Winter wheat varieties performance over years in variety trials in Switzerland

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Variety trial context

- Winter wheat varieties are tested on different experimental fields across Switzerland
- Each year, winter wheat varieties performance are reported and recommended to farmers according to a list
- Challenge: not easy to predict specific varieties response to specific environment linked to abiotic and biotic stresses

Case study: variety trial with 2 modalities over years

- 36 winter wheat varieties

- 4 years: 2021 to 2024

- Case study context: study variety response to none vs conventional application

➢ Find variety that are performing well also under limited available N in order to reduce N fertilization (economic and environmental cost)

- 2 treatments: conventional application of nitrogen (N) and no application of nitrogen
- Measurement to estimate varieties performance:

➢ Grain yield

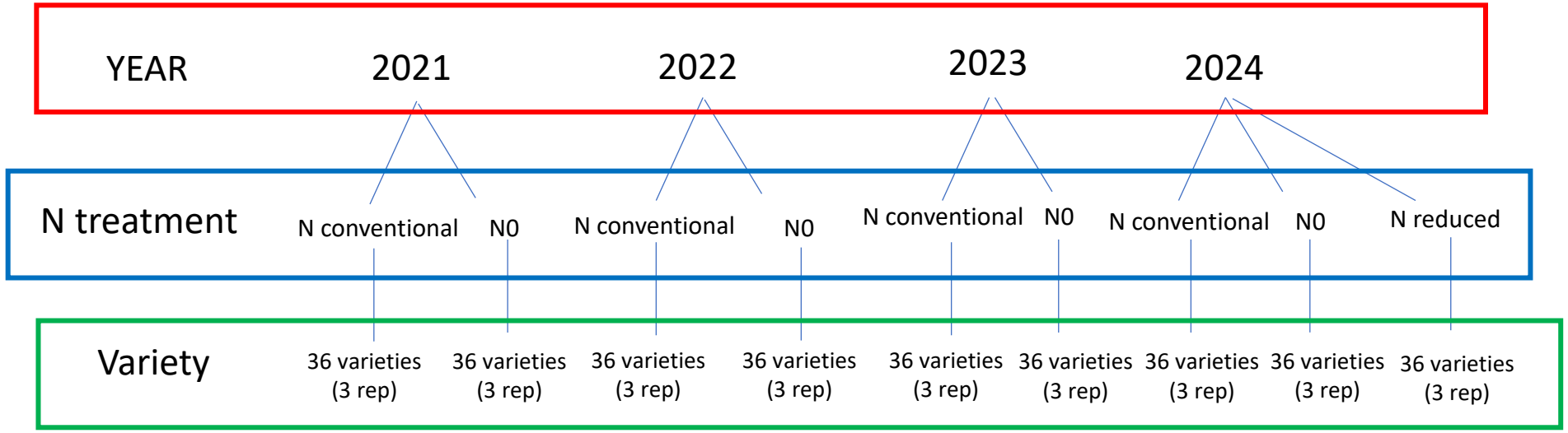
➢ Straw yield

➢ Grain protein

➢ Other physiological parameters (harvest index, leaf area index, chlorophyll content, canopy cover…)

Case study: experimental design

- 2 blocks corresponding to 2 treatments (conventional and no N treatment) within field
- 3 replicates of varieties by block
- 4 climatic conditions over 4 years



Data preparation

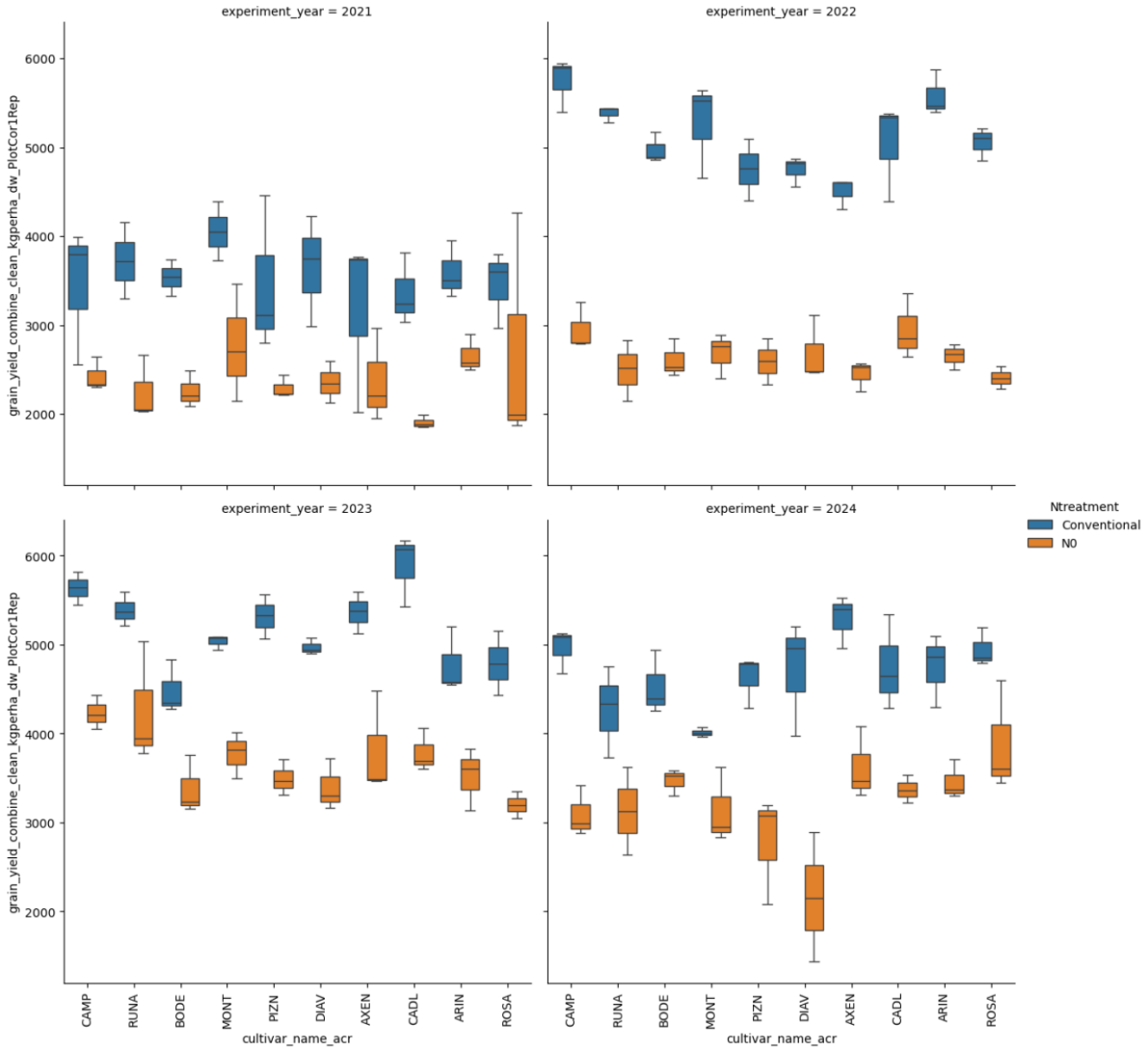
- The varieties tested are not always the same over years
- ➢ Find common varieties tested over 4 years

- The measurements to evaluate the variety performance are not always the same over years
- ➢ Find common variables measured over 4 years

- Due to experimental issue some values are lost and one replicate less can imbalance the statistical analysis (especially with rep=3)
- ➢ Remove varieties with not sufficient replicates

- Datasets are stored by years on excel sheet
- ➢ Merge datasets for over years analysis and visualisation

Estimate statistical differences: grain yield



Model parameters

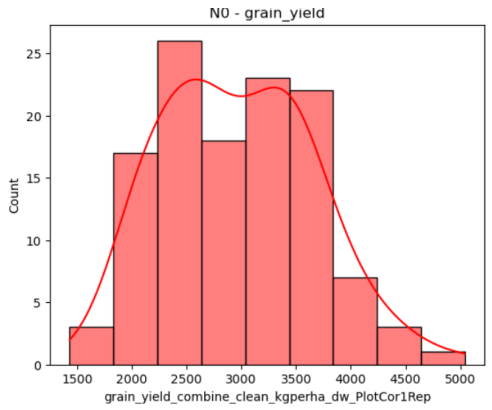
- Response variable: grain yield

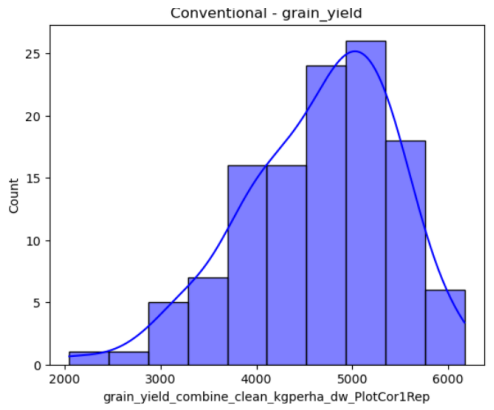
- 3 factors can be considered as explanatory variables:
  - Varieties : 10 levels
  - N treatment: 2 levels (N0, Conventional)
  - Years: 4 levels

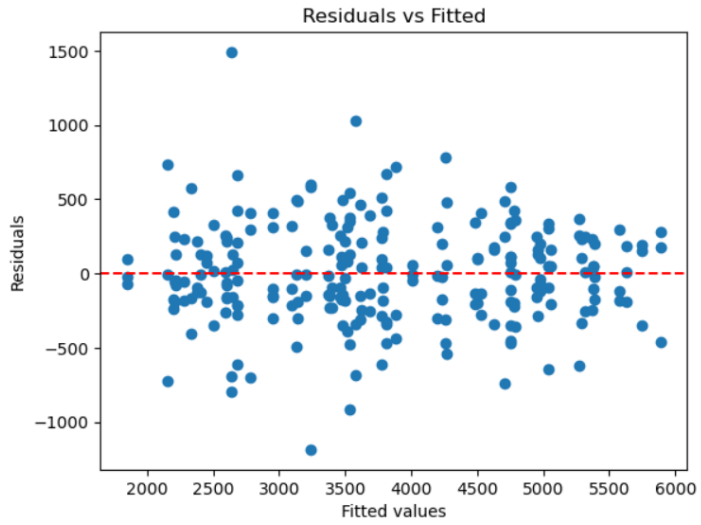
0.0066

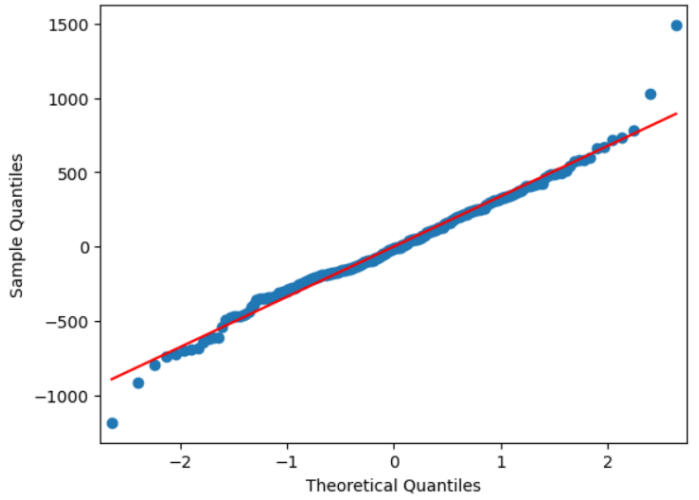
Statistical test options: ANOVA

- Model assumption:
  - ➢ Independence of Observations ✖
  - ➢ Normality ✖
  - ➢ Homogeneity of Variances (Homoscedasticity)
  - ➢ Additivity
  - ➢ Fixed Effects





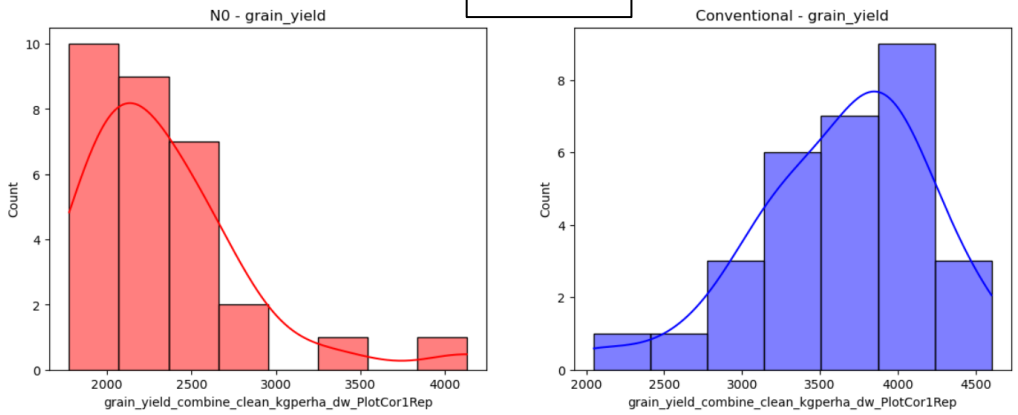




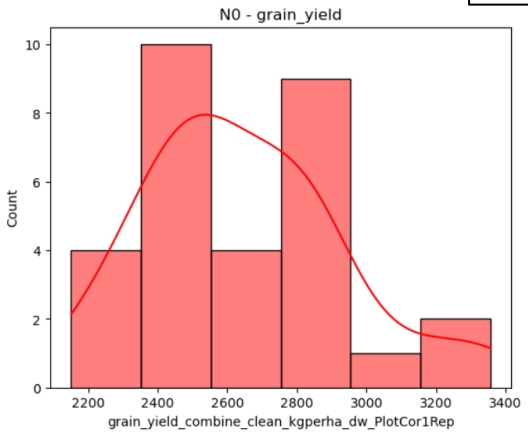
Shapiro-Wilk test p-value: 0.0067

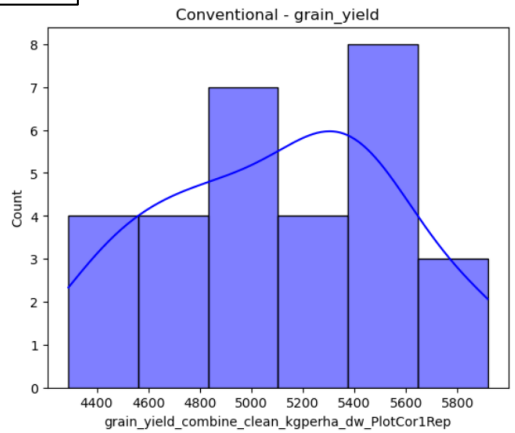
Data distribution by N treatment blocks and years

2021

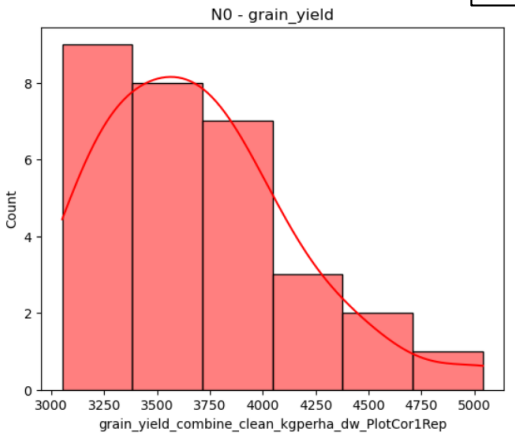


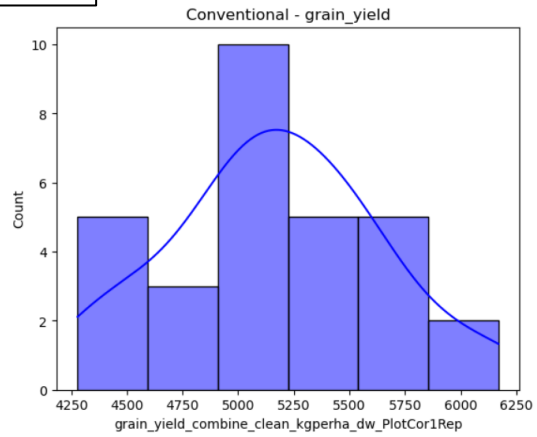
2022



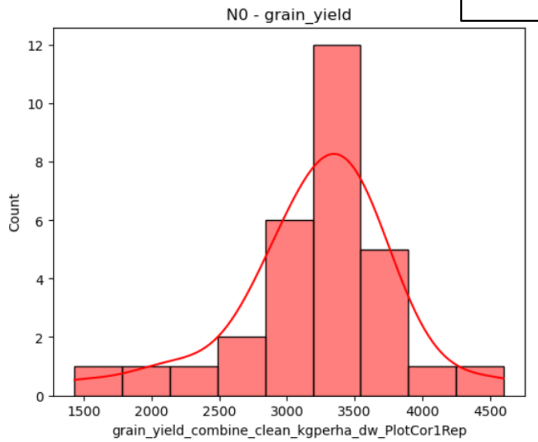


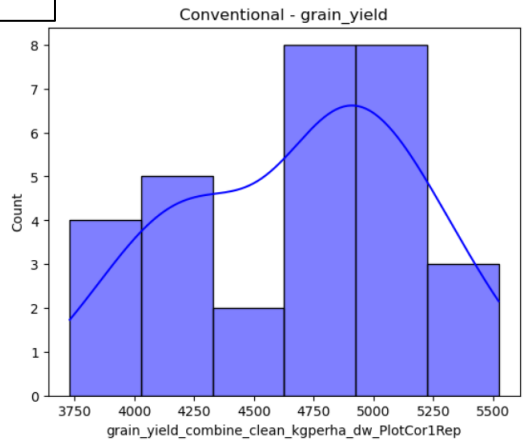
2023





2024





Linear mixed model

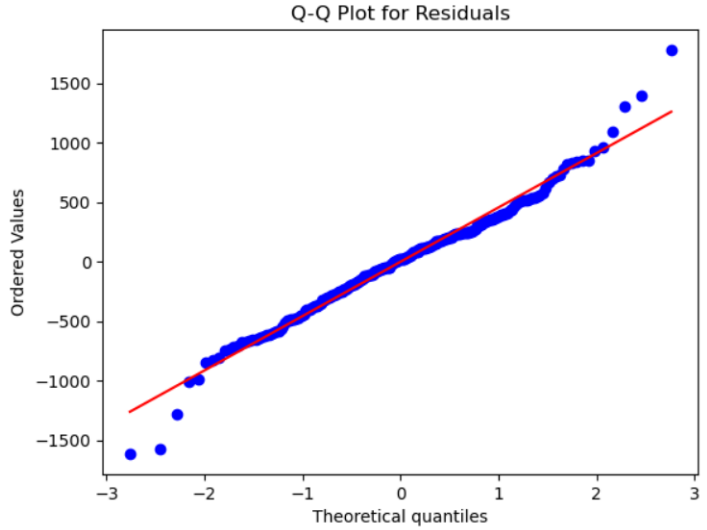
- Handles lack of independence of observations
- ➢ Fixed effects: **genotypes**
- ➢ Random effects: **N treatments** nested in **years factor**

(account for correlation between observations within the same treatment block)

- Python formula:

➢ Model = smf.mixedlm("grain_yield_combine_clean_kgperha_dw_PlotCor1Rep ~ **cultivar_name_acr**", data=merged_df, groups=merged_df["**experiment_year**"], re_formula="1 + **Ntreatmen**t")

- Normality of residuals ? ✖



Shapiro-Wilk Test: W=0.981, p-value=0.002

Mixed Linear Model Regression Results

Model:	MixedLM	Dependent Variable:	grain_yield_combine_clean_kgperha_dw_PlotCor1Rep
No. Observations:	240	Method:	REML
No. Groups:	4	Scale:	225366.5953
Min. group size:	60	Log-Likelihood:	-1777.0535
Max. group size:	60	Converged:	Yes
Mean group size:	60.0		

	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
Intercept	3459.534	1118.269	3.094	0.002	1267.768	5651.301
cultivar_name_acr[T.AXEN]	-51.542	137.042	-0.376	0.707	-320.140	217.056
cultivar_name_acr[T.BODE]	-218.613	137.042	-1.595	0.111	-487.210	49.985
cultivar_name_acr[T.CADL]	10.955	137.042	0.080	0.936	-257.643	279.553
cultivar_name_acr[T.CAMP]	185.972	137.042	1.357	0.175	-82.626	454.570
cultivar_name_acr[T.DIAV]	-277.565	137.042	-2.025	0.043	-546.163	-8.968
cultivar_name_acr[T.MONT]	-39.152	137.042	-0.286	0.775	-307.749	229.446
cultivar_name_acr[T.PIZN]	-209.978	137.042	-1.532	0.125	-478.575	58.620
cultivar_name_acr[T.ROSA]	-71.461	137.042	-0.521	0.602	-340.059	197.137
cultivar_name_acr[T.RUNA]	-12.474	137.042	-0.091	0.927	-281.072	256.123
Group Var	2038305.579	6673.745				
Group x Ntreatment[T.N0] Cov	-2267175.585	5328.917				
Ntreatment[T.N0] Var	3019187.484	4559.434				

Fit linear mixed models for each N treatments

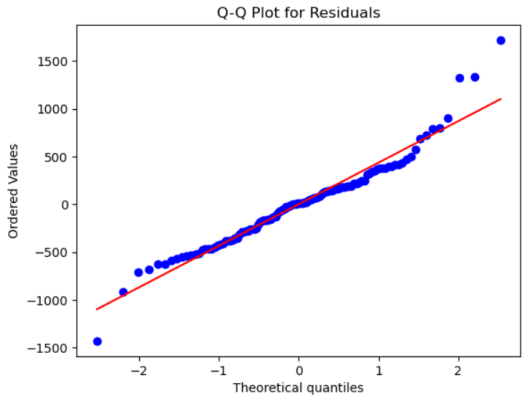
- A lot of variability seems not explained by the fixed effects (year effect)
- At this level, no significant differences between varieties are found
- Let's explore if there are significant variety differences within each year and within each N treatment block

N0

Mixed Linear Model Regression Results

Model:	MixedLM	Dependent Variable:	grain_yield_combine_clean_kgperha_dw_PlotCor1Rep
No. Observations:	120	Method:	REML
No. Groups:	4	Scale:	216423.5738
Min. group size:	30	Log-Likelihood:	-850.0383
Max. group size:	30	Converged:	Yes
Mean group size:	30.0		

	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
Intercept	3058.094	325.088	9.407	0.000	2420.932	3695.255
cultivar_name_acr[T.AXEN]	-5.775	189.923	-0.030	0.976	-378.016	366.467
cultivar_name_acr[T.BODE]	-142.335	189.923	-0.749	0.454	-514.577	229.906
cultivar_name_acr[T.CADL]	-68.870	189.923	-0.363	0.717	-441.111	303.372
cultivar_name_acr[T.CAMP]	107.142	189.923	0.564	0.573	-265.099	479.384
cultivar_name_acr[T.DIAV]	-428.236	189.923	-2.255	0.024	-800.477	-55.994
cultivar_name_acr[T.MONT]	9.907	189.923	0.052	0.958	-362.335	382.148
cultivar_name_acr[T.PIZN]	-286.609	189.923	-1.509	0.131	-658.850	85.633
cultivar_name_acr[T.ROSA]	-26.005	189.923	-0.137	0.891	-398.246	346.237
cultivar_name_acr[T.RUNA]	-37.297	189.923	-0.196	0.844	-409.539	334.944
Group Var	350588.660	636.544				



