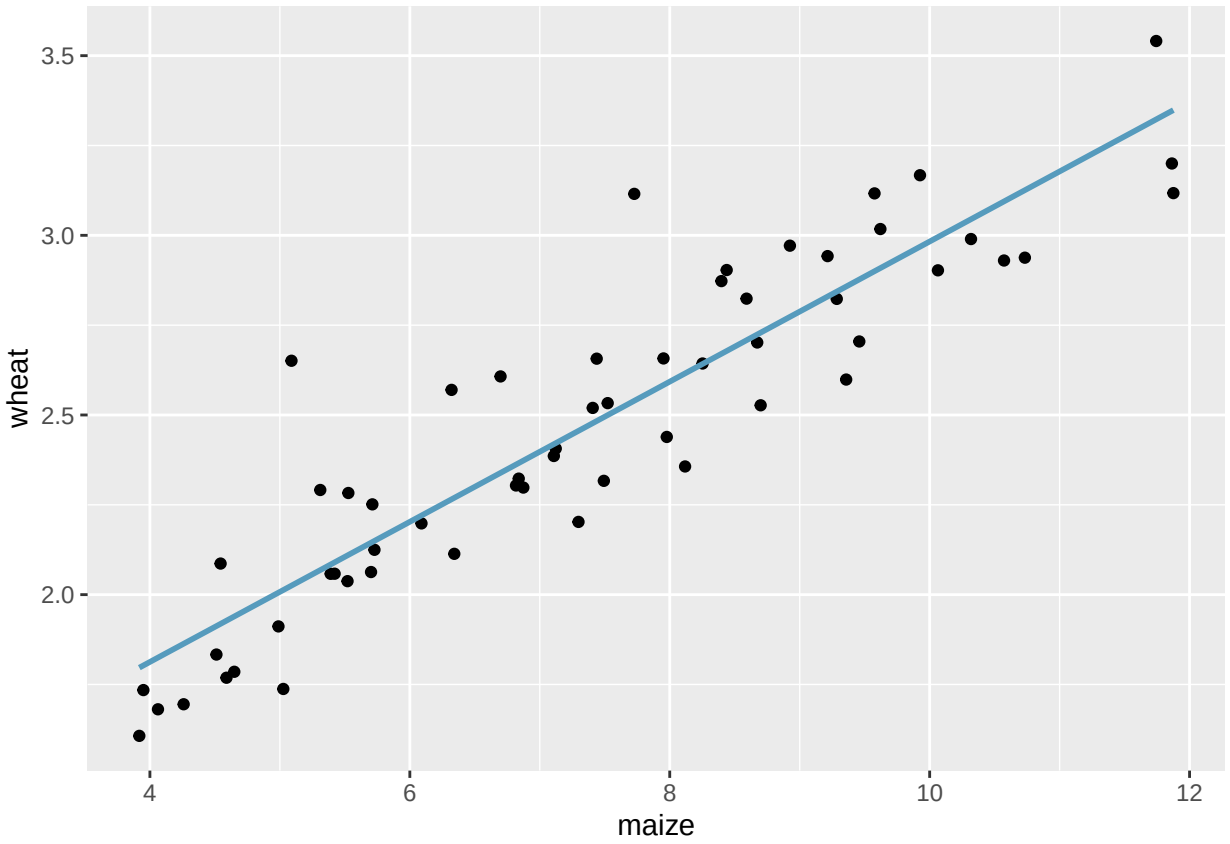
- make inferential claims about the model
- create confidence intervals for the slope

EDA

```
ggplot(crops_USA) +
  geom_point(aes(x = peas, y = wheat, color = Year)) +
  geom_smooth(aes(x = peas, y = wheat), method = "lm", se = FALSE, color = COL[1,1])
```




```
ggplot(crops_USA) +
  geom_point(aes(x = maize, y = wheat)) +
  geom_smooth(aes(x = maize, y = wheat), method = "lm", se = FALSE, color = COL[1,1])
```

