

## List of Publications

### Research papers published in national and international journals of repute

1. Ahmad, T. and Rai, A. (2002). An approach to GIS based spatial sampling procedures for environmental studies in agriculture. *Amer. J. Math. Manag. Sci.*, **22(3&4)**, 251-260.
2. Alam, Wasi, Wahi, S.D. and Kumar, Anil (2003). A comparative estimation approach for time series forecasting of oilseeds in India. *J. Farm. Sys. Res. Dev.*, **9(1)**, 120-121.
3. Arya, A.S. and Arya, Prawin (2004). Circulant designs: Critical review and new insight. *J. Ind. Soc. Agril. Statist.*, **57**, 289-308.
4. Bhar, Lal Mohan and Dey, A. (2003). Robustness of nested balanced incomplete block designs against missing data. *J. Ind. Soc. Agril. Statist.*, **56(1)**, 25-38.
5. Bhar, Lal Mohan and Gupta, V.K. (2003). Study of outliers under variance-inflation model in experimental designs. *Ind. Jour. Agric. Stat.*, **56**, 142-154.
6. Bhardwaj, S.P. and Sivaramane, N. (2002). Study of spatial integration of gur/jaggery markets in India. *Bihar J. Agric. Market.*, **10(1)**, 58-64.
7. Statistical studies on the effect of integrated nutrient management in rice-wheat sequence. *J. Farm. Sys. Res. Dev.*, **9(1)**, 66-68.
8. Chandran, K. P. and Prajneshu (2004). Computation of growth rates in agriculture: Nonparametric approach. *J. Ind. Soc. Agril. Statist.*, **57**, 382-392.
9. De, D., Chandra, Hukam and Singh, R.S. (2002). Farm power availability pattern and its impact on food grain productivity in Madhya Pradesh. *J. Agric. Engg.*, **39(3)**, 12-25.
10. Garg, R.N., Kumar, Rajendra, Kumar, Anil and Gupta, V.H. (2002). Study of correlation between physical properties of sandy loam soil and yield of wheat influenced by bio-gas slurry and fly ash. *J. Farm. Sys. Res. Dev. Assoc.*, Modipuram, Meerut.
11. Garg, R.N., Kumar, Rajendra, Taumar, R.K., Kumar, Anil and Gupta, V.K. (2003). Study of correlation between physical properties of sandy loam soil and

yield of wheat influenced by biogas slurry flyash. *J. Farm. Sys. Res. Dev.*, **9(1)**, 144-145.

12. Ghosh, H. and Das, A. (2004). Optimal diallel cross designs for the interval estimation of heredity. *Statist. Probab. Lett.*, **67**, 47-55.
13. Ghosh, H. and Das, A. (2003). Optimal diallel cross designs for estimation of heritability. *J. Statist. Plann. Inf.*, **116**, 185-196.
14. Gola, R.C. and Rai, Anil (2003). Two stage successive sampling with partial replacements of units. *J. Ind. Soc. Agril. Statist.*, **56(2)**, 155-165.
15. Gupta, V.K., Parsad, Rajender and Das, Ashish (2003). Variance balanced block designs with unequal block sizes. *Utilitas Mathematica*, **64**, 183-192.
16. Kandala, V.M. and Prajneshu (2003). Application of fuzzy regression methodology in agriculture. *Ind. J. Agri. Sci.*, **73**, 456-458.
17. Kapoor, J.K. and Kumar, Rajendra (2003). Study of main effects and their interactions for cultural cum manurial experiments with similar treatments of the same place over number of years. *Ann. Agric. Res.*, **24(3)**.
18. Kar, Abhijit, Chandra, Pitam, Parsad, Rajender, Samuel, D.V.K. and Khurdiya, D.S. (2003). Comparison of different methods of drying for banana (*Dwarf Cavendish*) slices. *J. Food Sci. Tech.*, **40(4)**, 378-381.
19. Kaul, Sushila (2002). Marketing and price structure of livestock products. *Bihar J. Agric. Market.*, **10(1)**, 51-57.
20. Kolluru, Ramesh, Rana, P.S. and Paul, Amrit Kumar (2003). On modeling for growth pattern in crossbred cattle. *Ind. J. Anim. Sci.*, **79(10)**, 1174-1179.
21. Krishan Lal and Gupta, V.K. (2003). Robustness of youden square designs against missing data. *J. Ind. Soc. Agril. Statist.*, **56(2)**, 107-116.
22. Krishan Lal and Jeisobers, T. (2002). Robustness of diallel cross designs against the loss of any number of observations (crosses) in a block. *J. Ind. Soc. Agril. Statist.*, **55**, 361-370.
23. Kumar, Jitender, Singh, Gynendra, Walia, S., Parsad, Rajender and Parmar, B.S. (2003). Control release formulation of butachlor; soil release and its bio-efficacy against *Eichnoacoloa*. *Ind. J. Agri. Sci.*, **73(8)**, 441-445.

