ABSTRACTS OF PAPERS PRESENTED AT THE 28TH ANNUAL CONFERENCE HELD AT HARYANA AGRICULTURAL UNIVERSITY, HISSAR IN JANUARY, 1975

1. On Two-Factor Qualitative-Cum-Quantitative Designs Associated to Rectangular PBIB Designs.

K. Kishen, A.N. Shukla and R.B. Tripathi, *Directorate of Agriculture, Lucknow, (U.P.)*

The problem of design and analysis of qualitative-cum-quantitative experiments has been investigated, among others, by Fisher (1935), Yates (1937), Williams (1952), Kempthorne (1953), Rayner (1953), Sardana (1961), Narayana and Sardana (1967) and Tyagi (1966).

In this paper, we have, by use of Rectangular PBIB designs with the parameters

$v=mn,\ b,\ r,\ k,\ \lambda_1,\ \lambda_2,\ \lambda_3,\ n_1=(n-1),\ n_2=(m-1),\ n_3=(n-1)\,(m-1)$;

of which Group Divisible (GD) designs, Latin Square (L_2), and Latin Rectangular designs are special cases, constructed two-factor qualitative-cum-quantitative designs of the types $m\times n$, $n\times m$, $m\times(n+1)$, $n\times(m+1)$ and developed the analysis of these designs both under the additive as well as proportional models.

List of the useful two-factor qualitative-cum-quantitative designs associated to Rectangular, Latin Rectangular, G.D. and L_2 designs have also been given along with the losses of information on quality (Q), quantity (N) and interaction (QN) under both the models.

2. Cylindrical Designs and Associated Asymmetrical Factorial Designs.

K. Kishen and A.N. Shukla, *Directorate of Agriculture, Lucknow, (U.P.)*

In this paper, we define a new association scheme called the cylindrical association scheme involving five associate classes, of

which the parameters are $v=mtl$, where m, t, l are any positive integers, each $\geqslant 2$, $n_1=(m-1), n_2=m(t-1), n_3=(l-1), n_4=(m-1)(l-1)$, $n_5=(t-1)$, $(l-1)$, $p_j^t k$ $(i, j, k=1, 2,..., 5)$. PBIB designs having this assocation scheme may be called Cylindrical designs.

We have given the methods of construction of these designs. We have also obtained the analysis of these designs in the elegant form by use of the characteristic roots and vectors $N . N'$, N being the incidence matrix of the Cylindrical designs.

We have also constructed the associated asymmetrical factorial designs of the type $m \times t \times l$ and have obtained their analysis by use of the characteristic roots and vectors of $N . N'$.

3. Change-Over Designs With Complete Balance For First And Second Residual Effects.

V.K. Sharma & M.N. Das, *I.A.R.S*, *New Delhi.*

The change-over designs considered by Williams (1949, 1950) satisfy all the conditions set out for the balance, render tidy analysis of the data and give the estimates of parameters with quite high precision, yet the non-involvement of the different treatment estimates viz. direct, first residual and second residual effects could not be achieved especially when the object of the experiment is to determine contracts between direct effects. To overcome this difficulty an attempt has been made, in this paper, to evolve a new class of change-over designs completely balanced for the first, and second residual effects of treatments. These designs allow the estimation of direct effects and hence of all contrasts between direct effects with minimum variance by making the estimation of these effects orthogonal to all other effects.

4. A Note On An Alternative Method of Construction Of GF (p^2).

K.R. Aggarwal, *Punjab Agricultural University, Ludhiana.*

Let p be a positive prime. Then elements of $GF(p^2)$ can be obtained as the elements of the set $\{a+ib/a, b\ GF\ (p_2), i=(-1)^{1/2}\}$ iff $p \equiv 3 \pmod 4$ can be written in the form $0, x^1, x^2..., x^{p^2-2}, x^{p^2-1}=1$. For $GF\ (3^2)$ the elements are $0, x=1+i, x^2=2i, x^3=1+2i,$

$x^4=2$, $x^5=2+2i$, $x^6=i$, $x^7=2+i$, $x^8=1$. For $GF(7^2)$, $GF(11^2)$, and $GF(19^2)$ the primitive roots $4+i$, $9+5i$ and $4+5i$, respectively.

5. Modified Latin Square Type PBIB Designs.

K.R. Aggarwal, *Punjab Agricultural University, Ludhiana.*

A modified latin-square type $[ML_i(s)]$ association scheme with i constants for the s^2 treatments is defined as follows :

Let s^2 treatments to be denoted by ij $(i, j=1, 2, \ldots, s)$, be arranged in an $s \times s$ square array. Let $(i-2)$ mutually orthogonal latin squares (MOLS) of order s exist. Let these $(i-2)$ MOLS be superimposed on the square array. Two treatments will be called (1) first associates, if they occur in the same row or column of the array ; (2) second associates, if they occur in positions occupied by the same letter in any of the $(i-2)$ MOLS, and (3) third associates otherwise.

The partially balanced incomplete block (PBIB) designs with the $ML_i(s)$ association scheme will be called $ML_i(s)$ designs, pseudo $ML_s(s)$ association scheme or pseudo $ML_s(s)$ designs can be defined when s is not a prime or a prime power.

The series of $ML_i(s)$ designs given in the form of the following Theorems can be constructed :

Theorem 1. A series of $ML_i(s)$ design with the parameters $v=s^2$, $b=(i-2)s$, $r=(i-2)$, $k=s$, $\lambda_1=0$, $\lambda_2=1$, $\lambda_3=0$, can be constructed when $(i-1)$ MOLS exist.

Theorem 2. A pseudo $ML_s(s)$ design with the parameters $v=b$, $=s^2$, $r=s-1=k$, $\lambda_1=0$, $\lambda_2=1$, $\lambda_3=0$ can be constructed when $(s+1)$ is a prime or a prime power.

These two series of $ML_i(s)$ designs can be taken as useful confounded factorial experiments of type s.

6. Further About Design Aspects Of Paired Comparisons.

G. Sadasivan, *I.A.R.S., New Delhi.*

The design aspect of paired comparison experiments have been the object of study by different authors as Kendall (1955), David and Wolock (1965), David (1963), and Sadasivan (1970, 74). In the present paper we are considering some designs for complete pairs and

others for fractional sets as standard comparison pairs and Symmetrical pairs. The main contributions in the paper are (1) the PBIB properties of square designs for standard comparson pairs (2) adoption of linked designs for S.C.P.'s (3) enumeration of linked paired comparison designs for Symmetrical pairs (4) enumeration of equivalent classes for Symmetrical pairs and (5) enumeration of combined sets for symmetrical pairs.