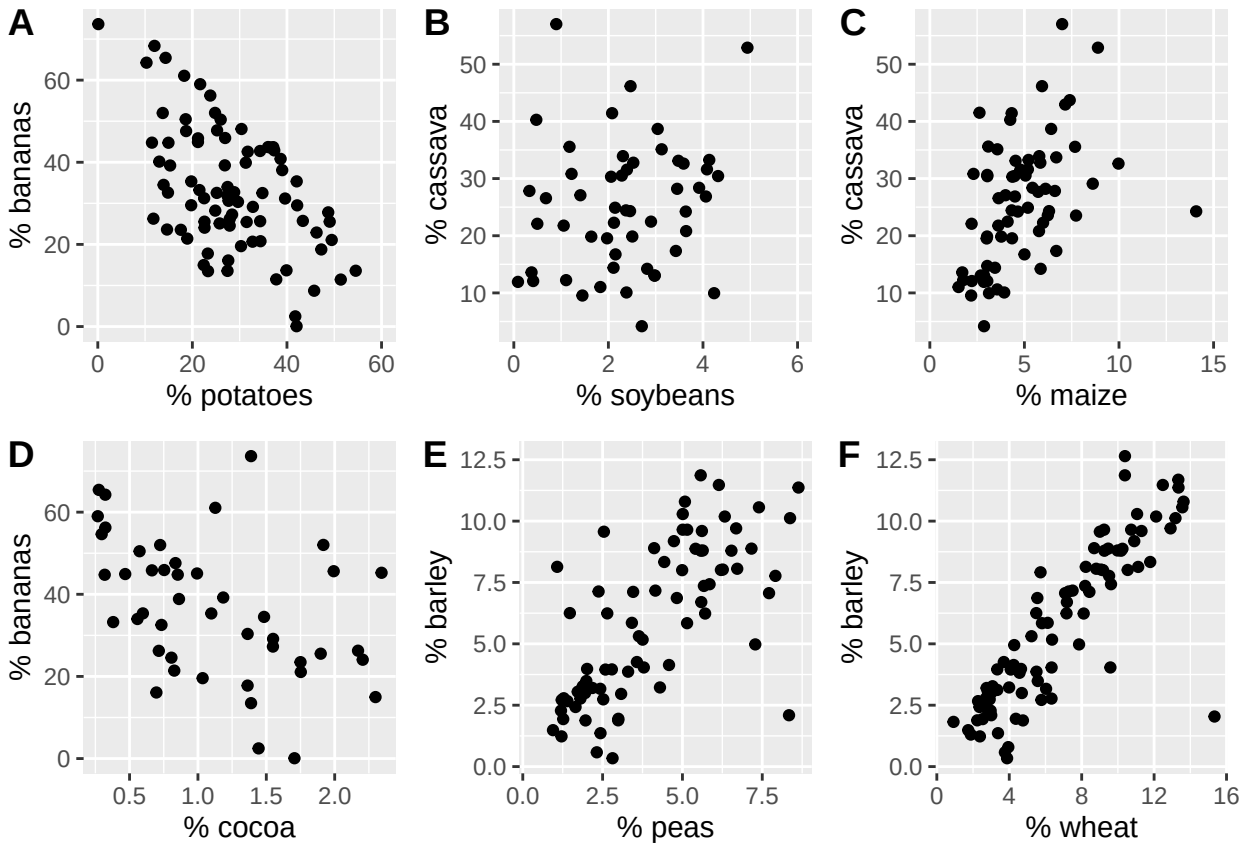


The code below is trying to find crops that have natural positive and negative correlations. Generally, yield is a function of population size, so I found the percent of a particular crop over all crop yield (summed over time) for a given country. Also, I filtered out countries that didn't have data for most of the crops.

```
library(ggpubr)
library(naniar)

mw <- ggplot(crops_USA) +
  geom_point(aes(x = maize, y = wheat))


crops_country <- key_crop_yields %>%
  filter(!is.na(Code)) %>%  # remove continents, etc.
  group_by(Code) %>%  # to sum and percent by country
  summarize(swheat = sum(wheat, na.rm = TRUE),
            srice = sum(rice, na.rm = TRUE),
            smaize = sum(maize, na.rm = TRUE),
            ssoybeans = sum(soybeans, na.rm = TRUE),
            spotatoes = sum(potatoes, na.rm = TRUE),
            sbeans = sum(beans, na.rm = TRUE),
            speas = sum(peas, na.rm = TRUE),
            scassava = sum(cassava, na.rm = TRUE),
            sbarley = sum(barley, na.rm = TRUE),
            scocoa = sum(cocoa, na.rm = TRUE),
            sbananas = sum(bananas, na.rm = TRUE),
            pwheat = 100*swheat / (swheat + srice + smaize + ssoybeans + spotatoes + sbeans + speas + s
            price = 100*srice / (swheat + srice + smaize + ssoybeans + spotatoes + sbeans + speas + sca
            pmaize = 100*smaize / (swheat + srice + smaize + ssoybeans + spotatoes + sbeans + speas + s
```

```
            psoybeans = 100*ssoybeans / (swheat + srice + smaize + ssoybeans + spotatoes + sbeans + spea
            ppotatoes = 100*spotatoes / (swheat + srice + smaize + ssoybeans + spotatoes + sbeans + spea
            pbeans = 100*sbeans / (swheat + srice + smaize + ssoybeans + spotatoes + sbeans + speas + s
            ppeas = 100*speas / (swheat + srice + smaize + ssoybeans + spotatoes + sbeans + speas + sca
            pcassava = 100*scassava / (swheat + srice + smaize + ssoybeans + spotatoes + sbeans + speas
            pbarley = 100*sbarley / (swheat + srice + smaize + ssoybeans + spotatoes + sbeans + speas +
            pcocoa = 100*scocoa / (swheat + srice + smaize + ssoybeans + spotatoes + sbeans + speas + s
            pbananas = 100*sbananas / (swheat + srice + smaize + ssoybeans + spotatoes + sbeans + speas
            ) %>%
  replace_with_na_all(condition = ~.x == 0)%>%
  mutate(nmiss = rowSums(is.na(.))/2) %>%
  filter(nmiss <= 5)  # filter out countries that don't have data for most of the crops.


sb <- ggplot(crops_country) +
  geom_point(aes(x = psoybeans, y = pbananas)) +
  xlim(c(0,6)) +
  xlab("% soybeans") +
  ylab("% bananas")

sc <- ggplot(crops_country) +
  geom_point(aes(x = psoybeans, y = pcassava)) +
  xlim(c(0,6)) +
  xlab("% soybeans") +
  ylab("% cassava")

mc <- ggplot(crops_country) +
  geom_point(aes(x = pmaize, y = pcassava)) +
  xlim(c(0,15)) +
  xlab("% maize") +
  ylab("% cassava")

peb <- ggplot(crops_country) +
  geom_point(aes(x = ppotatoes, y = pbananas)) +
  xlim(c(0,60)) +
  xlab("% potatoes") +
  ylab("% bananas")

cb <- ggplot(crops_country) +
  geom_point(aes(x = pcocoa, y = pbananas)) +
  xlab("% cocoa") +
  ylab("% bananas")

wb <- ggplot(crops_country) +
  geom_point(aes(x = pwheat, y = pbarley)) +
  xlab("% wheat") +
  ylab("% barley")

pob <- ggplot(crops_country) +
  geom_point(aes(x = ppeas, y = pbarley)) +
  xlab("% peas") +
  ylab("% barley")
```

```
ggpubr::ggarrange( peb, sc, mc, cb, pob, wb,
                   labels = c("A", "B", "C", "D", "E", "F"),
                   ncol = 3, nrow = 2)
```

