ABSTRACTS OF PAPERS

1. A Comparative Study of Multidimensional Sampling Plans

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The Multinomial sampling plan (MSP) and Inverse multinomial sampling plan (IMSP) are multidimensional efficient sampling plans in DeGroot's (1959) sense which has been discussed by Bhat and Kulkarni (1966). A comparative study of these two multidimensional sampling plans has been made for estimating $g(p) = \sum_{j=1}^{r} \lambda_j p_j$ (a linear function) of multinomial proportions., $p=(p_1, p_2, \ldots, p_r)$ where $p_j > 0$ $(j=1, 2, \ldots, (r+1))$ and $\sum_{j=1}^{r+1} P_j = 1$ and it has been assertained that IMSP is also useful sampling plan for estimating multinomial proportions or a linear function of it.

2. Improved Multivariate Product Estimators

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We have proposed 2 variants of the weighted multivariate product estimator due to John [1989] who suggested such a form of the estimator as was, in essence, no different from the one due to Singh [1967]. The 3 estimators including John's are compared from the standpoint of bias and mean square error. These estimators, if weights are optimally determined, are found to have the same approximate mean square error which, in turn, is equal to the one due to Singh [1967]. However, from the point of view of bias, the 2 newly proposed estimators are shown to be less biased than the one due to John (or Singh) under the usual conditions that are assumed to hold in the context of the product method of estimation. To demonstrate the reduction in bias through the use of these estimators, two examples from real population are considered.

The Chairman concluded the session with the following remarks :

- The status of statistical computing is poor. But, there is no room for despondancy.

- The process of modernisation has started.

- There are signs of all round improvement.

- In time to come more men and machines will be available.

- As far as Agricultural Statistics is concerned, the status is far from satisfactory.

- Computers must be used in improving the status of Agricultural Statistics.

- Future will be better.

3. An Empirical Procedure for Comparing the Performance of Linear Discriminant Functions

V.K. Bhatia and S.D. Wahi
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The linear discriminant function based on minimax linear procedure, which did not assume the equality of variance-covariance matrices amongst the two populations, together with corresponding D^2-values, were obtained and compared with Fisher's linear discriminant function. The genetic divergence (D^2-values) obtained by minimax linear procedure were higher than those for the linear discriminant function procedure where the covariance matrices were strikingly different. An empirical procedure using the bootstrap technique was used to further investigate the efficiency of the two procedures of linear discriminant functions. The results based on this procedure have confirmed the superiority of Minimax linear procedure method for the situations where covariance matrices of the groups under comparison are widely different. It yielded higher values of D^2-statistics for both the Minimax and Fisher's linear discriminant function which clearly indicate the bias of the D^2-statistics.

4. Estimation of Finite population Variance Under Unequal Probability Sampling

A.K.P.C. Swain and G. Mishra
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An alternative estimator to estimate the finite population variance is suggested and is compared with Liu's estimator and Chaudhury's estimator. An empirical study is carried out with the help of a variety of 50 natural and artificial populations for the comparison of efficiencies of these three estimators. It is observed that the proposed alternative estimator is the most efficient for 31 populations under consideration and is also found to take negative values less frequently than the Liu's estimator.

5. Optimal K-out-of-N systems with Provision for Repairs

M. Meenakshi Bai, Y. Krishna Reddy[*] and V.S. Munde[**]
S.V. Agricultural College, Tirupati.

A methodology has been reported for identifying optimal K-out-of- N stochastic reliability system based on some general assumptions. The newness in the model-formulation comprises in bringing in provision for repairs an important physical remification, not considered hitherto (in earlier literature). The basic tool of the methodology consists in minimization of expected total cost of the system's maintenanc per time-unit of its failure-free operation (corresponding to the steady-state case). The value of the results is brought out through a qualitative analysis based on some empirical/numerical work.

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6. Pre-Harvest Forecasting of Wheat Yield in Tarai Region of Uttar Pradesh on the Basis of Weather Variables.

A.K. Pandey and J.B. Singh
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An investigation was carried out to develop pre-harvest forecasting model for wheat in Nainital Tarai of Uttar Pradesh on the basis of weather and wheat yield data recorded from Agrometerological observatory and University farm, Pantnagar. The data were collected for a period of 23 years (1966–67 to 1988–89) for twenty two weeks from October to February, the vegetative growth period of wheat crop. The average value alongwith range and coefficient of variation of weather variables viz., maximum, minimum and mean temperature, mean relative humidity, pan-evaporation, number of bright sun-shine hours, wind speed and rainfall were studied grphically. Two models were studied to findout best fit pre-harvest yield forecasting model, using week numbers and correlation coefficient as weights respectively.

The weekly distribution of weather variables showed declining trend till second week of January and in-creased after wards in case of all the study variables except rainfall which had large variation. More rains in the beginning of November may decrease final yield of wheat crop. The forecasting model based on week numbers as weight was found to be superior because of higher R^2 value (0.87), smaller standard error of regression coefficient and being more consistent to simulate the yield for years not included in the study. It is possible to forecast yield in 15 week after sowing wheat crop i.e. in February, almost two months before the harvest. The weather index based on correlation coefficient as weights is superior, as prediction equation based on it explains more variation in the yield and it can be preferably used in future studies.

7. An Improved Unrelated Question Randomized Response Strategy

N.S. Mangat, Ravindra Singh and Sarjinder Singh
Punjab Agricultural University, Ludhiana – 141 004.

The paper considers the problem of estimating π, the proportion of human population belonging to the sensitive category. A new randomized response procedure using known π_y (the proportion of population possessing the non- stigmatized attribute) has been proposed. The proposed strategy provides unbiased and more efficient estimator of π than the one based on Greenberg *et al.*'s (1969) usual unrelated question randomized response model with known π_y.

8. On the Estimation of Harmonic and Geometric Means

Lalit Kishore
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Well known method of estimation of harmonic mean is , by first obtaining estimate of mean of reciprocals of the study variable and then taking its reciprocal. Similarly estimate of geometric mean is obtained by first obtaining estimate of mean of logs of the study variable and then taking its antilog. In the present work, improved regression type estimate of harmonic and geometric means are

obtained considering study variable with known arithmetic mean as auxiliary variable and reciprocals of study variable as study variable as study variable for the estimation of harmonic mean and natural logs of study variable as study variable for the estimation of geometric mean.

