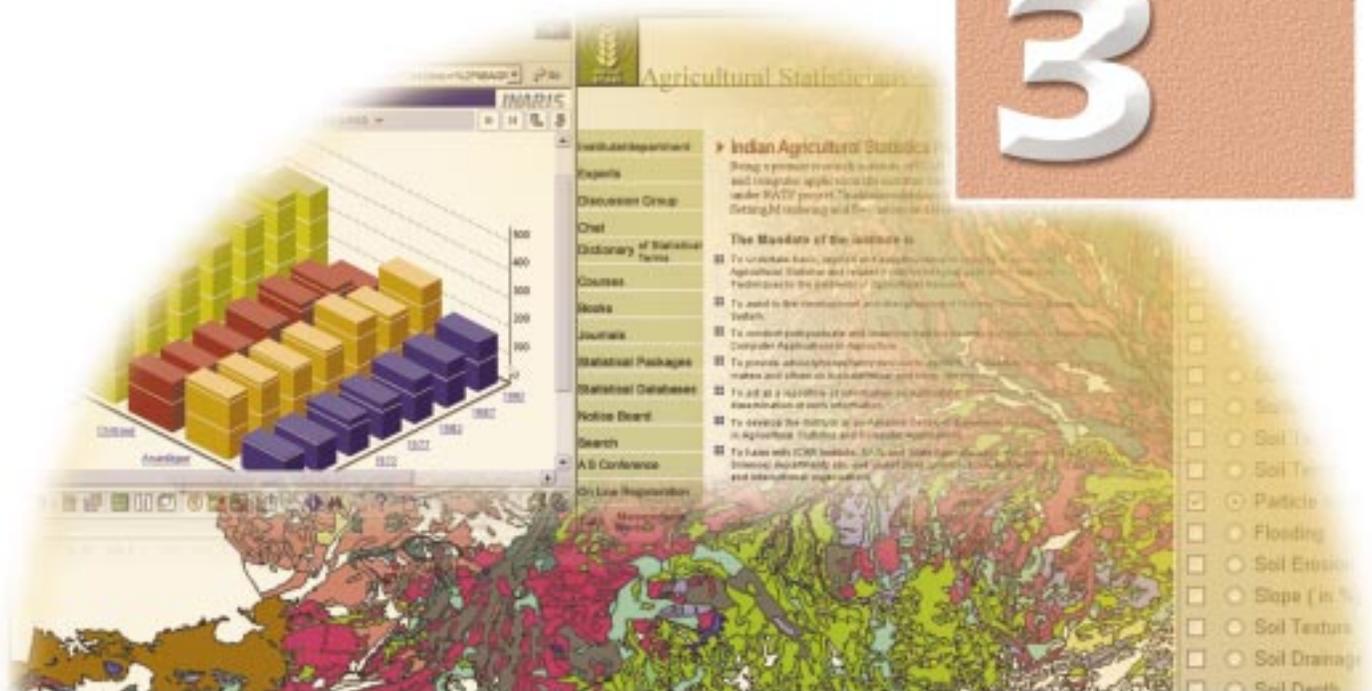


3



Research Achievements

The research targets set by the Institute were implemented by six Divisions of the Institute viz. Sample Survey, Design of Experiments, Biometrics, Forecasting Techniques, Econometrics and Computer Application. The basic, applied adaptive and strategic research in Agricultural Statistics and Computer Applications is carried out under six broad programmes that cut across the boundaries of the Divisions and encourage interdisciplinary research. The six programmes are as under:

1. Development and analysis of experimental designs for agricultural systems research
2. Forecasting and remote sensing techniques and statistical applications of GIS in agricultural systems
3. Development of techniques for planning and execution of surveys and analysis of data including economic problems of current interest
4. Modeling and simulation techniques in biological systems

5. Development of informatics in agricultural research
6. Teaching and training in agricultural statistics and computer application.

PROGRAMME 1: DEVELOPMENT AND ANALYSIS OF EXPERIMENTAL DESIGNS FOR AGRICULTURAL SYSTEMS RESEARCH

Cropping Systems Research

- Yearly and combined analysis (1994-2003) of data from experiments conducted at Ludhiana under AICRP on Long-Term Fertilizer Experiments revealed that in the presence of residual P fertility of 82 kg ha⁻¹ (1994) the reduction of P application by half under 100% NPK original treatment proved to be effective in sustaining the respective average yield levels of 31.85 and 48.71 q ha⁻¹ of maize and wheat in comparison to the corresponding yields of 30.4 and 48.8 q ha⁻¹ obtained with optimal

P application. With complete P omission under 100% NPK(-S) treatment the sustainable average maize and wheat yields obtained were 28.8 and 45.10 q ha⁻¹ vis-à-vis 31.1 and 46.1 q ha⁻¹ obtained with optimal P application.

The depletion of available zinc from the initial level of 2.7 mg kg⁻¹ to 0.62 mg kg⁻¹ over the years 1972-93 at Pantnagar became a yield limiting factor under the 150% NPK+S treatment. Its replenishment @ 25 kg ZnSO₄ ha⁻¹ from 1993 onwards significantly enhanced the average rice and wheat yields by 6.0 and 7.8 q ha⁻¹ respectively over the corresponding yields of 36.9 and 34.3 q ha⁻¹ obtained without zinc application.

The trend analysis of available phosphorus in soils under optimal and super optimal NPK treatments over the years 1972-2003 indicated its huge build up of 169.7 kg ha⁻¹ over its initial value of 12 kg ha⁻¹ at Palampur and of 200.7 kg ha⁻¹ over the initial level of 49 kg ha⁻¹ at Barrackpore thus indicating the need of management intervention for rescheduling P application so as to enhance efficient fertilizer use and economic profitability of the fertilizer added to the cropping systems.

- Summarization of results of experiment "Performance of crop varieties and their nutrient requirement conducted under the planning, designing and analysis of "ON FARM" research experiments planned under Project Directorate for Cropping Systems Research during 1990-2000 for Rice, Wheat, Jowar, Bajra, Maize, Oilseed and Pulse crops were completed. On the basis of trials conducted on farmers' field adopting only the improved varieties and continuing with existing practices for Rice and Wheat crops, the increase in productivity was observed to be 10.89% and 10.30%, respectively. In case when farmers had adopted improved varieties along with recommended dose of fertilizer, the increase in rice and wheat production was noted as 25.71% and 28.85%, respectively. The estimates of increase in productivity for rice crop due to adoption of new varieties varied from low of 2.38% for Punjab to a high of 16.61% in Maharashtra state under farmer's existing practices.

In case of adoption of new varieties of rice along with recommended fertilizer doses, Punjab has shown decrease in production of the

magnitude of 1.07%. This is due to farmers applying higher fertilizer dose 150 kg/ha of N + 40 kg/ha of P than the recommended dose of fertilizer 120 kg/ha of N.

