1. *The Simple and Modified Simple Poisson Processes and the Maximum Likelihood and Some Other Simple Estimators of Their Parameters. Mrs. V. Mukerji, Gokhale Institute of Politics and Economics, Poona.*

Tintner *et al.* have considered the application of the simple and modified simple Poisson processes to the process of regional development. In their modified simple Poisson process the variable takes only discrete values o, u, $2u$, ..., etc. In this note the joint probability-generating function of k equally spaced varibales from the simple Poisson processes are obtained. Further, the maximum-likelihood estimators of the parameters of the simple and the modified simple Poisson processes are obtained and the efficiencies of some simple least-squares and generalized least squares estimators of the parameter of the simple Poisson process are worked out. As the maximum-likelihood estimator of u has a rather complicated form and a still more complicated variance, some simple asymptotically unbiased estimates of u on the lines of Tintner *et al.*, and their variances are considered.

2. *A Note on the Geometrical Method of Solving Optimum Allocation in Multivariate Surveys. A. R. Kokan, Aligarh Muslim University, Aligarh.*

Optimum allocation of the sample numbers when several characters are under study can be stated as a problem of non-linear programming whose solution can be attempted in more than one way. In small-scale studies geometrical solutions can be obtained with ease. In this note an attempt is made to explain these geometrical methods in a few important sampling procedures and record some general properties which are observed in them. It is found that the cost function can be expressed as a convex function and the variances of the estimates of several characters under study as linear. When there are two characters under study or when two-strata or two-stage sampling, etc., is used, we note, among other things, that the cost function is a rectangular heperbola whose centre and vertex lie on fixed straight lines passing through the origin. A rule for obtaining the solution is also derived.

3. *An Integrated Approach to the Study of Wastage in Education.*
   G. Nageswara Rao and B. D. Tikkival, University of Rajasthan.

The problem of wastage in education has been studied by Deshmukh
and Kamat (*Artha Vijnana*, Vol. 2, 1960, Nos. 1, 2 and 3); Bhanot (*The
M.S. University Statistics Series*, 1961, No. 1); Chickermane (*Education
and Psychology Review*, Vol. 2, 1962, No. 1); Krishnan (*Education and
Psychology Review*, Vol. 3, 1963, No. 4) and others. These authors gave
different measures for different kinds of wastage. No measure has been
given so far to study three known types of wastage together. This paper
presents one such measure. The measures W_d, W_s and $W_{n.u.}$; for mea-
suring wastage due to drops, wastage due to stagnation and wastage due
to non-utility of training; are first defined. Then the total wastage W
is taken as $W_d + W_s + W_{n.u.}$. It is shown that the value, of W and its
components so defined, lies between 0 and 1 and is independent of the
units of measurement. The paper finally gives a case study to illustrate
various measures of different kinds of wastage.

4. *Influence of Rainfall and its Distribution on Paddy Yields. V. J. Shri-
   khande and M. S. Chaudry, Central Rice Research Institute,
   Cuttack.*

An attempt has been made in this paper to investigate the rela-
tionship between paddy yields and some weather factors. The average
yields for 1949 to 1962 under different treatments in one of the permanent
manurial trials in pogress at the Central Rice Research Institute,
Cuttack, have been utilised for the study. The weather factors included
for study are the amount of rainfall and the number of rainy days re-
presenting rainfall distribution in different months of the main growing
season. The technique of linear multiple regression has been adopted.
The regression function accounts for about 83 to 98 per cent of the vari-
ation in yields over years under different treatments.

The amount of rainfall in August and the number of rainy days
or the associated factors like sunshine hours in August and September
appear to influence the yield considerably.

5. *Growth of Electricity Consumption and National Income in India.
   B. N. Sahu, Dy. Director (Statistics), Bihar State Electricity
   Board, Patna.*

In the present paper, an attempt has been made to study the three
measures of correlation—the coefficient of regression, the coefficient of

determination and the standard error of estimate between the national income and the electricity consumption in India. The data relating to net national output at current prices and the consumption of electricity in India for the period 1949-50 to 1962-63 have been taken for studies from the reports "Estimates of National Income" and "Public Electricity Supply All-India Statistics" released by the Central Statistical Organisation and the Central Water and Power Commission, Government of India, respectively. With the help of these data, the values of the adjusted correlation coefficient (0·9822) and the coefficient of determination (0·967487) have been worked out. In view of the fact that the number of observations taken into consideration for studies is very small, the value of t has been worked out for testing the significance of the correlation coefficient, which is 18·87. This value is highly significant as 0·1% value of t on 12 degrees of freedom is only 4·318.

