Some Messy Experimental Designs

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Some Factors to Consider when Planning an Experiment

Question: Why should experimenters and/or researchers be interested in statistics?

Some Factors to Consider when Planning an Experiment

Question: Why should experimenters and/or researchers be interested in statistics?

Answer: Reliable facts are necessary to build a correct science or theory. Reliable facts are often not easy to come by. Statistics and the Design of Experiments are concerned with procedures for obtaining reliable facts.

Three Phases of Experimentation

1. Formulating the Experiment
2. Designing the Experiment
3. Analyzing the Experiment

Three Phases of Experimentation

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2. Designing the Experiment
3. Analyzing the Experiment

For which phase is a statistician most useful?

Formulating the Experiment

a) What problems are to be solved?

b) What is the experiment intended to show?
 What are the hypotheses?

c) What variables are going to be measured?

d) What factors are going to be varied?
What is the treatment structure?

e) Is the objective to show things are different or to show things are the same?

Designing the Experiment

a) What are the experimental units?
b) Are missing values likely? Why or why not?
c) How many experimental units should be used?
How many replications?
d) How should the data be collected?
e) Are there ways that the experimental units can be blocked?
f) Should the experiment be done according to an experimental plan?
g) How should the randomization of experimental units to treatments be done?
h) What assumptions are reasonable?

Designing the Experiment

i) How accurate is the experiment likely to be?
j) What models are likely to be most meaningful for the experiment?
k) What are problems that might occur?
l) Can the data that is collected be analyzed?
m) Will the data answer the important questions?
n) Are there independent replications?

Remarks:

"Convenience" often destroys many experiments or limits the amount of information that can be gained from an experiment.

Convenience is often an enemy of good experimental design.

Analyzing the Experiment

a) What statistical tests are likely to be appropriate?

b) Can the design be analyzed by a statistical package? If so how should the data be organized for computer entry?

c) Will one be able to communicate the results to others?

d) Are the assumptions made likely to be satisfied?
Can they be tested?
Can the data still be analyzed if the assumptions are not satisfied?

Selecting a Good Design

a) Keep the design somewhat simple.

b) Use blocking effectively. Smaller block size designs are more efficient than larger block size designs. Incomplete block designs are usually more efficient than complete block designs.

c) Make sure the design can be analyzed. Can it still be analyzed if there is missing data?

Examples of Simple Designs

- Completely Randomized Designs (CRDs)
- Randomized Complete Block Designs (RCBDs)
- Latin Square Designs
- Crossover Designs
- Graeco-Latin Square Designs
- Incomplete Block Designs
- Some Split-plot Designs
- Strip-plot Designs
- Many Confounded Designs

Some General Comments

1. Think about experiments in terms of treatment structure and design structure. Almost any treatment structure can be studied with any design structure.
2. Be sure to know and understand the difference between independent replications and dependent replications.
3. The analysis of the design structure provides estimates of the different error variances that may occur in an experiment.
4. The analysis of the treatment structure (i.e., the hypotheses to be tested) is similar for all design structures.
5. It is usually no harder to conduct an experiment with a well-designed plan than to conduct an experiment that is not well-designed.

Independent/Dependent Replications

Suppose that we want to compare the heights of black males to that of white males.

- We select one male from each population, and have 10 people measure each person's height.
- Denote the data by x_{ij}, i=1,2; j=1, 2, ..., 10
- Compute a t-statistic as $t = \frac{\bar{x}_1 - \bar{x}_2}{s\sqrt{\frac{2}{10}}}$ where $s = \sqrt{(s_1^2 + s_2^2)/2}$
- Reject a hypothesis of equality if $|t|$ is large.

Independent/Dependent Replications

Suppose that we want to compare the effects of storage temperature on the quality of CDs or DVDs.

- We randomly assign a high temperature and a low temperature to each of two storage chambers. Ten CDs are placed in each chamber. Three months later, the CDs are removed and measured for quality.
- Denote the data by x_{ij}, i=1,2; j=1, 2, ..., 10.
- Compute a t-statistic as $t = \frac{\bar{x}_1 - \bar{x}_2}{s\sqrt{\frac{2}{10}}}$ where $s = \sqrt{(s_1^2 + s_2^2)/2}$
- Reject a hypothesis of equality if $|t|$ is large.

Example 1

An experiment is to be conducted to study the effects of baking temperatures and surfactants on bread quality.

Four different baking temperatures are to be used in conjuction with five different surfactants. Denote the temperatures by 300^0, 350^0, 400^0, and 450^0, and denote the surfactants by C, S_1, S_2, S_3, and S_4. Two loaves will be made for each of the 20 combinations of temperature*surfactant combination.

The treatment structure is a two-way structure.

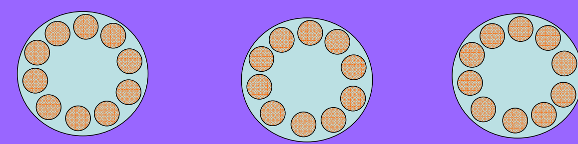
How should the experiment be conducted?

Some Possible Designs

1. A CRD.
2. A RCBD
3. A split-plot designs with temperatures randomly assigned to ovens and five loaves (one with each surfactant treatment) are placed simultaneously in the oven.
4. A split-plot design with doughs mixed so that four loaves can be made from each dough, and one loaf from each dough is placed into a different temperature oven.
5. Many other designs are also possible.