- A database of Experiments on Long Range Effect of Continuous Cropping and Manuring on Soil Fertility and Yield Stability for online storing and retrieving the data for different centres has been prepared. The database has been developed in the Microsoft Access 2000 with front end in Hyper Text Markup Language (HTML) and JavaScript.
- Database for the project on Statistical and Algorithmic Approach for Improved Estimation of Treatments Effects in Repeated Measurements Designs has been designed and parameters of 50 repeated measurements designs (RMDs) catalogued from literature have been entered into it. Computer softwares have been developed in Visual Basic for the generation of various types of RMDs which included Williams square designs, [Sharma (1981), Berenblut (1964)], 11 two-treatment RMDs, [RMDs (v, p=v, n=v (v-1))] obtained using Mutually Orthogonal Latin Squares [MOLS] for prime v, circular totally balanced RMDs (v, p=2v-1, n=v), [Varghese and Sharma (2000), RMDs Sharma (1977)] extra- period Williams Square RMDs, two classes (type II and type III) of partially balanced RMDs, [Saha (1970)] two-period RMDs [Balaam (1968)] totally balanced RMDs, [Dey and Balachandran (1976)] Balanced RMDs, [Lawless (1971)] and minimal balanced RMDs, [Sharma *et al.* (2003)].
- Experiments having non-normal and heterogeneous errors retrieved from Agricultural Field Experiments Information System (AFEIS) were investigated. The presence of outlier(s) were examined through a specially developed program in SAS/IML. The statistics like Cook Statistics, AP-statistic, Q-statistic were applied and it was observed that these experiments contain outliers.
- Under design and analysis of experiments for spatially correlated observations in block design setup, the coefficient matrix of reduced normal equations for estimating treatments contrasts has been obtained for a nearest neighbour correlation error structure and first order autocorrelation error structure. A series of Balanced Incomplete Block (BIB) designs that are neighbour balanced with parameters v=m(λ-1)+1 [v being prime or prime

power], $b = mv$, $r = mk$, $k = \lambda$, λ obtained by initial block solution (Sprott, 1956) have been tabulated with parameters and initial blocks.

- At Cropping Systems Research (CSR) centre, Faizabad, an experiment was conducted during 2002-03 to study the effect of different methods of sowing of wheat on yield of rice-wheat sequence. Wheat was sown by normal, late, transplanting and zero tillage methods. It was observed that maximum gross returns from rice-wheat sequence was obtained when wheat was grown by normal method.

Experimental Designs for Agricultural, Animal and Agro forestry Research

- Biological assays (bioassays) are a set of techniques relevant to the comparisons between the strength of alternative but similar biological stimuli (a pesticide, a fungicide, a drug, a vitamin, plant extract, etc.) based on the response produced by them on the subjects (e.g. an animal, a piece of animal tissue, a plant, a bacterial culture, subhuman primates or humans, living tissues, plants or isolated organisms, insects, etc.). The experimenter at times has to use incomplete block designs for the conduct of bioassays. As the contrasts to be estimated for bioassays are different from those in the usual experiments, the classical block designs are generally not efficient for bioassays. Information on efficient block designs for biological assays, at present, is scattered mostly in the form of research papers, dissertations, etc. There is, therefore, a need to consolidate the information at one place in the form of a catalogue for the benefit of experimenters and practicing statisticians. Simultaneously, it is also possible to obtain designs for bioassays that are optimal/efficient for all the relevant contrasts of interest with more efficiency as compared to the designs available in the literature. In view of the importance of efficient designs, a project entitled "Studies on block designs for biological assays" was undertaken with the objective to obtain and catalogue optimal/efficient block designs for bioassays. In order to familiarize the stakeholders with the importance of designing and analytical aspects of biological assays and to disseminate the findings of the research project, a

dissemination workshop was organized at the Institute on 15 February 2005. Besides familiarizing the participants with the findings of the project, various issues relating to practical problems of bioassays were discussed threadbare and some important recommendations were emerged from the workshop. The following are some of the salient achievements.

- Optimality of block designs for multiple parallel line assays that allow estimation of three contrasts of major importance but do not necessarily allow the estimability of other treatment contrasts has also been studied and a method to obtain such designs has been developed. A catalogue of 35 A-optimal block designs for $3 \leq m \leq 8$, $8 \leq k \leq 16$, $k < 4m$, $bk \leq 100$ has been prepared for one standard and three test preparations.
- A optimal block designs for asymmetric slope ratio assays have been obtained. A catalogue of 61 A-efficient block designs for asymmetric slope ratio assays has been prepared. Wherever, A-optimal design is not obtainable a lower bound to A- efficiency is provided.
- Besides cataloguing optimal/efficient block designs obtained in the studies on block designs for biological assays, a catalogue of the designs obtainable from the methods of construction available in literature is also prepared. A-optimality aspects of these designs for parallel line assays have been investigated. None of the designs in the parametric range $3 \leq m \leq 6$, $4 \leq k \leq 10$, $bk \leq 50$ have been found to be A-optimal for inferring on the contrasts of interest. Indeed it is possible that some designs with parameter combinations beyond these parameter combinations may turn out to be A-optimal.
- The analysis of crop data on agro forestry experiment pertaining to various characters received from the collaborative center for the year 2004 revealed that performance of the under storey crop was affected by the tree species and the distance of the crop from the tree base. The yield increased as the distance increased. The RBD analysis of tree data with 12 treatment combinations (4 tree species with 2 crops along with 4 sole trees, i.e. $4 \times 2 + 4$) in two replications indicated the treatment effects as significant. The

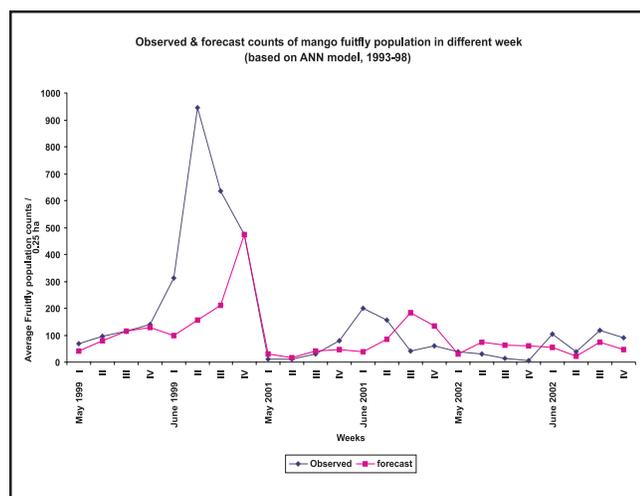
within group comparisons (4 groups from 4 tree species) for crude protein showed that the crude protein yield was significantly different in case of group containing babul indicating the effect of crops on babul.

- Trend-free binary variance balanced block designs under homoscedastic model and heteroscedastic model (error variance proportional to some power of block size) have been obtained when there is uniform trend within the blocks. Trend-free nested balanced incomplete block designs, when the trend effect is in nested blocks, have also been obtained.

PROGRAMME 2: FORECASTING AND REMOTE SENSING TECHNIQUES AND STATISTICAL APPLICATION OF GIS IN AGRICULTURAL SYSTEMS

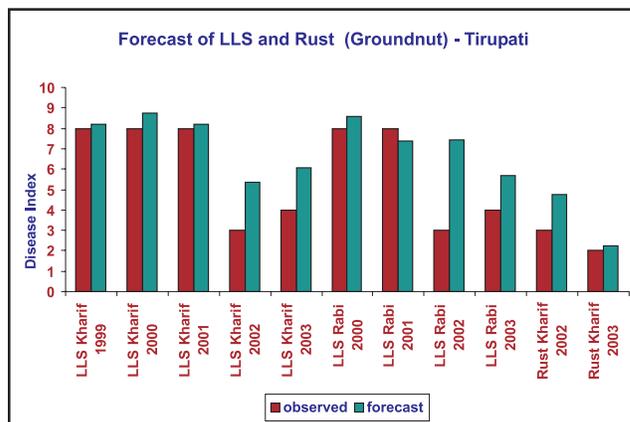
Forecasting Techniques in Agricultural System

- In a study in collaboration with Central Institute for Subtropical Horticulture, Lucknow, aimed for development of forewarning system for outbreak of fruit-fly and hoppers in mango crop, various non-linear models to study the fruit-fly pattern with time were examined. Models were refined by replacing time by a function of time and weather parameters with lags 2, 3 and 4 weeks as well as by using the available information for construction of the index of weather variables. The Artificial Neural Network (ANN) technique was also attempted by taking dependent variable as fruit-



fly population and independent variables as fruit-fly population in 2nd and 3rd lag weeks and weather variables in 2nd to 4th lag weeks. Forecasts for the years 1999, 2001 and 2002, using models based on data for 1993 to 1998 are shown graphically above.

