In principle the full model for these data would be:

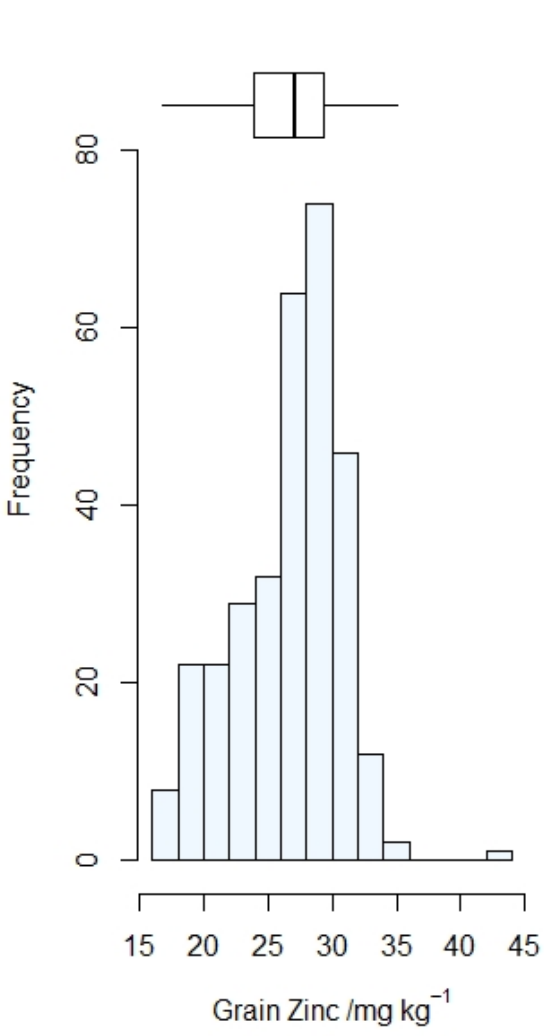
Fixed effects, slope, fertilizer, variety

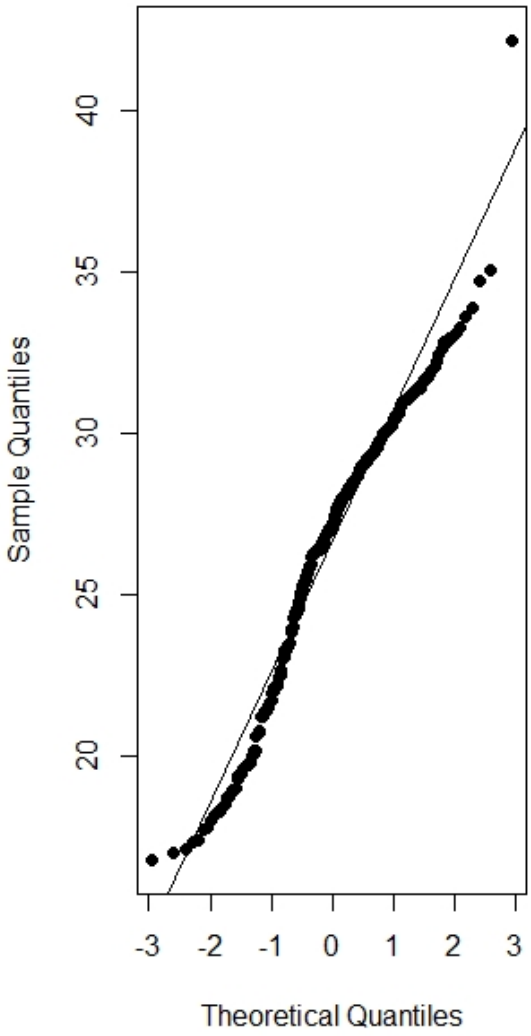
Random effects, Year and block within farm within location.

However, the way the randomization was done in the end, with all slope positions in a single farm within any location, it can be difficult to estimate the full model because of singularities. These will not automatically arise but will for some variables. Then, the strategy has been to run the full model where it can be, but to drop slope as a fixed effect where problems arise. Then one can examine the variance component for the farm random effect to get an idea of how important slope might be relative to other factors, as it will be a component of the between farm variance component in models where it is not a fixed effect.