24. Mathur, D.C., Sud, U.C., Bathla, H.V.L. and Sharma, D.P. (2003). **Comparison of crop cut and farmers' estimates**. *Ind. J. Agri. Sci.*, **73(2)**, 628-629.
25. Mogha, A.K., Gupta, R. and Gupta, A.K. (2003). **A two unit parallel system with correlated lifetimes and repair machine failure**. *Ind. Assoc. Probab. Qual. Rel. Trans.*, **28(1)**, 1-23.
26. Farooqi, Samir, Singh, Niranjan and Islam, Shahnawazul (2002). **Information technology potential and prospects**. *Agric. Extn. Rev.*, (Sept.-Oct.), 25-27.
27. Narain, Prem, Sharma, S.D., Rai, S.C. and Bhatia, V.K. (2003). **Evaluation of economic development at micro level in Karnataka**. *J. Ind. Soc. Agril. Statist.*, **56(1)**, 52-63.
28. Narang, M.S., Mehrotra, P.C. and Bhatia, A.K. (2003). **Post stratified estimator in two stage design using auxiliary information**. *J. Ind. Soc. Agril. Statist.*, **56(3)**, 222-229.
29. Singh, Niranjan, Farooqi, Samir and Dhandapani, A. (2002). **Integrated pest management and the World Wide Web**. *Agric. Extn. Rev.*, (Nov.-Dec.), 9-11.
30. Paul, Amrit Kumar and Bhatia, V.K. (2003). **Estimation of heritability using some auxiliary traits in dairy cattle**. *J. Ind. Soc. Agril. Statist.*, **56(2)**, 131-41.
31. Prajneshu and Kandala, V.M. (2003). **Mixed-influence nonlinear growth model**. *J. Ind. Soc. Agril. Statist.*, **56**, 19-24.
32. Rai, S.C. and Bhatia, V.K. (2004). **Dimensions of regional disparities in socio-economic development of Assam**. *J. Ind. Soc. Agril. Statist.*, **57**, 178-190.
33. Raju, B.M.K. and Bhatia, V.K. (2003). **Comparison of various measures of stability with respect to ranking ability under varying situations**. *J. Ind. Soc. Agril. Statist.*, **56(3)**, 276-293.
34. Raju, B.M.K. and Bhatia, V.K. (2003). **Bias in the estimates of sensitivity from incomplete G x E tables**. *J. Ind. Soc. Agril. Statist.*, **56(2)**, 177-189.
35. Singh, Randhir (2003). **Use of satellite data and farmers eye estimate for crop yield modeling**. *J. Ind. Soc. Agril. Statist.*, **56(2)**, 166-176.

36. Rathore, Abhishek, Parsad, Rajender and Gupta, V.K. (2004). **Computer aided construction and analysis of augmented designs**. *J. Ind. Soc. Agril. Statist.*, **57**, 320-344.
37. Sahoo, N., Rajput, T.B.S., Rao, A.R. and Bhattacharya, A.K. (2003). **Estimation of watershed run off through geomorphological parameters**. *J. Soil Water Cons.*, **2(1&2)**, 16-26.
38. Sandhya Kiran, P., Bhatia, V.K. and Rao, A. R. (2003). **Sampling distributions of heritability**. *J. Ind. Soc. Agril. Statist.*, **56(3)**, 294-301.
39. Sandhya Kiran, P., Bhatia, V.K. and Rao, A. R. (2004). **Robust method of estimation of heritability**. *J. Ind. Soc. Agril. Statist.*, **57**, 116-128.
40. Mishra, Sanyat, Gupta, Y.C. and Rao, A.R. (2003). **Correlation and path coefficient studies in Carnation**. *J. Ornaml. Horti.*, **6(1)**, 24-28.
41. Sarker, Subhra, Gupta, V.K. and Parsad, Rajender (2003). **Robust block designs for making test treatments - control treatment comparisons against the presence of an outlier**. *J. Ind. Soc. Agril. Statist.*, **56(1)**, 7-18.
42. Sethi, S.C., Mathur, D.C. and Sharma, S.K. (2003). **Role of holding size in cultivation of paddy crop**. *Haryana Eco. J.*, **23(1-2)**, 110-111.
43. Sethi, S.C., Mathur, D.C. and Sharma, S.K. (2003). **Price spread and marketing pattern of vegetable crops**. *Haryana Eco. J.*, **23(1-2)**, 131-132.
44. Sharma, V.K., Jaggi, Seema and Varghese, Cini (2003). **Minimal balanced repeated measurements designs**. *J. Appl. Statist.*, **30(8)**, 867-872.
45. Sharma, V.K. and Kaur, Rajinder (2003). **Statistical analysis of a long-term experiments on rice (*Oryza sativa*) based cropping systems**. *Ind. J. Agri. Sci.*, **73(7)**, 384-390.
46. Sharma, V.K., Kaur, Rajinder and Sharma, Amita (2003). **A statistical investigation on integrated nutrient supply system in a long-term experiment on rice-wheat cropping sequence**. *J. Farm. Sys. Res. Dev.*, **9(1)**, 59-65.
47. Sharma, V.K., Varghese, Cini and Jaggi, Seema (2002). **On optimality of change-over designs balanced for first and second order residual effects**. *Metron*, **60(3-4)**, 155-164.

48. Singh, G. and Chandra, H. (2002). **Analysis of growth trends in cost of cultivation of wheat crops in India.** *J.Agric. Situation in India*, **59(6)**, 341-349.
49. Singh, N. Okendro and Wah, S.D. (2003). **Effect of sample size and structure on the bootstrap estimate of variance of heritability.** *Ind. J. Anim. Sci.*, **73(5)**, 471-473.
50. Singh, Rakesh, Kumar, Jitendra, Deshwal, R.P., Randhawa, G.J., Walia, Suresh, Parsad, Rajender and Parmar, Balraj S. (2002). **Morphological, chemical and genetic variability in Neem accessions from north-west India.** *Ind. J. Plant Genet. Res.*, **11(3)**, 237-247.
51. Singh, G. and Chandra, Hukum (2003). **Analysis of economic factors and productivity in food grains production in India.** *Asian Eco. Rev.*, **45(2)**, 354-374.
52. Singh, Randhir (2004). **Application of remote sensing technology for crop yield estimation.** *J. Ind. Soc. Agril. Statist.*, **57**, 226-246.
53. Sinha, P., Prajneshu and Varma, A. (2004). **Statistical modeling and forecasting of powdery mildews affecting agricultural crops: An overview.** *J. Ind. Soc. Agril. Stat.*, **57**, 257-270.
54. Soam, S.K., Manikandan, M.R., Mishra, Dushyant, Sharma, Anu and Suman, R.S. (2003). **Participatory agroecosystem analysis and identification of problems of a village in bundelkhand region.** *Manage Extn. Res. Rev.*, **4(1)**, 21-31.
55. Varghese, Cini, Sharma, V.K. and Rao, A.R. (2003). **Optimality of circular cross-over designs balanced for first and second residuals.** *Utilitas Mathematica*, **64**, 221-228.

