REVIEW OF TEST OF SIGNIFICANCE

In our day to day life, knowingly or unknowingly, we study samples and infer about the populations. This is particularly so in the field of research where the populations may either be existing (real) or non existing (hypothetical). The principle reasons being reduced cost on resources, greater speed of completion of research, greater accuracy in the collection of data and greater scope of research.
We come across the following types of problems :

(1) Estimation of the population characteristics like mean, percentage, ratio of two variables, variance, correlation between two variables, regression of one variable on the other etc.
(2) To verify or test whether given sample has come from the pre-determined real or hypothetical population having the mean known and variance known or estimated.
(3) To verify or test whether two samples, independent or related have been drawn from the same real or hypothetical population with given mean and variance or its estimate.
(4) To verify or test whether multiple samples have come from the same population or not.

For the problems like (2), (3) and (4) the concept of test of significance has to be understood.

It is our experience that even when different representative samples are drawn from the same population their estimates of the population parametric values differ. The magnitude of such differences varies according to the sample sizes selected. However, it is also our experience that in biological research the distributions of the quantitative variables under study may be normal or slightly skewed. However, the distribution of sample means drawn from such populations always follows normal distribution with mean as that of the population and variance as the ratio of variance of the population to the sample size.

Under the situation many a time the question Aries in our mind whether the observed difference between the given sample estimate and the population mean in case of problem like (2), or whether the observed differences between two sample in problem like (3), or multiple samples in problems like (4) are due to sampling or some other reasons. Theory of test of significance can help in solving such problems.

Test of significance

It is a statistical procedure to decide whether the observed differences among the sample estimates and the population parametric values are significance are not at a specified level of significance.

Reasons for differences or deviations

The observed difference between the sample estimate and the population parameter or among sample estimates and the population parameters may be due to the following reasons.

(1) Differences due to sampling : After all sampling procedure has been adopted to infer about the population. However best sampling procedure might have been used for drawing the best representative sample. It is always excepted to show deviation between sample estimate and population parameters. Such deviations are expected to be smaller and have larger probability to get them. Such differences are considered as differences due to sampling fluctuation.

(2) Real difference: When the given sample or samples has/have not been drawn from the pre-determined real or hypothetical population or populations, we observed differences between or among sample estimate/estimates and population parametric values. Such deviations are expected to be larger and have smaller probabilities to get them. Such differences are considered as real differences.

The appropriate test of significance can decide whether such observed deviations are due to sampling errors or real.

Procedure of test of significance

Depending on the objectives laid out for the research the test of significance has to pass through the following steps.

Step 1 : Set the null hypothesis (H_o) and its alternative (H_a).

Hypothesis (H) : It is the statement specifying the parametric values of a distribution from which the sample or samples is/are drawn.

Null Hypothesis (H_o) : It is the hypothesis of equality of populations from which sample or samples are drawn. or it is the hypothesis of no difference among the populations from which sample or samples are drawn.

Alternate Hypothesis (H_a) : In the test of significance when the null hypothesis is set, from the sample it may be possible that the deviations are significant. Under the circumstances if H_o is not to be accepted some alternative hypothesis has to be accepted. So along with H_o, Ha has also to be specified. For example if two random samples A and B are drawn from the population the Ho can be $H_o : \mu_1 = \mu_2$ and H_a can be H_a : (i) $\mu_1 + \mu_2$ (ii) $\mu_1 > \mu_2$ (iii) $\mu_1 < \mu_2$. Where μ_1 and μ_2 are the populations from which sample A and sample B are drawn. Depending on logical reasoning or the past experience, the H_a has to be formulated.

Step 2 : Fix the level of significance. From the theory of sampling, based on null hypothesis, it is possible to workout the probability of getting the observed deviation or more of sample estimate and the population parameter. If such probabilities are large (usually greater than 5 %) we consider the observed difference as due to sampling fluctuation only and consider than as not significant. When the probabilities are low (usually less than 5 %) the differences are considered as significant and when they are very low (less than 1 %) the differences are considered as highly significant. Significant and highly significant differences are considered as real differences.