- The Institute has collaborated with Central Research Institute for Dryland Agriculture, Hyderabad in a detailed study under NATP with the responsibility to develop weather based forewarning system for important insects, pests and diseases for rice, sugarcane, pigeon pea, cotton, mustard and groundnut. Models based on weather indices (simple/weighted total of values of weather variables and product of weather variables taken two at a time) were developed and validated for cotton (whitefly, pink bollworm, American bollworm for Lam) and rice (gall midge for Cuttack). Modification and validation of the models for groundnut (late leaf for Tirupati); pigeon pea (pod borer, pod fly, phytophthora blight and sterility mosaic for Kanpur) and sugarcane (top-borer for Lucknow) has been undertaken. Forecasts of subsequent years, not included in model development, were close to the observed



values in all the cases. One example for groundnut (late leaf spot and rust) is presented below graphically:

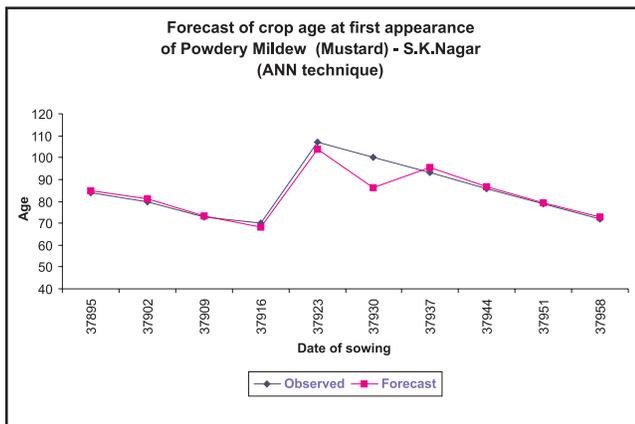
Logistic regression models were developed earlier by classifying the data on pyrilla into two classes (occurrence/non-occurrence). Similar models were developed for qualitative data on alternaria blight and white rust in mustard crop. These models were modified by categorizing the

data into three categories (low, medium and high). However, in all the cases, the modified models did not perform better than the models based on two categories. The forewarnings on the basis of models using two categories were found to be satisfactory in all the cases.

ANN technique has been tried for Powdery Mildew in mustard (S.K. Nagar). Different dates of sowing were taken as treatments in each year. ANN technique was used on the data of four years for forecasting maximum severity, crop age at first appearance and peak severity. Using this technique, forecasts for fifth year were obtained. The results indicated that technique worked very well for forewarning crop age at first appearance of disease whereas for other characters further

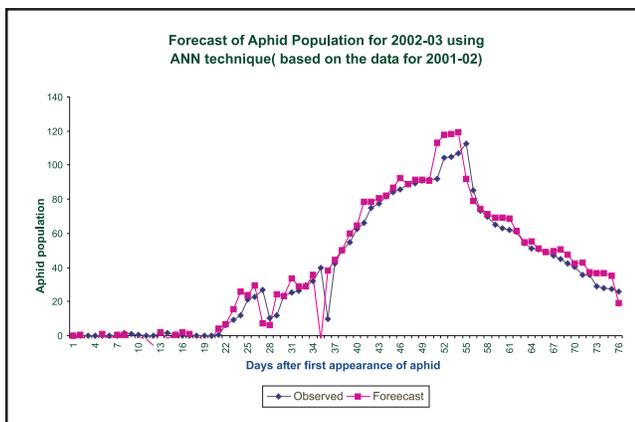
aphid development pattern in Bharatpur for the year 2001-02 using data lagged by ten days on weather and aphid population. The predictions were very close to the observed ones. Using this approach, forecasts for 2002-03 were obtained which are shown above graphically:

- Non linear models for aphid development pattern developed earlier were based on the cumulative mean temperature and cumulative mean relative humidity. These models were further modified by replacing cumulative weather variables by respective indices. Index of a weather variable was obtained by taking weights as zero/half/one if weather in a particular week was in unfavourable/ favourable/ highly favourable range for aphid. In order to use this approach for forecasting aphid population in advance, models were also developed using weather lagged by one week. These models captured the fluctuation in aphid population excellently.
- A study was taken up to develop nonlinear time-series models for describing and forecasting time-series data from the field of agriculture. Jalali and Pemberton (1995) extended the class of zeroth-order threshold autoregressive models to a much richer class of mixture models. Amongst their many properties, it is observed that their auto covariance structure has the same form as that of linear ARMA models although only a subset of possible auto covariance functions are obtainable with ARMA models. In this study the performance of mixture time-series models, viz. Gaussian Mixture Transition Distribution (GMTD) models and Mixture Autoregressive (MAR) models in real data sets was studied. As an illustration, the models were applied on weekly onion price data during first week of April, 1998 to first week of November, 2001 to describe behaviour of the time-series. The data of Nasik variety at Azadpur Mandi, New Delhi, collected from N.A.F.E.D., New Delhi was considered. It showed marked volatility by touching value of Rs. 4000 per quintal in October, 1998 and remained stable in the range of Rs. 450 to Rs. 700, depicting flat stretches with occasional bursts of large amplitude to the tune of Rs. 850 to Rs. 900, during October, 1999. In subsequent year, price remained on an average of Rs. 350 in first half and above Rs. 500 for second half exhibiting another phase of flat



refinement is needed. Forecasts for crop age at first appearance in fifth year for 10 different dates of sowing are given in following figure:

- ANN technique was also applied for studying



stretches. All these features prompted to apply MAR models to this data set. Tests for presence of unit root were made before fitting trend followed by seasonal adjustment through correlogram analysis. The detrended and deseasonalised series had shown presence of volatility due to the fact that chance of a sharp increase or decrease at some points was higher than that of a moderate change at some other point. This fact was explained through one and two-step predictive distributions which showed multimodality of predictive distribution and no constancy of volatility functions. Also Lagrange Multiplier (LM) test along with Naive-LM test, when the conditional mean is unspecified, was applied for testing presence of ARCH leading to volatility in data sets. The best models corresponding to GMTD and MAR families were selected on the basis of BIC and BIC* criteria. Two-component and three-component GMTD models for detrended and de-seasonalised weekly onion price series were considered. The order selection criterion followed was BIC as, unlike other criteria, viz. Akaike Information Criterion and final prediction error, it lead to a consistent order selection (Fan and Yao, 2003). The best GMTD model defined was found to be

$$F(\hat{e}_t | \hat{e}_{t-1}) = 0.11 \Phi\{(\hat{e}_t + 0.28\hat{e}_{t-1} - 0.29\hat{e}_{t-2})/0.54\} + 0.58 \Phi\{(\hat{e}_t - 0.61 \hat{e}_{t-1})/0.65\} + 0.31 \Phi\{(\hat{e}_t - 0.14\hat{e}_{t-2})/3.14\}$$

