ABSTRACTS OF PAPERS PRESENTED AT THE 23RD ANNUAL GENERAL MEETING HELD AT BOMBAY IN DECEMBER, 1969

1. *Conditional and Unconditional Test Procedures* by V.M. Joshi, Bombay.

In a recent paper on the above subject Durbin, (1969, p. 663) who favours the conditional analysis, has observed that 'it is surprising that no satisfactory objective criterion appears to have been put forward, which indicates an advantage in favour of the condition analysis'. In this paper an argument is given why such an objective criterion may be unlikely.

The argument is based on showing that when a given test procedure is applied repeatedly to the same population for which the null hypothesis is true (false) the actual number of times for which the type I (type II) error occurs is a random variable which has exactly the same distribution for the conditional and unconditional test procedures. It is, therefore, suggested that the reasons for pre-ferring the conditional analysis have to be sought in the application of the test procedures to an individual case.

2. *On use of more than one auxiliary characters—some new estimates* by P.C. Gupta. Rajasthan University, Jaipur.

If there are more than one auxiliary character highly correlated to character under study, they can be used to improve the efficiency of the estimates of population mean or total. Sometimes when the detailed information on a cheaper character is available but on the other auxiliary character is not available the usual procedure of Ratio or Product method of estimation has been adopted to estimate the population mean of the other auxiliary character. Further this has been used to build the new estimates. The expression for bias and variance of these estimates has been obtained for sub-samples and independent sample separately. Two linear cost functions have been used and conditions have been obtained for the proposed estimate to be better than usual ones.

3. *On Construction of change-over designs balanced for first residual effects* by G.M. Saha and M.N. Das, I.A.R.S., New Delhi.

Patterson (1952) has constructed balanced change-over designs in incomplete sequences through the method of symmetrically repeated differences. (By an incomplete sequence we mean one in which the number of periods is less than the number of treatments in the experiment). He has described his methods of construction separately under different numbers of periods. But, through the approach of Kulshreshtha and Das's (1969) recent method of constructing bib designs with more than one initial block, it has been possible to evolve a general method of constructing these balanced designs which unifies the methods of construction of Patterson (1952). Certain new designs have also been obtained through this general method.

Patterson (1952) has also given difference sets for constructing balanced designs for odd prime number v treatments of the form $4n+3$ (n, any positive integer) in $\frac{1}{2}(v+1)$ periods. Difference sets for odd prime number v of treatments of the form $4n+1$ in $\frac{1}{2}(v+1)$ have also been found out in the present investigation.

4. *A Method of obtaining Treatment Combinations for Nine Components of Second Order Interaction of 4^3 Factorial Experiment* by A.G. Sule, Poona.

Efforts have been made in this paper to demonstrate the method for obtaining the treatment combinations for nine components of the second-order interaction, NPK, NPK^2, NPK^3, NP^{2}K, NP^{2}K^2, NP^{2}K^3, NP^{3}K, NP^{3}K^2, and NP^{3}K^3 for a 4^3 factorial experiment with the help of the sets provided by Nair, K.R. (1938) or Kishen, K. (1942) for getting confounded arrangements. It has also been shown that extension of the Rule of Sarrus is not possible for obtaining the I and J components, as in the case of a 3^3 factorial experiment.

5. *"On orthogonal main effect plans for asymmetrical and symmetrical factorials"* by T.K. Gupta and M.N. Das, I.A.R.S., New Delhi.

Since the introduction of fractional replication by Finney (1945) several authors have put forward plans and analysis for both symmetrical and asymmetrical factorials. Main effect plans form an important class of fractional factorials. Several methods of obtaining

main effect plans for symmetrical factorials are available. But not much work seems to have been done on main effect plans for asymmetrical factorials.

This paper suggests a unified method for constructing orthogonal main effect plans for both symmetrical and asymmetrical factorials. Several plans with lesser number of combinations as compared to the existing plans have been obtained.

6. *"Estimation of Evapotranspiration from Meteorological Parameters"* by B. Padmanabhamurthy and S K. Dasgupta, Meteorological Office, Poona.

Evapotranspiration from a wheat cop was estimated from air temperature, wind speed, sunshine duration and relative humidity. The equation developed for the climatic conditions obtained at Poona is of the form :

$$Y = 2.276 + 0.371\ X_1 + 0.343\ X_2 + 0.014\ X^2_2$$
$$-0.771 \cos \frac{\pi\ X_3}{18} - 0.725 \cos \frac{\pi\ X_4}{11}$$

where Y = Cumulative five-day mean of evapotranspiration in tenths of mms.

X_1 = Cumulative five day mean of daily mean air temperature in tenths of °C.

X_2 = Cumulative five day mean of wind speed in tenths of kmph.

X_3 = Cumulatvie five day mean of daily bright sunshine expressed in tenths of hours, and

X_4 = Cumulative five-day mean of mean daily relative humidity expressed in units of tens.

Evapotranspiration estimated by this equation and tested for two years (1954-55 and 1957-58) from a wheat crop showed that within the limits of accuracy of observations the estimated values are closely related to observed values.

7. *"An almost unbiased regression estimate"* by G.K. Mishro, Bureau of Statistics and Economics, Cuttack.

The bias in regression estimate, which is of the order of $1/n$, may not be negligible, when the sample size n is small. As a result

of this, use of regression method of estimation may not be useful. Therefore, attempt has been made here to reduce the bias in the estimate by suitable modification of the estimation procedure. The bias in the estimate has been estimated and the same has been used as a correction to make the usual regression estimate almost unbiased. An unbiased estimate of the variance of the corrected estimate has been found out in a very simple form which is not possible in case of the usual regression estimate.

8. *The analysis of group of similar experiments involving several factors* by B.N. Tyagi, O.P. Kathuria and P.P. Rao, I.A.R.S., New Delhi.

In combining the results of similar experiments involving two or more factors under treatments there are several problems involved. Some of the interactions of main effects and treatment interactions with years may be present and some of them may be absent. Further, among the interactions that are present all of them may not be homogeneous. This makes the testing of treatment effects difficult.

The methods of combining results of such experiments have been discussed particularly when the results of individual experiments are available in the form of two-way tables of means and tables of mean and differential responses.

9. *"Blocking Mixture Designs"* by A.K. Nigam, B.H.U., Varanasi.

In the present paper we have derived the conditions required for blocking for estimating the parameters of a quadratic model in mixture variables have been derived. Mixture designs which satisfy these blocking conditions and hence are amenable to blocking have also been constructed.

10. *"Comparisons of estimates intra-stage sampling on successive occasions"* by O.P. Kathuria and D. Singh, I.A.R.S., New Delhi.

Using a two-stage sampling design, Singh and Kathuria (1969) obtained minimum-variance unbiased estimators under two different sampling patterns, namely (I) when a fraction p of the primary sampling units (psu's) with their samples of second stage units (ssu's) are retained from previous occasion to the current occasion and a fraction q of the psu's are selected afresh $(q+p=1)$, and (II) when

all the psu's in the sample on the previous occasion are retained on the current occasion but only a fraction p of the sample of ssu's within each psu is retained and a fraction q of the ssu's is selected afresh.