7. On Balanced Designs.

P.D. Puri & A.K. Nigam, *I.A.R.S., New Delhi.*

A design is said to be variance balanced if every elementary contrast is estimated with same precision and it is termed as efficiency balanced Calinski (1971), Puri and Nigam (1974), if effective information obtained on any contrast is same. In present note it has been shown that the necessary and sufficient condition for a connected design to be variance balanced is that $P=nk-Sn$ matrix has all its off-diagonal elements same and that for efficient balanced is that P Matrix is of the form $P=\theta\, r+1\, rr'$ where θ and 1 are some scalar constants. It has been shown that the variance balanced designs are not necessarily efficiency balanced, only in case of equi-replicated designs either property implies the other.

8. On Construction of Balanced Ternary Designs Through the Method of Differences.

A. Dey and R. Chakravarty, *I.A.R S., New Delhi.*

The method of differences is a well-recognised technique for the construction of incomplete blocks designs and related combinatorial arrangements. It was pointed out by Saha and Dey (Ann. Instt. Statist. Maths; 1973) that this method can be used for the construction of balanced ternary designs (cf. Tocher, J.R.S.S. (B), 1952) also. The purpose of the present paper is to obtain several new series of balanced ternary designs, using the method of differences. The following series of designs have been obtained :

(*i*) $V=2m+4=B$, $R=2m+2=K$, $\lambda=2m$, m any positive integer.

(*ii*) $V=4t+3$, $B=(2t+1)(4t+3)$, $R=4(2t+1)$, $K=4$, $\lambda=5$; $4t+3$ a prime or a prime power.

(*iii*) $V=4t+3$, $B=(2t+1)(4t+3)$, $R=(2t+1)(2t+2)$, $K=(2t+2)$, $\lambda=t(2t+3)$; $4t+3$ a prime or a prime power.

(*iv*) $V=4t+1$, $B=t(4t+1)$, $R=6t$, $K=6$, $\lambda=7$; $t>1$; $4t+1$, a prime or a prime power.

(*v*) $V=5t+1$, $B=t(5t+1)$, $R=7t$, $K=7$, $\lambda=8$; $t>1$; $5t+1$ a prime or a prime power.

(*vi*) $V=6t+1$, $B=t(6t+1)$, $R=5t$, $K=5$, $\lambda=3$; $6t+1$ a prime or a prime power.

9. On Construction of Balanced and Orthogonal Arrays.

Rupak Chakravarty and A. Dey, *I.A.R.S., New Delhi.*

A $v \times N$ matrix B with entries from a set Σ containing s symbols ($s \geqslant 2$) is said to be a Balanced Array with s symbols, v constraints, N assemblies and strength t, if every $t \times N$ submatrix of B contains the ordered $t \times 1$ column vector $(x_1, x_2, \ldots\ldots\ldots\ldots, x_t)'$, $x_i - e\Sigma$.

$$\mu(x_1, x_2, \ldots\ldots\ldots\ldots, x_t)$$

times, where

$$\mu(x_1, \ldots\ldots\ldots\ldots, x_t)$$

is invariant under any permutation of

$$(x_1, x_2, \ldots\ldots\ldots\ldots, x_t).$$

If

$$\mu(x_1, x_2, \ldots\ldots\ldots\ldots, x_t) = \mu, \forall > x_1, x_2, \ldots\ldots\ldots\ldots, x_t$$

the matrix B is called an Orthogonal array of strength t.

In this present paper, two series of Balanced arrays with three symbols and strength two are constructed. Two methods of construction of orthogonal arrays with two symbols and strength three are proposed.

10. A Game in Standard Comparison Pairs as a Mark OV Process.

G. Sadasivan, *I.A.R.S., New Delhi.*

The paper develops a game in Standard Comparison Pairs, that is a fractional set of paired comparisons in which a group of given treatments are compared with a standard. It is proved that the game has all the Markov properties. The states of the system are defined, the transition probabilities calculated and classification of states made. The probabilities of absorption to the last round

and duration of the game have been worked out for particular cases. The n-th order transition probabilities, the mean first passage times, the first passage probabilities and higher moments of first times to absorption and passage have also been worked out. The results are useful for studying the asymptotic properties of standard comparison pairs.

11. On a Model for Rank Analysis

S.C. Rai and S.C. Gupta, *I.A.R.S., New Delhi.*

The mathematical model for paired comparisons was postulated in such a way that the estimates were mathematically workable and the model was easy to apply and interpret. In the present paper, we have developed procedure for testing the appropriateness of the model and also investigated the reliability of the estimates used in paired comparisons. In paired comparisons, we assume the existence of non-negative parameters $\pi_1, \pi_2, \ldots, \pi_t$ associated with t treatments $T_1, T_2, \ldots, T_t$. The behaviour of the parameters is further defined with a probability statement that

$$P(T_i > T_j)\left(\frac{\pi_i^2}{\pi_i^2+\pi_j^2}\right)$$

For testing the appropriateness of the model, we have to test

$$H_0 : \bar{\pi}_{ij}=\pi_i^2/(\pi_i^2+\pi_j^2),\ i\neq j$$

$$H_1 : \bar{\pi}_{ij}\neq\pi_i^2(\pi^2+\pi_j^2) \text{ for some } i \text{ and } j$$

The likelihood ratio test is used. For large n, this test tends to usual test of goodness of fit.

The asymptotic distribution of the estimator of π_i, is worked out. The estimates of variances and covariances are also obtained. The procedures developed in the paper are explained by a numerical example.

12. Rank Analysis of Incomplete Block Designs : Large Sample Properties of the Bradley-Terry Model for Standard Comparison Pairs.

G. Sadasivan and D. Singh, *I.A.R.S., New Delhi.*

Sadasivan (1967) has proposed the method of fraction of paired comparisons for reducing the size of experiments in quality testing. Sadasivan & Rai (1973) have built up a model on the lines of Bradley and Terry for drawing inference from one of the fractional sets known as standard comparison pairs. In the present paper some of the large sample properties of the test statistic developed, therein are derived. First a model for (0, 1) scoring system for standard

comparison pairs is developed. In this case it is shown that the test under the special case (*ii*) of Bradley and Terry reduce to the sign test. Next the distribution of the test statistic T' for standard comparison pairs is derived, the power curves constructed and compared with those of complete pairs. The Pitman efficiency of the test procedure as modified by Norther is also calculated. It is found that the efficiency of standard comparison pairs is more under certain hypotheses.