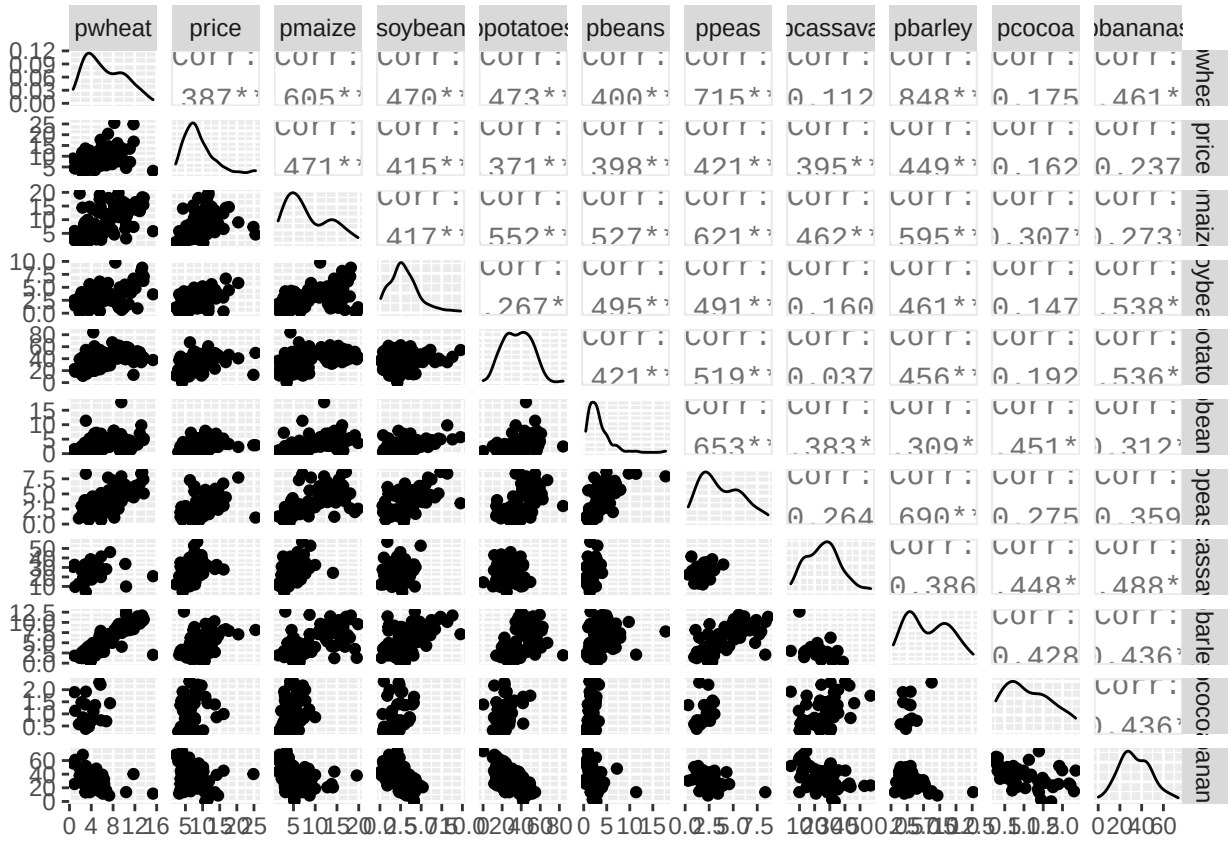



```
temptbl <- tribble(
 ~variable,  ~col1, ~col2, ~corval,
 "A", "potatoes", "bananas", round(cor(crops_country$ppotatoes, crops_country$pbananas, use = "pairwise
 "B", "soybeans", "cassava", round(cor(crops_country$psoybeans, crops_country$pcassava, use = "pairwise
 "C", "maize", "cassava", round(cor(crops_country$pmaize, crops_country$pcassava, use = "pairwise.compl
 "D", "cocoa", "bananas", round(cor(crops_country$pcocoa, crops_country$pbananas, use = "pairwise.compl
 "E", "peas", "barley", round(cor(crops_country$ppeas, crops_country$pbarley, use = "pairwise.complete.
 "F", "wheat", "barley", round(cor(crops_country$pwheat, crops_country$pbarley, use = "pairwise.complet
)

temptbl %>%
 kable(caption = "Correlation of percentage of total yield across different crops.",
  col.names = c("Graph", "x-variable", "y-variable", "correlation")) %>%
 kable_styling()
```

```
library(GGally)
ggpairs(crops_country[,13:23])
```

Table 1: Correlation of percentage of total yield across different crops.

