ABSTRACTS OF PAPERS PRESENTED AT THE 24TH ANNUAL CONFERENCE HELD AT MADRAS IN JANUARY 1971

1. Different Techniques of Estimating the Marketable Surplus of Paddy in West Godavary District of Andhra Pradesh.

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The present study was conducted in West-Godavary District of Andhra Pradesh with a view to ascertain the need for Modern Rice Mills in that district. The district has 16 Community Development Blocks. It was stratified into 3 strata based on area under paddy in the blocks. Stratum I contained four blocks each having an area of more than 80000 acres under paddy. Stratum II contained four blocks each having an area of 40,000 to 80,000 acres under paddy. Stratum III contained the remaining eight blocks having an area of less than 40,000 acres. Two blocks from Stratum I and one block each from Stratum II and Stratum III were selected at random. From each of the selected blocks two villages were selected at random and 10 cultivators were selected at random from each selected village. Marketable surplus of paddy (y), area under local varieties of paddy (x), area under high-yielding varieties of paddy (z) for the year 1968-69 from each of the selected cultivators were taken for the present study. Marketable surplus of paddy was estimated for Stratum I, Stratum II, Stratum III and for the whole district using

(1) Linear regression of y on x

(2) Linear regression of y on z

(3) Multiple linear regression of y on x and z.

2. The Inheritance of some Palmar Dermatoglyphic Patterns in Man.

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The total ridge count on fingers (TRG) is one of the very few polygenic traits of man whose inheritance seems to have been under-

stood satisfactorily. But very little is known about the other dermatoglyphic patterns.

The inheritance of the two dermatoglyphic characters *viz.* the '*a—d*' ridge count and the '*atd*' angle have been studied under the present investigation. Frequency distributions of the values of the characters in fathers, mothers, sons and daughters have been obtained from the palm prints of members of 100 families. While the *a—d* ridge count had a near Gaussian distribution suggesting several genes with small effects, the '*atd*' angle had a peaked distribution with lesser variation implying relatively fewer genes with larger effects. It was also noticed that genes on the X-chromosome influence the expression of the character.

The high values of mid-parent offspring correlation (.45) and heritability (.82) for *a—d* ridge count suggest the involvement of additive genes, whereas the low values of these (heritability .50) for '*atd*' angle imply a substantial contribution of the non-additive genetic and environmental components of variation.

3. Study on the trends in yield of rice and wheat in India during the First Three Five Year Plans.

Ravindra Saxena and M.G. Sardana, I.A.R.S., New Delhi.

The trends in yield rates of two most important food crops, rice and wheat, were studied over a period of twenty years, 1946-47 to 1965-66 comprising of pre-plan, first plan, second plan and third five year plans with the objective of finding out the impact of the first three five year plans on yield rates of these crops. The method of analysis followed was broadly the same as used by Panse (1964, the Journal of the Indian Society of Agricultural Statistics, No. 1, Vol. XVI) for studying the impact of first and second plan efforts on yield rates of rice and wheat.

At all-India level the average quinquennial yield of rice in the first, second and third plans had increased by 45, 90 and 20 kg./ha. as compared to the corresponding control qninquenniums. Madras was the only state which showed a steady increase in yield per hectare of rice during all the three five year plans. Next to Madras, Andhra Pradesh recorded significant increase in yield rates during the first and second plan periods.

Unlike rice, plan efforts had very little impact on the yield per hectare of wheat. At all-India level the increases in yield rates of wheat in the first and third plans were 80 and 72 kg./ha. respectively while practically no increase in yield was recorded in the second plan. The states of Gujarat, Punjab and Uttar Pradesh had contributed significantly to the increase in yield rates during the third plan.

4. EFFICIENCIES OF SOME ALTERNATIVE PROCEDURES IN TWO-STAGE SAMPLING ON SUCGESSIVE OCCASIONS.

O.P. Kathuria I.A.R.S., New Delhi.

In sampling on two occasions, using two-stage design, Abraham, Khosla and Kathuria (1969) considered a sampling procedure where a fraction np of primary stage units (psu's) along with a sample of mr second stage units (ssu's) are retained from first occasion to the second and a fraction nq of psu's along with ms ssu's are selected afresh ($p+q=1$, $r+s=1$).

When sampling is carried on to three occasions with the sampling pattern on the second occasion as given above, a number of different sampling patterns for selection of psu's and ssu's on the third occasion are available. We consider the following three sampling patterns to be of more importance. (I) Retain only npmr units from the second occasion to the third and select remaining units afresh, (II) retain only npm units from the second occasion to the third and select remaining units afresh, and (III) retain only nqmr units from the second occasion to the third and select remaining units afresh. Estimates were obtained for the mean on the current occasion and also for the change under each of the three sampling patterns and their relative efficiencies have been compared. In general, it was observed that for estimating mean on the current occasion, sampling pattern III is more efficient and for estimating the change, sampling pattern II is the best.

5. COMPLEX GENETIC CORRELATIONS

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This article presents some investigations on genetic correlations between certain types of relatives following the theory of path

coefficients as developed by Sewall Wright in 1918. All the correlations developed here correspond to diploid populations under equilibrium in Wright's sense, with respect to one locus and two alleles with no dominance. Second section presents some simple and interesting correlations and demonstrates the case with which one could obtain these correlations directly from path diagrams. Last section deals with genetic correlations for some complex situations.

