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INSTITUTE OF AGRICULTURAL RESEARCH STATISTICS

(I. C. A. R.)

ANNUAL REPORT

1969

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1.

INTRODUCTION

The Institute of Agricultural Research Statistics is the premier institute for research and training in agricultural and animal husbandry statistics in the country. It deals with research methodology for the improvement of techniques in agricultural and animal experimentation and sampling investigations. It also carries out research projects to demonstrate the feasibility of the techniques and to develop the methodology for evaluating the progress and impact of important development programmes. It provides advisory service and training in agricultural statistics, both to agricultural and animal husbandry research workers and professional statisticians.

The Institute of Agricultural Research Statistics has achieved international recognition due to high quality of research work and training. This can be judged from the fact that several research workers from this Institute have served as consultants and advisers in several Asian, African and Latin American countries. Several statisticians and trainees of this Institute are currently occupying high positions in the Universities and other research institutions of U. S. A., Canada etc.

The Institute made a modest beginning in 1930 as a statistical section of the Indian Council of Agricultural Research with one statistician and a limited staff. The principal function of the statistician was to assist agricultural officers in various states in planning experiments and in analysing data and interpreting the results. He was also responsible for scrutiny of the technical programmes and progress reports of research schemes of the Council. The activities of the statistical section entered a new phase towards the end of 1943 when, at the instance of the Government of India research was initiated for developing objective and reliable methods of collecting yield statistics of principal food crops. This led to the development of the crop cutting survey technique which has since been adopted by almost all the states in the country for estimating agricultural production. In the course of this work the statistical section had to undertake research in sampling theory and to train a large number of statisticians and field staff running into thousands. With

the increasing activities the 'Statistical Wing', as it came to be called, was reorganized into two units dealing with statistical applications to agricultural research and animal husbandry research. The organization was headed by the Statistical Adviser to the Council.

In 1945 the Council instituted regular post-graduate training courses both for Professional Statisticians wishing to specialize in agricultural statistics and for agricultural and animal husbandry research workers, desirous of acquiring knowledge of simple statistical methods required most often in their work. Although teaching and research was integrated, a small training unit consisting of whole time Professors, Assistant Professors and Demonstrators was constituted to be specially responsible for organising the various courses. The Institute soon acquired international recognition as a training and research institute in the field of agricultural statistics and was responsible for training foreign students and organizing seminars for the Food and Agricultural Organisation of the United Nations.

Valuable contributions have been made by the 'Statistical Wing', to the problem of improvement of crop acreage and production statistics. Sampling techniques were developed for securing objective and reliable estimates of marine fish catch and of livestock numbers. By the end of 1952 the crop cutting surveys for the estimation of principal food crops were extended to practically the whole country. In January, 1953, according to the decision of the Government of India the work of the large scale sample surveys on food crops and a few other surveys was transferred from the I. C. A. R. to the Directorate of National Sample Survey in the Ministry of Finance.

In 1952 two F. A. O. experts, Dr. Frank Yates, Chief Statistician, Rothamstead Experimental Station and Dr. D. J. Finney of Oxford University, were assigned to the Government of India to review the research and training activities of the 'Statistical Wing' and to advise them on its development. On their advice the activities of the 'Statistical Wing.' were expanded in many directions.

The organization moved into its present campus in August 1955. The campus provides facilities of a library, class-rooms and an auditorium besides office space for its technical and ministerial staff. A hostel with usual amenities and a playground are also provided for the trainees. In view of its role as a training and research organization the 'Statistical Wing', was designated as the 'Institute of Agricultural Research Statistics', in 1959. The mechanical data processing unit was also added to the Institute at about this time. This has been recently expanded with the addition of an I. B. M. 1620 electronic computer and other related equipment. These developments have enabled the Institute to discharge its functions more efficiently.

1.1 *Organizational structure of the Institute.*

Pending completion of the reorganization of the I.C.A.R. the Institute was not organised into appropriate divisions and sections. The Institute was headed by the Statistical Adviser till July, 1969 and thereafter by the Director. The head of the Institute was assisted by two Deputy Statistical Advisers*, one Senior Professor, 13 Senior Statisticians* and Professors, 24 Statisticians* and Assistant Professors, 27 Statistical Investigators, 64 Statistical Assistants and 57 Senior Computors. In addition there were (*i*) field staff consisting of 3 field officers, 7 Inspectors and 72 Supervisors and Enumerators for collection of data in pilot studies, and (*ii*) a mechanical data processing unit headed by an officer on Special Duty, and including two Programmers, 1 Mechanical Tabulation Officer, 2 Electronic Computer Operators, 3 Machine Operators, 3 Supervisors and about 50 Key Punch Operators, for mechanical processing of data.

The work is being organized broadly into five divisions with suitable statistical staff :—

1. Statistical research in agricultural sciences.
2. Statistical research in animal sciences.
3. Sample survey investigations.
4. Basic research and training; and
5. Mechanical and electronic processing of data.

The library of the Institute was managed by an Assistant Librarian and a lower division clerk.

The administrative sections of the Institute were headed by an Administrative Officer. He was assisted by an Assistant Administrative Officer and three Section Officers, a Junior Accounts Officer and other ministerial staff.

1.2 *Distinguished visitors and seminars.*

Seminars based on topics of current research conducted by officers and students of the Institute formed as usual an essential part of the activities of the Institute. In all 25 seminars were delivered in the year. Dr. R. R. Bahadur, Professor of Statistics, Chicago University, U. S. A., Dr. J. S. Rustagi, Professor of Mathematics, Ohio State University, U.S.A., Dr. M. S. Khamis of F. A. O., Dr. J. N. K. Rao, Professor of Statistics, University of Texas, U. S. A., and Professor P.S.R.S. Rao, University of Rochestor, New York, U.S.A., visited the Institute and delivered lectures on topics of current research.

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* The designations : Deputy Statistical Adviser, Senior Statistician and Statistician were changed to Senior Statistician, Statistician and Junior Statistician respectively from September, 1969 to ensure uniformity in designations with the scientists working in various institutes of I. C. A. R.

Trainees of various courses conducted by the Central Statistical Organisation visited the Institute a number of times in different batches for specialised training in Agricultural Statistics and Sampling Techniques. Besides students from Department of Statistics, Andhra University, Waltair; Government Agriculture College, Jammu; & Gujarat College of Veterinary Science and Animal Husbandry visited the Institute.

1.3 *Research collaboration with other institutes, universities colleges, and other institutions at national level.*

The Institute collaborated with the Agronomy and Soil Science and Agricultural Chemistry Divisions of the Indian Agricultural Research Institute in statistical analysis, summarisation of data and reporting of results under the All India Coordinated Agricultural Experiments Scheme of the I. C. A. R. The Institute also collaborated with the Soil Science and Agricultural Chemistry Division of IARI in planning and designing of experiments under the soil test-crops-response scheme.

The Institute carried out a pilot survey for estimating area of grazing land and its utilization in collaboration with the Indian Grassland and Fodder Research Institute, Jhansi. The IGFRI imparted training to the field staff in identifying grasses and in the analysis of grass samples for their chemical composition, for which staff was provided at Jhansi under the scheme. The Statistician at IGFRI was one of the project associates.

Most of the sample surveys initiated by the Institute were carried out through the administrative control of the state governments.

1.4 *Fellowships and studentships.*

During the year, 17 fellowships were awarded to students studying at the Institute in various courses and 11 fellowships to post-graduate students were continued. Five foreign students completed their training.

1.5 *Advanced training.*

Dr. P. Narain, Assistant Professor of Statistics who spent about two years in U. K., during 1967-69 was awarded the degree of Doctor of Philosophy by the University of Edinburgh, U.K.

Shri J. P. Jain, Statistician, spent about one and half a year in U. S. A. during 1968-69 and was awarded a Master of Science degree by the University of Missouri, U. S. A.

2.

STATISTICAL RESEARCH IN AGRICULTURAL SCIENCES

The programme of statistical research in agricultural sciences at the Institute was continued during the year under report. The main items of research included in the programme were (i) Planning of experiments, statistical analysis and summarisation of data collected under the All-India co-ordinated agronomic experiments scheme, (ii) Evaluation of yardsticks of additional production, (iii) Analysis of experiments and preparation of compendia of National index of field experiments, (iv) Economic analysis of data of manurial experiments conducted on gram and *arhar*, (v) Standardisation of horticultural experiments, (vi) Pilot study of pre-harvest forecasting of yield of jute crop, and (vii) Assessment of incidence of pests and diseases.

2.1 *Planning of experiments, statistical analysis and summarization of data collected under the All-India co-ordinated agronomic experiments scheme.*

The All-India co-ordinated agronomic experiments scheme was started during the Second Five Year Plan in collaboration with the I.A.R.I. and different states in the country and continued during the Third Five Year Plan. It consists of two parts :—

(i) Simple fertilizer trials on cultivators' fields, and

(ii) Model agronomic experiments at research centres.

Upto 1966-67, the experiments were conducted mostly with the indigenous varieties of cereals and a few cash and oil seed crops. However, with the advent of high yielding varieties, the technical programme of the scheme was reviewed in 1967-68 and modified to take up the study of responses of the newly developed varieties of cereals to fertilizers and other improved agricultural practices. The data collected during 1967-68 were processed and summarized and the main results were reported in the annual report for 1968.

The results obtained during 1967-68 were reviewed at the annual workshop of the scheme held in October, with a view to :—

(a) finding out how far the objectives of the scheme had been achieved, and

(b) locating gaps and lacuna on which new/further information need be collected.

In the technical programme for 1969-70, therefore, an experiment to obtain

information on intensive cropping to maximize production per unit area per unit time was also included. Further, since more than 3/4th of the cultivated area in the country is still un-irrigated, a study of responses of crops in dry farming areas to application of fertilizers as well as effect of different agronomic practices on their yields was also included in the programme. The trials in the dry farming areas are proposed to be conducted with effect from *kharif* 1970-71 onwards.

The details of work under the two parts of the programme are given below:-

2.1 (i) *Simple fertilizer trials on cultivators' fields.*

The main objectives of these trials were :—

(i) To determine the response of high yielding and indigenous varieties of cereals to nitrogen and phosphorus alone and in combination and to potassium over nitrogen and phosphorus.

(ii) To correlate the crop responses to fertilizers with soil test values, and

(iii) To prepare fertilizer schedules for different agro-climatic regions of the country.