with BIC value as 386.72. The standard errors for $(\hat{\alpha}_0, \hat{\alpha}_1, \hat{\alpha}_2, \hat{\sigma}_0, \hat{\sigma}_1, \hat{\sigma}_2, \hat{\phi}_{01}, \hat{\phi}_{02}, \hat{\phi}_1, \hat{\phi}_2)$ were (0.09, 1.28, 2.1, 1.24, 2.05, 0.95, 2.56, 1.65, 0.98, 2.45), respectively. The best three-component MAR model was a MAR (3; 2, 2, 1) with $\phi_k = 0$, $k = 1, 2, 3$ and the model is given by

$$F(\hat{e}_t | \hat{e}_{t-1}) = 0.33 \Phi\{(\hat{e}_t - 0.56\hat{e}_{t-1} - 0.36\hat{e}_{t-2})/2.08\} + 0.64 \Phi\{(\hat{e}_t + 0.26 \hat{e}_{t-1} + 0.13 \hat{e}_{t-2})/0.19\} + 0.03 \Phi\{(\hat{e}_t + 5.72 \hat{e}_{t-1})/9.44\}$$

with BIC value as 383.84. Finally forecasting of out-of- sample data was done for MAR model along with change in forecast interval. From both modelling and forecasting points of view, present study provided deeper understanding of behaviour of weekly onion price.

- For developing forecast models for important crops in UP state by extending existing district

level models and to refine the existing methodology at district level, models for forecasting rice, wheat and sugarcane yield for different districts of U.P. were developed based on weekly/fortnightly weather parameters and trend. Weather parameters considered were maximum temperature, minimum temperature, rainfall and relative humidity (morning). For each weather variable, a composite index was developed as weighted accumulation, weights being the correlation coefficients between detrended yield and weather variable in different periods (week for rice and wheat and fortnight for sugarcane). Similarly, for joint effects of weather variables, composite weather indices were developed as weighted accumulations of product of weather variables (taken 2 at a time), weights being correlation coefficients between detrended yield and product of weather variables considered in respective periods.

The mathematical form of the model at district level was

$$Y = a_0 + \sum_{i=1}^p a_i Z_i + \sum_{i \neq i'}^p a_{ii'} Z_{ii'} + cY_r + e$$

where

$$Z_i = \sum_{w=n_1}^{n_2} r_{iw} X_{iw}$$

$$Z_{ii'} = \sum_{w=n_1}^{n_2} r_{ii'} X_{iw} X_{i'w}$$

Y crop yield

X_{iw} value of i-th weather parameter in w-th period

r_{iw} correlation coefficient between detrended yield and i-th weather parameter in w-th period

$r_{ii'}$ correlation coefficient between detrended yield and product of X_i and $X_{i'}$ in w-th period

p number of weather parameters

n_1 initial period for which weather data were included in the model

n_2 final period for which weather data were included in the model

Y_r year

e error term

Models were also developed at agro-climatic zone

level. In these models along with weather parameters and trend, previous year's yield, moving averages of yield and per cent area under irrigation were also used to take care of variation between districts within the zone. District forecasts were aggregated to get zone and state level forecasts taking area under the crops in different districts as weights. Reliable forecasts of rice and wheat were obtained when the crop was about 11 weeks old i.e. around two and a half months before harvest whereas for sugarcane reliable forecast was obtained in middle of September i.e. about 5 months before harvest.

- For forewarning incidence of paddy pests, weekly light trap catch counts of pests - Green Leaf Hopper (GLH) and Gundhi Bug (GB) and weather data were compiled for 15 years (1987-99) for the period July-November. The life cycles of these pests were studied and graphical analysis of their counts revealed the weeks of peak incidence as 2nd and 1st week of October for GLH and GB respectively. Correlations between pest counts and lagged weather parameters were utilized to compute weather indices. Thereafter, forewarning models were developed by establishing relationship between pest counts and two weeks lagged weather indices via stepwise regression using 1985-97 data. The forecast models for GLH and GB were respectively obtained as

$$y_1 = 16.49 + 0.41 z_1 \text{ and}$$

$$y_2 = -1.49 + 0.33 z_2$$

where

y_1 = GLH pest count during 2nd week of October

$$z_1 = \sum_{w=m_1-3}^{m_1} r_{1w} x_{1w}$$

is the weather index where r_{1w} is the correlation coefficient of y_1 with weather variable x_{1w} i.e. minimum temperature in the w -th week and m_1 is the week of forecast i.e. 4th week of September

y_2 = GB pest count during 1st week of October

$$z_2 = \sum_{w=m_2-3}^{m_2} r_{2w} x_{2w}$$

is the weather index where r_{2w} is the correlation coefficient of y_2 with weather variable x_{2w} i.e. relative humidity in the w -th week and m_2 is the week of forecast i.e. 3rd week of September.

- Both the models could explain around 80% of the variation in pest counts. The pest count forecasts during weeks of peak incidence compared well with those of the observed ones for the subsequent years (1998 and 1999) not included in model fitting.

Remote Sensing and Geographic Information System

- For developing a survey methodology for estimation of crop area and crop yield in Meghalaya a pilot study was taken up in one district of the state namely Rhi-boi to estimate area under paddy crop by two approaches (i) Approach based on Remote Sensing, GIS along with survey data and (ii) Village Survey approach.

Under the first approach, the digital data of IRS-1D, LISS-III sensor pertaining to 8 September 2003 and 22 November 2003 were used. Due to undulating topography of the study area, there were large differences of area under paddy as obtained and actual area under paddy on the ground. The area under paddy crop falling on hill side or valleys may not be exposed to the satellite sensor, as satellite sensors are sun-synchronous. Further, small paddy fields are not detectable due to lower spatial resolution of the LISS-III sensors. In order to rectify the area under paddy crop due to undulating topology and misclassification errors, relationship between area under paddy in the image and actual area under paddy crop on the ground was established by measuring the actual area of some selected paddy fields by Global Positioning System (GPS) and comparing it with the area in the satellite image. This provided the corrected area under paddy, which was captured by satellite sensor. Further, area under paddy, which was not captured by satellite sensor due to hill shades and limitations of spatial resolution of the sensor, was rectified by conducting sample survey. This survey was carried out along the National Highway/State Roads by selecting a sample of field segments along the roads and actually measuring area by GPS and comparing this area again with the corresponding area of the satellite.

Under the second approach of village survey, a simple random sample of 20 villages was selected. The data pertaining to crops grown and

area under each crop was obtained by enquiry. A sample of 5 farmers was selected in each selected village for detailed enquiry. Area under paddy was recorded using GPS and by observation from 2 fields of the two selected farmers from these five farmers in each selected village and suitable estimators were developed.

The study is being extended in one more district of the state for estimating the crop acreage and yield for the entire state.

PROGRAMME 3: DEVELOPMENT OF TECHNIQUES FOR PLANNING AND ANALYSIS OF SURVEY DATA INCLUDING ECONOMIC PROBLEMS OF CURRENT INTEREST

Assessment and Evaluation Studies

- The study to finalise the farm mechanisation strategies in the country was carried out in three concurrent phases. As part of Phase-I, to crystallize the approach and the modalities relating to the study, a Seminar-cum-Group Discussion was organised and a document comprising of 10 status papers entitled "Status of Farm Mechanisation in India", was submitted.

In Phase-II, a large scale survey, adopting stratified multi-stage random sampling design, was planned and conducted in 120 randomly selected districts through 24 Centres (21 Centres of AICRP on FIM; GAU, Gujarat; SKUAST, Jammu; NDUAT, Faizabad) spread Nation-wide. The analysis of data for all the States was carried out.