6. Crop Responses to Fertilizers in Dryland Agriculture

A.R. Das & B.N. Tyagi, I.A.R.S., New Delhi.

The bulk of the cultivated area (nearly 80%) in the country is unirrigated of which a major part receives little rainfall throughout the year. Lack of adequate soil moisture not only serves as limiting factor for the normal crop growth but also inhibits the use of fertilizers in these areas. To assess and evalvate the effectiveness of fertilizers as measured by the additional output obtained, the results of experiments conducted at various research stations during the last few years were studied.

The results of experiments conducted at research stations in the states of Gujarat, Madhya Pradesh and Mysore on bajra, jowar, cotton and groundnut crops indicated varying responses to nitrogen and phosphorus from centre to centre. However, the magnitude of the responses at most of the centres was not very appreciable. At the optimum level of fertilizer application (as calculated by fitting response surfaces), an investment of one rupee was found to give return varying from Rs. 1.28 for bajra crop in Gujarat to Rs. 3.51 on jowar crop in Mysore.

7. Genetic Correlations in an Equilibrium Population

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Parent-offspring correlations, correlations between full sibs and half sibs are derived in this paper for populations which is under equilibrium under an arbitrary but fixed mating system. The different cases with one pair of genes at a locus (autosomal as well as sex-linked) are studied in detail and indication is given for generalisation in the case with multiple alleles.

8. A STUDY OF NON-RESPONSE IN 'REPEAT SURVEY'

I.C. Sethi and D. Singh, I.A.R.S., New Delhi.

The reliablity of any 'repeated occasion' survey is reduced, due to marked increase in non-response. When we have a 'repeated occasion' survey for a group of highly correlated characters, we can sometimes increase the reliability of 'repeated occasions' survey by obtaining an estimate of missing values of the characters of non-responding units.

Here an attempt is made to estimate the missing value of the characters of non-responding units, using the information on previous occasions aud recent occasion estimates under some restrictions using three different models. As is obvious this estimation will be valid only at macro-level and under the following assumptions :

(*i*) characters under study are highly correlated to each other ;

(*ii*) listing units in the investigation continues to possess at least same set of characters from one occasion to another and units which do not respond continue to remain at their previous places ; and

(*iii*) advancement of technology etc. has got effect of the order of macro-level over the non-responding units.

This type of estimation is possible in all cases except when unit has not responded (for all characters) at any of the previous occasions.

9. FACTORS INFLUENCING THE PRICE OF MILCH STOCK

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

The price of an animal depends on both quantitative and qualitative characters. The quantitative characters like level of milk production, age, order of lactation, stage of lactation and stage of pregnancy and the qualitative characters such as condition of health, colour, other conformation characteristics etc. are the factors which influence in pricing of an animal. The factors of

qualitative nature are purely subjective and cannot be measured. The present study is confined to see how far the factors of quantitative nature have the influence in pricing of a milch animal. Data pertaining to animals for which transaction took place during the period of enquiry in Madras (1957-59) and Calcutta (1960-62) to estimate the cost of production of milk, in Hissar district of Haryana (1963-63) to study the economics of raising cattle and buffaloes and in Krishna Delta areas of Andhra Pradesh (1967-69) have been utilised.

10. On the Efficiency of Different Procedures for the Estimation of Average Yield of Crop.

R.K. Mahajan, I.A.R.S., New Delhi.

An attempt has been made to compare the relative efficiencies of different procedures for the estimation of average yield of the high yielding variety of jowar crop, *viz*, hybrid jowar, collected under the scheme of "Assessment Surveys on High Yielding Variety Programme" from Mysore State. The different procedures used are, simple random estimator, separate ratio and regression estimators, combined ratio and regression estimators, arithmetic mean of the sample means estimators, proportional allocetion estimator and average of the pooled samples estimator. In case of biased estimators the formulae for bias has been developed. Among all these different estimators separate regression estimator has been found to be the most efficient one, but because of heavy calculations the next efficient estimator in order of preference, *i.e.*, separate ratio estimator should be used in order to have the maximum gain in efficiency.

11. The Use of Auxiliary Traits in Increasing the Efficiency of Selective Breeding

P. Narain and A.K. Mishra, I.A.R.S., New Delhi.

The genetic improvement in a quantitative trait in a population is usually affected by adopting selective breeding on the basis of the phenotypic values of the trait. The rate of this improvement can, however, be increased if the variations in this trait due to other

auxiliary traits particularly at the environmental level are minimised as far as possible. This technique was first initiated by Hazel (1943) with the introduction of selection indices. Later on Rendel (1954) extended this idea and studied the relationship between the selection index and the correction for one trait for variation in another. Since there might be more than one trait influencing the main trait, it is desirable to study the effect of the number of traits, the heritabilities and the genetic as well as phenotypic correlations on the genetic gain expected in this situation. Taking the expected genetic gain without the use of additional traits as a standard, the efficiency of selective breeding due to this technique is expressed as the ratio of the genetic gains in the two situations. In this paper the conditions under which this efficiency is increased have been studied theoretically with respect to n additional traits. A formula for the standard error of the efficiency when only one additional trait is involved has also been derived.