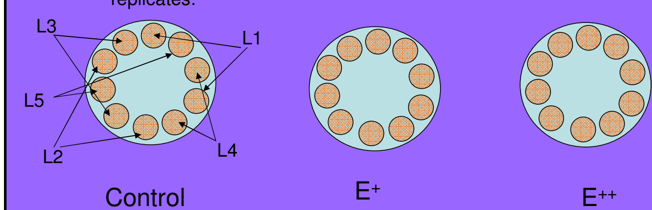
Example 2

An experiment was to be conducted to study the effects of five different levels of greenbug infestation on three varieties of sorghum. Using large coffee cans, containers were made which would hold ten test tubes with each test tube containing a sorghum plant.



Example 2 (continued)

The five levels of greenbug infestation were randomly assigned to two of the test tubes in each container. The varieties were randomly assigned to the containers. The three containers together form one complete replicate. The three containers forming a replicate were placed into a growth chamber. This was repeated in three more growth chambers giving four complete replicates.



Replicate 1

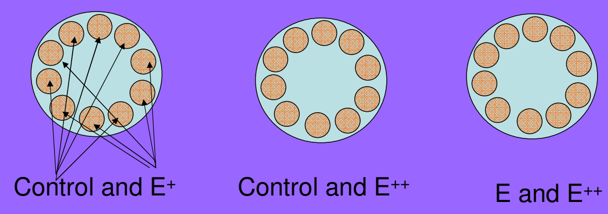
ANOVA Table

Source	DF
Varieties	2
Reps	3
Error A = V*R	6
Levels	4
V*L	8
Error B	96
Total	119

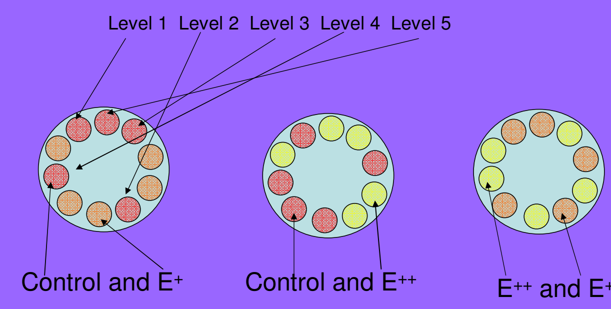
Between Container Analysis

Within Container Analysis

An Alternative Design



An Alternative Design



ANOVA Table

Source	DF
Container Sums	2
Reps	3
Error A = CS*R	6
Blocks (Rep) (unadj)	3x4=12
Levels	4
Varieties	2
V*L	8
Error B	82
Total	119

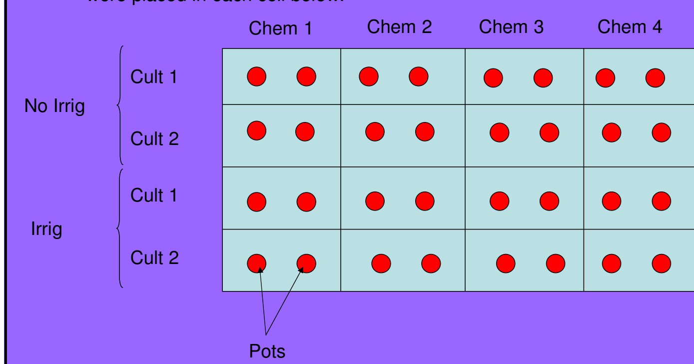
Between Container Analysis

Half Container Analysis

Within Container Analysis

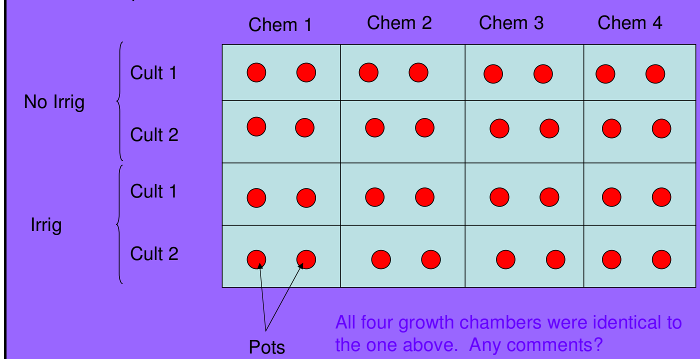
Example 3

The effects of four chemical treatments, two irrigation levels, and two cultivars was studied using four growth chambers. Two pots of plants were placed in each cell below.



Example 3

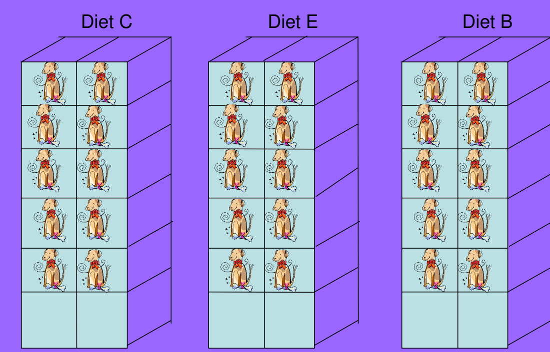
The effects of four chemical treatments, two irrigation levels, and two cultivars was studied using four growth chambers. Two pots of plants were placed in each cell below.



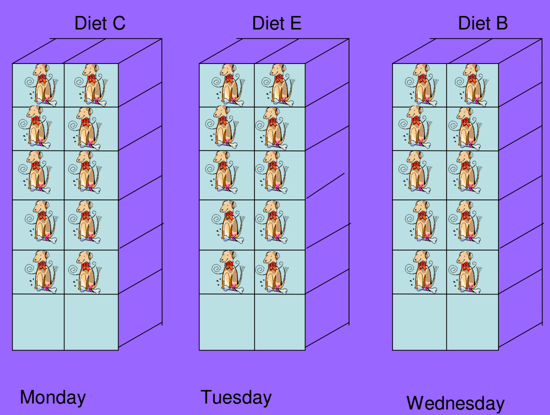
All four growth chambers were identical to the one above. Any comments?