9.　Pre-Harvest Forecasting of Rice yield at Pantnagar on the basis of Weather Parameters.

T.V. Hoa and J.B. Singh

G.B. Pant University of Agri. & Tech. Pantnagar - 263 145

The present study was conducted to investigate the effects of weather variables on rice yield at Pantnagar at different stages of crop growth and to forecast its yield based on 25 years (1965- 1989) weather data. The weekly distributions of maximum temperature, minimum temperature, relative humidity at 7 and 14 hours, rainfall, rainy days, sunshine hours and Pan evaporation during the different stages of rice season based on 22 weeks were studied. Five models with various combinations linear/quadratic terms of weather variables and week numbers/correlation coefficient between rice yield and weather variables were studied. The effect of one unit increase above average in weather variables on rice yield was also studied.

The weekly distribution showed that daily maximum temperature and pan evaporation reduced sharply in the seedling and early vegetative growth stages, minimum temperature remained more or less constant except at the maturity stage with a decreasing trend; relative humidity, weekly total rainfall and number of rainy days were high during the vegetative growth and reproductive stages while sunshine hours were low during this period. The forecasting model using linear terms of weather variables and correlation coefficients was found suitable because of high R^2 value and less number of variables. The effect of one unit increase above average, in case of pan evaporation was beneficial almost throughout the crop season; in case of maximum, minimum temperature, relative humidity, it was also beneficial at the end of seedling stage, and during the vegetative growth stage relative humidity, total rainfall, rainy days were beneficial while unit increase in minimum temperature, relative humidity (7 hr.) was found harmful. During the reproductive stage beneficial effects were observed by the unit increase in maximum and minimum temperature and harmful

effects were found by the unit increase in other variables. During maturity stage, unit increase in maximum and minimum temperature and relative humidity (14 hr.) had benificial effects while harmful effects were observed in other variables during this period. The forecasting model using weather data upto 13th week (the third week of August i.e. two month before harvest) was appropriate for forecasting rice yield as it explained 85 percent variation in yield.

10. Growth Rate of Area, Production and Productivity of Tobacco in India

J.S. Patel
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Data on area, production and productivity of tobacco in different States of India from 1951-52 through 1986-87 were subjected to growth curve analysis taking time period as an independent variable. The results revealed that exponential model was best for tobacco area while simple linear model gave the best fit for production and productivity. Positive and significant growth rates for productivity were observed for States as well as the country. Gujarat ranked first in India with a growth rate of 1.376 thousand hectare per year of area, 4.568 million kg per year of production and 35.009 kg per hectare per year of productivity.

11. Effectiveness of A.I. Under Field Conditions in Himachal Pradesh

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The present study was conducted in Himachal Pradesh for estimating the effectiveness of A.I. in cows, under field condition using systematic sub-sampling. The conception rate was estimated at 42.6 percent and female calf born at 51.7 percent. A comparison of systematic sub-sampling with SRS revealed that systematic was found more efficient as compared to simple random sampling.

In order to compare the effectiveness of A.I. in Himachal Pradesh, 12 districts were grouped into 3 categories viz. low, medium and high hills, 35 selected A.I. centres into three categories

according to number of A.I. performed viz. (i) upto 300 A.I. (ii) 301-600 A.I. and (iii) above 600 A.I and the year was divided into three conventional seasons viz. summer, rainy and winter.

The conception rate was the lowest (35.3%) in medium hills and the highest (49.7%) in high hills. It was the lowest (37.2%) for 3rd category of A.I. centre and the highest (50.5%) for Ist category of A.I. centre. No significant differences were observed in percentage of female calf born for different categories of districts as well as A.I. centres. The conception rate was found almost of the same order in different seasons while percentage of female calf born was the highest (52.6%) during summer and the lowest (48.6%) during rainy seasons.

12. Use of Biometrical Characters in Forecasting the Yield of Groundnut

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To develop suitable model for pre-harvest forecast of groundnut, based on available biometrical characters (yield attributes), a pilot study was carried out in Rajkot dist. (Gujarat) during khrif 1984 to 1986. Multistage stratified random sampling technique was used for selection of villages and fields in each taluk. For selection of biometrical characters (yield attributes) to enter finally in the forecast model, the technique of stepwise regression was used. Forecast models at flowering, pegging and pod development stages of crop growth were fitted. It was observed that forecast based on available attributes of groundnut (number of pegs and pods per plant), is possible about 4 to 8 weeks before harvest.

13. Improved Franklins Model for Randomized Response Sampling

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Two estimators of population proportion are introduced when randomized response sampling with a continuous randomizing distribution is used. The estimators have been obtained by using the method of moments. Both the proposed estimators are shownto

be more efficient than the corresponding estimators of Franklin (1989).

14. Comments on Regular Graph Designs

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Mitchell and John (1977) gave conjecture for the regular graph design to be E–optimal. Later Jacroux (1980) and Cheng (1980) discussed a systematic approach for regular graph design (RGD) to be E–optimal. Jacroux (1980) showed that if there exists a regular graph design, dε Dr having

$$Z_{dl} \geq \max \left[\frac{(rk-\theta-\lambda-2)v}{(v-2)\,k} \, , \, \frac{(rk-\theta+\lambda-1)}{k} \right]$$

then there exists an E–optimal RGD in D . When the inequality given above is strict, an E–optimal design in Dr, must be an RGD. Among the E–optimal regular graph designs listed in the original technical report of Mitchell and John (1976), Cheng (1980) showed that 17 of these designs are RGD and satisfied the condition of E–optimality. In the present investigation it is found that apart from the 17 GD designs discussed by Cheng (1980) three more group divisible designs are available which are RGD and satisfy the E–optimality criteria. The parameters of the three GD designs are as follows.

No.	v	b	r	k	m	n	λ_1	λ_2	Type of GD
1.	18	54	9	3	9	2	2	1	RGD
2.	30	75	10	4	15	2	2	1	RGD
3.	12	6	5	10	6	2	5	4	SGD

15. Trends in Area, Production and Productivity of Foodgrains in Andhra Pradesh and India- Projections by 2000 AD: AN Econometric Analysis

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An attempt has been made to examine the trends in area, production and productivity of important foodgrain crops and to project the same upto 2000 AD. The linear, exponential, quadratic and logistic functions were fitted to the data. The growth parameters were studied dividing the total period in to different sub-periods viz., Pre-green revolution (1956-57 to 1965-66), Green revolution (1965-66 to 1975-76), Post green revolution (1975-76 to 1984-85) and overall period (1956-57 to 1986-87).

Analysis of foodgrain production showed that the green revolution period has brought about considerable increase in production in the state as well as in the country mainly through rice. The tempo of green revolution period could not be maintained in the post green revolution period. It is also seen that growth is associated with instability. Increase in productivity was the major source of growth for cereal production particularly of rice and maize crops.