The trials on high yielding varieties of cereals were conducted in 30 districts while trials with indigenous varieties of cereals and cash and oilseed crops were taken up in 60 districts. Data of about 7200 trials were analysed and results summarised. The important findings are given below :—

High yielding varieties of different cereals like IR-8(rice), S-227 (wheat), CSH-I (*Jowar*), HB-1 (*Bajra*) and some of the maize hybrids out-yielded the local varieties even without the application of fertilizers. The average response of exotic varieties of rice to 60 kg. N per hectare exceeded that of the local varieties by about 200 kg. per hectare. The variety IR-8 was also found superior to other rice varieties in so far as its response was more consistent under varying soil and climatic conditions. In the case of wheat, the variety S-227(Kalyan Sona) gave a response of about 1000 kg. per hectare to 60 kg. N per hectare. An increase of about 40 to 80 per cent in the response was observed when the level of nitrogen was doubled. For hybrid maize, the response to 60 kg. N per hectare varied from 300 to 600 kg. per hectare. The response of the local varieties of maize was also of the same order. The *bajra* HB-1 gave a response of about 570 kg. per hectare to the application of 120 kg. N/ha in Aligarh district. There was no difference in the response of the hybrid and locally improved varieties.

Application of phosphorus showed a good response on red and yellow soil of Raipur, coastal alluvial soil of Thanjavur and medium black soil of Coimbatore. IR-8 as well as the other locally improved varieties showed a response varying from

600 to 900 kg. per hectare to 30 kg P_2O_5 per. hectare. For wheat the response to 30 kg. P_2O_5 per hectare varied between 300 to 550 kg per hectare. The responses of other crop varieties to phosphorus were moderate.

Potassium showed better response when it was applied in the presence of nitrogen and phosphorus in most of the districts. The highest response of about 1000 kg. per hectare was obtained to 30 kg. K_2O per hectare with rice variety TN-1 in Shahabad district. For other cereals, the responses to potash were moderate.

2.1 (ii) *Model agronomic experiments at research centres.*

The main objective of these experiments are :—

(i) To study the responses of high yielding varieties of cereals to nitrogen, phosphorus and potash applied alone and in combination,

(ii) To study the effect of improved agronomic practices on crop yields,

(iii) To study long term effects of fertilizers and organic manures,

(iv) To study the relative efficiency of different sources of nitrogen and phosphorus, and

(v) To determine maximum intensity of cropping possible in different agro-climatic conditions.

During the year under report data of 366 experiments conducted during 1968-69 at 44 centres on the high yielding varieties of cereals were analysed and summarized and the annual report was presented at the annual workshop of the scheme held during October, 1969. The main results are as follows :—

The highest yield of 3074 kg. per hectare was obtained when irrigation was applied at 70 per cent of the available soil moisture at Ludhiana. Delay in irrigation decreased the yields.

Regarding the varietal comparisons, it was observed that the high yielding varieties/exotic varieties of the cereals generally performed better than the locally improved varieties at almost all the centres. The response to the application of nitrogen was almost universal and generally varied from 500 to 2000 kg. per hectare at 60 kg. N per hectare, both for rice and wheat crops. At the higher level of 120 kg. N per hectare, the additional response varied from 300 to 800 kg. per hectare for rice and from 500 to 1500 kg. per hectare for wheat. For the other three crops *viz.* maize, *jowar* and *bajra* the response to nitrogen was also good although lower than that of the rice and wheat crops.

The response to phosphorus was observed at seven centres on rice crop, the highest being 2100 kg. per hectare at 60 kg. P_2O_5 per hectare on the alluvial, mixed

red, and black soils at Purafarm and Kuthulia farm. On wheat, phosphorus showed good response at almost all the centres.

Beneficial effect of potassium application on rice, wheat and maize was observed at a few centres, the response being only moderate. On the other crops the response to potassium was generally absent. Application of micronutrients, manganese, boron and molybdenum on rice crop showed a good response of the order of 850 to 1000 kg. per hectare at Kathulia farm.

Of the different weedicides tried, *Tok* E-25 at 1 litre a. i/ha after sowing in the case of direct seeded rice under upland conditions and *Stam* F-34 at 1-2 a. e./ha in the case of transplanted low-land rice were found to be effective in controlling the weeds.

For irrigated wheat, a seed rate of 100 kg. per hectare gave the best yield for optimum date of sowing.

Simazine at 2 kg. per hectare (50%WP) applied one day after sowing was found to be effective in controlling the weeds.

In the multiple cropping experiments, a production of 14.3 tonnes per hectare of grains was obtained with the rotation maize-wheat-chana at Pant Nagar and rice-rice-rice at Tirupati.

Pooled analysis of experiment no 1 on wheat and nos. 4,5a, and 10 on rice and wheat crops was completed and the summarised results were presented at the third annual workshop of the scheme. In addition, data of experiment no 5 where also summarised and report prepared. Compilation of data of remaining experiments excepting the long term experiments was taken up.

The third annual workshop of the All-India co-ordinated agronomic experiments scheme was held during 28th October to 1st November, 1969 at Pant Nagar. The annual reports summarising the results of experiments conducted at research centres and simple fertilizer trails under the high yielding variety programme as well as under the existing programme were prepared and presented at the workshop. In the light of the results obtained, the technical programme of the scheme was reviewed and revised.

2.2 *Evaluation of yardstick of additional production.*

Several improvement measures are suggested to step up agricultural production. In order to assess the additional production accuring from such developmental measures, a knowledge of the average response to the improvement measure(s) or yardstick is necessary.

During the year 1969-70, evalution of the yardsticks of additional production from the use of nitrogen, phosphorus and potash on vegetable and fruit crops and

exotic/dwarf/hybrid varieties of rice, wheat, maize, *jowar* and *bajra* from the data of experiments conducted on cultivators' fields was undertaken. Data of about 350 experiments conducted at research stations on vegetable and fruit crops were collected. Data of about 3200 experiments conducted on cultivators' fields on the response to nitrogen, phosphorus and potash on high yielding varieties were also collected and analysed. Summarization of results is now in progress. Some of the main results obtained are as follows:—

Variety-wise analysis of the data showed that the yardsticks of additional production from the use of nitrogen in tonnes per tonne of N evaluated at a dose of 60 kg. N/ha were 11.2 for TR-8, 11.5 for TN-1, 9.4 for locally improved varieties and 8.0 for local varieties of rice in *kharif* season. At a dose of 120 kg N/ha, the yardsticks of additional production were about 1.5 tonnes less. The corresponding yardsticks in *rabi* season were less by about a tonne for IR-8 half a tonne for locally improved varieties. The yardsticks of additional production in tonnes per tonne of P_2O_5 evaluated at 30 kg P_2O_5/ha over 60 kg N/ha were 13.2 for IR-8, 8.0 for TN-1, 10.5 for local improved varieties and 6.8 for local varieties in *kharif* season and 10.5 for IR-8,16.1 for TN-1 and 10.8 for local improved varieties. The yardsticks of additional production in tonnes per tonne of K_2O evaluated at 30 kg K_2O/ha over 120 kg N/ha and 60 kg P_2O_5/ha were 5.7 for IR-8, 9.9 for TN-1, 6.1 for local improved varieties and 6.5 for local varieties in *kharif* seasons and 13.5 for IR-8, 14.3 for TN-1 and 8.8 for local improved varieties in *rabi* season.

2.3 *National index of field experiments.*

With a view to maintaining at a central place the results of all the agricultural field experiments carried out at research stations all over the country, the scheme of national index of field experiments was started by I. C. A. R. in 1955. The main objectives of this scheme are (i) to collect the data of all field experiments other than purely varietal trials and (ii) to print the compendia of these experiments periodically for the benefit of agricultural research workers.

The data of about 9600 experiments conducted during the period 1960-65 were collected upto the year 1968-69. During the year 1969-70, the data of 2572 more experiments conducted during the period 1960-65 were collected and scrutinised. The results of all experiments conducted over a number of years and places were pooled together for the States of Gujarat, Madras, Orissa and Kerala.

In connection with the combination of results of experiments it was observed that the existing literature on the grouping of results of similar experiments conducted in time or and space does not fully solve a number of problems; particularly in the case of experiments involving several factors. Investigations are being carried

out to tackle these problems and some useful results have been obtained.

2.4 *Economic analysis of data of manurial experiments conducted on gram and arhar.*

A large number of experiments have been conducted at various agricultural research stations as well as on cultivators' fields to study the effect of application of P_2O_5 on various pulse crops. The results of these experiments have been reported in the two series of the National index of field experiments pertaining to the periods 1948-53 and 1954-59. The experiments conducted during the period 1960-65 are being consolidated in the third series of the compendium. Besides, results of the trials conducted on cultivators' fields are available in various reports of the All India co-ordinated model agronomic project.

It was felt necessary to study the response of pulses to the application of P_2O_5 in order to arrive at the optimum P_2O_5 requirements of these crops in different states. For this purpose, the results of about 400 experiments conducted during the years 1948-65 on Bengal gram have been extracted from the volumes of the National index of field experiments. The results of some more experiments conducted during the period 1960-65 are also likely to be available for consolidation and their data are being extracted. Also the results of about 380 trials conducted on cultivators' field during the period 1961-63 have been extracted from the reports of the co-ordinated model agronomic project. Consolidation of the results of these experiments is in progress.

2.5 *Standardisation of horticultural experiments.*

As a part of a long term project of standardisation of horticultural experiments, analysis of uniformity trial data collected from commercial orchards of orange in Nagpur (1968) was done. The relation between plot size and the variability was studied using a suitable mathematical model. The data collected in two more years are being analysed on the same lines.

2.6 *Pilot study on pre-harvest forecasting of yield of jute crop.*

The object of the study is to develop a methodology for pre-harvest forecasting of yield of jute crop on the basis of the biometrical observations such as plant density, height and girth of plants taken at various stages of growth of crop.

The field survey work was carried out during the period June-October, 1969 in about 400 fields selected at random in four blocks covered under the special package programme, taking one block each in the districts of Murshidabad, Nadia, Burdwan and 24-Parganas (N) of West Bengal. The scrutiny of the data received was in progress at the Institute.

2.7 *Estimation of incidence of pests and diseases*

The object of the scheme was to evolve a suitable methodology for estimation of incidence of pests and diseases and assessment of consequent loss in yield of crops.

