COURSE: STA 408
DESIGN & ANALYSIS OF EXPERIMENT

LECTURE DELIVERED BY

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COURSE CONTENTS

- Introduction
- Basic principles of Experimental Design; Randomization, Replication and Local control
- Completely Randomized Design (CRD); Description, Layout, Statistical analysis, advantages and limitations
- The Randomized Complete Block Design (RCBD); Description, Layout, Statistical analysis, advantages and limitations.
- Replication within block, missing observations.
- Efficiency of RCBD and CRD.
- The Latin Square Design; Description, Layout, Statistical analysis, advantages and limitations
- Missing observations in Latin Square Design, efficiency of Latin Square
- Factorial Experiment; Main effects, Interaction effects
- Effect in a 2^2 and 2^3 in Factorial Experiment, advantages and disadvantages.

RECOMMENDED BOOKS

- Boniface, D.R. (1995). "*Experiment Design & Statistical Methods*", Chapman & Hall.
- Chaudhry, S.M. and Kamal, S. (2010). *"Introduction to Statistical Theory"* Part II, Ilmi Kitab Khana, Urdu Bazar, Lahore.
- Clarke, G.M. (1994). "*Statistics & Experimental Design*". Edward Arnold.
- Clarke, G.M., and Kempton, R.E. (1997), "*Introduction to the Design & Analysis of Experiments*", Edward Arnold.
- Das, M.N. and Geri, N.C, (1986). "*Design and Analysis of Experiments*", John Wiley, New York.
- Harold, R. L (1992). "Analysis of Variance in Experimental Design". Springer Verlage
- Mead, R. (1988). "*The Design of Experiments*". Cambridge University Press, Cambridge.
- Montgomery, D. C., Design and analysis of experiments, Edition: 7th ed. Publisher: New Jersey : John Wiley, 2009

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DESIGN & ANALYSIS OF EXPERIMENT

LECTURE NO.1

Planning an experiment to obtain appropriate data and drawing inference out of the data with respect to any problem under investigation is known as ***design and analysis of experiment***.

Why all this?

INTRODUCTION

- **EXPERIMENT**

An experiment deliberately imposes a treatment on a group of objects or subjects in the interest of observing the response.

- **TREATMENTS**

In experiments, a treatment is something that researchers administer to experimental units.

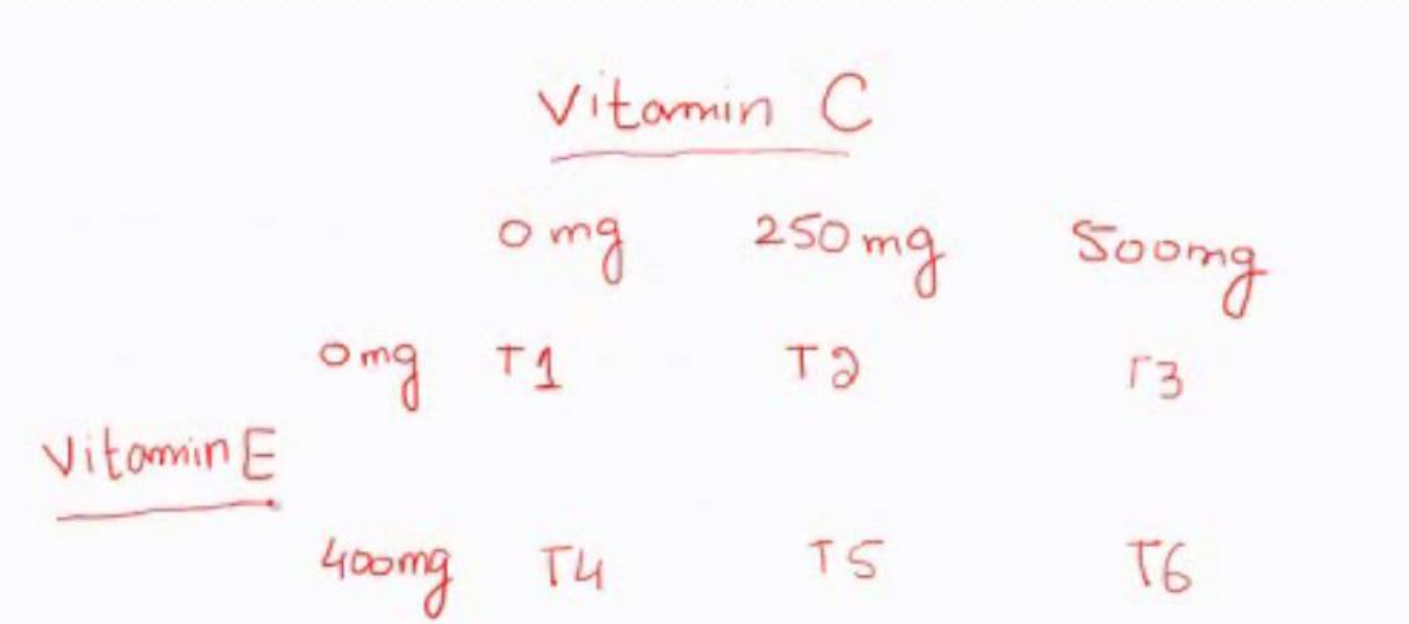
For example, a corn field is divided into four, each part is 'treated' with a different fertilizer to see which produces the most corn.