The finding of the study indicated that there was three fold increase in the total foodgrains production from 1956-57 to 1986-87. The area, production and productivity of total foodgrain crops by the turn of this century will be 8.3 million hectares, 19 million tonnes, 2041 kg ha^{-1} in Andhra Pradesh 131 million hectors, 221 million tonnes and 1383 kg ga^{-1} in India respectively.

16. Growth and Instability in Groundnut Production of Orissa

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· During the last two decades, the total oilseeds has registered significant growth (8.77 per cent) in production due to significant growth in groundnut production (10.86 per cent) and in area under the crop (10.97 per cent). But during the same period, the rate of

increase in productivity of groundnut was negative which was not significant. However, the highest instability was observed in production of groundnut but having lowest rate of convergence. Even though converging instability in production and productivity of both groundnut and total oilseeds were observed but these were not prominent. Hence, policies are to be framed to stabilise output of groundnut either by reducing the variability in productivity or increasing growth rate of productivity through improved seed-fertilizer technology in the State.

17. Estimation of Stability Parameter for Binary Responses

S.C. Rai[*] and Shanti Sarup
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The case of binary responses due to introduction of a new treatment has been discussed and a simple measure stability parameter has been defined. The sampling distribution of stability parameter has been worked out and a method for testing whether the treatment is stable or not has been presented. The range of the stability parameters is observed to be –1 to 1. For comparing stability parameters between two or more treatments or between two or more locations, a test procedure has been evolved. Procedures developed have been explained through illustrative examples utilising data on yield levels of rice and wheat crops in different districts of Madhya Pradesh covering the period of three decades through 1955–56 to 1984–85. The analysis revealed that the stabilities in respect of wheat productivity in respect of two groups of district (low productivity and high productivity districts) were of the same order. Further it was noticed that in group I, 50 percent of the low C.V. districts had shifted their position to the high C.V. category 40 percent of the high C.V. districts had changed their position to the low C.V. category after introduction of HYV programme. In group II 70 percent of low C.V. districts had moved to high C.V. category while only 20 percent of high C.V. districts had gone to the low C.V. category. From this analysis it could be inferred that the HYV programme had resulted the increased variability in the group II districts.

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18.   Growth of Fertilizer Consumption in Orissa — A District-Wise Analysis

P.N. Pradhan, S. Jena and A.K. Mitra
OUAT, Bhubaneswar

In this paper an attempt has been made to find out the growth-rates and trends in total and per hectare fertilizer consumption in Orissa and in thirteen districts for the period between 1968 and 1988. For this purpose log-linear and log–quadratic functions have been fitted to the relevant data.

The analysis shows that there was much disparity in fertiliser consumption among districts and between districts and the State-level. The five major irrigated districts accounted for 87.81 per cent of the fertiliser consumption during triennium year ending 1970-71. But it came down to 77.34 per cent during the triennium ending year 1987–88, indicating spread of fertiliser utilisation in the rest of the un-irrigated districts due to introduction of irrigation facilities and adoption of new technology.

19.   A Study on the Effect of Breed-Category-Sex Classifications on Cause of Death Among Cattle

D.K. Bhatia, S.N. Arya and Shivtar Singh
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Data on frequencies of cattle mortality secured through a survey in a hilly region of Himachal Pradesh were classified by cause of death on one side and breed category–sex on the other. These were reshaped into several contingency tables and χ^2-test of independence was applied separately to each table. In particular, Brandt-snedecor formula was used. Cause of death was found to be independent of category (i.e. young stock/Adult Stock) in the case of crossbred cattle but not in that of nondescript cattle. Sex effect on cause of death was not statistically significant. Breed classification was not significant for the young stock category but it was significant (P < .01) for the adult category implying that the crossbred adult cattle were affected by the various causes of death differently from the non-descript adults.

20.   Cluster Analysis of Genotypes on Comparison of Distances Measures with and without use of within Genotype Variability

S.D. Wahi
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Different procedures to cluster 45 genotypes of Hippeastrum hybridum are compared. The results of this study show that use of the within genotype covariance matrix can not significantly improve the classification. Different classification procedures behaved similar. An alternative procedure described in detail was best and could not be improved by reallocation. The quality of classification was checked by wilks Λ, the largest cannonical correlation and the rate of correct classification in a discriminant analysis afterwards. Although the results of such a discriminant analysis are too optimistic, they can serve as basis for the comparison of different procedures.

21.   Optimal Value of MPC for Linear Consumption Model

D.K. Grover and L.S. Kaushik
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The assumption of fixed income over the years has been relaxed for estimating mpc of linear consumption model. Incomes are assumed random for the model

$$C = \beta Y + \varepsilon$$

Where, C the consumption and Y the income are assumed to fluctuate randomly. An attempt has been made to find the optimum value of β i.e. mpc, by considering C^* the desired consumption, ρ the correlation coefficient and σ_y and σ_ε the standard deviations of income and error term. The mean square error of current consumption 'C' around desired consumption C^* is minimized for

$$\varphi = E\,[(\,C - C^*)^2]\ \text{and}$$

$$\varphi = \sigma_C^2 + (\overline{C} - C^*)^2$$

giving β^* the optimum value as

$$\beta^* = \frac{\overline{Y}\,(C^* - \overline{\varepsilon}) - \rho\ \sigma_Y\ \sigma_\varepsilon}{\overline{Y}^2 + \sigma_Y^2}$$

If only random fluctuations in income are considered then

$$\frac{\partial\,\overline{C^*}}{\partial\,\sigma_Y} < 0$$

showing that mean level of optimal consumption decreases as income uncertainty increases.

22. Estimators of Repeatability for Perennial Crops

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Most perennial species, according to Pearce (1953), are to some extent biennial in cropping and growth. There is no procedure available to estimate the repeatability parameter in the perennial crops which are invariably showing biennial rhythm. It has been shown by various workers that in presence of biennial rhythm the different existing procedures for estimation of repeatability give highly biased results. In the present study new procedures for estimation of repeatability, which are robust to bienniality, are proposed and their efficiencies are compared with the traditional methods of estimation based on ANOVA and principal components. In all seven estimation procedures are compared viz ANOVA, principal components based on sample correlation and covariance matrix, related multivariate method (structural analysis) based on sample correlation matrix, Abeywardena's estimators, Moving average I and Moving average II estimators.