#### **Research papers accepted for publication**

1. Chandra, Hukum and Singh, G. (2004). **Production and economic factor analysis in sugarcane cultivation in India from a statistical perspective.** *Ind. Sugar*, Journal of Indian Sugar Mills Association of India.
2. Chandran, K.P. and Prajneshu. **Modelling rice productivity: Additive nonparametric regression approach.** *Nat. Acad. Sci. Lett.*
3. Chattopadhyay, C., Agrawal, Ranjana, Kumar, Amrender, Bhar, L.M., Meena, R.L., Shekhar, Chander, Meena, P.D., Sharma, K.C., Chakravarthy, N.V.K., Mehta, S.C., Awasthi, R.P., Singh, S.N., Kumar, Ashok, Srinivasa Rao, M., Yella

- Reddy, D., Prasad, Y.G., Ramakrishna, Y.S. (2003). **Forewarning white rust on oilseed Brassica in India.** *J. Phytopathology*.
4. Devraj and Chaturvedi, K.K. **Internet for technology transfer in agriculture.** *Agric. Extn. Rev.*
  5. Dhekale, J.S., Parsad, Rajender and Gupta, V.K. **Analysis of intercropping experiments by using experiments with mixtures methodology.** *J. Ind. Soc. Agril. Statist.*
  6. Ghosh, H. and Pal, A. (2002). **Estimation of variance components in diallel cross design.** Edited book "Recent Advances in Mating Designs".
  7. Ghosh, H. and Prajneshu (2003). **Nonlinear time series modelling of volatile onion price data using AR(p)-ARCH(q)-in-mean.** *Cal. Stat. Assn. Bull.*
  8. Ghosh, H. and Prajneshu. **Nonlinear time-series modelling of volatile onion price data using AR(p)-ARCH(q)-in-mean.** *Cal. Stat. Assn. Bull.*
  9. Gupta, A.K., Mogha, A.K. and Gupta, R. (2003). **A two unit active redundant system with two phase repair and correlated life times.** *Aligarh J. Stat., AMU, Aligarh.*
  10. Singh, Gyanendra and Chandra, Hukum (2004). **Analysis of effect of use of fertilizer, irrigation and farm power in increasing food grains productivity in Maharashtra.** *PKV Res. J., Dr. Punjab Rao Deshmukh Krishi Vidhya Peeth, Akola, Maharashtra.*
  11. Handa, D.P., Jaggi, Seema, Gill, A.S. **Path analysis technique to assess the relationship of wheat yield with its components under agroforestry system.** *Ind. J. Forestry.*
  12. Handa, D.P., Jaggi, Seema, Gill, A.S. and Singh, N.P. (2003). **Impact of fruit trees on the yield of wheat crop.** *Ind. J. Forestry.*
  13. Handa, D.P., Jaggi, Seema, Gill, A.S. and Singh, N.P. (2003). **A correlation and path coefficient analysis of wheat components under multipurpose tree species.** *Ind. J. Forestry.*
  14. Jaggi, Seema, Handa, D.P., Gill, A.S. and Singh, N.P. **Land equivalent ratio for assessing yield advantages from agroforestry experiment.** *Ind. J. Agri. Sci.*

15. Kumar, Rajender and Kapoor, J.K. (2003). Study of output-input ratios of various crops at various levels of cultural practices at optimum level of fertilizer nutrients in the country. *Ann. Agric. Res.*, **24(4)**.
16. Misra, A.K., Om Prakash and Ramasubramanian, V. (2004). Forewarning powdery mildew caused by *Oidium mangiferae* in mango (*Mangifera indica*) using logistic regression models. *Ind. J. Agric. Sci.*
17. Panwar, Sanjeev and Kumar, Anil (2004). Non-linear growth modelling of apple productivity of different states in India. *J. Farm. Sys. Res. Dev.*
18. Parsad, Rajender and Satpati, S.K. Nested block designs for comparing test treatments with a control. *Utilitas Mathematica*.
19. Parsad, Rajender, Gupta, V.K. and Gupta, Sudhir. Optimal designs for 2-line and 4-line cross experiments. *Utilitas Mathematica*.
20. Paul, Amrit Kumar, Singh, Indra and Bhatia, V.K. A note on estimation of heritabilities of different dairy characteristics of Kankrej breed by different methods. *J. Anim. Res.*
21. Singh, Rajendra, Krishan Lal and Thomas, B.F. Analysis of lactation curves repeated measurements for unequal lactation length. *J. Ind. Soc. Agril. Statist.*
22. Ramasubramanian, V., Singh, R. and Rai, A. (2001). An empirical investigation on reliability of Jackknife estimation under two-phase sampling for stratification. *Ind. J. Appl. Statist.*
23. Rao, A.R. and Sanjeev Kumar. Bayesian estimation of heritability using Gibbs sampling for half-sib mating design. *Ind. J. Appl. Statist.*
24. Singh, G. and Chandra, Hukum (2004). Production and economic factors analysis of crop cultivation, (Part – I) Groundnut. *Ind. J. Oilseed Res.*, Directorate of Oilseeds Research, Hyderabad.
25. Singh, G. and Chandra, Hukum (2004). Production and economic factors analysis of oilseed cultivation, (Part – II) Rapeseed and Mustard. *Ind. J. Oilseed Res.*, Directorate of Oilseeds Research, Hyderabad.
26. Singh, G. and Chandra, Hukum (2004). Analysis of trends in food grains area, yield and production in Maharashtra. *PKV Res. J.*, Dr. Punjab Rao Deshmukh Krishi Vidhya Peeth, Akola, Maharashtra.