- **FACTOR**

A factor of an experiment is a controlled independent variable; a variable whose levels are set by the experimenter.

A factor is a general type or category of treatments. Different treatments constitute different levels of a factor.

EXAMPLE



- **EXPERIMENTAL UNIT**

The experimental unit is the basic entity or unit on which the experiment is performed. i.e. It is an object to which the treatment is applied and in which the variable under investigation is measured and analyzed.

For example, experimental unit may be:

IDENTIFY THE EXPERIMENTAL UNIT ?

- A teacher practices the different teaching methods on different groups in her class to see which yields the best results.

- A doctor treats a patient with a skin condition with different creams to see which is most effective.

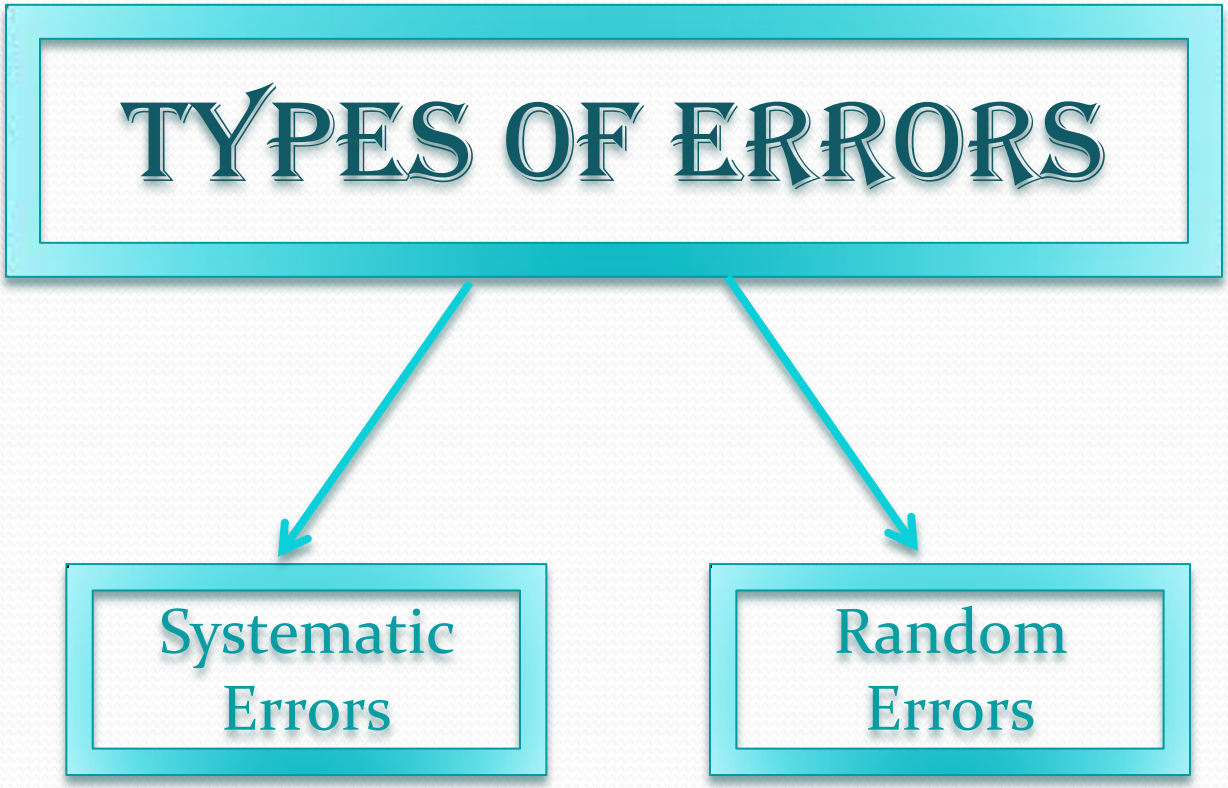
- **EXPERIMENTAL ERROR**

It describes the variation among identically and independently treated experimental units.

The various **origins of experimental error** include:

- ✓ The natural variation among the experimental units.
- ✓ Inability to reproduce the treatment conditions exactly from one unit to another.
- ✓ Interaction of treatments and experimental units.
- ✓ Any other extraneous factors that influence the measured characteristics.

TYPES OF ERRORS



- **EXPERIMENTAL DESIGN**

An experimental design is a plan to collect the data relevant to the problem under investigation. In such a way as to provide a basis for valid and objective inferences about the stated problem.

The plan usually consists of the selection of the treatments , specifications of the experimental layouts, allocation of the treatments and collection of observation for analysis.

- **PURPOSE OF EXPERIMENTAL DESIGN**

  - ✓ Get maximum information for minimum expenditure in the minimum possible time
  - ✓ Helps to reduce the experimental error
  - ✓ To ignore spurious effects, if any. *(FOR DETAIL, SEE THE LECTURE)*
  - ✓ To evaluate and examine the outcomes critically and logically.

STEPS IN DESIGNING AN EXPERIMENT

A statistically designed experiment may consist of the following steps.

- ✓ Statement of the problem
- ✓ Formulation of the hypothesis
- ✓ Choice of response or dependent variable.
- ✓ Selection of the factors to be varied.
- ✓ Choice of levels of these factors i.e. qualitative or quantitative and fixed or random.