Final report of the pilot-sample survey conducted for a period of 4 years from 1963-64 to 1966-67 on paddy in West Godavari district of Andhra Pradesh and the consolidated report of the pilot sample surveys conducted in three districts Cuttack, Thanjavur and West Godavari on paddy crop during the period 1959-60 to 1966-67 were prepared. The salient features in brief, of the consolidated report are given below :—

Among the major pests and diseases, Stemborer and Helminthosporium were observed in all the three districts. Gallfly, Jassids, Rats, Blast and Bund also occurred as a major pest and diseases in one district or the other. Incidence of most of the pests and diseases was found to be maximum during the observation recorded about a month before harvest. There was considerable variation in the incidence of almost all the pests and diseases over the year and the districts.

The overall percentage losses due to average incidence of all the major pests and diseases for varieties of different duration are given in Table 1.

The average avoidable loss overall the years during Samba season in Thanjavur district was of the order of 411 kg/ha with S.E. of 32 kg/ha and the average avoidable loss in West Godavari district was found to be 76 kg/ha and 204 kg/ha during *kharif* and *rabi* seasons respectively with corresponding standard error of 27 kg/ha and 32 kg/ha.

The expected net return (i. e. value of additional yield, less the cost of spraying on account of use of recommended plant protection measures) worked out to Rs. 188 per hectare with S.E. of Rs. 22 per hectare per Samba season in Thanjavur district and Rs. 89 per hectare with S.E. of Rs. 23 per hectare per *rabi* season in West Godavari district. The avoidable loss during *kharif* season in West Godavari district was found to be uneconomical.

Table 1. Loss in yield of paddy due to incidence of pests and diseases during different seasons in each district.

District	Season and Duration of Variety	Percentage loss in yield with S.E.	
Cuttack	Sarad (long duration Variety)	13 00	(2 63)
	Dalua (short ,, ,,)	7.13	(6.32)
	,, (medium ,, ,,)	11.38	(5.72)
Thanjavur	Kuruvai (short ,, ,,)	4.39	(1.03)
	,, (medium ,, ,,)	3.25	(0.33)
	Samba (long ,, ,,)	10.46	(1 65)
	Thaladi (,, ,, ,,)	3.96	(4.15)
W. Godavari	Kharif (,, ,, ,,)	10.57	(2.06)
	Rabi (medium ,, ,,)	14.43	(2.95)

3.

STATISTICAL RESEARCH IN ANIMAL SCIENCES

The programme of statistical research in animal sciences carried out at the Institute during the year under report included critical examination of breeding data, standardisation of techniques for measurement of sampling, and investigations for development of techniques for the study of cost of production of livestock and poultry products. Studies were carried out on the comparative performance of indigenous cattle (Bengal type) and their graded progeny with Hariana bulls. The comparative performance of various grades of sheep obtained by crossing Rampur Bushair ewes with exotic Polwarth rams was studied on the basis of data from a scheme sponsored by the Council. The studies involving standardisation of techniques for measurement and sampling covered those carried out in regard to estimation of solids-not-fat (S.N.F.) and temerature correction charts for density for varying fat percentages. The work under the project for standardising the procedure of sampling for assessing wool quality of a single fleece as well as that of fleeces from a group of sheep was continued during the period. The final reports on investigations carried out for studying the cost of production of sheep and wool in Himachal Pradesh and economics of raising cattle and buffaloes in Hissar district were prepared. Methodological investigations for development of techniques for estimation of availability and cost of production of milk, impact of milk supply schemes on rural economy in milk collection areas and cost of poultry and egg production under commercial management conditions were continued. A project for developing necessary methodology for building up a suitable index of cost of production of milk was initiated. The study concerning the development of sampling technique for objective estimation of area of grazing land and its utilisation continued in Jhansi district of Uttar Pradesh in close collaboration with, 'Indian Grassland & Fodder Research Institute,' Jhansi. The work on the preparation of Index of animal experiments was continued.

Fundamental investigations for studying the components of variance and estimates of genetic correlations between various production and allied characteristics and also the possibility of working out appropriate indices for selection are in progress with large bodies of data on herds of Red Sindhi, Kankrej, Kangayam, Tharparkar and Gir. Studies on feed-milk relationship were undertaken with data collected from large-scale surveys with a view to working out economic optimum levels of nutrients. Preliminary studies have been initiated for estimating morta-

lity and fertility rates among cattle and buffaloes with a view to constructing life tables for use in projecting bovine population.

3.1 *Study of comparative merits of selective breeding and grading up of local cattle* :

The Indian Council of Agricultural Research sponsored a co-ordinated scheme to be run at various farms in the country for studying the comparative merits of improving indigenous cattle by selective breeding and grading up with bulls of well-defined breeds. At the request of the Council and in pursuance of the recommendations of the then Animal Breeding Committee, the data collected at various centres were analysed at I.A.R.S. The results obtained on Khariar (Orissa), Umbalachery (Tamil Nadu) and Red Purnea (Bihar) type of cattle were reported in the previous years. During the year, the data on Bengal type of cattle were analysed.

Graded cows were significantly superior to the progeny in selective breeding group in regard to milk yield, yield per day of lactation and yield per day of calving interval but, had on an average significantly longer first calving interval and higher age at first calving. The average first lactation yield of graded cows was 554.6 kg. compared to 374.8 kg. for the progeny in selective breeding group. The average age at first calving was about 50 months for graded cows compared to about 43 months for progeny in selective breeding group. While graded cows yielded about half a kilogram more of milk per day of lactation than the F_1 progeny in selective breeding group, the additional cost of feeding per day per cow in milk was about twenty paise during 1961-64 and 1965-67 and thirty paise during 1964-65. The cost of feeding in selective breeding group being 86 paise during 1961-64, 84 paise during 1965-67 and 81 paise during 1964-65. The cost of feeding a dry cow per day was 12 paise more during 1961-64 and 1965-67 and 24 paise more during 1964-65 in grading up group than in selective breeding group. As a consequence, the feed cost per kg. of milk in grading up group was about 10 paise less than the cost in selective breeding group during 1961-64 and of the same order during 1965-67 and about 10 paise more during 1964-65. However the cost of feeding of young stock was more or less the same in both the groups. On an average, two services were required for a conception in the case of Bengal type bulls as well as Hariana bulls.

Graded calves were significantly heavier, weighing on an average about 2.5 kg. more at birth than Bengal type calves of similiar sex. Male calves weighed significantly more than female calves by about one kilogram. The average gain in weight in female calves at 18 months of age did not differ among the first generation calves in the two groups, while the second generation calves in grading up

group were significantly heavier, weighing about 8 kg. more compared to those in selective breeding group. Mortality rate did not differ in the two groups in the case of young stock of 6 months of age but, the mortality rate among graded female calves of one to three years of age was significantly higher than that among female calves in selective breeding group of the same age group.

3.2 *Statistical study of sheep breeding data* :

For assessing the comparative performance of various grades obtained by cross-breeding Rampur Bushair ewes with Polwarth rams, the data from 1962-68 available in the I.C.A.R. scheme for Improvement of Sheep and Wool on Regional Basis at the Central Sheep and Wool Research Station, Pashulok, Uttar Pradesh were analysed. The data pertained to annual greasy fleece weight of Rampur Bushair sheep and their cross-bred progeny and to various wool quality attributes of half-bred and three-fourth Polwarth ewes. Data on weight at birth, body weight at 16 weeks and at 12 months of age, mortality and fertility were also studied. The salient results obtained are reported in the following paragraphs :-

The differences between half-bred and three-fourth Polwarth ewes were not significant in regard to greasy fleece weight as well as various wool quality attributes except that three-fourths were superior in regard to fibre diameter. The graded Polwarth ewes were superior to Rampur Bushair ewes in regard to greasy fleece weight, the average greasy fleece weight being 1.36 kg. for half-breds, 1.33 kg. for three-fourths and 1.17 kg. in case of Rampur Bushair ewes. The fibre diameter decreased from 26.45 microns for half-breds to 21.13 microns for three-fourths.

No significant differences were observed between the two grades in regard to weight at birth and at 16 weeks and 12 months of age except that half-bred ram lambs weighed about 1.5 kg. more than the three-fourth ram lambs at 16 weeks of age, the average weight of three-fourth ram lambs being 12.25 kg. However, cross-bred ram and ewe lambs were significantly heavier at birth compared to Rampur Bushair lambs. The half-bred and three-fourth ewe lambs weighed about 0.40 kg. more at birth than Rampur Bushair ewe lambs for which the average birth weight was 2.15 kg. The average birth weight of half-bred and three-fourth ram lambs were 2.74 kg. and 2.56 kg. respectively compared to 2.27 kg. in case of Rampur Bushair ram lambs. Mortality rates in various age groups did not differ among half-bred and three-fourth progeny.

3.3 *Standardisation of methods for estimation of solids-not-fat (S.N.F.) in milk* :

In order to (i) develop appropriate formulae relating S.N.F. to density and fat, (ii) estimate correction factors for fat determined by Gerber method, and

(iii) prepare temperature correction charts for density, the Council sponsored a co-ordinated scheme which ran at four centres. The data collected on the chemical analysis of a large number of milk samples were studied under the project. Statistical studies pertaining to the first two objectives were completed and results reported in earlier years.

During the period, studies pertaining to temperature correction factors were completed and a report embodying the results was prepared and presented to Scientific Panels in December, 1969.

The appropriate relationship between temperature and density was found to be linear. The regression co-efficients were all significant and negative. Statistical tests further showed that there was no significant difference between the coefficients of the equations for the different breeds as also between the centres. On the basis of the tests, the equations were pooled, and the correction factors to be applied to density reading taken at temperatures other than 20°C to obtain density of milk at 20°C were estimated. Similar correction factors to obtain density of milk at 27°C were also estimated.

3.4 *Standardisation of the procedure of sampling from fleeces for the study of wool quality* :

The object of the investigation is to standardise the procedure of sampling for assessing wool quality of a single fleece as well as that of fleeces from a group of sheep so as to provide a basis for all scientific studies on fleece quality. As already reported the laboratory work was carried out at the Sheep Breeding Farm, Kamaraj Sagar, Ootacamund. Similar studies under the project are in progress at the Central Sheep and Wool Research Institute, Malpura (Rajasthan).

During the year under report, the statistical analysis of the data on fibre diameter, staple length, fibre length and crimps/cm. of 12 ewes each of 2 teeth and 4 teeth age groups of Nilgiri , Nilgiri × Romney Marsh and village flocks was completed.