Having established a high correlation between the national income and the energy consumption, the following two regression lines have been fitted.

(i) the regression line of Y (national income) on X (energy consumption), which is $Y = 7114·48 + 0·3963 X$, and

(ii) the regression line of X (energy consumption) on Y (National income), which is $X = -17008·86 + 2·4413 Y$.

The above fits appear to be quite good as 10 out of 14 residuals in both the cases, representing about 71%, lie within the range of $\pm \bar{S}ey\bar{x}$ (398·50) or $\bar{S}exy$ (989·12) and all within the range of twice the standard errors of their respective estimates.

An attempt has also been made to project the consumption of electricity by the end of the Third Plan, the Fourth Plan, the Fifth Plan and the Sixth Plan on the basis of the national income as indicated by the National Council of Applied Economic Research, New Delhi.

6. *Multivariate Test for Linearity of Means in Classification of Fleeces. U. G. Nadkarni, I.A.R.S., New Delhi.*

Using the technique of internal analysis of variates, it is first shown in this paper that only two characters, *viz.*, fibre-diameter and crimps per centimetre of a fleece contain most of the information for discriminating the fleeces into classes. A single linear function estimated by canonical analysis of the data on autumn fleeces of Magra sheep did not satisfy the condition of linearity of means, whereas it was satisfied for the data on spring and monsoon shearings. In general, a single

discriminant function for discriminating the fleeces into the classes may be used.

7. Loss of Heterozygosity in Populations under Mixed Random Mating and Selfing. G. L. Ghai, I.A.R.S., New Delhi.

In plant populations of interest to the breeder complete cross-fertilization at random or complete inbreeding such as selfing seldom obtains. There are crops like wheat and rice which are highly but not completely self-fertilized, the crops like cotton which are moderately self-fertilized and crops like various brassica species or maize which are largely cross-fertilized. It shall be, therefore, of interest to study populations under mixture of breeding systems. The present paper deals with the loss in heterozygosity due to mixed random mating and selfing.

When the population is completely selfed, the loss in heterozygosity in the case of several independently segregating loci can be easily worked out from that obtained for a single locus. The present study reveals that the loss in heterozygosity in populations under mixed random mating and selfing cannot be predicted from that obtained for a single locus when more than one locus is considered as is the case when population is completely selfed. The general expression for the loss in heterozygosity relative to that in the initial population in the n-th generation (F_n) due to mixed random mating and selfing has been obtained in the general case of several independently segregating loci, say k, and is given by

$$F_n = \sum_{i=1}^{k} {}^kC_i (-1)^{i+1} \left(1 - \frac{y}{1 - C_{ii}} \right) (1 - C_{ii}{}^n),$$

where $C_{ii} = x (\tfrac{1}{2})^i$, and x and y $(x + y = 1)$ are the proportions of selfing and random mating respectively. In the limiting case when $n \to \infty$, this reduces to

$$F_\infty = \sum_{i=0}^{k} {}^kC_i (-1)^i y (1 - C_{ii})^{-1}.$$

Values of F_n have been tabulated up to three factors for the first four generations and in the limiting case for different amounts of self-fertilization.

8.   *Genetic Variance and Covariance under Positive Assortative Mating.*
A. V. Rao and Prem Narain, I.A.R.S., New Delhi.

The possible consequences of a system of positive assortative mating with quantitative characters was considered, probably for the first time, by Bruce (1956), but his study was restricted to one generation only and he had not considered the cases when the genes are linked or when selection is combined with positive assortative mating.

In the present investigation the effect of positive assortative mating on genetic variance and covariance has been studied under varying conditions of dominance. The study deals separately with the situations (i) one locus segregating and (ii) any number of loci segregating, assuming in each case arbitrary gene frequencies. With one locus segregating, the effect of repeated positive assortative mating has also been dealt with giving general results for a population subject to this type of mating for '*n*' generations. The consequences, if two loci segregating are linked have also been worked out assuming gene frequencies as half in each case. The effect of selection combined with positive assortative mating when one locus is segregating with arbitrary gene frequencies has also been studied.

9.   *Study on the Economics of the Response of Milk Yield to Feed.*
N. S. Murthy and V. N. Amble, I.A.R.S., New Delhi.