In Phase-III, the identified experts on the basis of results obtained as well as on their own experience have prepared the mechanization strategy papers for different Agro Climatic Zones/ States. The draft report of the project was submitted to funding agency and a presentation-cum-discussion on the draft report was organised at the Institute on January 05, 2005 under the chairmanship of Shri Champak Chatterji, Additional Secretary, DOAC, Ministry of Agriculture. Chairman/Members of the Project Management Committee, senior officials of the DOAC, Ministry of Agriculture/ICAR, DES, CIAE, experts involved with the preparation of the strategy papers and the associate scientists participated in the meeting.

It was decided that for discussing these mechanization strategies with respect to their

implementation aspect etc., a 2-days National Workshop inviting senior officials of different State Governments; DOAC, Ministry of Agriculture, GOI; Farm Mechanisation Experts from different institutions and other private organizations may be organised at the NASC Complex during April 15 -16, 2005.

- In order to develop a user friendly software for the imputation of missing data based on neural network based imputation concept along with other alternative methods of imputation, requirement analysis was done.

Production and Area Estimation

- For studying the methodology of estimation of wool production a pilot study was taken up in one district each viz. Bikaner of Rajasthan and Kolar of Karnataka, the two major wool-producing states of the country in Northern and Southern region respectively. The estimates of sheep number, average wool yield and total wool production for Kolar and Bikaner districts were prepared and finalised. The difference in estimates obtained by using different estimators was also tested.
- From the study, "On efficient block level estimators of yield rates of important crops" grown in the two districts of Bhiwani and Sirsa of Haryana State as well as comparing the efficiency of production as obtained by crop cutting approach and the farmers' inquiry based approach, the accuracy comparison of crop cut estimates and the farmers' estimates were made with actual production values. The crop cut estimates by and large were found to be close to the actual production figures for crops harvested in multiple pickings, cotton, etc. There was no clear cut trend in respect of the closeness of crop cut estimates and the farmers' estimate to the actual production values for the other crops covered in the survey. However, the percentage standard errors associated with farmers' estimate were smaller in comparison to the percentage standard errors of the estimates obtained through crop cut approach.

Cost of Production Studies

- The study aimed at developing sampling methodology for estimation of cost of production of coconut in Kerala revealed that farmers'

receptivity to coconut production technologies ranged from low to medium level. Technologies such as basin opening and application of organic manures were the most commonly adopted practices. Plant protection, spacing for optimum plant density and cultivation of hybrid/high yielding varieties were the items of low level of adoption. Applications of chemical fertilizers, irrigation, intercultural operations, inter/mixed cropping and mixed farming was having medium level of adoption.

- From the study “On development of methodology for productivity of important flowers” estimated production of loose flowers on the basis of market arrival from Delhi as well as outside Delhi were found to be 14570.910 MT with 2.51% S E and 25829.580 MT with 1.50 % S E respectively. The corresponding figures for cut flowers were 670.68820 lakh with 1.53% S E and 2380.80237 lakh with 0.74% S E. The percentage of market arrival of loose flowers from Delhi and outside Delhi was of the order of 36% and 64% respectively. The corresponding figures in case of cut flowers were 22% and 78%. Percentage standard errors of the estimates of different kind of flowers traded in the three flower mandis of Delhi ranged from 0.94 to 7.75. It clearly indicated the applicability of sampling methodology adopted.

Technological Change, Risk and Uncertainty in Agriculture

- An econometric study of technological dualism in egg production was based on primary survey data of selected poultry farms in two districts Mansa and Ludhiana of Punjab state. The results revealed that the initial capital investment for Cage System farms was more than two folds as that of Deep Litter System farms in Mansa and nearly three folds in Ludhiana district. However, the average investment for a particular technology was higher for farms set up at Ludhiana compared to those at Mansa probably because of urbanization. The estimates of Cost and Returns on Layer Farms indicate that Cage System farms were earning more profit compared to the Deep Litter System farms in both the selected districts. The study showed that major factors influencing egg production are feed, labour, medicines and

electricity costs. The study of regression analysis showed that on both types of farms most of the input variables except for feed cost were not properly utilized. However, it was observed that if the poultry farms using Deep Litter System shifts over to Cage system of technology there may be a substantial saving in the input resources. The Chow test confirms the superiority of modern technology over the traditional one in terms of efficiency of inputs at both the districts. The existence of Technological Dualism in egg production revealed that inputs were not being efficiently used on Deep Litter farms. The Chow test further confirmed the fact that a shift to the modern (Cage) technology could save the inputs substantially. Factor share analysis in district Mansa revealed that the share of labour factor remained about 4 percent, the share of poultry feed which is a proxy variable for capital, was maximum of about 62 percent on both types of farms.

- The study on ‘Technical efficiency analysis of rice-wheat system in Punjab’, employed farm level rice-wheat system data of Punjab farmers to stochastic frontier for evaluating individual level of technical efficiency across given sample farms during 1985-86. Although empirical results of the study revealed an ardent economic viewpoint that the majority of farmers in Punjab did not appear very far from frontier but there existed possibilities of increasing rice and wheat output with better use of technical skills at least in deployment of factors of production under farm control efficiently.

Modeling for Agricultural Marketing

- The host wise details of brood lac in Jharkhand state was obtained as: Ranchi district: Ber Host –During Baisakhi crop, the average rate of brood lac was about Rs. 58.75/kg, Palas Host- Rs. 40/kg for Baisakhi crop and for Katki crop Rs. 21.43/kg and in W. Singhbhum: Rs.78/kg Kusum Host- in Jethwi crop of Rs.100 and for Katki crop Rs.106.25 respectively. Scrapped Lac/ Crop output – (i) Jharkhand State: Ber Host: In the Bundu block, in Baisakhi and Katki season, the average income from lac cultivation was about Rs. 3840. In Murhu block, the average income from lac cultivation was about Rs. 2720 in both the seasons. In W. Singhbhum the average

income from lac cultivation was about Rs. 2276 in two seasons. Palas Host: In the Bundu block, the average income from lac cultivation was about Rs.1327 in two seasons. Oramanjhi block, in all the selected villages the crop was affected due to adverse climatic conditions and the cultivators could earn only Rs.170 from both the crops. Murhu block, the average income from lac was about Rs. 2414.00 in two seasons. Silly block, the average income from lac cultivation was about Rs. 34.57 in two seasons. W. Singhbhum, the average income from lac cultivation was about Rs. 34.57 in two seasons. Kusum Host- the average income from lac cultivation was about Rs. 6195.50 in two seasons.

Income from Scrap Lac Production: Chhattisgarh, M.P. and Maharashtra States: The annual average income of different host trees from Lac cultivation in case of Ber host income on small farms was Rs. 545, on medium farms Rs. 272 and on large farms Rs. 224. Income from Palas host on small farms was Rs. 319, on medium farms Rs. 405 and on large farms Rs. 537. In case of Kusum host income on small farms was Rs. 641, on medium farms Rs. 1073 and on large farms Rs. 868.