- ✓ How factors are to be combined.
- ✓ Number of observations to be taken.

- ✓ Methods of randomization to be used.
- ✓ Mathematical model to describe the experiment.
- ✓ Data collection and processing.
- ✓ Application of statistical techniques to the experiment results.
- ✓ Drawing conclusions with measures of reliability of the estimates of any quantities that are evaluated.
- ✓ Evaluation of whole investigations particularly with other investigations on the same or similar problems.

BASIC PRINCIPLES OF EXPERIMENTAL DESIGN

The basic principles of experimental designs are:

- Randomization
- Replication
- Local Control

These principles make a valid test of significance possible.

RANDOMIZATION

It is a random process of assigning treatments to the experimental units.

Randomization is usually done by using tables of random numbers, by drawing numbered cards from a well shuffled pack of cards, or by drawing numbered balls from a well-shaken container.

PURPOSE OF RANDOMIZATION

- ✓ To remove bias and other sources of extraneous variation, which are not controllable .
- ✓ To form the basis of any valid statistical test.

REPLICATION

Replication is basically a repetition of the basic experiment.

In other words, it is a complete run for all the treatments to be tested in the experiment.

In all experiments, some variation is introduced because of the fact that the experimental units such as individuals or plots of land in agriculture experiments, cannot be physically identical. This type of variation can be removed by using a number of experimental units. We therefore perform the experiment more than once, i.e., we repeat the basic experiment. An individual repetition is called a replicate.

REPLICATION IS USED ?

- ✓ To secure more accurate estimate of the experimental error.
- ✓ To decrease the experimental error and thereby to increase precision.
- ✓ To obtain more precise estimate of the mean effect of a treatment.

LOCAL CONTROL

A term referring to the amount of balancing, blocking and grouping of the experimental units.

Balancing means that treatments should be assigned to the experimental units in such a way that the result is a balanced arrangements of the treatments.

Blocking means that like experimental units should be collected together to form a relatively homogeneous group. A block is also a replicate.