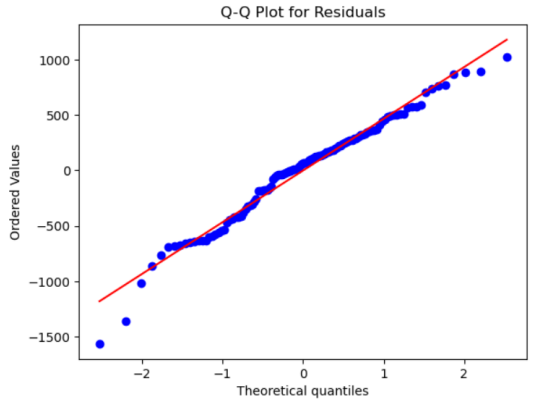
Shapiro-Wilk Test: W=0.956, p-value=0.001

Conventional N

Mixed Linear Model Regression Results

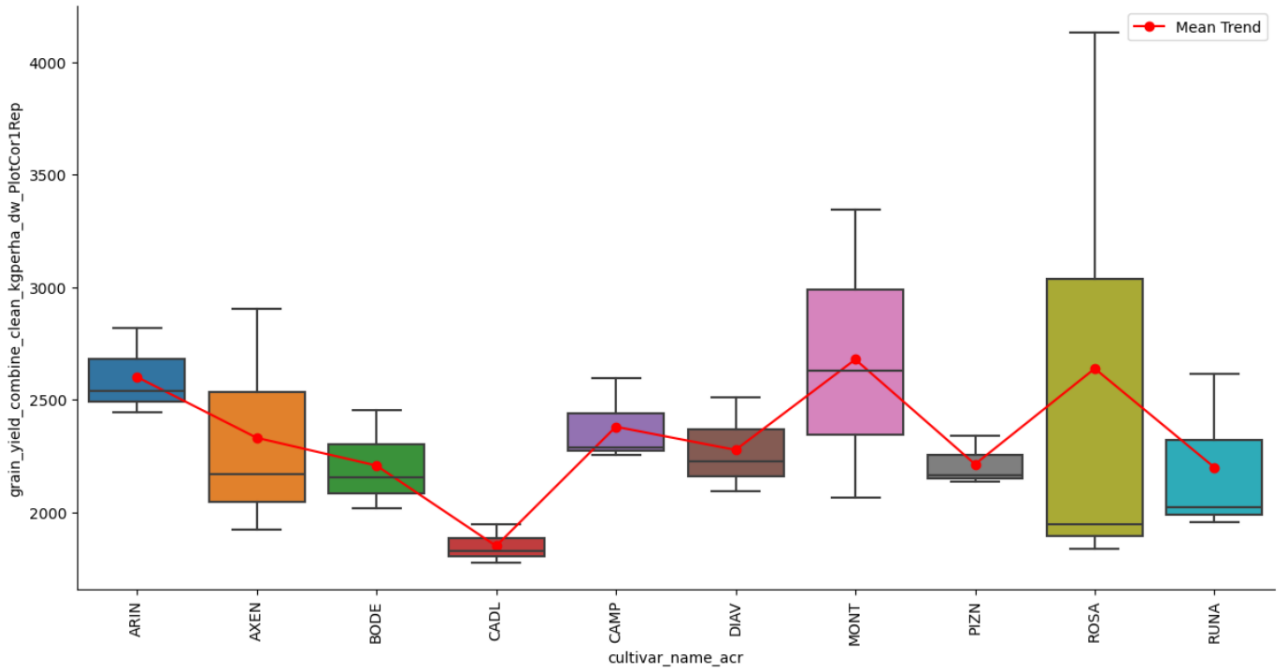
Model:	MixedLM	Dependent Variable:	grain_yield_combine_clean_kgperha_dw_PlotCor1Rep
No. Observations:	120	Method:	REML
No. Groups:	4	Scale:	241966.9754
Min. group size:	30	Log-Likelihood:	-856.4969
Max. group size:	30	Converged:	Yes
Mean group size:	30.0		

	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
Intercept	4700.548	377.036	12.467	0.000	3961.571	5439.524
cultivar_name_acr[T.AXEN]	-97.309	200.818	-0.485	0.628	-490.905	296.287
cultivar_name_acr[T.BODE]	-294.890	200.818	-1.468	0.142	-688.486	98.706
cultivar_name_acr[T.CADL]	90.780	200.818	0.452	0.651	-302.816	484.376
cultivar_name_acr[T.CAMP]	264.802	200.818	1.319	0.187	-128.794	658.397
cultivar_name_acr[T.DIAV]	-126.895	200.818	-0.632	0.527	-520.490	266.701
cultivar_name_acr[T.MONT]	-88.210	200.818	-0.439	0.660	-481.806	305.386
cultivar_name_acr[T.PIZN]	-133.347	200.818	-0.664	0.507	-526.943	260.249
cultivar_name_acr[T.ROSA]	-116.917	200.818	-0.582	0.560	-510.513	276.679
cultivar_name_acr[T.RUNA]	12.348	200.818	0.061	0.951	-381.248	405.944
Group Var	487967.949	834.382				



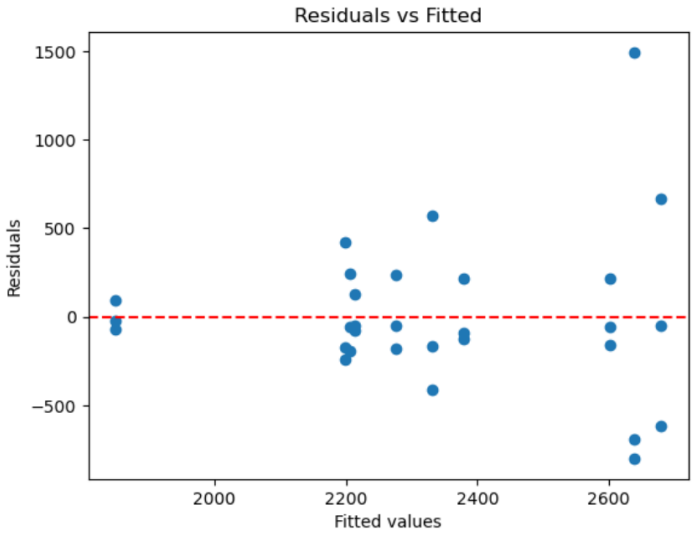
Shapiro-Wilk Test: W=0.979, p-value=0.054

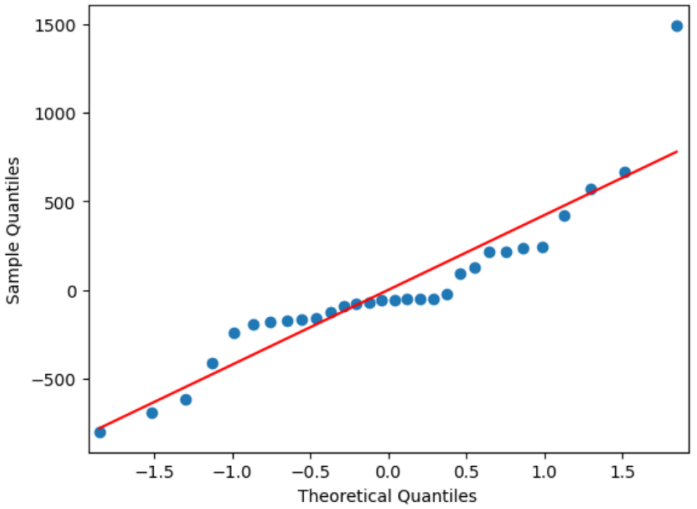
N0 analysis: 2021




```
Bartlett's Test Statistic: 21.162204888309002
P-value: 0.011949357713574856
The variances are significantly different (homogeneity of variance violated).
```

```
Kruskal-Wallis Test Statistic: 11.39139784946235
P-value: 0.2498313845196752
There is no significant difference between the groups.
```



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Shapiro-Wilk Test: W=0.883, p-value=0.003
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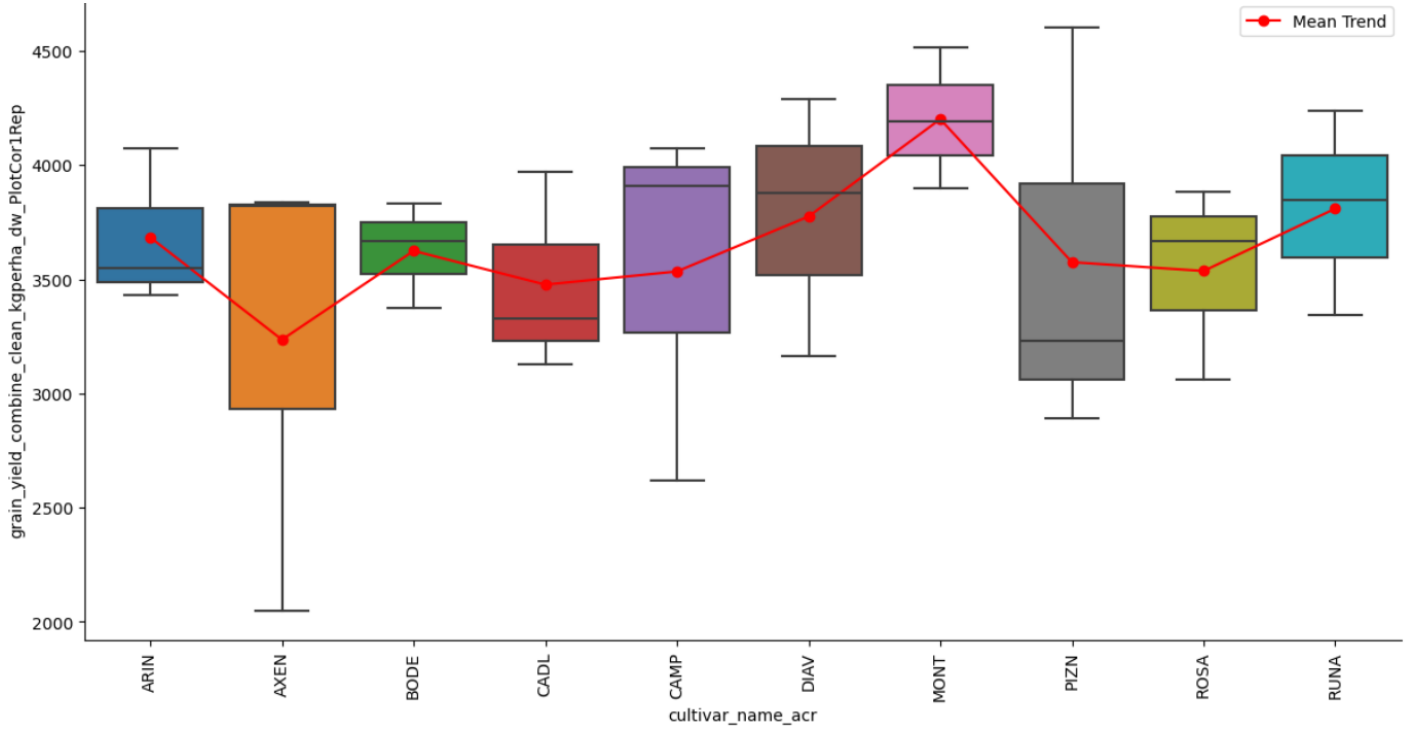
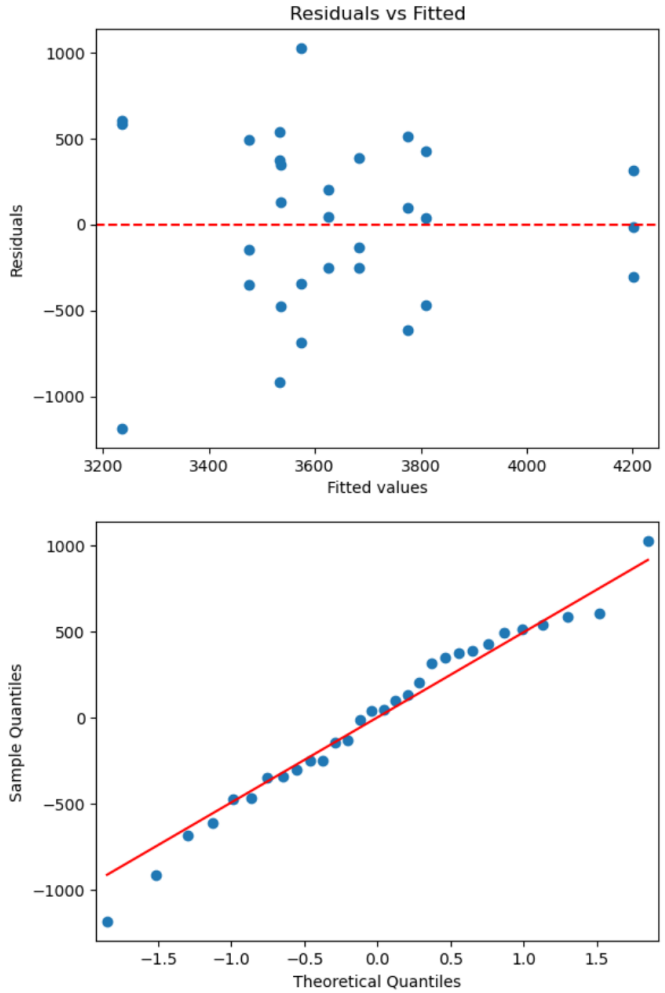
Conventional N analysis: 2021



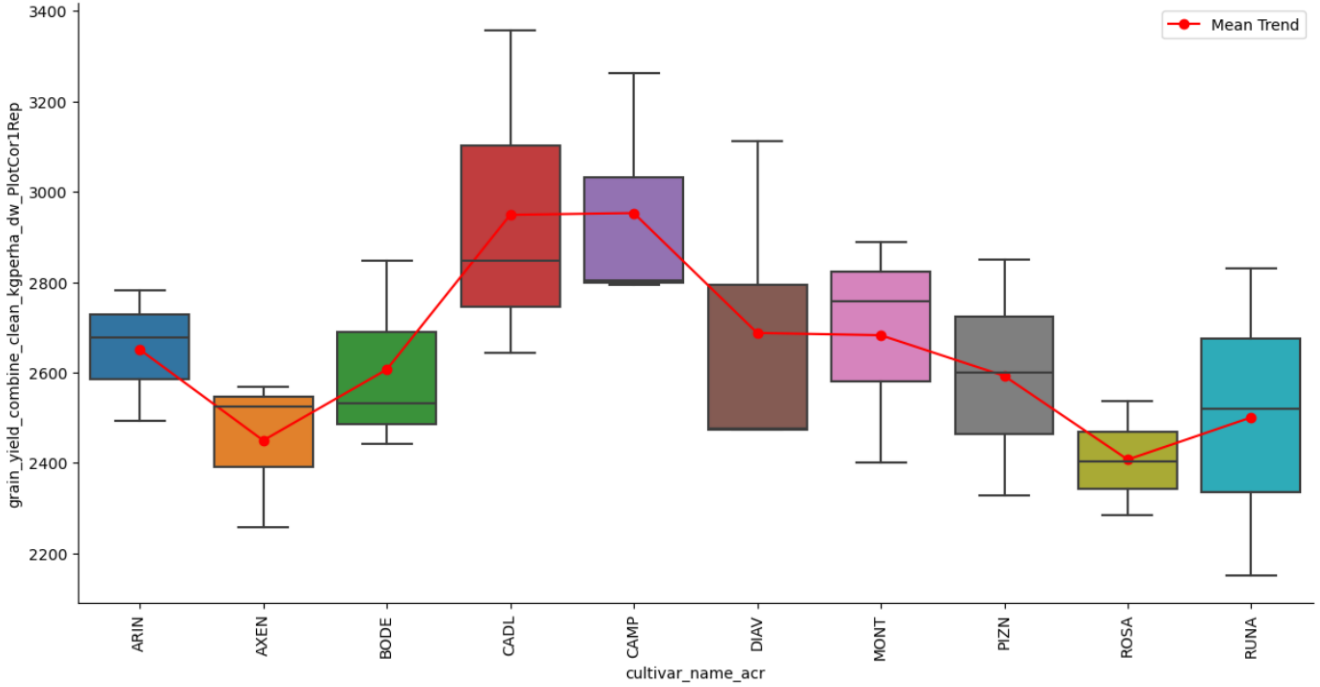


Shapiro-Wilk Test: W=0.980, p-value=0.833

Bartlett's Test Statistic: 8.809594737807885
P-value: 0.4550328502148302
The variances are not significantly different (homogeneity of variance met).

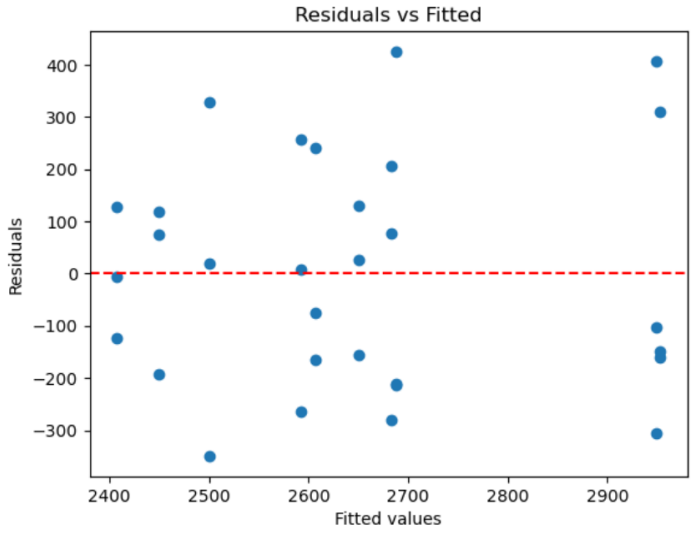
	df	sum_sq	mean_sq	F	PR(>F)
C(cultivar_name_acr)	9.0	1.740199e+06	193355.397277	0.525746	0.838819
Residual	20.0	7.355466e+06	367773.292242	NaN	NaN

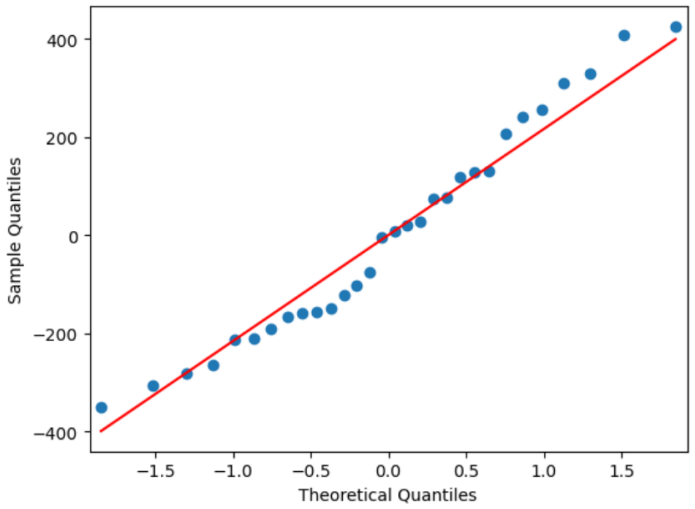
N0 analysis: 2022



Bartlett's Test Statistic: 3.888844197683194
P-value: 0.9185749111061812
The variances are not significantly different (homogeneity of variance met).

	df	sum_sq	mean_sq	F	PR(>F)
C(cultivar_name_acr)	9.0	9.290701e+05	103230.005615	1.475667	0.223524
Residual	20.0	1.399096e+06	69954.810694	NaN	NaN





Shapiro-Wilk Test: W=0.958, p-value=0.278

Conventional N analysis: 2022

```
ARIN vs. AXEN: Custom statistical test, P_val:2.710e-02
AXEN vs. CAMP: Custom statistical test, P_val:9.517e-03
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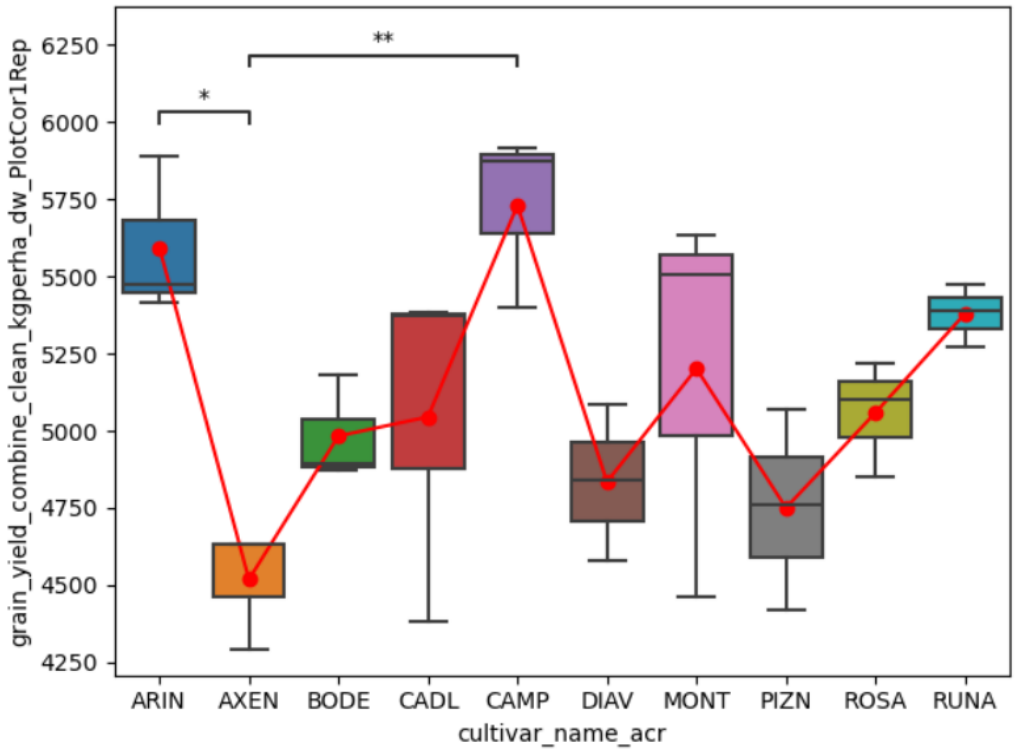
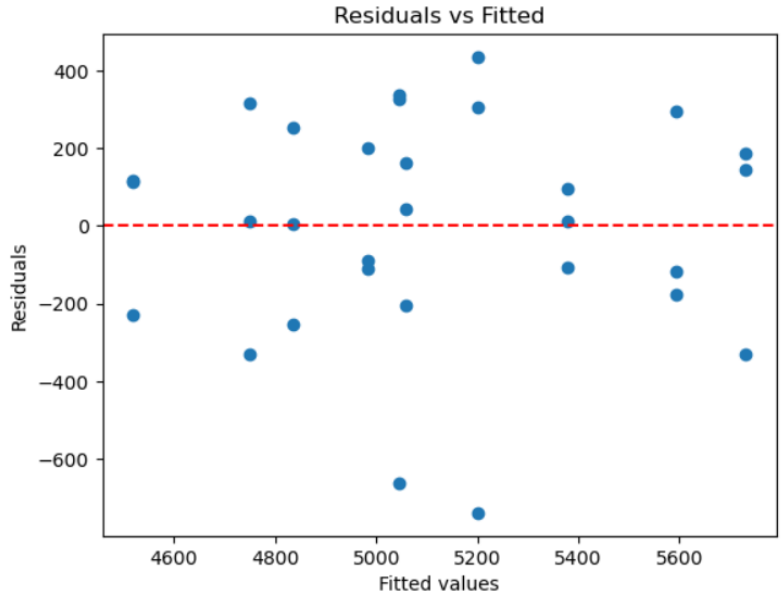
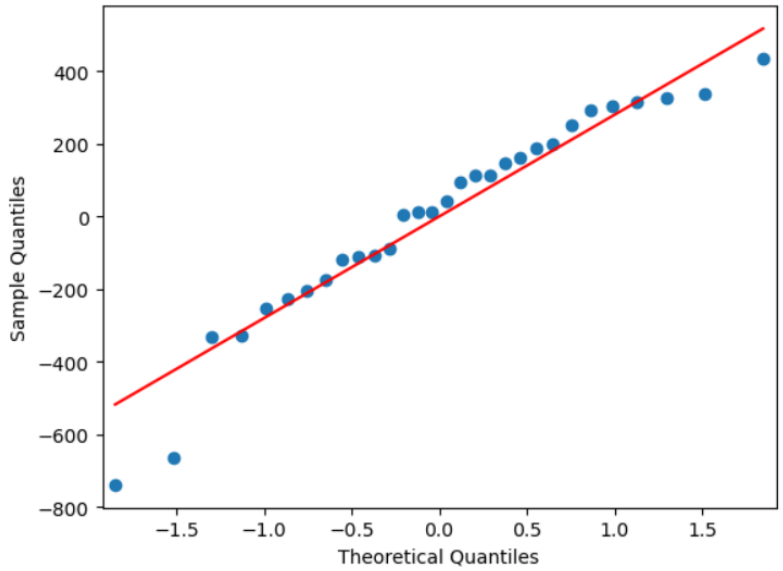