A simulation study conducted under the standard linear model and with fixed and random biennial effects indicated the superiority of Moving Average I and II estimators over the other traditional methods based on ANOVA and principal components. As expected, the newly proposed estimators of repeatability based on Moving averages are found robust to bienniality and gave almost comparable monte carlo bias and mean squared errors. The Moving average I estimators behaves similar to the Moving average II

estimator except for low values of repeatability, when it gives slightly higher bias and mean squared error as compared to the later. Overall, the Moving average II is the most preferred method as it gives the least bias and mean squared error for entire range of repeatability, sample size, fixed and random biennial effect and for different intensities of 'on' and 'off' phase trees.

23.   A note on the distribution of retention times of diary cattle with different level of exotic inheritance.

V.K. Bhatia and P.K. Malhotra
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The important aspect of retention time data analysis in dairy cattle is the model or distribution fitting. Once an appropriate statistical model for retention time is constructed and its parameters estimated its information can help to predict retention time, percentile estimate and culling probability estimates etc. To achieve this, different distributions of retention times viz Exponential, Weibull, Extreme value, Normal, Log Normal, Logistic, Log–logstic, Linear–Exponential and Gompertz have been examined. Both graphical as well as analytical methods have been used for fitting of the distribution. Using the graphical methods based on the probability plots, the distribution of retention time has been found to be Weibull. For the estimation of parameters of different distributions of retention times by the analytical methods, the procedure of maximum likelihood and least squares have been used. Based on the analytical methods, the distribution of retention time has again been found to be Weibull for all the categories of dairy animals. The estimates of parameters of Weibull distribution as obtained by analytical methods are found to be close to the graphical estimates. It is seen from the estimated parameters that there is an increase in the retention time with increase in the level of exotic inheritance upto 37.5 percent and thereafter a decline in retention time is noticed. Further from the culling probability estimates, it is concluded that 3/8th crossbreds have maximum retainability vis-a-vis maximum adaptability. It is also observed that culling is more intense for animals having higher level of exotic inheritance, in particular when animals are young and have completed few years of useful life at the farm which implies that animals are screened thoroughly at the initial phase of their useful life in the herd.

24. Comparative performance of Estimators of Repeatability

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The coefficient of repeatability is being extensively used by animal breeders (Jain, 1982) for improvement in repeatable characters such as milk yield in diary cattle, egg production in poultry, wool yield in sheep etc. A number of estimators of repeatability are available in literature. These are mainly based on analysis of variance and principal components methods. In this study, six estimation procedures are compared; ANOVA, principal components based on sample covariance matrix and also on the sample correlation matrix, a related multivariate method (structural analysis) based on sample covariance and also on the sample correlation matrix, the maximum likelihood estimation.

A simulation study is conducted for the nine different values of population parameter for small moderate and large sample sizes indicated that when the standard linear model assumptions are met, the estimators are quite similar except when the repeatability is small. It is also noticed that the ANOVA and structural correlation estimators are underestimating the repeatability coefficient for almost entire range of population values (0-1). In general the increase in sample size has considerably reduced the monte carlo bias and mean squared error of all the estimators. Considering the overall results of this study, maximum likelihood appears to be the most preferred method. The results of this study are also found consistent with the earlier results reported by Mansour *et. al.* (1981).

25. On Some Aspects of Estimation & Comparison of Retention Times of Different Categories of Dairy Cattle.

V.K. Bhatia and P.K. Malhotra
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The retention time or length of useful life of an animal in the herd as realised is of great importance to animal breeders, animal nutritionists and Statisticians because it is directly or indirectly related to many characteristics such as low production,

reproduction problems, replacement of heifers etc. Like any other failure time, it takes different values and therefore can be considered as a continuous random variable subjected to the mechanism of censoring. Because of the presence of censored observations, the conventional parameteric and non- parameteric techniques cannot be used. This therefore, calls for the use of other statistical procedures to study various function of retention times. In this paper the various functions of retention times viz retention function, probability density function and culling function have been obtain for various categories of crossbred cattle. These functions have been estimated by the method of Life Table analysis. From the functions as well as from their median retention time, it is concluded that animals with level of exotic inheritance as 37.5 percent (3/8th breds) are best adaptive whereas animals having proportion of exotic inheritance as 87.5 percent (7/8th breds) are least adaptive to Indian conditions existing at the Military Dairy Farms. Further the culling pattern of various categories of animals have also been tested statistically for the significant differences with the help of non-parametric tests in the presence of censored observation. It is seen that the retention times of crossbreds with level of exotic inheritance as 37.5 percent and 50 percent are significantly different from other crossbreds. It is also noted that 3/8th breds and half breds are not statistically different from each other in their retention times. It is concluded that 3/8th breds and half breds are similar to each other as far as their retainability in comparison to all other crossbreds.

26. Partial Diallel Crosses Based on Three Associate Class Association Schemes

L.S. Kaushik and P.D. Puri
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The partial diallel crosses (PDC) based on three or higher associate class association schemes generally provide small partial diallels which may lead to serious mistakes in interpretations. Above all, PDC's may not exist in some cases due to the singularity of $A(=NN')$ matrix where N is the incidence matrix of the design.

In the present paper, the construction and analysis of PDC's of moderate sizes based on rectangular, cubic, extended triangular and group divisible three associate class association schemes have been given. First design has been obtained by crossing a line with

its first and second associates, second design by crossing with first and third associates the third design by crossing with second and third associates. Quite often, a breeder wants to include the parents in the sampled crosses for calculating heterosis etc., so the analysis of Partial diallel crosses has been presented by including and excluding the parents. By inclusion of parents, the PDC will exist for all v(number of lines) and s(number of times a line is involved in crosses) due to non-singularity of A-matrix. The method of analysis has been presented by making use of latent roots and idempotent matrices. Wherever possible, simplified expressions have been obtained for computing sum of squares due to general combining ability effects. The relative efficiencies of three designs constructed for each association scheme have also been compared.

27. Relationship Between Retention Times and Explanatory Variables in Dairy Cattle

V.K. Bhatia and P.K. Malhotra
IASRI, New Delhi - 110 012

In addition to estimation & comparison of retention time functions, it has also been recognised that certain characteristics of animals (productive of reproductive) and of his disease status may markedly influence retention in the herd and thus demands the exploring of these prognostic factors of the animals. The relationship between retention time and the production and reproduction traits has been examined with the help of the parametric model of location–scale type and by culling proportional model which is a non-parametric model. It is seen that the first lactation length, first and second lactation yield, are important variables related to retention times of crossbred cattle. The culling probability estimates obtained for different retention times in respect of several hypothetical values of first or second lactation milk yields are low for the animals with level of exotic inheritance around 50 percent indicating that their chances of retention at the farm are more when compared with other crossbred animals. Considering information on yield characteristics, it is observed that 3/8th breds and 7/8 breds have respectively the lowest and the highest culling rates among the crossbreds when the animals have completed or are completing their first lactation. In order to make use of these techniques effectively for finding out the explanatory variables related to retention time, one must include, besides first and second

lactation characteristics, some other characters such as information relating to health of the animal, economic returns from the animal, environmental factors, body weight characteristics and various post vaccination effects etc.