Food Security and Poverty Alleviation

- The study was based on primary data collected for base year, 2001 and the year 2004 on household food and nutritional security for tribal, backward and hilly areas under "Jai-vigyan national science and technology mission project". The results pertaining to Ajmer district of Rajasthan revealed that the number of sheep maintained by participating farmers and non-participating farmers were almost of the same order. The average yield of wool per animal was reported to be 2 kg by participating farmers and 1.72 kg by non-participating farmers. There was an increase in yield of wool per animal over the base year. It was found that cost of rearing of sheep has declined by about 24 percent on participating farmers over the base year. Overall, net income over input costs was found to be nominal on participating as well as non-participating farmers. The level of employment was higher on participating farmers in comparison to non-participating farmers. The availability of employment seemed to have been reduced for both categories of farmers. It was found that there was surplus consumption of cereals and millets, milk and sugar by all categories of farmers. The percent change in food security, when compared to the base year, indicated that consumption of surplus food items, viz. cereals, milk and sugar have decreased marginally. All the farmers opined a decrease in the rate of mortality and morbidity of sheep as a result of technological intervention.
- In Kangra district of Himachal Pradesh, there was a significant increase in the number of sheep and goats on participating farms. The increase in wool productivity was higher on participating farms in comparison to the non-participating farms over the base year. The rearing cost per farm was lower in case of participating farmers. The increase in gross income was more on participating farms than non-participating farms. The level of employment was also higher for the participating farmers. When compared to the base year, it was observed that there was a decrease in employment on participating as well as non-participating farms. The consumption of cereals, milk, sugar and fat and oils was more than the recommended quantity. The change in consumption over the base year indicated a marginal increase in consumption of cereals and milk and significant increase in other food items like pulses, vegetables, fruit, sugar and fat and oils on participating farms. The participating farmers indicated that they have observed a decrease in the rate of mortality and morbidity of animals due to technology intervention.
- Under the study on, "Determinants of performance of Self-Help Groups (SHG) in rural micro-finance", the divergences between Andhra Pradesh and Uttar Pradesh states in terms of agro climatic and socio-economic parameters was examined. SHG progress in both states was very diverse while it was very fast in Andhra Pradesh compared to Uttar Pradesh. Despite higher growth rate of population, higher share of cultivators, lower female literacy and higher female population in Uttar Pradesh, the SHGs progress was slow in Uttar Pradesh as compared to that in Andhra Pradesh. This scenario rejected the hypothesis that there should be a higher positive correlation between female population and number of SHGs.

The organizational setup in Andhra Pradesh showed that commercial banks had performed better as compared to regional rural banks. On the other hand, despite the vast expansion of formal credit system in Uttar Pradesh, more than half of the rural households were still outside the ambit of institutional credit.

The socio-economic conditions of two districts of Andhra Pradesh were also diverse. The analysis of determinants of repayment showed that the variable of economic homogeneity was main responsible factor in both the districts of Andhra Pradesh. It was also observed that socio-economic diversity existed in selected districts of Uttar Pradesh too. Regarding determinants of repayment of loans, the analysis showed that higher amount of loan and socially more heterogeneous groups were the main factors responsible for default in repayment of loan in Kanpur district. In Jaunpur district of Uttar Pradesh, economically and socially more heterogeneous group might add to default in repayment of loan.

Further there were diversities in socio-economic factors in both states and probably these factors were not considered at the time of formulation of policies in Uttar Pradesh. The overall position of SHG programme in Andhra Pradesh was better as compared to Uttar Pradesh. The study suggested the various steps for improving the SHG programme in Uttar Pradesh.

- In the study "Water-food security scenario analysis for 2025: Agro-ecological regional approach" a chapter entitled "Resource Analysis for Sustaining Water-Food Security in AER-4" was published in the proceedings (No.12) of NCAP. The results revealed that cropping pattern in agro-ecological sub region AESR 4.3 and AESR 4.4 was dominated by foodgrain crops. Using policy interactive dialogue model (PODIUM) the water food security scenario analysis was done for AESR 4.3 and AESR 4.4. Alternative scenarios namely, the business as usual scenario (BAU) which assumed a continuation of current trends in water and food demand-supply drivers and the food secure sustainable groundwater use scenario (GWS) postulates no ground water mining and sustaining food security in future, were analyzed for these AESRs upto 2025 with specific

set of interventions. BAU scenario analysis showed that the sub-region 4.3 has food deficit and declining groundwater balance, whereas sub-region 4.4 has a very large food deficit but stable groundwater balance. On the other hand, GSW scenario analysis emphasized on yield growth in AESR 4.3 to eliminate the food deficit but groundwater depletion would continue unabated.

Agricultural Research Data Book 2004

- Agricultural research is a vital input for planned growth and sustainable development of agriculture in the country. The Council being an apex scientific organisation at national level plays a crucial role in promoting the accelerating use of science and technology programme relating to agricultural research and education. It also provides assistance and support in demonstrating the use of new technologies in agriculture.

Information pertaining to agricultural research, education and related aspects available from different sources is scattered over various types of published and unpublished records. The Agricultural Research Data Book 2004, which is 8th in the series, is an attempt to put together main components/indicators of such information. The Data Book comprising of 231 tables, is organized, for the purpose of convenience of the users into eleven sections namely, Natural Resources, Environment, Agricultural Inputs, Fisheries, Horticulture, Production and Productivity, Produce Management, Export and Import, Indian Position in World Agriculture, Investment in Agricultural Research & Education and Human Resources under National Agricultural Research System (NARS). It also contains at the end, list of important National and International Institutions associated with agricultural research and education along with their addresses, telephone numbers and e-mail addresses. The Data Book has been compiled through the joint efforts of the Indian Agricultural Statistics Research Institute (IASRI) and the Computer Centre of the Indian Council of Agricultural Research (ICAR). It is the eighth edition and contains the latest information/data as available in the country at the end of April, 2004.

Accordingly, the Agricultural Research Data Book 2004 has been published during May, 2004

and was released during the Directors Conference on 14 July, 2004. It was distributed among the members of the Governing Body, senior-level officers of the Council, Vice Chancellors of SAUs, Directors of ICAR Institutes and other senior level officials under NARS.

The preparation of Agricultural Research Data Book 2005 is in progress.

PROGRAMME 4: MODELLING AND SIMULATION TECHNIQUES IN BIOLOGICAL SYSTEMS

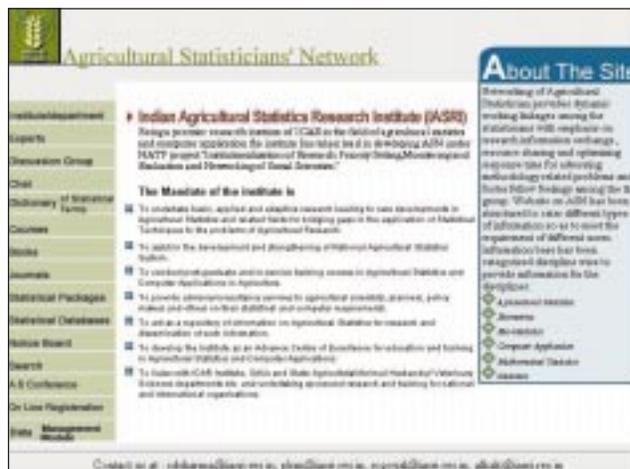
Computer Simulation Studies and Applications of Re-sampling Techniques like Bootstrap in Biological Investigations

- In an empirical investigation, "to study the influence of fixed effects on estimates of heritability" it was observed that the bias was reduced considerably and became negligible when the data was adjusted for all the fixed effects present in the data under half-sib model. A close similarity was observed with the estimates obtained by mixed model technique in terms of percentage of bias in the estimates of heritability. The bias would be quite high if all the fixed effects considered in the model were not utilised for the adjustment and was observed to be a function of sample size. Similar results were obtained for estimating sire-component heritability under full-sib model. The method of fitting constants proved comparable to mixed model technique for moderate and high values of heritability. However, in case of low heritability the bias in the estimates of sire-component heritability from data adjusted for all the fixed effects was slightly higher as compared to estimates obtained by using mixed model technique.

