Linear Model :—

A statistical model is actually a linear relation of the effects of the different levels of a no. of factors involved an experiment along with one or more terms representing error effects. The effect of any factor can be either fixed or random.

~~Types of model :—~~

eg: ① The effect of two well defined level of irrigation are fixed as each irrigation level can be reasonably taken to have a fixed effect.

② If the variety of a crop is taken as a factor with no. of varieties of the crop as its level, then the effect of the varieties will be random.

The random effects belong to a finite or an infinite popⁿ. The error effects are always random and may belong either to a finite or infinite popⁿ.

Page
Date

Types of model :- There are three types of model.

(i) Fixed effects model, ii) mixed effects model (iii) random effects model.

(i) **Fixed effect model**:- A model in which each of the factors has fixed effect and only the error effects is random is called a fixed effect model.

ii) **Mixed effects Model** :- Models in which some factors have fixed effect and some have random effects are called mixed model

iii) **Random effects Model**:- Models where all the factors have random effects are called random models.

Transformations:- The main technique for the analysis of the data collected from various designs is the method of analysis of variance. This method is applicable only when the data satisfy the following assumptions:

(i) The effects of blocks, treatments and error are additive
(ii) The variance of the obserⁿ is constant.
(iii) The obserⁿ are distributed indeptly.
(iv) The obserⁿ have a normal distⁿ

There are certain types of data where all these assumptions are not statisfied. eg. when the data are in the form of percentages of say, seeds that germinate in a plot, the no. of rare insects present in soil samples or the no. of particular

types of impurities in milk sample, the assumption that the variance is constant for the different obser's does not hold good. In the first case above the obserⁿ have binomial distⁿ and hence the variance, which depends on the unknown percentage is not a constant. In other two cases the obserⁿ have a poisson distⁿ.
The method of analysis of variance is not applicable to these cases.
In such a case a non-linear transformation of the obserⁿ may improve matters in the sense that the transformed obserⁿs satisfy the above assumption (I)-(III).

~~Let X be transformed to a funⁿ F(X)~~

Let X denote a variate s.t.

$$V(X) = f(m)$$

where m is the mean of X and f(m) denotes a funⁿ of m

Page
Date

Let x be transformed to a fun^n F(x). It is known that the approximate variance of F(x) is given by.

$$V(F(x)) \cong \left(\frac{\partial F}{\partial x}\right)^2_{x=m} \cdot V(x) = \left(\frac{\partial F}{\partial x}\right)^2 f(m)$$

putting these variance equal to a constant say c^2, we get

$$\left(\frac{\partial F}{\partial x}\right)_{x=m} = \frac{c}{\sqrt{f(m)}}$$

$$\text{or } F(x) = \int \frac{c}{\sqrt{f(m)}}\, dx.$$

which (F(x)) satisfied all the assumption (i)-(iv).

Basic concepts of Design of experiments :-

Some Terms :-

Experiments :- An experiment is a device to obtain answers to some scientific query.

In comparative experiments we compare the effects of two or more factors on some pop^n characteristics.
eg:- comparison of different varieties of a crop; different fertilizers in an agricultural experiment. different diets or medicines in a dietary or medical experiment.

In an absolute experiment we determine the absolute value of some pop^n characteristics
eg :- the IQ of a group of students.

Treatments :- Various objects of comparison in a comparative experiment are called treatments. eg :- In an agricultural experiment different fertilisers in different varieties of crops are treatments.

Experimental unit :- The smallest subdivision of the experimental material in which the treatments are applied and on which the variable under study is measured is called an experimental unit.
Thus in an agricultural field experiments the plot of land on which a treatment is applied is an experimental unit. In a feeding experiment of animals, an animal is an experimental unit.

Experimental Errors :- Let a large homogeneous field is divided into different plots (of equal shape and size) and different treatments are applied to these plots. If the yield from some of the treatments are more than those of others. the experimenter is faced with a problem of deciding the observed differences are really due to treatment effects or they are due to chance factors is spoken as experimental error.
The experimental error provides a basis for comparing different treatment. The loss is its value more sensitive in the experiment.

Page
Date

It is therefore, important to estimate & control the experimental error.

Uniformity trials :— The fertility of soil does not in general increase or decrease uniformly in any direction but is distributed in the entire field in a random manner. Uniformity trials helps ~~us~~ ~~any~~ to divide the field into zones of equal soil fertility. For this the field is divided into small plots of the same size and the same treatment is applied to all the plots and the yield in each plot is noted. This enables one to divide the field into relatively homogeneous subgroups (blocks) of equal fertility to control the experimental error. The curves joining the plots of equal fertility give the isofertility contours. Uniformity trials give us a graphic picture of the variation of soil fertility. Uniformity trials also give us an idea about the shape and size of plots to be employed.

Principal of Experimental Designs :— For the validity of statistical analysis and enhancing the precision of the experiments we observe three basic principles. i) replication ii) randomisation iii) local control.

i) Replication :— Replication means the repetition of the same treatment in a no.

of plots. ① purpose being to get an estimate of the error-variance of the experiment ② Replication serves to reduce experimental error and thus enables us to obtain more precise estimates of the treatment effects. ~~From~~. We know the the standard error (S.E.) of the mean of a sample of size n is $\sigma/\sqrt{n}$, where σ is the standard deviation (per unit) of the popⁿ. Thus if a treatment is replicated r times ~~then~~ the S.E of mean effect is $\frac{\sigma}{\sqrt{r}}$, where σ^2 is the variance of the individual plot is estimated for 'error' variance.