A study of the different aspects of the problem of minimizing the feed cost of production of milk and maximizing the net revenue to the dairy farmer has been made by utilizing the data collected by *I.A.R.S.* in Punjab State during 1961–62. Converting the feed input values into Total Digestible Nutrients (T.D.N.) and Digestible Crude Proteins (D.C.P.) several production functions were fitted for milk yield against T.D.N. less D.C.P. and D.C.P. and compared. The least cost combination of concentrates satisfying minimum standards of nutrients, for a given level of production were worked out for various price ratios of concentrates by the technique of linear programming. The economic level of production where the profits will be maximum could be studied by two approaches. In the first empirical approach the optimum level was obtained by making use of the least cost combinations of concentrates already worked out. In the second approach, economic production level is worked out by the classifical approach of maximising the profit function by the issue of programming techniques. This approach could not be carried to its practical conclusion as it

involved non-linear programming requiring use of electronic computor. The rate at which one unit of green fodder substitutes one unit of concentrate and also the optimum combination of them for a given level of production were worked out.

10. *Disequilibrium Due to Linkage in Inbred Populations. Prem Narain, I.A.R.S., New Delhi–12.*

It was established by Hardy (1908) and Weinberg (1908) independently that whatever be the composition of the initial population, random mating will within one generation produce a stable genotype distribution with unchanged gene frequencies, provided the population considered is large. Hardy-Weinberg law, however, does not apply to the distribution of two pairs of genes. As pointed out by Li (1955), in this case, the equilibrium is not established in one generation of random mating but the approach to equilibrium is very rapid. If, however, the two pairs of genes happen to be linked, the rate of approach to equilibrium will be slow and will depend on the intensity of linkage. When the population is inbred instead of randomly mated, the equilibrium condition with respect to a simple locus was given by Wright (1921 *a*) in terms of the gene frequencies and the coefficient of inbreeding. Wright's equilibrium law is regarded as a generalization of Hardy-Weinberg Law (for which the coefficient of inbreeding is to be taken as zero). When, however, two pairs of genes linked or otherwise are taken into consideration, it is expected that the genotypic proportions in the inbred population will be not in equilibrium. This disequilibrium has been investigated in the present paper with respect to two pairs of linked genes.

11. *Unbiased Ratio and Regression Type Estimators. Dr. B. V. Sukhatme and N. S. Sastry.*

Mickey ("Some finite population unbiased ratio and regression estimators," *Jour. Amer. Stat. Assoc.,* 1959, **54,** 594–612) has put forward a general theory for constructing 'unbiased ratio and regression type estimators' in Simple random sampling without replacement, using information on the population means of several auxiliary variates. For a sub-class of his general class of estimators he has obtained non-negative unbiased estimators of the variance. No attempt has, however, been made to investigate the variance of the proposed class of unbiased estimators.

The present authors have undertaken a critical study of Mickey's unbiased ratio and regression type estimators. The study includes

the unbiased estimation of the variance of Mickey's estimator in its general form, investigation of the precision of the unbiased ratio and regression type estimators based on a single auxiliary variate in large samples when compared with the usual biased ratio and regression estimators, large sample efficiency of the unbiased ratio type estimators based on two auxiliary variates when compared with the Olkin's weighted and biased ratio estimator, development of Mickey's principle to obtain unbiased ratio and regression type estimators and the unbiased estimators of their variance in two-phase sampling, extension of all the results concerning the efficiency with one auxiliary variate in single-phase sampling to the two-phase sampling, construction of separate and combined unbiased ratio type estimators and the unbiased estimators of their variance for stratified simple random sampling without replacement, and finally some numerical results concerning the performance of the unbiased ratio type estimators with respect to the usual biased ratio estimators.

12.   *Controlled Simple Random Sampling. M. S. Avadhani and B. V. Sukhatme.*

When units are drawn one after another with equal probabilities and without replacement from a finite population, it is well known that all possible samples of a given size are equally likely to materialise. As such, the sampling procedure may result in the selection of a sample which is not quite desirable. For example, it may happen that the sampling units are spread out very much into the interior thereby not only increasing considerably the expenditure on travel but also affecting adversely the supervision and organization of fieldwork. All these factors seriously affect the quality of the data collected and consequently the precision of the estimate of the parameter, in question, would be reduced. Such samples which are not desirable are referred to in literature as non-preferred samples. There is, therefore, a clear need for developing a suitable sampling methodology which reduces the risk of getting a non-preferred sample from the population to the minimum possible extent and then conforming to the fundamental principles of random sampling.