PROGRAMME 5: DEVELOPMENT OF INFORMATION TECHNOLOGY IN AGRICULTURAL RESEARCH

- NATP project 'Institutionalization of Research Priority Setting, Monitoring and Evaluation and Networking of Social Scientists' was completed. PIMSNET was developed for implementation. For Monitoring and Concurrent Evaluation (M&CE) of the research projects running under NATP, the M&CE mechanism was developed and implemented through the PIMSNET at all the

AED's offices. PIMSNET is available on the Internet (<http://www.pimsnet.gen.in>) and contains data of all 845 sub-projects running under different research modes of NATP. To bring more awareness about PIMSNET system usage, sensitization-training workshops at all the Agro-Ecosystem Directorates of NATP and PIU, NATP, New Delhi were organized during July-August 2004. To provide a comprehensive view of



Homepage – Agricultural Statisticians' Network

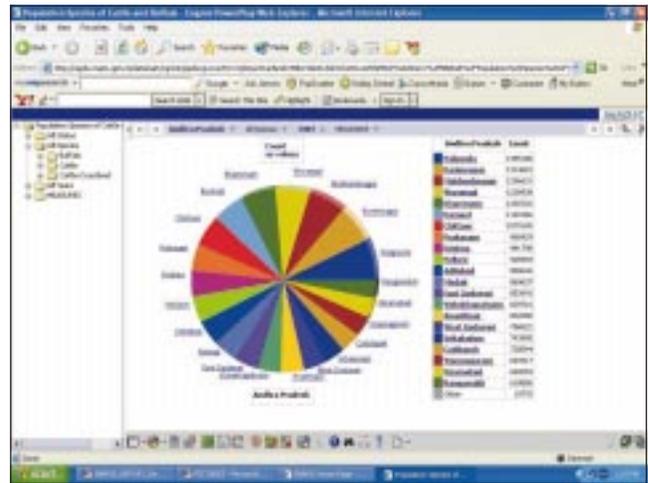
research information in statistics within the NARS a web site for agricultural statisticians <http://iasri.res.in/ASN/> was designed and developed.

The website is accessible across the world and thus provides an opportunity to share the scientific resources through a common platform and enhances the multidisciplinary research and act as a key to nourish the agricultural research. PIMSNET was initially designed to cater the needs of the personnel directly or indirectly related to NATP project and in its extension phase (01-01-2004 to 31-3-2005), its capabilities were extended to handle online M&CE of projects being undertaken at the ICAR institutions as a part of Plan activities and AP-Cess funded projects undertaken at ICAR institutions and SAUs. Technical documents on ASN and PIMSNET were prepared. Reports as required by NATP, PIU were provided from PIMSNET.

- Under the NATP Mission Mode Project 'Integrated National Agricultural Resources Information System' (INARIS) the design and development of flexible Central Data Warehouse (CDW) of

agricultural resources of the country at IASRI, New Delhi (lead center) and databases on different subjects at respective co-operating centers were undertaken. The target users of information systems and decision support system developed under this project are (i) Research Managers, (ii) Research Scientists and, (iii) General Users. In this project a state of art CDW of agricultural resources of the country was developed at IASRI, New Delhi and was probably the first attempt of data warehousing of agricultural resources in the world. This provided systematic and periodic information to research scientists, planners, decision makers and developmental agencies in the form of On-line Analytical Processing (OLAP) decision support system. The above project was implemented with active collaboration and support from 13 other ICAR institutions, namely NBSSLUP, Nagpur (for soil resources), CRIDA, Hyderabad (for agro-meteorology), PDCSR, Modipuram (for crops and cropping systems), NBAGR, Karnal (for livestock resources), NBFGR, Lucknow (for fish resources), NBPGR, New Delhi (for plant genetic resources), NCAP, New Delhi (for socio-economic resources), CIAE, Bhopal (for agricultural implements and machinery), CPCRI, Kasargod (for plantation crops), IISR, Calicut (for spices crops), ICAR Research Complex for Eastern Region Patna (for water resources), NRC-AF, Jhansi (for agro forestry) and IIHR, Bangalore (for horticultural crops).

In all 59 databases on agricultural technologies generated by Council, research projects in



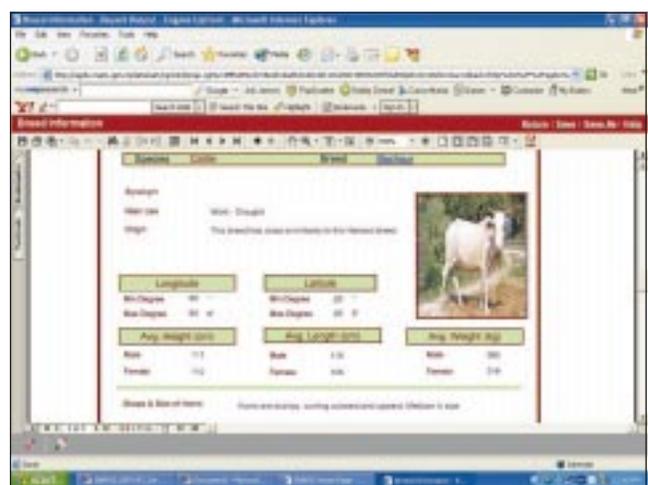
Graphical presentation of multi-dimensional cube

operation and related agricultural statistics from published official sources at least from the year 1990 onwards at the district level were integrated for the development of above data warehouse. Subject-wise data marts were created; multi-dimensional data cubes developed and published on Internet/Intranet. The web site of the project is already launched (www.inaris.gen.in) and the multidimensional cubes, dynamic reports, GIS maps, adhoc-queries and information systems are already available to the users.

The information of this data warehouse are available to user in the form of decision support system in which all the flexibility of the



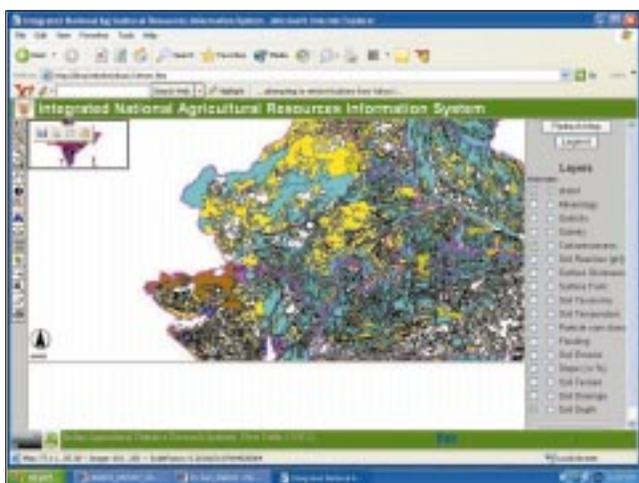
Homepage – INARIS



Dynamic report from CDW

presentation of the information, its on-line analysis including graphic is inbuilt into the system.