In repeat surveys one is often interested not only in obtaining estimate of the character for the most recent occasion but also in studying the change in the character from previous occasion to the current occasion. It has been found that if the objective is to obtain an estimate of mean on the current occasion then sampling pattern I is generally better than pattern II (if $S_b{}^2 \geqslant S_w{}^2$ and $\rho_b \neq 0$) and if the objective is to obtain an estimate of change then sampling pattern II is to be preferred if $\rho_b \geqslant 0$ whatever be the values of $S^2{}_b$ and $S^2{}_w$.

11. *Ranking in Fractional Triad Comparisons* by S.C. Rai, I.A.R.I., New Delhi.

The analysis of experiments involving ranking in triple comparisons has been developed by Pendergrass and Bradely (1960). In the present paper the author has investigated this model and extended it to the case of fractional triad comparisons. If there are t treatments and the members of all the triplets where a particular treatment (say T_1) appears are ranked in order of acceptability, then there will be $\dfrac{(t-1)(t-2)}{2}$ such triplets which will be included in the study. It is assumed that treatments $T_1, \ldots, T_t$ have true ratings $\pi_1, \ldots \pi_t$ on a particular subjective continuum which satisfies the following conditions.

$$\pi_i \geqslant 0 \text{ and } \sum_{i=1}^{t} \pi_i = 1$$

In the comparisons of T_1, T_i and T_j $(i \neq j, i, j = 2, \ldots t)$ the model used is

$$P(T_1 > T_i > T_j) = \pi_1{}^2 \pi_i / \triangle 1ij$$

where $P(T_1 > T_i > T_j)$ represents the probability that the treatment T_1 is rated top, T_i central and T_j bottom in acceptability and

$$\triangle_{1ij} = \pi_i{}^2(\pi_1 + \pi_j) + \pi_i{}^2(\pi_1 + \pi_j) + \pi_j{}^2(\pi_1 + \pi_i)$$

A test procedure has been developed and the maximum likelihood estimates of $\pi_i \ldots \pi_t$ are obtained. The main results are discussed

for large values of n but the nature of sample distributions of the test statistic is also indicated. A test statistic is also suggested to test the appropriateness of the model.

The method is also extended and applied when the fractional triad comparisons are made in groups of repetitions by different judges at different times or under different circumstances.

The paper concludes with a brief numerical example and discussion.

12. *Estimation Procedures in cashewnut Survey* by S. B. Aggarwal and S.S. Pillai, I.A.R.S., New Delhi.

In this paper efficiency of separate and combined ratio estimates based on a single auxiliary variate as well as the one using multiple auxiliary variates has been studied for estimating the total number of cashewnut trees in a survey in which stratified sampling design with unequal probability and with replacement has been used. The gain in efficiency due to pps over simple random sampling, due to stratification over unstratified pps sampling as also the sample size required for estimating the total number of trees with a standard error of 5% have also been worked out.

13. "*On Regression method of analysis of IBD with quantitative treatments*" by Satya Paul and M.N. Das, I.A.R.S., New Delhi.

Usually incomplete block designs involve treatments which are qualitative in nature like varieties of crops but such designs are also used with quantitative treatments. In Bio-assay the responses obtained from the doses usually have linear relation with the doses. In such situation, for estimating the dose effect precisely, randomised block designs may be used for eliminating the block variation when the subjects are available in the form of blocks. Estimation of dose effects is done from the average or through method appropriate for incomplete block designs.

In the present study an alternative method of estimation of treatment effects after eliminating block effects has been given when the treatments are quantitative and bear a relation with the response. The method consists of first fitting the relation between dose and response using two-way non-orthogonal data in general with treatment and block classification and then estimating the effect of treatments (doses) through interpolation with the help of the relation,

14. *An alternative method of Systematic Sampling* by D. Singh, Padam Singh and C. Asok, I.A.R.S., New Delhi.

Systematic sampling has got a nice feature of selecting the whole sample with one random start. There are some disadvantages of systematic sampling *viz.* no valid estimate of sampling error can be obtained from sample itself. In the present investigation an alternative systematic sampling is suggested and which is named as modified systematic sampling. Modified systematic sampling is superior to the usual systematic sampling in the sense that it besides providing unbiased estimate of population mean, suggests procedures for calculating unbiased estimate of the sampling variance from the sample itself.

Modified systematic sampling is extended to multistage designs. Use of auxiliary variates is also made to improve the estimate in case of modified systematic sampling.

Relative efficiency of modified systematic sampling is discussed for the populations with linear and exponential correlogram and it is observed that modified systematic sampling is generally more efficient than simple random sampling and sometimes it may prove better than usual systematic sampling. In the end some numerical examples are taken to illustrate the efficiency of modified systematic sampling.

15. *Provenance Trials on Eucalyptus Camaldulensis in Western Rajasthan* by R.K. Bohra, R.N. Kaul, and M.N. Das, I.A.R.S., New Delhi.

In the process of taming the desert, some fast growing and better surviving tree species are needed. Thus, to study the survival and growth for some exotic tree species in the extreme desert conditions, provenance trials are being conducted at Central Arid Zone Research Institute, Jodhpur on the seeds of *Eucalyptus Camaldulensis* collected from different regions in Australia. The emphasis is on simple provenance tests with the sole purpose of determining the most suitable seed source for large scale planting projects.

A study on percentage survival has revealed that seeds collected from those regions in Australia having similar climatic conditions and soil types to that of Western Rajasthan have better survived. The findings on growth attributes like plant height and

collar diameter of survived trees, subjected to analysis of data in two-way classification with disproportionate cell frequencies by the method given by Das (1953), have also resulted in similar conclusions. Thus, it appears that provenances from dry inland areas where the water courses are dry during the greater part of the year will prove the most drought resistant in the arid conditions.

In the present investigation an attempt has been made to obtain suitable components of adjusted varietal sum of squares. Efforts have also been made to divide the thirty-three provenances into groups and then test for the group to group variation.

16. *Influence of some weather factors on the yield of rice* by Arun K. Ghosh & S.V.S. Prakasha Rao, Central Rice Research Institute, Cuttack.

A relationship between some weather factors and the yield of rice was investigated. The weather factors considered were maximum and minimum temperature, relative humidity, rainfall and its distribution, bright sunshine hours and evaporation. The yields obtained from control plots of a long term compost ammonium sulphate carried over for 17 years at this Institute were utilized for the study. The growth period of the crop were split up into three phases *viz.*, active tillering and vegitative lag phase, reproduction phase and the ripening phase. The influence of the weather factors on the yield of rice crop were discussed through results obtained from this study.

17. *Incomplete Block Bio-assay Designs for Multiple Symmetrical Parallel Line Assays* by A. C. Kulshreshtha, Institute of Advanced Studies, Meerut University, Meerut.

When several test-preparations are to be assayed against the same standard preparation then it is well known that adoption of multiple assays is more economical. The usual incomplete block designs, which are available in literature, are not optimum for bio-assays.