Example 4

A drug company was comparing the effects of five diets on small dogs. There were five diets, A, B, C, D, & E.



Each rack of dogs was measured once a week for several weeks.



Example 5

An experiment was conducted to study the effects of six herbicide treatments, four wheat varieties, and three nitrogen levels.

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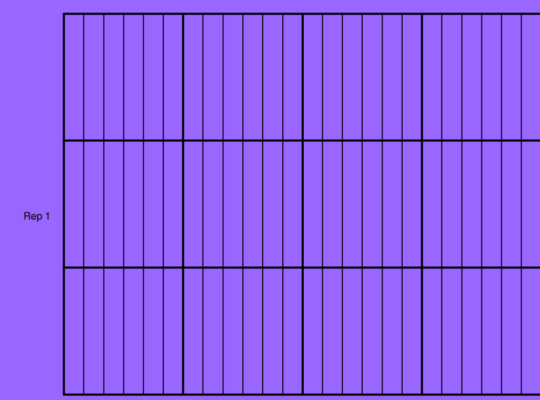
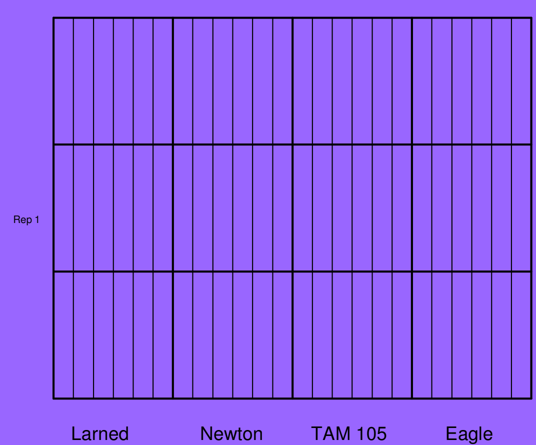
Herbicides	**Wheat Cultivars**	**Nitrogen Rate**
H1: 2,4-D ester	Newton	0 pounds
H2: Glean 75 DF	TAM 105	40 pounds
H3: Surflan 4 AS	Eagle	80 pounds
H4: 2,4-D + Surflan	Larned	
H5: Glean + Surflan		
H6: Control		

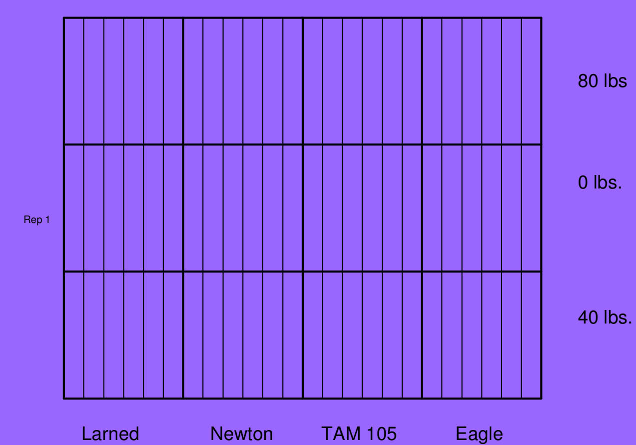
Field Plot for Rep 1 (there were two more reps)

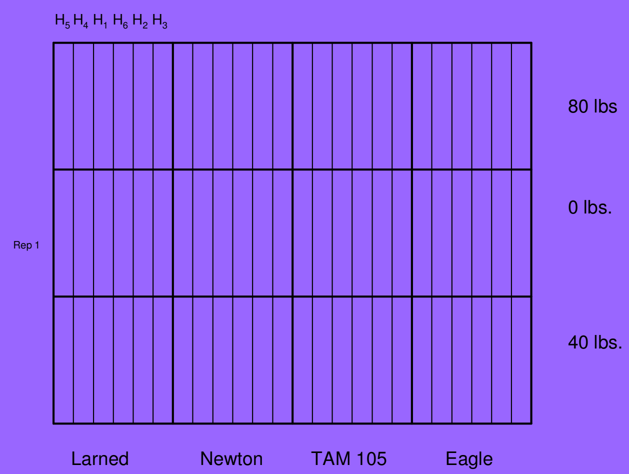


Field Plot for Rep 1 (there were two more reps)

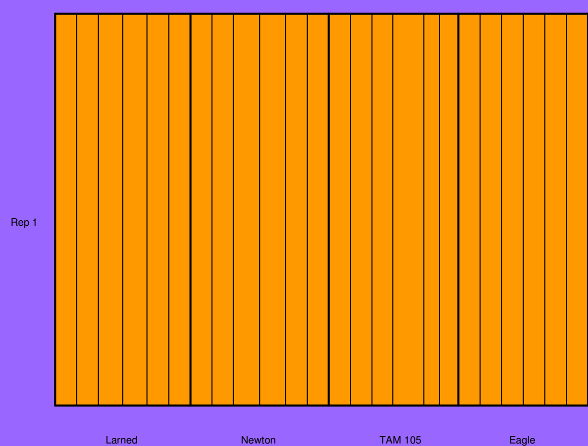


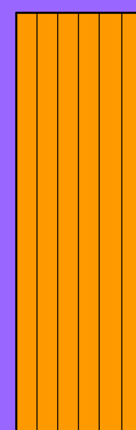
Field Plot for Rep 1 (there were two more reps)





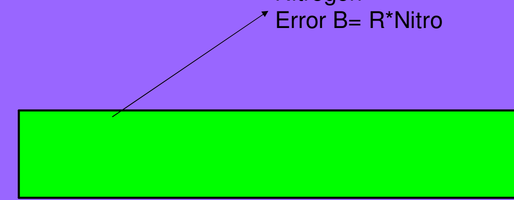
How do we analyze the data?