It has been found that the efficiency depends on the phenotypic correlations amongst $n+1$ traits and n parameters c_i's representing correlated response in the main trait due to selection on the i-th etc. auxiliary trait. When all the phenotypic correlations are equal, the efficiency is found to be independent of variations in c_i's. For very large n the efficiency settles down to an asymptotic value depending on the value of the phenotypic correlation and the average value of the c_i's. It is further found that the efficiency is always greater than one and increases with the increase in n provided the phenotypic correlation and the average value of the c_i's are of opposite signs. When the set of auxiliary traits are independent amongst themselves the efficiency depends on n, the average value and the variance of the phenotypic correlations between the main trait and the auxiliary traits, the average values of the c_i's and the covariance between the phenotypic correlations and the c_i's. The efficiency increases with decrease in covariance and also when the covariance is negative. Though the efficiency is greater than 1 when the average values of the phenotypic correlations and c_i's are of ogposite sign, it would also be greater than 1 even when these two are of the same signs provided the covariance is highly negative.

The above technique of increasing genetic improvement has also been applied to data on cattle of Kankrej breed collected from the herd at Anand. It has been found that so far as the milk yield in first lactation is concerned, the genetic gain can be increased by

about 3 per cent and 6 per cent with the use of age at first calving and the body weight of the calf in first lactation respectively. However, when both of these auxiliary traits are used simultaneously to correct for variations in the milk yield in first lactation, the genetic gain in milk yield can be increased by as much as 11 per cent.

12. A Study on Cluster Size in Livestock Surveys

A.S. Sethi and M. Rajagopalan, I.A.R.S., New Delhi.

In a finite population of elements, the number of clusters of elements that could be formed is inversely proportional to the cluster size. In the development of the theory of cluster sampling this aspect is generally ignored as it is regarded that the clusters are already available for taking samples. In this work the solution of the problem of cluster sampling, when the no. of clusters is a function of cluster size, is attempted by using the census of bovine population in 60 villages of Krishna district in Andhra Pradesh.

With and without the consideration of an appropriate cost function, the efficiency of cluster sampling was studied for the data and was found that cluster size of three villages provides maximum efficiency for estimating total bovine population.

A functional relationship between the cluster size and the mean square between elements of a cluster was attempted for the data. It was seen that this mean square is independent of the cluster size.

Using this fact, the expression for the variance of cluster sampling was obtained and with the appropriate cost function, the optimum cluster size was determined. It was concluded for the data used, that it would not be advantageous to use cluster sampling and it is preferable to use simple random sampling.

13. On Varietal Pairing Experiments to Study Varietal Co-operation

S. S. Narula, I.A.R.S., New Delhi.

In tuber crops like potato it is not possible to exploit hybrid vigour. Instead attempts are being made to exploit varietal co-

operation to augment production. The technique for the purpose consists of planting pairs of seeds coming from two different varieties in the same hole so that they get a chance to help mutually or otherwise. Such experiments are already being conducted for the study of varietal co-operation. Special designing and analytical problems are involved for such experiments. The data collected from the experiments can be analysed for the estimation of varietal-pair effects as also to assess if any particular variety shows any high co-operative effect so that in general its pairing with any other varieties accounts for increased production. The present investigation provides suitable design for the estimation of what may be called general varietal co-operative effect as also the effect of varietal pairs by evolving suitable analytical technique in several types of designs.

14. Fisher's Regression Integral versus Regression Function of Selectsd Weather Factors in Crop-Weather Analysis

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The inherent complexity of the relationships between the yields of farm crops and the previous weather which largely control those yields, arises primarily from the complexity of the problem of specifying the weather itself and specifying the true critical periods which influence the crop environment hence crop growth and yield. The Wheat crop under Crop-Weather observations at Jalgaon and Niphad was subjected to a detailed examination by (*a*) Fisher's Regression Integral and (*b*) Regression Function of selected weather factors.

Fisher in his paper on the influence of rainfall on the yield of Wheat at Rothamsted, has developed a method with the premises that (*a*) the meteorological varieties to be employed must be chosen without reference to the actual crop record and (*b*) relationships of complicated character should be sought only when long series of crop data are available.

The second method consists in picking out in an objective manner, *i.e.* without any personal bias, the prior meteorological features which have the most significant influence on the final yield.

By Fisherian technique, consistently high multiple correlation coefficients (M.C.C.) were obtained at both the stations by taking

into consideration all the 52 weeks ending with the week of harvest, the values without trend removal being 0·874 for Jalgaon and 0·806 for Niphad. The number of independent variables was six.

By the second method it was found that for both the stations there are three critical presowing rainfall periods, one period at the time of crown-root initiation and another at the time of grain formation. These five statistically significant periods yielded a M.C.C. of 0·916 for Jalgaon and 0·848 for Niphad.

It was also found that there is a good agreement between the two methods in the general trend of response but not in the degree of response especially at Jalgaon where the crop is grown in heavy black soil with high water holding capacity.

By the second method which is comparatively more simple, it is possible to include other meteorological factors such as temperature occurring in the critical crop phase namely primordial initiation. Thus by the inclusion of maximum temperature the M.C.C. has improved still further to ·926 at Jalgaon while at Niphad, inclusion of maximum and minimum temperature has enhanced M.C.C. to 0·922.