Assuming that no ancillary information on the units of the population is available, the authors have proved that there exists a class of random sampling designs which can reduce the probability of getting a non-preferred sample to the minimum possible extent and yet they provide estimates which are at least efficient as those obtained in the case of simple random sampling.

13. *Recent Study on Plot Sizes for Estimation of Crop-Production.* D. Singh, K. S. Krishnan and P. N. Bhargava, I.A.R.S., New Delhi-12.

A number of studies for determining the optimum plot size in crop-cutting surveys have been undertaken in India and abroad. These studies have indicated that very small plot sizes for crop-cutting experiments give considerable over-estimation in the yield rate. The Bureau of Statistics and Economics of Orissa State collected data on large scale on two types of cuts, namely circular cut of 4 feet radius and a square cut of area 1/160th acre in the course of their crop-surveys planned during the year 1962-63. N.S.S. in collaboration with the concerned States, collected similar data in the course of their land utilisation survey in the 18th round in the States of Andhra Pradesh and Bihar. The crops covered were respectively paddy and maize crop in the two States. For a substantial number of the fields under experiment whole field harvests were also obtained. The data in respect of paddy crop for Orissa and Andhra Pradesh have been analysed by the authors and the results again indicated that small cuts gives overesimation of yield rate by about 6 to 8%.

14. *On a Derivation of Wishart Distribution.* M. V. Jambunathan, Karnatak University, Dharwar.

It is well known that several methods of deriving the Chi-square distribution and its multivariate analogue, the Wishart distribution, are available. This paper gives a simple and direct method of obtaining the Chi-square distribution as well as its multivariate generalisation, based on a simple mathematical principle designated as the *intrinsic functionality principle.*

This principle states that in order to obtain the distribution of a statistic Q, if the probability differential is integrated over the domain Q to $Q + dQ$, then any function of Q occurring in the expression for the probability density may be moved out of the integral sign, and further the integral of what remains of the integrand will be a function of Q only.

Thus if $X' = (x_1, x_2, \cdots, x_n)$ denote n independent observations on the variate x distributed as $N(0, 1)$, then the distribution of $Q = (X'X)$ is obtained by integrating

$$C \exp. \left(-\frac{Q}{2} \right) \Pi \, dx_i$$

over the domain Q to $Q + dQ$. According to the principle enunciated above, this distribution will reduce to

$$C \exp. \left(-\frac{Q}{2}\right) \int_{dQ} \Pi \, dx_i = C \exp. \left(-\frac{Q}{2}\right) f(Q) \, dQ,$$

wher $f(Q)$ is a function whose nature is to be determined.

Similarly, from the joint probability differential of n sets of independent observations drawn from the p-variate normal distribution, namely,

$$\text{Constant. } \exp. \left(-\tfrac{1}{2} tr \, \Sigma^{-1} S\right) dx,$$

the distribution of the Wishart matrix S is obtained as

$$\text{Constant. } \exp. \left(-\tfrac{1}{2} tr \, \Sigma^{-1} S\right) \, F(S) \, dS$$

where the function $F(S)$ remains to be determined. Simple and straightforward methods of determining the nature of $f(Q)$ and $F(S)$ are furnished in the paper.

Further, the same method is also applied to derive the distribution of the sum of two or more independent Chi-square variates or independent Wishart matrices with the same covariance matrix.

PART II

1. *Commercial Production of Milk. K. C. Raut, I.A.R.S., New Delhi.*

In a country like India, although milk production is in the hands of millions of small producers, very few are of commercial type habitually selling milk. The reason for less number of people engaged in the milk trade is due to the fact that they are ignorant of the quantitative aspects of the enterprise, have limited resources for investment on assets, equipment and animals and the non-availability of milch stock with high productivity. The relationship between the net income and amount of investment on fixed and working capital is studied in the paper. For this purpose data collected in the surveys conducted by the I.A.R.S. to estimate the cost of production of milk have been utilized,

2. *Economic Use of Vaccine under the Rinderpest Eradication Campaign.*
Mahendra Nath, I.A.R.S., New Delhi.

In the course of mass immunisation of cattle and buffaloes in the country under the Rinderpest Eradication Campaign it was found that there was a considerable wastage of vaccine in the field. The high wastage was mainly due to the reason that each ampoule normally contained 100 doses of vaccine which had to be used within two hours once an ampoule was opened. Consequently, for any number of animals in a village over and above a multiple of 100, some doses, varying from 1 to 99, had necessarily to be wasted. The wastage could thus be reduced if a suitable proportion of ampoules containing a smaller number of doses of vaccine could also be supplied to the field staff along with ampoules containing 100 doses. It was worked out that if ampoules of two sizes only are to be prepared, for optimum utilisation of vaccine about 20% of the ampoules put out should contain half the normal number of doses.