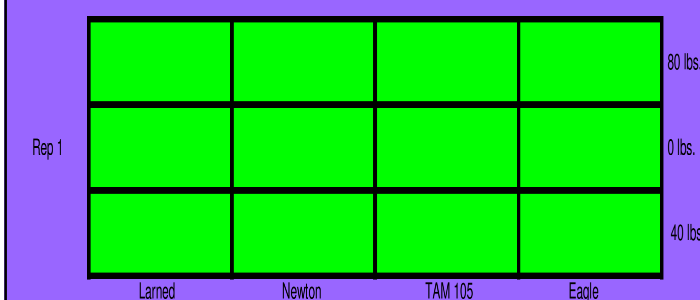


SV	DF
Rep	2
Cultivar	3
Error A=Rep*Cult	6

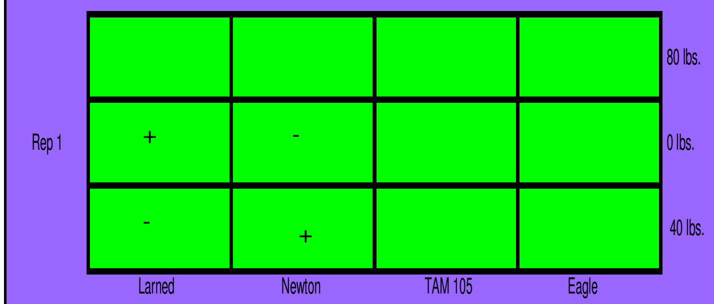
SV	DF
Rep	2
Nitrogen	2
Error B= R*Nitro	4



SV	DF
Rep	2
Cultivar	3
Error A=Rep*Cult	6
Nitrogen	2
Error B= R*Nitro	4

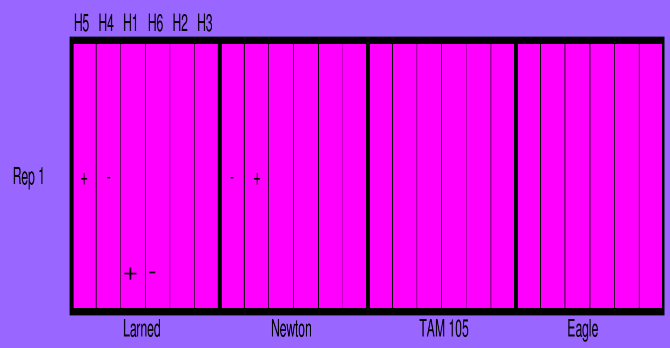


Consider a Cultivar * Nitrogen Interaction Contrast



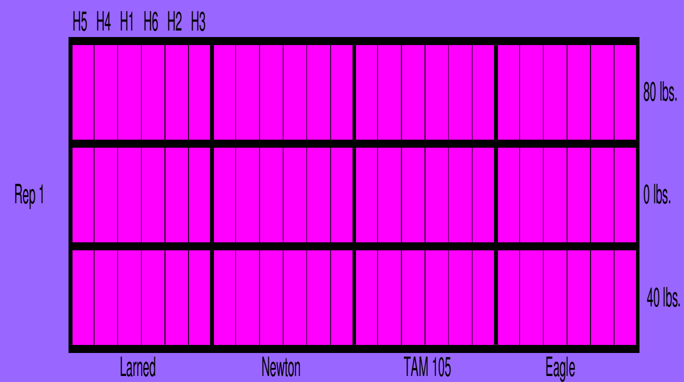
Consider a Cultivar * Nitrogen Interaction Contrast

SV	DF
Rep	2
Cultivar	3
Error A=Rep*Cult	6
Nitrogen	2
Error B= R*Nitro	4
Cult*Nitro	6
Error C=R*C*N	12

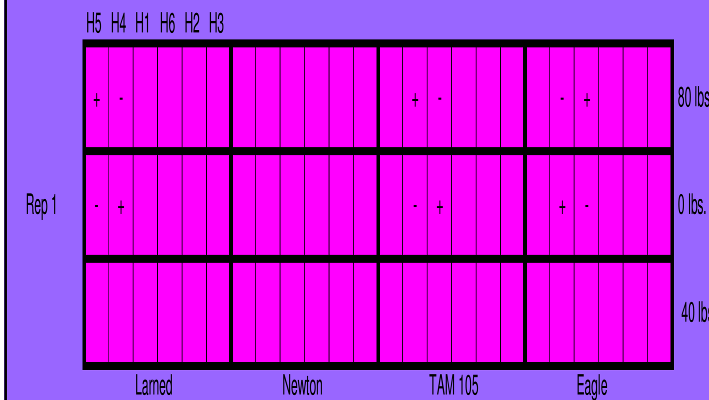


Herbicide contrasts and Herbicide*Cultivar contrasts both involve the same experimental units.