Graph	x-variable	y-variable	correlation
A	potatoes	bananas	-0.54
B	soybeans	cassava	0.16
C	maize	cassava	0.46
D	cocoa	bananas	-0.44
E	peas	barley	0.69
F	wheat	barley	0.85




```
temp <- cor(crops_country[,13:23], use = "pairwise.complete.obs")
diag(temp) <- NA
temp %>%
  quantile(na.rm = TRUE)
```

```
##         0%        25%        50%        75%       100%
## -0.5379375  0.1501472  0.3975110  0.4706361  0.8476391
```

```
temp
```

```
##                pwheat      price     pmaize  psoybeans   ppotatoes     pbeans
## pwheat             NA  0.3870334  0.6052646  0.4703257  0.47255763  0.3996283
## price       0.3870334         NA  0.4707395  0.4151908  0.37077250  0.3975110
## pmaize      0.6052646  0.4707395         NA  0.4169392  0.55154020  0.5272872
## psoybeans   0.4703257  0.4151908  0.4169392         NA  0.26707097  0.4950204
## ppotatoes   0.4725576  0.3707725  0.5515402  0.2670710          NA  0.4209704
## pbeans      0.3996283  0.3975110  0.5272872  0.4950204  0.42097040         NA
```

```
## ppeas      0.7150342  0.4214549  0.6210329  0.4914803  0.51887085  0.6533319
## pcassava   0.1116904  0.3948280  0.4620643  0.1603862  0.03726667  0.3833298
## pbarley    0.8476391  0.4494305  0.5949681  0.4611248  0.45560077  0.3092119
## pcocoa     0.1752966  0.1622816  0.3071385  0.1467342  0.19181424  0.4508198
## pbananas  -0.4614798 -0.2374004 -0.2732579 -0.5379375 -0.53592716 -0.3116874
##                ppeas    pcassava    pbarley     pcocoa   pbananas
## pwheat     0.7150342  0.11169041  0.8476391  0.1752966 -0.4614798
## price      0.4214549  0.39482801  0.4494305  0.1622816 -0.2374004
## pmaize     0.6210329  0.46206428  0.5949681  0.3071385 -0.2732579
## psoybeans  0.4914803  0.16038617  0.4611248  0.1467342 -0.5379375
## ppotatoes  0.5188708  0.03726667  0.4556008  0.1918142 -0.5359272
## pbeans     0.6533319  0.38332979  0.3092119  0.4508198 -0.3116874
## ppeas             NA  0.26378967  0.6898022  0.2753218 -0.3588672
## pcassava   0.2637897          NA -0.3860976  0.4482220 -0.4879015
## pbarley    0.6898022 -0.38609755         NA  0.4284665 -0.4355787
## pcocoa     0.2753218  0.44822200  0.4284665         NA -0.4356990
## pbananas  -0.3588672 -0.48790150 -0.4355787 -0.4356990         NA
```

SLR

```
crops_USA %>%
  lm(wheat ~ peas, .) %>%
  tidy()
```

```
## # A tibble: 2 x 5
##   term        estimate std.error statistic  p.value
##   <chr>          <dbl>     <dbl>     <dbl>    <dbl>
## 1 (Intercept)    1.94      0.253      7.67 2.73e-10
## 2 peas           0.257     0.119      2.16 3.50e- 2
```