To obtain precise quantitative information regarding the extent of actual reduction in the wastage of vaccine through judicious use of 100 and 50 dose ampoules in the ratio of 4:1, an observational programme was planned in a few districts in the States of Gujarat, Madhya Pradesh, Rajasthan and Uttar Pradesh and the results are presented in the paper.

3. *Analysis of Crop Rotation—Comparison of a Three-Crop Rotation With and Without Legume. K. N. Agarwal, I.A.R.S., New Delhi.*

A three-crop rotation of sorghum-cotton-wheat has been compared with an improved four course rotation of sorghum-groundnut-cotton-wheat laid out at Institute of Plant Industry, Indore, under rainfed conditions in respect of (a) yields, (b) effects of rotation on the fertility of soil as calculated from regressions of crop yields on years, (c) comparison of both the rotations as regards to their economics. In such experiments differences in yields of two plot totals are not free from year differences and *vice-versa*. Therefore, 'methods of fitting constants' have been applied to separate out components of variances which are involved in linear form among various comparisons of interest. The results obtained by analysing above experiment have been discussed in detail.

4. Design and Analysis of Experiments with Mixtures. J. S. Murty, I.A.R.S., New Delhi.

Scheffe (1958, 1963) considered the method of exploration of a response surface for investigating properties of multi-component systems as a function of their composition. The criterion is that the property studied depends upon the proportions of the components present but not on the amount of the mixture so that if, in an n-component system, $x_i\ (x_i \geqslant 0)$ is the proportion of the i-th component in the mixture, $x_1 + x_2 + \cdots + x_n = 1$. He introduced two types of designs namely, Simplex-Lattice and Simplex-Centroid designs and associated them with polynomial regression function where the number of parameters in the polynomials is just the same as the number of points in the design. He was thus left with no 'degrees of freedom' for testing the lack of fit. Further, he scored out the Least Squares estimation of the parameters on the plea that it would be cumbersome.

In the present investigation, simple procedures for the Least Squares estimation of the parameters of a quadratic or a cubic model fitted to a design with any number of components have been obtained. The procedures have been generalised to a polynomial of given order. Fractionation of the designs has been successfully achieved using the B.I.B.D.'s and P.B.I.B.D.'s. Further, asymmetrical designs suitable to the experiments with mixtures have been evolved and simple analysis of these designs has been proposed.

5. A Type of Non-Rotatable Response Surface Design. K. C. George and M. N. Das, I.A.R.S., New Delhi.

For the exploration of response surfaces Box and Hunter (1957) introduced rotatable design. Though these designs applied extensively for the industrial and engineering experiments, their application for agricultural experiments seems to be limited. W. M. Walker, J. Pesek and E. O. Heady (1963) applied a Central Composite design in three factors for studying the effect of Nitrogen, Phosphorus and Potassium fertilizer on the economics of producing blue grass forage. But the design adopted by them was not exactly rotatable, as they took five equi-spaced doses for each of the factor instead of those required by the rotatable design. As a result, the design becomes one corresponding to the rotatable design in which all the relations excepting $\Sigma x_i = 3 \Sigma x_i^2$. x_j^2 were satisfied. Even though the authors still call the design a Central Composite design. We have in the present paper investigated such designs in general along with a comparison of them with the corresponding rotatable design.

6. *On Selection of Independent Variables in Multiple Regression and Other Linear Models.* M. V. Pavate,* C. L. Narayana and M. Subrahmanyam, Central Tobacco Research Institute, Rajahmundry. `

A method of selection of best predicting variables in multiple regression has been attempted in this paper by introducing a necessary and sufficient condition for maximisation of multiple correlation coefficient and partial correlation coefficient simultaneously.

Further, classification of independent variables, with respect to a given dependent variable as auxiliary and interacting variables has also been discussed.

7. *Design and Analysis of Some 4-Factor Qualitative-cum-Quantitative Experiments.* C. L. Narayana, Central Tobacco Research Institute, Rajahmundry and M. G. Sardana, Central Potato Research Institute, Simla.