In the present investigation we have obtained two series of incomplete block designs for multiple symmetrical parallel line assays with c test-preparations, where $c=2^e-1$ and e is a positive integer. These two series are based on BIB and circular (Das, 1960)

designs respectively. The proposed incomplete block bio-assay designs estimate all the c 'preparation-contrasts' and the 'combined slope' contrast with full information. Since these are the only contrasts used in the estimation of relative potencies, the proposed designs are optimum.

Further it is attempted to define the various dose-contrasts in such a way that not only the contrasts but their estimates too are orthogonal. This has been done using the orthogonal contrasts of a 2^n-factorial.

18. *On some Chemical Balance Weighing Designs* by Lalit Kishore, Rockefeller Foundation, New Delhi and A. Dey I A.R.S., New Delhi.

It is well known that when it is required to find out weights of several light objects, it is possible to increase the precision of estimation by weighing the objects in suitable combinations. The problem of weighing designs is to choose such combinations suitably such that the variance of the estimated weights is minimum possible.

In the present paper, methods of construction of weighing designs for a chemical balance problem are studied, using the incidence matrices of balanced incomplete block designs and balanced ternary designs. It is shown that under certain restrictions, it is possible to obtain 'optimum' weighing designs.

19. *"Incomplete Block Designs and Triallel Crosses"* by K. N. Ponnuswamy and M. N. Das, I.A.R.S., New Delhi.

In hybrid breeding programmes various types of crosses such as single, three-way and double crosses are used. The term three-way crosses, three-way hybrid or triallel crosses symbolized by (AB) C refers to the cross of a line c with an unrelated F_1 hybrid (AB). Thus if we have v lines we will have $3(V_3)$ different crosses in a Full triallel.

The structure and analysis of the three-way hybrids have been given by Rawlings J.O. and C.C. Cockerham (1962). As the number of lines increases the number of triallel crosses becomes too large to manage within the resources of the breeder. Recently a method of sampling the triallel *i.e.* partial triallel crosses (p.t.c.) was given by Hinkelmann (1965).

The p.t.c. is a set of crosses where in each line occurs exactly in rf crosses as parent and rt crosses as half parent and each crosses (ij) k occurs either once or not at all.

Through the present investigation a simple method of obtaining plans for p t.c. by using incomplete block designs with $k \geqslant 3$, has been obtained.

Even a p.t.c. becomes too large, for the block to have an effective control over the experimental error, as the number of lines increases An attempt has been therefore made also to provide plans with smaller blocks for full as well as partial triallel crosses. Methods of analysis have been given for all these cases.

20. *"Analysis of two-letter truncated factorial experiment"* by A.K. Mishra and B.S. Gill, I.A.R.S., New Delhi.

Let there be m factors, $A_1, A_2 \ldots \ldots A_m$ at two levels each and n factors $B_1, B_2 \ldots \ldots B_n$ at three levels each. If

$$a_1^{x_1} a_2^{x_2} \cdots a_m^{x_m} b_1^{z_1} b_2^{z_2} \ldots \ldots b_n^{z_n}$$

where $x_i = 0, 1$ and $z_j = 0, 1, 2$ denotes any treatment combination, then a k-letter truncated factorial experiment is defined as an experiment with all such treatment combinations for which $\Sigma x_i + \Sigma z_j = k$. In the present paper a systematic procedure of obtaining the main effects and other interactions from 2-letter truncated experiments of 2^m, 3^n and $3^n \times 2^m$ factorial experiments has been considered.

21. *The use of transition probability matrices in studies on limits of response to selection* by P. Narain, I.A.R.S, New Delhi.

Algebraic treatment of selection processes in finite population assume time as a continuous variable. Answers are then obtained in the form of solutions to differential equations. Narain and Robertson (1969 b), however, assumed generations as discrete and described selection in terms of transition probability matrices. General equations were presented for the chance of fixation or loss of a gene and for the mean and variance of time to fixation or loss. In particular, a detailed investigation was made with respect to populations involving single locus. In this paper, the results obtained by Narain (1969 a) for populations involving tri-allelic

loci are presented. Using computers to carry out matrix operations, it has been shown that the chance of fixation of a gene $\overline{A_1}$ at a tri-allelic locus $A_1 - A_2 - A_3$ depends on $N\overline{S}$ and N^2V_m where $\overline{S}$ is the average superiority of A_1 over A_2 and A_3 lumped together and V_m is the variance superiority *viz.* multiple allelic variance introduced by Narain (1965). The chance of fixation increases as $N\overline{S}$ increases in almost the same manner as in the case of two alleles at a locus. It, however, decreases as N^2V_m increases. The behaviours of mean time until fixation of A_1 as well as mean time until homozygosity have also been studied.

22. *On Estimation of Heritability in Non-random mating populations* by A.D. Godbole & M. Rajagopalan, I.A.R S., New Delhi.

Methods of estimating heritability widely cited in literature assume that the parents belong to the same random mating population. In practical situations, this assumption is not valid as the parents are often subjected to selection before use for propagation. Further in a random mating population, the scale of measurement of characters is so chosen that the phenotypic variation is partitioned into additive genotypic variation, dominance variation and environmental variation. It is shown that in non-random mating populations, an extra term due to covariance between additive effects and dominance deviations would also find a place in such a partition.

Assuming that the parents belong to two different non-random mating populations, expressions for estimates of heritability by the usual methods of :

(*i*) intra-sire regression of progeny on dams,

(*ii*) intra-class correlation between paternal half-sibs, and

(*iii*) partitioning of full-sib data by analysis of variance have been obtained.

It is shown that the first method provides a biased estimate of heritability in dams' generation and this bias can be removed by using covariances between dams and progeny, and between maternal half-sibs.

It is found that the two remaining methods do not provide estimates of heritability either in parental or progeny generations.

Therefore these two methods should not be used when the two parents are believed to be not belonging to the same random mating population.

23. *Analysis of fixed crop rotations in split plot* by K. N. Agarwal, I.A.R.S., New Delhi.

Analysis of crop rotation presents many novel features which are not involved in annual experiments. Yates (1954) discussed analysis of experiments containing different rotations. Agarwal (1968) extended his method and discussed the analysis when crop cycle is either incomplete or yields of intermediate years are not available. Patterson (1953) discussed the analysis of fixed crop rotation in randomised block. The objective of the present paper is to describe the analysis of fixed crop rotation when some fertilizer is applied in split plot.

The analysis of experiment of this type broadly consists (a) the analysis for the effects such as direct, residual and cumulative for each treatment as judged by analysis of the appropriate plot totals over the period, (b) the interaction of these effects with years as judged by the combined analysis of individual year data. Normally there are, therefore, two components of errors *viz.* (i) a part denoted as 'p' which is constant over year but varies from plot to plot with variance, σ_1^2 and (ii) a part denoted by 'y' which varies from year to year within plot with variance σ_4^2.

When the experiment is in split plot the treatment comparisons of interest are (a) comparison of treatments such as direct, residual and cumulative obtained from main plot averaged over years, (b) interaction of above comparison with years, (c) comparisons of sub-plot treatment and their interaction of sub-plot treatments with years.

The above comparison gives rise to four different errors as (i) main plot error, (ii) main plot X year error, (iii) sub-plot error and (iv) sub-plot X year error.