```
Bartlett's Test Statistic: 9.24690216708312
P-value: 0.4148023297396884
The variances are not significantly different (homogeneity of variance met).
```

	df	sum_sq	mean_sq	F	PR(>F)
C(cultivar_name_acr)	9.0	3.832210e+06	425801.133291	3.618656	0.007953
Residual	20.0	2.353366e+06	117668.321377	NaN	NaN






```
Shapiro-Wilk Test: W=0.941, p-value=0.098
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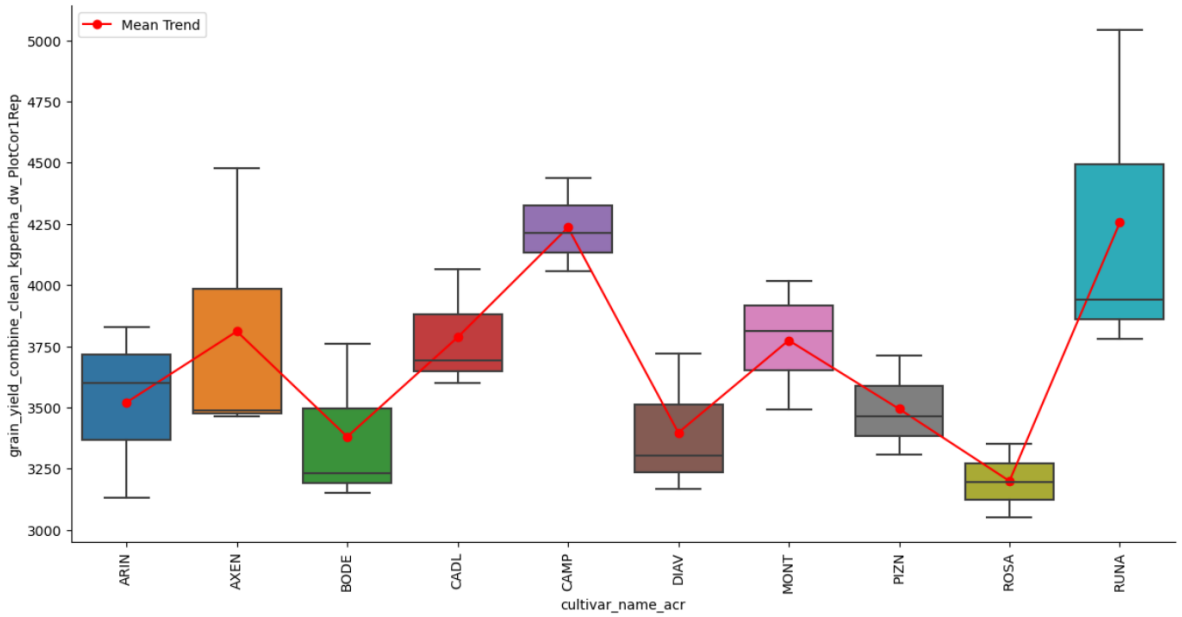
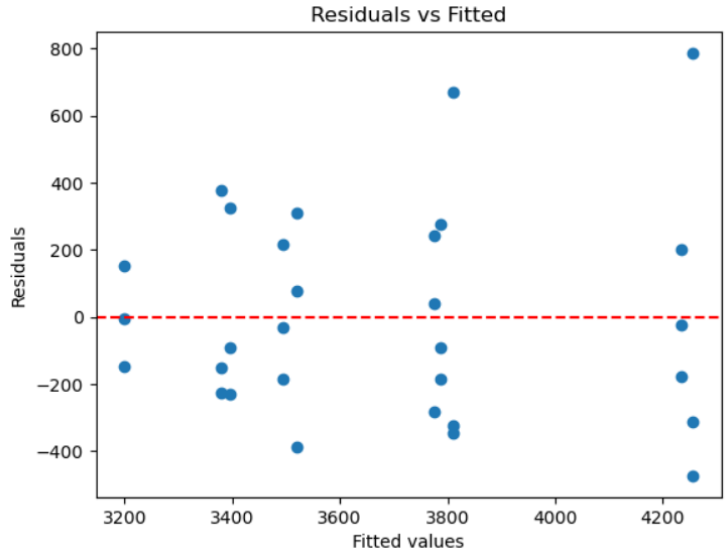
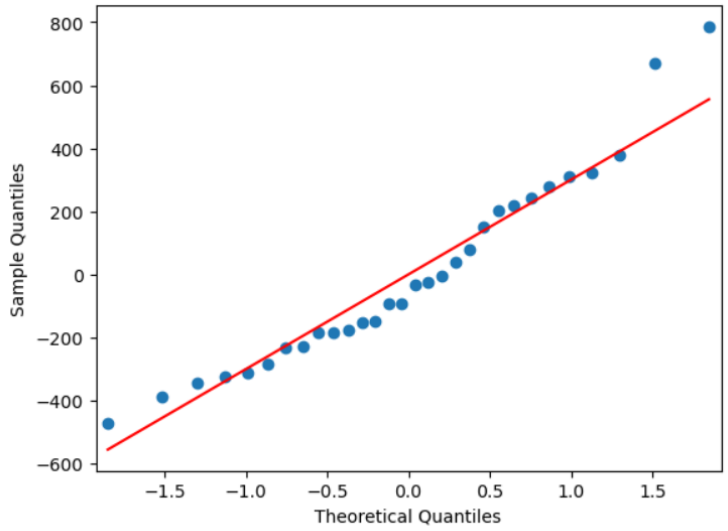
N0 analysis: 2023



Bartlett's Test Statistic: 7.406273016990933
P-value: 0.5948990035238204
The variances are not significantly different (homogeneity of variance met).

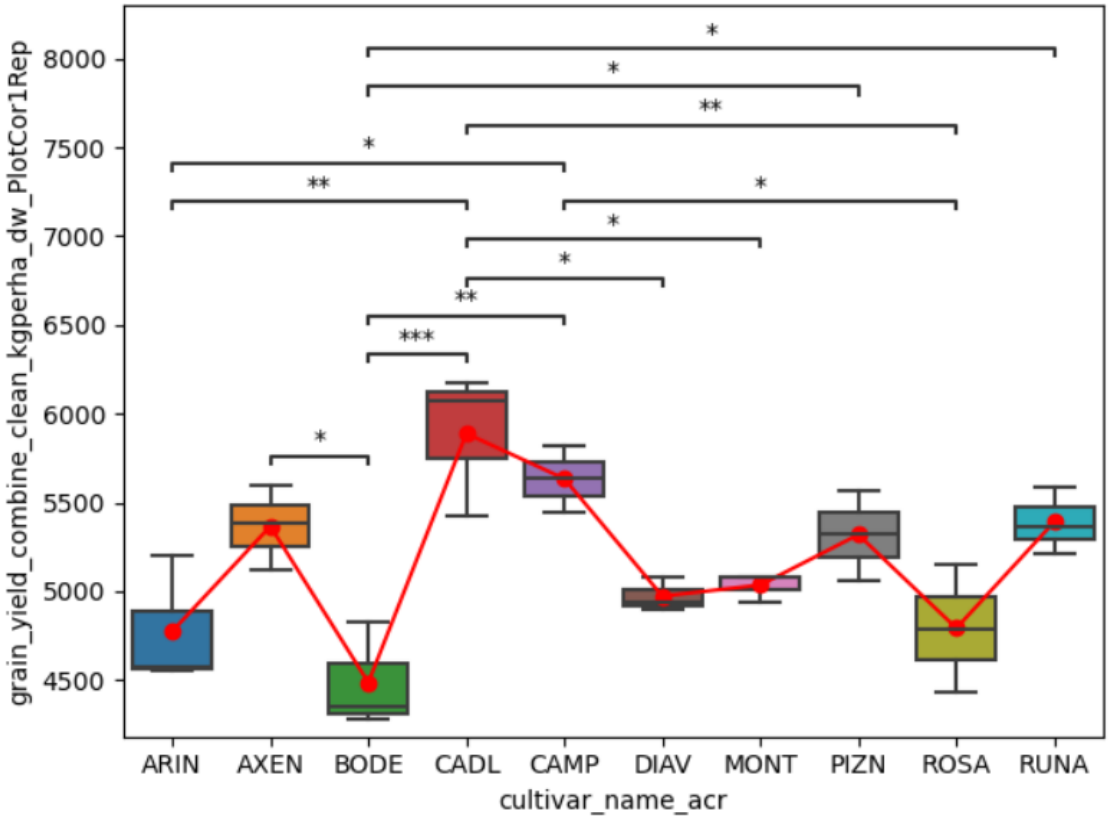
	df	sum_sq	mean_sq	F	PR(>F)
C(cultivar_name_acr)	9.0	3.410594e+06	378954.920347	2.797207	0.026552
Residual	20.0	2.709524e+06	135476.197805	NaN	NaN





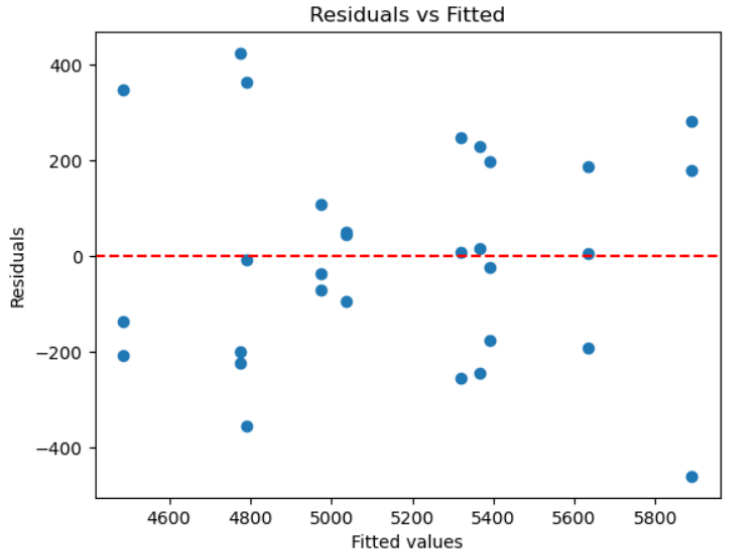
Shapiro-Wilk Test: W=0.946, p-value=0.136

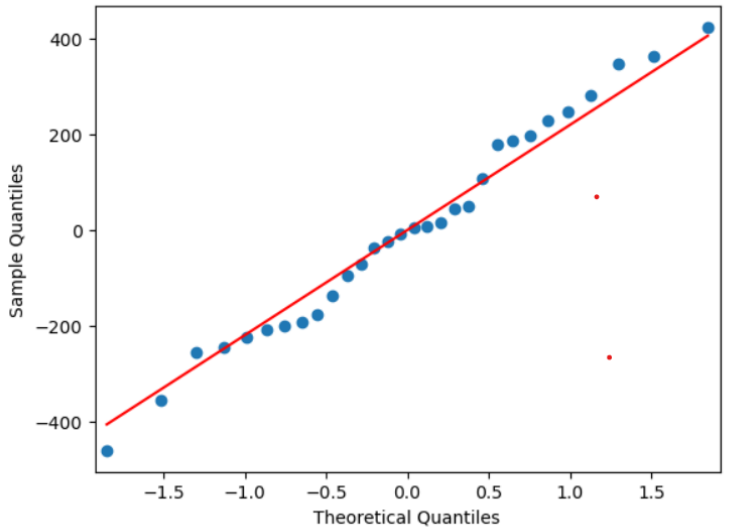
Conventional N analysis: 2023



	df	sum_sq	mean_sq	F	PR(>F)
C(cultivar_name_acr)	9.0	4.989126e+06	554347.311137	7.672642	0.00008
Residual	20.0	1.444997e+06	72249.860362	NaN	NaN

Bartlett's Test Statistic: 6.785088500241943
P-value: 0.6594834543853669
The variances are not significantly different (homogeneity of variance met).

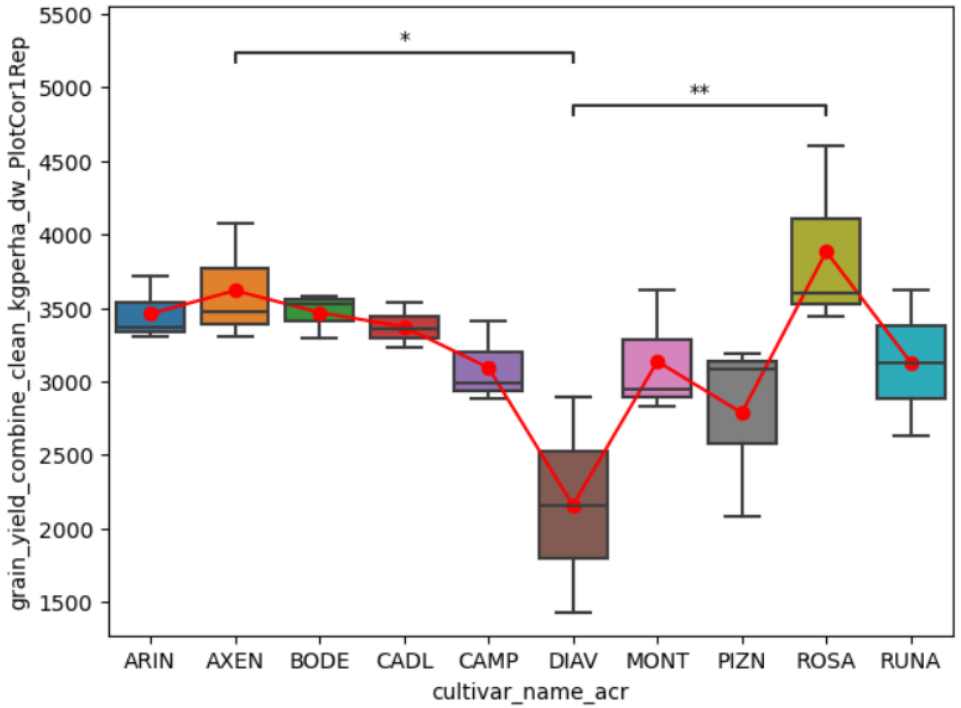




Shapiro-Wilk Test: W=0.980, p-value=0.838

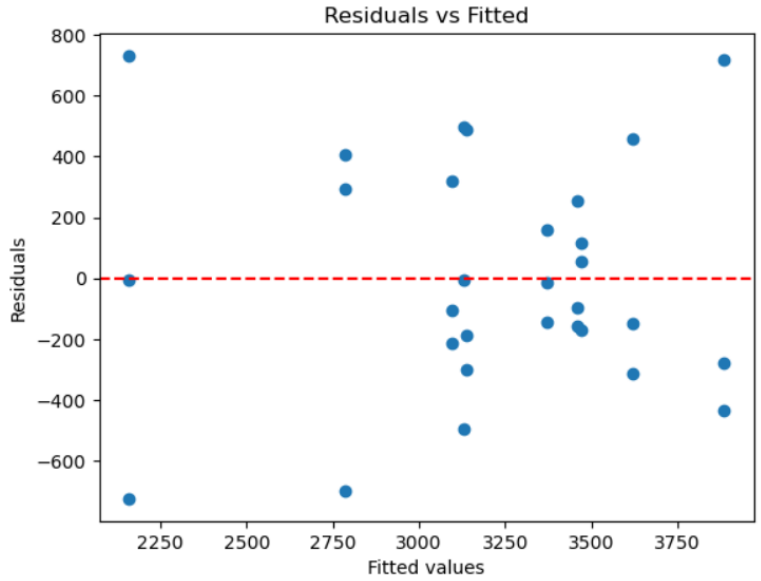
N0 analysis: 2024

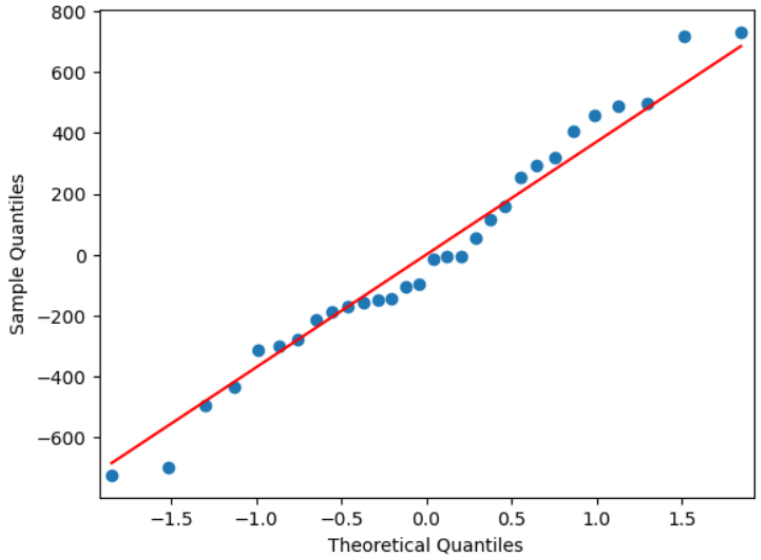
```
DIAV vs. ROSA: Custom statistical test, P_val:4.678e-03
AXEN vs. DIAV: Custom statistical test, P_val:2.198e-02
```



	df	sum_sq	mean_sq	F	PR(>F)
C(cultivar_name_acr)	9.0	6.261364e+06	695707.124299	3.373153	0.011272
Residual	20.0	4.124966e+06	206248.296859	NaN	NaN

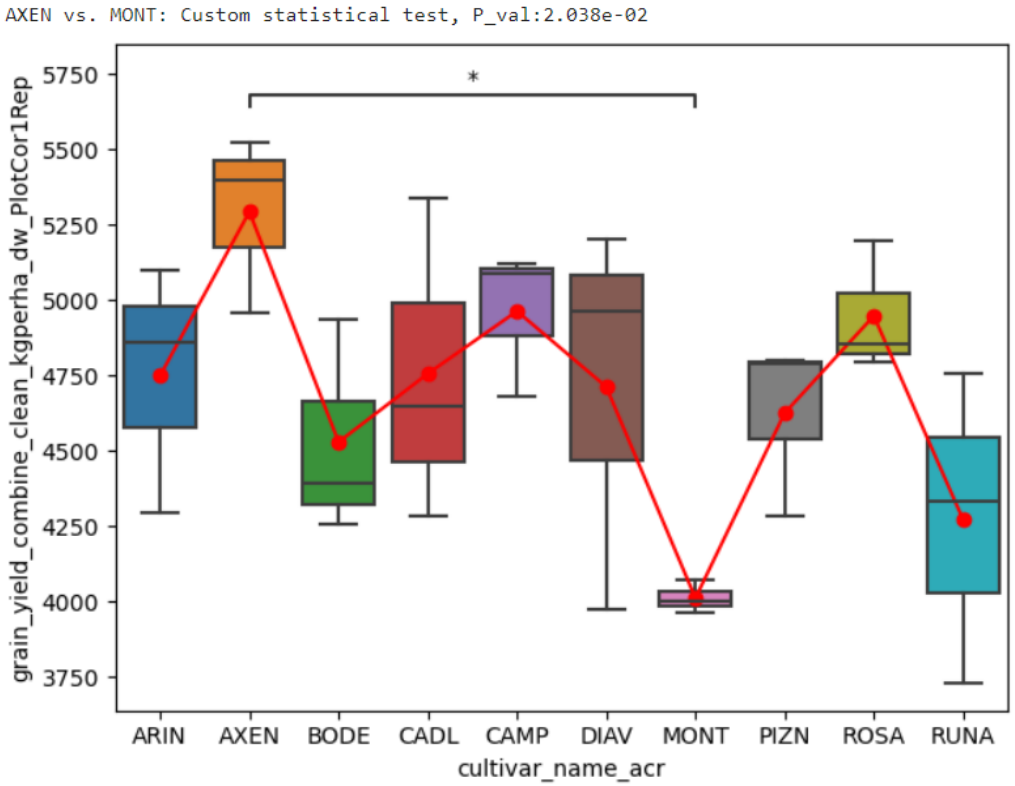
```
Bartlett's Test Statistic: 8.024622816168675
P-value: 0.5316667461540587
The variances are not significantly different (homogeneity of variance met).
```





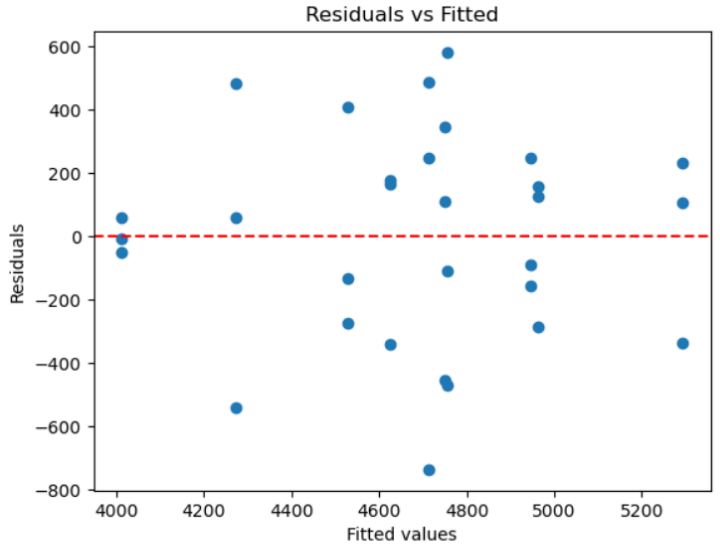

```
Shapiro-Wilk Test: W=0.975, p-value=0.680
```