28. Studies on Correlation and Path analysis of Yield and Nitrogen Fixation Traits in Mungbean (*Vigna radiata*)

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The present investigation was carried out to study the analysis of variance, genotypic and phenotypic variances, genotypic and phenotypic coefficients of variation, heritability, genetic advance, correlation and path analysis of yield and nitrogen fixation traits in mungbean (*Vigna radiata* L. Wilczok). In general, phenotypic variance and phenotypic coefficient of variation were higher than the corresponding genotypic variance and genotypic coefficient of variation. The genotypic coefficient of variation was the highest for traits, namely, number of primary branches/plant, volume of fresh nodules, 100 grain weight and dry weight of plant while the highest values for phenotypic coefficient of variation were recorded for number of primary and secondary branches/plant, number of nodules on primary and secondary roots, dry weight of plant, volume of fresh nodules and fresh and dry weights of nodules. The highest genetic advance was noticed for plant height while 100 grain weight showed highest value for heritability. Nearly half of the total traits under the present study showed significant values of heritability while remaining traits showed its low value. Further, certain characters, *viz.*, volume and weight of fresh nodules, number of primary branches/plant, number of nodules on primary and secondary roots, days to 100 percent flowering and days to maturity were highly correlated with grain yield/plant, emphasizing the significance of these characters in selecting the genotypes for higher grain yield in mungbean. However, amongst all characters, plant height, length of pod and number of pods/ plant showed additive effects towards grain yield. The overall observations on path coefficient analysis suggested that future plan may base on single plant selection for grain yield on *per se* performance.

29.   **A Modified Analysis of Triallel Crosses**

Naveen Aggarwal and L.S. Kaushik
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The analysis of triallel crosses by including parents, Back crosses, F_1's and their reciprocals alongwith three way cross hybrids has been presented by relaxing certain restriction in the model used by Ponnuswamy, Das and Handoo (1974). The formulae for estimating the genetic parameters, computing sum of squares and for obtaining variances of estimates of parameters have been presented both under fixed and random model. The analysis presented have orthogonal partitioning of various components and consequently leads to a simplified analysis. The analysis also enables testing of heterosis, reciprocal differences and making of some meaningful comparisons between different types of populations obtained in the experiment on the pattern of scaling tests of Mather (1949). The method of analysis has been illustrated with a numerical example.

30.   **Predictive association of Essential Oil Yield in Peppermint (*Mentha piperita* L.) Under Two Different Environment Conditions.**

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Genotypic, phenotypic and environmental correlation coefficient were calculated for seven major essential oil yield contributing characters in thirty eight genotypes of Peppermint (*Mentha piperita L.*) during two harvesting seasons. Correlation coefficients varied considerably between seasons, both indirection as well as magnitude. Herb yield (HY) and oil content (OC) showed highly significant positive genotypic and phenotypic correlations with oil yield (OY) in both the seasons. Number of leaves (NL) and leaf area per leaf (LAL) showed significant correlations with OY in the second season only, the former being negatively correlated. Environmental correlation coefficients remained comparatively lower and had a similar trend of association as observed for genotypic and phenotypic correlations. All the characters under study possessed very high heritability estimates (88%) except leaf-stem ratio.

Heritability estimates in the second season remained lower for all the characters in comparison to that in the first season. Number of leaves possessed the largest genetic advance followed by HY. In the first season, OC exhibited the highest positive direct effect on OY followed by HY, whereas in the second season, the vice versa hold good. Herb yield had its largest indirect effect through increments in plant height (PH) followed by LAL, while OC had its largest indirect effect through reduction in PH followed by increment in leaf-stem ratio. The residual effects remained much lower in both the seasons. The study indicated that leaf-area per leaf, oil content and herb yield would be the most desirous characters when the objective is to enhance the oil yielding potential of *Mentha piperita*. The predicated joint regression models indicated the significance of herb yield and oil content in explained the variation in oil yield.

31. Analysis of Genetic Parameters in Mungbean

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Thirteen diverse and elite pure breeding lines of mungbean and their F_3's and F_4's excluding reciprocals were analysed to characterise nature and magnitude of genetic variances governing yield traits. The maximum coefficient of variation and the genetic advance for plant height in F_3 and for number of nodules in F_4 were observed. The pod length exhibited minimum coefficient of variation and the minimum genetic advance. Genetic advance was found to be dependent on heritability estimates. Significant positive correlation for pods/plant was observed in F_3.

32. Statistical evaluation of Effects of Dates of Transplanting and Fertilizer Application on Crop Yield of Rice

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The date of transplanting of rice crop has a significant effect on its production. The optimum date of transplanting depends not only on variety of the crop but also the moisture condition during the crop period as well s on the irrigation schedule. The present study

indicates how loss in yield due to delay in transplanting can be compensated or minimized by properly adjusting the fertilizer dose and also to identify varieties of rice best suited for normal and delayed transplanting. Experiments were conducted at 10 centres under All India Coordinated Agronomic Research projects. A response of 13 q/ha to 20 q/ha at some centres could be obtained, by interaction of dates of transplanting and fertilizer application.

33.   Constructions for Some Classes of Neighbour Designs

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A technique used in virus research required the arrangement in circles of samples from a number of virus preparations in such a way that over the whole set a sample from each virus preparation appear next to a sample from every other virus preparations. In this paper, two new methods of construction of incomplete block neighbour designs are given. Method I deals with treatments $v = 2t-1$, $t > 1$ and odd positive integer, by arranging the treatment systematically in the initial blocks and methods II deals with treatments $v = kt+1$, a prime or prime power (either $k \equiv 0 \bmod 2$ or $t \equiv 0 \bmod 2$ or both $k > 2$) by using Galois field.