Analysis of qualitative-*cum*-quantitative experiments involving dummy treatments present some novel features not ordinarily met with in case of factorial experiments involving only quantitative factors. These features have been studied in detail in this paper by presenting the appropriate designs and their methods of analysis, both under the additive and proportional models for the following type of 4-factor experiments which are of practical utility in agricultural experimentation:

Sl. No.	n		p	
	quantities	qualities	quantities	qualities
1	3	2	3	2
2	3	4	3	2
3	3	4	3	4
4	3	3	3	3

8. *Response of Rice to the Application of Mineral Nitrogen in Madras State.* K. A. Seshu and C. T. Natarajan.

The response of the paddy crop to the application of graded doses of mineral nitrogen in the form of ammonium sulphate, recorded in

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* At present with the Indian Central Cotton Committee.

the 'varietal response to - manuring' experiment carried out during two to five years from 1958–59 at six representative centres of paddy cultivation in Madras State, *viz.*, Aduthurai, Pattukottai, Amba-samudram, Tirur, Palur and Coimbatore, reported in this paper. The ammonium sulphate was applied over a uniform basal dressing of 5,000 lb. green leaf and 150 lb. of superphosphate per acre, both in the presence and absence of potash at 30 lb. K_2O per acre. There were five equispaced doses of ammonium sulphate to give 0, 15, 30, 45 and 60 lb. nitrogen per acre. Both at Aduthurai and Pattukottai representing the Tanjore delta, the Kuruvai and samba crops did not show response to nitrogen. There was, however, clear evidence of response in the thaladi crop, presumably due to nitrogen exhaustion of the soil by the immediately preceding Kuruvai crop. At Ambasamu-dram in the Tirunelveli tract, both Kar and pishanam crops responded to nitrogen, while at Tirur and Palur, the response was neither clear nor consistent. It is possible that at Tirur, the application of mineral nitrogen might even be deleterious. The response curves fitted for the crops and centres where the response to nitrogen was evident show only the linear trend suggesting that there is scope for increased doses of nitrogen above 60 lb. till the rate of response reaches a maximum and begins to drop appreciably.

9. *Construction and Analysis of Truncated Factorial Designs. B. S. Gill and M. N. Das, I.A.R.S., New Delhi.*

In the usual factorial designs with factors at two levels, the demand on experimental resources increases with the number of factors both due to (i) large number of treatment combinations and (ii) considerable number of combinations each involving three or more non-zero levels. Fractionally replicated designs were suggested for overcoming the first of the two.

The present paper aims at construction of designs for controlling both these factors. The designs which are fractional replicates of 2^n designs and does not contain any treatment combination involving a specified number, say, K or more non-zero levels, have been considered while the choice of such treatment combination is no problem, the analysis of such designs is not straightforward. For the analysis, help was taken of electronic computor for inverting the coefficient matrix of the normal equations appropriate for such designs. A close scrutiny of the inverted matrices led to a systematic way of estimation of main effects and interactions. For example, in a design involving six factors

and retaining treatment combinations with three non-zero levels the estimation of any two factor interaction such as AB comes out as

$$AB = (a - 1) [(bc + \cdots ef) - 2 (b + \cdots + f) + 3].$$

Like ordinary factorial designs these designs also need blocking for increasing precision. A simplified method of blocking for odd numbers of factors when the non-zero levels retained in any combination is not more than two, has been worked. Through this method all such designs can be split into k equal blocks of size $(k + 1)/2$, where k is the number of factors.

10. *On Estimating Sheep Population and Wool Yield. M. Rajagopalan and D. Singh, I.A.R.S., New Delhi.*

The Institute of Agricultural Research Statistics is conducting since 1959, a series of sample surveys in different sheep breeding tracts of the country for evolving a suitable sampling technique for objective estimation of wool production and to collect reliable data on sheep keeping practices. The method of approach followed in these surveys led to an investigation into the efficiency of different procedures of estimating sheep numbers and wool yield. The results of this investigation are discussed in this present paper with the help of the data collected in the survey in Rajasthan during 1960–61.

11. *Multivariate Regression Estimate. G. K. Sukhla.*

Precision of the estimates is increased by using regression method when information on an auxiliary variable correlated with the character under study is used. Present study deals with regression estimate when such information on more than one auxiliary variable is used to obtain more precise estimates. Under certain assumptions $\bar{y}_{lr}$ defined here, as an unbiased estimate of population mean and its variance is given here.

$$\bar{y}_{lr} = \bar{y} + \hat{B}' (\bar{X}_n - \bar{X}_N)$$

where B and $(\bar{X}_n - \bar{X}_N)$ are vectors.

$$V(\bar{y}_{lr}) = S_y^2 \frac{(1 - R^2)}{n} \{1 + n (\bar{X}_N - \bar{x}_n)' s^{-1} (\bar{X}_N - \bar{x}_n)\}.$$

The expression for double sampling multivariate regression estimate has been also obtained.