The analysis has been developed by assuming a random effect model as

$$z_{ijkl} = \mu + r_i + m_j + \delta_{ij} + y_k + (my)_{jk} + v_{ijk} + s_l$$
$$+ (ms)_{jl} + w_{ijl} + ys_{kl} + (mys)_{jkl} + \epsilon_{ijkl}$$

where z_{ijkl} is the yield from ith replicate with jth main plot, kth year and 1th sub-plot. μ is the general mean, δ_{ij}, v_{ijk}, w_{ij1}, ϵ_{ijkl} are the error components each distributed normally with 0 mean and variance σ_m, σ_{mv}, σ_{ms}, and σ_{sy} respectively.

The analysis has been illustrated by an example.

24. *Evaluation of cultivators' Family Labour in cost of cultivation of crops* by Bhagat Singh, I.A.R.S., New Delhi.

The basis of evaluation of cultivators' family labour has been a matter of controversy. The question is whether such labour should be evaluated on the basis of wage rate for permanent labour or that for casual labour. Unanimity of approach on this issue has been hard to find and the cost of human labour remains variable due to differences in approach to the evaluation of family labour. In the present study an attempt has been made to examine the relative importance and composition of human labour and also to estimate the differences in cost estimates due to the different bases of evaluation of cultivator's family labour. The cost data collected by the Institute of Agricultural Research Statistics in 1962-63 by cost accounting method for wheat and cotton (desi) from 320 holdings of Bhatinda, Ludhiana, Sangrur and Hissar districts of (then) Punjab were used for this study.

It has been observed that human labour, on an average, accounts for 35·2 and 51·5 per cent of the total operational cost of wheat and cotton respectively. The cultivator's family labour on the average accounts for 73·4% and 77·8% of the work performed by male labour for the two crops respectively. Female labour was found to have been employed on casual labour basis only.

The cost of human labour has been found to be lower when the family labour is evaluated at the wage rate of permanent labour as compared to with the wage rate of casual labour. The extent of decrease is of the order of 20·1% and 14·9% for wheat and cotton respectively. Such differences were of the order of 10 3 and 7.8 per cent in case of total operational cost. The differences were more pronounced for small size holdings *i.e.* below 15 acres, being 26·7% and 18.7% for human labour and 20·6% and 9·9% for total operational costs for wheat and cotton crops respectively.

25. *Estimation of the Incidence of Pests and Diseases in Paddy Crop* by B. K. Makin and M. G. Sardana, I.A.R.S., New Delhi.

During the last decade the Institute of Agricultural Research Statistics (ICAR) has conducted pilot sample surveys in Cuttack (1959-62), Thanjavur (1962-66) and West Godavari (1963-66) for evolving suitable sampling and measurement techniques for estimation of the incidence of pests and diseases in paddy crop and assessment of consequent of crop losses.   Different estimation procedures for the average incidence of pest or disease are discussed in this paper.   The results are illustrated with the help of the data kharif (1964-65) of West Godavari from the survey conducted in West Godavari district.

26. *"Double sampling for estimation of cost of cultivation of crops"* by G. Sadasivan, I.A.R.I., New Delhi.

There are two methods for estimation of cost of cultivation of crops.   They are the survey method and the cost accounting method.   Survey method is subject to response bias, but is definitely cheaper.   A combination of survey method with cost accounting method will definitely decrease the cost of the survey.   In this paper, a model combining the two methods is developed with a provision for elimination of bias of the survey method.   Alternative methods of estimation of cost per acre and cost per maund after accounting for the bias of the survey method are also discussed.

27. *"Application of multivariate symmetric means in unbiased estimation of population mean with several supplementary variables"* by V. Ramachandran and S. S. Pillai, I.A.R.S., New Delhi.

The problem of utilizing ratio type, product and ratio-cum-product estimators when one or more auxiliary variables are available has been dealt by several authors.   In the present study the question of developing unbiased ratio type, product type and ratio-cum-product type estimators has been taken up and approximate estimators along with their variances have been worked out. The following estimates, the variances of the estimates and estimates of these variances are obtained by using the concept of multivariate symmetric means.

      (*i*) Multivariate unbiased ratio type estimator of the population mean corresponding to Olkin's biased multivarate

ratio estimator using data on two or more supplementary variables ;

(ii) Multivariate unbiased product type estimator ;

(iii) Generalized multivariate unbiased estimate where p of the supplementary variables having +ve correlation and q of them having − ve correlation with the variable under study ; and

(iv) Unbiased ratio-cum-product type estimator ;

An empirical study has been made by using these estimators and results are included as illustration.

28. *Use of factorial designs for obtaining incomplete block designs with any number of varieties* by A.K. Banerjee and M.N. Das, I.A.R.S., New Delhi.

Given an incomplete block design with say v treatments a factorial design of the series 2^n is taken, n being so selected that $2^{n-1} < v \leqslant 2^n$. Next the confounded design is obtained by using suitable block size taking at least two replications. Then the treatment combinations are equated to the varietal numbers such that a group of combinations may be used to designate a single variety. The estimate of the varietal effects and analysis of variance have been obtained through the analysis of the 2^n design.

29. *A Survey of Sheep and Wool Production in the Districts of Ferozepur, Bhatinda, Sangrur and Patiala* by Sudarshan Kumar, Directorate of A.H., Punjab.

According to Livestock Census, 1966, there were about 4.43 Lakh of sheep in the State, out of which 80 per cent of the population are located in the districts of Ferozepur, Bhatinda, Sangrur and Patiala. In order to upgrade indigenous sheep in these Districts, an Intensive Sheep Development Project is being established during Fourth Plan period where an integrated programme of Sheep and Wool Development like Extension, Cross-Breeding, vaccination, etc. would be taken up. For the collection of basic information on sheep population, breed, age composition, level of wool production, management practices, mode of disposal of wool etc., a sheep survey was conducted in these Districts. The results are discussed in the paper.

30. *"On overall estimation in two-stage successive sampling."* by A.K. Srivastava and Shivtar Singh, I.A.R.S., New Delhi.

In sampling on successive occasion, apart from the population mean on the most recent occasion and the change occurring between two occasions, one may be interested in obtaining an overall estimate for the entire period. Sometimes, it may even be the most important object of the study. In this paper an overall estimate of the population mean alongwith its variance have been developed for two stage design utilising the entire information collected on all the occasions under the following cases :

(*i*) Retaining only a fraction p of the primary stage units (psu's) with their samples of ssu's and selecting a fresh fraction q of psu's $(p+q=1)$;

(*ii*) Retaining all the psu's from the preceding occasions but from each psu retaining only a fraction r of ssu's within them and selecting a fraction s of ssu's afresh.

The correlation pattern considered here for the same unit on different occasions is of a general type. The study is made for a fixed sample size with the same sample fraction retained over all the occasions.

31. *Factors influencing the economy of milk production* by Praduman Kumar and K.C. Raut, I.A.R.S., New Delhi.