The system also provides facility of spatial analysis of the data through web using functionalities of Geographic Information System (GIS). Apart from this, subject wise information systems have been developed for the general users. The user of this system has the access of subject wise dynamic reports through web. The facilities of data mining and generation of ad-hoc queries were also extended to limited users. Therefore, the dissemination of information from this data warehouse for different categories of



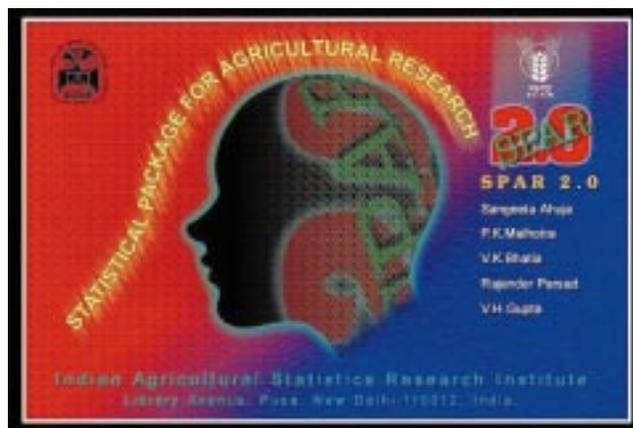
GIS map for spatial analysis

users is through web browser with proper authentication of the users.

- In another NATP project 'Development of Expert System of Extension' an interactive website of Agricultural Extension was developed. This project was designed to help farmers to take appropriate decisions and disseminate need based research findings to millions of the farmers at a time, which was neither possible nor practicable by conventional system of extension. The extension website was also relevant as the conventional extension system was lacking human and financial resources to meet the needs of millions of the farmers in diverse agro-climatic conditions. Farmers information needs, effectiveness of the technology, efficiency of the website, its adoptability and cost was considered in very fast

changing electronic scenario. Java Expert System Shell (JESS) was used to develop the Expert System. The system was built with a user-friendly utility to create the online decision trees to solve the various problems of the farmers. With the help of this web based utility, experts of different crops and domains can make decision trees to solve the problems from their locations and the website enables the farmers to find the solution of their problems in an interactive fashion. The decision trees can be developed for variety selection, identification of diseases, insect pests, weeds and their control measures etc. The expert system of extension developed is generic in nature and allows the entry of any crop and for any region of the country. Although keeping in mind the scope of this project under the limited resources and time only information of seven selected crops was considered. The expert system contains various user-friendly forms to capture the information.

- The development of the Statistical Package for Agricultural Research (SPAR 2.0) was completed. SPAR 2.0 is a Windows Version of SPAR 1.0 with



Statistical Package for Agricultural Research (SPAR 2.0)

some additional modules. It was developed to overcome the limitations of SPAR 1.0. This package has been developed in Microsoft Visual C++ 6.0 language, which is ideally suited for this job as it has powerful features and excellent numerical support. This package is user-friendly, interactive, password protected, completely menu-driven. Context-Sensitive Help with Index, Contents and Search facility has also been provided in the package. The package consists

of the following eight modules, which have sub-modules for various type of data analysis:

- Data Management - (i) Editing of data and (ii) Transformation of data
- Descriptive Statistics - (i) Measures of Central Tendency, (ii) Measures of Dispersion, (iii) Generation of Moments, (iv) Measures and Coefficients of Skewness, (v) Measures and Coefficients of Kurtosis and (vi) Measures of Partition Values
- Estimation of Breeding Values - Generations Means (Six Parameter Model, Five Parameter Model, Three Parameter Model) and Scaling and Joint Scaling Tests
- Correlation and Regression Analysis - Estimates of the Regression Coefficients, Analysis of Variance of Regression, and Regression Equations (linear regression or multiple), Simple Correlation, Partial and Multiple Correlations, Validity of Test of Significance and Path Analysis.
- Variance and Covariance Components Estimation - Computation from ANOVA, Components of Variances such as Phenotypic Coefficient of Variation, Genotypic Coefficient of Variation and Heritability (broad sense), Standard Error and Critical Differences, Bivariate Analysis of Variance and Covariance Components such as Phenotypic Covariance, Genotypic Covariance
- Stability Analysis - (i) Eberhart and Russell's, (ii) Perkins and Jinks' and (iii) Freeman and Perkins' Models
- Multivariate Analysis - (i) Cluster Analysis, (ii) Discriminant Analysis and (iii) Principal Component Analysis
- Mating Design Analysis - (i) Complete Diallel, (ii) Partial Diallel, (iii) Line x Tester (with parents), (iv) Line x Tester (without parents), (v) Three Way Cross, (vi) Double Cross and (vii) North Carolina Designs Analysis
- Under the Institute project "Statistical Package for Animal Breeding (SPAB 2.0)" following twelve more modules were developed:
 1. Creation of variables for analysis
 2. Calculation of inbreeding coefficient
 3. Estimation of genetic gain
 4. Estimation of genetic trend
 5. Estimation of producing ability

6. Principal component analysis
7. Cunningham's selection index
8. Sire evaluation using SRLS
9. Sire evaluation using REML
10. Simple sign test
11. Paired sign test
12. Wilcoxon signed rank test

- For 'Development of Expert System on Wheat Crop Management' information for four modules viz. variety selection, plant protection, cultural practices and harvest was collected from different sources and catalogued. Database for all the modules has been designed. Coding of two modules for developing the inference engine was completed. A major portion of variety selection module and plant protection module was completed. A requirement analysis workshop was organized in the Institute to discuss the requirement of the farmers and obtain the advise of the experts in developing the proposed expert system.

Information System for Agricultural and Animal Experiments

- Agricultural Field Experiments Information System contains the details of 19386 experiments conducted at various agricultural research stations in the country. The information of experiments stored includes location specification, objectives, treatments details, basal conditions viz. soil type, date of sowing/harvesting, seed rate, spacing, site history, design details, etc. The data stored can be retrieved as per the user requirements. The system has been modified using JAVA technology so as to make web-based system. The transformation of existing database into web-based system has been undertaken.
- National Information System on Long Term Fertilizer Experiments (NISLTFE) is being developed to store and maintain the data generated under long term fertilizer experiments conducted at various organizations under the Horticulture, Crop Sciences and Natural Resource Management Divisions of ICAR. NISLTFE is a web-based application using Java technology. The system has three layered architecture viz., Client Side Interface Layer (CSIL), Server Side Application Layer (SSAL) and Database Layer (DBL). CSIL has been developed using HTML and

Java Script whereas SSAL is implemented using Java Server Pages. DBL has been implemented using MS ACCESS 2000.

Linkages with the organizations engaged in LTFE were established and about 25 scientists were identified as Nodal Officers for supplying the necessary information and data for NISLTFE. Different information tables relating to various attributes under NISLTFE were prepared and accordingly the user interface was designed and developed for data entry and updation. Reports generation module wherein a variety of dynamic reports relating to different aspects of LTFE could be generated, is under preparation. Home Page and Logo of NISLTFE with related links were prepared.

- National Information System on Animal Experiments (NISAE) has been developed wherein the information relating to the experiments conducted in the country in various disciplines of Animal Sciences can be stored at a central place in a compatible form. The information

stored includes location specification, species, breed, principal investigator, objective and salient results achieved, etc. The system is a web-based application using JAVA technology. The system has three-layered architecture viz., client side interface layer (CSIL), a service side application layer (SSAL) and database layer (DBL). CSIL has been developed using HTML, JAVA Script using browser as front end whereas SSAL is implemented using Java Server Pages. DBL has been implemented using Microsoft Access 2000.

PROGRAMME 6: TEACHING AND TRAINING IN AGRICULTURAL STATISTICS AND COMPUTER APPLICATION

Another important activity of the Institute is to impart education and to conduct post graduate and in-service training courses in Agricultural Statistics and Computer Applications. The achievements made under this programme are outlined separately in Education and Training.