15. Forecasting yield of Bajra on the basis of weather parameters of Ahmedabad District

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With the help of CDC-3600 Computer, variability of Ahmedabad District rainfall based on fifty years data for all overlapping periods of 7 to 28 days was computed for June to October. Periods in which the coefficient of variation is less than 100% have been found and are presented to facilitate detailed examination by agricultural scientists with a view to developing suitable varieties which can be grown successfully during such periods.

The periods in which rainfall has some significant correlation with the yield of bajra have been located. It is found that the variability of rainfall during such periods is higher than 300%. It is also observed that both maximum and minimum temperatures of certain periods have some significant effect on bajra yield. With the help of rainfall and temperature of these periods, regression equation

has been developed to forecast the yield of bajra. This equation has been tested by comparing the forecasted yield with reported yields of recent years. The agreement is satisfactory.

16. Estimates of Milk Yield and per capita availability of milk in Maharashtra

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The four important Livestock products *viz.* milk, egg, wool and meat are the basic needs of the human life. An integrated survey to study the production, consumption and utilisation levels of these livestock products was taken up in Maharashtra State in early 1970 and is in progress. The sampling plan followed was a multi-stage stratified random sampling with the villages as first stage units, the household as the second stage units, and the animals in the households, as third stage units. The present study provides results for summer season only. The average daily milk yield of a cow in milk was estimated to be 0·622 kg. and that of a buffalo in milk 2·258 kg. The corresponding estimate for a milch cow and a milch buffalo was 0 236 kg. and 1·175 kg respectively. The total production was estimated to be of the order of 2102 tonnes of which 888 tonnes were cow milk and 1214 tonnes buffalo milk.

It was estimated that per capita availability of milk in Maharashtra in summer season was 47 gms. per day, 20 gms. being cow milk and 27 gms. buffalo milk.

17. An Alternative approach to Olkin's Multivariate Ratio Estimate

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Let there be p auxiliary x-variables $(x_1, x_2, \ldots, x_p)$ with the variable y under study. $\hat{Y}R_1, \hat{Y}R_2, \ldots, \hat{Y}R_p$ are population estimates of y based respectively on the ratio estimates $\bar{y}/\bar{x}_1, \bar{y}/\bar{x}_2, \ldots, \bar{y}/\bar{x}_p$. Let us denote the biases of $\hat{Y}_{R_1}, \hat{Y}_{R_2}, \ldots, \hat{Y}_{R_p}$ by $B_1, B_2, \ldots, B_p$ respectively and let B represent the bias of $\hat{Y}_{MR}$.

The proposed estimate say Y_{MR} for multivariate and let B represent the bias of Y_{MR}.

The proposed estimate say $\hat{Y}_{MR}$ for multivariate ratio $\hat{Y}_{MR}=W_1\hat{Y}_{R_1}+W_2\hat{Y}_{R_2}+.....+W_p\hat{Y}_{R_p}$ where $\sum_{i=1}^{p} W_i=1$ and the weight W_i can be selected subject to the following three alternatives

I $V\left(\hat{Y}_{M_R}\right)$ is minimised

II $V\left(\hat{Y}_{M_R}\right)$ should be minimised subject to $B=\sum_{i=1}^{p} W_iB_i=0$

III A fixed variance of $V(\hat{Y}_{MR})=V_o$ can be taken at our discretion where $V_o \geqslant$ minimum $V(\hat{Y}_{MR})$ and the bias $B=\sum_{i=1} W_iB_i$ should be minimised.

Case I was dealt by Olkin (1958), in his paper. The other two cases are considered in the present study. The results are illustrated with the help of an empirical data.

18. SOME MAIN-EFFECT PLANS FOR 3^n FACTORIALS

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The construction of main-effect plans for symmetrical and asymmetrical factorials has gathered considerable attention in the recent past. In the present paper, some new main-effect plans for 3^n factorial are suggested. The method makes use of the incidence matrix of a suitable balanced ternary design. The method of analysis is simple. The efficiency of the proposed plans is also compared with those of the existing main-effect plans, and it is found that the proposed plans are superior to the existing ones.

19. Sequential application of non-parametric T-test

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If fixed numbers of observations are made sequentially the outcome of the test can be anticipated by following the procedure suggested by Alling (1963). This procedure consists in calculating least upper and greatest lower bounds for any subsequent value of statistics and the continuation or termination of the experiment depends upon these values. The procedure was illustrated using Wilcoxons rank sum test. This test is useful in case of location parameter when alternative hypothesis is one sided. It was already shown by the author and B V Sukhatme, that when the alternative hypothesis is two sided the power of the T test proposed and studid in detail by them is more than that of Wilcoxon's test. Therefore it would be desirable to use T test when alternative hypothesis is two sided. In the present paper it has been shown that the T test proposed earlier can be used squentially in similar fashion and decisions can be taken earlier.