In practice it is not always necessary to workout the actual probabilities of observing such differences but depending on nature of distributions of the sample estimates readymade tables (like that of Z, t, F and χ^2 distributions) tables have been developed to decide whether the observed differences can be considered as significant or not at as specified level of probability. Thus level of significant can be defined as "The maximum probability of rejecting the null hypothesis when it is true." Usually 5 % and 1 % probability levels are fixed as levels of significant. 5 % levels of significance indicate that on the basis of the null hypothesis the probability of getting an observed difference or more between the sample estimate and the population parameter is 5 % or less. In such situation the observed difference is considered as significant. 1 % level of significance indicate that the probability of observing such deviation or more is as low as 1 %. Such differences are consider as highly significant.

Step 3 : Decide about the test criterion

The following test criteria are usually chosen for carrying out the test of significance

1. Z : for one sample and two samples test
2. t : for one sample and two samples test
3. F : for two or more samples
4. χ^2 : for quantitative or enumerative types of data

I N T R O D U C T I O N

Experiment

An experiment is a planned inquiry to obtain new facts or confirm or deny the result of previous experiment. Such inquiry can aid in an administrative decision, such as recommending a variety, a feed, a cultural practices, a fertilizer, a pesticide or a fungicide etc.

Type of experiments

1. **Preliminary experiments** : Here investigator tries out large number of treatments in order to obtain leads for future work. Here replications are not taken for such treatments tried e.g. number of pesticides for control of diseases - take single observation for each treatment and take decision that some of them worth trying for use.
2. **Critical experiments** : Here the investigator compares response to different treatments using sufficient observations of the responses to give reasonable assurance of detecting meaningful differences.
3. **Demonstrational experiments** : Such experiments are performed when extension workers compare a new treatment or treatments with a standard or local one. Critical experiments are very important. For such experiment, it is essential to define the population to which inferences are to be apply, design the experiment accordingly and make measurements of the variables under study.

Objectives of an experiment: In designing an experiment, state objectives very clearly as questions to be answered, hypothesis to be tested and effects to be estimated.

Experimental Unit :

An experimental unit or experimental plot is the unit or material to which a treatment is to be applied OR it is a group of material to which a treatment is to be applied in single trial of the experiment. The experimental unit may be a plot of land, a patient in a hospital, an animal, a group of pigs in a pen, a batch of seeds etc.

Treatment

The treatment is the procedure whose effect is to be measured and compared with other treatments e.g. the varieties, manures, chemicals, methods of seed treatments, nutritional and other factors in case of animal.

Precision

The term precision is concerned with the repeatability of measurements. The precision of a measurement denotes the closeness with which the measurement approaches the average of a long series of measurements made under similar conditions. Precision or Sensitivity or amount of

information is measured as the reciprocal of the variance of a mean. As the size of sample (n or r) increases $\sigma^2_x = \sigma^2/n$ or r) decreases and precision increases. A comparison of two sample means becomes more sensitive i.e. can detect a smaller difference between the population means, as the sample sizes increase.

Experimental Error

It is a measure of the variation which exists among observations on experimental units treated alike.

There are two major sources of such error.-

a. The inherent variability which exists in the experimental material to which treatments are applied.

b. The variation which results from any lack of uniformity in the physical conduct of the experiment.

The relative magnitudes of the variation due to these two sources will be different for various fields of research.

It is important that every possible efforts be made to reduce the experimental error in order to

(i) improve the power of test,
(ii) to decrease the size of confidence interval and
(iii) to achieve some other desirable goal.

How the error can be reduced ?

a. Handling the experimental material in such a way that the effects of inherent variability are reduced or error is controlled by