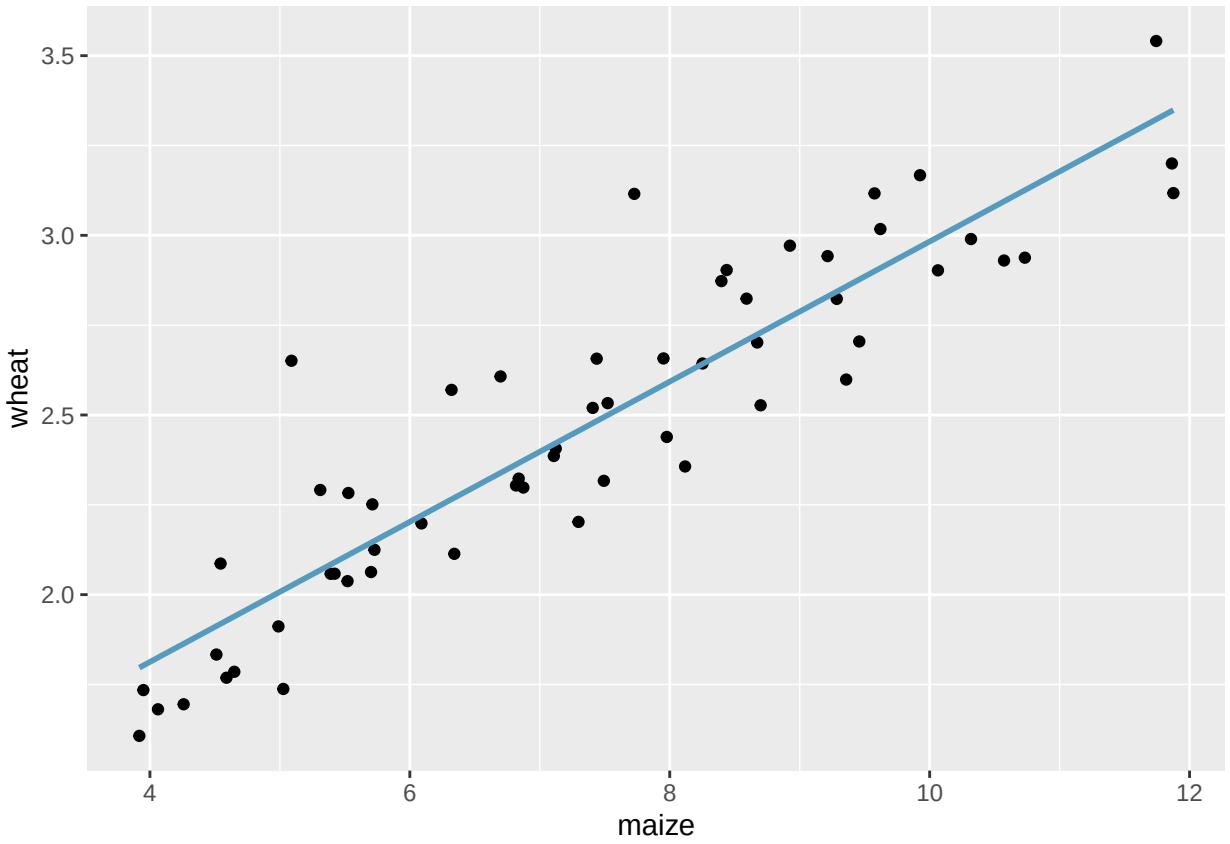
```
crops_USA %>%
  lm(wheat ~ maize, .) %>%
  tidy()
```

```
## # A tibble: 2 x 5
##   term        estimate std.error statistic  p.value
##   <chr>          <dbl>     <dbl>     <dbl>    <dbl>
## 1 (Intercept)    1.03     0.0912      11.3 4.13e-16
## 2 maize          0.195    0.0119      16.4 5.04e-23
```

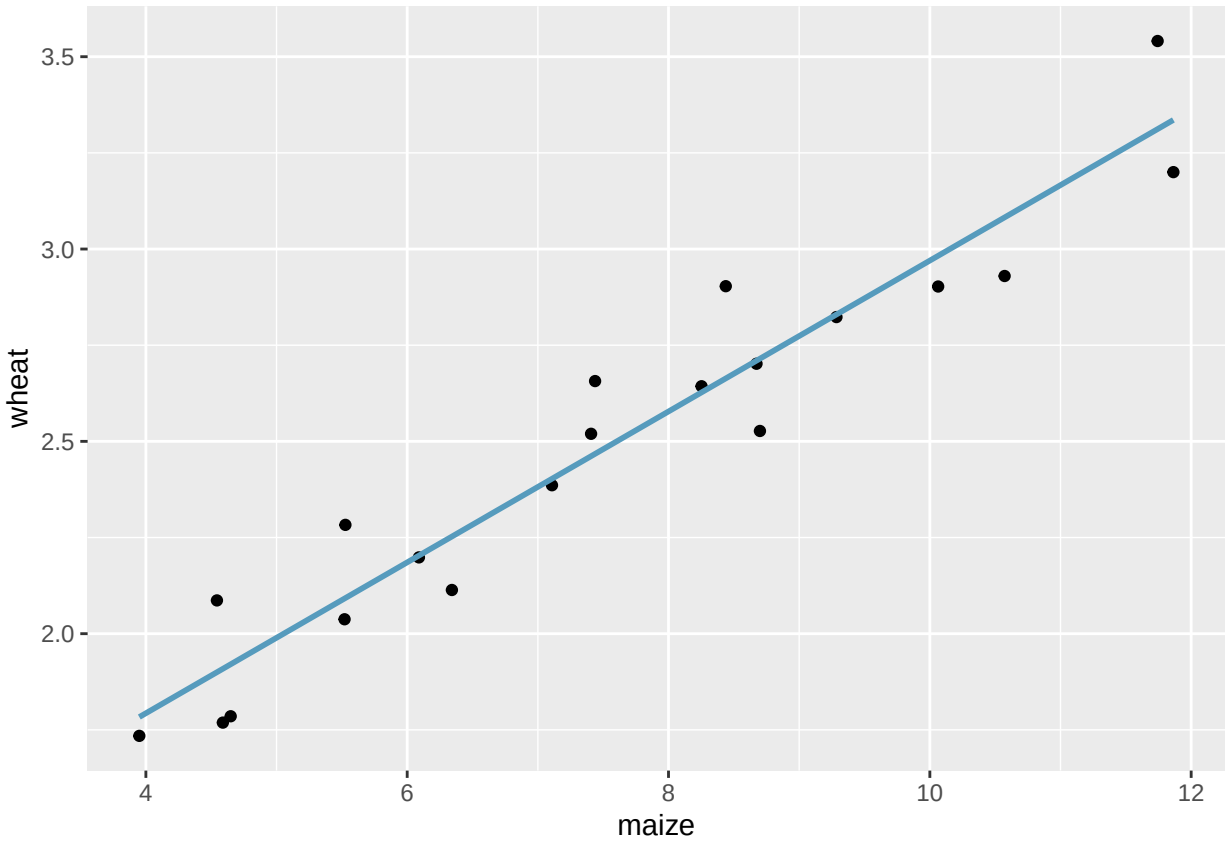
Sampling distribution

```
set.seed(4747)
crops2 <- crops_USA %>%
  sample_n(size=20)
crops3 <- crops_USA %>%
  sample_n(size=20)
crops_many <- crops_USA %>%
  rep_sample_n(size = 20, replace = FALSE, reps = 50)
```