Zinc

Exploratory analysis of the raw data. Summary statistics are output in R

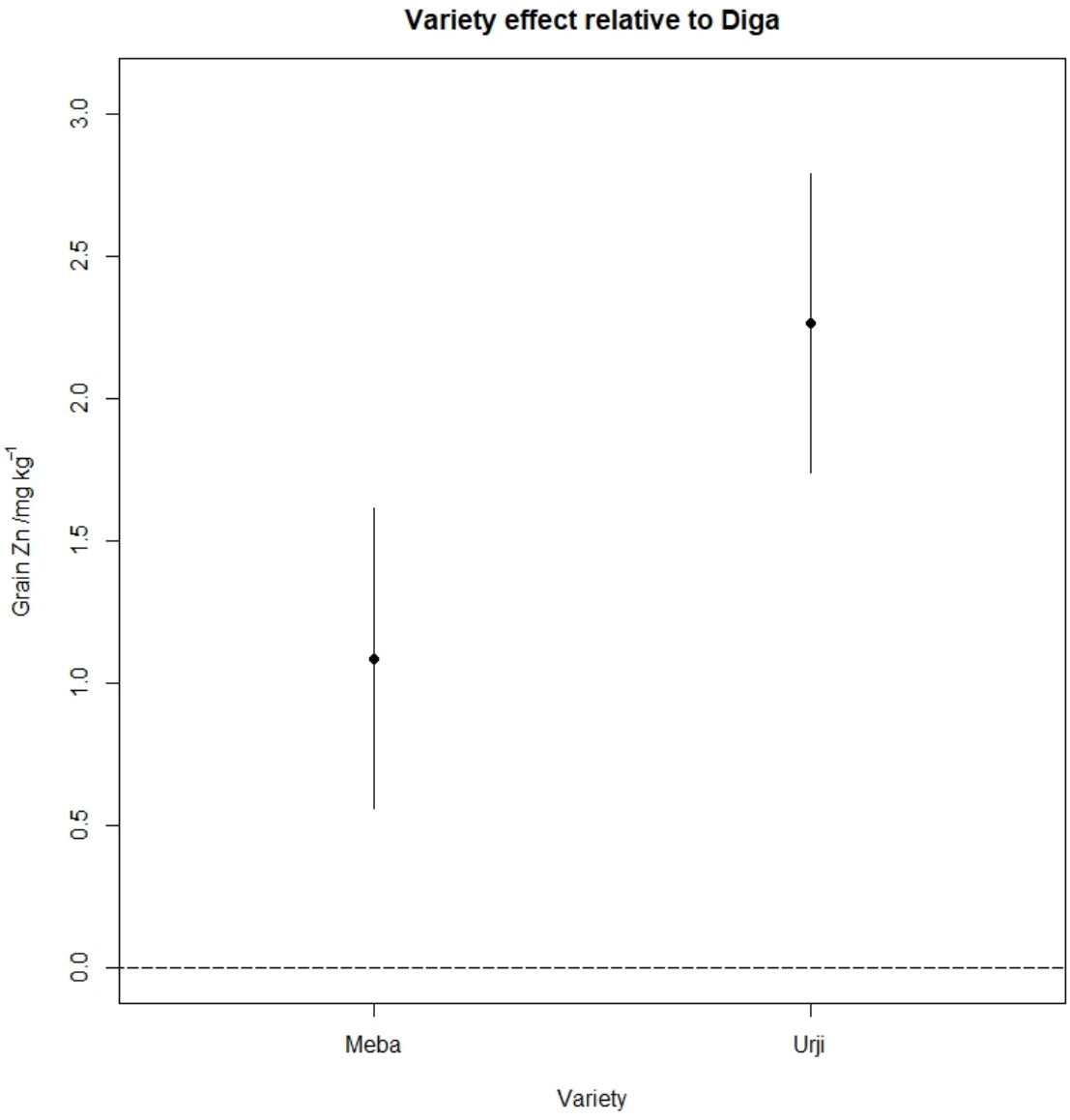




Analysis of variance for first basic model

```
> anova(model,refit=F)
Type III Analysis of Variance Table with Satterthwaite's method
                    Sum Sq Mean Sq NumDF  DenDF F value    Pr(>F)
FERTILIZER         167.939  41.985     4 274.68 11.3002 1.672e-08 ***
VARIETY            243.631 121.815     2 274.40 32.7865 1.707e-13 ***
FERTILIZER:VARIETY  27.619   3.452     8 275.85  0.9292    0.4926
```

Note there is evidence for differences among the fertilizer treatments, and between the varieties, but no evidence for an interaction. For this reason, further outputs are based on a model with this interaction dropped, specifically the following plots for fertilizer and variety effects



Finally, we run the model (interaction dropped) with the fertilizer main effect replaced by four orthogonal contrasts. These contrasts are as follows.

C1: The comparison between the mean grain Zn for the 0.3NPKS treatment and all the treatments with NPKS at recommended rate.

C2: Within the full NPKS rate, the Fe main effect (difference between treatments with Fe and no Fe)

C3: Within the full NPKS rate, the Zn main effect (difference between treatments with Zn and no Zn)

C4: The Fe/Zn interaction: does the response to Zn depend on the level of Fe?

```
> anova(model.r2)
Type III Analysis of Variance Table with Satterthwaite's method
         Sum Sq Mean Sq NumDF  DenDF F value    Pr(>F)
C1       35.635  35.635     1 282.63  9.6062 0.0021348 **
C2       11.903  11.903     1 282.93  3.2088 0.0743113 .
C3       49.416  49.416     1 282.97 13.3211 0.0003125 ***
C4       18.363  18.363     1 282.98  4.9502 0.0268756 *
VARIETY 265.974 132.987     2 282.49 35.8493 1.334e-14 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

So, we can see strong evidence for a main effect of Zn fertilizer, some evidence for an interaction of Fe and Zn, moderate evidence for a difference between the 30% NPKS and NPKS treatments and a strong variety effect. This interprets the two key plots above.

The summary function applied to this final model allows to examine the variance components for each random effect.

Note that the between farm variance is small (0.3155), smaller than season, location or block effects. This suggests that slope position is not a major source of variation in grain Zn content.