34.   Use of Bootstrap Technique for Variance Estimation of Heritability Estimators.

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Although a number of estimators have been proposed in literature for the estimation of heritability but there is still a need for a dependable estimator of its precision. The present study is an attempt to find out reliable estimate of standard error of the heritability using the application of analytical procedure 'bootstrap'. The bootstrap technique was carried on the data generated by computer for different values of population parameters. From every data set thus generated 100 bootstrap replications were taken. The results obtained from simulated data as well as from bootstrap

samples, it is seen that in almost all the cases, the measure of central tendency of the estimates of heritability (whether based on mean or median) is very close to the estimated value of heritability from the simulated data rather than population parameter. This clearly shows that bootstrap is not the appropriate technique for getting a close estimate of the population parameter. It only depends upon the original sample considered for generating different bootstrap samples. It is observed that value of the standard error based on the adequate number of bootstrap samples is very close to the true value of standard error. Thus the closeness of the bootstrap estimates to the expected values and the consistency of their performance irrespective of the nature of sample increase the amount of dependency upon the method of bootstrapping.

35. Statistical Assessment of Crop Sequences

K.C. Bhatnagar and G.L. Khuana
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The evaluation of the performance of a crop sequence in an area is limited to working out its monetary value. But this is not based on any statistical test or scientific procedure. In this paper, the performance of alternative crop sequences were tested using Duancan's Multiple Range Test which helped in identifying most suitable and promising crop sequences in terms of monetary returns and energy equivalent ($Kx10^6$ Cals./ha). An attempt is also made to examine the consistency of the performance of a sequence over years. The data utilized pertained to Integrated Production Trials conducted under AICARP (ICAR) during the years 1986-87 to 1989-90 at C.S.R. centre Ludhiana in the central plain zone of Punjab. Rice–Potato–Wheat–Greengram was the most promising crop sequence both interms of monetary returns (Rs.42,220/ha) and energy equivalent ($52.06kx10^6$ cals./ha) followed by Rice–Wheat–cowpea (G.F.) in terms of monetary returns (Rs. 32,744/ha) and Maize–Potato–Wheat–Greengram in terms of calories ($40.75kx10^6$). These sequences were also seen to be consistent in their performances over years and are suitable for adoption in the area.

36. Graphical Presentation of Bivariate Data of Intercropping Experiments

G.L. Khurana

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Graphical presentation and Interpretation of the results relating to Intercropping experiments using statistics through bivariate technique made the discussion more comprehensive. In the first two experiments conducted at Hanumangarh and Bichpuri, arhar was sown as maincrop and moong as intercrop. Whereas in the third experiment at Ludhiana, cotton was sown as maincrop and moong as Intercrop. Results exhibited through graphs showed that at Hanumangarh, yield of moong (17.62 q/ha) for treatment T13 (Growing of maincrop with skip row method of planting and giving 100% fertilizer to the Intercrop) was the highest in the yields of arhar, whereas yield of arhar (15.31 q/ha) under treatment T7 (Growing of main crop as well Intercrop with normal method of planting and full fertility level) was the highest in the yields of moong. At Bichpuri, treatment T7 with its highest moong yield (18.20 q/ha) seems to be the best, since yield of Arhar (22.13 q/ha) with this treatment at this centre was also found highest. At Ludhiana, growing of moong crop with paired row method of planting with full level (100%) of fertilizer gave the highest yield of the order of 5.72 q/ha where as growing of cotton with normal method of sowing and full dose of fertilizer gave also highest yield (3.56 q/ha).

37. Exploiting Interactions at Reduced Level for Higher Productivity

G.L. Khurana

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A study was conducted to obtain interactions at reduced levels for higher productivity, utilising experimental data on production potential under resource contraints under All India Agronomic Research Project (ICAR) for the year 1982-86 for different crop sequences viz rice-wheat, jowar-wheat and bajra-wheat for different locations. The statistical design adopted in such experiments was strip-plot with treatments combination of four inputs (agronomic factors) during kharif such as date of sowing (D1 and D2), fertilizer

application (F1 and F2), plant population (P1 and P2) and weed control (W1 and W2). During rabi, the plant population was replaced by irrigation (I1 and I2). The suffixes 1 and 2 indicate, the optimum level and the reduced level respectively. The data were subjected to appropriate statistical analysis applying multiple regression and Analysis of means (ANOM) techniques for arriving at meaningful conclusions. The interactions that could possibly be exploited at reduced levels for rice-wheat sequence in Raipur (M.P.) and Kalyani (West Bengal) was D1 F1 P2 W2. For Kathulia-farm (M.P.) and masodha (U.P.) the interaction at reduced levels were found as D1 F2 P1 W1 and D2 F1 P2 W2 respectively. For all the four locations, the interaction of normal date of sowing (D1) with recommended level of fertilizer (F1), reduced level of irrigation (I2) and hand weeding (W2) was found suitable. For Rudrur (A.P.), in kharif D1 F2 W2 and in rabi D1 I2 W2 were suitable choices. In black soils of Sehore (M.P.) during kharif, interactions D1 F2 P2 W2 and in rabi D2 F1 I1 W2 were found suitable. In the fine clayey soils of Akola (Maharashtra) the suitable interaction found for Jowar was D2 F2 W2 with either level of P and during rabi D2 F1 I1 with either level of weed control (W) was found suitable. In the alluvial soils of Bichpuri (U.P.) and Hisar (Haryana) during kharif, it was found that interaction of reduced fertilizer application (F2) alongwith reduced plant population (P2) together with sowing at normal date and hand weeding (W) was suitable for bajra crop. During rabi reduced fertilizer application together with optimum level of Irrigation (I1), chemical weeding (W1) but sown at normal date (D1 F2 I1 W1) was found suitable for wheat crop.

38. Comparative Study of Different Varieties of Wheat Grown in Different States

Satya Pal, G.L. Khurana and C.H. Rao.
IASRI, New Delhi – 110 012.

The study based on the crop cutting experiments conducted in the states of Haryana, Punjab and U.P. was done by utilising the pooled results over different districts. Percentage of S.E. was taken as the main frame for this study. The design adopted for these experiments was stratified four stage random sampling. The strata were the community developments blocks. Villages and cultivators growing high yielding varieties of the specified crop constituted the first and the second stage units. The third stage unit was the field

sown with the high yielding variety of the specified crop. The fourth stage unit was the randomly allocated plot of given shape and size. Performance of different varieties of wheat were compared among states. It was found that Sonalika was better as compared to other varieties. Arjun showed better results (2986 kg/ha with % S.E. 5.6) in Punjab.

