CHAPTER-II
Review of Literature

Research work done by various researchers helps on to organize ones research on proper line and utilize proper tools for interpretations of its results. The review helps to avoid short comings and repetitions of faults which may deviate from the research facts.

Long term fertilizer experiments are repositories of valuable informations regarding the sustainability of intensive agriculture. Over the years, fertilizer use became a key factor in enhancing agricultural production, because of which its consumption increased enormously. Indiscriminate use of chemical fertilizers, however, leaves a deleterious effect on the soil and environment which necessitates studies on the impact of fertilizers in a holistic manner. In this context, long term agricultural field experiments with primary focus on plant and soil nutrient aspects have been proved to be of significant importance as evidenced by the ‘Rothamsted Classical Experiments’ initiated about 160 years ago. These experiments have provided valuable data on agronomic, ecological and environmental aspects with significant scientific value. Drawing inspiration from Rothamsted model, a series of long term fertilizer experiments were initiated in different locations in India during the last century with the main focus on production and development of fertilizer requirement for various cropping systems and providing practical guidance to extension workers. An All India Coordinated Research Project on Long Term Fertilizer Experiments was launched during September, 1970 at 11 centres through the aegis of the ICAR.

1. Bhuyan K.C. (1986) “A method for combined analysis of split plot designs with heterogeneous error variances”. The effect of heterogeneous error variances are most serious when the analysis of variance technique is to be used as a method of statistical inference in analyzing a group of experiments. The problem is mainly due to the presence of places-treatments interaction. The presence of places treatments interaction indicates the
unstability of the treatments over places. However, it may not be likely that all the treatments under study are unstable over the places. In such a situation the best thing to be done is to select first, a group of treatments which are more or less stable overall experimental conditions and then to recommend the best group of treatments through pooled analysis. A method for selection of a group of whole-plot and sub-plot treatments which are stable over the places and exact method for testing homogeneity of treatment means, even with heterogeneous error variances, is described in this paper.

2. Bhuyan K.C and Gupta T.K (1982) “A group of different Designs with Heterogeneous Error Variances” For a group of experiments conducted following different designs with the same set of treatments, it is assumed that the error variance is constant for a particular experiment but it varies from experiment to experiment. Assuming error variances to be unknown, combined estimators of treatment contrast and test on treatment parameters based on all the experiments are provided. The estimation and test are based on the work of James (1954, 1951). The suggested test provides an exact test when the error degree of freedom of individual experiments are large.

3. Biswas Asim K, Karmoker P.K and Biswas Asim K. (1990) studied “The use of Ranks in the Analysis of Long Term Experiments on Tea in North East India. The analysis of lone-term experimental data on tea by ANOVA of individual year is valid but not the combined analysis over years due to heterogeneity variance-covariance matrix. This is due to successive years plots yield correlation, the magnitude of which is generally dependent upon the time lag. Among the various methods the Rank method was found to provide fairly accurate inference in testing the significance of treatment and treatment X year effects and also better practical interpretation of the results in conformity with the results based on individual year’s analysis.

4. Carmer S.G, Nuquist W.E. and Walkar W.M (1989) studied least significant differences for combined Analysis of experiments with two or three factor treatment Designs in Randomised Complete Block Split-plot and Split-
Block experiment the design discussed include a majority of the two factor design repeated over environment.

Experimental design that use complete confounding of some treatment effect are sometime poorer choices than the less complex Randomised Complete Block Design. In some cases there may be meaningful criterion for the complete confounding of main plot treatment effects with the incomplete blocks the randomised complete design should be given for consideration in combined analysis of experiments.

5. **Eberhart S.A and Russel W.A. (1966)** “Stability Parameters for Comparing Varieties” in this study the data from two single—cross dialets and a set of 3-way crosses were examined to see whether genetic differences could be detected. Genetic differences among lines were indicated for the regression of the lines on the environmental index with no evidence of nonadditive gene action. The estimates of the squared deviations from regression for many hybrids were zero, whereas extremely large estimates were obtained for other hybrids.

