AL/Systems

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THE OPEN UNIVERSITY OF SRI LANKA

B.Sc. /B.Ed. Degree Programme, Continuing Education Programme

APPLIED MATHEMATICS-LEVEL 04

PSU 2182/ PCU 2142- DESIGN AND ANALYSIS OF EXPERIMENTS

OPEN BOOK TEST 2010/2011

Duration: One and Half Hours.

Date: 01.03.2011	Time: 4.00 p.m- 5.30 p.m

Answer all questions.

1. An experiment was conducted to investigate the effects of commonly used fertilizers on the growth of carrot cultivation. In the experiment, following fertilizer mixtures were used as the treatments.

   Mixture 1: Ammonium Sulphate & compost 1.1 mixture

   Mixture 2 : Monocalcium Phospate & compost 1.1 mixture

   Mixture 3 : Ammonium Sulphate only

   Mixture 4 : Monocalcium Phospate only

   Above four fertilizer mixtures were applied at random to eight plots of carrots that were more or less similar such that each treatment is assigned for two plots. The weights of the applied fertilizers for different plots were equal.

   At the end, the weights (in Kilograms) of the roots obtained from each plot were measured.

   i. How many treatments are tested and what are they?

   ii. How many replicates are there in the experiment?

   iii. What is the response variable of this experiment?

   iv. What kind of design structure is used in this experiment? Justify your answer.

   v. How do you apply the concept of randomization in conducting this experiment?

   vi. Clearly describing the notation you use, write down a model for the response measured on a randomly selected plot

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2. An experimenter is interested in studying the effects of three diets D_1, D_2, and D_3 on the growth of mice. You are called to assist the experimenter with the designing of this experiment.

   i. Explain what type of design you would use if,

      a) Nine offspring born at one time to a particular mother are available.

      b) Eighteen offspring for six species, each containing three offspring born at one time to a particular mother are available.

   In each case give reasons for your answer.

   ii. Explain how you use random number table to allocate each treatment to the experimental units for each case given in parts (a) and (b).

   iii. What are the advantages and disadvantages of using the design structures you suggested in parts (a) and (b)?

3. An advertising firm is interested in studying the effect of four types of sales advertisements (*A*, *B*, *C* and *D*) on the sales amount of a certain product in a city. The stores in the city can be divided into three groups as small scale, middle scale and large scale according to the size of their sales amount. Each group has four stores of same size. It is known that the sales amount depends on the scale of the store. However, the effect of the sales advertisement does not depend on the scale of the store.

   i. What is the design structure to be used in this experiment? Justify your answer.

   ii. Clearly explain how you would instruct the advertising company to conduct this experiment.

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Answer Guide

1) i. 4 treatments. mixture 1, mixture 2, mixture 3 , mixture 4.
ii. 2 replicates
iii. Weights of the roots
iv. Completely Randomized Design
In a CRD structure, all experimental units are assumed homogeneous and the treatments are assigned to the experimental units completely at random. In this experiment, it is used 8 plots of carrots that were more or less similar. So it can be assumed that all experimental units are homogeneous. Four treatments can be assigned to eight experimental units in a completely random manner.

v. This is an experiment with 4 treatments and 8 experimental units. That means 2 replicates for each treatment. Eight runs should be made in random order. Suppose that we number the runs as follows.

Fertilizer	Experiment run number	
Mixture 1	1	2
Mixture 2	3	4
Mixture 3	5	6
Mixture 4	7	8

Now select a random number between 1 and 8. Suppose we get 5. Then the 5^{th} plot with mixture 3 is run first. This process would be repeated until all 8 have been assigned a position in the test sequence.

vi. $Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$ i=1,2,3,4 j=1,2

Y_{ij} = Observation for the j^{th} plot to which fertilizer i is applied.
μ = General mean of response
α_i = Effect of i^{th} fertilizer
ε_{ij} = Random error

2) (i) a) We can consider nine offspring (mice) as a homogeneous group and we can use CRD to allocate treatments to experimental units.
b) We have to control the variation that arises due to different species when designing the experiment. Hence the suitable design structure in this situation is RCBD with 6 blocks where each block represents specie.

(ii) a) There are 9 offspring and we need to allocate 3 treatments to these offspring. To do this first number the mice from 1 to 9. Then using random number table read random numbers of 1 digit ignoring the numbers that are greater than 9. Allocate D1 diet to

mice corresponding to the first 3 numbers, Diet D2 to mice corresponding to the next 3 numbers and so on until all treatments are allocated to all mice.

b) Here each specie will be treated as a block and there are 3 mice. To allocate treatment to mice, first select specie. Then number the treatments in a convenient way. For example one can give 1 to D1, 2 to D2 and 3 to D3. Then using random number table read random numbers of 1 digit ignoring numbers greater than 3. Finally assign the treatment corresponding to each number to each mouse in selected specie. (For example if the random numbers are 2,1,3 then allocate treatment D2 to first mouse, D1 to second mouse and D3 to third mouse. Carryout the same process for allocating treatments for the remaining species.

(iii) a) Completely Randomized Design (CRD)

Advantages	**Disadvantages**
• Flexibility: Any number of treatments or replicates may be used. Also number of replicates may vary from treatment to treatment. All available experimental units can be used. • Statistical Analysis is simple even with unequal replications. • Statistical Analysis remains simple even with missing data.	• Inefficient • Since the randomization is not restricted, the experimental error includes the entire variation. • The experimental units need to be homogeneous.

b) Randomized Complete Block Design (RCBD)

Advantages	**Disadvantages**
• More precision than CRD. • No restriction on the number of blocks or the number of treatments. • Statistical analysis is relatively simple even with missing values.	• When the variation among experimental units within a block is large it will produce a large error term.

3) (i) Randomized Complete Block Design
Groups of the stores can be considered as blocking factor, and it is known that the sales amount depends on the scale of the store and effect of the sales advertisement does not depend on the scale of the store.

(ii) The study involves 4 types of sales advertisements and 3 scales of stores. Since there are 3 blocks (small, medium, large) each advertisement can randomly assigned to one store in each block. We assign four treatments to four stores (small or medium or large) in a completely random manner.