27. Varghese, Cini and Sharma, V.K. **A series of resolvable PBIB(3) designs with two replicates.** *Metrika*.
28. Vats, M.R., Sehgal, D.K. and Mehta, D.K. (2004). **Mid course bifurcation of plots in long term fertilizer experiments.** *Appl. Statist.*
29. Wahli, S.D. and Rao, A.R. **Estimation of variance of repeatability estimators for perennial crops.** *Ind. J. Appl. Statist.*
30. Wahli, S.D., Lal Chand and Bhatia, V.K. **Study on growth pattern in crosses and pure Indian breeds of goats.** *Ind. J. Anim. Sci.*

## **Research Project Reports**

### **(i) Published**

1. **A study of land use statistics through integrated modelling using Geographic Information System** by Anil Rai, A.K. Srivastava, Randhir Singh and V.K. Jain.
2. **Design and analysis of Agroforestry Experiments** by DP Handa, Seema Jaggi, V.K. Sharma and A.S. Gill.
3. **Development of GIS based techniques for identification of potential agro-forestry areas** by Tauqueer Ahmad, Randhir Singh and Anil Rai.
4. **Development of statistical procedures for selecting genotypes simultaneously for yield and stability** by A.R. Rao, V.T. Prabhakaran and A.K. Singh.
5. **Impact assessment of technology intervention and crop diversification in tribal, backward and hilly areas (Programme 6) pertaining to Improvement in Migratory Sheep Production Programme for Tribal Farmers in Northwest, Annual Report (2002-2003)** by Sushila Kaul and D.R. Singh.
6. **On robust estimation of heritability (2003)** by V.K. Bhatia and Amrit Kumar Paul.
7. **Planning, designing and statistical analysis of data relating to experiments conducted under the AICRP on long term fertilizer experiments (1997-2002)** by M.R. Vats, D.K. Sehgal and D.K. Mehta.

8. Ad-hoc study reports on “Study of existing monitoring mechanism for research projects in different ICAR Institutes and SAUs” under National Agricultural Research System by S.D. Sharma, Ashok Kumar, R.C. Goyal and P.K. Malhotra.
9. Ad-hoc study reports on “Information support for management of agriculture” by S.D. Sharma, A.K. Srivastava, H.V.L. Bathla, U.C. Sud, R.K. Pandey, P.K. Malhotra, Randhir Singh, Ashok Kumar, Anil Rai, Prachi Mishra and Sushila Kaul.

#### **(ii) Finalised**

1. Statistical investigation on the fertilizer use efficiency in relation to cultural practices by Rajender Kumar and J.K. Kapoor.
2. Statistical studies on competition effects among neighbouring units in field experiments (AP-Cess Funded) by Seema Jaggi and V.K. Gupta.
3. A diagnostic study of design and analysis of field experiments by Rajender Parsad, V.K. Gupta, P.K. Batra, R. Srivastava, Rajinder Kaur, Ajit Kaur Bhatia and Prawin Arya.
4. Forecasting the loss in yield due to weeds by Madan Mohan, Rajvir Sharma, T. Rai and Ranjana Agarwal.
5. Forecasting sugarcane yields using multiple Markov chains by Ramasubramanian V., Ranjana Agarwal and L.M. Bhar.
6. As part of project entitled “Study relating to formulating long term mechanization strategy for each agro climatic zone/State”, a document entitled “Status of Farm Mechanisation in India”, comprising 10 edited status papers by eminent experts, has been submitted to the DOAC, Ministry of Agriculture on Sept. 29, 2003.
7. Studies on data processing techniques for statistical analysis of large field variability in hilly and salt affected soil regions by V.K. Bhatia and Rajender Parsad.

#### **Books**

1. Agricultural Research Data Book 2003 (May 2003). H.V.L. Bathla, K.K. Tyagi, R.S. Khatri, Jagbir Singh, J.P. Goyal, S.C. Agarwal and R.M. Sood.

## **Dissertations approved**

### **(a) Ph.D. (Agricultural Statistics)**

#### **1. Kandala Venu Madhav - Study of statistical modelling techniques in agriculture**

Nonlinear Schafer model is extensively used in fisheries to obtain maximum sustainable yield and corresponding optimum fishing effort. If the parameters of this nonlinear model are replaced by “expected value” parameters, the resulting form, as a pleasant surprise, reduces to an exact linear form. Thus the nonlinear Schafer model can be fitted easily by using “Multiple Linear Regression” technique. This procedure is illustrated on some shrimp catch-effort data. Further, for describing the path of adoption of High Yielding Varieties in the country during post green revolution era, a four-parameter nonlinear mixed influence growth model is investigated. Employing nonlinear estimation procedures, it is found that some parameter estimates did not converge to biologically meaningful values. Subsequently, one parameter of the model is re-parameterized by using “expected value” parameter. Consequently, the resulting form is successfully fitted to the data and hypothesis testing is then carried out through Wald’s test. Application of statistical models requires “precise” data, which is quite often not possible. Further, there is also fuzziness or impreciseness in the underlined phenomena describing relationships between explanatory and response variables. The methodology of “Fuzzy Regression” is thoroughly discussed to handle various situations, viz., Phenomena is fuzzy, Phenomena and response variables are both fuzzy and Phenomena, response and explanatory variables are all fuzzy. A program in SAS is developed. Subsequently, the methodology is applied to various real data sets from the field of agriculture. Superiority of this newly developing approach over conventional “Multiple Linear Regression method” is clearly demonstrated. Further, fuzzy ARIMA approach to handle fuzzy time series data is also studied in detail. The methodology developed is successfully applied to real data and its superiority over Box-Jenkins ARIMA approach is established. The above approaches of “Statistical Modelling” are model driven. However, if there are several explanatory variables, it is seldom possible to have an idea of underlying nonlinear functional relationships between them. To this end, an extremely versatile approach of “Neural Networks (NNs)”, which is data driven, is rapidly developing. NNs learn from examples and capture subtle functional relationships among the data even if the underlying relationships are unknown. Thus NNs are well suited for problems where solutions require knowledge that is difficult to specify but for which there are enough data points. In this sense, NNs can be regarded as the multivariate, nonlinear, nonparametric statistical method. This modelling approach with the ability to learn from experience is extremely useful for many practical problems in agriculture. A number of NN models are thoroughly