13. Construction of Balanced and Partially Balanced Asymmetrical Factorial Designs $q \times 3^n$ through Ternary Block Designs.

K.N. Agrawal, *I.A.R.I., New Delhi.*

Kishen and Tyagi (1964) constructed balanced asymmetrical factorial designs $q \times 2^2$ and $q \times 3^2$ in $2q$ and $3q$ plots blocks by associating pairwise balanced designs of q treatments with confounded pencils of 2^2 and 3^2 symmetrical factorial designs. Sreenath (1967) constructed these designs by taking incidence matrices of three BIB designs of q treatments with block size ki ($i=1, 2, 3$) such that $\Sigma k = q$ and sum of the three incidence matrices be a unitary matrix and associating them with blocks of confounded symmetrical designs $(3^n, 3^p)$ in $3p$ plots block ($p<n$).

The method of construction of asymmetrical factorial designs given by Kishen and Tyagi (1964) requires a pairwise design and that of Sreenath (1967) requires three BIB design of q treatments such that $\Sigma k = q$ with some of the three incidence matrices a unitary matrix. Designs satisfying these requirements are not available for all values of q.

In the present paper, ternary block designs constructed by Murty and Das (1967), Das and Rao (1968), Agarwal (1974) were utilised in the construction of the balanced asymmetrical factorial designs $q \times 3^n$ in $q \times 3^p$ plots blocks by associating the incidence matrix of ternary block designs with the blocks of symmetrical factorial designs $(3^n, 3^p)$in 3^p plots blocks. The analysis of these designs and recovery of information on affected interaction have been worked out.

Partially balanced asymmetrical factorial designs (Kishen and Tyagi, 1963) of the type $q \times 3^n$ in $q \times 3^p$ plots blocks were also constructed through partially balanced ternary (PBT) designs of q treatments (Mehta, Nigam and Agarwal, 1974) by associating the incidence matrices of these designs with the blocks of symmetrical factorial design $(3^n, 3^p)$ in 3^p plots blocks. A systematic analysis of these designs and the recovery of information on affected interactions have been worked out.

14. Some Aspects of Pairwise Comparison and Ranking.

G. Sadasivan., *I.A.R.S., New Delhi.*

This paper develops some aspects of pairwise comparison and ranking. Here different methods of ranking by row-sum procedures of Kendal are examined. Associate the parameters θi with item i. Then the probability for pereference of item i to item j is denoted by $F(\theta i - \theta j)$ where $F(t)$ is a distribution function. Then, the different ranking procedures are examined under the assumption that : (1) the distribution is rectangular, (2) the distribution is symmetric. Using the above distribution a method known as reduced ranking procedure is discussed which involves the construction of a risk function and computation of its values for every ranking vector. The procedure stipulates that we should select that ranking which involves minimum risk. A procedure for ranking from fractional pairs which involves the maximisation of $W_p(A)$, the probability that the score vector is a under the assumption that the underlying preference matrix is p is also developed in this paper. It is shown in the case of standard comparsion pairs that the row-sum procedure is optimal and estimation of ranking by row-sum procedure satisfies the sufficiency condition. A model for ties is also developed and extended to fractions of k-tuples. Estimation by row-sum procedure is shown to be sufficient in this case also.

15. Rank Analysis in Paired Comparisons

S. C. Gupta and S. C. Rai, *I.A.R.S., New Delhi.*

Experiments involving ranking within small groups of treatments are particularly appropriate in sensory judgement investigations. The method of paired comparisons is useful in such situations. In the present paper, we have developed a mathemtical model for analysis of experiments involving ranking in paired comparisons. It is postulated that the t treatments have true ratings $\pi_1, \pi_2, \ldots, \pi_t$ on a particular subjective continuum through out the experiment. Every $\pi_i \geqslant 0$ and $\sum_{i=1}^{t} \pi_i = 1$. Further we assume that when treatment i appears with treatment j in a block, the probability that treatment i obtains top rating is taken to be $\frac{\pi_i^2}{(\pi_i^2 + \pi_j^2)}$. Assuming probability the independence of treatment comparisons for all pairs and repititions, the likelihood function is obtained. The maximum likelihood estimates of the treatment parameters are obtained. The model permits tests of hypothesis of general class and the estimation of treatment ratings. Two special tests are considered to test the null hypothesis that true treatment ratings are equal. The

methods of pooling and combining the result of several judges are also developed. The utility and application of the model are explained by a numerical example.

16. Some Exact Tests for Fractional Paired Comparisons.

G. Sadasivan., *I.A.R.S., New Delhi.*

Paired comparison experiments are generally conducted to compare t stimuli such as flavours or colours which are presented in pairs to a group of judges. The judge is to express his preference for one of each pair assuming no ties. To reduce the size of paired comparison experiments Sadasivan (1967) has suggested fractionation of pairs. One of the fractions used in situations where a standard stimulus is compared with others is the Standard Comparison Pairs. Another fractional set named Symmetrical Pairs is obtained by forming pairs cyclically. A Bradley-Terry type model for analysis of data from Standard Comparison Pairs has been built by Sadasivan and Rai (1973). Two models for analysis of data for symmetrical pairs have been built by Sadasivan and Sundaram (1972, 1973). The model for Standard Comparison Pairs gives only an overall test for a particular score vector and hence cannot be used for (1) testing the significance of the difference between pairs of stimuli. The models built for symmetrical pairs also are giving only overall or asymptotive tests. In this paper exact tests for cases (1) and (2) are developed for single replicate as well as replicated Standard Comparison Pairs and symmetrical Pairs. Distributions of the test statistics are developed and tables of critical regions given for the different types of comparisons.

17. I. T. O. Method for Determining Correlation Between Relatives in Random Mating Population Involving Multiple Alleles.