In each age group, the variation between sheep was significant as estimated from the regional as well as composite samples. Further, between region and region × sheep interaction components were also significant in the case of regional samples. Taking number of cuts, number of fibres and wool yield per region as weighting factors it was observed that means of each character weighted with wool yield did not differ significantly from those obtained by other two weighting factors. The fibre diameter, staple length and crimps/cm. based on the samples obtained by three composite sampling methods and overall averages obtained from regional samples, unweighted and weighted with wool yield did not differ significantly.

Further studies with the data collected from Sheep Research Station, Pashulok (U. P.) and Sheep Breeding Farm, Kamarajsagar, Tamil Nadu are in progress. The data being received from C. S. W. R. I., Avikanagar, Rajasthan are being studied simultaneously.

3.5 *Study of economics of raising cattle and buffaloes :*

A large scale survey to estimate the cost of raising young stock and of maintaining adult cattle and buffaloes was carried out in Hissar district of Haryana state during 1963-67. The final report of the project was prepared and considered by the Working Group on Livestock Costing Studies as well as by other Scientific Panels of I. C. A. R. during the period under report. The broad findings of the enquiry are as follows :—

The cost of rearing a male cow-calf from birth till 3 years of age was estimated to be Rs 695/- including family labour and Rs 520/- excluding family labour. For a female cow-calf, the rearing cost from birth till 3 years of age was Rs 425/- including family labour and Rs 300/- excluding family labour. The cost of rearing a female buffalo calf from birth till 3 years of age was estimated to be Rs 615/- including family labour and Rs 460/- when family labour was excluded. Hardly any male buffalo-calf was reared upto 3 years of age. The cost of rearing a male buffalo-calf upto 2 years of age was worked out to be about Rs. 290/- including family labour and Rs 120/- excluding family labour. The average maintenance cost of a milch cow was Rs 1.60 per day and that of a milch buffalo was Rs 3/- per day. The daily expenditure on a bullock was about Rs 2.00. Feed accounted for 70 to 80 per cent of the gross cost. The cost per kg of cow milk was about Re 1.00 as compared to 83 paise for buffalo milk when family labour was included and 85 paise and 72 paise respectively when family labour was excluded. The average daily milk yield of a cow in milk was 2.7 kg and that of a buffalo was 5.4 kg. The average butter fat content was 4.4 per cent in cow milk and 6.5 per cent in buffalo milk. A buffalo in milk was fed about 3.1 kg of greens, 7.3 kg of dry roughage and 800 grammes of concentrates per day and a cow in milk was given about 2.2 kg. of greens, 7.5 kg of dry roughage and 400 grammes of concentrates. A dry animal although was fed as much dry roughage as given to the animals in milk, it was given less of greens and very little of concentrates. The age at first calving for cows was on an average 45.5 months and that for buffaloes 49.7 months. The average lactation length of a cow was about 9 months and dry period about 6 months. In the case of buffaloes, the lactation length was one month more and dry period a month less than that of a cow. The calving interval was about 440 days both for cows and buffaloes. A number of ancillary studies have also been made utilising the data collected in the survey.

3.6 *Study of cost of production of sheep and wool :*

The object of the investigation is to develop a suitable sampling technique for studying the economics of sheep rearing in relation to wool production under migratory and stationary types of managements in hilly tracts. On the basis of a complete enumeration of 88 randomly selected villagess, 44 each from Mandi and Mahasu districts, a random sample of 10 villages from Mandi district and 11 villages from Mahasu district was selected for collecting information regarding stationary flocks. Out of all the migratory flocks in the villages covered under complete enumeration, seven groups of migratory fllocks, three from Mandi district and four from Mahasu district were selected at random for detailed enquiry. For each selected flock, detailed information was recorded for a period of two years (1963-65). Data on wool yield at each shearing, body weight of selected sheep and supplemental feed given to them were recorded by direct weighment, while information on other items was obtained through carefull enquiry and observation The final report on the project was considered by the Scientific Panels of I.C.A.R. during the year under report. The broad findings of the investigation are as follows :—

The average flock size was about 50 in migratory flocks in Mandi district and only 10 in Mahasu district. In the stationary flocks, the average flock size was four or five in each district. The average annual cost of maintenance of a sheep was Rs 7.80 and Rs 5.45 in Mandi district and Rs 20.55 and Rs 18.50 in Mahasu district in the case of migratory flocks in the two years respectively while it was Rs 21.55 and Rs 31.50 in Mandi district and Rs 16.40 and Rs 17.10 in Mahasu district in the case of stationary flocks in the two years respectively. Labour formed the major component of cost accounting for 65 to 80 percent of gross cost. The average maintenance cost of sheep was apportioned to obtain the average cost of wool and mutton. The average cost per kg of wool in migratory flock was Rs 3.91 and Rs 3.43 respectively in the two years in Mandi district and Rs 12.96 and Rs 8.64 in Mahasu district. The average cost per kg of mutton was Rs 1.47 and Rs 1.29 in two years respectively in Mandi district and Rs 4.68 and Rs 3.46 in Mahasu district. The maintenance cost per sheep was also apportioned into that for mutton and wool for stationary flock by excluding the family labour. The cost varied from Rs 3.0 to Rs 4.0 per kg. of wool and from Rs 1.10 to Rs 1.50 per kg of mutton in the two years in Mandi district. In Mahasu district, the average cost per kg of wool and mutton was Rs 3.70 and Rs 1.50 respectively in two years.

The average annual greasy fleece weight per sheep in migratory flock was 993 gms and 948 gms in the two years in Mandi district and 712 gms and 837 gms in Mahasu district. In the case of stationary type flocks, the average yield was 557 gms

and 644 gms in Mandi district and 642 gms and 751 gms in Mahasu district in the two years respectively.

In migratory flocks, about 73 per cent of the wool produced in Mandi district and 38 per cent in Mahasu district was sold in the first year. The proportion of wool sold in the second year in both the districts was less than 18 per cent. In the case of stationary flocks, entire quantity of wool produced was utilised at home.

3.7 *Study of the impact of milk supply schemes on rural economy in milk collection areas :*

As a result of assured market and guaranteed prices of milk offered by urban milk supply schemes, it is likely that changes take place in the production of milk and economy in the rural areas from where milk is drawn. With a view to developing a suitable sampling technique for assessing these changes, surveys were carried out in the rural milk collection areas of Delhi Milk Scheme during 1966-67 and of the Dudh Sagar Dairy, Mehsana, during 1967-68.

The proportions of animals in milk during various seasons and the average quantity of feed consumed from those households in which different categories of animals were fed separately were worked out for the D.M.S. area. In the supplying area, the proportions of cows in milk were estimated at 48 per cent during summer and rainy seasons and 39 per cent in winter. The corresponding figures for the respective seasons for control area were 38, 42 and 36 per cent. In case of buffaloes, the figures in the two areas were of the same order, viz., 58, 53 and 69 per cent in three seasons. The average quantity of feed consumed per day by a cow in milk was of the order of about 20 kg during winter and rainy seasons and about 15 kg in summer. The corresponding figures for buffaloes in milk were of the order of 30 kg. and 22 kg. The quantity of roughages consumed by dry animals was slightly less as compared with that for animals in milk but concentrates were fed appreciably at lower rate. The quantity of concentrates fed to the animals in the non-supplying areas was comparatively more than that in the supplying areas.

The estimates of the average daily feed consumption per milch animal were also worked out for the supplying areas of Mehsana district. On the basis of the analysis of partial data from Mehsana area, it is estimated that the average daily milk yield per buffalo in milk maintained by a commercial producer was about 5.0 kg in winter season and 3.6 kg in summer season in the areas supplying milk to organised dairies. The corresponding daily milk yield per buffalo in the non-supplying areas was 4.2 kg in winter season and 3.1 kg in summer season. Compilation and tabulation work in respect of the study on cost of cultivation of selected

feed and fodder crops also remained in progress during the period under report.

3.8 *Estimation of availability and cost of production of milk :*

A sample survey was taken up in Krishna delta area, Andhra Pradesh during 1967-69 to estimate the availability of milk and its disposal in different seasons in the area and to estimate the cost of production of milk. The field work of the survey in Krishna Delta area of Andhra Pradesh was completed in July, 1969. A similar survey was initiated in Dhulia region of Maharashtra state during December, 1969.

A progress report incorporating the results obtained during the preliminary enumeration of households and during the first year of detailed enquiry in Krishna Delta area was prepared and presented to the working group on Livestock Costing Studies and other Scientific Panels of I.C A.R. during November December, 1969. The broad results are as follows :—

About 83 per cent of the stall owners in the area maintained only milch buffaloes, 15 per cent had both buffaloes and cows and only about two per cent had only cows. Half the number of stall owners were commercial producers, majority being cultivators. On an average, there were two milch animals per stall. Majority of the animals in the area were non-descript.

The average daily milk yield per buffalo in milk was 1.7kg in rainy season and 2.0 kg in each of winter and summer seasons. A cow in milk gave on an average 1.2 kg, 1.3 kg and 1.1 kg per day in the three seasons respectively. The average butter fat content in buffalo milk was 6.3 per cent and in cow milk 4.9 per cent.

The overall daily production of milk in the area was about 461 tonnes, out of which as much as 89 per cent was accounted for, by buffalo milk.

3.9 *Study of cost of poultry and egg production :*

The main object of the survey is to evolve suitable methodology for the estimation of poultry and egg production. This would involve estimation of, (i) cost of production of table and hatching type eggs, cost of rearing birds from day old to adult stage and the cost of maintenance of cocks and layers with a reasonable precision, and (ii) estimation of various components of cost and their variation in monetary terms as well as physical quantities. The field work of the survey started in Dasuya-Tanda areas of Hoshiarpur district in Punjab during 1967 was completed in October, 1969. A similar survey was initiated in Delhi and surrounding areas. In the Dasuya-Tanda region, the collection of data to build an index of cost of poultry and egg production was initiated during the period under report.

A rapid analysis of the data collected from the first centre in Punjab state, for a period of four months of the winter season of 1967-68 and pertaining to a random sample of about half the number of selected farms was carried out to get an idea of the contribution of various components of cost of maintaining an adult bird and cost of production of an egg. It was observed that feed formed the major portion of the cost of maintaining an adult bird, accounting for about 95 per cent of the gross cost excluding unpaid labour. Unpaid labour accounted for about 5 to 9 per cent of the gross cost of maintaining an adult bird while paid labour was negligible. Average cost of an egg varied from 12 to 16 paise, almost all the cost accruing from maintenance of layers. Further analysis is in progress.