20. On Independent Sampling

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

Sometimes several samples are taken from the same finite population, each aimed to estimate the population mean. The results obtained from the different samples are often pooled to get a more precise estimate. Though an unbiased estimate of the population mean is obtainable from a weighted average of the individual estimates, the sample sizes being used as weights, the variance of the pooled mean and also its estimate cannot be obtained in any straightforward manner, particularly when there are some common units in the different samples. In the present investigation an attempt has been made to define several suitable sampling schemes and then obtain the various estimators corresponding to each one of them by utilising the results obtained in respect of balanced n ary designs. The exact variance expressions have been worked out in each of the cases.

21. On the Ratio Method of Estimation

V.K. Srivastava, B.H.U., Varanasi.

The purpose of this paper is two-fold. Firstly, an estimator of the population mean $\overline{Y}$ is proposed.

$$Y_R = \ominus\ (\bar{y}/\bar{x})\ \overline{X}$$

where $\bar{y}$ and $\bar{x}$ are unbiased estimators of $\overline{Y}$ and $\overline{X}$ respectively and $\ominus$ is a scalar. Two values of $\ominus$ are obtained, one is so chosen that $\overline{Y}_R$ is unbiased and the other such that the mean squared error of $\overline{Y}_R$ is minimised. The bias and mean squared error are obtained in each on case. Secondly the paper presents some remarks on the approaches commonly adopted for analysing the finite sample behaviour of ratio estimators.

22. Estimation of Genetic change in some Indian Herds of Cattle

P. Narain and L.K. Garg, I.A.R.S., New Delhi.

Amble et al (1967) estimated average genetic gain per year for location yield in various Indian breeds of cattle by combining an estimate of the heritability of the trait and its selection differential. It is desirable to compare these predicted estimates with the actual genetic changes undergone in a given herd during the several years of its maintenance. However, not many methods are available to measure genetic changes along with its standard error from the records maintained in a herd. Smith (1962) estimated genetic changes in a set of pig records collected over nine years, in a closed herd. With this end in view, therefore, the breeding data relating to cattle for Red Sindhi Herd at Hosur and Bangalore, Tharparkar Herd at Patna and Kangayam Herd at Hosur, and Kankrej Herd at Anand spread over about 25 years for each herd were analysed. Several important traits like milk yield in first lactation, yield per day of lactation, yield per day of calving interval, lactation period, calving interval and age at first calving were considered. The genetic change was estimated as pooled within sire within generation regression on time of the difference between the herd and the individual sire means. The standard error of the genetic change was also estimated with the help of a formula developed for this purpose. The results indicated that there was significant genetic

decrease in the age at first calving in respect of the herds Tharpakar, Kangayam, and Kankrej. The percentage genetic decreases were estimated as 4·3, 4·4 and 7·8 respectively in these three herds. For other traits, however, there were no significant genetic changes.

23. On Some Replacement Patterns in Multistage Successive Sampling

A.K. Srivastava, I.A.R.S., New Delhi.

In sample surveys, sometimes, it is desirable to repeat the surveys at certain intervals. This procedure, apart from providing the estimates of averages on the most recent occasion utilising the information on previous occasions, also provides overall estimates and the estimates of change occurring between any two occasions. In two-stage designs, the case where primaries are partially retained along with the secondaries has been considered. Once the sample fraction for primaries np (n being the number of primaries to be selected) has been decided, the experimenter is confronted with the situation to choose one of the several replacement patterns available. Some of the patterns available in the literature are due to Eckler (1955), Rao and Graham (1964), Savdesia and Seth (1968) etc. Assuming constancy of variances and covariances, Singh, D. (1968), has compared two replacement patterns for three occasions for estimating the mean as well as overall estimate. Under pattern I the same sample fraction (np) is retained from one occasion to the next and each time a fresh sample fraction (nq) is randomly selected from the units not used upto that time. Under pattern II, the sample fraction repeated on the second occasion is not repeated on the third occasion but a fresh sample is selected in its place. Keeping in view the limitations of the assumptions made in the paper of Singh, D. (1968), these two patterns are compared under less stringent conditions for h occasions. The correlation model considered is a generalisation of product model of correlations considered by Tikkiwal, B D. (1951). It is observed that both the replacement patterns provide equally efficient estimates for the mean on the most recent occasion as well as overall estimate under the model considered. It may, however, be remarked that this model of correlation is of much practical utility. Further, the second pattern cannot provide an estimate of change between any two occasions

which are distant at least two occasions apart. It indicates that in most of the practical situations, pattern I should be preferred.

24. CONSTRUCTION AND ANALYSIS OF CIRCULAR CHANGE-OVER DESIGNS

G.M. Saha and M.N. Das, I.A.R.S., New Delhi.

A class of designs called circular change-over (CRCO) designs is obtained by associating circular designs of Das (1960) to special-type latin squares of Williams (1949) and sets of mutually orthogonal latin squares. Like circular designs, CRCO designs have also the desirable features such as simplicity of construction and availability of designs for any number of treatments in any block sizes. A unified method of analysis of circular designs and a general theory for construction and analyis of incomplete block change-over designs, *i.e.*, the change-over designs which are obtained by associating incomplete block designs with latin squares are, first, developed. Application is then made to give construction and analysis of circular change-over designs. Extra-period (EP) CRCO designs are also discussed. Direct and only first residual effects of treatments are considered for analyses of all CRCO and EPCRCO designs. A table of various efficiency factors of a wide range of CRCO designs is presented. The average efficiencies of a large number of CRCO designs are seen to compare favourably with those of designs of Patterson and Lucas (1962). A number of designs of the new class may be added in the list of Patterson and Lucas (1962) to give it a wider coverage of designs.