Studies have been undertaken to know the extent to which various factors influence the economy in milk production. All the studies carried out in our country in this respect partain to only farm conditions. Results obtained in farm conditions may not be similar to those obtained in village management conditions. Attempts have been made to work out the effects of various factors influencing the economy of milk production in the case of Haryana cows maintained under village conditions utilising the data collected during a survey carried out by the Institute of Agricultural Research Statistics in Hissar district of Haryana State. The factors considered in the study include lactation length, dry period, lactation yield, maintenance cost, etc. The study would also indicate the effect of preceding dry period and lactation length on lactation yield. Attempts have also been made to indicate how economy in milk production can be obtained.

32. *"On successive sampling with multistage design"* by Shivtar Singh, I.A R.S., New Delhi.

The theory of successive sampling in one-stage design has been developed by Jesson (1942), Patterson (1950), Eckler (1955), Yates (1950), Tikkiwal (1953), etc. It has been further studied, for multistage design, by Kathuria (1959) Kathuria, and Singh (1969), Singh, D. (1968). In the present paper an attempt has been made to obtain the best linear unbiased estimate of the population mean on the most recent occasion and the change occurring between any two occasions utilizing all the information collected on previous occasions, for two-stage design under the following cases :

1. Partially replacing primary stage units (psu's) and keeping secondary stage units (ssu's) in retained psu's fixed.

2. Keeping psu's fixed and partially replacing ssu's.

Considering sample size to be fixed (n, say) a fixed sample-fraction (np) has been retained on all the occasions which is supplemented by a fresh sample (of size nq) on each occasion. The entire investigation has been done under a general correlation pattern. The results obtained by previous authors follow as particular cases under the above retention pattern.

33. *"An alternative approach for interpretation of data collected from groups of experiments,"* by S. Rawlo and M.N. Das, I.A.R.S., New Delhi.

The usual approach of interpretation of data collected from groups of experiments aims at finding out, if any treatment contrast remains the same or not within premissible error from environment to environment. It does not throw any light as to if any particular treatment has a tendency to behave uniformly or otherwise with changing environment. Keeping the latter objective in view, an alternative approach of interpretation of such data has been presented in the paper. The methodology discussed in the paper has been applied to the data collected from controlled experiments conducted in research stations and simple fertilizer trials conducted in cultivators' fields. From an interpretation of the results obtained from the analysis of these data, some treatments could be singled out as promising in specific region.

34. *"A method of estimating sheep population using auxiliary information"* by S.S. Gupta, I A.R.S., New Delhi.

The Institute of Agricultural Research Statistics has conducted sample surveys in different parts of the country for evolving a suitable sampling technique for estimation of sheep population and wool production. For the purpose of the survey in each stratum a sample of *n* villages was selected for counting of sheep in each of the two off-seasons. In each of the two shearing seasons a sub-sample of *n'* villages from these *n* villages were selected for estimation of wool yield. In these *n'* villages also sheep in each flock were counted before shearing. In this paper a method has been suggested for estimating the sheep population for a given occasion as also the average sheep population per season using the information on sheep population given in the preceding livestock census. An illustration of the method is given using the data for a district in the survey conducted in Andhra Pradesh during 1963-64.

35. *"Size of sampling units for estimation of number and production of eggs in poultry"* by I.C. Sethi, D. Singh and V.V.R. Murthy, I.A.R.S., New Delhi.

In pilot sample surveys on livestock products conducted in the past by Institute of Agricultural Research Statistics the units at the second and third stage were selected in clusters, a cluster containing three to five units. Although a sampling design using cluster sampling is known to be less efficient than a simple sub-sampling design, the former has a specific advantage over the latter, since the cost of the survey is usually less when cluster sampling is used.

A study has now been made to work out the relative efficiency of cluster sampling as compared to sub-sampling design for both the situations viz. :

(*i*) when the cost is not taken into consideration ;

(*ii*) when the cost is taken into consideration.

For this study three types of estimates viz. simple estimate, separate ratio and combined ratio estimate have been considered.

The study indicated that when cost was no consideration the variance of the estimate of the number of fowl layers or total egg production for cluster sampling was as expected higher than that

of design without cluster sampling. On the other hand when cost of both sampling designs has been taken into consideration *viz.* cost is fixed, the cluster sampling has been found to be more efficient. In this context optimum sample sizes at each stage of selection have also been worked out for the above fixed cost.

36. *Estimation of annual meat production through random-sample survey technique* by J.S. Maini and V.V.R. Murty, I.A.R S., New Delhi.

Meat (beef from cattle, buffalo flesh, mutton from sheep, goat flesh and pork from pigs), is produced on each day of the year mostly in recognized slaughter houses. It is known that a large number of animals are also slaughtered privately in butcher houses and households. As the current official estimates of annual meat production worked out by DMI were not based on any objective enquiries, Institute of Agricultural Research Statistics who had developed techniques earlier for estimation of milk, wool and eggs, had conducted a pilot survey in a part of Tamilnadu during 1966-67 for developing sampling methodology for estimation of meat production.

The approach made for estimating annual meat production was as follows :

The estimate of number of animals slaughtered in the area during the year consisted of two components viz. the official estimate of the number of animals slaughtered in the registered slaughter houses and the number slaughtered privately as estimated from the sample of villages, towns and households in the survey. The average meat production per animal was estimated from a sample of animals selected out of those slaughtered on the day of visit of the enumeration in a sample of registered slaughter houses. The meat production of an animal was recorded by actual weighment.

The study indicated that nearly 20 per cent of the animals slaughtered during the year were from butcher houses and households and these animals accounted for 30 per cent of the total annual production. Similarly sheep and goats accounted for 60 per cent of the total meat production. The total annual meat production was estimated as 19·4 thousand tonnes with a standard error of 4·3 per cent. Production of meat from pigs (pork) was not estimated as a very negligible number of pigs were reported to be slaughtered in registered slaughter houses or privately.

37. *"Restricted selection index on dairy cattle"* by M Gurnani, National Dairy Research Institute, Karnal.

Smith (1936) constructed an index for selection of plant lines using the concept of discriminant function given by Fisher (1936) to derive a linear function based on observable characteristics. Hazel (1943) presented the principles of constructing and using selection indexes for selection in animals which permit the attainment of maximum genetic progress. Hazel and Lush (1942) compared theoretically the efficiency of three methods of selection and found the total score method to be most efficient. Kempthorne and Nordskog (1959) extended the concept of constructing a selection index based on several traits but keeping the value of one or more traits, but not all, constant.

In the present study a number of restricted and unrestricted indices for selection of Tharparkar dairy cattle at the National Dairy Research Institute, Karnal were constructed taking different combinations of four characters viz . (*i*) first lactation production (X_1), (*ii*) second lactation production (X_2), (*iii*) age at first calving (X_3), and (*iv*) first calving intervals (X_4) as the basis of selection and improvement. The situations considered are : (*i*) when the genotype (G_i) of the *i* th trait is excluded from the total genotypic score (H), · (*ii*) the observations (X_i) on the *i*th trait are excluded from the index (I) as the basis of selection and (*iii*) when an *i*th character is desired to be kept constant at a predetermined optimum level.