K. C. George and Prem Narain, *I.A.R.S., New Delhi.*

Li and Sacks (1954) explained an easy technique to obtain the joint distribution and correlation of a pair of relatives with the help of conditional probability matrices obtained from the parent-offspring relationship. These conditional probability matrices, are denoted by I.T.O. matrices, giving the conditional probabilities for the offspring to have both genes, one gane or no gane identical by descent. This method is, however, applicable to the case of a single locus with two alleles and a random mating population. No attempt has been made so far to extend this method to the case of multiple alleles.

In this paper, the formation of the I. T. O. matrices is explained in the case of single locus with s alleles. It has been observed that

the patten of the I. T. O. matrices remain the same except in their dimensions. In the generalised case, the dimensions of the I. T. O. matrices become $1/2\ s\ (s+1) \times 1/2s\ (s+1)$. The joint distribution as well as the correlation between any pair of relatives can be obtained with the help of the generalised I. T. O. matrices. Similar extensions hold good in the case of sex-linked genes also. However, the dimensions of the four forms of T and O matrices are $1/2\ s\ (s+1) \times 1/2\ s\ (s+1)$, $1/2\ s\ (s+1) \times s$, $s \times 1/2\ (s+1)$ and $s \times s$, respectively. It has been found that the correlation between relatives is made independent of the number of alleles provided we assume the genic effects to be additive only.

18. Productivity of Feed with Respect to Egg Production under Commercial Management Conditions.

T. Jacob and B. Marutiram, *I.A.R.S., New Delhi.*

The paper deals with the studies on the relationship between egg production and the feed cost, which is the most important factor contributing to the total cost of production of an egg. Such information would be of use for a proper understanding of poultry management as an industry and for its development on efficient and economic lines. The data collected under the scheme for estimation of cost of production of poultry and eggs carried out by the Institute of Agricultural Research Statistics in Dasua area of Punjab were utilised for the study.

Different forms of relationship between feed cost per layer per fortnight in a farm and the corresponding egg production were tried separately for each farm size category. Tests of significance showed that the linear equation fitted the data well. The marginal products worked out to be around 0.05 indicating that if the feed cost is increased by 20 paise per bird per fortnight the corresponding per bird production is expected to increase by one egg. Thus in the farms under study there is scope for increasing the production through increased level of feeding.

19. Some Designs for Sensory Evaluation.

G. Balachandran and G. Sadasivan, *I.A.R.S., New Delhi.*

In this paper some of the designs which can be used in food technology, standardisation, quality testing of cereals etc. have been developed. The designs developed can be used for conducting experiments involving paired comparisons of different types like complete pairs, symmetrical pairs and standard comparison pairs.

The method of paired comparisons is a well known method of ranking objects according to the response they produce on a set of subjects. Bose (1956) has developed linked paired comparison design for testing agreement among the judges. The designs developed by him have a lot of symmetry and are similar to balanced incomplete block designs with an additional restriction. In the present work, similar designs for comparing the effects of a certain set of varieties rather than for testing the concordence among the judges have been developed. Some designs with good combinatorial properties have been obtained in this case. In the case of symmetrical pairs also some solutions for parametric relations which lead to simple arrangements have been obtained. For the practitioners of sensory evaluation these arrangements will be useful. For standard comparison pairs also, similar arrangements have been obtained. The method of analysis for these designs are not yet developed. Any one of the existing models namely :—

(*i*) Thurstone Mosteller Model
(*ii*) Bradley-Terry Model
(*iii*) Kendall's Model
(*iv*) Scheffe's Model and
(*v*) Hubei's Model can be modified to suit our requirements.

The correspondence between experiments involving full paired comparisons and 2^n factorial system is also drawn. In the process two new coefficients of concordence have been devised. The method of measuring interactions from paired comparison experiments is also developed.

20. Comparative Performance of Rambouillet X Local in Jammu and Kashmir.

Gopalan, R., Marutiram, B. and Srivastava, A.K., *I.A.R.S., New Delhi.*

Data on various wool quality characteristics and greasy fleece weight as well as various vital characteristics covering a period of fifteen (15) years from 1952 were utilised to make a critical comparison of the performance of local (Gaddi) Rambouillet and their crosses. Pure Rambouillet was superior to its cross-bred progeny and local sheep so far as production characteristics were concerned but suffered from higher mortality. Three-fourth Rambouillet were superior to half-breds in respect of greasy fleece weight, fibre dimeter and fleece

density but were found inferior to half-breds in so far as adaptability characters are concerned. The greasy fleece weight, fineness and fleece density showed an increasing trend as the proportion of Rambouillet blood increased from zero to one. Fibre length showed a decreasing trend as the proportion of Rambouillet blood increased to 75 per cent. A policy of large scale upgrading of local (Gaddi) sheep with Rambouillet up to 75 per cent exotic blood for fine wool production appears safe for adoption under local conditions. However, it would be worthwhile to secure information regarding the performance of inter breds of different exotic blood levels for evolving a new breed of fine wool sheep.

21. Multipurpose Surveys on Successive Occasions in a Two-stage Design.

C.L. Agarwal and P. C. Gupta, *Rajasthan University, Jaipur.*

In repeated sampling enquiries the application of successive sampling technique, with partial replacement of sampling units on subsequent occasion, has many advantages. It may be convenient, cheaper and sometimes necessary to study a number of correlated characters instead of a single one. The several characters on successive occasions was first discussed by Tikkiwal (1955, 67) for unistage sampling design under a specific correlation pattern.

Singh and Singh (1973) has developed the estimators for various characters for $h(h>2)$ occasions without restricting the correlation pattern in a unistage design. Further they have extended these results for a two stage sampling design for a specific replacement pattern which allows only replacement of primary stage units (psu).

In the present paper, for simplicity, two characters have been studied in a two stage sampling design under a more general replacement pattern than one considered by Singh and Singh (1973), which allows the replacement of psu as well as of second stage units (ssu). No restriction on the correlation pattern has been imposed. Singh and Singh (1973) replacement pattern follows as a special case of this replacement pattern.

22. A Product Type Composite Estimator on Two Occasions in Two Stage Sampling Design.

P.C. Gupta and C.L. Agarwal, *Rajasthan University, Jaipur.*

The use of ratio method of estimation in successive sampling was first discussed by Avadhani (1963). Purakam and Koop (1966)

used it for a two stage design when first-stage units are drawn with varying probabilities and with replacement and obtained conditions in which the ratio-type composite estimator of the population total was superior to conventional two stage estimator.