25. ALTERNATIVE PROOF OF NON EXISTENCE OF UMVU ESTIMATOR IN UNIFIED THEORY OF SAMPLING

M.N. Deshpande, Institute of Science, Nagpur.

In this note, the class of unbiased estimates is represented in different ways and using that representation non-existence of UMVU estimator is proved very easily. The existence of UMVU estimation for unicluster design is shown. One more restriction is imposed on class of unbiased estimation and in that class H.T. estimator is shown to be best.

26. Multivariate Ratio-type Estimators in Double Sampling for Two stage Designs

S.B. Agarwal and S.S. Pillai, I A.R.S., New Delhi.

Hartley and Ross (1954) developed an unbiased ratio type estimator in the case of simple random sampling when the information on the auxiliary character is known for the population. Sukhatme (1962) studied ratio type estimators in the case when the information on the auxiliary character is lacking. Unbiased ratio type estimation was extended to two stage sampling design by Garg (1968) for the case of single as well as two phase sampling.

In the present investigation unbiased multivariate ratio type estimators for two stage sampling designs have been developed. For obtaining the unbiased ratio estimators the extended method of symmetric means developed by Tukey (1956) and later generalised by Robson (1967) has been used. By using this extended method, variances and co-variances of several estimators have been worked out for the same order of approximation. The results have been illustrated with the help of empirical data. The investigation tends to show that the method of estimation suggested here may be tried out when adequate auxiliary information is available, as it is likely to give unbiased estimates with substantial reduction in variance over the estimates based on the mean of means.

27. Use of auxiliary information in two stage successive sampling

Shivtar Singh, I.A.R.S., New Delhi.

In sampling on successive occasions the information collected on the previous occasions is utilised to improve the estimates on a most recent occasion. When some auxiliary characters, highly correlated with the character under study, are available, they can further be utilised to improve the estimates on a most recent occasion. Estimates of mean have been discussed in unistage successive sampling by J.A. Sastri (1970). Apart from getting the estimate of the mean on a most recent occasion, one may be interested in estimating the change occurring between any two occasions as well

as an overall estimate. In the present investigation estimation procedures for providing these estimates have been discussed for a multistage design.

28. On a Method of Construction of Confounded Asymmetrical Designs in Single Replicate

R.K. Bohra and M.N. Das, I.A.R.S., New Delhi.

To bring about economy in the use of resources as also to ensure flexibility, it is desirable to obtain designs involving smallest feasible number of replications, providing mutually independent estimates of all the effects. This has been achieved by constructing the confounded asymmetrical factorial designs of the type $q \times 2^2$ in $(q+1)$ plot blocks, where q is any number, in single replicate, in which one of the levels of the factor of asymmetry has been repeated once. The method of construction discussed in the present investigation is a suitable compromise between the method given by Das (1960) and Banerjee and Das (1969). An interesting fact about these designs is that through them, the different affected interactions are estimable mutually independently even in single replication and as such they establish their superiority over the designs given by Binet et al. (1965) in single or more replicates.

By the present technique of construction, the balanced designs can also be obtained in comparatively much lesser number of replications than required by the existing methods. For example, a balanced design, 5×2^2 in 12 plot blocks can be obtained in only 3 replications.

29. Approximately Optimum Stratification on the Auxiliaty Variable

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For the fixed total cost the problem of optimum determination of (*i*) the total number of strata to be constructed, (*ii*) allocation of the sample to different strata and (*iii*) the strata boundaries on the auxiliary variable scale, has been considered. It is assumed that the cost of observing the study variable y on a unit of size x is

$c(x)$ and the regression of y on x (the auxiliary variable) is of the form

$$y=\lambda(x)+e,$$

where e is the error term such that $E(e/x)=O$, and $V(e/x)=\phi(x)$ for all x in the range (a, b) of x with $(b-a) \leq \infty$. We also assume that the cost of constructing L strata is given by $\psi(L)$ with $\psi(1)=O$.

It is shown that optimum number of strata (L) to be constructed is the solution of the differential equation

$$YL^3\,\psi'(L)+\beta L\psi'(L)-4\beta(C-C_o-\psi(L))=O,$$

where

$$Y=\int_a^b \sqrt{\phi(x)\,c(x)}\,f(x)\,dx,\quad \beta=\left[\int_a^b \sqrt[3]{p(x)}\,dx\right]^3\Big/96,$$

C=total cost, C_o=Overhead cost and $p(x)=f(x)\,g(x)$ where $f(x)$ is marginal density of x and

$$g(x)=\left[\frac{\phi^2C'^2+C^2\phi'^2+4C^2\phi\lambda'^2-2\phi C\phi'C'}{(\phi c)^{3/2}}\right]x$$

For a given L, a new sum $\sqrt[3]{p(x)}$ rule has been obtained which gives approximately, optimum strata boundaries (AOSB) on the scale of x. According to this rule the AOSB$[x_h]$ are the solution of the equation.

$$\int_{x_{h-1}}^{x_h} \sqrt[3]{p(x)}\,dx = \int_{x_h}^{x_{h+1}} \sqrt[3]{p(x)}\,dx,\quad h=1, 2,\ldots, L-1$$

Various ways of determining the optimum allocation of the sample of different strata have been discussed. The paper concludes with a numerical example which illustrates the manner in which the theory developed in the paper can be used in practice.