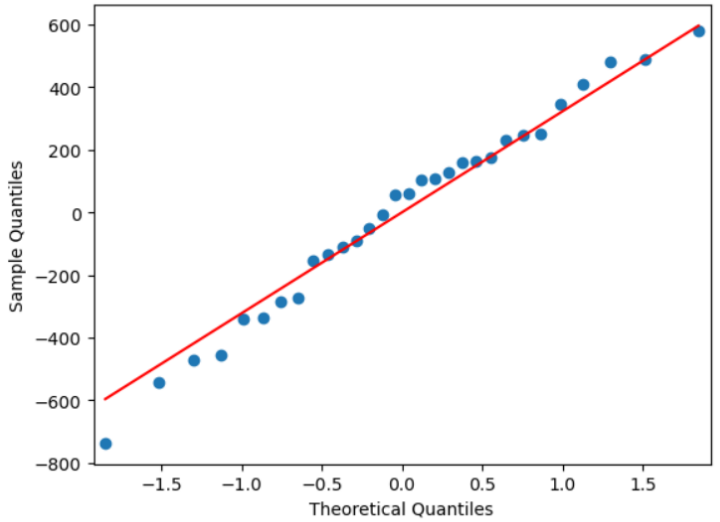
Conventional N analysis: 2024



Bartlett's Test Statistic: 8.809594737807885
P-value: 0.4550328502148302
The variances are not significantly different (homogeneity of variance met)

	df	sum_sq	mean_sq	F	PR(>F)
C(cultivar_name_acr)	9.0	3.530605e+06	392289.441904	2.514883	0.041199
Residual	20.0	3.119743e+06	155987.146134	NaN	NaN

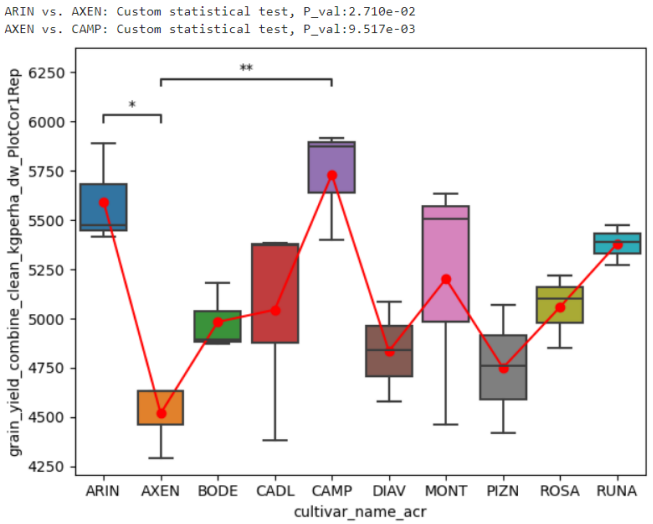




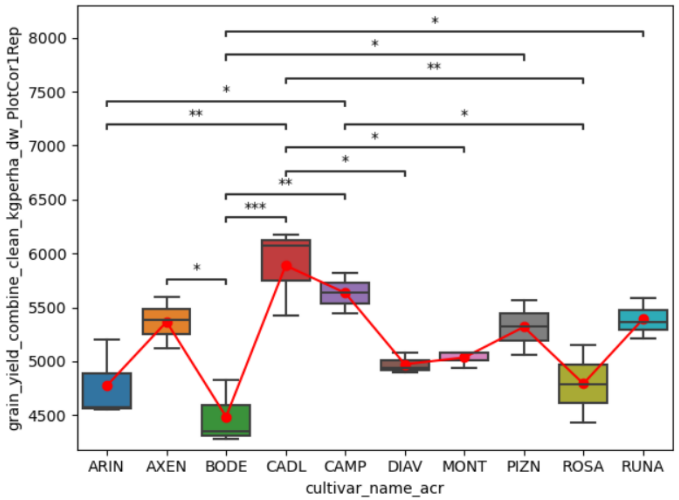
Shapiro-Wilk Test: W=0.980, p-value=0.836

Summary: statistical differences between varieties

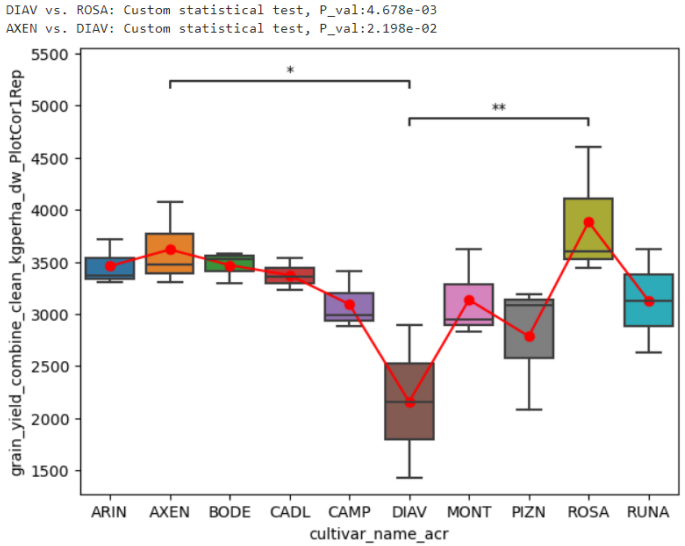
Conventional N - 2022



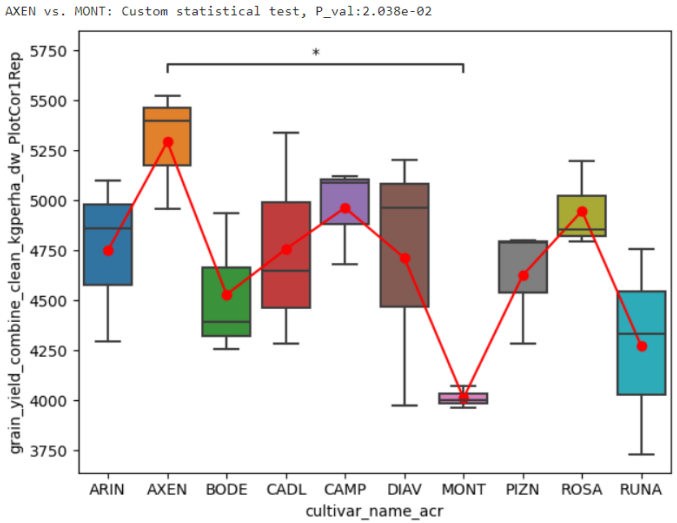
Conventional N - 2023



N0 - 2024

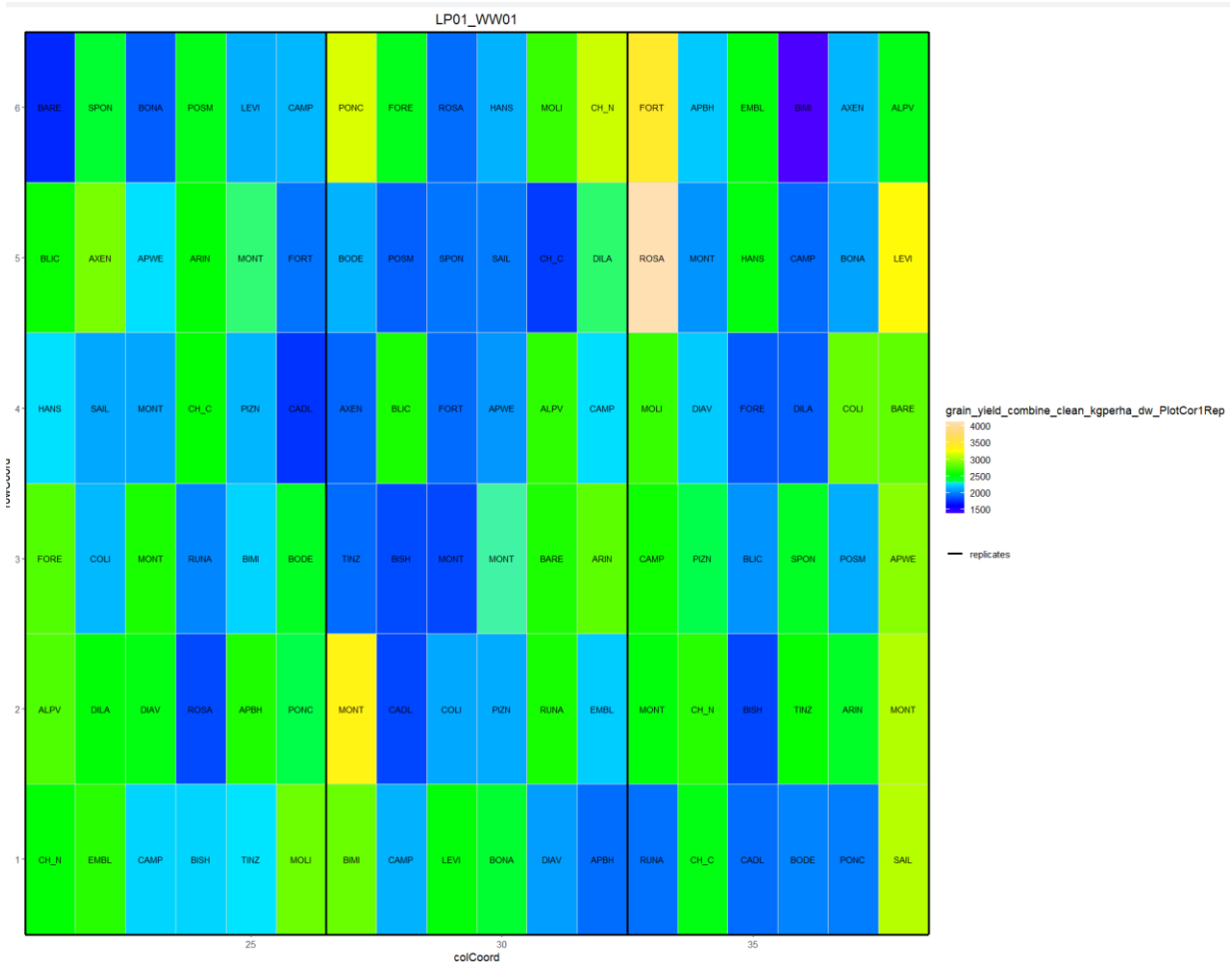


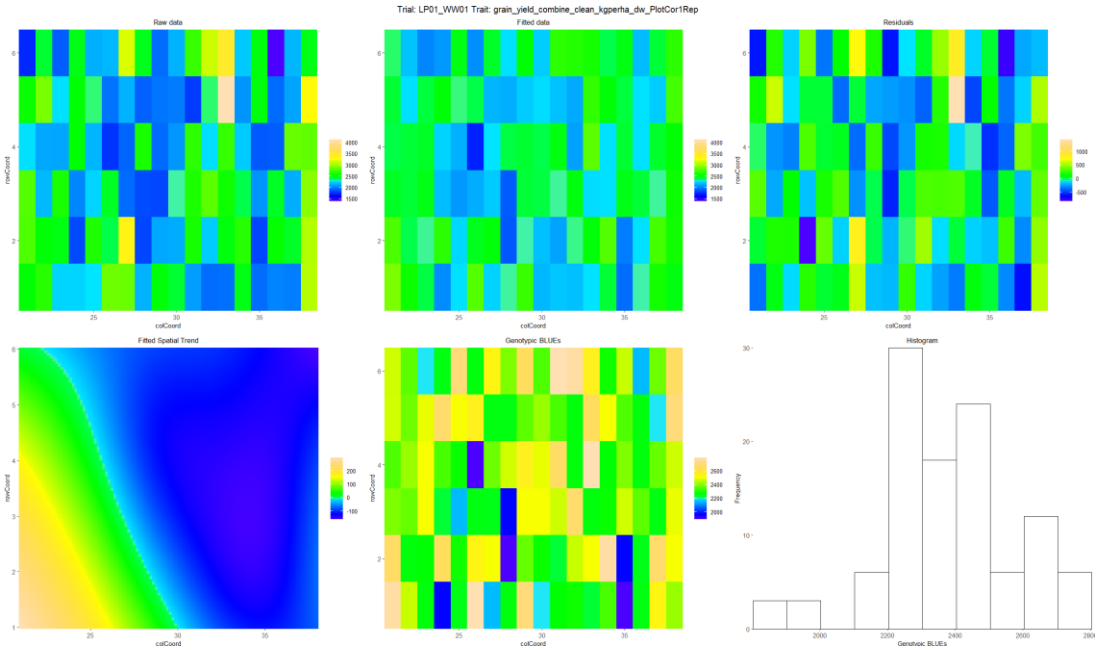
Conventional N - 2024



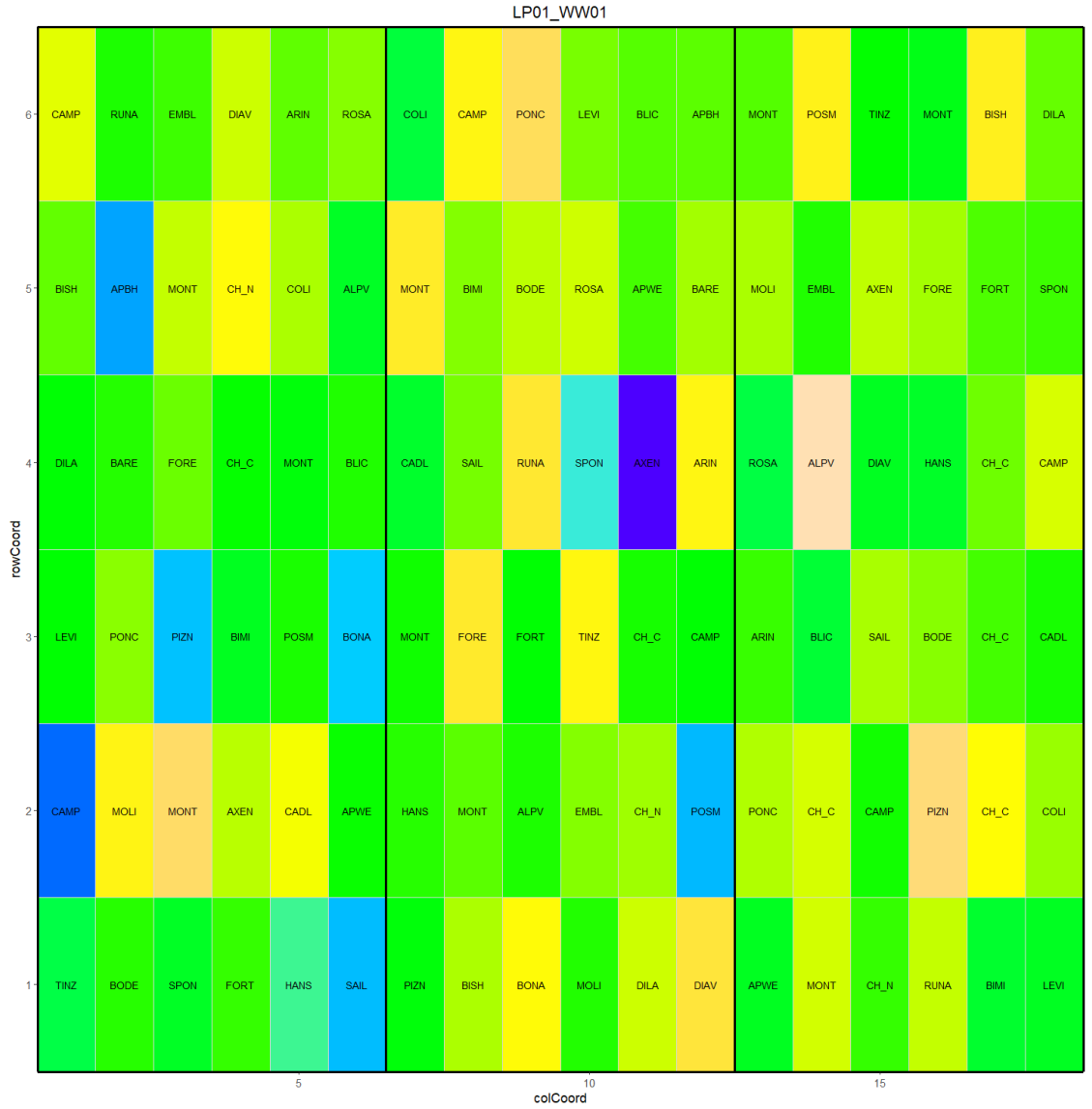
- 2021: grain yield too low – no significant differences found between varieties in both N treatment block.
- N0: no significant differences found, except in 2024.
- Campesino variety: consistent high grain yield over years and significantly different from other varieties.
- Axen variety: high grain yield over years with significant differences from other varieties but sensible to rainy weather condition (2021).

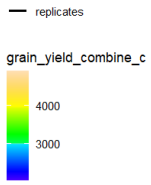
N0 – 2021- h2 = 0 (0)

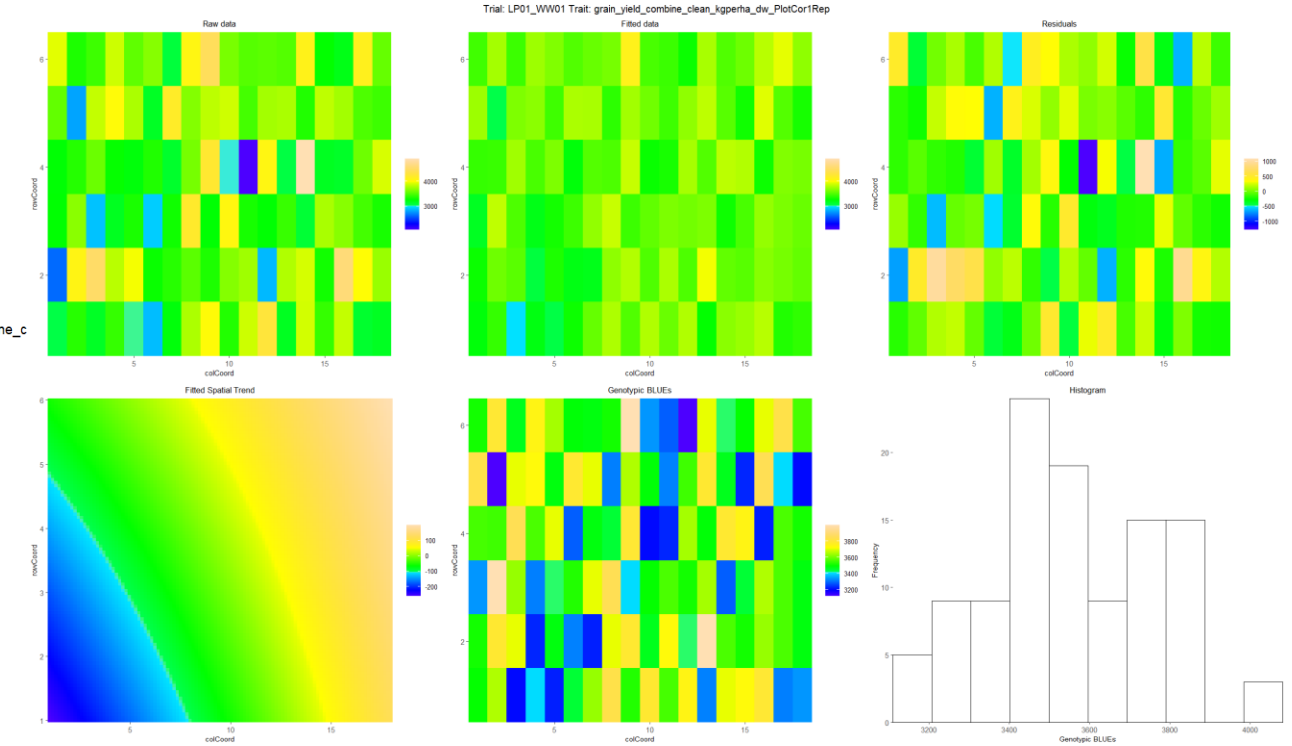

LP01_WW01
BARE SPON BONA POSM LEVI CAMP PONC FORE ROSA HANS MOLI CH_N FORT APBH EMBL BIMI AXEN ALPV
BLIC AXEN APWE ARIN MONT FORT BODE POSM SPON SAIL CH_C DILA ROSA MONT HANS CAMP BONA LEVI
HANS SAIL MONT CH_C PIZN CADL AXEN BLIC FORT APWE ALPV CAMP MOLI DIAV FORE DILA COLI BARE
FORE COLI MONT RUNA BIMI BODE TINZ BISH MONT MONT BARE ARIN CAMP PIZN BLIC SPON POSM APWE
ALPV DILA DIAV ROSA APBH PONC MONT CADL COLI PIZN RUNA EMBL MONT CH_N BISH TINZ ARIN MONT
CH_N EMBL CAMP BISH TINZ MOLI BIMI CAMP LEVI BONA DIAV APBH RUNA CH_C CADL BODE PONC SAIL
25
30
35
colCoord
grain_yield_combine_clean_kgperha_dw_PlotCor1Rep
4000
3500
3000
2500
2000
1500
replicates


Trial: LP01_WW01 Trait: grain_yield_combine_clean_kgperha_dw_PlotCor1Rep
Raw data
Fitted data
Residuals
Fitted Spatial Trend
Genotypic BLUEs
Histogram
rowCoord
colCoord
Frequency
Genotypic BLUEs

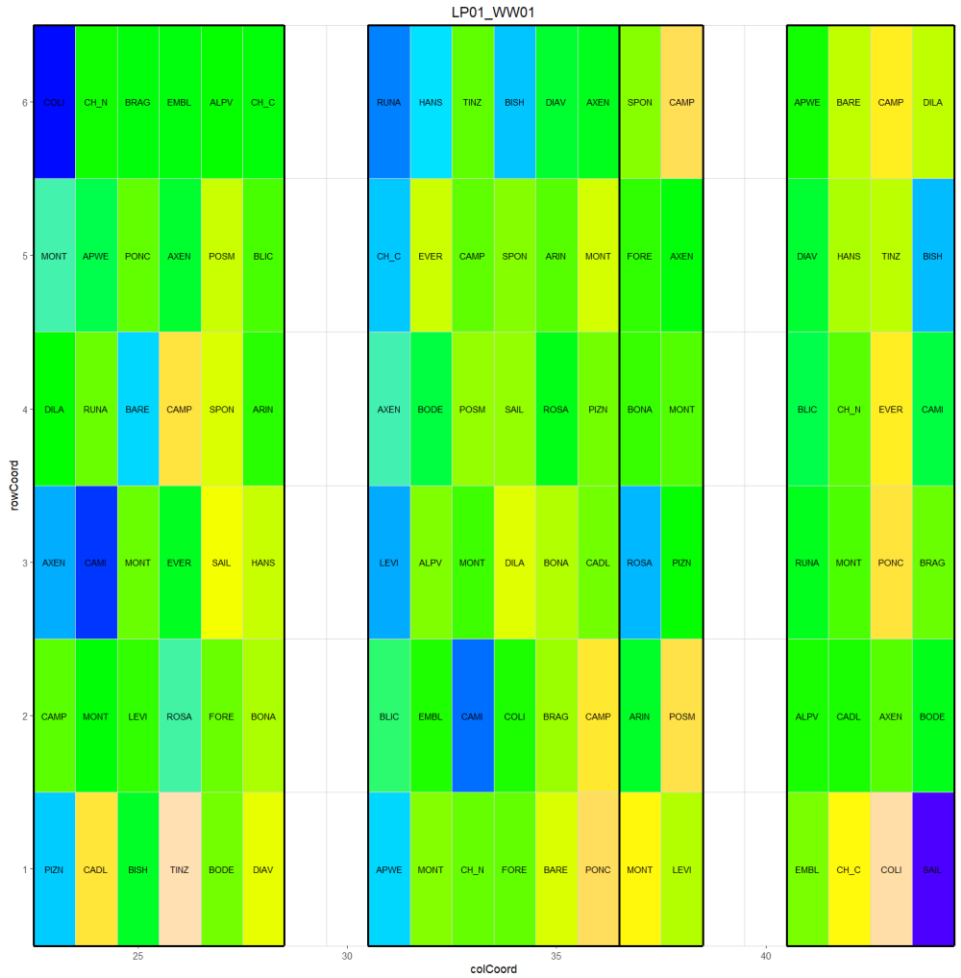
Conventional N – 2021- h2 = 0 (0)