Utilising the fact, that situation do exist when the characters are negatively correlated from occasion to occasion, Gupta (1970) gave a product type composite estimator of the population mean and obtained various conditions for it to be superior than conventional estimator. In the present investigation the use of product method of estimation has been made in a two-stage sampling design when the first stage units are selected with probabilities proportional to sizes with replacement and second stage units within each selected first stage unit are selected with simple random sample without replacement.

23. Some Alternative Eatimators in Rao, Hartley & Cochran's Scheme of Sampling.

Ravindra Singh, *Punjab Agricultural University, Ludhiana.*

Rao, Hartley and Cochran (1962) have suggested a simple procedure of selecting a sample with unequal probabilities and without replacement. The unbiased estimate of population total corresponding to this scheme has been shown to be always more efficient than the estimate corresponding to the *PPS* with replacement scheme. In this paper we have suggested certain alternative estimators for the Rao, Hartley and Cochran's scheme. The efficiency of these estimates has also been investigated.

24. Studies in Systematic Sampling for Crop Estimation of Guava.

A. H. Manwani & K. B. Singh, *I. A.R.S., New Delhi.*

The data collected from survey on guava in Allahabad district of U. P. conducted by the Institute of Agricultural Research Statistics have been analysed so as to find out whether the average yield rate of guava could be estimated equally efficiently by recording the yield data from a systematic sample of pickings taken at regular intervals varying between one to seven days from the selected orchard instead of recording the entire yield obtained from all the pickings of the trees selected in the orchard. Different systematic sampling schemes have been compared with those involving stratification of harvesting period of weeks or fortnights as also with the scheme involving the selection of harversting days in the form of clusters of two

or more consecutive days. It has been found that efficiency of sampling scheme involving selection of days in the form of clusters of two or more consecutive days is of the order of 20 to 68 per cent depending upon the size of the cluster as compared to simple random selection of days. On the other hand, the loss in efficiency due to systematic selection of days with varying intervals ranging between one to six days, was of the order of 3 to 35 per cent as compared to the recording of yield date on all the days on which the pickings took place in the selected orchards. The studies have indicated that the design involving recording of yield of the selected trees by visiting the selected villages once in every five days is the most efficient one which will provide almost as efficient estimates of the average yield as that obtained by recording the yield of the selected trees for all the pickings during the entire harvesting period. Thus, this type of systematic sampling design will involve hardly 1/5th of the travelling cost between the villages as compared to the sampling design involving recording the entire yield from all the pickings on the selected trees.

25. Procedure for Estimating Pepper Production.

A. S. Sethi and J. N. Garg, *I.A.R.S., New Delhi.*

The usual technique adopted in crop estimation survey for estimation of crop production is not applicable for pepper crop. This is due to the fact that the crop is mostly grown in mixed condition with several other garden crops and this renders the concept of recording area under the crop a difficult one. In this paper an attempt has been made to compare different estimates of the number of pepper standards and estimates of average yield per bearing standard in order to provide an estimate of production. Four different estimates of number of pepper stadards have been examined and their relative efficiencies compared. Three different estimates of average yield per bearing standard are also investigated and their percentage standard errors compared. A procedure of estimating the total production has been suggested. The results of the investigation are discussed with an illustration of the data collected in a sample survey for estimation of pepper standards and average yield per standard conducted by the I. A. R. S. in Kerala State during the year 1966-67.

26. A Procedure of Sampling with Varying Probabilities.

Padam Singh, *I.A.R.S., New Delhi.*

In the present paper a procedure of selecting a sample of required size ensuring inclusion probability proportional to size has

been suggested. The suggested procedure has the following advantages :

(*i*) The procedure is simple and applicable for any sample size.

(*ii*) It is possible to find revised probability selection in a simple way.

(*iii*) It is possible to rearrange the units in most of the case-for obtaining a positive solution for the revised probabilities of selection.

The relative efficiency of the suggested procedure has been examined with some of the well-known existing methods with the help of numerical illustration.

27. On Estimation of Multiple Characters.

M. Srinath and A.K. Srivastava, *I.A.R.S., New Delhi.*

In this paper some aspects of multicharacter studies have been examined. In sample surveys, interest more often lies in recording information on several characters from the same sampling units. Sometimes, information on all the characters may not be available from all the sampling units *e.g.* in fruit surveys with villages or clusters of villages as sampling units, some of the units may not be growing all the fruit crops. Some sampling procedures which can be used for this purpose under different circumstances, have been discussed. The technique of double sampling for stratification, with strata having same combinations of characters, has been examined and is found to perform better than the standard technique of domain studies, under a prevalent cost function constraint.

28. Some Further Aspects of Two-Dimensional Varying Probability Sampling.

G. Sadasivan, *I.A.R.S , Library Avenue, New Delhi.*

In the present paper some further aspects of our extension of Brewer's (1963) model of pps sampling to the case of two dimensional populations is discussed. In this case the selection of two rows and two columns without replacement forming a sample of four units is considered. In the model for two dimensional populations, the study variable y can be classified into MN classes, M classes pertaining to Z and N classes for W where Z and W are correlated to Y. Associated with each value of Y, there is some function X of Z and

W, such as a measure of size. In general $X=f(Z,W)$. In the simple model $X=ZW$. Under these assumptions the equation for inclusion probability for a particular unit is set out and the model solved for revised probabilities. One simple solution and the corresponding variance estimators for the Hurwits-Thompson estimator are considered. Some approximate general solutions of the equations are also tried along with the estimators of variances. The efficiency of this model is compared with the other sampling schemes.

29. Trends in Yield Rates of Maize in India During the First Three Five Year Plans

A.C. Kaistha, A.K. Banerjee and S.C. Rai, *I.A.R.S., New Delhi.*

Apart from rice and wheat, maize is also considered an important cereal crop in India. The annual output of this crop is about 7.4 million tonnes. In the present paper, an attempt is made to study the trend in the yield rates of maize during the period 1950-51 to 1965-66 with a view to finding out the impact of first three five year plans on the average yield of this crop in different states of the country. The study is carried in five important states of the country which covers about 77% of the total area under maize. The method of analysis as developed by Panse (1959 and 1964) has been used in the present study.

The result obtained in the study lead to the conclusions that at All-India level the increase in yield rates in the plan period over the corresponding control period was highest during the first plan being 179 kg/ha followed by increases of 131 and 122 kg/ha during the third and second plan periods. Madhya Pradesh showed a steady increase during all the three plans. Uttar Pradesh recorded depressions in yield rates during first and second plans while Bihar indicated significant increase during second and third plans and Rajasthan showed significant increase during first and third plans.