studied. As an illustration a feed forward multilayered network trained using back propagation is discussed at length. The methodology is then applied to forecast wheat productivity of Junagadh district using weekly weather data of several variables, like, temperature, relative humidity, wind speed, and sunshine hours. To this end, a standard software package is also employed. Appropriate Neural Networks models are also identified for forecasting time series data on crop production and a comparison of the corresponding results obtained through ARIMA approach is also made. Finally, a synergistic approach based on both ARIMA and RBF Neural Networks is used and is empirically compared with ARIMA and Feedforward Networks.

**(Guide: Dr. Prajneshu)**

## **2. (Ms.) P. Sandhya Kiran - On some statistical properties of estimates of heritability**

This thesis is concerned with examining the distributional properties of heritability, identification of different procedures for robust and admissible estimation of heritability, exploring Bayesian analysis in estimation of variance components and heritability and comparison of different identified procedures in different situations. In order to identify suitable method for estimation of heritability in various practical situations, the data having presence of aberrant values, unequal numbers of records and non-normality distribution of observations have been considered for the present study. It was observed that the estimates of heritability obtained from half-sib data follow normal distribution. In the case of full-sibs, the sire+dam component of heritability estimates and sire component of heritability estimates at higher parametric values were found to follow normal distribution, while sire component of heritability estimates at lower parametric values follow lognormal and gamma distributions. A Monte Carlo study was conducted to compare the performance of Modified ANOVA method, which keeps restriction on the parameter space of the variance components, with the other traditional methods ANOVA, ML, REML and MIVQUE (0) in presence of unbalancedness and scale contamination. It was observed that the modified ANOVA estimator has lesser MSE than ANOVA for all the parametric values of heritability under different sample sizes. However REML showed consistent results in different situations. The multivariate approach using delete-d jackknife technique was found to be better than ANOVA and REML when information is available only on fewer offspring per sire. In the case of data containing outliers, robust method of estimation yielded accurate and reliable estimates of heritability as compared to other methods of estimation. The applicability of Bayesian technique was also studied in the estimation of heritability and the results are very encouraging in the sense that they gave non-negative estimates for all the practical situations. Finally this study has

proved to be very helpful in finalizing computer strategies to arrive at a valid estimate of heritability.

(Guide : Dr. V. K. Bhatia)

## **(b) M.Sc. (Agricultural Statistics)**

### **1. Ananta Sarkar - Analytical techniques for long-term experiments**

Long-term experiments are those experiments that are continued on the same set of experimental units over a sequence of years with preplanned sequence of treatments or crops or both. The major objective of these experiments is to monitor the changes in soil properties and crop productivity as a result of continuous application of treatments and to identify the most suitable treatment. Long-term experiments may be with seasonal crops, annual crop sequences, perennial crops, etc. We have restricted to long-term fertilizer experiments on a fixed crop sequence. These experiments are being conducted at 17 locations under the aegis of All India Co-ordinated Research Project (AICRP) on Long Term Fertilizer Experiments (LTFE) of Indian Council of Agricultural Research using a randomized complete block design. Treatments in these experiments are graded levels of fertilizers. Same design layout (including randomization) is followed over years.

The analytical techniques for long term experiments available in literature have been consolidated. The data for each year is separately examined using 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. Therefore, we suggested the use of multivariate analysis of variance (MANOVA). The comparison of treatments after MANOVA is a problem. For comparison of treatments, ANOVA based on score of first principal component explaining more than 75% of variation is generally attempted. In some situations, first principal component may not explain more than 75% of variation and even if it explains, still about 25% of variation remain unexplained. The inference made on the basis of a partial variation of the population may be misleading. To tackle this problem, we have developed a multivariate treatment contrast analysis procedure based on Wilk's Lambda criterion. All these analytical techniques have been illustrated with the help of data from Ranchi and Ludhiana centres of AICRP on LTFE. Several paired treatment comparisons that are non-significant through univariate analysis are found to be significant through multivariate contrast analysis. It is, therefore, recommended that the data pertaining to these experiments should be analyzed through MANOVA. If the number of years for which the experiment is conducted are more than error

degree of freedom, then MANOVA may be performed using a suitable number of principal components.

For studying the trend behaviour of available soil nutrients, the data from Ranchi and Ludhiana centres are plotted. On the basis of shapes of plotted curves, different linear and non-linear models were fitted. Adjusted  $R^2$ , root mean square error and percentage prediction error values are taken as model selection criterion. Partial data sets (excluding last four years) are used for model building and predictions of available soil nutrients are done for the last years. In most of the cases, the prediction error is found to be less than 5%.