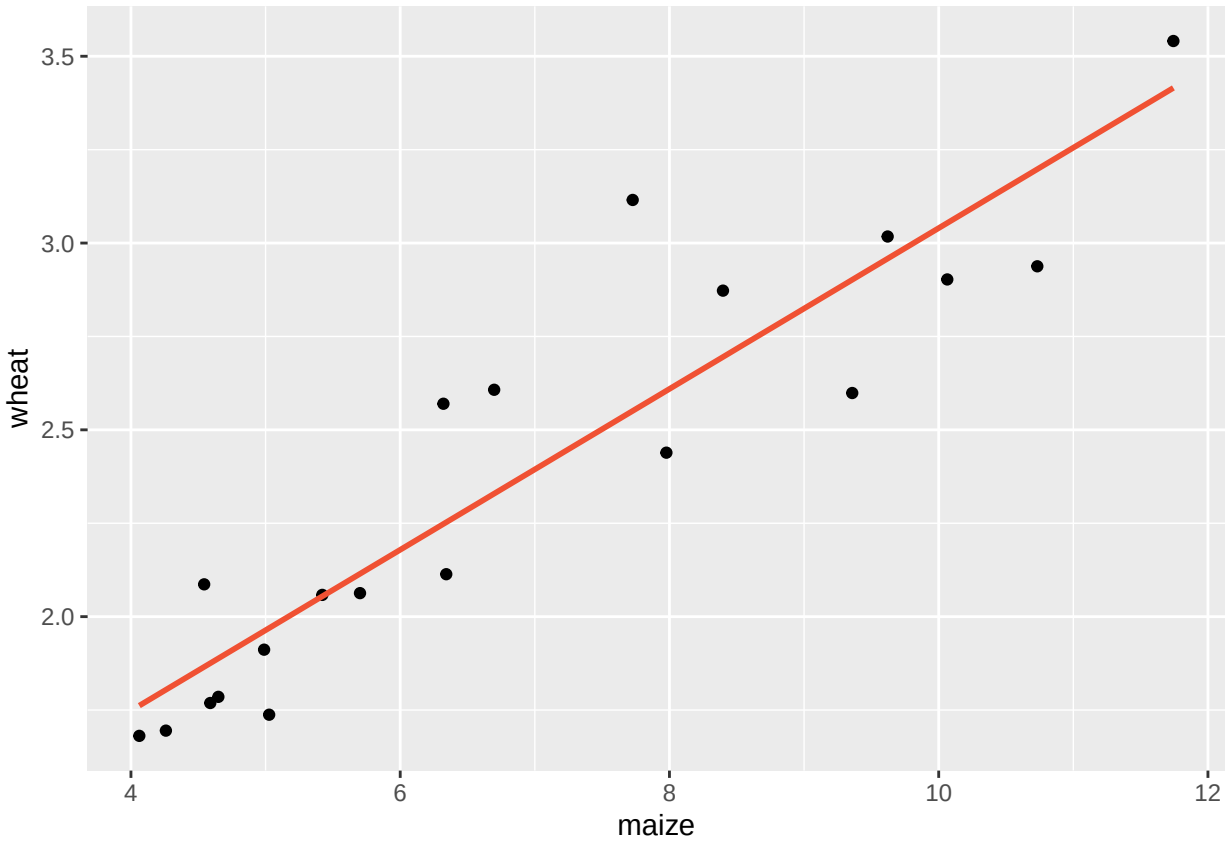
```
ggplot(crops_USA) +
  geom_point(aes(x = maize, y = wheat)) +
  geom_smooth(aes(x = maize, y = wheat), method = "lm", se = FALSE, color = COL[1,1])
```