6. **Dr.Gandhi Prasad N.S (2002)** studied an alternative approach for the analysis of Long Term Single site Experiments. In the study, a method similar to Stability Analysis was developed for the analysis of data from Long Term Experiments with fixed crop rotation. In this modified approach stability parameters of Eberhart & Russel (1965) are proposed to be estimated by weighted least squares method instead of ordinary least squares. Weighted Regression of treatment mean on experiment is more appropriate as the variance of treatment mean changes from year to year.

7. **Gomez (1970)** This study is “An extension of the method of joint analysis of experiments in Completely Randomized Blocks”. In 1958, P.F.Gomez and Guimartes R.R proposed a method of joint analysis of experiments in Complete Randomised blocks with some common treatments.

8. **Guertal E.A, Raun W.R ,Westerman R.L and Borman R.K. (1994)** — Applications of Stability Analysis for single site, long term experiments. In this paper the author studies the three long term experiments which were
analyzed using stability analysis and linear regression of treatment means on year. All the experiments conducted for 16 years and all were soil fertility studies receiving varying amounts of annually applied N, P, and K. A randomised Block Design is used in each of these continuing long term experiments.

The conclusion of the studies was that the usefulness of stability analysis is dependent on the following conditions (i) Slopes from the simple linear regression of treatment mean on year should be equal to zero or if the slopes are not equal to zero and are slightly positive or negative. All slopes within the set of treatments of interest should be equal.

In continuous single site experiments stability analysis should not be performed on data set that contain significant slope components from regression of treatment mean on year.

9. Gupta V.K and Nigam A.K. (1982) studied the model useful for approximating Fertilizer response relationships, second order response surfaces have been used widely by experimenters when the response is assumed to be related to the input factors. This model has some disadvantages, though it is very simple in fitting. One disadvantage is the necessarily built in symmetry about the modal value. An inverse type polynomial which is a second degree polynomial but which is asymmetric in form, is an alternative to the ordinary second order polynomial. It has been found that if the observations have long tail to the right side then the performance of this polynomial is better than the ordinary polynomial. For symmetric situations the two polynomials behave equally well. However, for negatively skewed observations, the performance of ordinary polynomial is better than the performance of the inverse type polynomial.

10. Katyal V and Hegde D.M.(1994)-“Statistical Analysis of Long Term Experiments in Rice-Rice system”. From the yield trend equation it was observed that the kharif yield would decrease after a lapse of 28 years, however, during rabi, the yield actually started declining after 11\textsuperscript{th} year and the decline would be sharp after 20\textsuperscript{th} year.
11. **Maruti G.R., Vitthal K P R and Ramkrishna Y.S (2005)** studied the statistical modeling and optimization of Fertilizer nutrients for rain fed crops based on soil and weather parameters under dryland conditions. The data generated from Long Term Fertilizer Experiments (LTFE) conducted for a period of 12 seasons in the same experimental site for rainfed crops at different locations of AICRP for dryland agriculture.

   Based on regression models calibrated for predicting yield through rainfall and land degradation. It was found that Sorghum yield had a higher coefficient of determination or productivity ($R^2$) followed by other crops.

12. **Marawar S S, Jahgirdar S.W. and Kakde S.J. (1999)** studied to identify the factors Discriminating Defaulters from Non defaulters in Agricultural Finance. In his study an attempt has been made to develop a criteria which helps to classify the borrowers into defaulters and non defaulters with the help of Discriminant Function Analysis. The result of the study indicated that percentage of irrigated area to operated area, per capita income from crop production, per capita consumption, proportion of loan put under production purposes and repayment capacity were found to be most important factors in discriminating defaulters from non defaulters.

   The Discriminant function analysis revealed that the size of land holding and total income are the important factors which are useful in classifying the small and medium farmers into litigants and non litigants. Land ownership has been the main factor contributing to the involvement of farmers in legal disputes. These findings provides government officials and pleaders in concentrating their efforts to educate the farmers in restraining from the involvement in legal disputes.

13. **Mcintosh M.S (1983)** studied the “Analysis of Combined Experiments”. Most field experiments are conducted over two or more locations or years, yet statistical references do not contain sufficient detail for complete analysis. The purpose of this paper is to provide a reference for analysis of combined experiments. With more than one factor.
14. **Nambier K K M (1985)** “All India Coordinated Research Project On Long Term Fertilizer Experiments and its Research Achievements”. Balanced use of chemical fertilizers (at 100-150 per cent of NPK) based on soil test values continued to maintain sustained high level of production in almost all the soils and cropping systems. Incorporation of FYM (along with 100 per cent of NPK) enhanced the productivity.