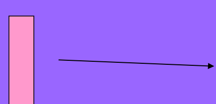
SV	DF
Rep	2
Cultivar	3
Error A=Rep*Cult	6
Nitrogen	2
Error B= R*Nitro	4
Cult*Nitro	6
Error C=R*C*N	12
Herbicide	5
Herbicide*Cultivar	15
Error D=R*H*C+R*H	40

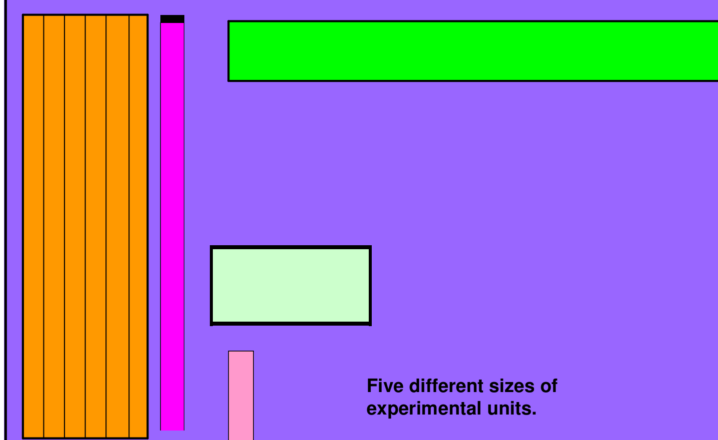


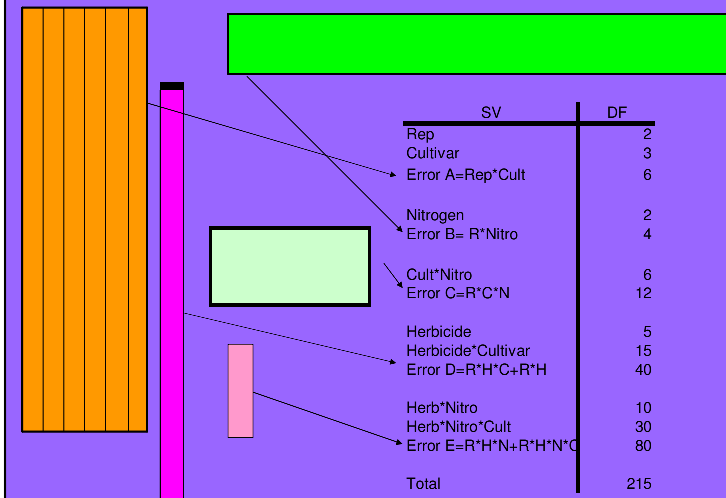
Consider a Nitrogen*Herbicide interaction contrast and a Nitrogen*Herbicide*Cultivar interaction contrast.



SV	DF
Rep	2
Cultivar	3
Error A=Rep*Cult	6
Nitrogen	2
Error B= R*Nitro	4
Cult*Nitro	6
Error C=R*C*N	12
Herbicide	5
Herbicide*Cultivar	15
Error D=R*H*C+R*H	40
Herb*Nitro	10
Herb*Nitro*Cult	30
Error E=R*H*N+R*H*N*C	80







SV	DF
Rep	2
Cultivar	3
Error A=Rep*Cult	6
Nitrogen	2
Error B= R*Nitro	4
Cult*Nitro	6
Error C=R*C*N	12
Herbicide	5
Herbicide*Cultivar	15
Error D=R*H*C+R*H	40
Herb*Nitro	10
Herb*Nitro*Cult	30
Error E=R*H*N+R*H*N*C	80
Total	215

Example 6

An experiment was conducted to determine the effects of protein and energy levels on lambs.

Protein Levels	**Energy Levels**	
High	E1	Both Low
Low	E2	
	E3	Both High
	E4	

Each of the eight diet combinations were randomly assigned to two lambs selected at random from a group of 16 lambs. Data was collected for a week, then each lamb that received E1 during the first week, received E2 during a second week. Those getting E2 the first week, received E1 the second week. Similarly, each lamb that received E3 during the first week, received E4 during the second week. Those getting E4 the first week, received E3 the second week.

How do we analyze this data?

Design

Lamb	Protein	Time 1 Energy	Time 2 Energy
1	High	E1	E2
2	High	E2	E1
3	High	E3	E4
4	High	E4	E3
5	High	E1	E2
6	High	E2	E1
7	High	E3	E4
8	High	E4	E3
9	Low	E1	E2
10	Low	E2	E1
11	Low	E3	E4
12	Low	E4	E3
13	Low	E1	E2
14	Low	E2	E1
15	Low	E3	E4
16	Low	E4	E3

Design - Consider Protein

Lamb	Protein	Time 1 Energy		Time 2 Energy	
1	High	E1		E2	
2	High	E2		E1	
3	High	E3		E4	
4	High	E4		E3	
5	High	E1		E2	
6	High	E2		E1	
7	High	E3		E4	
8	High	E4		E3	
9	Low	E1		E2	
10	Low	E2		E1	
11	Low	E3		E4	
12	Low	E4		E3	
13	Low	E1		E2	
14	Low	E2		E1	
15	Low	E3		E4	
16	Low	E4		E3	

Protein Contrast

Lamb	Protein	Time 1 Energy		Time 2 Energy	
1	High	E1	+	E2	+
2	High	E2	+	E1	+
3	High	E3	+	E4	+
4	High	E4	+	E3	+
5	High	E1	+	E2	+
6	High	E2	+	E1	+
7	High	E3	+	E4	+
8	High	E4	+	E3	+
9	Low	E1	-	E2	-
10	Low	E2	-	E1	-
11	Low	E3	-	E4	-
12	Low	E4	-	E3	-
13	Low	E1	-	E2	-
14	Low	E2	-	E1	-
15	Low	E3	-	E4	-
16	Low	E4	-	E3	-

Protein Contrast (Between Lamb Contrast)