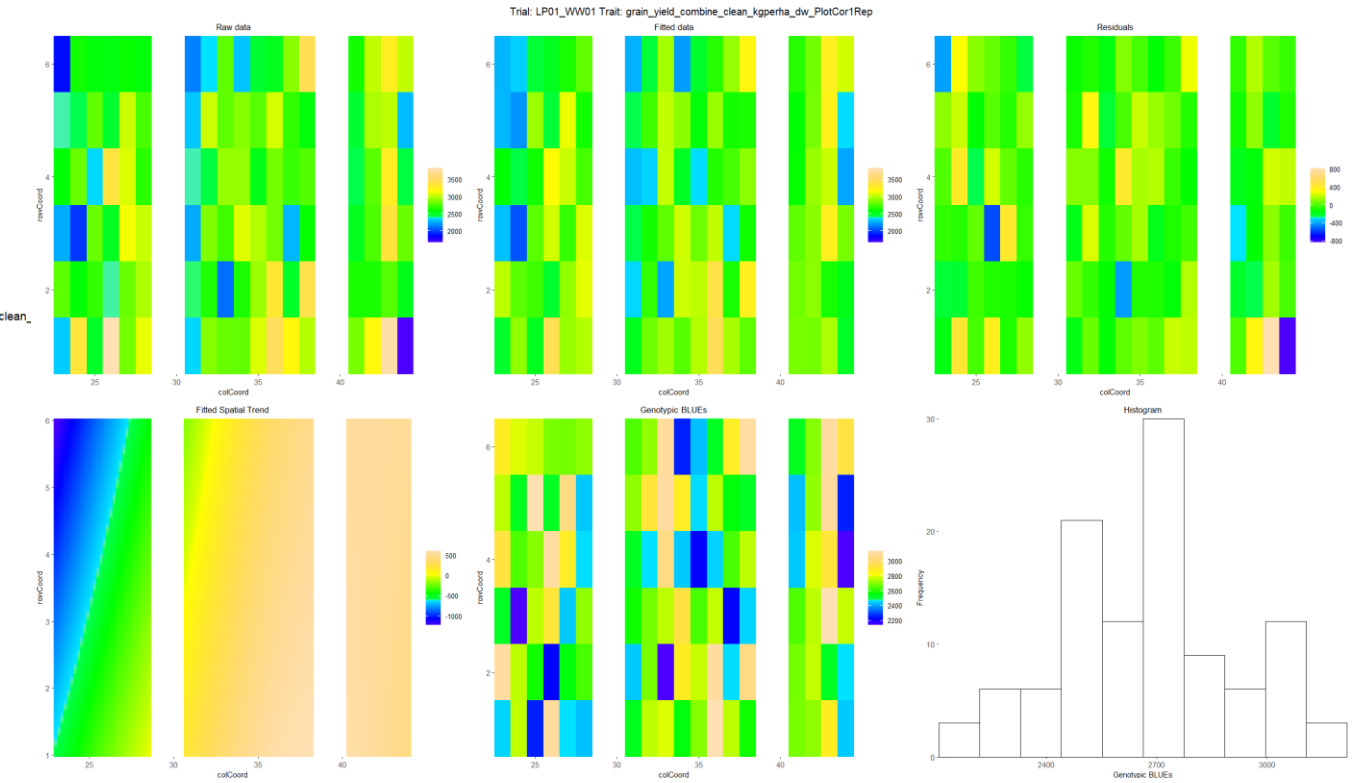




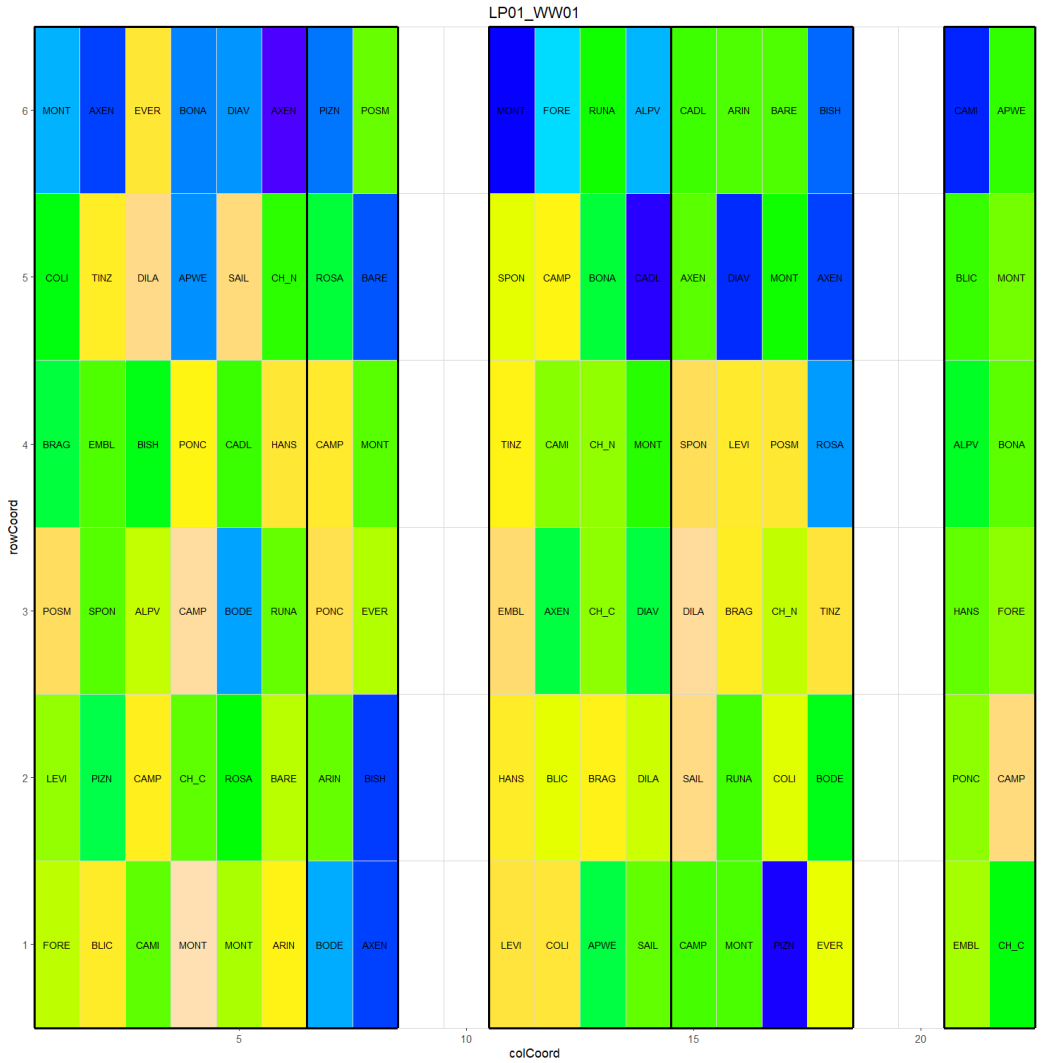


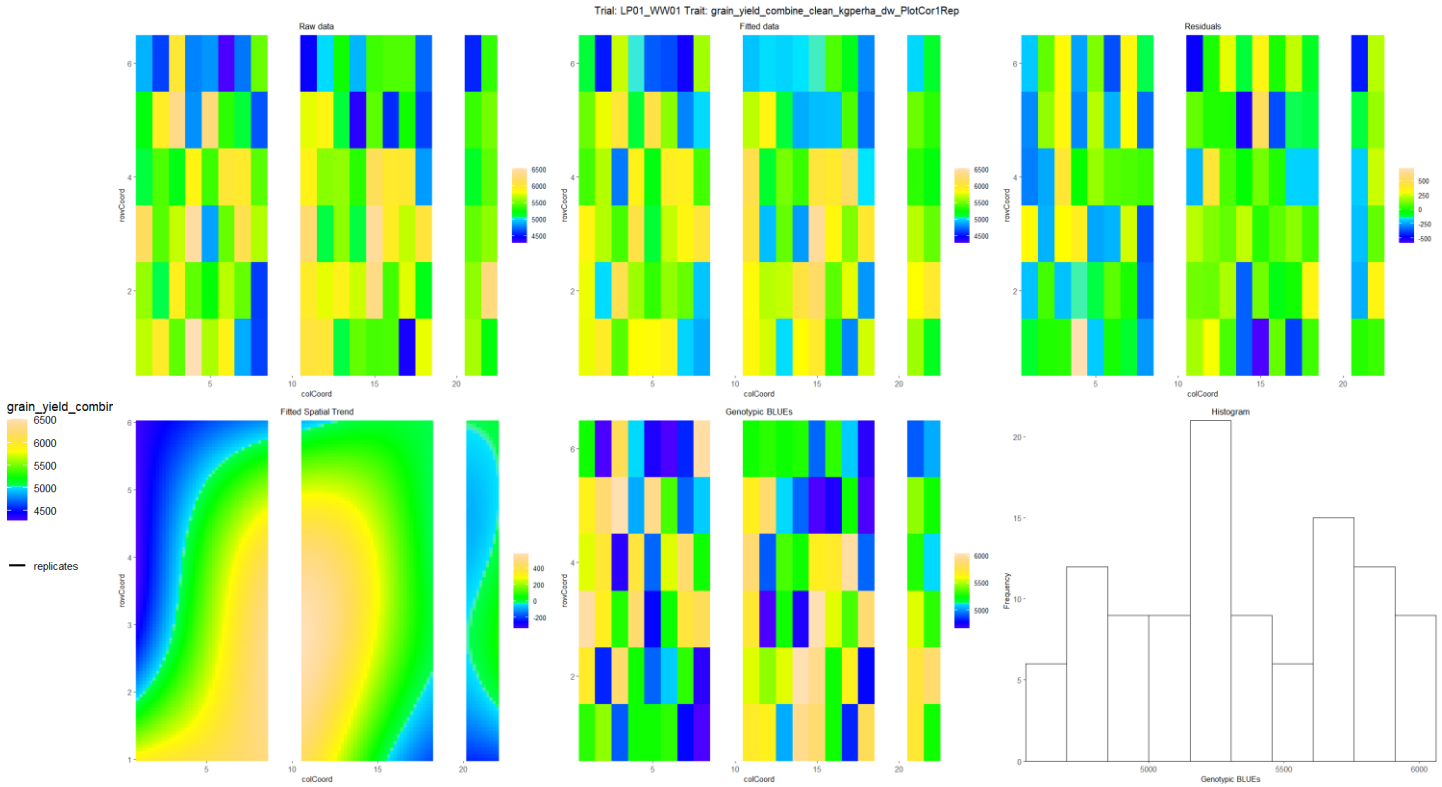
N0 – 2022- h2 = 0.61 (0.89: 10 Var)



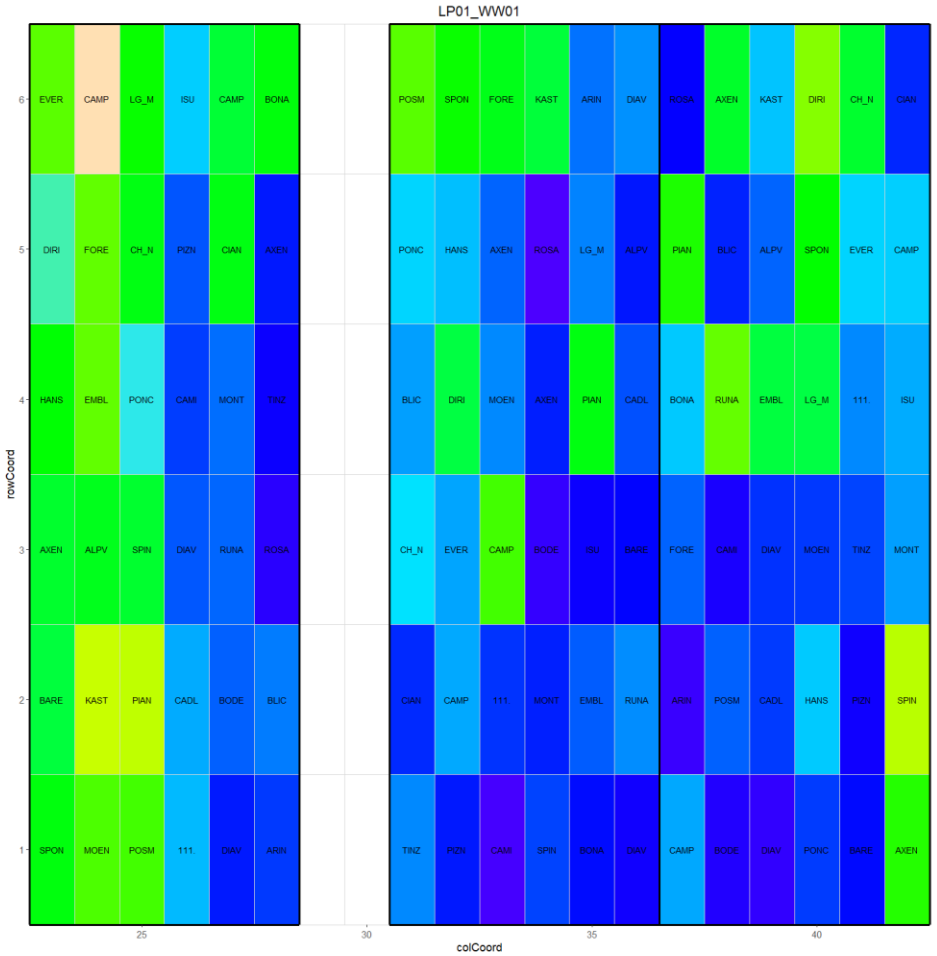


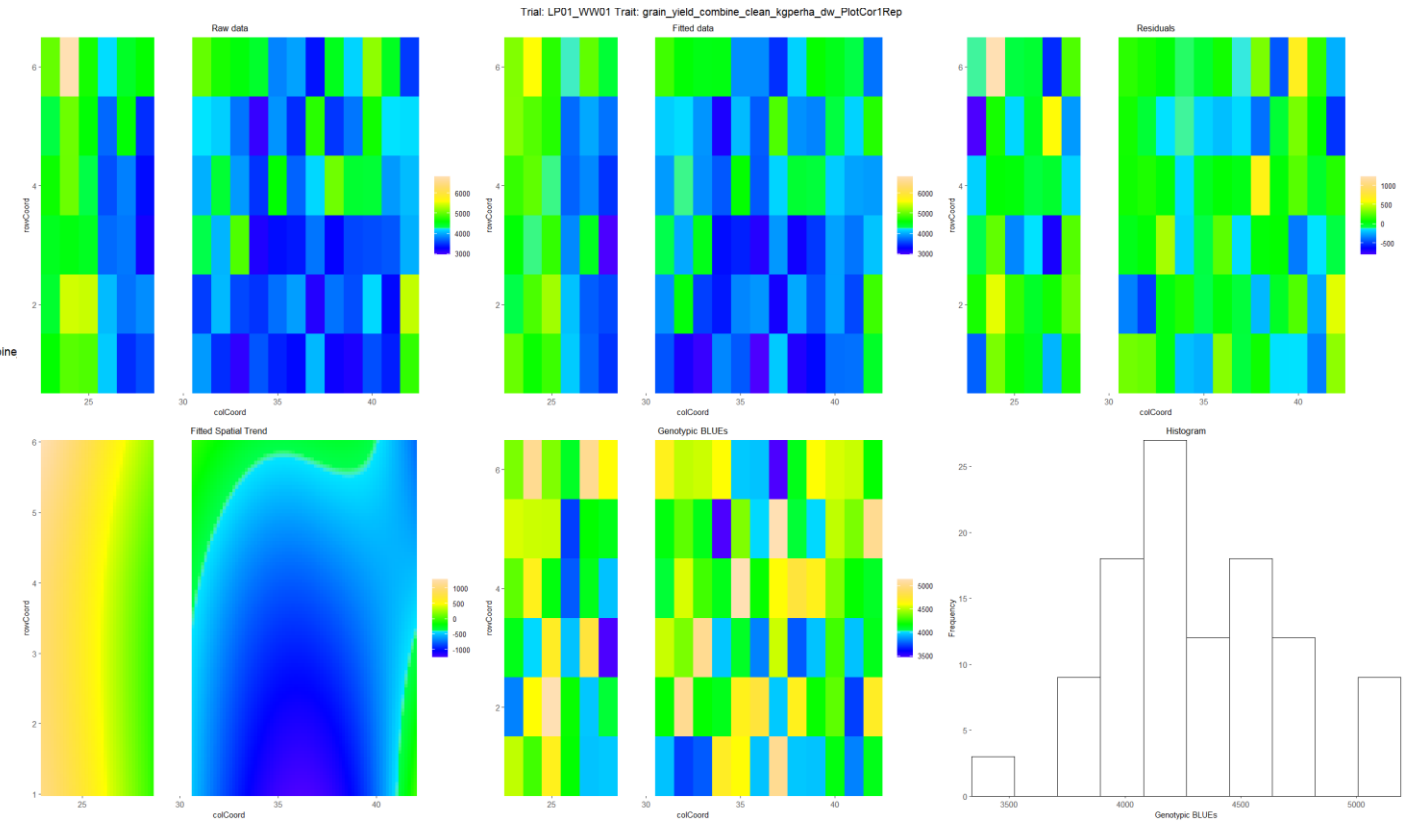
Conventional N – 2022 – h2 = 0.87 (0.85: 10 Var)



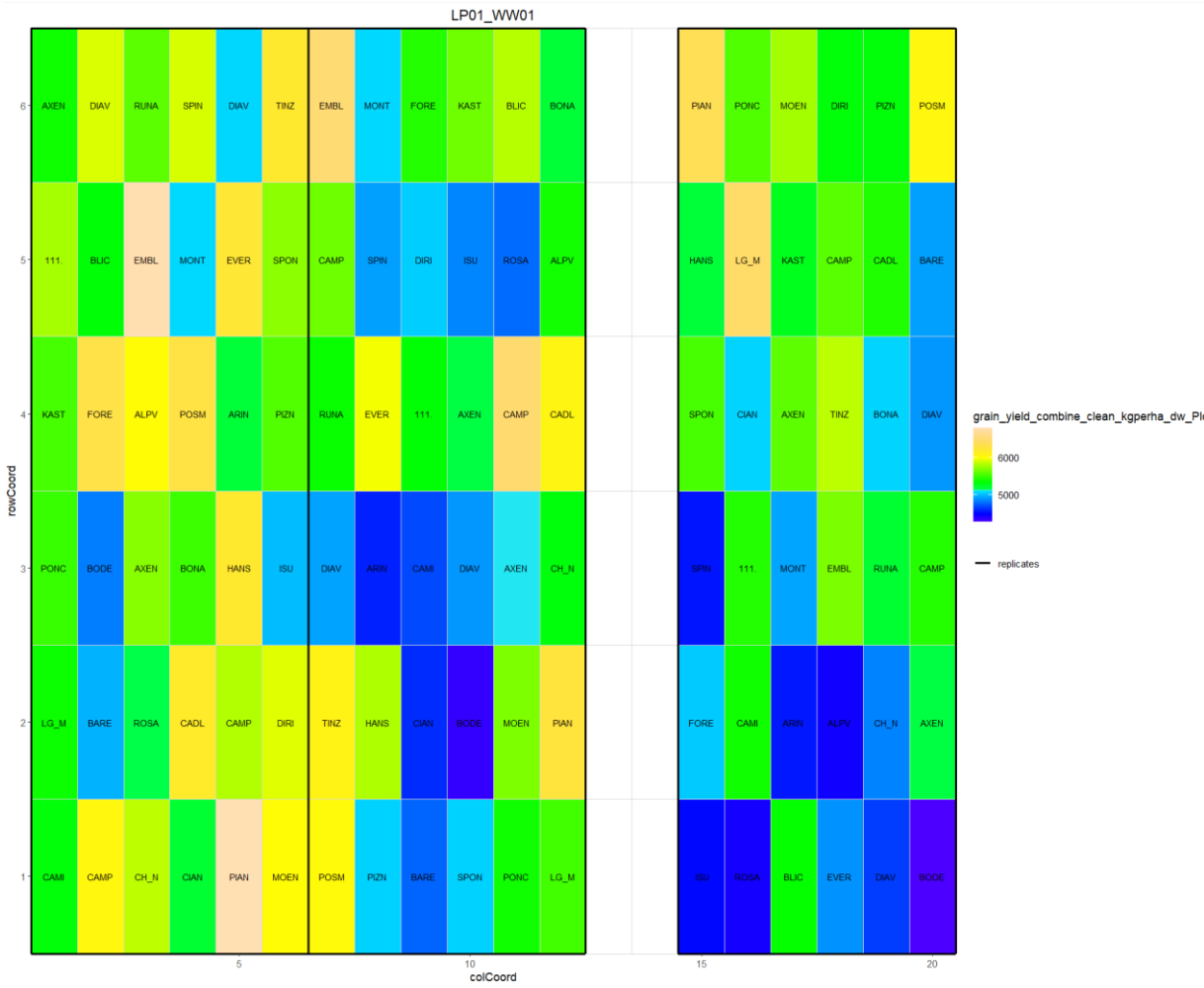


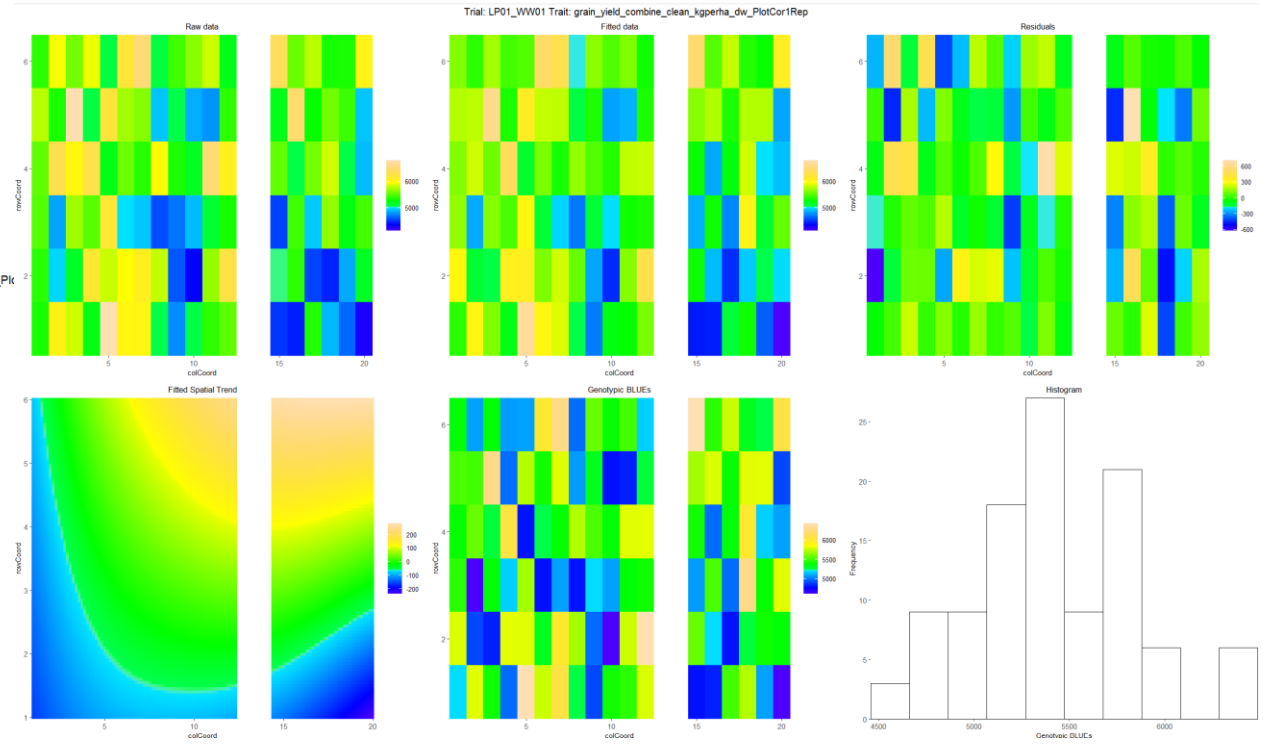
N0 – 2023 – h2 = 0.79 (0.75: without plot cor; 0.88: 10 Var)