Need based liming of acidic soils not only restored yield stability but also improved productivity.

Application of N,P,and K at 100 per cent ( and above) , improved appreciably the build-up of N,P and K in most of the soils. However, application of N,P and K at 50 per cent ( of the recommended doses) indicated drawn down of these nutrients in the soil in comparison to the initial levels.Appreciable increase in organic carbon level was also recorded under 100 per cent NPK plus FYM treatment and was significant in most of the cases.

15. **Pandey U.K and Murlidharan M.A.(1977)**-An application of Discriminant Function in Agricultural Finance- The present study attempts to develop criteria for classifying the borrowers according to their willingness to repay the loans on the basis of differences in their socio-economic characteristics . The objective of the study were to classify the borrowers into non-defaulters and defaulters on the basis of differences in their socio-economic characteristics ,and secondly , to classify the defaulters into non-willful and willful defaulters on the basis of differences in their socio-economic characteristics.

In this he used a Discriminant Function approach to discriminate between the groups of non-defaulters and defaulters or non-willful and willful defaulters.

The Discriminant function Analysis indicated that the percentage of income from sources other than crop production to the total income , amount of loan put under production purposes (utilization of loan) ,per capita consumption expenditure and percentage to cash expenditure to total
expenditure were the major characteristics which classified the borrowers into defaulters and non defaulters. Similarly, literacy, percentage of income from the sources other than crop production to the total income, operated size of holdings and percentage of cash expenditure to the total expenditure were the major characteristics which classified the defaulters into willful and non willful defaulters groups. However, the utilization of loan and operated size of holdings were the major characteristics which classified the borrowers into defaulters and non defaulters and into willful and non willful defaulters respectively.

16. Prabhakaran P.V and Rani John (1996) studied an alternative approach for the analysis of data of long term experiments it is necessary to repeat or trial of a set of treatments at a number of places and in a number of years in order to know the susceptibility of the treatment effect to place and climatic variations the usual practice is to perform a joint analysis applied for groups of experiments.

The method developed in this paper is an extension of Friedman's two way analysis of data from groups of experiments. An extension of Quade test for groups of experiments might be better than the test proposed by Friedman'. For extremely small number of treatments. However, for large number of treatments both the tests are equally powerful. The procedure presented in the paper specially suited for the analysis and interpretation of data from groups of experiments involving relatively larger number of treatments.

17. Prabhakaran P.V and Rani John (1996) studied “An alternative approach for the analysis of data of long term experiments”. In this study he suggested a new method for the analysis of data of repetitive trails with dependent set of observations. The method was applied to the data generated from the permanent manurial trail on rice at Pattambi and the results indicated that it is slightly more efficient than the usual split-plot analysis and the analysis of groups of experiments.
18. Pramod Kumar and Lalith Achoth (2001) in their paper “Performance of Regional Rural Banks in India-A Principal Component Analysis Approach.” Agricultural growth and conditions of small and marginal farmers depends on the performance and progress of Regional Rural Banks. The study seeks to examine the performance of Regional Rural Banks in various states of India with the objectives to evaluate the performance of Regional Rural Banks and distinguish between Regional Rural Banks of the states with good performance and bad performance and to identify the factors having a bearing on the performance of Regional Rural Banks.

Discriminant Function Analysis was done to find out factors which discriminate the two groups. In order to ensure the overall performance a balance between potential and functional priority should be set with regard to the structure of lending area of operation and bank and branch expansion.

It is observed that the factors which discriminate the two groups are (i) Number of districts covered (ii) short term credit (Amount) (iii) Agricultural investment (amount) (iv) Short term (amount per account) (v) Deposit (Amount per account). Thus, RRBS should selectively expand into areas where the potential for agriculture exists and resource mobility should have a balanced portfolio comprising a blend of short term loan, term loan and amount of loan per account.

19. R. VijayaKumari. and Dr. A. Nageswara Rao (1996)-Factors Discriminating Litigant farmers from Non-Litigant Farmers. This study is an attempt towards studying the closely associated factors of the truly effected farmers from other farmers.