**(Guide: Dr. Rajender Parsad)**

## **2. Ajay Krishanrao Kankure – Small area estimation of crop yield at block level using satellite data**

In agricultural surveys the estimates of crop yield are presently being worked out at the district level through the General Crop Estimation Surveys. But while planning at the grass-root level, it becomes imperative to obtain these estimates at smaller levels such as community development blocks and village panchayats. Sample surveys designed to provide estimates for larger areas are inadequate to provide adequate precision for small areas. The growing demands for reliable estimates at smaller areas makes small area estimation in survey sampling an important topic. A number of small area techniques are available in the literature, which are applicable under different situations subject to data availability. With the help of remote sensing technology quick and fairly accurate estimates of crop yield can be obtained which would lead to advance forecasting of the total crop production of the country. In case of estimation of crop yield on the basis of crop cutting experiment at block level it was considered necessary to investigate some small area estimation techniques using remote sensing satellite data. The remote sensing image for Rohtak district was obtained and developed using the digital image processing methods. The district was divided into two strata; (1) High vegetation and (2) Average vegetation on the basis of NDVI values. Post-stratified estimators namely; Direct estimator, Synthetic estimator, Generalized Regression estimator, and Structure Preserving estimator were developed for estimation of wheat crop yield at block level for Rohtak district of Haryana and compared for 1997-98 and 1999-2000 data using small area estimation techniques. It has been found that the synthetic estimator gives the best estimate as it has lowest standard error in comparison with the Direct and GREG estimator. The generalized regression estimator has the larger standard error among all the estimators for almost all the blocks. The results were found to be consistent for both the years.

**(Guide: Dr. R. Singh)**

### **3. Gaurav Goyal - Crop yield forecast using double sampling**

Forecast models based on plant characters, require periodic measurement of plant characteristics. The periodic collection of data on plant characters is coupled with certain limitations, namely cost and partially missing data. One possibility to deal with such problem is 'use of double sampling' where data on less costlier variables is collected on all the units ( $n$ , say) of the sample and data on the variables involving more cost and labour are collected on the sub sample ( $m$ ). The values for the non sampled variables in the remaining units ( $n-m$ ) are predicted using their relationship with other variables in the sampled units ( $m$ ) and information on agricultural inputs. The present study applies regression approach to forecast sugarcane yield using the concept of double sampling. The variables used were observations on number of canes, spacing and farmers' appraisal of yield/ha. The number of canes was identified as the character involving high cost/labour/sophisticated instruments for its observation. To study the feasibility of the suggested methodology, a sub sample of 70 per cent and 50 per cent of the total sample size was taken to collect the actual data on number of canes and models were fitted for it. The results indicate that the forecasts based on the suggested methodology were comparable to those obtained using the complete data. Under the presence of significant multicollinearity the principal components of variables shall be employed in conjunction with the methodology. Under the limitation of availability of labour/cost/instruments for observing and for missing data, the suggested methodology may be applied to arrive at equally reliable forecasts.

**(Guide: Dr. Ranjana Agarwal)**

### **4. Jitender Singh Tomar - Design for studying competition effects**

In field experiments, generally the plots within a block are placed side by side. The response from a given plot may be affected by the treatments applied to its neighbouring plots besides the treatment applied to the plot itself. Interdependence of adjacent plots because of their common needs is referred to as competition effect. Interference, also interpreted as competition, between neighbouring units is a serious source of bias. Understanding the structure of these competition effects helps in minimizing such bias to a great extent. This involves construction of a design in which two competing treatments occur together in same order. The linear model involving these competition effects is taken and the information matrix for estimation of direct effects and neighbour effects has been derived. Characterization of block design for competition effects, in terms of the information matrix, has been obtained. Some methods of constructing block designs balanced for neighboring competition effects has been developed. A catalogue of the block designs obtained has been prepared

that contains the parameters, efficiency and initial blocks. A method of constructing block designs partially balanced for neighboring competition effects has also been described. The designs obtained are partially balanced with two associate classes i.e. those treatments that appear as neighbours to any treatment are first associates and rest are second associate. The efficiency of these designs has also been computed.

(Guide: Dr. Seema Jaggi)

#### **5. Rama Krishna Singh - Robustness of balanced treatment incomplete block designs against exchange of a test treatment**

The present thesis deals robustness of balanced treatment incomplete block designs against exchange of a test treatment. Ideally, it is expected that in any experimental situation there will be a perfect match between the available resources and the resources required for the conduct of experiment. It is also envisaged that in the layout and execution of an experiment everything shall go according to the plan. The problem of missing observations, outliers and presence of trends for robustness of designs are some of the results of things going wrong at the layout or at other stages of the execution of experiment. Apart from the above-mentioned disturbances during the planning or conduct of experiment discrepancies due to interchange and exchange of treatments may creep in either accidentally or due to the constraints in the experimental resources. The earliest work done in this direction was by Pearce (1948), who studied the procedure of analysis of randomized block design when one treatment substitutes another. In context of block design one may encounter the following discrepancies: (i) exchange of treatment takes place i.e. in a block design at least one of the treatment in some of the blocks get substituted by some other treatment included in the trial (ii) the interchange of treatment takes place i.e. at least a pair of the treatments each belonging to different blocks in the design get interchanged in the layout or in other words each of the units get allotted to a treatment originally designated for other. In order to overcome such a situation one must think of designs, which are insensitive or robust against such disturbances. In experimental situation for making test treatment control comparisons generally standard reinforced balanced incomplete block (SR-BIB) designs are of much use. SR-BIB is a special form of BTIB design in which a BIB design consisting of test treatments is augmented in each block with one replicate of control treatment. Robustness of balanced treatment incomplete block designs is studied. The information matrix of residual design when exchange of one test treatment has taken place has been obtained. As a particular case robustness of SR-BIB designs has been studied using the efficiency criterion of robustness. Since the algebra to obtain eigenvalues of matrix of residual design is not tractable, the efficiencies of SR-BIB

designs (obtained by adding a single control treatment in each block of a BIB design catalogued in Parsad, Gupta and Khandur (2000)) after exchange of a test treatment have been obtained using SAS (Statistical Analysis System) package. These designs turn out to be fairly robust. The utility of robust designs in practical situation like scarcity experimental material etc. has been illustrated.