The robustness of the selection indices with regard to variation in the relative economic values of the four traits upto 30 per cent was also studied.

38. *"On the Estimation of the population total in the presence of Non-Response"* by C. Asok, I.A R.S., New Delhi.

For estimating the population total under simple random sampling in the presence of non-response it has become customary to consider the population to have been consisting of two strata one being the 'response' stratum and the other one the 'non-response' stratum. Obviously this division of the population into two distinct strata is an over-simplification as chance plays a part in determining whether a unit is found and measured in a given number of attempts. So an attempt is made to estimate the population total unbiasedly together with its variance and non-response component assuming that

each unit of the population has a specified probability representing the chance that it would be measured by a given field method if it fell in the sample. Appropriate modifications have been suggested for working out these formulae when an estimate of probability of enumeration is available.

39. *Statistical Method in the Standardization of Food Products* by Dr. B.N. Singh, Indian Standards Institution, New Delhi.

This paper discusses as to how the statistical methods provide sound, statisfactory and economic solutions to a variety of problems encountered in the formulation and implementation of standards. In particular, it touches upon the specification of quality, prescription of test methods, formulation of sampling plans and sensory testing.

While formulating the Indian standard on honey, the collection and statistical analysis of data from four leading organizations in the country showed that honey as obtained from the honey bees was not as uniform in quality as was generally thought to be. The analysis also helped in arriving at suitable specification limits for the various characteristics of honey as laid down in IS : 4941-1968 Specification for honey.

In case of IS:561-1962 BHC Dusting Powders, statistically designed investigations showed that the precision of two methods, namely, total organic chlorine content and hydrolysable chlorine content for the determination of BHC content, was more or less the same and hence both have been prescribed in the aforesaid standard.

Again, in case of honey (IS: 4941-1968), condensed milk (IS: 1166-1957) and dry salted seer fish (IS: 5198-1969), the statistical analysis of the data helped in arriving at the suitable sampling plans for ascertaining their conformity to relevant specification requirements.

The paper also dwelt upon the sensory testing with particular reference to the work done by ISI. In case of IS: 3077-1965 Roasted and Ground Coffee, it was shown how the grading and quality evaluation of coffee can be done by tasting a cup of coffee, assigning scores to taste and odour on an objective basis and analysing the data arising therefrom. Similarly, in case of IS: 2868-1964 Canned Pineapples, a statistical criteria was given for judging the agreement among the judges with regard to the grading of the product.

40. *Optimum utilization of fertilizers based on responses potentiality* by V. G. Sharma and G. C. Shaligram, Department of Agriculture, Poona.

Maharashtra has been experiencing a deficit in food-grains since a long time because of its low crop yields due to two main factors viz. (1) lack of irrigation facilities, the area irrigated being hardly 7% of the cropped area, and (2) very low use of fertilizers by the farmers due to uncertainty of rainfall and its distribution. To meet this deficit efforts are being made to step up crop production through the following measures :

(*i*) Greater use of fertilizers.

(*ii*) Increasing the area under irrigation.

(*iii*) Adoption of intensive package of cultivation practices over large areas.

(*iv*) Cultivation of hybrid and high yielding varieties on large scale.

The use of fertilizers and cultivation of hybrid and high yielding varieties are found from past experience to be the only sure and quick methods of increasing the crop production. The farmers have also realised the importance of these two measures and are rapidly becoming fertilizer-minded and switching over to high yielding varieties. However, judicious distribution of fertilizers is very essential for achieving desired results with maximum efficiency. The present note deals with this problem for only cereals with a suggested plan of distribution based on the response potentiality of the crops and districts.

The crop responses to fertilizers have been assessed on the basis of fertilizer-cum-varietal trials conducted on cultivators' fields on a sound scientific basis since 1961-62, covering 52 crop districts and 4 major cereals viz. paddy, bajri, jowar and wheat. The results show that crop responses to application of N, P and K singly are additive and application of fertilizers to the crop with assured soil moisture are consistently higher in case of certain districts and crops. Economic responses have been computed for 41 crop districts in respect of N, 39 crop districts in respect of P and 45 crop districts for K. An attempt has been made to see how far a rational fertilizer distribution programme could help to increase the cereal production of the State and reduce the deficit.

Based on the increase in population and per capita consumption, it has been estimated that the cereal requirements in Maharashtra in 1974-75 will be about 76 lakh tonnes, after taking into consideration the seed requirements and wastage, etc. As against this, the present stabilised production stands at 56 lakh tonnes. Crop-wise deficit to be made up works out to 8·8, 7·5 and 4.2 lakh tonnes of rice, wheat and millets respectively.

This deficit could be met to the extent of 8·1 and 1·6 lakh tonnes for rice and wheat respectively by applying fertilizers to crops with recommended doses in the districts where economic responses have been observed. In case of millets fertilizing the crop on this basis will create a surplus of 12.5 lakh tonnes. The deficit in case of rice and wheat could be very much reduced by growing high yielding varieties. It is proposed to cover under hybrid and high yielding varieties about 4 lakh hectares in case of each of rice and wheat and 26 lakh hectares under jowar and bajri together. The additional production expected from the High Yielding Varieties Programme is 1·3 lakh tonnes of rice, 1·4 lakh tonnes for wheat and 12·5 lakh tonnes millets. This would, however, still leave a deficit of 2·5 lakh tonnes in rice and 4·5 lakh tonnes in wheat. The surplus in millets would increase to 25·4 lakh tonnes.

41. *The effect of Incomplete penetrance of a gene on the genetical consequences of Assortative mating* by K.M. Reddy and P. Narain I.A.R.S., New Delhi.

Mating individuals on the basis of similarity or dissimilarity between their phenotypes is known as assortative mating. Previous studies on the genetical consequences of such a system of mating were conducted by Fisher (1918), Wright (1921), Breese (1956) and Rao and Narain (1967). Some of these investigations revealed that the effect of assortative mating depends on the precision whereby potential parents may be assigned to particular genotypic intra or inter mating groups. Any factor influencing the expression of a genotype must therefore affect the consequences of such a system of mating, as for instance dominance or epistasis. It may also happen that a gene, which can be dominant or recessive does not produce its effect in combination with other genes or under certain environmental conditions. The gene is then said to have incomplete penetrance. A certain portion of individuals of a particular genotype cannot then be distinguished from the other genotypes. The genetical consequences of

assortative mating in such cases have therefore been investigated in this paper with respect to a single locus with two alleles.

With the help of computer it has been found that while with complete positive assortative mating the population ultimately becomes homozygous, with incomplete penetrance it maintains heterozygosity. The average inbreeding coefficient of individuals at equilibrium decreases as penetrance decreases, the decrease depending on the frequency of the gene. In the case of negative assortative mating the average inbreeding coefficient of individuals at equilibrium which is negative with complete penetrance, increases as penetrance decreases and is independent of gene frequency. In this case it is further found that the rate of approach to equilibrium with incomplete penetrance is more than with complete penetrance.

42. *Use of Ancillary Information in Collapsing Strata* by S. Mohanty and Padam Singh, I.A.R.S., New Delhi.