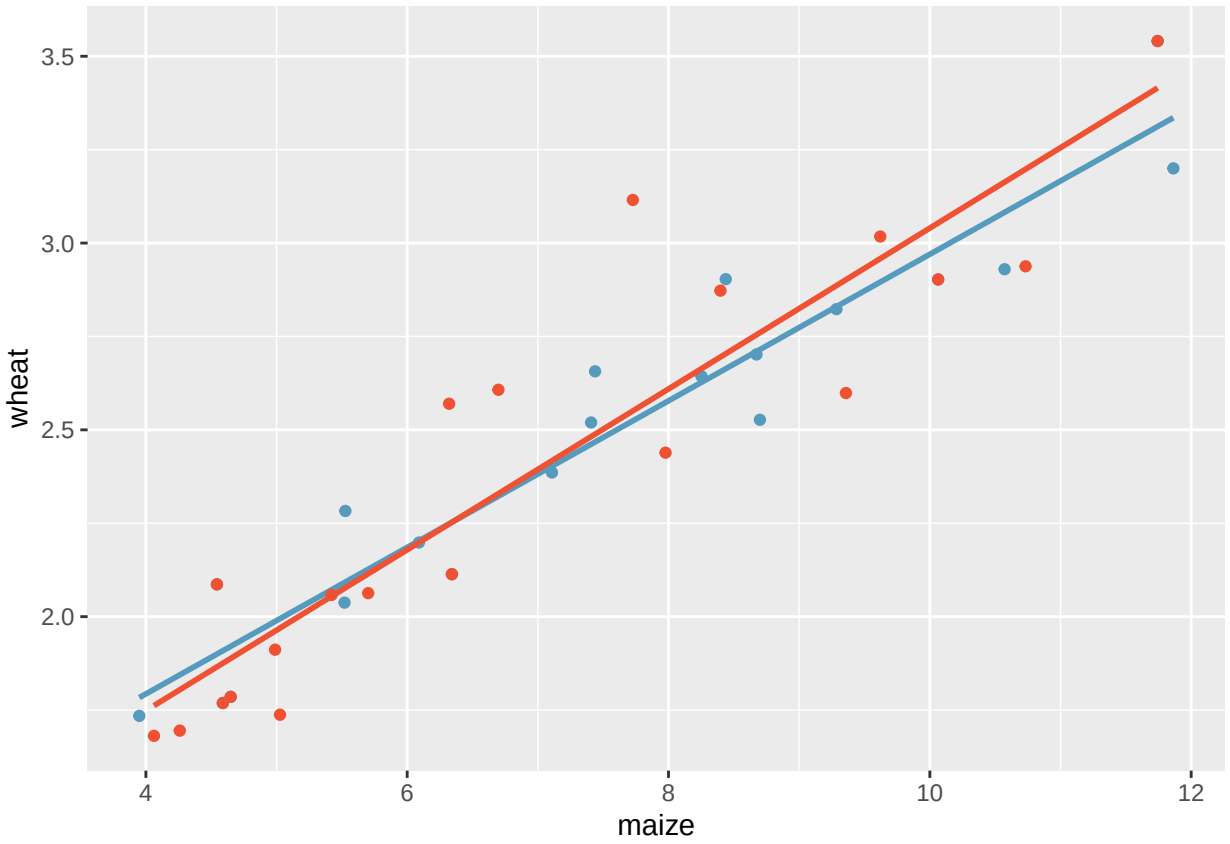
A subset of size 20 items shows a similar positive trend between maize and wheat, despite having fewer observations on the plot.



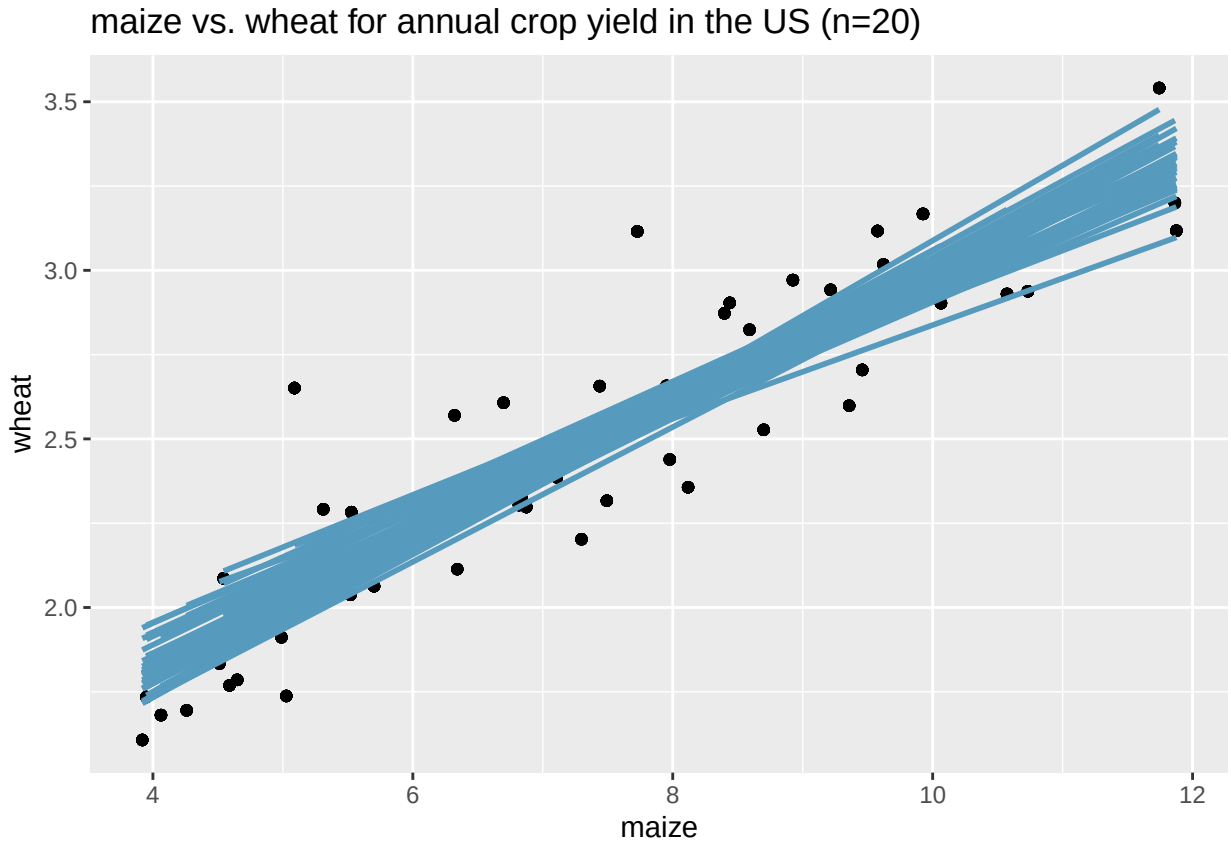
A second sample of size 20 also shows a positive trend!