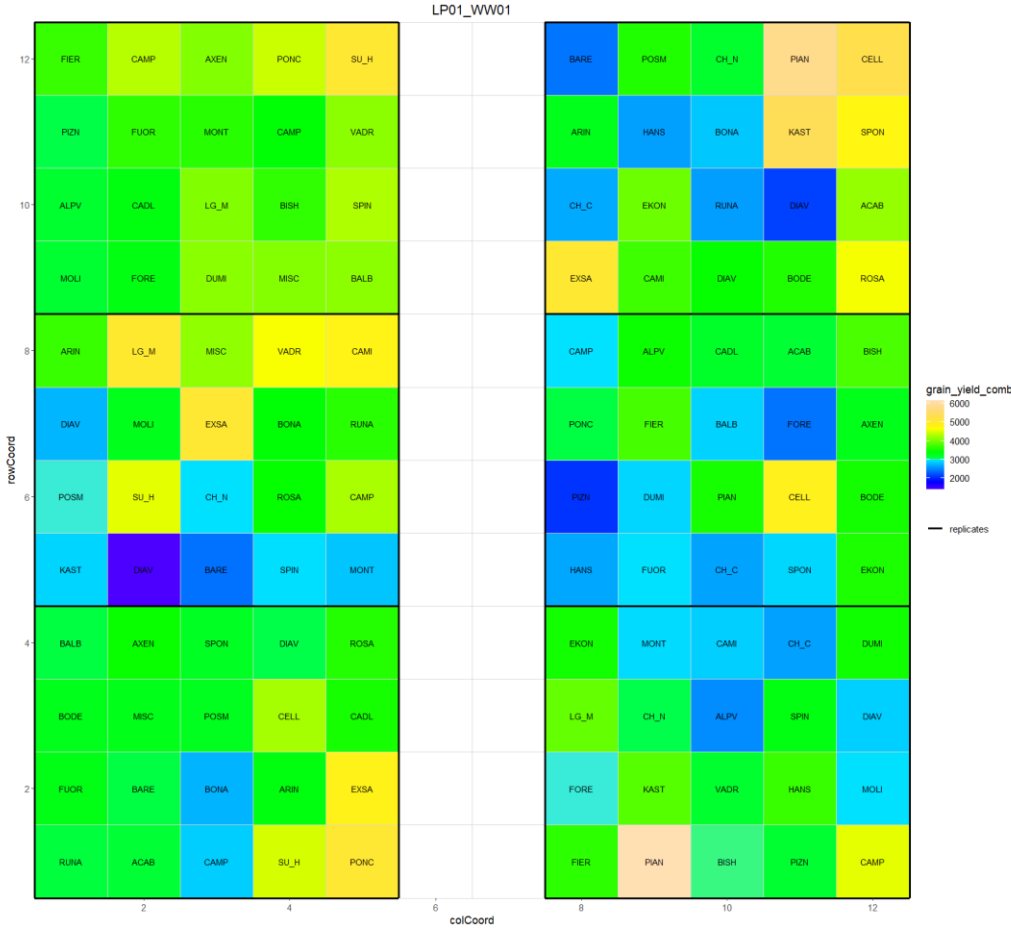


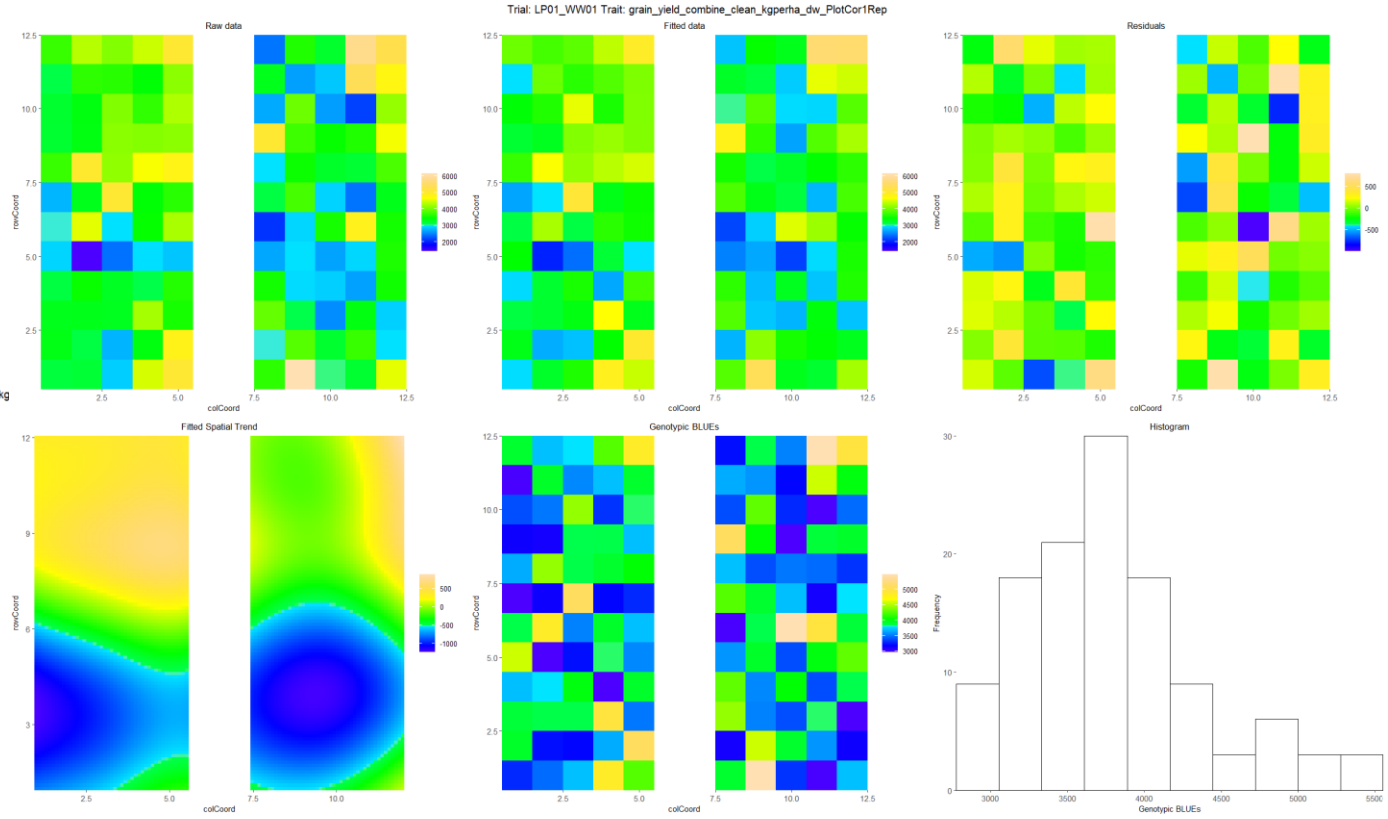
Conventional N – 2023 – h2 = 0.89 (0.91: without plot cor; 0.94: 10 Var)



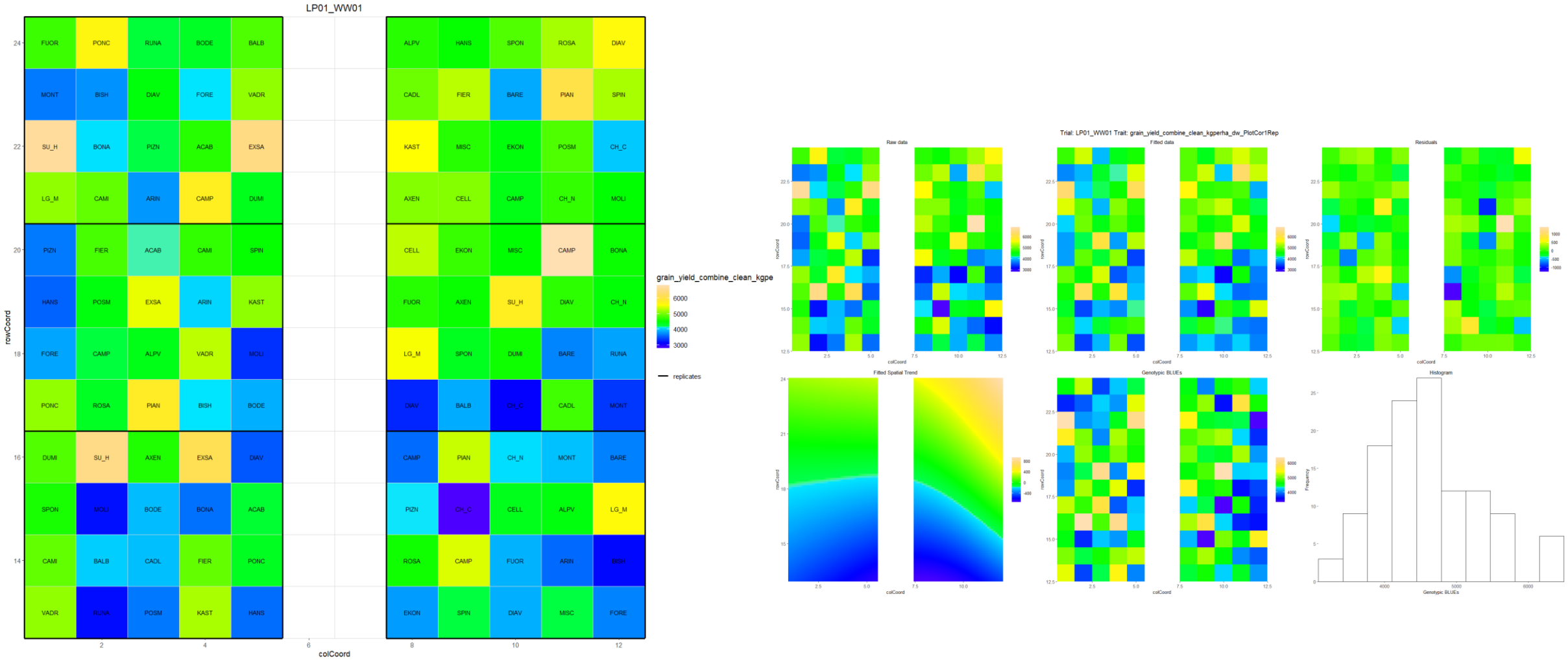


N0 – 2024 – h2 = 0.84 (0.87: without plot cor; 0.85: 10 Var)

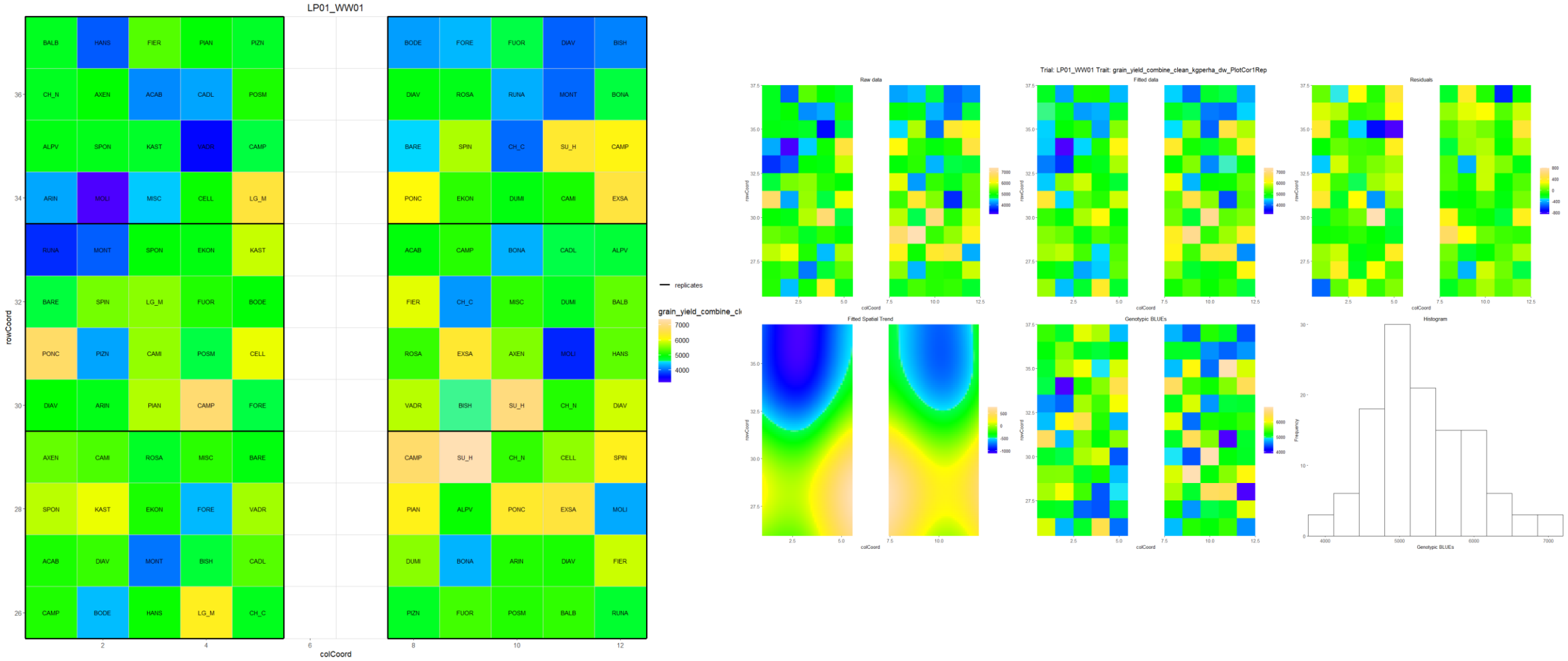




N reduced– 2024 – h2 = 0.94 (0.93: without plot cor; 0.91: 10 Var)

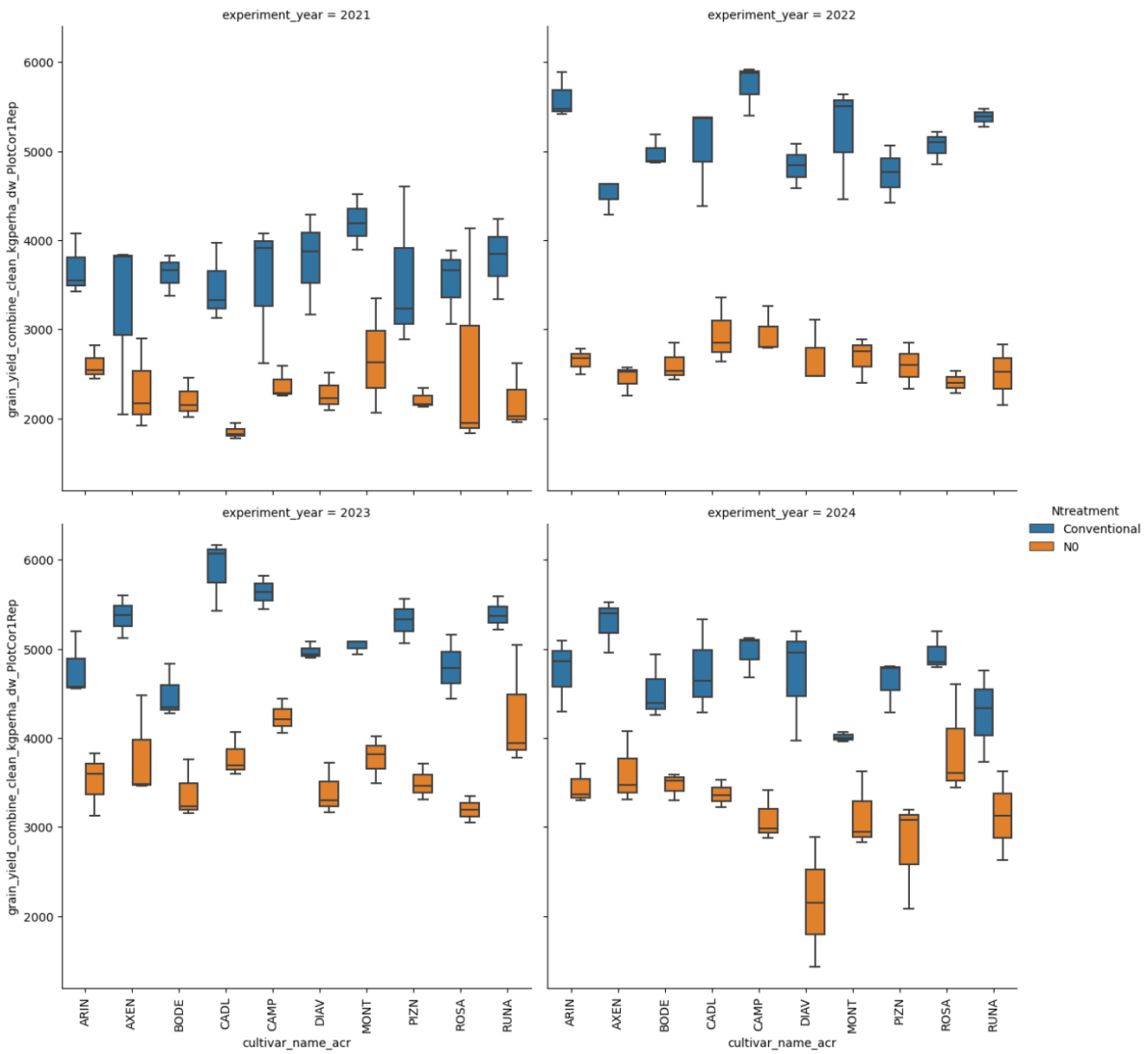


Conventional N – 2024 – h2 = 0.94 (0.91: without plot cor; 0.98: 10 Var)

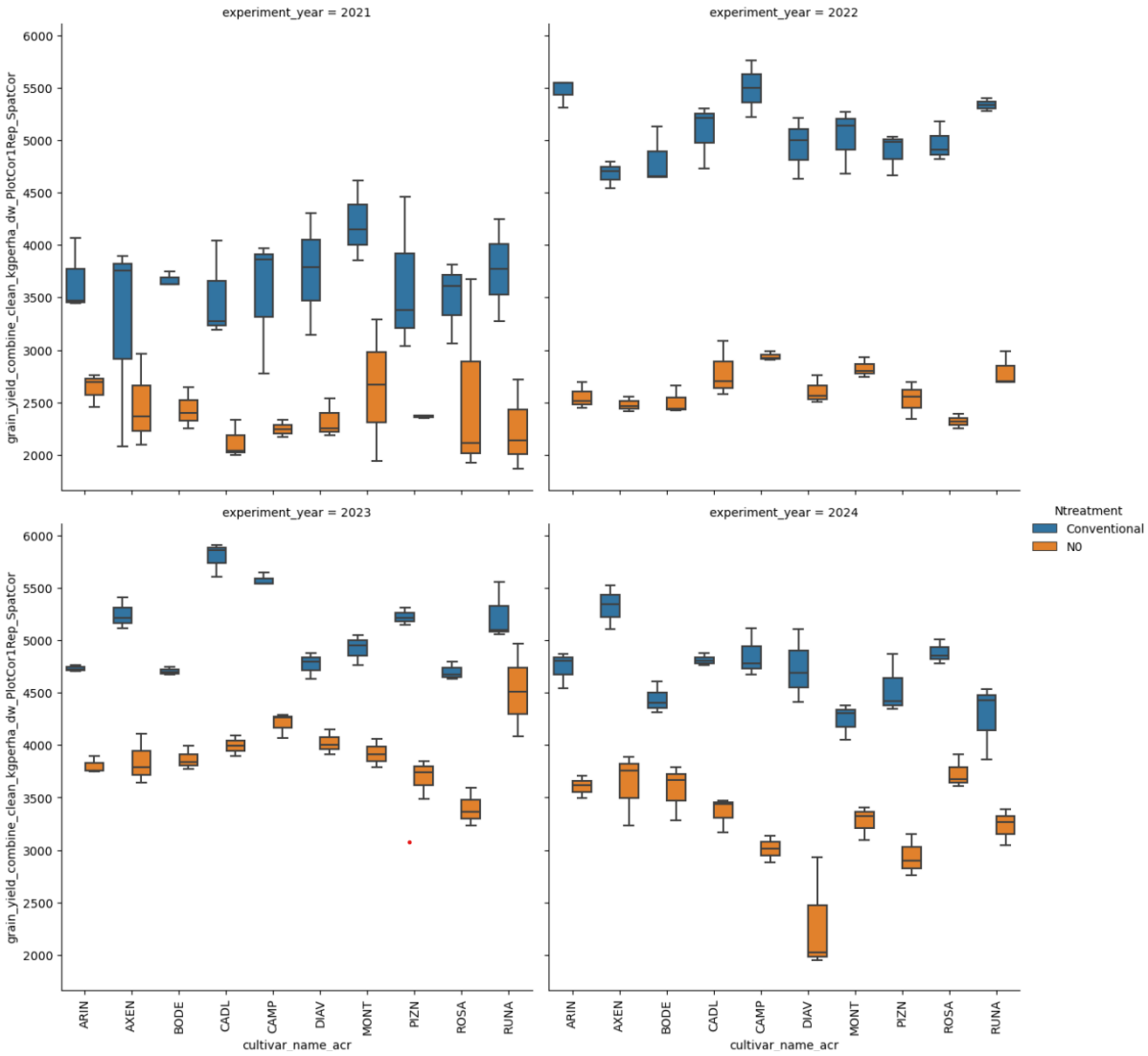


Impact of spatial correction over years

Before correction



After correction



Impact of spatial correction over years

Before correction

Mixed Linear Model Regression Results

Model:	MixedLM	Dependent Variable:	grain_yield_combine_clean_kgperha_dw_PlotCor1Rep
No. Observations:	240	Method:	REML
No. Groups:	4	Scale:	225366.5953
Min. group size:	60	Log-Likelihood:	-1777.0535
Max. group size:	60	Converged:	Yes
Mean group size:	60.0		

