8.4: Try It!

Exercise 8.4.1

Researchers are investigating the effect of storage temperature on bacterial growth for two types of seafood. They set up the experiment to evaluate 3 storage temperatures. There were 9 storage units that were available, and so they randomly selected 3 storage units to be used for each storage temperature, and both seafood types were stored in each unit. After 2 weeks, bacterial counts were made. After taking a logarithmic transformation of the counts, they produced the following ANOVA:

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
temp	2	107.656588	53.828294	Var(Residual) + 2 Var(unit(temp)) + Q(temp, temp*seafood)
seafood	1	3.713721	3.713721	Var(Residual) + Q(seafood, temp*seafood)
temp*seafood	2	2.647594	1.323797	Var(Residual) + Q(temp*seafood)
unit(temp)	6	44.050650	7.341775	Var(Residual) + 2 Var(unit(temp))
Residual	6	5.590873	0.931812	Var(Residual)

a) For each factor, indicate whether it is a fixed or random effect.

b) Identify the treatments and describe (in words) the treatment design.

c) Describe the randomization used.

d) Compute the F-statistic for the temperature effect in the ANOVA, and determine significance for the effect.

Show Solution

a) temp=fixed, seafood=fixed, storage unit=random

b) Temperature and Seafood, factorial design. Each seafood type is combined with each temperature level in the experiment.

c) Split-plot in a CRD. Temperature levels were assigned (randomly) to storage units. Then the storage unit set at a given temperature is split to accommodate each of the two seafood types.

d) $F_{Temperature} = 53.83/7.342 = 7.3318 F_{critical} = 5.14$, so reject H_0.

Exercise 8.4.2

Answer the questions based on the following output:

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
group	3	6429.388333	2143.129444	Var(Residual) + 3 Var(blk*group) + Q(group,group*tech_int)
tech_int	2	881.408750	440.704375	Var(Residual) + Q(tech_int,group*tech_int)
group*tech_int	6	207.507917	34.584653	Var(Residual) + Q(group*tech_int)
blk	3	408.985000	136.328333	Var(Residual) + 3 Var(blk*group) + 12 Var(blk)
blk*group	9	466.543333	51.838148	Var(Residual) + 3 Var(blk*group)
Residual	24	595.696667	24.820694	Var(Residual)

a) For each factor, indicate whether it is a fixed or random effect

b) Identify the treatments and describe (in words) the treatment design.

c) Describe (in words) the randomization used.

d) Compute the F-statistic for each effect in the ANOVA, and determine significance (i.e., compare $F_{calculated}$ to $F_{critical}$ for each effect).

Show Solution

a) group = fixed, tech_int = fixed, blk = random

b) group and tech_int, crossed for a factorial treatment design

c) Split-plot in a RCBD, with *group* as the whole plot treatment and *tech_int* as the subplot treatment with *blk* as the blocking factor.

d) group: $F = \dfrac{2143.129444}{51.838148} = 41.3427$, $F_{critical} = 3.86$, reject H_0

tech_int: $F = \dfrac{440.704375}{24.820694} = 17.7555$, $F_{critical} = 3.40$, reject H_0

group $\times$ tech_int: $F = \dfrac{34.584653}{24.820694} = 1.3934$, $F_{critical} = 2.51$, do not reject H_0

blk: $F = \dfrac{136.3283}{51.8381} = 2.6299$, $F_{critical} = 3.86$, do not reject H_0

Exercise 8.4.3

1. An experimenter wants to compare the yield of three varieties of oats at four different levels of manure. Suppose 6 farmers agree to participate in the experiment and each farmer will designate 3 fields from their farms for the experiment.

a. What is the treatment design?
b. What is the randomization design?

Show Solution

a) **Treatment design**: 3×4 factorial with oat variety and manure levels as factors having 3 and 4 levels respectively

b) **Randomization design**: Three oats varieties will be randomly assigned to the 3 fields from each farm using RCBD with farms as blocks. Four manure levels are then randomized within each field using an RCBD. So the randomization design is a split-plot in RCBD.

2. In an agricultural setting, an experimenter is applying one of two irrigation methods randomly to 6 plots where all plots are similar in moisture, soil type, slope, fertility, etc. Each plot is then subdivided into 5 portions and 5 levels of nitrogen fertilizer are applied randomly to these portions.

a. What is the treatment design?
b. What is the randomization design?

Show Solution

a) **Treatment design**: 2×5 factorial with irrigation method and fertilizer levels as factors having 2 and 5 levels respectively

b) **Randomization design**: Split-plot in CRD with the whole factor as irrigation method and subplot factor as fertilizer level

3. A survey was conducted among 100 high schoolers who were potential athletes to learn about their preferences on financial benefits. The sample consisted of an equal number of male and female students and 3 incentive types were offered: a 20% tuition reduction for all 4 years; a 50% tuition reduction in the first year, but renewable based on freshman GPA; and full room and board for all 4 years.

a. What is the treatment design?
b. What is the randomization design?

Show Solution

a) **Treatment design**: A single factor study with 3 levels; the factor of interest is incentive type

b) **Randomization design**: RCBD with gender as the blocking factor