3.10 *Index of cost of production of milk :*

The object of the study is to investigate the possibility of building up an index of cost of production of milk in the areas where detailed enquiries on cost of production of milk were carried out earlier; namely, West Bengal, Tamil Nadu and D.M.S. milk collection areas. This will indicate the relative increase or decrease in the cost of production of cow milk and buffalo milk in the area of operation and provide basic material helpful to the dairy projects in the area in formulating their price policies. The collection of data was started in West Bengal in December, 1968, in D.M.S. milk collection areas in January, 1969 and in Tamil Nadu in April, 1969.

A note indicating the index of feed cost in winter and summer seasons, 1969, in West Bengal separately for cows and buffaloes and for summer season 1969 in Tamil Nadu was prepared, and considered by the Working Group on Livestock Costing Studies and other Scientific Panels of I.C.A.R. during November-December, 1969.

3.11 *Estimation of area of grazing land and its utlisation :*

The pilot study aims at evolving a suitable sampling technique for obtaining objective and precise estimates of the grazing area and its yield rates, the botanical classifications and the chemical analysis of grasses available as well as the practices followed in the utilization of grazing area. The field work of the survey continued in Jhansi district in Uttar Pradesh during the period under report. The data collected during the period were scrutinised and analysis was in progress.

3.12 *Studies in genetic correlations and selection indices relating to cattle :*

The objectives of the investigations are to study the components of genetic variation and genetic correlation between various production and allied characteristics and examine the possibilities of working out appropriate indices of selection.

During the year the data for the Red Sindhi herd at Hosur and Bangalore, Kankrej herd at Anand, Kangayam herd at Hosur and Gir herd at Bangalore were utilised to estimate the genetic correlation between age at first calving and milk yield in first lactation and also between birth weight and milk yield. By adopting the intra-sire regression method, the genetic correlation between milk yield in first lactation and age at first calving could not be estimated for Red Sindhi and Kangayam herds at Hosur and Gir herd at Bangalore. In these cases the method of half-sib analysis was applied. It was further observed that sometimes the estimate obtained by intra-sire regression method changes considerably with a little change in a single observation. These aspects of the estimation procedure are being further investigated.

3.13.3 *Study of feed-milk relationship in bovines* :

The project envisages the study of feed-milk relationship and the estimation of optimum level of nutrients required for milk production.

The data collected from Sirsa area in Hissar district under the survey to study the economics of raising cattle and buffaloes in Hissar were taken up for the study. The data pertaining to winter season were stratified according to breed, lactation order and stage of lactation. Data for Hariana cows and Murrah buffaloes with lactation order 1 to 3 and stage of lactation not exceeding six months were considered, and the feed items consumed by the animals were converted into their nutrient equivalents. The corresponding milk yields were also tabulated, and three functions, viz., linear, quadratic and Cobb-Douglas were fitted. The quadratic equation, even though explained maximum variation, did not show any significant improvement over the linear. The results, however, are based only on one stratum. Data from other strata are being taken up for similar analysis.

3.13.4 *Investigations into the suitability of sampling plan for milk recording in key village blocks* :

The object of the investigation is to try out the sampling plan for milk recording developed by the Institute in a few selected key village blocks with a view to judging its statistical efficiency and operational feasibility in the field.

The work, in the first instance, was undertaken in the key village block under the administrative control of the National Dairy Research Institute, Karnal during 1964, and the results were reported earlier. It was observed that, on the whole, the plan was efficient and operationally feasible. However, it was felt that a few more centres were to be covered before its final recommendation for large scale use.

As reported in the annnal report for 1968, work was undertaken in two more key village blocks, viz., Chatta in U.P. and Mandapeta in Andhra Pradesh in 1966 and 1967 respectively. During the period under report, the analysis of data on milk yield of animals selected in Chatta block was taken up and estimates of average lactation yield was of the order of 500 kg for cows and 11,00 kg for buffaloes. Both the estimates were fairly precise in that their standard errors were of the order of 3.5 per cent. Studies relating to estimation of annual milk production in the area were also carried out.

3.15 *National index of animal experiments :*

The object of the scheme is to collect and analyse data pertaining to all experimental investigations on animals carried out at the various research centres in the country with a view to preparing a compendium of the processed results so as to enable the research workers to review the work already done in particular subjects and to plan future investigations on proper lines. Data pertaining to 580 experiments carried out during the period 1945-65 at I.V.R.I. were scrutinised and statistscal analysis in respect of 150 experiments was completed during the period. Five model forms along with the abbreviations common to all experiments were sent to members of the Direction Committee for comments. Information on 90 experiments on animal nutrition were transcribed for presenting them in the compendium.

4.

SAMPLE SURVEY INVESTIGATIONS

Sample survey investigations undertaken by the Institute have the primary aims of developing and demonstrating the use of sample survey technique as a practical and reliable method of securing data in a wide variety of fields in agriculture and animal husbandry. Once appropriate sampling designs, field procedures, and methods of estimation, become available through these investigations, the state departments of agriculture and animal husbandry are expected to adopt them for collecting regularly the much needed data for planning and development. The investigations which were in progress during the year under report are described below :—

4.1 *Survey of fertilizer and other manuring practices :*

The objects of the surveys were given in the last year's annual report. During this year analysis of the data collected from the surveys carried out in the districts of Bangalore (Mysore), Nizamabad (Andhra Pradesh), Varanasi (U.P.), Coimbatore and Tiruchirapalli (Tamil Nadu) was completed. In the first four districts the survey was conducted during 1966-67 and in Tiruchirapalli during 1967-68. The analysis of the data collected in the surveys in the districts of Nizamabad (U.P.), Krishna (Andhra Pradesh) and Ferozepur (Punjab) was undertaken.

The results of the survey in Bangalore district showed that although only seven percent of the total cropped area was irrigated as much as 74 percent of the area received farm yard manure and 12 percent chemical fertilizers. Percentages of area benefited by chemical fertilizers and farm yard manure for paddy were of the order of 26 and 92 respectively. The corresponding figures for sugarcane crop were 87 and 75 and for *ragi* 10 and 83. In Nizamabad district it was found that 48 percent of the cropped area was irrigated and 50 percent of the area benefited by chemical fertilizers and 74 percent by farm yard manure. For paddy crop the area benefited by chemical fertilizers was of the order of 91 percent and that by farm yard manure 95 percent. The corresponding figures for *jowar* were nine percent and 76 percent and for maize crop 67 percent and 94 percent. The rates of application of nitrogen in terms of ammonium sulphate were 250 kg per hectare for paddy, 96 kg per hectare for *jowar* and 143 kg per hectare for maize. In Varanasi district 38 percent of the cropped area was irrigated. It was found that 23

percent of the area was benefited by chemical fertilizers and 35 percent by farm yard manure. In this district for the paddy crop 41 percent of the area was benefited by chemical fertilizers and 25 percent by farm yard manure. For the wheat crop the corresponding figures were 23 percent and 44 percent and for barely 22 percent and 52 percent respectively. The rates of application of nitrogen in terms of ammonium sulphate for paddy was 98 kg per hectare, for irrigated wheat 175 kg per hectare, for unirrigated wheat 114 kg per hectare and for barley crop 79 kg per hectare. In Coimbatore district 36 percent of the cropped area was irrigated. The area benefited by chemical fertilizers was of the order of 32 percent and by farm yard manure 67 percent. For paddy crop as much as 92 per cent of the area was benefited by chemical fertilizers and 58 percent by farm yard manure. The corresponding figures for *jowar* were 10 and 66 and for cotton 61 and 83. The rates of application of nitrogen in terms of ammonium sulphate ranged from 250 kg per hectare to 319 kg per hectare for the paddy crop, from 129 to 197 for *jowar* and 230 kg per hectare for cotton.

In Tiruchirapalli district about 46 percent of the cropped area was irrigated and 37 percent of the area was benefited by chemical fertilizers and 80 percent by farm yard manure. About 83 percent of the area under paddy was benefited by chemical fertilizers and 90 percent by farm yard manure. The corresponding figures for *jowar* were eight and 10 and for groundnut 26 and 82. The rates of application of nitrogen in terms of ammonium sulphate were 307 kg per hectare for paddy, 253 kg per hectare for *jowar* and 71 kg per hectare for groundnut.

4.2 *Surveys on fruits and vegetables :*

During the year under report the field work of the pilot survey on vegetables in Poona and Nasik districts of Maharashtra was completed. The data collected in the first round of the survey were analysed and report prepared. The data of the second round were being analysed. As regards the sample survey on fruit crops the report on the sample survey conducted on mango and *litchi* collected during the first round in Bihar and on apple and other temperate fruits in Himachal Pradesh were prepared and submitted to the Scientific Panels. A consolidated report on the results of the survey on apple and other temperate fruits in Nainital region of Uttar Pradesh was also submitted to the Scientific Panels. In addition, analysis of the data collected during the third round of the survey on vegetables in Delhi state was in progress.

4.3 *Survey on cashewnut and spices crops :*

During the period under report the data collected under the survey in Andhra Pradesh during the years 1966-67 and 1967-68 were analysed and report

prepared. The results of the survey showed that out of 13·15 lakh trees about 89 percent were of bearing age. The average yield per tree was estimated at 8.33 kg. while the total production of cashewnut was estimated to be of the order of 9120 tonnes during the year 1967-68. The corresponding estimate for average yield per bearing tree for the year 1966-67 was 8.99 kg and that of production was of the order of 8,332 tonnes. The data received from a similar survey in Madras for the year 1968-69 and that from Maharashtra for the years 1967-68 and 1968-69 were taken up for statistical analysis during the year.

Analysis of the data on the sample surveys conducted during the years 1966-67 and 1967-68 on pepper crop was completed. The total number of bearing and non-bearing standards were estimated to be 53.66 and 9.26 millions with percentage standard error of 5.7 and 7.0 respectively. The average yield of dry pepper was estimated at 0.442 kg per standard with a percentage standard error of 11.5 in the year 1966-67 and 0.468 kg per standard with a percentage standard error of 7.5 in 1967-68. The total production of dry pepper was estimated at 25,045 tonnes during 1966-67 and 26,175 tonnes during 1967-68. *Murruku* was found to be the most commonly used support for pepper cultivation in the state. The important varieties of pepper were found to be Balankotta, Karimkotta, Kalluvalli, Padappan and Kothinadan. The harvesting time taken to pluck the berries with spikes was found to be 25 minutes per standard.