39.   Wheat Production in India in 2000 A.D.

T. Rai
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An attempt is made to estimate the best production functions for wheat growing states and also for All India, based on time series data from 1970-71 to 1986-87, using the technique of stepwise regression in the linear model $Y_j = a + \sum_{i=1}^{5} b_i \ X_{ij} + e_j$, where Y_j is the wheat production of jth state corresponding to input variables such as area unirrigated, area irrigated, area under high yielding varieties, total fertiliser nutrients and proportion of actual to normal rainfall. The relationship explains 95% of the variation. The coefficient for area irrigated which is highly significant shows that unit increase in if will increase the production by 3.64 units. Assuming the continuance of linear form of growth rate, a criterion for increase in the input variables is suggested to achieve the target of 80 million tonnes by the end of 2000 A.D.

40.   A Statistical approach to Identify the Contribution of Natural Resources for Production of Coarse Cereal in India and its States

T. Rai
IASRI, New Delhi - 110 012

An attempt is made to work out the linear growth rate of coarse cereal production and its input resources such as area unirrigated, area irrigated and area under high yielding varieties based on time series data from 1970–71 to 1986–87. These growth rates are useful for future-prediction of coarse cereal production assuming the

continuance of linear form. In spite of highly significant negative growth rate of –0.72% of gross cropped area, a significant increase in the growth rate of coarse cereal production is achieved @ 1.05% due to significant increase in area (19.4%) under high yielding varieties. A desirable combination of these input variables and another input variable taken as the proportion of actual to normal rainfall, which directly influence the coarse cereal production, has also been identified by fitting stepwise regression in the linear model

$$Y_j = a + \sum_{i=1}^{4} b_i X_{ij} + e_j \text{ for the states and whole India. The}$$

relationship explains 57% of the variation and the coefficients of both area unirrigated and area under high yielding varieties are highly significant.

41. A Time Dependent Branching Process — An Application

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Galton-Watson branching process provides a realistic model for the study of population growth in different fields. However, the underlying assumption regarding the time homogeneity of the offspring distribution may not usually be satisfied and situations are common where the growth pattern depends upon the prevailing environment. Fearn (1972, 1976) relaxed the above assumption and considered the offspring distribution as time dependent. Gupta *et. al.* (1992) studied a process where time dependent emigration is allowed.

In this paper, the effect of emigration on a time-dependent branching process has been discussed. The emigration has been taken as time-dependent. The model has been extended to account for situations where two different types of individuals are produced. The model has been applied to an infected plant population which undergoes spray of an insecticide at different times. The expected number of infected plants and their variance have been obtained. The result is used to draw inferences about the healthy plants (after killing infection through insecticide spray).

42.   On the Analysis of Unbalanced Data with Repeated Observations

B. Singh

IVRI, Izatnagar (U.P.) – 243 122

The analysis of data from unbalanced two-way classification with repeated observations has been discussed. The modified Brown-Forsythe F-statistic and Box-approximation in one-way lay out with unequal error variance are extended to analyse such data. The size of modified F, Box-approximation and the conventional method are compared with the exact value by means of an example. It is found that the modified F and Box-approximation provide the size of the test more close to the exact value than the conventional method. For computational simplicity the modified F may be used for analysing such data in practical applications.

43.   Yardsticks of Phosphorous at Varying Levels of Nitrogen on Mustard

C.H. Rao and Satya Pal

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Phophorous is applied to mustard in the presence of nitrogen, as phosphorous is not effective in the absence of nitrogen. Hence there is a necessity for studying the yardsticks of phosphorous at varying levels of nitrogen. The usual practice of getting the response due to phosphorous is to take the difference of responses due to N+P and and nitrogen alone. But this includes the whole interaction. In this paper, a methodology developed for evaluating the yardsticks of an input in the presence of another input is adopted. The data on experiments conducted on cultivator fields (AICARP) during 1981–87 has been utilized. In the states of Assam, Haryana and Punjab the presence of nitrogen didn't improve the yardsticks. Further there is a reduction in these states. The yardsticks of phosphorous at 10, 20, 30, 40 kg/ha in the presence of nitrogen at 20, 40, 60 kg/ha were lowest in Orissa and in the range 2.78–3.18 where as for the same levels they were high in Manipur and Punjab, in the ranges 8.72–13.75 and 7.63–14.74 respectively.

44.   On the Confidence Interval of Variance Components in One Way Unbalanced Random Model.

Krishan Lal and B. Singh
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Exact expressions for the probability of confidence interval of group variance component in unbalanced one way random model are presented. Numerical results show that due to unbalancedness in data the probability of confidence interval of group variance (σ_a^2) component decreases. Increase in the apriori value of σ_a^2 also causes a decrease in probability. However, the decrease in probability of confidence interval due to unbalancedness and value of σ_a^2 is not remarkable.

45.   Multiplicative Correction Factors for Genetic Groups in Crossbred Cattle for Sire Evaluation

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The multiplicative ratio factors for 1787 Friesian x Sahiwal (Fr x Sw) crossbred cows were developed for first lactation 300 days milk yield for six genetic groups. The various genetic groups studied were 1/4 Fr, 3/8 Fr, 1/2 Fr, 5/8 Fr, 3/4 Fr and 7/8 Fr x Sw crossbreds. Gross ratio factor method was used for developing the multiplicative correction factors for different genetic groups for removing differential effects of genetic groups in sire evaluation. Friesian halfbreds (50% Fr + 50% Sw) excelled all the other genetic groups for various economic traits, hence these halfbreds were taken as a base and the multiplicative correction factors of the remaining five genetic groups were developed. The multiplicative ratio factors for genetic groups were developed by using separately (1) unadjusted means of first lactation 300 days milk yield and (2) means adjusted for other non-genetic (fixed) effects by methods of least squares.

It was observed that the adjustment of daughters for different levels of genetic inheritance did not alter the ranking of sires as

compared to the breeding value of sires estimated without adjustment for the differences in the genetic groups of the daughters.

46. Economic Efficiency of Nitrogen and Phosphorous Fertilisation on Rainfed Moong in Telangana Region of Andhra Pradesh

C.H. Rao and Satya Pal
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Moong, an important Kharif crop in Telangana region of Andhra Pradesh is mostly grown under rained conditions. Being a leguminous crop, it helps in fixation of soil nitrogen, and so phosphorous is one of the main nutrients required by the crop. Utilizing the data on experiments conducted during 1977–87 in the districts of Medak, Khamman, Karimnagar, Adilabad and Nizamabad, quadratic response surface was fitted and optimum economic combination of N and P was obtained. The most economic doses of N and P were found to be 13.20 kg/ha and 50.83 kg/ha respectively.