Two groups are required to be of roughly equal for the application of Discriminant function. With the Discriminant function, it is able to measure the net effect of variables and the effect of the variable by holding other variables constant. The relative importance of variables in regard to their power to discriminate the two groups can also be known with the help of Discriminant Function.
The Discriminant function analysis revealed that the size of land holding and total income are the important factors which are useful in classifying the small and medium farmers into litigants and non litigants. In case of large farmers those who has higher per cent area under commercial crops and higher income are inclined to have legal dispute with other farmers. Land ownership has been main factor contributing to the involvement of farmers in legal disputes. These findings proves certain guidelines to the local leaders, non government and social organizations and government officials and pleaders in concentrating their efforts to educating the farmers in restraining from the involvement in legal disputes.

20. Raheja S.K. and Tyagi B.N.(1974) studied the statistical analysis of replicated field trials on Cultivators fields. The method of statistical analysis developed in this paper is, therefore directed towards obtaining the expected values of the mean sums of squares for different components leading to appropriate tests of significance and standard errors for differences in mean yields of various treatments.

The results would be generally required to be presented at the district level instead of presenting these at the zonal level. For obtaining estimates at the district level one can use weighted averages, the area under the crop being taken as weight. In this case however, simple mean has been taken as the zones were approximately of equal size.

The results shows that the responses of paddy to N, P, and K were significant, the other being non significant.

21. Rai S.C and Rao P.P (1980) studied the use of ranks in Groups of Experiments by ranking the individual observations of different treatments in each replication. This method is very useful specially for the trials when the error variances are not homogeneous and analysis of variance technique is not valid.

22. Rai S.C and Rao P.P (1984) studied rank analysis of groups of Split plot experiments. In this study a method which does not involve some of the assumptions needed in the case of analysis of variance has been developed.
In this new method ranks of treatments are considered instead of their actual values and suitable tests are developed for comparing the means of ranks of different treatments in the case of factorial experiments laid out in split plot designs.

The method described in the paper uses information on ranks and makes no use of the quantitative values of observations as such. For this reason no assumption is required to be made as to the nature of underlying universe. The technique of rank analysis has been suggested to overcome the situations when the error variances are heterogeneous in pooling the results from groups of experiments. The procedures for the presence of interaction between treatments and places or years have also been evolved.

23. Rao P.P. and Bhargava P.N. (1985) “Intercropping data analysis through the method of Ranking” For the analysis of intercropping data, the approach adopted in the past was converting the yield component crops into univariate or applying the usual bi-variate analysis technique. These methods have some limitations. In the present paper some of the limitations have been discussed and a distribution free method through ranking is proposed. The test statistic “C” is also given. The significance of “C” indicates that the mean ranks obtained by the treatments is not due to chance. Any pair of treatment mean ranks may be compared by students –t test. This method is also extende for the groups of experiments.

24. Raun W.R., Barreto H.J. and Westerman R.L (1993) “Use of Stability Analysis for Long Term soil fertility Experiments”. Long Term fertility Experiments with replications are often statistically analyzed as split plot in time. Years are often shown to be significantly different and inconsistency of treatment effects over years enters year-by-treatment interaction which are difficult to interpret. The objectives of the study were to evaluate long term fertility experiments by stability analysis and relative stability and to observe possible benefits of these analysis to complement conventional analysis of variance procedures. Stability analysis may also be useful for multilocations.
experiments and continuous site experiments where treatments are applied to same plot year to year.

Recommendation strategies could possibly be refined by the added use of stability and relative stability analysis when assessing agronomic treatment response over time. As issues of sustainability analysis become increasingly important, stability analysis and relative stability may assist in our understanding of yield as a function of environment, as well as identifying areas that warrant further investigation.

25. Rawlo S. and Das M.N. (1978) studied on An Alternative Approach for Interpretation of data collected from Groups of Experiments. In the usual analysis of groups of experiments it not possible to find, if any, particular treatment has a tendency to behave uniformly or otherwise with changing environment. For studying the stability of performances of different varieties of Barley, a method was initiated by Finlay and Wilkinson (1963), Eberhart and Russel (1966) proposed a model involving a stability coefficient for variety assessment. This technique has been extended here for assessing manurial treatments. This stability analysis method has been applied for the interpretation of data collected from an experiment conducted in a research station and to the data from simple fertilizer trials conducted in three districts for four years. From an interpretation of the results obtained from the analysis of the data some treatments could be singled out as promising.