If the population is highly variable, we may have deep stratification such that only one unit is sampled from each stratum. In this case the usual formula for estimating $V(\bar{y}_{st})$ can not be used. Cochran (1963), suggested a method of collapsing strata in pairs such that the two strata to be collapsed should have (a) equal population mean (b) equal population size. As the assumptions of Cochran are too restrictive, Seth (1966) suggested an alternative estimate for estimating the variance.

In the present investigation a general method of collapsing any number of strata is suggested and the use of ancillary information is made in collapsing the strata. Some ancillary information is used to estimate the character under study more efficiently.

In the end an example is taken to illustrate the use of ancillary information in collapsing the strata and improving the estimate.

43. *Impact of high yielding varieties on agricultural production in India* by S.K. Raheja, C.R. Leelavathi & S.R. Bapat, I.A.R.S., New Delhi.

The performance of high yielding/exotic varieties of cereals particularly on rice and wheat crops was reviewed on the basis of results obtained from experiments at selected research centers and trials at cultivators' fields conducted under Co-ordinated Agronomic

.Experiments scheme as also from the various all India Co-ordinated Crop Improvement projects for the past few years. It was observed that in general, the high yielding varieties yielded more than the indigenous varieties at the basic fertility level. With the application of nitrogen, the response of high yielding varieties of rice and wheat was more marked at the higher levels of application. The variet'es showing consistently good performance were IR-8 in case of rice and Kalyan sona for wheat. In the case of maize, jowar and bajra, varieties showing better performance were Ganga 2, CSH-1 and HB-1 respectively, although the number of experiments on these crops was somewhat smaller compared to rice and wheat.

Good response of high yielding varieties to the application of the phosphorus was observed. at a number of places in cultivators' fields trials. There were indications of a higher response to phosphorous when it was applied in the presence of nitrogen in some of the regions. Application of potash also showed economic responses in some areas when it was applied over nitrogen and phosphorus.

A study of response curves and surfaces for nitrogen, phosphorous and potash based on the results of experiments on cultivators' fields was also made to work out the optimum combinations of different nutrients for the various regions in the country.

44. *Studies on the forecasting of yield of cotton and efficiency of different plot sizes.* by D.S. Ranga Rao, V.G. Sharma and S.G. Patki, Department of Agriculture, Poona.

An attempt at forecasting of cotton yield was done on the basis of the count of bolls (burst) and their weight at the time of picking. The observations were recorded in respect of random strips of 11 ft. length in each of 6 rounds in a random sub-sample of plots selected for the crop estimation surveys on cotton during the two years 1955-56 and 1956-57 in East Khandesh district of Maharashtra.

For this purpose, all the pickings of the selected plots in the sub-sample were supervised and a record maintained of (a) the number of bolls and (b) weight of 100 bolls at each picking.

The main indications emerging from the analysis are as follows:

(i) The ratio of the total number of bolls picked in the two seasons was in fair agreement with the ratio of the yield rates of the crop in the two seasons at the district level.

(*ii*) Irrespective of the time taken for the crop to attain maturity, the percentage average number of bolls bursting at each picking, the total number of bolls during the entire season remained practically the same under different field conditions.

(*iii*) The average weight of a boll at any one picking (on the basis of the weight recorded of 100 bolls at each picking) was fairly uniform under different field conditions.

(*iv*) High correlation was observed between the yield of the first two pickings to the total yield of all pickings. The study revealed that either the ratio estimation or regression method could be adopted for forecasting the total yield at a stage when the first two pickings are over and yield data thereof are available.

(*v*) During the course of the investigation the efficiency of different plot sizes was also undertaken.

45. *Use of Auxiliary Information in Successive Sampling* by J.A. Sastry and M. Rajagopalan, I.A.R.S., New Delhi.

In successive sampling, information on auxiliary characters highly correlated with the character under consideration could be used for :

increasing the efficiency of the estimate for current occasion. Expressions for the estimate and its variance are obtained for sampling on two occasions using a single ancillary variate. The efficiency of the estimate as compared to the one without using the auxiliary information and the optimum sampling fractions are also obtained.

46. *Genetical Structures of Populations as Discrete, Finite Stochastic Processes* by S. Shunmugasundaram and G. Sadasivan, I.A.R.S., New Delhi.

Propagation occurs in plant kingdom largely by self-fertilization and cross-fertilization under natural conditions. This is true of many crop plants. In the present study we have investigated about the possible genetical structures of populations under mixed breeding systems. The studies of Bennet and Binet (1956) and Ghai (1964) have been extended to the cases of multiple alleles, fertility and viability changes, variation in the proportions of crossing and selfing and also fertility and viability rates from generation to generation. The genotypic structures under such cases have been derived. We

have also attempted to represent these structures as finite, discrete Markov Processes. The concept of Markov Processes is applicable because the genotypic structures change with the genotype (state) as well as time (generation). In this attempt, we have also described Hardy-Weinberg Law by a Stochastic linear equation and the same has been extended to the case of mixtures of breeding systems with changing fertilities and viabilities and also changing proportions of each breeding system. Incidentally, we have described and also studied the properties of sib-mating by a Markov matrix. Finally, giving certain proportions of breeding systems and certain rates of fertility and viability, we have formed some tables of the genotypic frequencies of the respective types for the first, second, third and limit generations.

47. "*Choice of a Model for Projecting Installed Generating Plant Capacity of India*" by B.N. Sahu, Bihar State Electricity Board, Patna.

In this paper, an attempt has been made to study the rate of growth of installed generating plant capacity of India since the commencement of the Five Year Plan and then to forecast short term and long term achievements with the help of a suitable growth curve. Recognising the concave shape of the curve plotted to installed generating plant capacity data and also the reliability of fit for long term projection, the logistic curve of growth,

$$Y = \frac{K}{1 + be^{-at}} \qquad \qquad ...(i)$$

has, at first, been fitted to the data. But on estimation of b by

$$\log e^b = a (N-1)/2 + \frac{1}{2} \sum_{t=o}^{N-1} \log_e \left(\frac{K}{Y_i} - 1 \right) \qquad ...(ii)$$

it is noticed that the value of the expression $\left(\frac{K}{Y_i} - 1 \right)$ for the last three values of Y becomes negative. This confirms that installed generating plant capacity data of India are not amenable to logistic fit. Alternatively, the exponential curve of the form,

$$Y = ab^x \qquad \qquad ...(iii)$$

has been fitted to the data.

From equation (*iii*) the compound growth rate of installed generating plant capacity and its standard error work out to 11·82% and 0·36% respectively. It is also confirmed from the analysis of variance that 98·9% of the total variation in log Y is explained by the above equation which further assures the reliability of fit.

In view of the importance of reliable estimates of installed generating plant capacity in fixing the targets for successive Five Year Plans, an attempt has also been made to project the country's installed generating plant capacity at the beginning and the end of the Plan periods right upto the Sixth Five Year Plan on the basis of the exponential equation, and to compare the results with the estimates arrived at by the Central Electricity Authority.