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12. *Interrelationship among Factorial Designs with Different Numbers of Levels.* P. S. Rao and M. N. Das, I.A.R.S., New Delhi.

J. S. Mehta (1964), applying a linear transformation on the levels of the factors taken two at a time, obtained the factorial fraction of $_3n$ design from the $_2n$ design in 2^n combinations. He has further considered the transformed 3^n designs obtained from confounded (or grouped) $_2n$ designs and analysis has been given for both the above cases. In the present investigations some other transformation of the same type has been utilised to obtain fractions of 4^n from 2^n designs. The fractions of 2^n designs obtained by confounding the interaction of any two factors of the same group result in fractions of asymmetrical factorial designs. Analyses for the above transformed designs have been given and it is observed that the main effects and two factors interactions are all not estimable independently of each other. This is possible if only $n/2$ of the n factors are taken into consideration (remaining being suppressed where the $n/2$ factors consist of one and only one from each of the two factors taken together for the transformation).

13. *Application of Analysis of Variance Technique in the Farm-Management Surveys for Assessment of Agricultural Development.* D. K. Bhattacharya, I.C.J.C., Calcutta.

It has been shown that the technique of Analysis of Variance can be applied to yield satisfactory results in agro-economic surveys with special relevance to the 'Study on Farm Management and Cost of Production of Crops' investigated by the Socio-Economic and Evaluation Branch, Department of Agriculture and Community Development, Government of West Bengal. The survey was conducted on three types of regions from each of which villages were selected at random and from each village cultivators were selected in stratified random way. Considering the 'advice and investment' given to cultivators as treatment while those of the selected cultivators who were not given 'advice and investment' behaved as control, it has been proposed to test the different hypotheses, *viz.*, (a) Response diversity of different regions to the given treatment, (b) Variability in the achievement of the treatment for different individuals and (c) Differential achievement of the treatment with respect to control.

Since the effect of treatment on cultivators, and hence that of the cultivator on the yield is random, the yield in a plot has been considered as a random variable consisting of a mean effect, effect due to

a region, effect due to a cultivator, the joint effect of the region and cultivator and an error. Following Scheffe's mixed model analysis of variance, the method of analysing the data and test procedures for the different hypotheses have been given.

14. *Economic Response Approach to Fertilizer Use. A. G. Khare, Statistician, Department of Agriculture, M.P.*

Large number of experiments with nitrogenous fertilizers were conducted in Madhya Pradesh State during the course of the last ten years. The responses to varying levels of N were studied for major food grain crops in specific agroclimatic zones. The optimum doses were calculated fitting the quadratic response curves to the data yield. The area under the crops in these zones were then considered for assessing the total requirement of fertilizers and the corresponding production of these crops have been estimated.

The study is intended to emphasize the need for adopting the economic response approach for the distribution of fertilizers.

15. *Survey of Sheep and Wool Production in the Plains of Punjab. P. S. Brar, G. S. Mahal and S. Kumar.*

The Sheep Survey was conducted in the plains of Punjab during 1963–64. The objects of the survey were:

(i) To get reliable estimate of total sheep, their breed composition and wool production in the State.

(ii) To collect data on wool trade, marketing facilities and turn-over of wool business in the various wool markets of the State.

The survey covered the entire State excepting the districts of Hoshiarpur, Kapurthala, Jullundur, Kangra, Kulu, Lahul and Spiti and Simla. This area included 77% of the sheep in whole of Punjab State. For the purpose of survey, the region was divided into 13 strata.

A sample of 25 Tehsils was selected from the entire region and allocated to the strata in proportion to the sheep population of each stratum per Livestock Census, 1961. From each Tehsil, three clusters of three villages were selected. Selection at every stage is with equal probability without replacement. For the estimation of wool yield and body weight, one more stage of sampling was introduced. From every flock in each of the village/town selected, two rams, two ewes

and two lambs were selected at random. The fieldwork was carried
out for a period of four months from last week of July to the last week
of October, 1963.

The analysis of data collected revealed that there were about
7·87 lakh of sheep in the Plains of Punjab State. This figure was
estimated with percentage standard error of 7·7. The percentage of
increase in the sheep population since livestock census was 15. The
total wool production in the September shearing season was estimated
at 5·11 lakh kg. with percentage of standard 10·17.