(Guide: Dr. R. Srivastava)

## **6. Ram Kumar Chaudhary - Use of Hansen and Hurwitz technique in successive sampling**

The problem of non-response in data collection is a common problem especially in case of mail surveys. When population is dynamic in nature and interest is to estimate the population parameter for the current occasion, sampling on successive occasions is suggested. In the present study, an attempt has been made to handle the problem of non-response in estimating the population mean for the current occasion in the context of sampling on successive occasions using Hansen and Hurwitz technique, when there is non-response in data collection. To obtain the minimum variance linear unbiased estimator (MVLUE) zero function approach has been used. The MVLUE of the population mean for the current occasion along with minimum variance has been obtained. The optimum fraction to be matched has been determined which minimize the variance of the estimators. The estimation of population mean for the current occasion in sampling on two occasions when there is non-response on both the occasions has been developed. The estimators of the population mean for the current occasion have been developed as a particular case when there is non-response on the first occasion and second occasion only. Different estimators so obtained have been compared. The percentage loss due to non-response over usual case for different cases has been shown empirically for different values of different parameters.

It has been shown that the percentage losses due to non-response over usual case increases with increase in values of both correlation between matched portions and fraction to be unmatched while, it decreases with increase in values of correlation between matched portions among the non-respondents. Also, the percentage loss in precision over usual case is maximum for the case, when there is non-response on both the occasions while, it is least when there is non-response only on the first occasion. It has also been shown that there is saving in cost of the survey over usual case when Hansen and Hurwitz technique is used for estimation in case of non-response. The saving in cost of the survey decreases with increase in correlation between matched portions or fraction to be unmatched while it increases with increase in correlation between matched portions among the non-respondents. The theory so obtained for estimation of population mean for the current occasion in

sampling on two occasions has been demonstrated with the help of an empirical study using survey data. The theory developed for the sampling on two occasions has been generalized for the case of sampling on 'h' occasions. The MVLUE along with variance of the estimator and fraction to be unmatched has been obtained. Also, the limiting values of constant  $G_h$ , fraction to be unmatched and variance have been determined assuming that correlation between matched portion and matched portion among the non-respondents is equal. The limiting value comes out to be  $\frac{1}{2}$  which is equal to the usual case.

(Guide: Dr. H. V. L. Bathla)

### (c) M.Sc. (Computer Application)

#### 1. Ashutosh Prasad Maurya – On-line data management system for on-farm trials

Farmers adopt the technologies evolved through trials conducted on research stations after they are tested in their conditions. These trials on farmers fields are conducted to test the consistency and adoptability of technologies developed by research stations and also to propagate the technologies among farmers. These on farm trials are conducted after dividing the country into 32 NARP Zones / Districts. Obviously, these trials are conducted for various cropping systems and the data collected in the project is right now filled manually and submitted to IASRI and Project Directorate for further analysis. Data schedules for each type of trials are filled in by research scientists. The data from these centers is then received by post and lot of effort is made in scrutinizing, coding and validation of the data. This validated data is then converted to electronic form for statistical analysis. During scrutinizing many trials are rejected because of certain discrepancies. The on-line data management system for on-farm trials (WebFarm) is a software to customize recording of the On-Farm Trials under Indian Council of Agricultural Research. With the development of this WebFarm the data generated at each center will be available to IASRI and PDCCSR in electronic form. This will reduce the delay in receiving the data and its subsequent transfer to electronic form. Further, IASRI can distribute the work of checking of schedules, coding of data and converting data to electronic form to the various centers conducting on-farm trials. As a result, the can be directly used for the statistical analysis. The present software has a three-layered architecture. Client Side Interface Layer is implemented in HTML and JavaScript. Server Side Application Layer is a connection between client side layer and the Database and is implemented in Java Server Pages. Database Layer is implemented in Microsoft Access 2000. The developed WebFarm can be implemented as a network-based system with a server so that information is available on-line. WebFarm runs at any node of the Internet through a browser. Security features are provided in such a way

that only administrator can access the database. It has facilities for browsing and searching the information and on-line help for smooth navigation. Further provision is made for interacting with the System Administrator through email.

**(Guide: Dr. I. C. Sethi)**

## **2. Dharmendra Singh - Web based examination and evaluation system**

The advent of computers and their extensive potential of faster access to information have revolutionized almost all the facets of human life. It has major impact in the field of education where World Wide Web has been used for interactive learning and research. Nowadays, web based examination system have been used as an effective solution for mass education and evaluation. In any examination, the concerned authority has to undertake a complete exercise starting from the preparation of question bank, setting of the question paper, conducting the examination and evaluation of the answer sheets. In all these stages, there is a need of subject experts and the entire process requires much more time and effort. The development of a web based examination and evaluation system will be an effective substitute, replacing the traditional paper based examination system. A Web Based Examination and Evaluation System has been developed taking the ICAR JRF examination as a model and it provides online examination and evaluation facility. It is user-friendly software developed in Java Server Page (JSP) having a three-layered architecture. Client Side Interface Layer is implemented in Hypertext Markup Language (HTML) and JavaScript. Server Side Application Layer is implemented in Java Server Pages and Java Database Connectivity. Database Layer is implemented in Microsoft Access 2000. Questions paper consists of multiple choices, true/false and matching type questions that are generated randomly without repetition giving flexibility to examination authority in the conduct of the examination at different times. The students may get the score immediately after appearing in the examination. Software also has the provision for online addition, modification and deletion of questions and other administration activities. Security features are provided in such a way that only concerned person can access the database.