Thus the precision of the experiment is inversely proportional to the square root of replication. However, greater is no of replications more is the cost and hence greater precision is achieved only at increased cost.

ii) Randomisation :- Randomisation means choosing an allocation of treatments to the plots (experimental unit) at random so that ~~all these possibilities~~ each treatment gets an equal chance of showing its worth.

The main objective of randomisation is

(a) The validity of the statistical tests of significance e.g. the t-test for testing the significance of the difference of two means or the 'ANOVA' F-test for testing homogeneity of several means; depends on the fact that the statistic under consideration obeys some statistical distribution. Randomisation provides a logical basis for that and makes it possible to draw inference by the use of statistical theories based on prob theory.

The purpose of randomness is to assure that the sources of variation, not controlled in the experiment, operate randomly so that the average effect on any group of units is zero. Randomisation eliminates bias in any form.

Remark:- Randomisation without replication is not sufficient.

Local control:- The purpose of the local control or blocking is to increase the accuracy of the experiment without substantial increase of cost. To achieve local control, ~~units into homogeneous groups according to these sources of variations~~ we detects some sources of variation in the experimental units and classify the experimental units into homogeneous groups according to these sources of variations. This is done in such a way that the sums of squares due to these sources of variations can be calculated seperately and hence the error sum of squares is reduced thus increasing the precision of the experiment.

When the experimental units in one direction there is a gradient (of fertility) in one direction only i.e. one way local control is used and the plots are classified according to the single sources of variation - the design is called a two-way design.

If there are two sources of variability among experimental units acting in directions which are perpendicular to one-another, units are classified into homogeneous groups according to these orthogonal sources of variations and two-way local control is used - one along rows and one along columns and such a design is a three-way design (L.S.D.)

The more local control is used the more sensitive the experiment becomes; however the complexity of the analysis also increases.

Size and Shape of Plots and Blocks :-

The size of plots depends on a no. of factors such as the total experimental area available, the no. of treatments, the no. of replication of each treatment, the crop and so on. If the total experimental area remains fixed, then an increase in the size of the plot will result in decrease in the no. of plots and consequently results in an increase in the size of block and decrease in the no. of blocks. ~~While deciding about the~~ ~~so~~ while deciding about the no. of plots it should also be kept in mind that an increase in the no. of plots increases the non-experimental areas or the so called guard-areas by which we mean the strips of land.

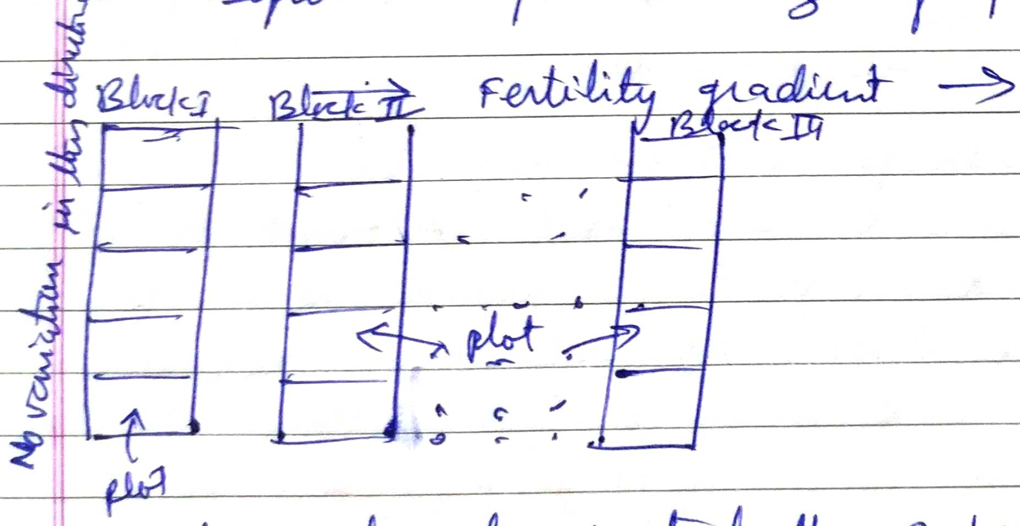
Fairfield Smith gives an empirical relationship betn the plot size and the plot variance. The relation is known as Fairfield Smith variance law & expressed as

$$V_x = \frac{V_1}{x^b} \Rightarrow \log V_x = \log V_1 - b \log x$$

Where V_x is the variance of the yield per unit area from plot size x units, V_1 is the variance among plots of size unity. b the regression coeff. is a soil characteristic indicating relationship betn adjacent units.

~~The limiting value of b are 1 and 0. b=1 mean that experimental~~

The shape and size of the plot depends upon the ~~upon~~ shape and size of plots.



In order to control the experimental error it is desirable to divide the whole experimental area into different subgps (blocks) s.t. within each block there is as much homogeneity as possible but betn blocks there is maxm variation. Further each block is to be divided into as

Page
Date

many plots as the no. of treatments. For maxi^m precision the plots should be rectangular in shape with their long sides parallel to the direction of the fertility gradient and the blocks should be arranged one after the other along the fertility gradies as shown above.