Lamb	Protein	Time 1 Energy		Time 2 Energy	
1	High	E1	+	E2	+
2	High	E2	+	E1	+
3	High	E3	+	E4	+
4	High	E4	+	E3	+
5	High	E1	+	E2	+
6	High	E2	+	E1	+
7	High	E3	+	E4	+
8	High	E4	+	E3	+
9	Low	E1	-	E2	-
10	Low	E2	-	E1	-
11	Low	E3	-	E4	-
12	Low	E4	-	E3	-
13	Low	E1	-	E2	-
14	Low	E2	-	E1	-
15	Low	E3	-	E4	-
16	Low	E4	-	E3	-

Design - Consider Energy Levels

Lamb	Protein	Time 1 Energy		Time 2 Energy	
1	High	E1		E2	
2	High	E2		E1	
3	High	E3		E4	
4	High	E4		E3	
5	High	E1		E2	
6	High	E2		E1	
7	High	E3		E4	
8	High	E4		E3	
9	Low	E1		E2	
10	Low	E2		E1	
11	Low	E3		E4	
12	Low	E4		E3	
13	Low	E1		E2	
14	Low	E2		E1	
15	Low	E3		E4	
16	Low	E4		E3	

E1 vs E2 (Within Lamb Contrast) - E3 vs E4 is similar

Lamb	Protein	Time 1 Energy		Time 2 Energy	
1	High	E1	+	E2	-
2	High	E2	-	E1	+
3	High	E3	0	E4	0
4	High	E4	0	E3	0
5	High	E1	+	E2	-
6	High	E2	-	E1	+
7	High	E3	0	E4	0
8	High	E4	0	E3	0
9	Low	E1	+	E2	-
10	Low	E2	-	E1	+
11	Low	E3	0	E4	0
12	Low	E4	0	E3	0
13	Low	E1	+	E2	-
14	Low	E2	-	E1	+
15	Low	E3	0	E4	0
16	Low	E4	0	E3	0

E1+E2 vs E3+E4 (Between Lamb Contrast)

Lamb	Protein	Time 1 Energy		Time 2 Energy	
1	High	E1	+	E2	+
2	High	E2	+	E1	+
3	High	E3	-	E4	-
4	High	E4	-	E3	-
5	High	E1	+	E2	+
6	High	E2	+	E1	+
7	High	E3	-	E4	-
8	High	E4	-	E3	-
9	Low	E1	+	E2	+
10	Low	E2	+	E1	+
11	Low	E3	-	E4	-
12	Low	E4	-	E3	-
13	Low	E1	+	E2	+
14	Low	E2	+	E1	+
15	Low	E3	-	E4	-
16	Low	E4	-	E3	-

Time Contrast (Within Lamb Contrast)

Lamb	Protein	Time 1 Energy		Time 2 Energy	
1	High	E1	+	E2	-
2	High	E2	+	E1	-
3	High	E3	+	E4	-
4	High	E4	+	E3	-
5	High	E1	+	E2	-
6	High	E2	+	E1	-
7	High	E3	+	E4	-
8	High	E4	+	E3	-
9	Low	E1	+	E2	-
10	Low	E2	+	E1	-
11	Low	E3	+	E4	-
12	Low	E4	+	E3	-
13	Low	E1	+	E2	-
14	Low	E2	+	E1	-
15	Low	E3	+	E4	-
16	Low	E4	+	E3	-

Protein x LE (Within Lamb Contrast) - Protein x HE is similar

Lamb	Protein	Time 1 Energy		Time 2 Energy	
1	High	E1	+	E2	-
2	High	E2	-	E1	+
3	High	E3		E4	
4	High	E4		E3	
5	High	E1	+	E2	-
6	High	E2	-	E1	+
7	High	E3		E4	
8	High	E4		E3	
9	Low	E1	-	E2	+
10	Low	E2	+	E1	-
11	Low	E3		E4	
12	Low	E4		E3	
13	Low	E1	-	E2	+
14	Low	E2	+	E1	-
15	Low	E3		E4	
16	Low	E4		E3	

Protein x CE (Between Lamb Contrast)

Lamb	Protein	Time 1 Energy		Time 2 Energy	
1	High	E1	+	E2	+
2	High	E2	+	E1	+
3	High	E3	-	E4	-
4	High	E4	-	E3	-
5	High	E1	+	E2	+
6	High	E2	+	E1	+
7	High	E3	-	E4	-
8	High	E4	-	E3	-
9	Low	E1	-	E2	-
10	Low	E2	-	E1	-
11	Low	E3	+	E4	+
12	Low	E4	+	E3	+
13	Low	E1	-	E2	-
14	Low	E2	-	E1	-
15	Low	E3	+	E4	+
16	Low	E4	+	E3	+

Protein x Time (Within Lamb Contrast)

Lamb	Protein	Time 1 Energy		Time 2 Energy	
1	High	E1	+	E2	-
2	High	E2	+	E1	-
3	High	E3	+	E4	-
4	High	E4	+	E3	-
5	High	E1	+	E2	-
6	High	E2	+	E1	-
7	High	E3	+	E4	-
8	High	E4	+	E3	-
9	Low	E1	-	E2	+
10	Low	E2	-	E1	+
11	Low	E3	-	E4	+
12	Low	E4	-	E3	+
13	Low	E1	-	E2	+
14	Low	E2	-	E1	+
15	Low	E3	-	E4	+
16	Low	E4	-	E3	+

LE x Time (Between Lamb Contrast) - HE x Time is similar

Lamb	Protein	Time 1 Energy		Time 2 Energy	
1	High	E1	+	E2	+
2	High	E2	-	E1	-
3	High	E3		E4	
4	High	E4		E3	
5	High	E1	+	E2	+
6	High	E2	-	E1	-
7	High	E3		E4	
8	High	E4		E3	
9	Low	E1	+	E2	+
10	Low	E2	-	E1	-
11	Low	E3		E4	
12	Low	E4		E3	
13	Low	E1	+	E2	+
14	Low	E2	-	E1	-
15	Low	E3		E4	
16	Low	E4		E3	