The main purpose of the principle of local control is to increase the efficiency of an experimental design by decreasing the experimental error.

TYPES OF DESIGNS

1- Systematic designs

2- Randomized designs

SYSTEMATIC DESIGNS

In systematic designs treatments are applied to the experimental units by some systematic pattern, i.e. by the choice of the experimenter.

FOR EXAMPLE:

The experimenter wishes to test three treatments and he decides to have four repetitions of each treatment. The arrangements of three treatments over the experimental area could be : *(FOR SOLUTION, LISTEN THE LECTURE)*

RANDOMIZED DESIGNS

In randomized designs , as the treatments are applied randomly therefore the conclusions drawn are supported by statistical tests.

In this way, inferences are applicable in wider range and the random process minimizes the systematic error.

The analysis of variance techniques are also suitable to randomized designs only.

CLASSIFICATIONS OF RANDOMIZED DESIGNS

- **Completely Randomized Design (CRD)**
- **Randomized Complete Block Design (RCBD)**
- **Latin Square Design**

"Detailed discussion will be made in further lectures"

EXAMPLE

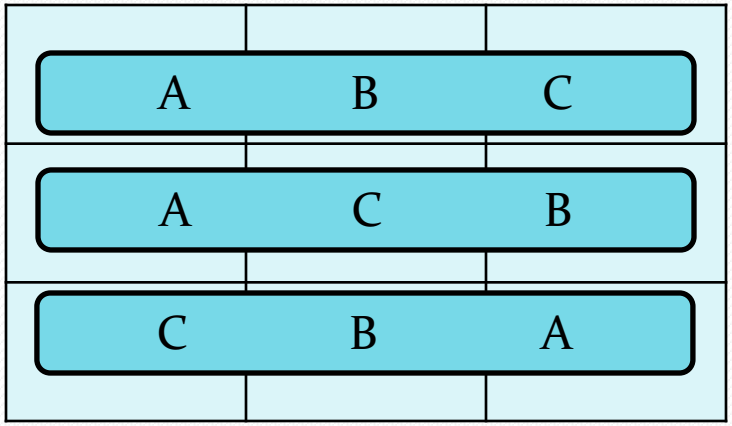
A market gardener wants to test three types of peas, A, B, C, on his land. He has a square plot which he divides into nine equal squares, three to be planted with each type of pea. The problem which he then faces is which square to plant with which type.

- One method is **Completely Randomized Design** which might,

C	A	C
B	A	A
B	B	C

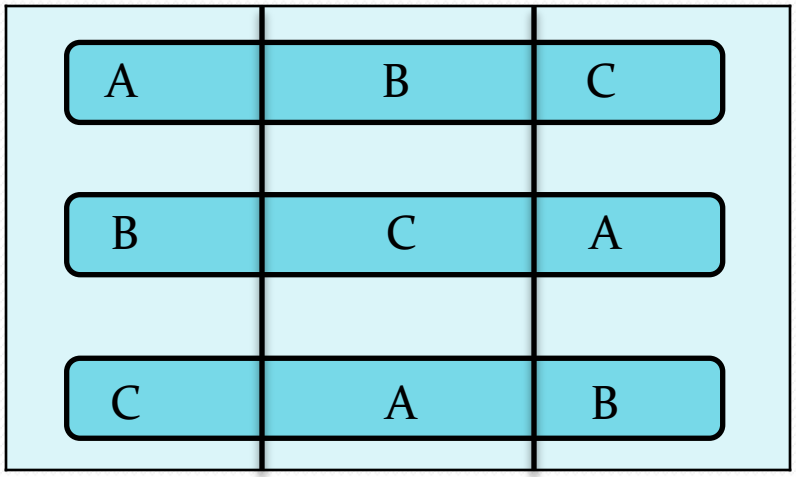
This would be all right if all the plots were equally desirable. If however, there were prevailing north wind so that the northernmost plots were exposed, he might decide to use ,

- **Randomized Complete Block Design**, where each of the types A, B and C is planted once in each west-east block.



If the gardener also felt that the soil to the east was rather better than that to the west, he would use ,

A **Latin Square design**, where each type of pea is planted once in each row (west-east), and once in each column (north-south).



THANK YOU