```
Random effects:
 Groups                       Name        Variance Std.Dev.
 BLOCK_ID:(FARM_ID:LOCATION) (Intercept)  0.3290  0.5736
 FARM_ID:LOCATION            (Intercept)  0.3155  0.5617
 LOCATION                    (Intercept) 19.4043  4.4050
 YEAR                        (Intercept)  0.8907  0.9438
 Residual                                 3.7096  1.9260
```

Supplementary Table 1. Effect of fertilizer type and finger millet variety on biofortified finger millet Zn concentration

Factors	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr (>F)
Fertilizer	167.939	41.985	4	274.68	11.3002	$1.672e^{-08}$ ***
Variety	243.631	121.815	2	274.40	32.7865	$1.707e^{-13}$ ***
Fertilizer: variety	27.619	3.452	8	275.85	0.9292	0.4926

Significance codes: *** < 0.001

Supplementary Table 2. Type III Analysis of Variance with Satterthwaite's method for grain Zn concentration

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
C1	35.635	35.635	1	282.63	9.6062	0.0021348**
C2	11.903	11.903	1	282.93	3.2088	0.0743113
C3	49.416	49.416	1	282.97	13.3211	0.0003125***
C4	18.363	18.363	1	282.98	4.9502	0.0268756*
Variety	265.974	132.987	2	282.49	35.8493	$1.334e^{-14}$***

Significance codes: *** <0.001; **< 0.01; *< 0.05

C1: The comparison between the mean grain Zn for the T4 (30% NPKS) and all the treatments (NPKS at recommended rate)

C2: Within the NPKS at recommended rate, the $FeSO_47H_2O$ main effect (difference between treatments with $FeSO_47H_2O$ and no $FeSO_47H_2O$)

C3: Within the NPKS at recommended rate, the $ZnSO_47H_2O$ main effect (difference between treatments with $ZnSO_47H_2O$ and no $ZnSO_47H_2O$)

C4: The $FeSO_47H_2O$/$ZnSO_47H_2O$ interaction: does the response to $FeSO_47H_2O$ depend on the level of $ZnSO_47H_2O$

Supplementary Table 3. The variance components of random effects for grain Zn concentration

Groups	Name	Variance
Block within the farm	Intercept	0.3290
Slope position	Intercept	0.3155
Location	Intercept	19.4043
Season	Intercept	0.8907
Residual		3.7096

Supplementary Table 4. Effect of fertilizer type and finger millet variety on biofortified finger millet grain iron concentration, Ethiopia

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr (>F)
Slope position	140.01	140.01	1	2.985	1.9644	0.256013
Fertilizer	1781.52	445.38	4	274.420	6.2488	7.959e-05***
Variety	719.14	359.57	2	273.683	5.0448	0.007055 **
Fertilizer:variety	1021.69	127.71	8	274.800	1.7918	0.078574.

Significance codes: *** <0.001; **< 0.01; *< 0.05

Supplementary Table 5. Type III Analysis of Variance with Satterthwaite's method for grain Fe concentration

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
C1	0.71	0.71	1	282.15	0.0097	0.9215000
C2	679.75	679.75	1	283.29	9.3327	0.0024654**
C3	17.22	17.22	1	283.29	0.2364	0.6272052
C4	987.87	987.87	1	283.13	13.5630	0.0002763***
Variety	738.34	369.17	2	281.78	5.0685	0.0068774**

Significance codes: ***< 0.001; **< 0.01; *<0.05

C1: The comparison between the mean grain Fe for the T4 (30% NPKS) and all the treatments (NPKS at recommended rate),

C2: Within the NPKS at recommended rate, the $FeSO_47H_2O$ main effect (difference between treatments with $FeSO_47H_2O$ and no $FeSO_47H_2O$),

C3: Within the NPKS at recommended rate, the $ZnSO_47H_2O$ main effect (difference between treatments with $ZnSO_47H_2O$ and no $ZnSO_47H_2O$), and

C4: The $FeSO_47H_2O$/$ZnSO_47H_2O$ interaction: does the response to $FeSO_47H_2O$ depend on the level of $ZnSO_47H_2O$

Supplementary Table 6. The variance components of random effects for grain Fe concentration

Groups	Name	Variance
Block within the farm	Intercept	12.16
Farm within the location	Intercept	21.51
Location	Intercept	172.56
Residual		72.84