4.4 *Assessment surveys under the I. A. D. P.*

During the period under report the surveys were continued in 17 districts covered under the Intensive Agricultural District Programme. In all the districts refresher training courses were arranged for the survey staff by the statistical officers in charge of the survey work in the respective districts.

Analysis of data collected during 1968-69 under the agronomic and agro-economic survey was in progress. The analysis of data regarding crop cutting experiments conducted during 1968-69 was completed. The results indicated appreciable increase in the yield rates of the wheat in the districts of Shahabad, Ludhiana and Aligarh, as compared to the previous year. It was of the order of 12 percent in Shahabad and 4 percent in Ludhiana and Aligarh. The percentage increase in the yield rates of maize during 1968-69 as compared to the previous year was of the order of 45 in Ludhiana and 19 in Aligarh. The yield rates of paddy also showed encouraging results in many districts. The increase in yield rate during 1968-69 as compared to the preceding year varied from 4 percent in Alleppey district to 28 percent in Mandya. An appreciable increase of more than 20 percent in yield rate of paddy was also recorded in Surat-Bulsar and Thanjavur districts during 1968-69.

Special emphasis was laid for collecting data on crop yield and other related characters on high yielding varieties of cereal crops grown in the IADP districts. The results indicated that during 1968-69, the increase in yield rate of high yielding varieties of paddy over the indigenous ranged from 60 to 100 percent in the districts of Sambalpur, Surat-Bulsar, West Godavari, Alleppey, Cachar and Palghat. In the districts of Raipur and Shahabad it was more than 40 per cent and in the districts of Mandya and Thanjavur the differences were of moderate order. The difference in the yield rates of high yielding varieties of wheat and local varieties was of the order of 150 percent in Jammu, 90 percent in Ludhiana, 70 percent in Shahabad and 30 percent in Aligarh. The differences in yield rates of hybrid maize, *jowar* and *bajra* over the local varieties were found to be of moderate order. Rate of consumption of fertilizer was substantially higher for high yielding varieties in all the districts and in a number of them the farmers have adopted the recommended doses for these varieties.

4.5 *Surveys for assessment of high yielding varieties programme :*

Objects and designs of the surveys were reported in the annual report for the year 1968. During the period under report the surveys were started in the states of Haryana, Punjab, Maharashtra, Mysore, Andhra Pradesh, Tamil Nadu and Assam. The data on yield for the *rabi* 1968-69 received from the states of Haryana and Tamil Nadu were analysed.

In Haryana the survey was conducted in the districts of Rohtak and Gurgaon. The results indicated that the yield rates of high yielding varieties of wheat as compared to local varieties were higher by 59 percent in Rohtak and by 68 percent in Gurgaon.

In Tamil Nadu the survey was conducted during *rabi* 1968-69 on paddy in the four districts of Coimbatore, North Arcot, South Arcot and Chingleput. During this season I.R-8 was grown in all districts. The results indicated that the yield rate of I.R-8 was higher than that of local varieties by 93 percent in Coimbatore, by 143 percent in North Arcot and 81 percent in South Arcot and 91 percent in Chingleput.

The data were also analysed to obtain the extent of adoption of chemical fertilizers by farmers and their rates of application both for high yielding and local varieties of crops

4.6 *Sample surveys for estimation of agricultural production at the block level :*

As already reported, the Institute conducted pilot sample surveys for obtaining the estimates of agricultural production at the block level in 3 districts one from

each state during the year under review. The field work was completed in these states by the end of September, 1969.

During the period under report the data collected during the year 1967-68 in 55 districts were analysed and reports prepared. In addition the data for 1968-69 *kharif* season collected in the 8 districts mentioned above were analysed and repor s prepared.

The results of analysis indicated that the extent of correlation between pre-harvest estimates and crop cutting estimates remained at the same level as in the previous years in most of the states. The estimates of yield were accompanied with moderate standard errors.

4.7 *Pilot surveys for estimation of livestock products and study of livestock practices.*

As reported in the last year's report the Institute initiated during 1968, two pilot sample surveys one for estimation of meat production in Haryana and the other for estimation of milk production and study of bovine practices in Himachal Pradesh. The field work of the meat survey in Haryana was completed in February 1969 and of the milk estimation survey in Himachal Pradesh in July, 1969.

As already reported the Institute had proposed conducting two pilot sample surveys for evolving an integrated technique for estimation of principal livestock products simultaneously and for studying the attendant animal husbandry practices of bovine sheep, poultry, etc. during the Fourth Five Year Plan. The first survey in Northern region comprising Punjab, Haryana and Himachal Pradesh was initiated in March, 1969 and the second survey in Andhra Pradesh would be started during 1970.

The statistical analysis of the data collected from a pilot survey on meat production in Tamil Nadu during 1966-67 was completed and a report thereon was presented to the Scientific Panels The study indicated that the estimate of total meat production in the tract comprising districts of Coimbatore, North Arcot, Salem, South Arcot and Thiruchirapalli during 1966-67 was of the order of 19.4 thousand tonnes with a standard error of 4.3 percent.

The statistical analysis of the data collected in the sample surveys in Haryana and Himachal Pradesh were undertaken during the year.

The second meeting of the Direction Committee constituted for guiding the work of pilot sample survey on livestock products was held on 9th June, 1969. The Committee recommended that a workshop meeting and a seminar on Livestock Statistics should be held by the Institute. These would be held in March, 1970.

On the basis of the data collected in the sample surveys conducted for estimation of wool production in different states of the country it was estimated that during 1966 the all India wool production, excluding pulled wool was of the order of 28.42 thousand tonnes.

5.

STATISTICAL STUDIES IN AGRICULTURAL ECONOMICS.

In Agricultural Economics, the Institute has been giving technical guidance in the statistical aspects of Agricultural Economics Research schemes undertaken by the various research Institutes/Agricultural Universities, State Departments, etc. During 1969-70, the following schemes run by the various Institutes were completed:–

(i) The scheme on 'Cost of Marketing and Marketing Margin in Wheat in Agra', sponsored by the B. R. College, Agra, mainly aimed at finding out the cost of marketing of wheat as it moves from the producer to the consumer and margins at various levels in the Bichpuri Block, Agra district. The scheme was completed by the end of September, 1968 and its final report is still awaited.

(ii) The object of the scheme on 'Economics of Lift Irrigation', using electric power in South Kanara district Karnatak University, Dharwar, was to study economic benefits of lift irrigation, its effects on cropping pattern, land productivity etc., magnitude of cost of the irrigated crops and their consequence and the net and gross additional income and additional employment created etc. The conclusions of this study suggested that electric pump sets are cheaper to picotah and oil engines as modes of lifting water. And the operational cost per acre falls with increase in the size of holdings, and it is relatively more on higher duration crops as compared with short duration crops. Its final report was also considered by the Scientific Panel for Agricultural Economics, Statistics and Marketing at its June, 1969 meeting which has suggested some modifications to be made before the report is published. The modified report is still awaited from the author.

(iii) The scheme on 'Factors Associated with Farm and Family Investment' of Punjab Agricultural University, Ludhina aiming at identifying the areas in which the farmer is investing his income particularly the increments in his income is still continuing. Its report for 1966-67 was considered by the Scientific Panel for Agricultural Economic, Statistics and Marketing at its meeting held in December, 1969 which recommended that the Director, Gokhale Institute of Politics and Economics may go through the report for its improvement and revision.

(iv) The Scientific Panel also recommended the constitution of a Sub-Committee for considering the details and technical programmes of various schemes

on price-spread studies recommended by the Governing Body of the Council. The Sub-Committee has been constituted as recommended.

Besides this, consequent on the recommendations of the Scientific Panel for Agricultural Economics, Statistics and Marketing and Standing Committee on Agricultural Economic, Statistical and Marketing Research, a seminar on 'Methodology of studying Agricultural Productivity' will be arranged in August, 1970.

6.

TRAINING ACTIVITIES

The Institute of Agricultural Research Statistics conducts training in agricultural and animal husbandry statistics mainly for three groups of students. The first group consists of research workers in agricultural and animal husbandry fields whose primary interest is not statistics but for whom knowledge of statistics is essential in their research work. Two courses called the Junior Certificate Course and the Senior Certificate Course of six months and one year duration respectively are conducted for their benefit. The second group consists of those deputed by State Governments/Research Institutes who have post-graduate degree in mathematics or statistics and possess experience of handling statistical data in a responsible capacity. The students in this group qualify themselves as professional statisticians in the fields of agriculture, animal husbandry and allied sciences. Two courses called the Professional Statistician's Certificate Course and the Diploma Course, each of one years' duration are conducted for their benefit. In the latter course the student is required to work on a research project for a whole year and submit a thesis thereon which should be such as to form the basis of a publishable paper. The third group consists of students who wish to qualify for the M. Sc. and Ph. D degrees in agricultural statistics awarded by the Post-Graduate School of the Indian Agricultural Research Institute. The major course in statistics for this group of students are offered at this Institute while the minor courses in agricultural disciplines are given at the Indian Agricultural Research Institute.

During the year under report, seven students were declared sucessful in the Professional Statisticians' Certificate Course and 17 in the Senior Certificate Course on the basis of the examination held in June, 1969. Three foreign students, one each from Syria, Philippines, and Iraq completed their training in I.A.R.S. Two of them also qualified for this Senior Certificate Course. Examination for 14 students for the Junior Certificate Course of which two were foreign students was held in January, 1970. Two trainees from South Vietnam completed their training in Machine Tabulation in January, 1970. Eight students were awarded M.Sc. degree and one was awarded Ph.D. degree in agricultural statistics. The theses of six students were approved for the award of diploma in agricultural and animal husbandry statistics. In the new degree courses which were started from October 1969, 13 students including four departmental candidates were admitted to the

M.Sc. course and two students including one departmental candidate were admitted to the Ph.D. course.