CE x Time (Within Lamb Contrast)

Lamb	Protein	Time 1 Energy		Time 2 Energy	
1	High	E1	+	E2	-
2	High	E2	+	E1	-
3	High	E3	-	E4	+
4	High	E4	-	E3	+
5	High	E1	+	E2	-
6	High	E2	+	E1	-
7	High	E3	-	E4	+
8	High	E4	-	E3	+
9	Low	E1	+	E2	-
10	Low	E2	+	E1	-
11	Low	E3	-	E4	+
12	Low	E4	-	E3	+
13	Low	E1	+	E2	-
14	Low	E2	+	E1	-
15	Low	E3	-	E4	+
16	Low	E4	-	E3	+

Protein x LE x Time (Between Lamb Contrast) - P x HE x T is similar

Lamb	Protein	Time 1 Energy		Time 2 Energy	
1	High	E1	+	E2	+
2	High	E2	-	E1	-
3	High	E3		E4	
4	High	E4		E3	
5	High	E1	+	E2	+
6	High	E2	-	E1	-
7	High	E3		E4	
8	High	E4		E3	
9	Low	E1	-	E2	-
10	Low	E2	+	E1	+
11	Low	E3		E4	
12	Low	E4		E3	
13	Low	E1	-	E2	-
14	Low	E2	+	E1	+
15	Low	E3		E4	
16	Low	E4		E3	

Protein x CE x Time (Within Lamb Conrast)

Lamb	Protein	Time 1 Energy		Time 2 Energy	
1	High	E1	+	E2	-
2	High	E2	+	E1	-
3	High	E3	-	E4	+
4	High	E4	-	E3	+
5	High	E1	+	E2	-
6	High	E2	+	E1	-
7	High	E3	-	E4	+
8	High	E4	-	E3	+
9	Low	E1	-	E2	+
10	Low	E2	-	E1	+
11	Low	E3	+	E4	-
12	Low	E4	+	E3	-
13	Low	E1	-	E2	+
14	Low	E2	-	E1	+
15	Low	E3	+	E4	-
16	Low	E4	+	E3	-

SV	DF	
Total	31	
Lambs	15	Between Lamb Analysis
Protein	1	
CE	1	
Protein x CE	1	
LE x Time	1	
HE x Time	1	
Protein x LE x Time	1	
Protein x HE x Time	1	
Error A	8	
LE	1	Within Lamb Analysis
HE	1	
Time	1	
Protein x LE	1	
Protein x HE	1	
Protein x Time	1	
CE x Time	1	
Protein x CE x Time	1	
Error B	8	

Example 7

An experiment was being conducted to compare three treatments on pigs. The treatments were A: uninfested, B: infested and treated, and C: infested and untreated.

The experiment was conducted on 24 male and 24 female pigs. The 24 pigs of each gender were assigned to blocks according to weight. There were three pigs in each block. That is, there are 8 blocks of male pigs and 8 blocks of female pigs.

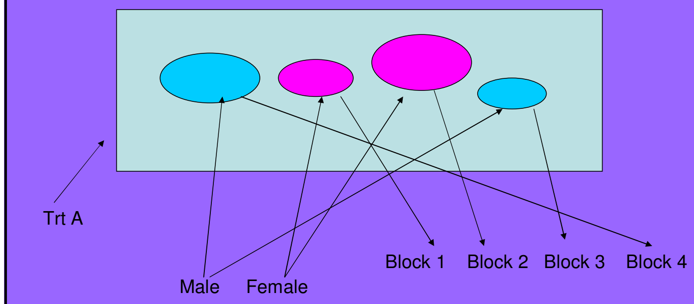
Two pigs of each gender which have been assigned the same treatment are placed in the same pen. Thus, there are 12 pens each containing four pigs, two males and two females.

Because of the nature of the treatments, the pigs that are assigned to the same pen must all receive the same treatment.

Finally, measurements are taken on each pig weekly for five weeks. How should the resulting data be analyzed?

The fixed effects are Trt and Sex. Blocks and Rep are random effects.

Pigs within a Pen



Pens 1, 5, and 9 look like this except that Trt B is assigned to Pen 5 and Trt C is assigned to Pen 9.

Each pig is measured 5 times over a 5 week period.

Reps 1 and 2

Rep	Pen	Pig	Sex	Trt	Blk
1	1	1	F	A	1
1	1	2	F	A	2
1	1	3	M	A	3
1	1	4	M	A	4
1	2	5	F	B	1
1	2	6	F	B	2
1	2	7	M	B	3
1	2	8	M	B	4
1	3	9	F	C	1
1	3	10	F	C	2
1	3	11	M	C	3
1	3	12	M	C	4
2	4	13	F	A	5
2	4	14	F	A	6
2	4	15	M	A	7
2	4	16	M	A	8
2	5	17	F	B	5
2	5	18	F	B	6
2	5	19	M	B	7
2	5	20	M	B	8
2	6	21	F	C	5
2	6	22	F	C	6
2	6	23	M	C	7
2	6	24	M	C	8