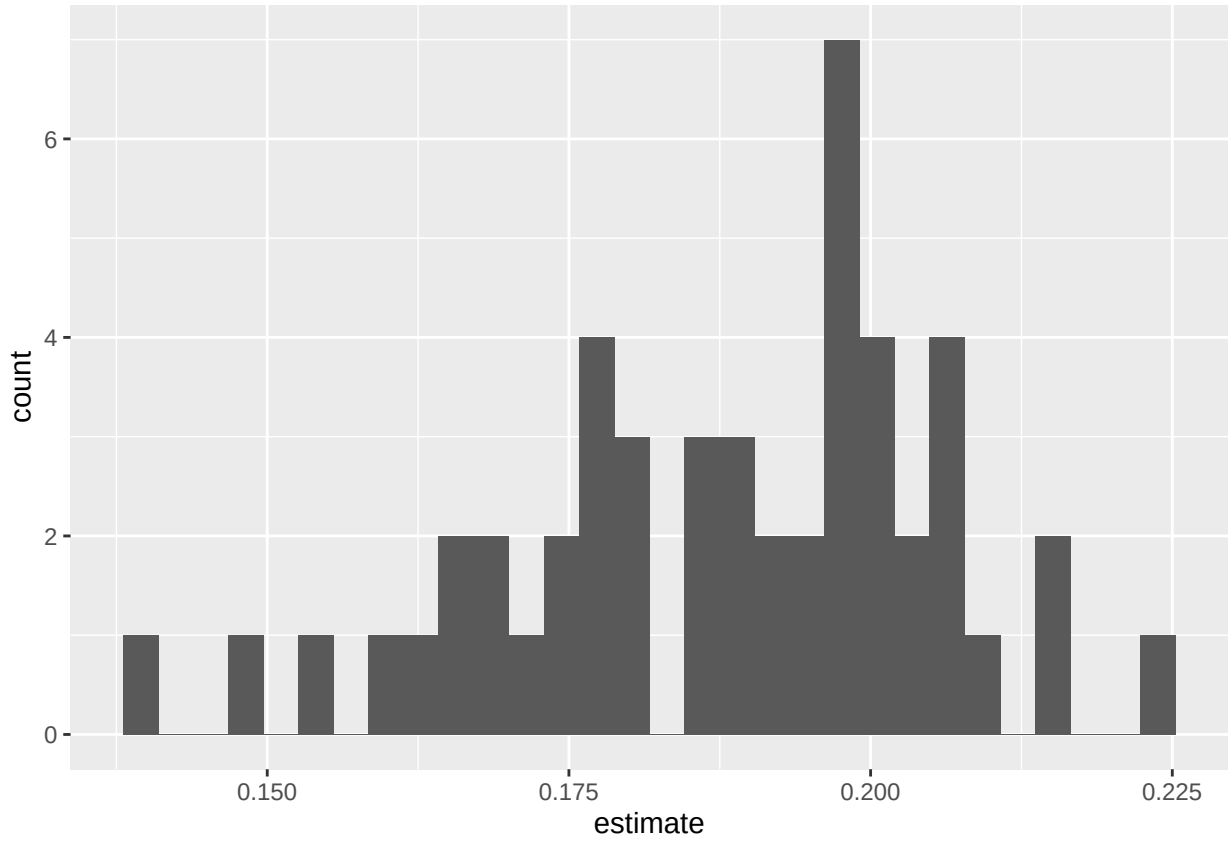


But the line is slightly different!



That is, there is variability in the regression line from sample to sample. The concept of the sampling variability is something you've seen before, but in this lesson, you will focus on the variability of the line instead of the variability of a single statistic.


maize vs. wheat for annual crop yield in the US (n=20)
wheat
3.5
3.0
2.5
2.0
4
6
8
10
12
maize


count
6
4
2
0
0.150
0.175
0.200
0.225
estimate