30. Methodological Problems of Determination of Cost of Cultivation of Apples.

Bhagat Singh and A H. Manwani, *I.A.R.S., New Delhi.*

The determination of cost of cultivation of fruits excepting banana poses a number of problems, the cultivation of fruits being inherently different from that of field crops. The present paper is an attempt to bring out these problems and to suggest methods for

determination of cost of cultivation of apple. The procedure has been illustrated with the help of data relating to a cluster comprising 12 orchards in Tehri district of U.P.

Different costs involved in the cultivation of apple have been divided into :

(*i*) initial costs on account of planting the orchard

(*ii*) costs incurred on bringing up of the orchard up to the bearing stage

(*iii*) costs on account of capital investments on tools, implements and farm structures alongwith repairs incurred thereon

(*iv*) cost of maintenance during the year under observation and

(*v*) cost of harvesting and watch and ward.

It has been suggested to work out the cost of cultivation per 100 trees a tree being the producing unit.

Alternative concepts of cost of apple cultivation have been developed depending upon the allowance one is prepared to give to the producer as under :

Cost A : Paid human labour + imputed value of unpaid human labour + cost of purchased and home produced material inputs + cost on account of depreciation of fixed capital and repairs thereon + interest on capital invested in plantation.

Cost B_1 Cost A + Cost of harvesting and watching.

Cost B_2 Cost B_1 + Cost of supervision.

Cost C_1 Cost B_2 + Interest on working capital.

Cost C_2 Cost B_2 + Rental value of land.

Cost C_3 Cost B_2 + Interest on working capital.

31. Effciency of Cluster Sampling Sub-Clusters of C.A.S. System

B.B.P.S. Goel and D. Singh, *I.A.R.S., New Delhi.*

In situations where although the list of individual elements in the population is available yet cluster sampling is used for the sake of operational convenience or economy *BS* (clustering before sampling) and *CAS* (clustering after sampling) procedure for the formation of clusters were introduced by the authors (1973). Practical criteria formation of clusters under these two systems of cluster sampling

were also formulated. It was mentioned that the clusters of *CAS* type formed according to the distance criterion for certain type of populations were expected to be more efficient than *CBS* type clusters or individual elements for a fixed cost of the survey. The absolute efficiency of such clusters is, however, likely to be low in relation to individual elements as is true for most of the natural clusters.

In this paper the concept of sub-clusters of *CAS* system has been introduced. Corresponding to N clusters of *CAS* type formed according to the distance criterion we can form S sets of N sub-clusters where s is given by

$$s = \pi_{i=}^{N} si = \pi_{i=1}^{N} \frac{(Mi-1)_\theta}{(M-1)}$$

M_i is the size of the ith *CAS* cluster and M is the size of the sub-cluster. A random sample of n sub-clusters from any of these s sets can be used to estimate the population mean. Although sub-clusters of every set will be overlapping yet for sub-cluster formed according to some of the criteria the bias in the estimate based on the simple mean of cluster means will be small and the absolute efficiency of such sub-clustors is expected to be more even than individual elements. Thus the cost efficiency of sub clusters formed according to these criteria will be much higher than the cost efficiency of *CBS* clusters or individual elements.

32. Some Information on Mortality Among Milch Animals Under Village Conditions

K.C. Raut and Shivtar Singh, *I.A.R.S., New Delhi.*

Information on mortality among milch stock is of practical value for formulating animal improvement programme. Mortality rate, age at death of animals will be of special significance for cattle insurance projects. Such information is not available for cows and buffaloes maintained in different regions in the country as no special scheme has been launched for the purpose. Only from a few large scale sample surveys carried out for various purposes, some information is available on mortality of animals. It has been worked out that the mortality rate varies from 1.1% to 5.9% among milch cows and 3.0% to 5.4% among milch buffaloes, based on data collected in Hissar district (Haryana), Krishna delta area (Andhra Pradesh) and Dhulia region (Maharashtra). Distribution of animals according to age at death and the number of calves born till death have been worked cut for different regions.

33. Power Estimators.

Rajinder Singh and Randhir Singh, *Punjab Agricultural University, Ludhiana.*

Jankins, Ringer and Hartley (1973) have considered a class of biased estimators which they termed root estimators. This class is defined by

$$\bar{y}=k\sum_{j=1}^{K} C_j\left(\frac{1}{n}\sum_{i=1}^{r} y_i^j\right)^j$$

where the number of terms, K and the coefficients C_j are suitably chosen a priori. This class of estimators has smaller mean square error (MSE) than $\bar{y}$ for the positively skewed populations. The above idea has been further explored by introducing another class of biased estimators which for the negatively skewed distribution has smaller MSE than $\bar{y}$. The class of estimators we have studied and which we have termed power estimators is defined by

$$\bar{y}_k=\sum_{j=1}^{K} C_j\left(\frac{1}{n}\sum_{i=1}^{r} y_i^j\right)^{y_j}$$

where K and C_j are suitably chosen a priori as in the above case. The properties for two special cases of particular importance, namely square and cube estimators respectively, of y_k when

(*i*) $K=2;\ \bar{y}_2 = C_1\bar{y}+C_2\bar{y}$

where

$$x_i=y_i^2$$

and

(*ii*) $K=3,\ C_2=0,\ \bar{y}_3=C_2\bar{y}+C_3(\bar{z})^{\frac{1}{3}}$

where

$$z_i=y_i^3$$

have been discussed in detail for some negatively skewed parametric distributions.

34. Basic Unit of Measurement in the Cost of Cultivation of Apples-Area or a tree.

Bhagat Singh and Jag Mohan Singh, *I.A.R.S., New Delhi.*

The mode of cultivation of apples is different from field crops and many fruit crops as well. Apart from other methodological

problems a question arises as to whether the cost of cultivation of apple should either be worked out on hectare basis or on per tree basis. Data on number of trees per hectare have been presented for 60 orchards of Almora and Tehri Districts of U.P. for 1973-74 which did not follow any trend in number per hectare in the selected clusters of villages. The number of fruit trees varied from 92 to 354 per hectare. Analysis of variance was also carried out which did not explain any variation between clusters or between age groups. It has further been argued that tree being the producing unit, inputs are applied to the individual tree. Output also depends upon the tree or number of trees per hectare. It has thus been suggested to adopt a tree to be the basic unit for working out the cost of cultivation/production of apples.