30. A Study of Rotation Sampling

I.C. Sethi and D. Singh, I.A.R.S., New Delhi.

There are many studies, notably in agricultural, sociological and economic research which are concerned with estimating characteristics of a population on 'repeated occasions' in order to measure

their trends over-time. This type of studies are not only useful for estimating the present status of any economy but are also useful for estimating the change in the economy under consideration.

Usually in this type of study we draw sample on successive occations with some of the units common between any two occasions while the rest different from occasion to occasion. As a result of this burden on some of the respondents increases which results in reducing their co-operation to the enumerators. To reduce this defect, in the present investigation a rotation scheme has been developed to select sample on 'successive occasions' for multi-stage sampling designs. For this, three different type of sampling plans are developed to estimate one or more characters at the same time. Using these sampling designs an attempt has been made to obtain the minimum variance linear unbiased estimates of :

1. the population mean vector of characters at the most recent occasion ;
2. the change in the population mean vector of characters from one occasion to another ;
3. an overall estimate of the population mean vector of characters over all occasions, for dynamic population, and
4. the modified population mean vector of characters at past occasions using knowledge of estimates of population mean vector of characters for following occasions, for two stage sampling design.

31. FOUR AND SIX LEVEL SECOND ORDER ROTATABLE DESIGNS

A.K. Nigam, B.H.U., Varanasi and A. Dey, I.A.R.S., New Delhi.

Rotatable designs were introduced by Box and Hunter (1957). Subsequently, various methods were evolved by different research workers to construct these designs. In literature, no second order rotatable design exists which has four levels for each of the factors, though situations exist in practice where four-level designs are required. In the present paper, a method of construction of 4-level second order rotatable designs has been given. A method of con-

structing second order rotatable designs with factors each at 6 levels is also given.

32. On Plans for Fractional Asymmetrical Factorials with Blocking

Basant Lal, I.A.R.S., New Delhi.

Several methods for the construction and analysis of asymmetrical factorial designs have been discussed in literature, [Kishen and Srivastava (1959), Das and Rao (1967) etc.,] but not with any suitable fractions of the designs taken.

An attempt has been made to find out a method of obtaining fractions of asymmerical factorials of the type $3^m \times 2^n$. The fraction size is always of the form 2^k with block size 2^p. The fractions are obtained from the symmetrical design and then converted to the asymmetrical design. The plans are self explanatory and can be used as such. This technique has been extended also to cover qualitative-cum-quantitative experiments, both fractional and complete.

33. On Some Ratio and Product Type Estimators

P.C. Gupta, Rajasthan University, Jaipur,

Some ratio and product type estimators for estimating the mean $\overline{Y}_N$ of a finite population have been considered, where the valus of $\rho(C_y/C_x)$ can be guessed in advance. The estimate considered is

$$\overline{Y}_{R^*} = \phi \frac{\bar{y}_n \overline{X}N}{\bar{x}_n} + (1-\phi)(\overline{X}_N/\bar{x}_n)^2\bar{y}_n$$

where ϕ is obtained by minimising the variance of $\overline{Y}_{R^*}$ and opt ϕ comes out to be $2-\rho\, C_y/C_x$.

For the exact value of $\rho\, C_y/C_x$, the estimator has a smaller large sample variance as compared to conventional ratio estimate but concoides with that of linear regression estimate.

Further it has been observed that if we consider another estimator

$$\overline{Y}^{**}{}_R = a_1\bar{y}_n(\overline{X}_N/\bar{x}_n\} + a_2\,\bar{y}_n(\overline{X}_N/\bar{x}_n)^2 + a_3\bar{y}_n(\overline{X}_N/\bar{x}_n)^3$$

where $a_1+a_2+a_3=1$, no optimum unique solution of a_i's exist and any optimum solution (say $a_2=a_3$) will result in the same form of the variance as discussed above. Thereby, indicating that we cannot improve the variance of such type of estimators beyond that of linear regression estimator.

A similar treatment fof the product type estimator has been given and it has been observed that optimum variance of $\overline{Y^*}_p$, which is given by

$$\overline{Y^*}_p = \phi\bar{y}_n(\bar{x}_n/\bar{X}_N)+(1-\phi)\bar{y}_n(\bar{x}_n/\bar{X}_N)$$

When exact value of $\rho C_y/C_x$ is known in advance concoides with that of linear regression estimate and cannot be improved beyond it, even we define another estimator $\overline{Y}^{**}p$,

$\overline{Y}^{**}_p=a_1\bar{y}_n(\bar{x}_n/\bar{X}_N)+a_2\bar{y}_n(\bar{x}_n/\bar{X}_N)^2+a_3\bar{y}_n(\bar{x}_n/\bar{X}_N)^3$; $a_1+a_2+a_3=1$ with the same reasoning as discussed above.

34. On alternative methods of blocking for the full diallel crosses

K.N. Ponnuswamy and M.N. Das, I.A.R.S., New Delhi.