In this study, the response of Sorghum to 18 fertilizer treatments applied over a period of 13 years from 1979-80 to 1991-92 was analyzed to study the extent of variation due to weather.

For this purpose the years were classified into homogeneous groups using cluster analysis. Six weather variables at four stages of crop growth were used. Weights were applied to differences in variables according to their importance for calculating distances between years. Method of complete
linkage was used to combine years. 13 years could be classified into 5 homogeneous clusters. Mean yields of these clusters were significantly different from each other for all treatments and control. Variation in response due to cluster was examined by regressing responses over clusters. It was found that quadratic equation were good fit and accounted for more than 80% variation in the responses.

It was observed that the differences in responses of different treatments were not high in favorable weather years.

27. Saksena Asha, Bhatia Ajit Kaur and Sikarwar H.S. (2001) studied the behavior of wheat response to long term fertilizer application. Response of wheat to eighteen fertilizer treatments and a control applied over a period of thirteen years were analyzed to study the extent of variation due to changes in weather and soil fertility. Regression of responses over clusters (formed on the basis of homogeneous weather conditions) were found to be quadratic in nature. Clusters accounted for 8 to 54 percent variation in responses of treatments containing no P₂O₅. However, variation accounted in responses of other treatments was between 87 and 95 percent. Difference in responses of various treatments in unfavorable years was smaller than in favorable years. .80 Kg ha⁻¹ was optimum dose of nitrogen. P₂O₅ was found to be essential nutrient. No steady deterioration in responses of any treatment was observed. Performance of treatment N80:P80:K40 was best in favorable as well as unfavorable years.

28. Sarkar Ananta, Rajendra Prasad and Vats M.R. (2005) studied the multivariate analysis of variance of data from Long term Fertilizer Experiments. In LTFE, the treatments are applied to the same set of experimental units over a sequence of years. These experiments are generally conducted in Randomized Block Design. Same designed layout (including randomization) is followed over years. In this study the data from AICRP on LTFE of ICAR using randomized Complete Block Design is used. He had suggested that multivariate analysis of variance (MANOVA) is better over the univariate analysis of variance (ANOVA). Combined analysis of data over years using
the procedure of groups of experiments or Split Plot analysis (taking years as sub plots.) is not valid because the observations from the same plot may be correlated.

The inference made on the basis of a partial variation of the population may be misleading. To tackle this problem, he developed a multivariate treatment contrast analysis procedure based on Wilk’s Lambda criterion. Several pair wise comparisons that are non significant through univariate analysis are found to be significant through multivariate contrast analysis.

29. Shivmurthy M and Girija P.P (2001) in their study on “ Discriminant Function Analysis of Characteristics of Fruits And Vegetables growers marketing through HOPCOMS and other Channel .The Cooperative marketing societies can be looked as the best alternative channel which can look after the interest of the fruits and vegetable growers. But the extent of use of this channel is very low Wadkar et. al. 1994 .Sudha and Subramanyam,1996. Therefore, this study has been designed with the objective of identifying the factors discriminating the fruits and vegetables growers in marketing the produce through HOPCOMS Horticulture Producers Cooperative Marketing And Processing Society and other channels OC like Commission Agents ,Wholesalers, Pre-harvest contractors Retailers etc.

Discriminant Function results reveals that HOPCOMS users were characterized with higher mean values on all the variables except three variables ,i.e age, loyalty to market channel and level of aspiration for financial status in these variables. OC users had higher mean. Coefficient of Discriminant function and the distance between two groups revealed that 10 variables contributed positively for discrimination between two groups and five were negatively contributed.

Highly significant chi-square value of the Discriminant function and high percentage of correct classification of the group membership indicated that function was able to predict the group membership clearly based on measured variables. Thus, the producers who are more stable in social, economical and agricultural background seem to prefer HOPCOMS , the cooperative
marketing system. Suitable strategies need to be devised to attract producers from lower socio-economic background. These blocking characteristics need to be overcome by providing remedial measures in order to encourage the cooperative movement in marketing of vegetables & fruits.