35. Sampling Problems in Sugar-cane Pests,

J.P. Chaudhary and N.L. Bhatia, *Haryana Agricultural University, Hissar.*

Sugarcane pests are the chief bottlenecks in successful cultivation of sugarcane. Both yield and quality of sugarcane are drastically reduced by the ravages caused by them. Since the problems of sugarcane pests are complex in nature, it is very difficult to assess accurately the population, incidence, extent of infestation and the losses caused by them. However, the losses caused by sugarcane borers alone are estimated to be about Rs. 70 crores annually in India. Various workers have adopted different methods of sampling *i.e.* on the basis of clump, sugarcane area, row length and random sampling from the harvested lots for several pests of sugarcane. About 125 pests of sugarcane have been reported in India, but for convenience sake these have been classified into three major categories *viz.*, sucking, boring and chewing types. A brief review of techniques and methods adopted so far in sampling has been reviewed.

36. Impact of Tube-well Irrigation on Agriculture in Meerut District.

K.K. Tyagi and S.C. Rai, *I.A.R.S., New Delhi.*

Irrigation plays an important role in increasing the agricultural production. A study was undertaken in the district of Meerut for assessing the impact of Tube-well irrigation on agriculture. Design adopted for the survey was one of multistage stratified random sampling. Benefits of irrigation in terms of average area irrigated by

each tube-well have been worked out. The records of tube-well department were found in close agreement with the survey findings. A study has also been made on the non-utilisation of tube-well in the district. The main reasons for non-functioning of tube-well in their capacity are defective and inadequate irrigation channels and lack of electric power when required. Mechanical, hydel and civil defects accounted on an average for closures of tube-wells for about 700 hours in a year. On enquiry it was found that yield rates of rice, potato, maize and sugarcane have considerably gone up due to tube-well irrigation and cultivators are raising two or three crops in the field in a year.

37. Statistical Studies on Some Economic Traits of Indian Buffaloes.

R. Singh and H.P. Singh, *I.A.R.S., New Delhi.*

Milch buffaloes constitute only one third of the total population of milch cattle and buffaloes in India and they account for 59 per cent of the total milk production, yet not much work has been done to study the genetic parameters which are prerequisites for the improvement of buffaloes on scientific lines. In the present paper we have studied the variability with respect to different characters for different herds of buffaloes maintained at various Indian Military Dairy Farms. Repeatability coefficients for the lactation milk yield and the lactation period have been obtained by the methods proposed by Manglik (1963) and Gurnow (1961).

38. About Some Estimates of Characters of Mobile Populations.

G. Sadasivan and V.K. Dwivedi, *I.A.R.S., New Delhi.*

The marking or tagging technique is a valuable method of estimation of characters of a mobile population. The principle of the method is simple. A number of animals are caught and marked or tagged in some manner. They are then released in the area from which they are taken. Later, more animals are caught and the ratio between the number of marked and unmarked animals affords an estimate of population number. The method was used by Peterson (1896) and Lincoln (1930). The idea to estimate population number by using single stage inverse sampling procedure was first given by Bailey (1951). Chapman (1952) extended this procedure for more than one stage.

In this paper we have given some new estimates for population number from inverse sampling with replacement along with the

existing estimate by Chapman and studied some of their properties. It is found that Chapman's estimate is sufficient, satisfies the condition of minimum variance and uniqueness. It is also found that it is the most efficient estimator among the class of estimators discussed. The estimators are compared for errors as well as biases theoretically as well as numerically. An estimate of recruitment rate is developed by using a Posson process.

39. Estimation of Annual Wool Production and Sheep Rearing Practices in Maharashtra During 1972-73.

S.M. Patel, R.B. Patil and A.D. Godbole, *Department of Animal Husbandry, Poona (Maharashtra).*

A survey was conducted during March 72 to February 73, adopting stratified random sampling. The State was divided in four strata excluding Greater Bombay district. For collecting species-wise (separately for ram, ewe and lamb) wool yield and body weight; two stage stratified random sampling was adopted. The data were collected from 75 village clusters of 2 villages each and selected afresh for every season in proportion to sheep population of each stratum.

The important results are as follows :—

Sheep are reared in 38.5 percent villages of the State. The percentage of households rearing sheep is only 5.6 with average sheep population of 135 per village.

The majority of flocks are of stationary type (78.9 percent) contributing 64.3 percent of sheep population of the State.

The average flock size of the migratory flock was double than that of stationary flock with overall average flock size of 32 sheep (one ram, 25 ewes and 6 lambs).

The estimated number of sheep during the year was 1.87 million comprising of 7.2 percent rams and wethers, 70.4 percent ewes and 22.4 percent lambs. White bodied sheep were 27.6 percent.

The estimated wool yield per sheep per clip was 244 gm. and estimated annual wool production of the State was 911 tonnes.

The reduction in total number of sheep comprises of mortality 19.6 percent and sale for slaughter and home consumption 30.44 percent whereas the addition was due to lambing which was 79.3 percent of total adult ewes.

40. Calf Rearing in Rural Areas.

Shivtar Singh and R.L. Rustagi, *I.A.R.S., New Delhi.*

According to the last livestock census, calves up to three years of age constitute about 29 per cent of bovines in India, and majority of these are in rural areas. In order to formulate Animal Husbandry improvement programmes on scientific lines, it is desirable to know the cost of rearing calves under village conditions. It is hoped that calf rearing, in addition to generating adequate employment to the family, will go a long way in improving the economic status of those engaged in this profession. Although studies on economics of rearing calves have been done in some livestock farms, the only study in an objective manner regarding the economics of raising cattle and buffaloes in a rural area was carried out by the Institute of Agricultural Research Statistics during 1963-66, in Hissar district of Haryana State.

In the present study an attempt has been made to work out the cost of rearing calves based on the data collected in large scale surveys conducted by I.A.R.S. for the estimation of availability and cost of milk production in Krishna delta area (Andhra Pradesh) and Dhulia region (Maharashtra).