In all 25 seminars of various topics of interest were delivered during the year under report by the officers and students of the Institute. In addition, a number of special lectures were given by several eminent statisticians from foreign countries and the F.A.O., who visited India during this period. Dr. R. R. Bahadur, Professor of Statistics, Chicago University, U. S. A., delivered a course of lectures on "Large deviation theory and Satistical Inference" from 14th to 24th March, 1969. Dr. J.S. Rustogi, Professor of Mathematics of Ohio State University, U.S.A., gave a series of eleven lectures on "Sequential decision theory" in July, 1969. Besides, Dr. H. S. Khamis of the F.A.O., Dr. J.N.K. Rao of the University of Texas, U.S.A., and Professor P.S.R.S. Rao of the University of Rochester, U.S.A., delivered lectures on various topics for the benefit of staff and students of the Institute.

Regular trainees of various courses conducted by the Central Statistical Organisation visited the Institute for specialised training in agricultural statistics and sampling techniques. Students from the department of Statistics, Andhra University, Waltair, Government Agricultural College, Jammu, and Gujarat College of Veterinary Science and Animal Husbandry also visited the Institute during this year. The students of the Junior Certificate, Senior Certificate, and the Professional Statisticians' Certificate Courses visited the Indian Agricultural Research Institute, New Delhi, and the National Dairy Research Institute, Karnal. The students of the Senior Certificate and the Professional Statisticians' Certificate Courses also visited the Indian Veterinary Research Institute, Izatnagar, during the year under report.

7.

DATA PROCESSING

The Institute is equipped with an Electronic Computer—an I.B.M. 1620 Model II with Floating Point Arithmetic operations and Index Registers, 3 Disk Drives, a Card Read/Punch and an On-line Printer. In addition, it has 40 punching and verifying machines and 10 pieces of tabulating equipment like Sorters, Collators, Reproducing Punches, Tabulators etc. in the 80 column and 40 column ranges.

During the year under report, the work of coding, punching and verification, relating to the various research projects of the Institute, undertaken in this Unit, expressed in terms of number of cards punched and verified, came to approximately 3 million cards. About 1600 listings and 650 tables were turned out on the tabulating equipment.

Almost the entire statistical work of the Institute turned out during the year, was programmed on the Electronic Computer. Throughout the year, Electronic Computer was run in two shifts, each of six hours duration. Besides, special shifts were organized to cope with the rush of work during peak periods.

Apart from the Institute, the facilities of the Computer Centre continued to be utilised by the staff and the students of I.A.R.I., the Central Agricultural Research Institutes Under the Indian Council of Agricultural Research, various Agricultural Universities and other bonafide scholars and research workers of Agricultural Colleges.

The students of M. Sc. and Ph. D. courses at I.A.R.S. also continued to utilize these facilities for the processing of data and solution of their research problems. Thesis problems of a large number of students of I.A.R.I. from the various Divisions were programmed and executed on the Electronic Computer during the year.

The installation of the Electronic Computer has given a powerful fillip to the research activities not only of the Institute, but also that of the above mentioned Organisations which have been using the facilities of this Centre. The time lag between the collection of data and the publication of results has been considerably reduced. Deeper and sophisticated analysis is now being carried out. Many a research problems which were not formerly attempted because of the computational difficulties involved, are now being undertaken. More and more students are using

complex designs and are seeking the help of the Electronic Computer for programming their research problems.

The demand for time on the Electronic Computer has, therefore, been progressively increasing and it is now proposed to increase the working hours of the Centre to 18 hours a day as soon as the extra staff required for this purpose is in position.

Among the outside users, special mention may be made of the agricultural universities of Ludhiana and Pant Nagar and Rockefeller Foundation, who made extensive use of the system for the thesis work of their M Sc and Ph.D students and for analysis of data collected in the various research schemes respectively. The Directorate of Economics and Statistics also had their research work programmed on this Electronic Computer. Particular mention may be made of the linear, quadratic and exponential growth rates of area, production and productivity of various crops and States which were programmed on this Electronic Computer.

During the year under review, an extensive use of the I.B.M's application programmes like LP system 1620 and 'Universal Function Fitter' popularly known as "SUFF" was made.

During the year under report, the Computer Centre System actively participated in the training programmes of the Institute. Apart from In-service training, Course A.S. 129 dealing with statistical methods and computer analysis was given to M.Sc. (Agricultural Engineering), M.Sc. (Agricultural Statistics) and other students of the Post-Graduate School of the Indian Agricultural Research Institute.

Dr. Carl F. Kossack was assigned to the Institute by the F. A. O. as a 'Data Processing Expert', during the year. Dr. Kossack is the Head of the Department of Mathematics Statistics and Computer Science in the University of Georgia, U.S.A. He had earlier worked in Pardue University and with the International Business Machines, U.S.A.

Dr. Kossack has prepared a plan for the reorganisation of the Computer Centre so that it may :-

(i) act as a service centre for the entire agricultural community of Delhi.

(ii) undertake research in Computer technology and

(iii) organise training in programming and Computer technology.

He has also suggested that the Computer Centre should take up new applications and the Electronic Computer should not only be used as a fast calculator, but also as an information processor.

8.

BASIC RESEARCH

It is observed that in many agricultural research and other institutes only very simple designs are used for various types of experiments. One of the reasons for such action is that the analysis of other types of designs is somewhat complicated. This is true particularly for asymmetrical factorial experiments for which many times the less desirable split plot designs are adopted. For improving the situation a straight forward and easy to work method of analysis of confounded asymmetrical factorial designs has been evolved in the Institute as a part of the research work of one of the Diploma students.

One of the objectives of factorial experiments is to obtain from the data collected through them an optimum combination of the levels of the factors included in the experiment. This purpose is not served by studying the main effects and interactions of the factors. For this, fitting of response surface becomes necessary. For such purpose there are special designs called response surface designs. One of the Ph. D. students worked on the problem of finding suitable criteria for the choice of such designs in different situations. Several new series of designs were also obtained.

When observations are available from an experiment conducted over several places and years, the usual method of analysis is to study the over-all treatment effects and also the interaction of the treatments with place as well as years. A Diploma student attempted to study this problem through an alternative method. This method attempts to work out a stability coefficient for each of the treatments. The lower the coefficient the more stable is the treatment over varying environments. Those treatments which yield highest and at the same time show a smaller value of the co-efficient are considered fit for recommendations. Usually nitrogen was found to be having higher value of the coefficient indicating thereby that nitrogen is very much sensitive to change of environment.

For collection of data through sample survey the technique of systematic sampling is very easy to work but this method has the drawback that no valid estimate of sampling error is obtainable. One of the Diploma students modified the existing systematic method of sampling by combining systematic and cluster sampling techniques. This method is easy to work and supplies at the same time estimate of sampling error.

9.

PUBLICATIONS

Publications by the officers and members of staff and students of the Institute are listed in Appendix II. A list of dissertations approved for the award of Ph. D. and M. Sc. degrees and the Diploma in Agricultural Statistics of the Institute is given in Appendix I.

10.

SUMMARY OF THE REPORT

10.1 *Statistical research in agricultural sciences.*

10.11 *All India coordinated agronomic experiments.*

The analysis of data of 7,200 experiments collected from 90 districts all over the country under the All-India coordinated agronomic experiment scheme showed that high yielding varieties of different cereals like IR-8 (Rice), S-227 (Wheat), CSH-1 (*Jowar*), HB-1 (*Bajra*), and some of the maize high breeds out-yielded the local varieties even without the application of fertilizers. The average response of exotic varieties of rice to 60 kg. N/ha was more by 200 kg/ha than that observed in case of local varieties. The application of 60 kg. N/ha to Kalyan Sona gave an average response of 1000 kg/ha. An increase of 40 to 80 per cent in response was observed when the dose was doubled. Response to phosphorus and to potassium in presence of N and P were also observed in some areas.

10.12 *Model agronomic experiments.*

Results of 356 complex experiments spread over 44 model agronomic centres showed that the high yielding exotic varieties performed better than the locally improved varieties. The response to nitrogen was almost universal and varied from 500-2000 kg/ha on rice and wheat at 60 kg. N/ha. The additional response to 120 kg N/ha varied from 300 to 800 kg/ha on rice and 500-1500 kg/ha on wheat. The response to phosphorus was good at a number of centres, while that to potassium was moderate and was observed at a few centres. On wheat, at Ludhiana, highest yield was obtained when irrigation was applied at 70 per cent available moisture. Delay in irrigation decreased the yields. On this crop, a seed rate of 100 kg/ha. gave the best yield for optimum date of sowing. In the multiple cropping experiment, a production of 14.3 tonnes per hectare of grains was obtained with the rotation maize-wheat-chana at Pantnagar and rice-rice-rice at Tirupathi.

10.13 *Yardsticks of additional production.*

The yardsticks of additional production of rice (un-husked) evaluated from the data of about 3,200 experiments conducted on cultivators' fields were 11.2 tonnes per tonne of nitrogen for IR-8, 11.5 for TN-1, 9.4 for locally improved varieties and 8.0 tonnes per tonne of nitrogen for local varieties of rice in the *kharif* season when the application was at the rate of 60 kg. N/ha. Yardsticks o

additional production evaluated for application of phosphorus at 30 kg. P_2O_5/ha over 60 kg. N/ha were 1 .2, 8.0, 10.5 and 6.8 tonnes per tonne of P_2O_5 respectively for these varieties. Yardsticks of additional production in tonnes per tonne of K_2O evaluated for 30 kg. K_2O/ha over 120 kg. N/ha and 60 kg. P_2O_5/ha were 5.7 for IR-8, 9 9 for TN-1, and 6.1 for locally improved varieties.

The unit dealing with studies in agricultural sciences also attended to compilation of National index of field experiments, economic analysis of manurial experiments conducted on gram and *arhar*, pilot studies on preharvest forecasting of yield of jute crop and conducting sample surveys for studying the incidence of pests and diseases of rice crop.