	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
Intercept	3459.534	1118.269	3.094	0.002	1267.768	5651.301
cultivar_name_acr[T.AXEN]	-51.542	137.042	-0.376	0.707	-320.140	217.056
cultivar_name_acr[T.BODE]	-218.613	137.042	-1.595	0.111	-487.210	49.985
cultivar_name_acr[T.CADL]	10.955	137.042	0.080	0.936	-257.643	279.553
cultivar_name_acr[T.CAMP]	185.972	137.042	1.357	0.175	-82.626	454.570
cultivar_name_acr[T.DIAV]	-277.565	137.042	-2.025	0.043	-546.163	-8.968
cultivar_name_acr[T.MONT]	-39.152	137.042	-0.286	0.775	-307.749	229.446
cultivar_name_acr[T.PIZN]	-209.978	137.042	-1.532	0.125	-478.575	58.620
cultivar_name_acr[T.ROSA]	-71.461	137.042	-0.521	0.602	-340.059	197.137
cultivar_name_acr[T.RUNA]	-12.474	137.042	-0.091	0.927	-281.072	256.123
Group Var	2038305.579	6673.745				
Group x Ntreatment[T.N0] Cov	-2267175.585	5328.917				
Ntreatment[T.N0] Var	3019187.484	4559.434				

After correction

Mixed Linear Model Regression Results

Model:	MixedLM	Dependent Variable:	grain_yield_combine_clean_kgperha_dw_PlotCor1Rep_SpatCor
No. Observations:	240	Method:	REML
No. Groups:	4	Scale:	147767.2230
Min. group size:	60	Log-Likelihood:	-1729.9127
Max. group size:	60	Converged:	Yes
Mean group size:	60.0		

	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
Intercept	3921.850	988.213	3.969	0.000	1984.989	5858.712
cultivar_name_acr[T.AXEN]	-35.865	110.968	-0.323	0.747	-253.359	181.628
cultivar_name_acr[T.BODE]	-148.730	110.968	-1.340	0.180	-366.224	68.763
cultivar_name_acr[T.CADL]	32.127	110.968	0.290	0.772	-185.367	249.621
cultivar_name_acr[T.CAMP]	82.481	110.968	0.743	0.457	-135.012	299.975
cultivar_name_acr[T.DIAV]	-217.925	110.968	-1.964	0.050	-435.419	-0.432
cultivar_name_acr[T.MONT]	-17.973	110.968	-0.162	0.871	-235.467	199.521
cultivar_name_acr[T.PIZN]	-173.911	110.968	-1.567	0.117	-391.405	43.582
cultivar_name_acr[T.ROSA]	-141.406	110.968	-1.274	0.203	-358.899	76.088
cultivar_name_acr[T.RUNA]	25.592	110.968	0.231	0.818	-191.902	243.086
Group Var	1011207.138	4337.099				
Group x Ntreatment[T.N0] Cov	-1310812.732	4861.578				
Ntreatment[T.N0] Var	2696785.104	5015.576				

Impact of spatial correction over years: N0

Before correction

Mixed Linear Model Regression Results

Model:	MixedLM	Dependent Variable:	grain_yield_combine_clean_kgperha_dw_PlotCor1Rep
No. Observations:	120	Method:	REML
No. Groups:	4	Scale:	216423.5738
Min. group size:	30	Log-Likelihood:	-850.0383
Max. group size:	30	Converged:	Yes
Mean group size:	30.0		

	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
Intercept	3058.094	325.088	9.407	0.000	2420.932	3695.255
cultivar_name_acr[T.AXEN]	-5.775	189.923	-0.030	0.976	-378.016	366.467
cultivar_name_acr[T.BODE]	-142.335	189.923	-0.749	0.454	-514.577	229.906
cultivar_name_acr[T.CADL]	-68.870	189.923	-0.363	0.717	-441.111	303.372
cultivar_name_acr[T.CAMP]	107.142	189.923	0.564	0.573	-265.099	479.384
cultivar_name_acr[T.DIAV]	-428.236	189.923	-2.255	0.024	-800.477	-55.994
cultivar_name_acr[T.MONT]	9.907	189.923	0.052	0.958	-362.335	382.148
cultivar_name_acr[T.PIZN]	-286.609	189.923	-1.509	0.131	-658.850	85.633
cultivar_name_acr[T.ROSA]	-26.005	189.923	-0.137	0.891	-398.246	346.237
cultivar_name_acr[T.RUNA]	-37.297	189.923	-0.196	0.844	-409.539	334.944
Group Var	350588.660	636.544				

After correction

Mixed Linear Model Regression Results

Model:	MixedLM	Dependent Variable:	grain_yield_combine_clean_kgperha_dw_PlotCor1Rep_SpatCor
No. Observations:	120	Method:	REML
No. Groups:	4	Scale:	130522.5070
Min. group size:	30	Log-Likelihood:	-823.3860
Max. group size:	30	Converged:	Yes
Mean group size:	30.0		

	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
Intercept	3149.505	356.019	8.846	0.000	2451.720	3847.289
cultivar_name_acr[T.AXEN]	-43.261	147.492	-0.293	0.769	-332.339	245.817
cultivar_name_acr[T.BODE]	-52.636	147.492	-0.357	0.721	-341.714	236.442
cultivar_name_acr[T.CADL]	-82.682	147.492	-0.561	0.575	-371.760	206.396
cultivar_name_acr[T.CAMP]	-48.653	147.492	-0.330	0.742	-337.731	240.426
cultivar_name_acr[T.DIAV]	-335.577	147.492	-2.275	0.023	-624.656	-46.499
cultivar_name_acr[T.MONT]	13.985	147.492	0.095	0.924	-275.093	303.063
cultivar_name_acr[T.PIZN]	-268.208	147.492	-1.818	0.069	-557.287	20.870
cultivar_name_acr[T.ROSA]	-143.661	147.492	-0.974	0.330	-432.739	145.417
cultivar_name_acr[T.RUNA]	47.887	147.492	0.325	0.745	-241.191	336.965
Group Var	463490.228	1071.578				

Impact of spatial correction over years: conventional N

Before correction

Mixed Linear Model Regression Results

Model:	MixedLM	Dependent Variable:	grain_yield_combine_clean_kgperha_dw_PlotCor1Rep
No. Observations:	120	Method:	REML
No. Groups:	4	Scale:	241966.9754
Min. group size:	30	Log-Likelihood:	-856.4969
Max. group size:	30	Converged:	Yes
Mean group size:	30.0		

	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
Intercept	4700.548	377.036	12.467	0.000	3961.571	5439.524
cultivar_name_acr[T.AXEN]	-97.309	200.818	-0.485	0.628	-490.905	296.287
cultivar_name_acr[T.BODE]	-294.890	200.818	-1.468	0.142	-688.486	98.706
cultivar_name_acr[T.CADL]	90.780	200.818	0.452	0.651	-302.816	484.376
cultivar_name_acr[T.CAMP]	264.802	200.818	1.319	0.187	-128.794	658.397
cultivar_name_acr[T.DIAV]	-126.895	200.818	-0.632	0.527	-520.490	266.701
cultivar_name_acr[T.MONT]	-88.210	200.818	-0.439	0.660	-481.806	305.386
cultivar_name_acr[T.PIZN]	-133.347	200.818	-0.664	0.507	-526.943	260.249
cultivar_name_acr[T.ROSA]	-116.917	200.818	-0.582	0.560	-510.513	276.679
cultivar_name_acr[T.RUNA]	12.348	200.818	0.061	0.951	-381.248	405.944
Group Var	487967.949	834.382				

After correction

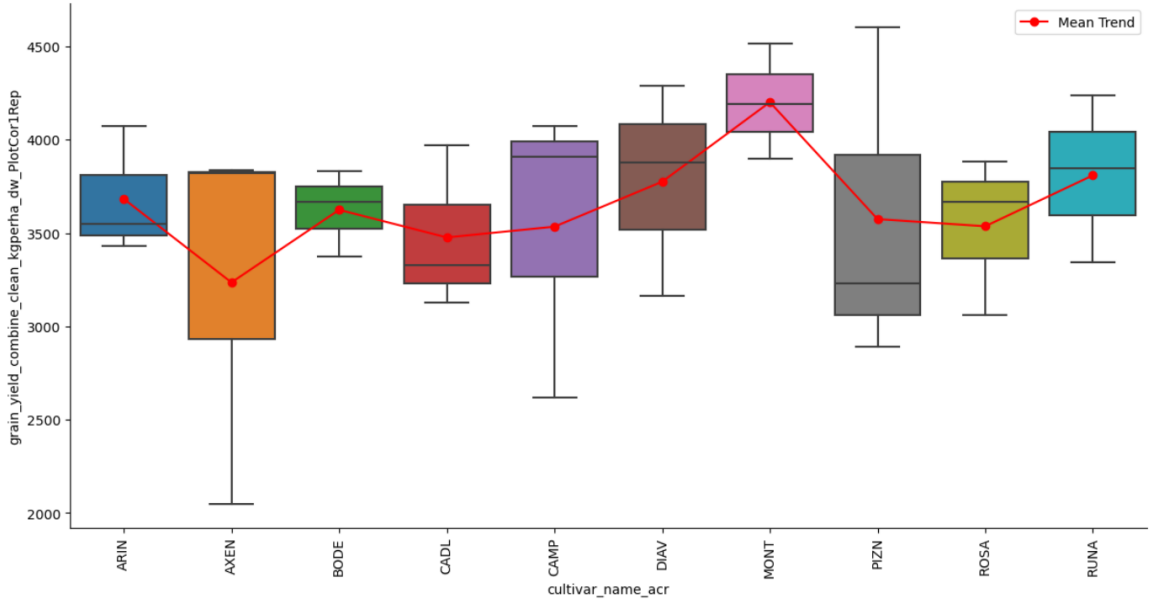
Mixed Linear Model Regression Results

Model:	MixedLM	Dependent Variable:	grain_yield_combine_clean_kgperha_dw_PlotCor1Rep_SpatCor
No. Observations:	120	Method:	REML
No. Groups:	4	Scale:	165352.6236
Min. group size:	30	Log-Likelihood:	-836.0159
Max. group size:	30	Converged:	Yes
Mean group size:	30.0		

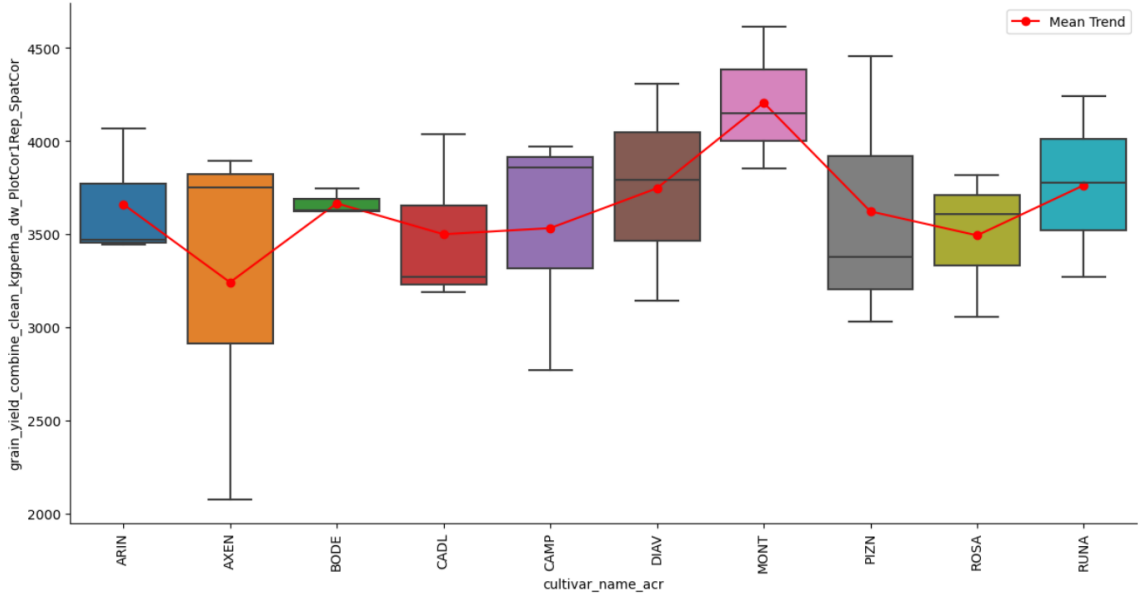
	Coef.	Std.Err.	z	P>|z|	[0.025	0.975]
Intercept	4650.747	357.007	13.027	0.000	3951.025	5350.468
cultivar_name_acr[T.AXEN]	-28.470	166.008	-0.171	0.864	-353.840	296.900
cultivar_name_acr[T.BODE]	-244.825	166.008	-1.475	0.140	-570.195	80.546
cultivar_name_acr[T.CADL]	146.936	166.008	0.885	0.376	-178.434	472.307
cultivar_name_acr[T.CAMP]	213.615	166.008	1.287	0.198	-111.755	538.986
cultivar_name_acr[T.DIAV]	-100.273	166.008	-0.604	0.546	-425.643	225.097
cultivar_name_acr[T.MONT]	-49.931	166.008	-0.301	0.764	-375.301	275.440
cultivar_name_acr[T.PIZN]	-79.614	166.008	-0.480	0.632	-404.984	245.756
cultivar_name_acr[T.ROSA]	-139.150	166.008	-0.838	0.402	-464.521	186.220
cultivar_name_acr[T.RUNA]	3.297	166.008	0.020	0.984	-322.073	328.668
Group Var	454699.527	936.878				