47. Statistical Distributions of Some Traits Related to Sahiwal– Jersey Crossbred Cows of Terai Region

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Various routine statistical tests are based on the assumption of normal population. It is essential to test the normality of the characters before applying any statistical test procedure. It is necessary to study the statistical distributions of various important characters related to animal science. It is also very important to study the pattern of distribution of the same character in different calvings in order to investigate the relative changes if any. The first two calvings are very important because the peak performance of the crossbreds takes place in these calvings. The present study was undertaken to know the distribution pattern of two important characters namely age of cow at calving and milk yield, in first two

successive calvings. It was found that the variable age of cow at first calving, milk yield of first lactation and milk yield of second lactation follows normal distribution whereas age of cow at second calving follows Pearson's Type I distribution.

48.   An Improved Class of Estimators Using Supplementary Information for Estimating Finite Population Variance

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A general class of estimators is considered for finite population variance $\sigma_y^2 = N^{-1} \sum_{i=1}^{N} (y_i - \bar{y})^2$ of a character y when information on a supplementary character x is used. For the class some regularity conditions are used. The proposed class is more efficient and wider than the one considered by Srivastava and Jhajj (1980).

49.   Comparative Study Of Some Farming Systems

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Agriculture, animal husbandry and some aquaculture based farming systems were studied for comparison. It was found that for small holdings, in general, aquaculture-based intensive farming system is having more employment opportunity, higher income and productivity than agriculture, animal husbandry and aquaculture alone. Amongst all considered farming systems fish-cum-pig system has shown highest income to farming families having own land and labour with highest investment followed by fish-cum-poultry system. Net income was highest in fish-cum-poultry system. Annual investment was found least in Agriculture with lesser income but highest return per rupee investment. Productivity and net profit can be further enhanced by developing more intensive, suitable and sustainable farming systems.

50. **Analysis of Binary Unbalanced Data Through Generalised Linear Mixed Model**

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A methodology for analysis of classified binary unbalanced data under mixed model structure is proposed which is non-iterative conceptually simple and easy to program. The algorithm comprises estimation of fixed effects through generalised linear mixed model (GLMM) equations, estimation of variance components needed in GLMM equations through the well known Henderson's method of fitting constants, and testing of differences among fixed effect levels through relevant hypotheses formulation and then using the Wald statistic. The technique is applied to reanalyse the data of Beitler and Landis (Biometrics, 1985) yielding similar results.

51. **Trend in Milk and Milk Product Prices vis–a–vis Other Food Items in Punjab**

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The study on Price behaviour of milk and milk products as well as other food items was undertaken for Punjab State utilising the monthly data on prices of cow milk, buffalo milk, curd, barfi, ghee and other food items over a period of 1983–90 obtained from office of Economic and Statistical Advisor of Punjab, Chandigarh. The monthly price indices were obtained by the method of link relatives. The cow milk prices ruled within a narrow range with the indices being lowest in March (95.9) and highest in July (103.0) and those for buffalo milk prices, ranged between 95.7 (January) and 102.8 (August). The curd prices showed a similar pattern as that of milk. Ghee prices showed wide variation with monthly indices ranging between 85.2 (May) and 110.8 (September); barfi prices, moved within a range of 96.5 (March) and 103.0 (August).

Wheat prices were lowest in May and June with an index of 92 and highest in December (106). On the other hand, the monthly price indices for rice ranged between 92 (February) and 110 (August). The range in monthly price indices was between 90.4 (February) and 112.8 (November) for Maize; 93.2 (February) and 106.6 (August) for Jowar and 94.0 (February) and 104.9 (September)

for Bajra. Price indices of pulses except arhar moved within a narrow range while in the case of Arhar the indices ranged between 90 to 108. Generally the pulse prices ruled lower upto April and then started showing an increasing trend till November and thereafter started decreasing. Among edible oils, highest variation in monthly price indices were observed for mustard oil ranging between 84.8 (March) and 106.9 (November). The price indices for vanaspati ghee and groundnut oil moved within a narrow range varying between 96.6 (March) and 102.9 (November) for groundnut oil. Generally the edible oil prices were above average between July and December. The monthly price indices for goat meat ranged between 96.8 (February) and 103.2 (December) while that of eggs between 84 (May & June) and 117 (December). Sugar prices fluctuated within a narrow range of 93.2 (April) and 104.7 (July) as compared to gur prices which varied between 85.2 (March) and 115.3 (September). Wide variations were observed both in onion and potato prices with onion price indices ranging between 65.7 (June) and 153.2 (November) and potato indices between 69.1 (February) and 128.1 (October).

Trend analysis showed that buffalo milk prices had higher annual growth rate of 7.49 per cent compared to cow milk (6.69%). The curd prices increased at the rate of 7.2 per cent per annum while ghee prices at 6.81 per cent and barfi at 6.53 per cent. Among cereals, the annual compound growth in basmati rice prices was highest (11.40%) followed by Bajra (7.72%), Maize (7.29%), Jowar (6.2%), Rice begmi (6.0%) and wheat (5.4%). Among pulses, the gram dal recorded highest annual growth rate of 12.15 per cent followed by moong sabut (10.81%), moong split (10.13%), Arhar (9.32%), Urd sabut (8.97%) and Urd split (8.36%). The prices of groundnut oil among edible oils showed highest annual growth rate of 12.66 per cent followed by vegetable ghee (8.85%) and mustard oil (8.12%). Though wide monthly variation in egg prices were observed, the annual growth rate was only 5.53 per cent compared to 10.77 per cent for goat meat. Gur prices showed slightly higher annual growth rate (8.74%) than sugar (7.40%). Onion prices grew at the rate of 8.1 per cent per annum while that of potato 6.17 per cent. It may be concluded from the above findings that the growth in milk and milk product prices has remained low as compared to prices of other food items.

52. On Software for Generating Tables of Bivariate Normal Iso-probable Quantile Pairs

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Application of software BIVNOR has been developed for generating tables of quantile pairs to attain the given probability level, for specified value of correlation coefficient of Bivariate Normal Prob. Distribution. This obviously is bivariate generalization of the inverse of Univariate Normal Probability Distribution which gives quantile value for the given probability level. Software for the same was developed by Milton and Hotchkiss. Although number of software have been developed for obtaining the probability of Bivariate Normal Distribution, but not a single for its inverse. This is an attempt to meet this gap.

Such a software is an indespensible tool for cases where decision models are required to be built, considering both uncertainties and inter-dependencies of course in their simplest form. This creates complexity in the model but that is unavoidable. Software BIVNOR has been used in formulating Joint Chance Constrained Programming Model, where system uncertainty was taken as given probability *i.e.* acceptable risk involved in decision making process as well as for the system inter-dependencies specified as correlations existing between the parameters of the system under optimization.