The set of all possible crosses between two groups of lines (individuals) as well as the set of all possible single crosses among a group of lines (individuals) is called a diallel cross. The diallel analysis helps, to understand the role of gene action, to know whether or not the population of lines will provide useful genetic material for hybrid breeding programmes and to choose the suitable lines for hybrid breeding.

Usually diallel crosses are tried in Randomised block designs or completely randomised designs. The World Collection of Genetic Material available helps the breeder to have large number of suitable lines for the diallel analysis. In such cases the number of diallel crosses becomes too large and hence the need for incomplete blocking. So far not much attention has been paid in this direction.

Recently Sivaram (1968) suggested a method of blocking for the full diallel crosses but in that the specific combining abilities (s.c.a.) of lines are confounded with block effects. So in this paper an attempt has been made to provide alternative methods of block-

ing which provide the estimates of general combining ability (g.c.a.) and s.c.a. of lines. Designs are provided for all the four possible cases of the diallel crosses.

35. A Method of Reduction of Bias in Ratio Estimates

V. Ramachandran, I.I.M., Ahmedabad.

The bias of estimates like $\hat{R}$, $\hat{Y}$ may be expanded in a Taylor series of the form

$$E(\hat{R}) = R + b_1/n + b_2/n^2 + \ldots\ldots$$

Let the sample be divided into g groups each of size m, where $n = gm$. Let Rj be the ordinary ratio $\Sigma y/\Sigma x$ computed from the sample of jth group. Quinouille (1956) has produced a method of adjustment which reduces the bias of the estimates from order $1/n$ to order $1/n^2$. The utility of this method for ratio estimates was pointed out by Durbin (1959) and J.N.K. Rao (1965). The present study investigates the advantages of one choice of g over the other.

36. Augmentation of levels of Second Order Rotatable Designs (SORD)

T.K. Gupta, I.A.R.S., New Delhi.

There are various fields where response surface designs can be utilised. In the field of certain social sciences, study of response surface has a wide applicability. However, in many studies in social sciences, response surface methods require wider ranges for the factors as such more number of levels for each of the factor of the design are preferred.

In this paper some modification in the construction of SORD obtained from balanced incomplete block (BIB) designs have been suggested, which results in giving increasing number of levels of the factors with minimum increase in design points. In particular, if to a

SORD obtained from BIB designs when $(r \neq 3\lambda)2v$ new design points are added, v being number of factors, then we can get designs with 7 levels for each factor and adjusting the levels suitably, the design will maintain the property of rotatability.

37. Optimum allocation of units in a three-stage sampling design and application

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Estimate of the optimum number of first, second and third stage sampling units are given for a three stage sampling design used in evaluating the effectiveness of school lunch programme being carried out by the state of Orissa. When the objective of a study is not necessarily that of estimating population mean or total, the feasibility of a cost minimisation problem, often encountered in a sample survey, is discussed.

38. Bias in Estimating Variance of Successive Sampling Estimator

Randhir Singh, I.A.R.S., New Delhi

When a survey is repeated at some regular intervals of time to obtain current estimates, the use of ancillary information obtained on some previous occasion is desirable to increase the efficiency.

The improved estimate of population mean on 2nd occasion is unbiased if β (the regression coefficients of Y on X *i.e.*, second occassion observations on 1st occasion observaions) is known. But in practice β is estimated from the common units in the sample and the estimate of mean is still unbiased if x and y follow a bivariate normal distribution.

But the estimate of variance of the mean estimator is not unbiased. In the present investigation an expression for relative bias in estimating variance has been worked out which is given by

$$\text{Rel. bias} = [pq/(1-p^2q)]\left[p^2 - \frac{(1-p^2)^{(n+1)/2}}{n\pi} (1-p^2q^2) \frac{\sqrt{(n-2)/2}}{\sqrt{n^2}} \right.$$

$$\left. \Sigma\, 2^{n+r\ 3} p^r \frac{/(n+r-k)/2\sqrt{(r+3)/2}}{\sqrt{r+1}} \right]$$

39. ANALYSIS OF SPLIT PLOT DESIGN WITH ERRORS CORRELATED AND VARIANCES HETEROGENEOUS

M.G. Mittal & S.K. Raheja I.A.R.S., New Delhi-12

In long term experiments conducted at the same site, the tests of significance based on the usual analysis of variance are not applicable since experimental errors from year to year are correlated and may also have heterogeneous variances. The problem was considered for a randomised block design by earlier workers like Graybill, Scheffe, Siotani and J. Robinson and L N. Balaam, and appropriate tests of significance were obtained.

In this note, tests of significance have been developed for split experiments repeated over years at the same site.

40. GRADING OF STATES ON THE BASIS OF INDICATORS OF ECONOMIC DEVELOPMENT

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In this paper, an attempt has been made first to group the Indian States according to the levels of economic development and then to fix some priority in the matter of sanctioning special Central assistance so as to reduce the prevailing economic imbalance between the States. Forming 3×3 classification of (*i*) density of population and average index of per capita state income, (*ii*) density of population and percentage of non-agricultural income and (*iii*) density of population and average per capita electricity consumption on the assumption that the first five States as having high ranks, the next five medium rank and the last five as having low ranks, it is observed that according to all the three different arrangements, Tamil Nadu and West Bengal even with low density.