Stability Analysis For Yield And its Components in Rice (ORYZA SATIVA). As rice is a major cereal source of energy, continuity in yield amelioration and step wise stabilization is thus the most important philosophy in rice breeding. The quantum can be realized by breeding a genotype performing the best over all the environments. The best way to achieve net increase in the overall production would be to develop genotypes specific to specific environment. Present study therefore, was conducted to identify stable genotypes of rice for different agronomic characters under diverse environments.

Analysis of variance and pooled analysis of variance showed that genotype mean squares were highly significant for all the characters. It indicated that there were sufficient differences among the genotypes.

31 Singh B. (2001) studied “On the performance of two sample linear Discriminant Function” . In his study he uses the Fisher’s linear Discriminant function. The linear Discriminant function yields optimal results in the sense of smallest probability of misclassification (PMC) when parameters are known. He also obtained numerical values through simulated sample from multivariate normal populations for certain apriori values of parameters to study the performance of SLDF (Sample linear Discriminant Function) and the validity of theoretical results for practical applications.

32 Soni P.N., Sikarwar H.S. and Mehta D.K (1988) on their study of Long Term Effects of Fertilizer applications on productivity in rice-wheat sequence, the experiments were conducted on the same site on rice and wheat crops grown in sequence with graded levels of fertilizers. The results in general indicates very little scope of reducing or skipping any amount of nitrogen, phosphorus and potassium either for rice crop or to the wheat. Continuous application of these major nutrients to the crops at
recommended level of 120Kg.N +80Kg.P\(_2\)O\(_5\) +40Kg K\(_2\)O per hectare could sustain high yield and maintain soil fertility. A Linear Regression approach was used.


   “An investigation of the Validity and usefulness of Trend Analysis for field plot data” in this blocking is sometimes ineffective in accounting for a field’s systematic, spatial variation. In such cases, trend analysis has been proposed as an alternative method. This procedure fits a polynomial regression function to account for some of the systematic variability. Computer simulated data were used to test the statistical validity of trend analysis. Data simulation facilitated this evaluation, because the experimental condition of treatment variation, systematic variation and random variation could be computer generated within prescribed limits. The validity of the significance levels in trend analysis was evaluated. Also, trend analysis was compared to the random complete block analysis with regard to power of test and estimation of treatment effects. These studies show that with proper restrictions on choosing the surface model, trend analysis has true significance levels close to assumed levels. In addition, trend analysis was often superior to the randomized block analysis in power, and offered less biased estimates of treatment effects, especially when the pattern of systematic variation was complex and curvilinear.

   Trend analysis is a valuable addition as a data analytic tool. These studies reinforce the conclusion that in experiments where blocking turns out to have been ineffective, trend analysis can be both statistically valid and useful.

34. **Tyagi B.N, Kathuria and Rao P.P (1970)** The analysis of groups of experiments involving several factors. The object of the study was to present methods for combining results of similar factorial experiments conducted over a number of years or at a number of places particularly in case when the data are available in the form of two-way tables of means along with their standard errors. In such cases no information is available about second and higher
order interactions between factors. Therefore, these interactions have been ignored from the combined analysis without any loss of information.

In agricultural field experimentation the results of an experiment conducted at a particular place or in a particular year are not of much practical use unless the experiment is repeated at a number of places over a number of years. The results of the experiments after pooling over a number of places or years will be more broad-based and more stable and help the research workers in formulating future experimental programmes and the extension workers in discriminating information for practical farming.

In combining the results of similar experiments involving two or more factors under treatments there are several problems involved. Some of the interactions of treatment effects with year may be present and some of them may be absent. Further among the interactions that are present all of them may not be homogeneous. This makes the testing of treatment effects difficult.

The methods of combining results have been illustrated with the help of an example.


For the Long Term Fertilizer Experiments conducted on crop sequence, the analysis of data is usually undertaken for individual crop in the sequence as no sound procedure of analysis is available for combining different crops in the sequence. As treatment effects are likely to vary from crop to crop, it is difficult to decide what weight of one crop is equivalent to unit weight of another crop. In such cases the common practice is to convert the yield of individual crop in monetary terms.