**(Guide: Dr. R. C. Goyal)**

## **3. Gurubana Kanhar - Animal nutritional experiments information system**

The application of information technology is growing rapidly in almost all the fields at global level. This technology increases the working efficiency by reducing time. The information on animal nutrition experiments that have been conducted under the National Agricultural Research System to study the efficacy of proper growth due to the feeding of animals in a scientific and systematic manner is available in reports and research papers. If it is made available to the researchers on

the Internet, it will help them in planning their experiments in a more scientific way and will avoid duplication of research efforts. With the objective of keeping records of such experiments in compatible form at one place and providing useful information, "Animal Nutritional Experiments Information System (ANEIS)" has been developed. ANEIS provides information on various aspects of experiments like location, species and their breeds, information on the research, summary of the experiments, etc., and will be a ready reckoner for use as a reference material. Efforts have been made to provide the data of the experiments in simple but in an exhaustive manner. ANEIS is based on JAVA technology, which is platform independent. Therefore, the administrators having varying hardware and software facilities will not face any difficulty in implementing and using ANEIS. The present work has a three-layered architecture. The Client Side Interface Layer is implemented in HTML and JavaScript. Server Side Application Layer is a connection between client side layer and the Database and is implemented in Java Server Pages. Database Layer is implemented in Microsoft Access 2000. ANEIS can be implemented as a network-based system with a server so that information is available on the Internet through a browser. Security features have been included, so that only administrator can access the database. Further provision is made for interacting with the System Administrator through email. ANEIS is User-friendly and Interactive Software and a person with very little knowledge can operate and get the desired information.

**(Guide: Sh. H. S. Sikrawar)**

#### **4. (Ms.) Priyanka Sahi - Development of a window-based software for the analysis of two-stage survey data**

Standard statistical softwares are very commonly used for analysis of sample survey data. But these softwares generally do not take into account the common characteristics of survey data: such as stratification, clustering etc. Two-stage sampling is very frequently used in sample survey. Therefore, some suitable specialized software should be used to analyse sample survey data. Some of the important softwares used for survey data analysis are PC CARP, SUDAAN, STATA, WesVarPC, CENVAR, CLUSTERS, EPI INFO, VPLX, etc. These are either very costly or they are DOS-based. So software, Survey Data Analysis Package (SDAP), for analysis of two-stage survey data has been developed using Visual Basic 6.0, which is more flexible, menu driven and user-friendly. SDAP has three analyses modules - Totals, Ratios and Difference of two ratios for analysing two-stage survey data. Sampling fractions are calculated for both first and second stages. Analyses can be done on selected or all variables as per requirement and there is no restriction on maximum number of variables. SDAP calculates two-stage estimates, standard error, and coefficient of variation for survey data. Help regarding data files, analyses, etc. is available. Shortcut menus are also there in the toolbar. Data files can be text

or notepad files. Outputs can be displayed, saved and printed using appropriate menus. A novice user who is familiar with basic windows applications can use SDAP.

(Guide: Dr. V. K. Mahajan)

#### **5. Shalendra Tripathi - Integrated library management information system**

Integrated library management information system (ILMIS) is a web-based solution for the library, developed in Java Server Page (JSP) for acquisition control, serial control and library catalogue system. It has a three-layered architecture. Client Side Interface Layer is implemented in HTML and JavaScript. Server Side Application Layer is implemented in Java Server Pages and Java Database Connectivity. Database Layer is implemented in Microsoft Access 2000. ILMIS can be implemented as a network-based system with a server at IASRI so that information is available on-line. ILMIS runs at any node of the Internet through a browser. Security features are provided in such a way that only administrator can access the database. There is provision to insert, update and delete the information. It has facility to browse and search the collection in the ILMIS. It has on-line help to facilitate smooth navigation. Procurement of the books is the primary in-house operation of any library. ILMIS assists in acquisition control. Preparing the list of requested books, checking for duplicate title, author and publication year, generating order form content, printing purchase orders to suppliers, items received, reminder to suppliers for late delivery are the activities which ILMIS provides for acquisition control. Serial control has additional facilities over and above the acquisition control. Catalogue control includes addition, deletion, and modification of the books, periodicals and thesis in the catalogue. Facility has been provided for user management under 'User Management' module. Link has been provided to CIRCOSYS for circulation control, which concerns the record keeping of books and other literature issued to users and what they have returned. It also helps in checking pilferage and losses and in promptly locating which of the documents stand with whom and when these are due. ILMIS provides search facility of books, periodicals and thesis by title, author, keywords etc. to library members. Library member can see the issued and overdue book by himself or herself.

(Guide: Dr. S.D. Sharma)

#### **6. Vinod Kumar Yadav - Web based information system on pesticides and their decontamination**

India has a major share in the agricultural production in the world and the second largest producer of fruits and vegetables. With the advent of new upcoming technologies and research work undertaken in the field of agriculture, it has become possible to minimize the losses in crop production due to infestation by the

insects/pests, diseases, weeds, and mites. The pesticides play a vital role in safeguarding the crops, saving the losses and help in realizing potential yield of crops. The savings affected through the usage of the crop protection chemicals (i.e. pesticides) is estimated at 30 percent of the total agricultural production. But the information about pesticides (which includes general information, their protection schedules, status, MRL values, residues analysis, decontamination methods etc.) is available in books, journals, magazines; manuals etc. and are beyond the reach of common person across the world. So there is a need to put the information in electronic format through the Internet. To meet the above requirements, an Information System on Pesticide and their Decontamination (INSPEDEC), has been developed. The present work has a three-layered architecture - Client Side Interface Layer has been implemented in HTML and JavaScript, Server Side Application Layer implemented in Java Server Pages and Database Layer in Microsoft Access 2000. The INSPEDEC can be implemented as a network-based system and runs at any node on the Internet through a browser. Security features are provided in such a way that only administrator can access the database. It has facilities for browsing and searching the information and on-line help for smooth navigation. Further provision is made for interacting with the System Administrator through email. A person with little knowledge can operate and get the desired information.

**(Guide: Dr. P. K. Malhotra)**