10.2 *Statistical research in animal sciences.*

A study of comparative merits of selective breeding and grading up of local Bengal type of cattle with Haryana bulls, showed that graded cows were significantly superior in regard to milk yield per lactation, yield per day of lactation and yield per day of calving interval. The average first lactation yield of graded cows was about 180 kg. more as compared to 375 kg. of those in selective breeding group. However, taking into consideration their feed per kg. of milk and age at first calving and calving interval as well, it appeared that grading up of local Bengal type of cattle with Haryana would not be economical. The study of performance of various grades obtained by cross breeding Rampur Bushair ewes with Polwarth rams showed that the graded Polwarth ewes were superior to Rampur Bushair ewes in regard to greasy fleece weight. The annual greasy fleece weight of half breds was 1.360 kg. for 3/4ths it was 1.330 kg. while in case of Rampur Bushair ewes it was 1.177 kg. The fibre diameter decreased in 3/4ths compared to half breds. From this study and other studies carried out on various cross bred sheep from exotic breeds it appears that before finally recommending the 3/4ths graded exotic sheep as suitable for local conditions, it would be advisable to secure more information on the performance of 3/4ths grades. The correction factors for obtaining density of milk at 20°C and 27°C were worked under the project for standardization of methods for estimation of solids-not-fat in milk. These correction factors would be of valuable help in arriving at S. N. F. content of milk at various temperatures From a survey to estimate the cost of raising young stock and maintaining adult cattle and buffaloes carried out in Hissar district of Haryana State, it was estimated that the cost of rearing a male cow calf from birth till three years of age was Rs. 695/- and for female cow calf it was Rs. 425/-. In the case of female buffalo calf, the cost of rearing was about Rs. 615/-. It was observed that the prices realized by the farmers are compara-

tively less than the cost on rearing these calves. In order to make the cattle rearing enterprise more remunerative in rural areas of the breeding tract, it would be essential to provide adequate market facilities as well as to take steps to reduce the cost of rearing.

Besides these, studies were also undertaken for standardization of the procedure of sampling from fleeces for the study of wool quality for evaluating the economics of raising cattle and buffaloes for obtaining cost of production of sheep and wool, for observing the impact of milk supply schemes on rural economy in milk collection areas, for obtaining indices of cost of production of milk, for estimation of area of grazing land and its utilization, for obtaining genetic correlation and selection indices relating to cattle and for investigating into the suitability of sampling plans for milk recording in key village blocks.

10.3 *Sampling investigations.*

Under the sample survey investigations conducted by the Institute, a reliable method has been evolved for obtaining reasonably accurate estimates of extent of cultivation and production of pepper as well as for studying the practices followed by farmers in its cultivation. A study of the data collected on crop yields and other related characteristics of high yielding varieties of cereal crops in I.A.D.P. districts indicated that during 1968-69 the increase in yield rate of high yielding varieties of paddy over the indigenous varieties ranged from 60 to 100 percent in the districts of Sambalpur, Surat, West Godavari, Alleppey, Palghat and Cachar. In the districts of Raipur and Shahabad it was more than 40 per cent, and in the districts of Mandya and Thanjavur, the differences were moderate. The differences in yield rates of high yielding varieties of wheat and local varieties were of the order of 150 per cent in Jammu, 90 per cent in Ludhiana, 70 per cent in Shahabad and 70 per cent in Aligarh. A survey conducted to assess the impact of high yielding varieties programme in Coimbatore, North Arcot, South Arcot and Chingleput districts in 1968-69 showed that IR-8 was grown in all these districts. The results indicated that the yield rate of IR-8 was higher than that of local varieties by 93 per cent in Coimbatore, 143 per cent in North Arcot, 80 per cent in South Arcot and 91 per cent in Chingleput. Besides the survey mentioned above, sampling investigations were conducted by the Institute on fruits, vegetables and cashewnut crops during the year. Surveys were also taken up for studying fertilizer practices of farmers; for obtaining block-level estimates of agricultural production and for estimating livestock products and practices of farmers in rearing livestock.

10.4 Training in agricutural statistics.

Under the research and training programme of the Institute, 17 fellowships were awarded to students in various courses and 11 fellowships given to earlier post-

graduate students were continued. Five foreign students completed their training during the year. One dissertation for Ph.D., eight dissertations for Master's degree and four dissertations for Diploma were approved for the award of degree or diploma as the case may be. Twenty-one technical papers were published by the officers of the Institute during the year in standard journals both within the country and outside.

10.5 Data processing.

In the mechanical and electronic data processing unit of the Institute, 3,000,000 cards were punched and verified. About 1600 listings and 650 tables were prepared on the tabulating equipment. Almost the entire statistical work of the Institute was programmed on the IBM-1620 Electrical Computer installed at the Institute.

10.6 Basic research in design of experiments and sampling.

A straight forward method and easy to work method of analysis of confounded asymmetrical factorial experiments has been evolved.

Certain criteria for the choice of the response surface designs have been evolved. Several new series of response surface designs have also been obtained.

An alternative method of analysis of groups of experiments by finding the value of a stability coefficient for each treatment has been evolved. This method gives an idea if a treatment can resist adverse conditions and still contribute to better performance.

An alternative method of systematic sample capable of providing estimate of error variance has been evolved. This method is easy to work like the existing method of systematic sampling.

APPENDIX I

List of dissertations approved for the award of Ph. D. degree, M. Sc. degree and Diploma in Agricultural Statistics.

Ph.D. Degree

1. DEY, ALOKE. Some investigation on response surface designs.

M.Sc. Degree

1. AGGARWAL, S.B. Estimation procedures in cashewnut surveys.
2. BABIKER, G.E.K. Statistical study of borrowings and pattern of expenditure of cultivators in Ludhiana district.
3. KUMAR, PRADUMAN. Factors influencing the economy of milk production.
4. MAKIN, B.K. Estimation of the incidence of pests and diseases in paddy crop.
5. MISRA, A.K. Analysis of two letter truncated factorial experiment.
6. SATYA-PAUL. On regression method of analysis of incomplete block designs with quantitative treatments.
7. SETHI, I.C. Size of sampling units for estimation of number and production of eggs in poultry.
8. SHUNMUGA SUNDRAM. Genetical structures of population as discrete, finite stochastic processes.

Diploma.

1. RAO, G.S.P. Use of information on ancillary characters in I.A.D.P. Assessment Survey.
2. RAWLO, S. An alternative approach for interpretation of data collected from groups of experiments.
3. RAY, S. A unified method of analysis of confounded factorial experiments.
4. SINGH, PADAM. Contribution to systematic sampling.

APPENDIX II

List of papers published during the year 1969.

1. ABRAHAM, T.P., KHOSLA, R.K. and AGGARWAL, K.N. Uniformity trials on black pepper. *Ind. Jour. Agril. Sci.* **39 :** *790-806, 1969.*

2. ABRAHAM, T P., KHOSLA, R.K. and KATHURIA, O.P. Some investigations on the use of successive sampling in pests and diseases survey. *Jour. Ind. Soc. Agri. Stat. Vol. 21, No. 2, 1969.*

3. BANERJEE, A.K. and DAS, M.N. On a method of Construction and analysis of any confounded asymmetical factorial design. *Cal. Stat. Ass. Bull. Vol. 18.*

4. DAS, M.N. and RAO, S.V.S.P. On construction and analysis of balanced-n-ary designs, *Jour. Ind. Stat. Ass. Vol. 6 (in press).*

5 DAS, M.N. A note on admissible estimators. *American Statistician, April.*

6. DEY, A. and DAS, M.N. Some results in matric algebra. *Jour. Maths. Soc.*

7. JACOB, T., AMBLE, V.N., MATHUR, M.L. and SUBA RAO, A. Milk production function and optimum feeding schedules. *Ind. Jous. of Agri. Eco.*

8. JAIN, V.C. A note on one and two stage sampling from finite population and effect of enlargement of P.S U's on the variane in two stage design. *Sankhya Series B, Vol. 31, Parts 1 and 2.*

9. KATHURIA, O.P. and SINGH, DAROGA. On two stage sampling on successive occasions. *Aust. Jl. Statistics, Vol. 11.*

10. KULSHRESHTA, A.C. and DAS, M.N. On methods of decoding linear codes and detecting quasi perfect codes. *Jour. Math. Soc.*

11. MAINI, J.S. and MURTY, V.V.R. Estimation of annual meat production using random sample survey technique. *Agricultural Situation in India, October.*

12. NARAIN, P. and ROBERTSEN, A. Limits and duration of response to selection in finite populations : the use of transition probability matrices. *Ind. Jour. Heredity. Vol. 1 pp. 79-97.*

13. NARAIN, P. A note on the diffusion approximation for the variance of the number of generations until fixation of a neutral mutant gene. *Genet. Res. Camb. Vol. 15.*

14. RAUT, K.C. and AMBLE, V.N. Breed variation in cost of milk production. *Agri. Situation in India, Feb. 1969.*

15. RAO, S.V.S.P. and DAS, M.N. Incomplete weighing designs through balanced ternary designs. *Jour. Ind. Soc. Agri. Stat. Vol. 21.*

16. RAJAGOPALAN, M. and MAINI, J.S. Wool production and sheep keeping practices in some important sheep breeding tracts of India. *Agricultural Situation in India, September.*

17. SETH, G.R., SARDANA, M.G. and KHOSLA, R.K. Field losses caused by pests and diseases in paddy crop. *Jour. Agri. Situ. Ind. Nov. 1969.*

18. SETH, G.R., SARDANA, M.G., KHOSLA, R.K. and KALYANARAMAN, V.M. Preharvest losses due to incidence of pests and diseases in paddy crop. *Ind. Jour. Agri. Soc. Vol. 39, 1969.*

19. SADASIVAN, G. Designs for paired and triad comparisons. *Jour. Ind. Soc. Agri. Stat. Dec.*

20. SINGH, K.B. and GOEL, B.B.P.S. Utilisation of bullock power in erstwhile Punjab State. *Agricultural Situation in India, July.*

21. SINGH, D., MURTY, V.V.R. and GOEL, B.B.P.S. Comparison of some estimates of milk production. *Jour. Ind. Soc. Agri. Stat. Vol. 21, No. 1.*

List of papers accepted for publication.

1. GOEL, B.B.P.S., RAO, D.V.S. and MURTY, V.V.R. Bovine milk production in India during 1966 and its per capita availability. *Agricultural Situation in India.*

2. NARAIN, P. The average number of generations required to attain limits of genetic improvement. *S.A.B.R.O. Newsletter Vol. 2, No. 2.*

3. SADASIVAN, G. An Index for measurement of health in Applied Statistics. *J.R.S.S. Series C.*

4. SAHA, G.M. and DAS, M.N. Construction of partially balanced incomplete blo k designs through 2^n factorials and some new designs for two associate classes. *Jour. Combinatorial theory.*

5. SETH, G.R., SARDANA, M.G. and Malik, C.L. A note on methodology for studying the influence of weather on crop yields. *Ind. Jour. of Meteorology and Geophysics.*

6. SETH, G.R., SARDANA, M.G. and KHOSLA, R.K. Assessment of loss in yield of paddy crop due to incidence of pests and diseases in West Godavari district. *Oryza.*