Rep	Pen	Pig	Sex	Trt	Blk	B vs C	A vs (B+C)/2	Rep	Rep*Trt	
1	1	1	F	A	1	0	2	1	0	2
1	1	2	F	A	2	0	2	1	0	2
1	1	3	M	A	3	0	2	1	0	2
1	1	4	M	A	4	0	2	1	0	2
1	2	5	F	B	1	1	-1	1	1	-1
1	2	6	F	B	2	1	-1	1	1	-1
1	2	7	M	B	3	1	-1	1	1	-1
1	2	8	M	B	4	1	-1	1	1	-1
1	3	9	F	C	1	-1	-1	1	-1	-1
1	3	10	F	C	2	-1	-1	1	-1	-1
1	3	11	M	C	3	-1	-1	1	-1	-1
1	3	12	M	C	4	-1	-1	1	-1	-1
2	4	13	F	A	5	0	2	-1	0	-2
2	4	14	F	A	6	0	2	-1	0	-2
2	4	15	M	A	7	0	2	-1	0	-2
2	4	16	M	A	8	0	2	-1	0	-2
2	5	17	F	B	5	1	-1	-1	-1	1
2	5	18	F	B	6	1	-1	-1	-1	1
2	5	19	M	B	7	1	-1	-1	-1	1
2	5	20	M	B	8	1	-1	-1	-1	1
2	6	21	F	C	5	-1	-1	-1	1	1
2	6	22	F	C	6	-1	-1	-1	1	1
2	6	23	M	C	7	-1	-1	-1	1	1
2	6	24	M	C	8	-1	-1	-1	1	1

Contain Pen Effects

Error for Trts

Rep	Pen	Pig	Sex	Trt	Blk	Rep	Sex	Rep*Sex
1	1	1	F	A	1	1	1	1
1	1	2	F	A	2	1	1	1
1	1	3	M	A	3	1	-1	-1
1	1	4	M	A	4	1	-1	-1
1	2	5	F	B	1	1	1	1
1	2	6	F	B	2	1	1	1
1	2	7	M	B	3	1	-1	-1
1	2	8	M	B	4	1	-1	-1
1	3	9	F	C	1	1	1	1
1	3	10	F	C	2	1	1	1
1	3	11	M	C	3	1	-1	-1
1	3	12	M	C	4	1	-1	-1
2	4	13	F	A	5	-1	1	-1
2	4	14	F	A	6	-1	1	-1
2	4	15	M	A	7	-1	-1	1
2	4	16	M	A	8	-1	-1	1
2	5	17	F	B	5	-1	1	-1
2	5	18	F	B	6	-1	1	-1
2	5	19	M	B	7	-1	-1	1
2	5	20	M	B	8	-1	-1	1
2	6	21	F	C	5	-1	1	-1
2	6	22	F	C	6	-1	1	-1
2	6	23	M	C	7	-1	-1	1

Contain Blk Effects

Rep	Pen	Pig	Sex	Trt	Blk	Rep	Sex	Rep*Sex	Blk			
1	1	1	F	A	1	1	1	1	1			
1	1	2	F	A	2	1	1	1	-1			
1	1	3	M	A	3	1	-1	-1		1		
1	1	4	M	A	4	1	-1	-1		-1		
1	2	5	F	B	1	1	1	1	1			
1	2	6	F	B	2	1	1	1	-1			
1	2	7	M	B	3	1	-1	-1		1		
1	2	8	M	B	4	1	-1	-1		-1		
1	3	9	F	C	1	1	1	1	1			
1	3	10	F	C	2	1	1	1	-1			
1	3	11	M	C	3	1	-1	-1		1		
1	3	12	M	C	4	1	-1	-1		-1		
2	4	13	F	A	5	-1	1	-1			1	
2	4	14	F	A	6	-1	1	-1			-1	
2	4	15	M	A	7	-1	-1	1				1
2	4	16	M	A	8	-1	-1	1				-1
2	5	17	F	B	5	-1	1	-1			1	
2	5	18	F	B	6	-1	1	-1			-1	
2	5	19	M	B	7	-1	-1	1				1
2	5	20	M	B	8	-1	-1	1				-1
2	6	21	F	C	5	-1	1	-1			1	
2	6	22	F	C	6	-1	1	-1			-1	
2	6	23	M	C	7	-1	-1	1				1
2	6	24	M	C	8	-1	-1	1				-1

Rep	Pen	Pig	Sex	Trt	Blk	Sex x Trt	
1	1	1	F	A	1	0	2
1	1	2	F	A	2	0	2
1	1	3	M	A	3	0	-2
1	1	4	M	A	4	0	-2
1	2	5	F	B	1	1	-1
1	2	6	F	B	2	1	-1
1	2	7	M	B	3	-1	1
1	2	8	M	B	4	-1	1
1	3	9	F	C	1	-1	-1
1	3	10	F	C	2	-1	-1
1	3	11	M	C	3	1	1
1	3	12	M	C	4	1	1
2	4	13	F	A	5	0	2
2	4	14	F	A	6	0	2
2	4	15	M	A	7	0	-2
2	4	16	M	A	8	0	-2
2	5	17	F	B	5	1	-1
2	5	18	F	B	6	1	-1
2	5	19	M	B	7	-1	1
2	5	20	M	B	8	-1	1
2	6	21	F	C	5	-1	-1
2	6	22	F	C	6	-1	-1
2	6	23	M	C	7	1	1
2	6	24	M	C	8	1	1

Free from both block and rep effects

Error is all that is left

```
proc mixed;
 class rep sex trt blk;
  model y=trt sex sex*trt;
  random rep rep*trt rep*sex blk;
  run;
```

Error for trt

Source	DF
rep	3
trt	2
rep*trt	6
sex	1
rep*sex	3
blk	8
sex*trt	2
Error	22

Error for sex

These make up the 15 df for comparing blocks

Now we have to take care of the five weekly repeated measures part of the experiment.

Now we have to take care of the five weekly repeated measures part of the experiment.

This is your assignment. Send me your answers by 10 p.m. tonight!