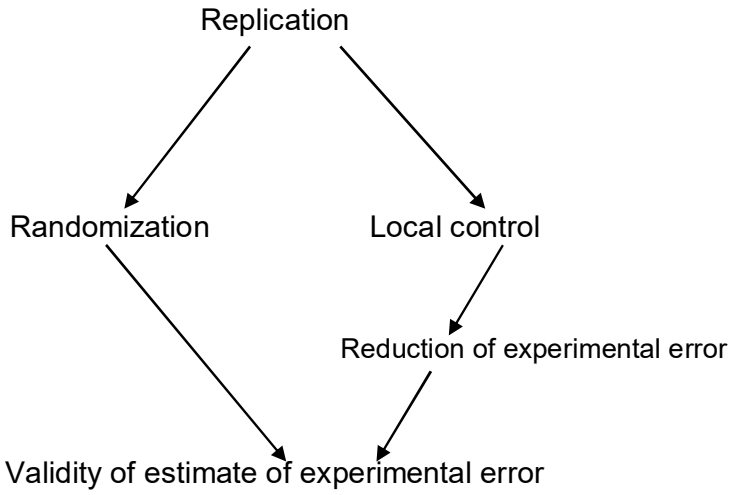
(i) experimental design,
(ii) use of concomitant observations i.e. by statistical control of error
(iii) the choice of proper size and shape of the experimental units.

b. Refine the experimental technique of experimental design by

(i) Uniformity in the application of treatments.
(ii) Control be exercised over external influence.
(iii) Suitable and unbiased measures of the effects of the treatments should be made available.
(iv) Avoid gross error by proper supervision and scrutiny of data.

PRINCIPLES OF EXPERIMENTAL DESIGN

Experiment is the main tool of agricultural research. The aim of an experimenter is to know whether the given treatment is effective or not, if effective, the magnitude of the effect must also be ascertained. The purpose of conducting an experiment is to know these facts. The main difficulty in conducting an experiment is that in which some extraneous factors mark or confuse the treatment effects. For elimination of these extraneous effects some basic principles are to be followed in planning an experiment. They are replication randomization and local control. These three principles were developed by Ronald A Fisher and F Yates and their associates at Rothamsted Experimental Station in course of their work. These three principles were involved in designing of all the experiments. That is they seek to provide by means of randomization and replication, unbiased comparison of treatments against their standard errors and aim at reducing these course with the help of replications and local control. Fisher has pictured their relationship as follows:



To understand these interrelationships the three said principles should be considered in detail.

Replication

When a treatment appears more than once in an experiment, it is said to be replicated. In otherworlds, repetition of treatment in an experiment is known as replication.

Why replications are necessary ?

(i) provide an estimate of experimental error,

(ii) improve the precision of an experiment by reducing the standard deviation of a treatment mean i.e. standard error,

(iii) increase the scope of inference of the experiment by selection and appropriate use of quite variable experimental units and

(iv) effect control of the error variance.

Factors affecting the number of replication

i. Degree of precision required.
ii. Number of treatments
iii. Design of experiment
iv. Funds and time available

Randomization

The allotment of the treatments to the experimental units by random procedure is known as randomization.

Functions

i. It assures unbiased estimates of treatment means and differences among them and

ii. it assures unbiased estimates of experimental error and thereby valid test of significance.

Local Control

The random allocation of treatments to experimental units while giving an estimate of treatment differences are free from any systematic influence of environment or bias as well as providing a correct test of significance. It is also desirable to reduce the experimental error as far as practicable without interfering with the statistical requirement of randomness because the lower the experimental error the smaller the real difference between treatments can be detected to be significant.

The reduction of experimental error can be achieved by having more homogeneous adjacent experimental units than those widely separated in an experiment. The principals which provides with greater homogeneity of a group of experimental units to reduce the experimental error is known as the local control. Based on this, various forms of plot arrangements, to suit the requirement of particular problems, experimental designs have been evolved.

Analysis of Variance

It is a summary of how much of the total variability among individual responses or yield can be explained by the treatment means and how much remains as unexplained variation among the responses or yields for a given treatment.

or

It is a mathematical process of partitioning the total sum of squares into various recognized sources of variation.

Aims of Analysis of Variances

1. To sort out the total variance and thereby estimate the variance components.
2. To test the predetermined hypotheses.
3. To evaluate the hereditary contribution in genetics problems.
4. To split up the total variation in two parts viz.,
    (i) controlled variation due to treatment and
    (ii) uncontrolled variation due to experimental error.

Assumptions underlying ANOVA

For valid use of ANOVA certain assumption should be satisfied.

1. The population from which each sample mean has been drawn is normally distributed.
2. The treatment effects and error are additive in nature.
3. Errors are normally and independently distributed with mean zero and common variance σ^2.