16. *A Comparative Analysis of Growth in Grain Sorghums. B. R.
Murthi and Ganga Prasada Rao, Botany Division, I.A.R.I.,
New Delhi.*

Growth analysis of grain sorghums in relation to adaptability
revealed significant varietal differences with respect to the amount and
rate of production of dry matter and the pattern of its distribution
between the earhead and the rest of the plant (Rao and Murty, 1963).
This is of interest to plant-breeders of arid and semi-arid regions where
limitations of moisture in the later part of the season necessitates selec-
tion of types with capacity for rapid accumulation of dry matter.

The several reported attempts to obtain a satisfactory and simple
formula to cover the entire period of growth and to permit discrimi-
nation between different varieties and their limitations were examined.
An analysis of growth of the above three sorghum varieties of Deccan
region is, therefore, attempted by polynomial regression using diffe-
rences in the log of the character from a fixed origin, as the dependent
variable and time as indepentent variable in the form.

$$\text{Log } Y_t - \log Y_o = d + \beta_1 t + \beta_2 t^2.$$

where t represents the time in days from the date of first sampling.
This method was compared and found to be nearly as effective as the
asymptotic regression outlined by Stevens (1951) and Patterson (1956)
but simpler in application and effective in discriminating between
varieties in growth analysis.

17. *Role of Transformation for Construction of Design of Experiments.
M. N. Das and J. S. Maini, I.A.R.S., New Delhi.*

For construction of factorial incomplete block designs group theory,
Galois field and finite geometry have been applied extensively. But
it appears that no attempt has been made to exploit the principle of

transformation of levels of factors for construction of designs except-
ing that Addleman obtained some asymmetrical confounded factorial
designs by making two or more levels of some factors equal in con-
founded symmetrical factorial designs. In the present investigation
we have attempted to obtain new designs by transforming suitably
the levels of different factors in the existing factorial and other designs.
Through this design we have constructed (i) fractionally replicated
designs of 3^n series, the size of fraction being 2^n, (ii) asymmetrical
rotatable designs and (iii) fractionally replicated designs of 2^n saving
up to a desired order of interaction.

18. *Use of Aerial Photography for Estimation of Area according to
the Land Use in Unsurveyed Tracts. V. V. R. Murty, I.A.R.S.,
New Delhi.*

The statistics of land use in the country are mostly based on the
reports of a field to field enumeration facilitated in such areas, where
the land has been cadastrally surveyed and primary agency exists.
The detailed survey maps and the land registers available in such areas
serve the purpose of sampling in estimation of the yield per acre on a
scientific basis. However, there are several tracts in the country,
although important from the agricultural point of view, which are not
still cadastrally surveyed.

The I.C.A.R. had taken steps to explore the possibility of making
use of the techinque of aerial photography to bridge the gap existing
in respect of statistics of area of crops in unsurveyed tracts. In the
past pilot investigations were conducted in certain typical tracts using
the method of aerial photography. The results of the investigations
showed that the black and white photography could provide reasonably
good maps of villages for use as a frame for sampling. On the basis
of the results obtained from such investigations, a survey was under-
taken in the plain area of Rupsi tract (20 sq. mile) known to be an
important paddy tract in Goalpara District of Assam State. Black and
white photographs of the tract were obtained as 53 contact prints of
6″ scale end and their enlargements of 16″ scale. A study of the photo-
graphs for estimating field areas according to land use, using the
appropriate sampling devices was carried out at I.A.R.S. For this
purpose some staff of the Institute had earlier received necessary
training at the Office of the Surveyor-General of India in various aspects
of aerial photography techniques. These staff also visited the tract
photographed in order to study the crop appearance and other topo-
graphical features on the photographs.

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For the study a "Mosaic" was prepared from all the 53 contact prints. A sample of 230 points were located at random on the mosaic and for each sample point the land use of the area-unit in which the point had fallen was determined. As an alternative method a sub-sample of 40 points was selected from 230 points and for each such point 3 grids of sizes $1'' \times 1''$, $2'' \times 2''$ and $4'' \times 4''$ were marked accurately on the photograph with the points as the centre of these sample grids. The area according to land use in each of these sample grids was measured with the help of a planimeter.

The results of the study indicate the feasibility of using the technique of aerial photography for estimating crop areas in unsurveyed tracts. Taking into account the cost of various operations involved in such analysis, a study has been made on the relative efficiency of different sampling techniques.