

Analysis of Peacock and Rutledge experiments
on growth under cold conditions
 prepared by Jason A. Osborne, October, 2003

The dry weights of a total of $N = 96$ plugs were measured. The experimental factors under investigation are summarized below:

- A: Cultivar ($a = 8$ levels)
- B: Temperature ($b = 3$ levels)
- C: Replication ($c = 6$ levels for each cultivar)

The experiment was a laid out in a completely randomized block design, where plugs from the 8 cultivars were randomized to locations within each block and 3 plugs of each cultivar were randomly assigned to the three temperature treatments (Greenhouse, $-1^{\circ}C$ and $-4^{\circ}C$.)

At the lowest temperature ($-4^{\circ}C$), almost all dryweight measurements were 0 (84 out of 96 measurements). So, it is recommended that these measurements be reported, but not included in the analysis, as this absence of variability constitutes a major violation of assumptions underlying ANOVA.

A mixed model which takes block effects as random is given by

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + S_k + E_{j(ik)}$$

where α_i denote CV effects, β_j denote temperature effects, $(\alpha\beta)_{ij}$ denote CV-by-temperature interaction effects, S_k denote random block effects and E_{ijk} are random error terms. The last two are assumed iid normal with variance components σ_s^2 and σ^2 , respectively.

The analysis of variance summarized in the table below indicates significant cultivar and highly significant temperature effects, with temperature effect differing significantly by cultivar. There was no evidence of any block effect.

The GLM Procedure

Dependent Variable: drywt

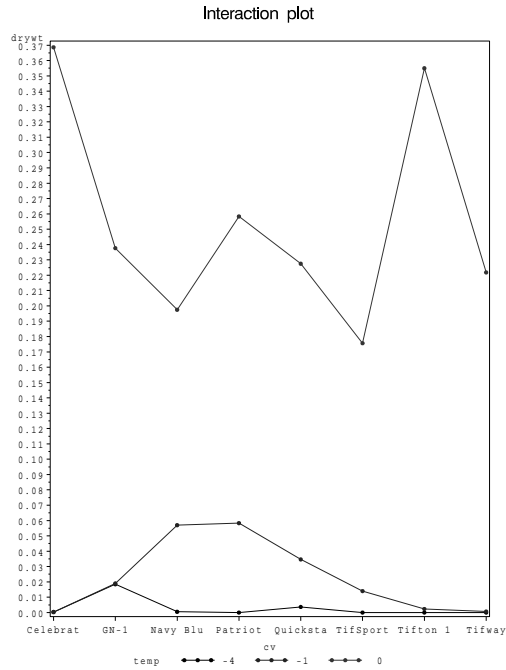
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	20	1.55400092	0.07770005	16.38	<.0001
Error	75	0.35572049	0.00474294		
Corrected Total	95	1.90972141			

R-Square	Coeff Var	Root MSE	drywt Mean
0.813732	49.44600	0.068869	0.139281

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	7	0.08462532	0.01208933	2.55	0.0207
temp	1	1.29154401	1.29154401	272.31	<.0001
cv*temp	7	0.14795824	0.02113689	4.46	0.0003
Rep	5	0.02987334	0.00597467	1.26	0.2903

(Interactions between the block and the treatments were investigated, but none explained any variation in dry weight, so they were not included in the model.)

The interaction plot below indicates the nature of the interaction; it appears that the mean dry weights of some cultivars are not as badly affected by the temperature drop than others.



A table of these means is given below:

cv	temp	drywt LSMEAN	Standard Error	Pr > t	LSMEAN Number
Celebrat	-1	0.00033333	0.02811565	0.9906	1
Celebrat	0	0.36866667	0.02811565	<.0001	2
GN-1	-1	0.01900000	0.02811565	0.5013	3
GN-1	0	0.23766667	0.02811565	<.0001	4
Navy Blu	-1	0.05700000	0.02811565	0.0462	5
Navy Blu	0	0.19750000	0.02811565	<.0001	6
Patriot	-1	0.05833333	0.02811565	0.0414	7
Patriot	0	0.25833333	0.02811565	<.0001	8
Quicksta	-1	0.03466667	0.02811565	0.2214	9
Quicksta	0	0.22750000	0.02811565	<.0001	10
TifSport	-1	0.01400000	0.02811565	0.6200	11
TifSport	0	0.17566667	0.02811565	<.0001	12
Tifton 1	-1	0.00233333	0.02811565	0.9341	13
Tifton 1	0	0.35500000	0.02811565	<.0001	14
Tifway	-1	0.00066667	0.02811565	0.9811	15
Tifway	0	0.22183333	0.02811565	<.0001	16

Differences between the -2^0 measurements and the Greenhouse measurements are considered for each cultivar. These differences are compared, using a Bonferroni correction for the $\binom{8}{2} = 28$ pairwise contrasts. The temperature differences for each cultivar (cv1diff-cv8diff) and contrasts among them are given below. An asterisk denotes a significant difference using experimentwise error rate 0.05.

Dependent Variable: drywt

Parameter	Estimate	Standard Error	t Value	Pr > t
cv1diff	0.36833333	0.03976154	9.26	<.0001*
cv2diff	0.21866667	0.03976154	5.50	<.0001*
cv3diff	0.14050000	0.03976154	3.53	0.0007*
cv4diff	0.20000000	0.03976154	5.03	<.0001*
cv5diff	0.19283333	0.03976154	4.85	<.0001*
cv6diff	0.16166667	0.03976154	4.07	0.0001*
cv7diff	0.35266667	0.03976154	8.87	<.0001*
cv8diff	0.22116667	0.03976154	5.56	<.0001*
cv2diff - cv1diff	-0.14966667	0.05623131	-2.66	0.0095
cv3diff - cv1diff	-0.22783333	0.05623131	-4.05	0.0001*
cv4diff - cv1diff	-0.16833333	0.05623131	-2.99	0.0037
cv5diff - cv1diff	-0.17550000	0.05623131	-3.12	0.0026
cv6diff - cv1diff	-0.20666667	0.05623131	-3.68	0.0004*
cv7diff - cv1diff	-0.01566667	0.05623131	-0.28	0.7813
cv8diff - cv1diff	-0.14716667	0.05623131	-2.62	0.0107
cv3diff - cv2diff	-0.07816667	0.05623131	-1.39	0.1686
cv4diff - cv2diff	-0.01866667	0.05623131	-0.33	0.7408
cv5diff - cv2diff	-0.02583333	0.05623131	-0.46	0.6473
cv6diff - cv2diff	-0.05700000	0.05623131	-1.01	0.3140
cv7diff - cv2diff	0.13400000	0.05623131	2.38	0.0197
cv8diff - cv2diff	0.00250000	0.05623131	0.04	0.9647
cv4diff - cv3diff	0.05950000	0.05623131	1.06	0.2934
cv5diff - cv3diff	0.05233333	0.05623131	0.93	0.3550
cv6diff - cv3diff	0.02116667	0.05623131	0.38	0.7077
cv7diff - cv3diff	0.21216667	0.05623131	3.77	0.0003*
cv8diff - cv3diff	0.08066667	0.05623131	1.43	0.1556
cv5diff - cv4diff	-0.00716667	0.05623131	-0.13	0.8989
cv6diff - cv4diff	-0.03833333	0.05623131	-0.68	0.4975
cv7diff - cv4diff	0.15266667	0.05623131	2.71	0.0082
cv8diff - cv4diff	0.02116667	0.05623131	0.38	0.7077
cv6diff - cv5diff	-0.03116667	0.05623131	-0.55	0.5811
cv7diff - cv5diff	0.15983333	0.05623131	2.84	0.0058
cv8diff - cv5diff	0.02833333	0.05623131	0.50	0.6158
cv7diff - cv6diff	0.19100000	0.05623131	3.40	0.0011*
cv8diff - cv6diff	0.05950000	0.05623131	1.06	0.2934
cv8diff - cv7diff	-0.13150000	0.05623131	-2.34	0.0220