Finally, the reliability of fitting an exponential curve of growth in this case has been compared by fitting (*i*) an exponential curve of growth to a combined series of 33 years of data (16 years of actual observations and 17 years of projected values) and (*ii*) a log polynomial (orthogonal) to 16 years of actual data, and relative merits of these models have also been discussed in this paper. It is observed that for fitting the growth curve to installed generating plant capacity data, a suitable degree of log polynomial equation is more advantageous than the exponential equation, but for future projections the choice should go in favour of the exponential equation.

48. *Results of the sample surveys conducted in Kolaba district (Maharashtra) during 1955-56 and 1961-62 for ascertaining the cultural and manurial practices,* by N P. Joshi Department of Agriculture, Poona.

With the emphasis on formulation of plans for increased production programme at the district level, the need for reliable information of land utilization, farm and cultural practices adopted by cultivators, the resources in agriculture, size of operational holding and form of tenancy etc. was considered as a pre-requisite. Accordingly the State Government launched a survey for collection of data, by sampling, on cultural and manurial practices of the State at the end of the Second Plan and continued the same during the third Plan period. The survey was repeated in some districts to study the changes in manurial practices.

Results obtained are summarised below : —

(i) Proportion of holdings decreased with the increase in size of holdings. Nearly 55% of the holdings were of size upto 2·5 acres and for about 75% of the holdings the size was upto 5 acres and below. These holdings covered only 28% area of the district. 36% of the area was accounted for by 6% to 7% holdings which were of size more than 15 acres. Average size of the holding was of the order of 4.72 acres in the 1st round and 4.99 in the second round.

(ii) In the first round of the survey, it was observed that nearly 53% were tenant cultivated while 37% were entirely owner cultivated and 10% were partly leased and partly owned. During the second round, the percentage of tenant cultivated holdings decreased by 10% to 43% while owner cultivated holdings increased by 6% to 42%. The partly owned and partly leased holdings increased by about 4%.

(iii) In the first round, about 86% of the total cropped area was accounted for by paddy, 9% by nagli, 4% by pulses and 1% by other hill millets. Area under paddy rose to about 90% in the second round while that of nagli and warai remained the same. Area under pulses declined to less than half percent in the next round. The extent of double cropping was very negligible, being less than 2%.

(iv) During the first round nearly 76 thousand acres or 14% of the cropped area was covered by manure, of which nearly 63,000 acres was under paddy. In the 2nd round, the estimated manured area rose to 91,000 acres or 16% of the total cropped area in the district. The area benefited by manure under paddy was 86,000 acres during that year. The break up of the manured area according to kind of manure used were also obtained. The proportion of manure according to size of holdings was classified.

(v) Consumption of F.Y.M. was estimated to be 1·82 lakh tons with a S.E, of 8·4% in the first round. It decreased to 1·06 lakh tons with a S.E. of 13·5%. The quantity of ammonium sulphate was estimated at 1,825 tons with a S.E. 12·2% while the quantity of superphosphate consumed during 1961-62 was estimated at 1,814 tons with a S.E of 10·7%.

49. *Comparative study of utilization of bullock power in hilly and plain areas*, by K.B. Singh and B.B.P.S. Goel I.A.R.S., New Delhi.

Bullocks which are likely to continue as a basic source of energy in agriculture in the country, suffer from serious under employment, in spite of their being put to variety of uses.   Some interesting results to this effect based on the data of the sample survey for estimation of milk production and study of bovine practices in Punjab (plain area) were published by the authors in July, 1969.   More recently studies were conducted on the data of a similar survey in Himachal Pradesh (hilly area) and the present paper gives the results of comparative study of utilization of bullock power in the two types of areas.   The study reveals that the under employment of bullocks in hilly areas is more serious than that in plain area.   While in plain area on the average 41 percent of the bullock days were utilized the corresponding estimate for the hilly areas was 68 percent.   In the plain area the average number of hours per day a bullock worked and the per capita output of work (in terms of hours per day) were estimated at 5.9 and 3.5 respectively where as in hilly areas the comparable figure were 5.0 and 1.6 respectively.   Assuming a conventional figure of 8 hours of work per day per bullock the idle capacity of bullock power in the hilly and plain areas has been estimated at 80 and 55 percent respectively.

For hilly areas the size of holding was also included in the study and an interesting finding is that as the holding size increases both the number of bullocks per acre as also the idle capacity, go down.

50.   *A study for the improvement of forecast estimates of area under cotton* by S.G. Patel, Department of Agriculture, Poona.

Cotton is the most important commercial crop in Maharashtra. Forecasting the area under the crop well in advance of the final estimates assumes considerable importance particularly as the crop sown in June-July is on the field till Janurary-February in major part of the cotton tract.   As the final forecast estimates are not become available till May, an attempt was made to obtain estimates of the actual area sown on the basis of area enumeration carried out by patwaris in the sample villages selected for the crop estimation survey on cotton.   For this, ratio method and regression method of estimation were used.   For the ratio method, the data collected during the four years 1952-53 to 1955-56 were used, it was observed that with the sample size adopted, it would be possible to estimate the area

under cotton at the district level with a standard error of 3 to 6 per cent. Using the regression method with the fourth forecast area under cotton as independent variable and the actual area under the crop as dependent variable 26 years data for the period 1926-27 to 1951-52 showed that it would be favourable to obtain more reliable and timely estimate of the actual area sown.

51. *Studies in the experimental variation of paddy crop in relation to Statistical and Non-Statistical factors* by G. C. Shaligram, Poona.

With a view to study the effects of various statistical and non-statistical factors on the statistical efficiency of the agronomic experiments, actual data of C.V.'s obtained from 108 experiments conducted on paddy on research stations during the period of last 10-15 years was studied. Six factors viz. (*i*) plot size, (*ii*) statistical design, (*iii*) error d.f. (*iv*) types of treatments, (*v*) soil-climate complex, and (*vi*) period-effects were studied in relation to their effect on the magnitude of C.V. Frequency distributions of the experiments in the two-way classification of range of C.V. and the groups of each factor were worked out. The results of the study showed that—

(*a*) The plot size could be reduced to about 200 sq. ft. without affecting the precision of the experiment. The smaller plot size, on the other hand, may increase the precision because of effecting homogeneity in soil fertility. It would also be advantageous from the practical convenience of reducing land availability and cost of cultivation.

(*b*) Adoption of better statistical designs like 'split plot' to bring in greater soil homogeneity for more precise comparison of treatment effects and providing greater d.f. for estimation of error were also found useful in increasing the statistical efficiency.

(*c*) A higher precision of experiments is expected in those types of experiments where treatments are more homogeneous and stable. Hence greater precision was observed in varietal experiments than in other types of experiments.

(*d*) Northern and southern regions of western ghats with assured rainfall and homogeneity of soils produced higher precision of experiments than the eastern region of Vidarbha with less homogeneity of soils and rainfall.

(e) Greater homogeneity of cultivation practices, types of treatments, uniformity of cropping, selection of uniform sites are helpful in increasing the precision of the experiments. Recent periods, being influenced by large variations of cultivation practices, types of widely varying treatments, conducting experiments on same site year after year, have shown lesser statistical efficiency. Hence greater care in creating homogeneous conditions is necessary to achieve higher statistical efficiency.