41. Sugar Industry in India—Facts and Figures.

N.L. Bhatia, K.L. Bahl and C.N. Babu, *H.A.U., Hissar.*

In our country the area under sugarcane is hardly 1.7 percent of cultivated area whereas the area under food grains is 75%. If this large area under food grains cannot solve the food problem, the encroachment in this tiny 1.7 percent area may not be of much avail in this direction. What is actually needed is to increase our national average yield per unit area of the food grain crops which is very low as compared to the advanced countries of the world. Sugarcane yield is also too low (about five tonnes of "gur"/hectare in our country) but being an efficient photosynthetic plant *i.e.* in C^4 cycle physiologically it has more biological yield potential than most of cereals and pulses. A proposition suggested by some of the economists is to shift sugar industry of North India to South as south provides a congenial climate for this tropical crop as the crop can grow with easy facility and at low cost of production, the farmer consider it as sure crop will not give up growing of this crop under any circumstances in the North.

Sugar besides being the cheapest source of energy it also serves as a protein conserving agent. It improves the palatability and also serves as a preservative. It has other multifarious uses in industry and commerce. In the era of energy crisis power alcohol produced from molasses may perhaps be the cheapest solution. In India per capita consumption of sugar is only 7.0 kg. as compared to 60 kg. in Cuba and 50 kg, in U.S.A.

In order to meet our ever-increasing national demand of more sugar and to earn sizable foreign exchange especially during this period of exorbitant prices of sugar in the International market due importance is to be given to the second largest industry of our country. Crores of rupees have been invested in it. Ignoring this industry means colossal economic loss and creating a huge socio-economic problem of unemployment. Suggestions regarding substitute of sugar also does not seem to be praticable. Saccharine has its hazards to human health. Maize syrup also cannot meet our demands.

42. Relative Efficiency of Ratio and Regression Estimators as Compared to Sample Mean Estimator for Estimating the Mean of a Finite of a Population Following Bivariate Normal Distribution.

Srinivas Bhagwan and A.H. Manwani, *I.A.R.S., New Delhi.*

Ratio estimator for mean of a finite population in simple random sampling design is said to be superior to the sample mean under the condition

$$\rho > 1/2\ C_x/C_y$$

where, C_x and C_y are coefficients of variation of the study and auxiliary variates respectively and ρ is the coefficient of correlation between two variates. Also, the regression estimator is said to be always more efficient than sample mean and as well as ratio estimator whatever be the value of ρ. In the present paper, the validity of these statements has been examined on the basis of an artificial populations generated from bivariate normal populations with given values of means and variances and taking four different values of ρ *viz.*, 0.25, 0.50, 0.70 and 0.90. A sample of 200 units was selected from each of these populations and Monte Carlo study was carried out so as to compare the efficiency of ratio and regression estimators versus sample mean estimator on the basis of 200 repeated samples of size ranging between 10 to 40 units each.

The study indicated that when the value of ρ was 0.30, both ratio and regression estimators were less efficient as compared to

sample mean, irrespective of the size of sample. The efficiency of ratio estimator in this case was found to be in the range of 60 to 70 per cent while, that of regression was in the range of 66 to 82 per cent depending upon the sample size. However, for the value of $\rho=0.5$ and above both the ratio and regression estimators were more efficient as compared to sample mean. The efficiency of ratio estimator with a sample size of 10 units increased from 145 to 362 per cent while that of regression increased from 145 to 553 per cent as the value of ρ increased from 0.50 to 0.90. However, with a sample size of 30 units, the efficiency of ratio was found to lie in the range of 127 to 395 per cent while that of regression was in the range of 128 to 807 per cent.

While comparing the efficiency of ratio versus regression estimator, the study has indicated that when value of ρ was of the order of 0.9, the regression estimator was definitely superior to ratio estimator, however, for the values of lying between 0.50 to 0.70, the ratio seemed to be slightly more efficient than regression.

43. Impact of First Three Five Years Plans on the Yield Rates of various Food Crops in the State of Bihar

A. C. Kaishta, *I.A.R.S., New Delhi*

The chief industry of India has always been agriculture. About 70 per cent of the people in the country are dependent on agriculture for their livelihood. Since the first five year plan, (1951-52 to 1965-66) agriculture has been given a top priority for its development. However, in spite of plan efforts, the progress in some of the states has not been as satisfactory as one will desire it to be. Bihar is one such state. In the present paper an attempt has been made to study the trends in the yield rate of various food crops in Bihar State during the period 1951-52 to 1965-66. The study has also been made to find the extent of impact of first three five year plans on the yield rates of various food crops. The main object of the study is to ascertain the magnitude of changes in the yield rates of different crops during the first, second and third five year plans as compared to yield rates during the 1950-51 treated as control. Attempts have also been made to determine how far these changes could be ascribed to plan efforts as distinct from changes arising from influence of uncontrolled seasonal conditions.

The crops covered in the study are rice, maize, jowar, bajra, ragi, wheat, barley, gram and tur. It was observed that there was

highly significant change from plan to plan in the yield rates of all the crops in the state. Yield rates are also observed to be significant within different years of various plans for all the crops. The comparison of first plan and pre-plan revealed a significant increase in the yield rates of rice, jowar, wheat and gram only. Second plan when compared with the first indicated a significant increase in the case of rice, and maize only. Third plan when compared with the second plan indicated increase in the case of all crops, except ragi and barley.

44. Use of canonical correlation for determining the sampling region to assess fleece quality in Indian Sheep.

R. M. Acharya, S. C. Agarwal and C. L. Arora, *Central Sheep and Wool Research Institute, Avikanagar.*

Region best representative of the total fleece in Indian Sheep has yet not been determined, although some work on correlating individual fleece quality determined from regional samples with those determined from composite sample with a view to determine the best sampling region has been attempted.

The present paper describes the use of canonical correlation (Bartlet, 1941) for determining the Sampling region to assess fleece quality in Indian Sheep. Wool samples (six monthly growth) from six body regions viz. neck, wither, back, shoulder, midside and britch were taken from 39 Chokla ewes (4 teeth) during March, 1972 shearing season. A composite sample representing the entire fleece was prepared by poolIng a representative sample from each region. Wool quality attribute viz. staple length, average fibre diameter, and medullation percentage for the regional as well the composite samples were determined by standard procedures.

The results from the present study indicate a highest canonical correlation for the midside with the composite wool with respect to all the wool quality attributes taken together followed by the back region. This is suggestive of midside to be the best representative region for aseessing the total fleece of an individual sheep.