N0 analysis: 2021

Before correction

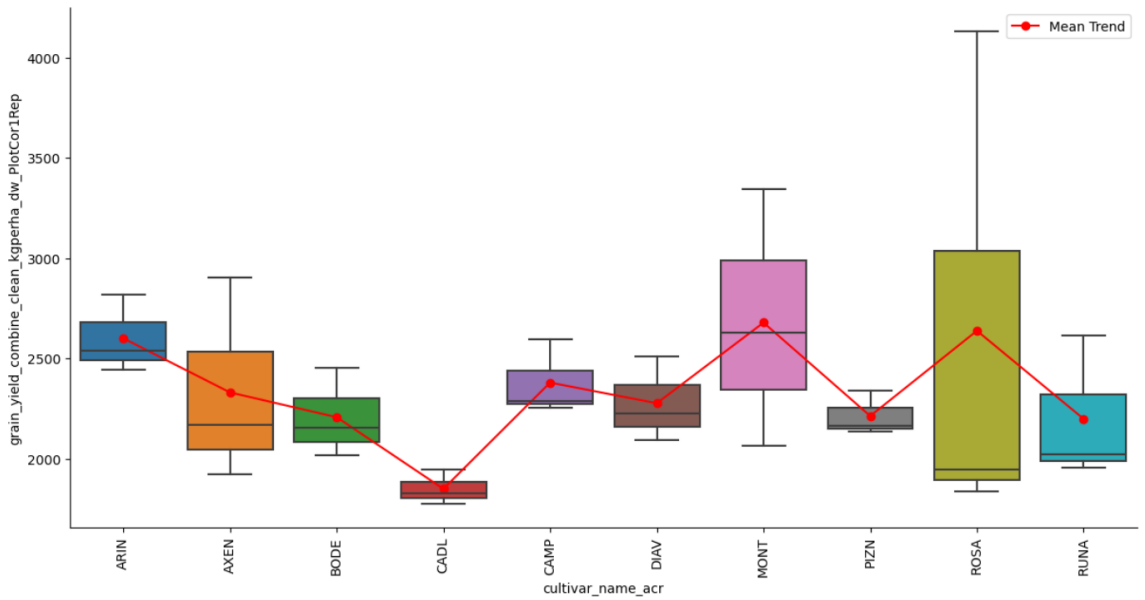


After correction

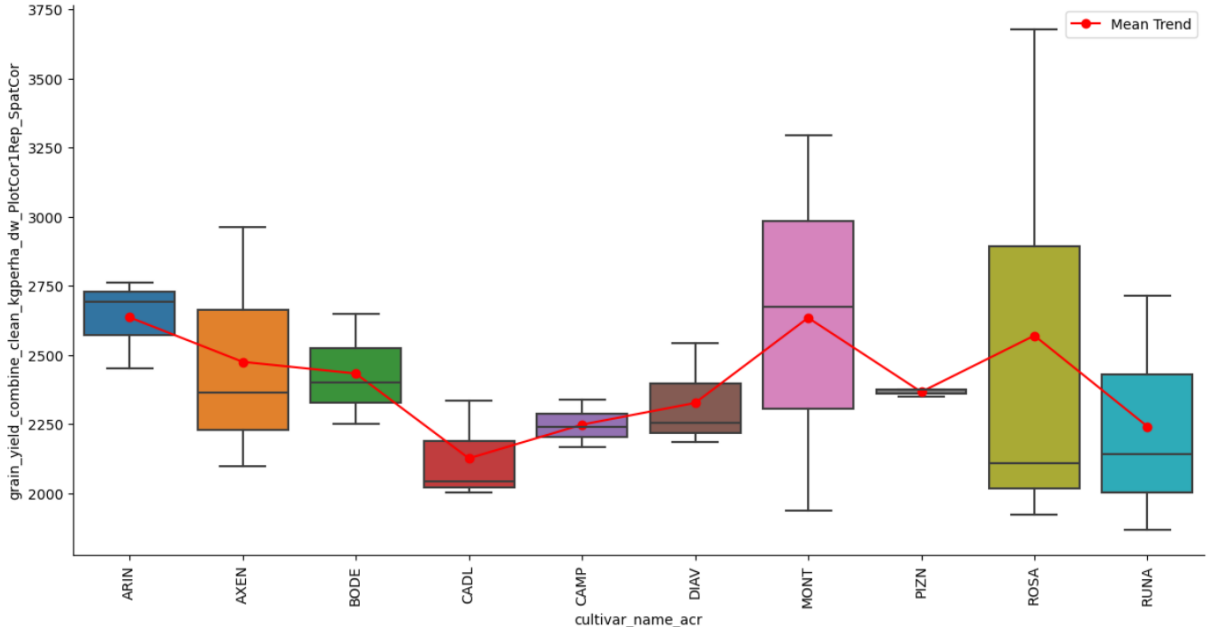


Conventional N analysis: 2021

Before correction

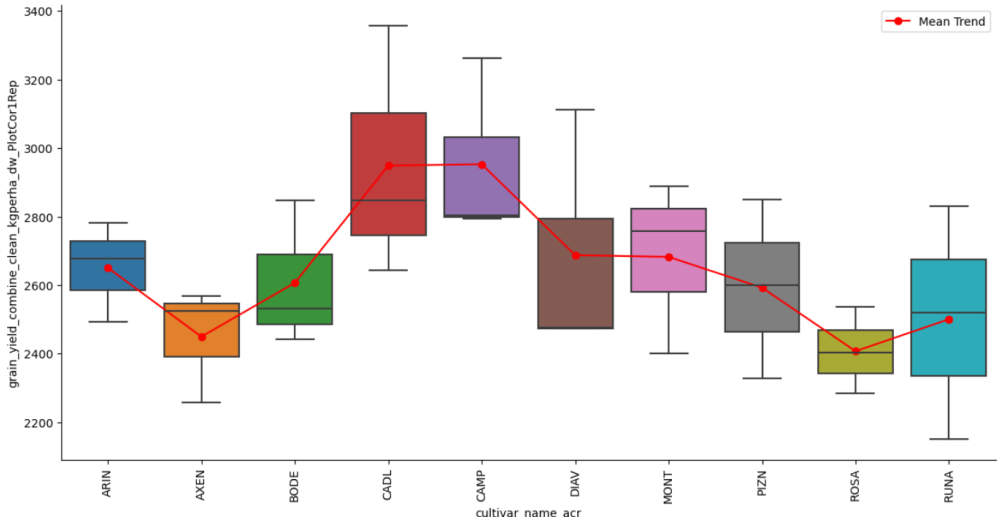


After correction

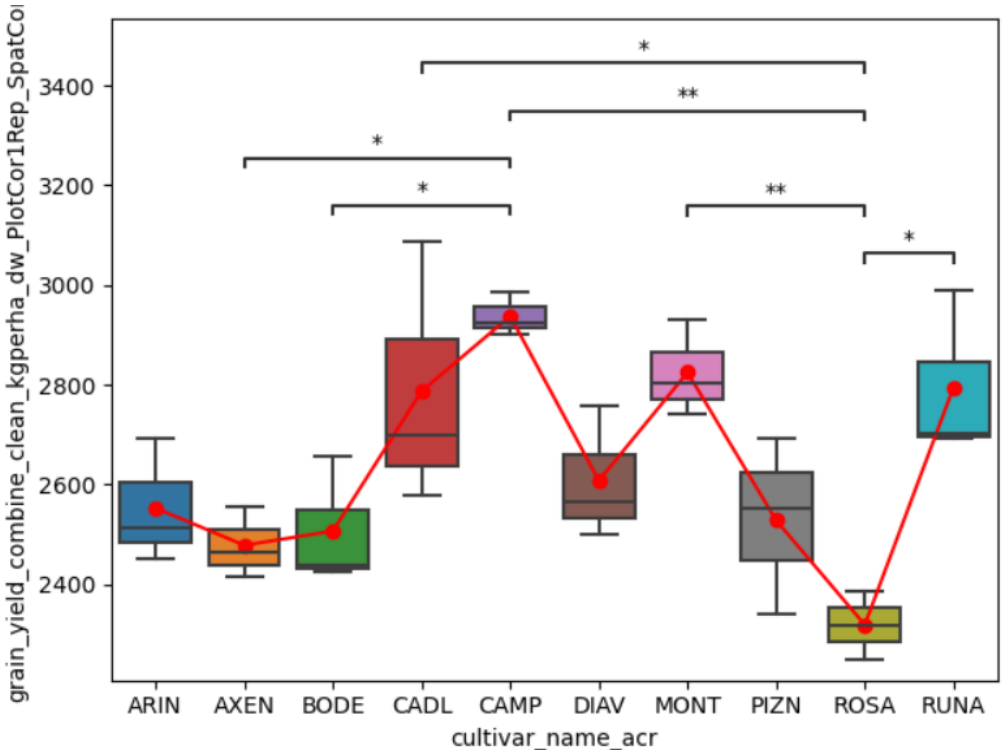


N0 analysis: 2022

Before correction

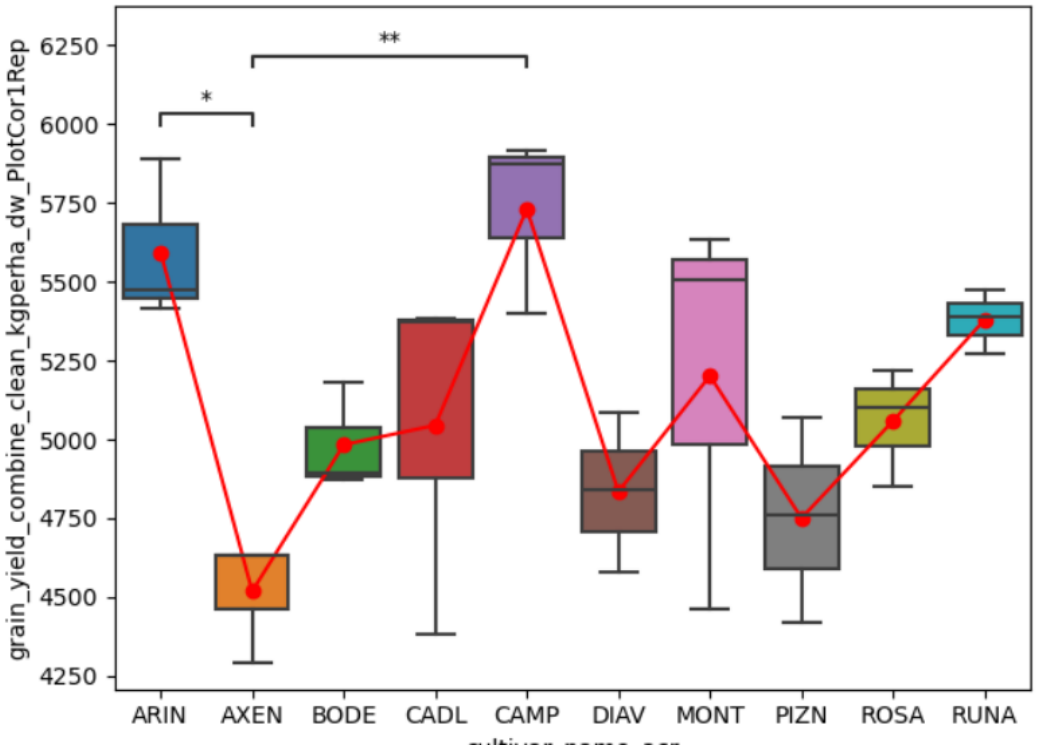


After correction

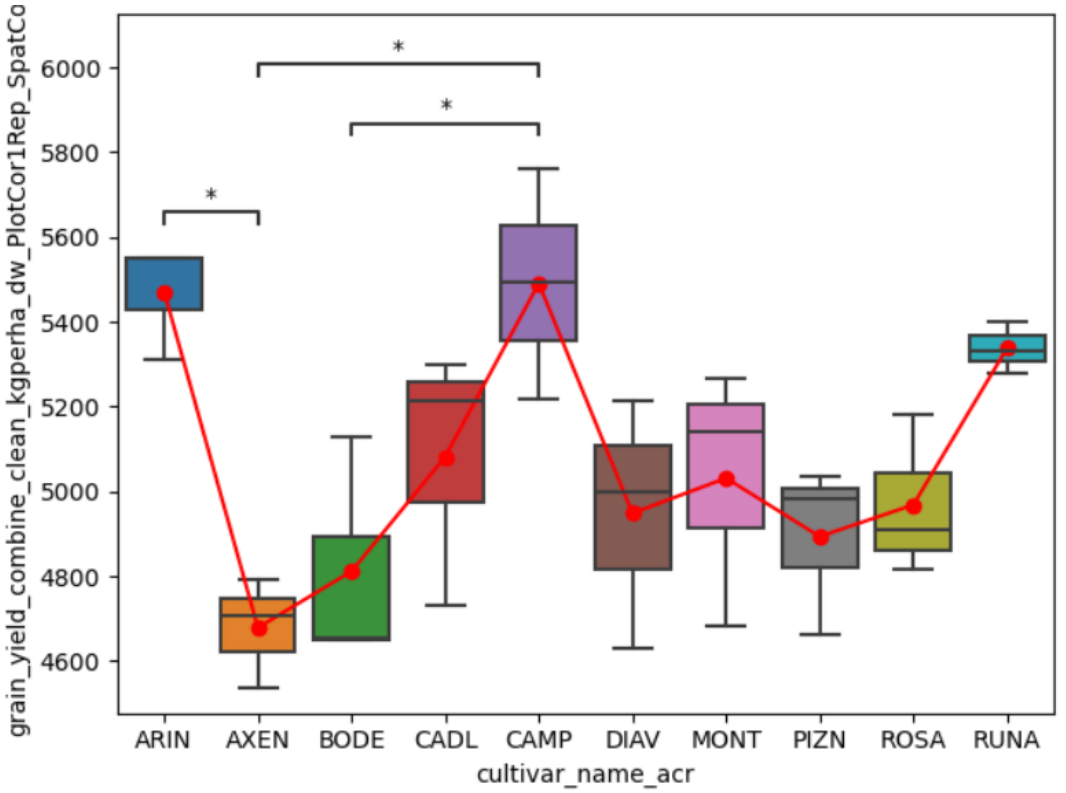


Conventional N analysis: 2022

Before correction

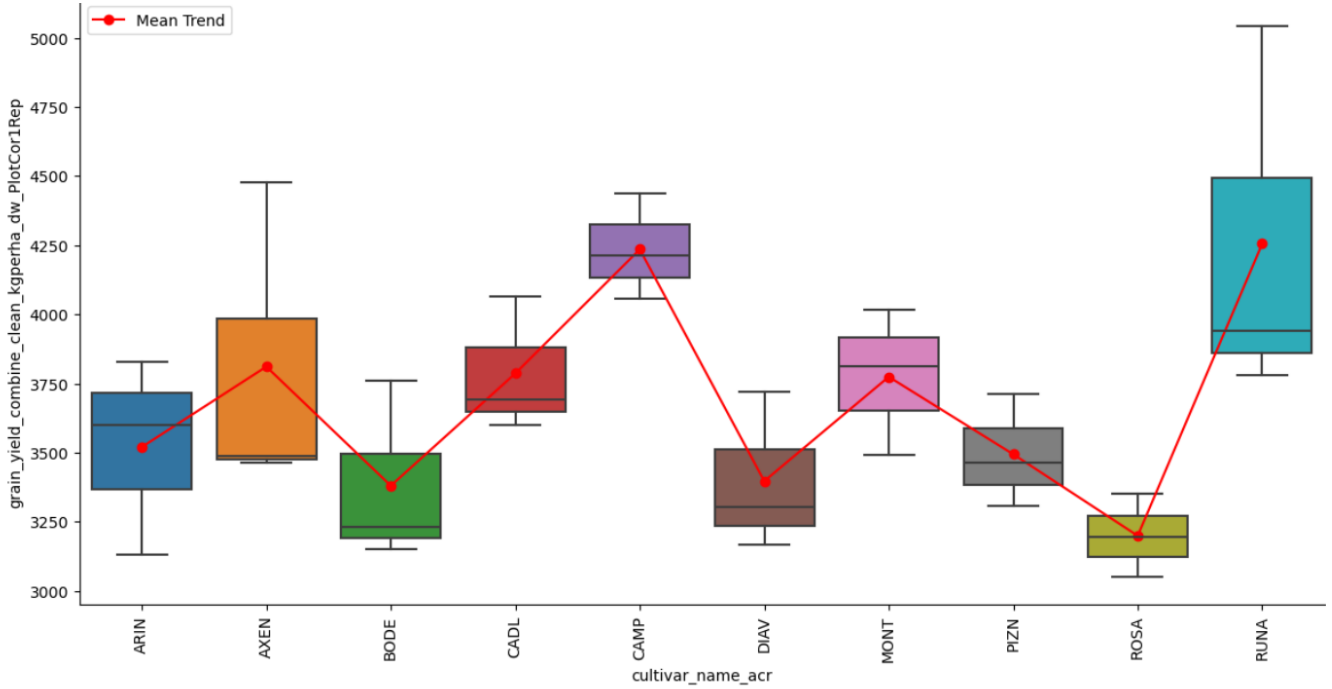


After correction

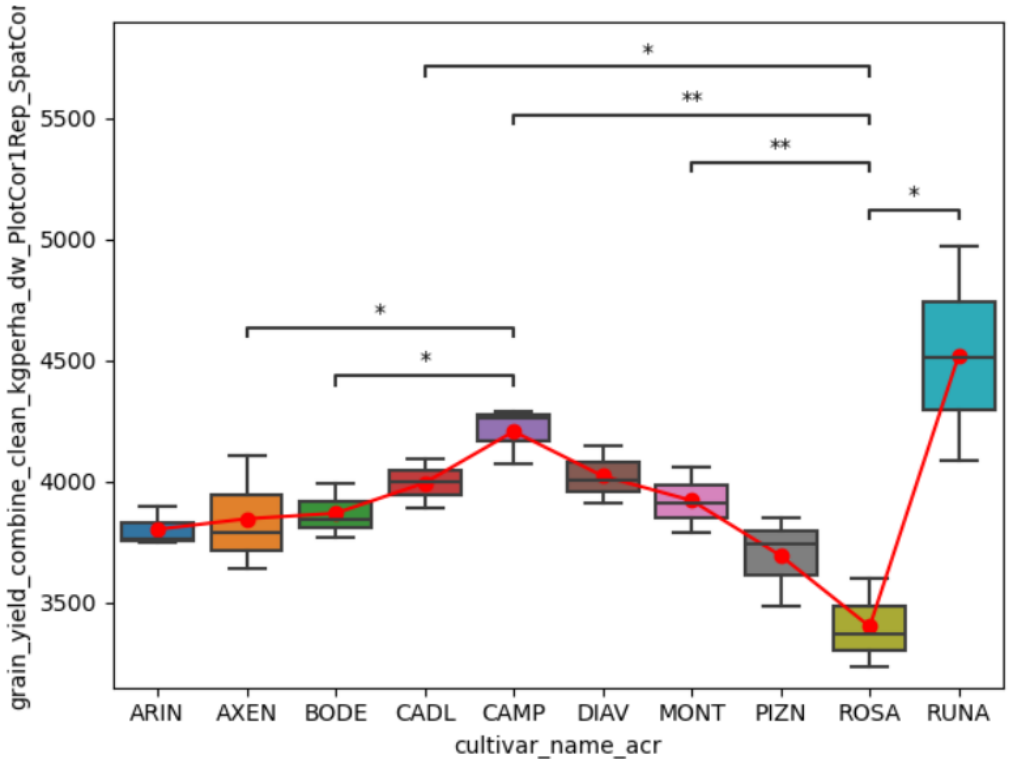


N0 analysis: 2023

Before correction

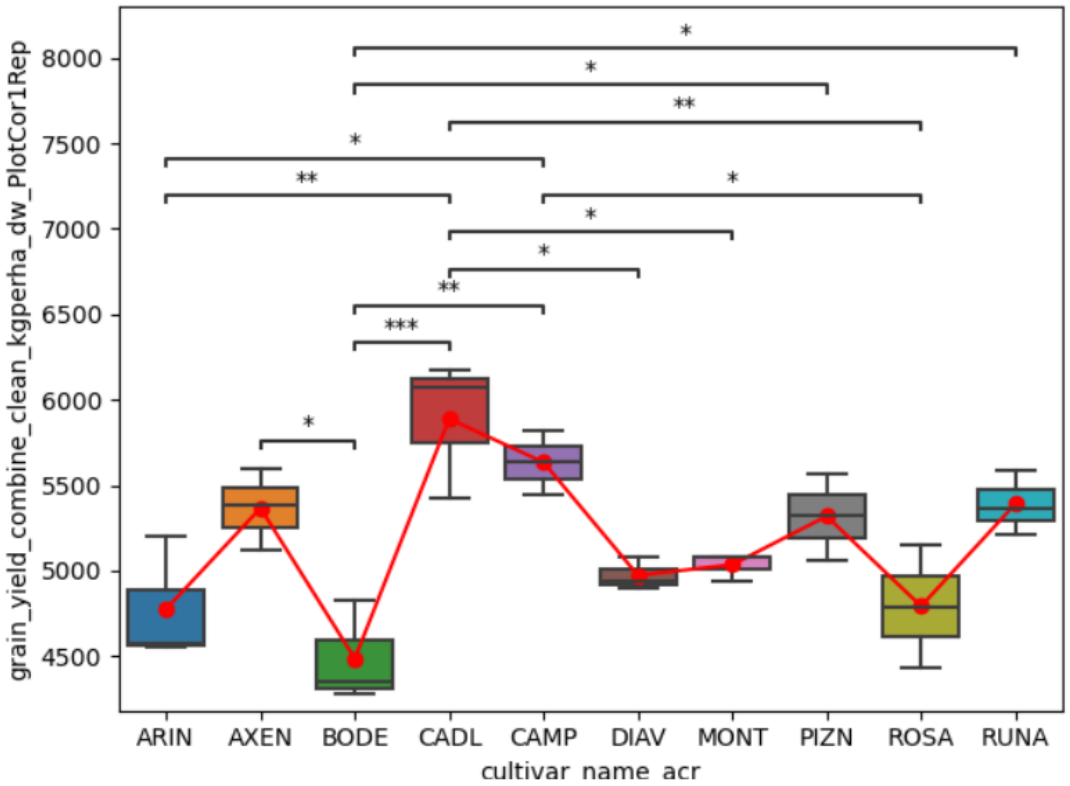


After correction

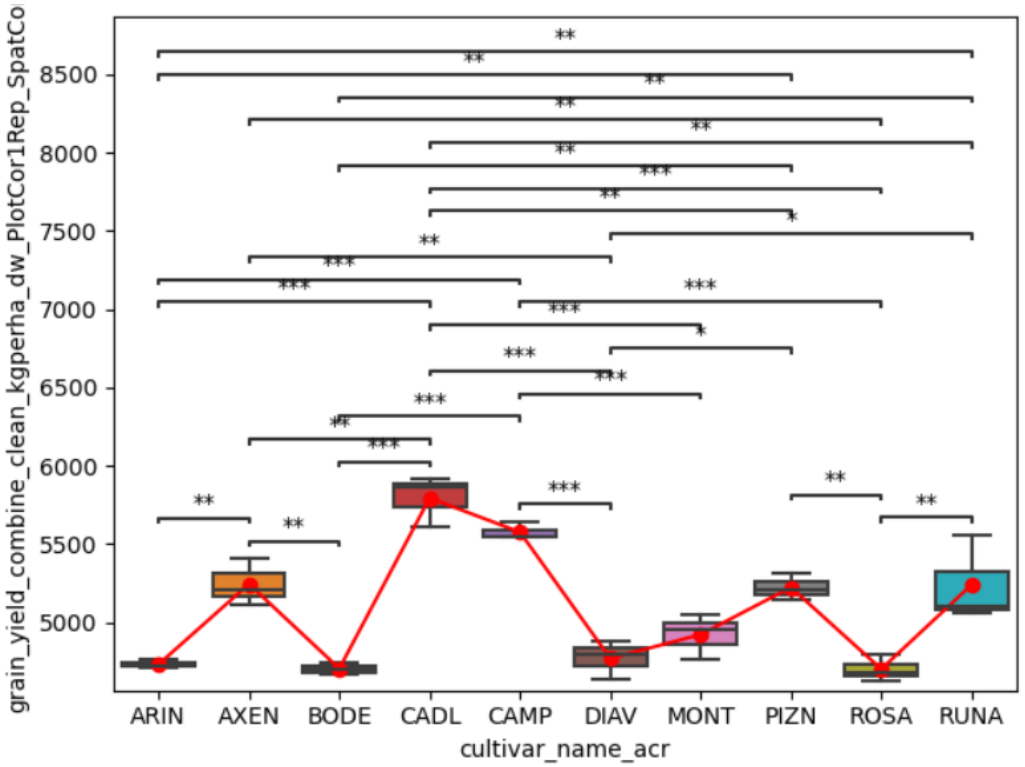


Conventional N analysis: 2023

Before correction

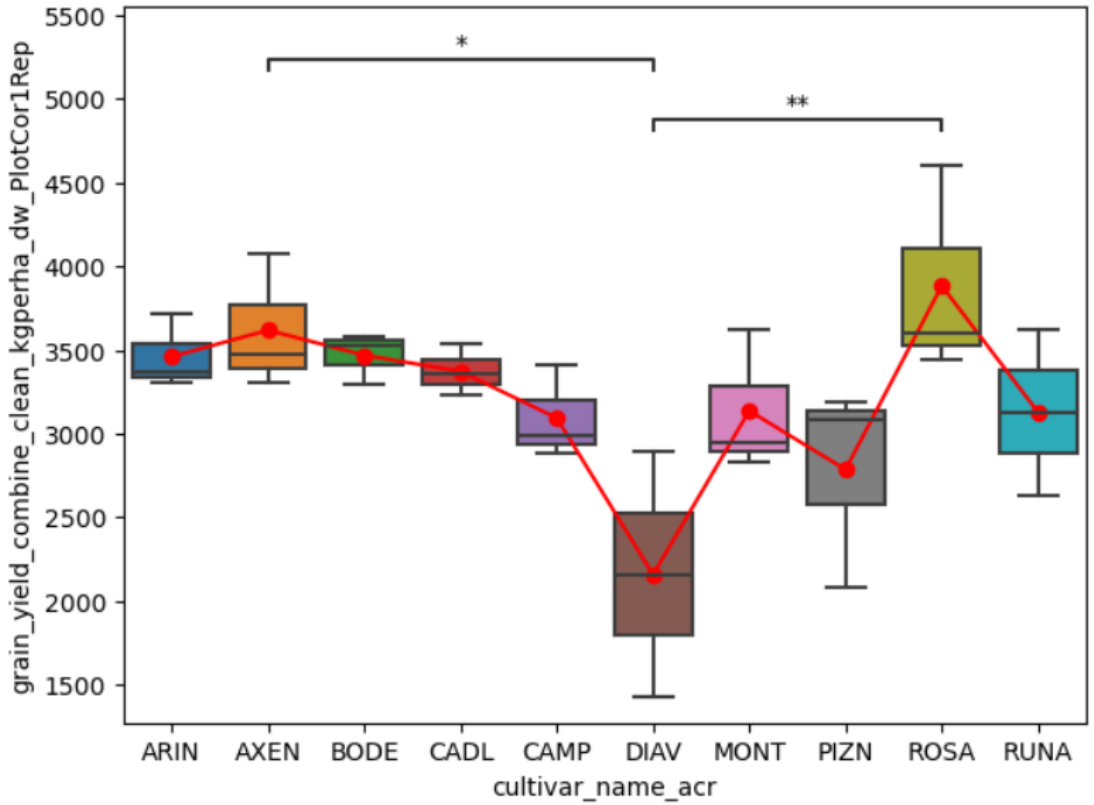


After correction

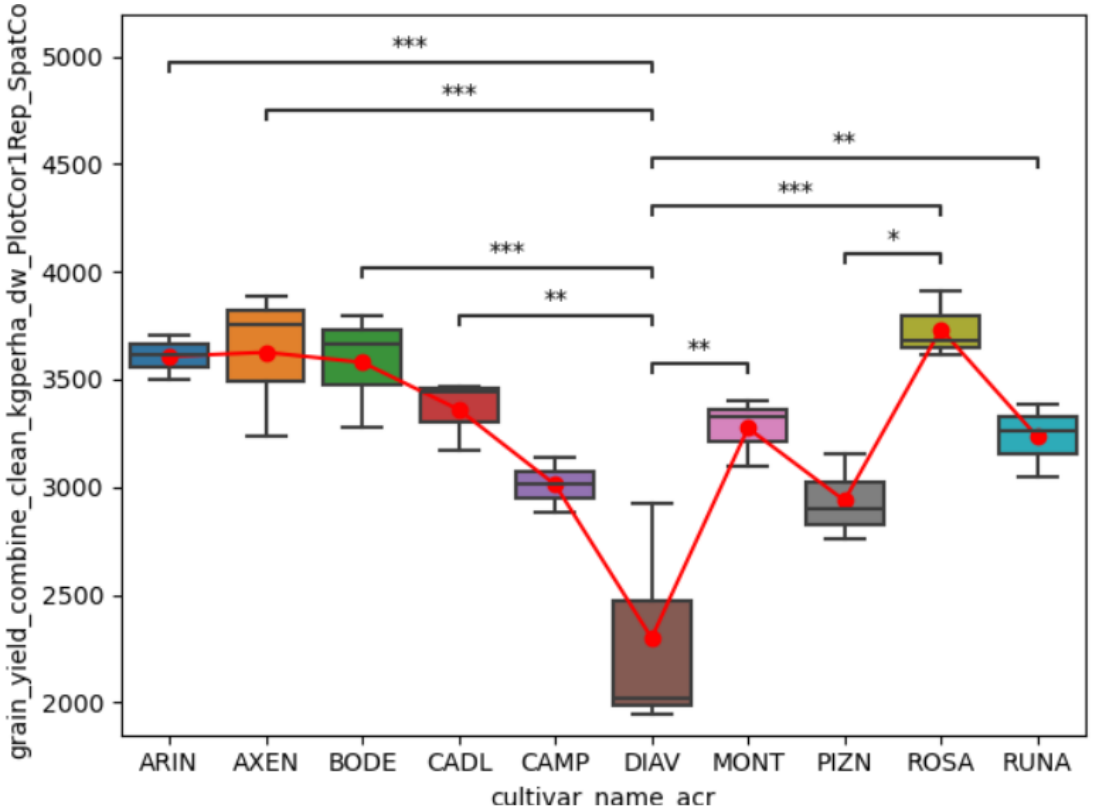


N0 analysis: 2024

Before correction

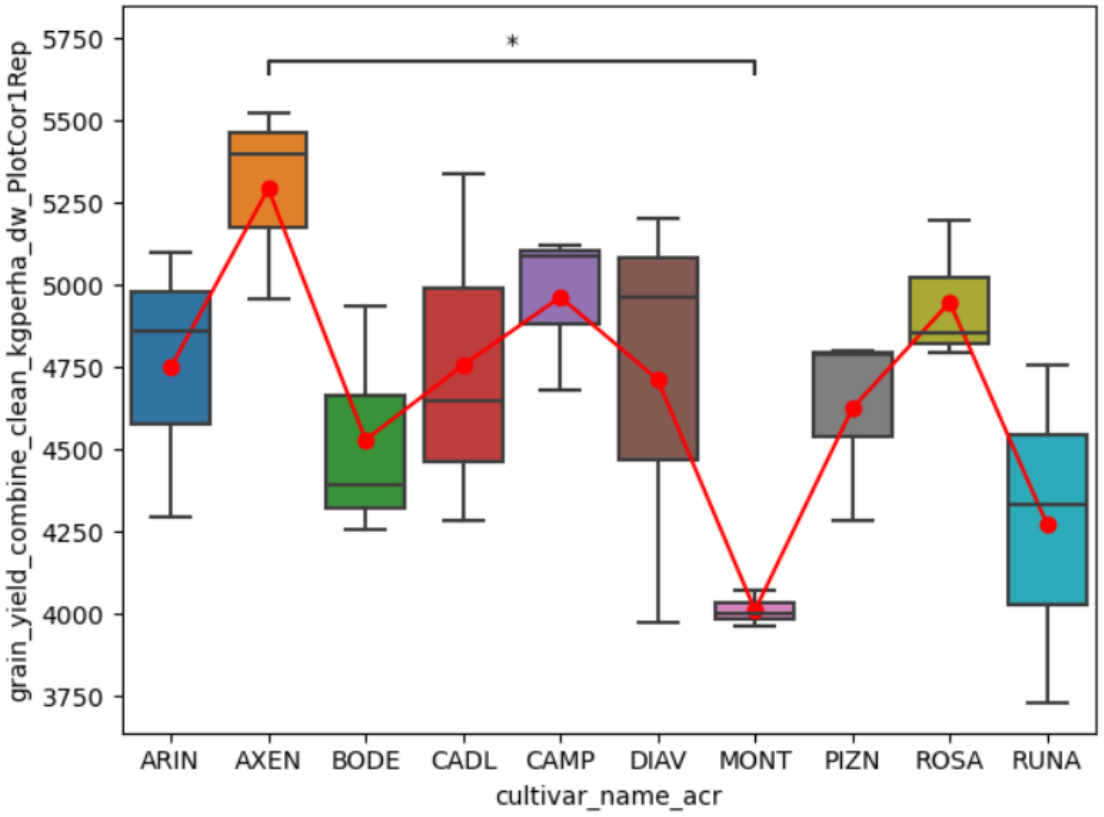


After correction



Conventional N analysis: 2023

Before correction



After correction