ON CONTRIBUTIONS OF VINAYAK GOVIND PANSE*

BY

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[*Only 18 months ago we had an occasion to felicitate Dr. V.G. Panse on his 62nd birthday by presenting him with a volume of articles by his colleagues, students and friends in appreciation of the great services he rendered to the development of agricultural statistics in the country. Ill as he was, he nevertheless was moved and overwhelmed on seeing the book. He read the titles of the various papers, enquired about the progress of work in the different fields and expressed his keen desire to see his numerous colleagues and friends. He showed the same determination to overcome his ailment which he showed during his active years in developing agricultural statistics, often against very great odds. Till almost the last moment he was alert, active and gave every indication that he might recover. We reproduce in this number an assessment of his contributions to agricultural statistics written by his distinguished colleague and close friend, Dr. P. V. Sukhatme. .....—Ed.*]

1. Statistical Method in Agricultural Research. Born in Maharashtra on 11 January, 1906, Dr. Vinayak Govind Panse received his early education at Nasik and graduated in 1927 from the University of Bombay with mathematics, chemistry and physics as his subjects. He started his career as Agronomy and Chemical Assistant at the Institute of Plant Industry at Indore in 1927. It was here working with Dr. Hutchinson, the noted plant breeder, that Panse developed his interest

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in the use of quantitative techniques in agronomy. Plant breeding in those days was more an art than a science depending for the most part on the judgment and skill of the plant breeder. Mass selection, which was the method in use and which consisted of choosing from the material under selection a number of plants which appeared to have superior value, bulking the seed from these, raising from the seed the next generation and continuing selection in this generation, was obviously inefficient in that the selection was subject to a large amount of environmental or non-genetic variability present in the field. Instead of bulking the seed obtained from different selected plants, breeders saw the need to sow it in separate progeny rows and to make the selection on the basis of progeny means. The selections thus made would be subject to only a fraction of the environmental variation to which the individual plants are subject. Nevertheless, there was no assurance in the method that the estimates of progeny means would be unbiased. The small and variable amount of seed presented further difficulty in arranging replicated trials which could provide sufficiently accurate estimates of the progeny means. The difficulties in conducting randomised replicated tests were particularly large in the early stages of breeding when the material was even more heterozygous as the genetic values contributed to experimental error. Hutchinson and Panse set about adapting the randomised block and split plot designs to the plant breeding material at Indore and succeeded in developing what is known as replicated progeny row and compact family block designs. The results of their work were publised in the Indian Journal of Agricultural Science (1935, 1937).

This, however, was only a beginning of more significant contributions to statistical methods in quantitative genetics. For, apart from an efficient method of field testing, a factor of fundamental importance in plant selection is the recognition of the fact that only a part of variability in plant population is genetic, the rest being environmental. The breeders' success depends upon the initial choice of material containinig a high degree of genetic variability and exploiting it to the maximum extent possible. Panse (1940) showed how the genetic component of observed variability could be estimated by taking the regression of progeny means on parental value and explained the importance of selecting plants on their deviations from plant means rather than on their own values. He took the study of quantitative techniques a lot further by introducing appropriate genetic models which helped to bring out the effects of the number of segregating genes, the magnitude of their action, the modification due to dominance

and the influence of environment on progress due to selection. This work which Panse carried out under the guidance of Sir Ronald Fisher in England was published in the Journal of Genetics (1940 *a*) and Annals of Eugenics (1940 *b*) and earned him Ph. D. from the University of London. In the normal circumstances, Dr. Panse would have continued this fruitful line of work but war interrupted his studies and he returned to India in June 1940.

On his return Panse was appointed to the newly created post of Statistician at the Institute of plant Industry at Indore. It was then that I first came in contact with his work. I was statistician at the Indian Council of Agricultural Research in New Delhi and had just commenced a statistical analysis of the 10 years' data of a goat-breeding project at Etah in U.P. Drawing extensively on the methods developed by Panse, I found to my astonishment and dismay that the improvement in milk yield recorded in the goat breeding project at Etah was not so much due to a genetic improvement of the stock through selection as due to extraneous factors. Animal breeders naturally found it difficult to accept that a project run by an eminent breeder over 10 years could possibly have failed in recording a real improvement, particularly when year after year the reports showed appreciable increases in milk yield. However, the results of the statistical study left little doubt that the original stock did not have sufficient genetic variability and: that in consequence no substantial progress could be achieved in improving the genetic potential of the herd for milk. But for the help in this work given by Dr. Panse, it would have been difficult to convince the animal breeders in those days of the need and value of satistical methods in planning animal breeding programmes and assessing their results. It was in fact the success of this statistical appraisal which led to the expansion of the statistical unit of the Indian Council of Agricultural Research (I.C.A.R.) which was later to form a full-fledged Institute of Agricultural Research Statistics under the direction of Dr. Panse himself. The influence of Dr. Panse's early work can be seen in the increasing recognition, by animal husbandry workers all over the country, of the need for planning animal experiments based on statistical principles and for using statistical methods in the appraisal of their results, It led to important contributions from Panse himself and from his staff and students in the Division, notably from V.N. Amble, T.R. Puri and S.D. Bokil.

In 1946 Panse was promoted to the post of Deputy Director, Research, of the Institute of Plant Industry at Indore and later was

made its Director. Panse's vision was so broad that no one could possibly have better filled this post which he held with such distinction until 1951 when he moved to Delhi as Statistical Adviser to I.C.A.R. It was during the years 1946-51 that I had an opportunity of frequently visiting the Institute of Plant Industry at Indore and to see at first hand the variety of experimental designs used on the farm, their simplicity and efficiency, and the use of statistical methods in the analysis of the simple experiments on cultivators' fields in districts around Indore which provided a wealth of information on response to fertilizers and other treatments with their sampling errors. It was discussion of the various problems of experimental designs and statistical methods which agricultural research workers faced in their work at the farm and in the cultivators' fields which led Panse and me to write jointly a book on Statistical Methods in Agricultural Research which continues to be the leading college textbook all over the country. The book was published by I.C.A.R. in 1954 and has already gone through three editions. It was translated into Spanish by Miss Ana Maria Flores and published by Fondo de Cultura, Mexico. It was mainly the work of Dr. Panse and bears the stamp of his practical knowledge acquired in the field.

2. *Sampling Techniques for Estimating Yield.* The Statistician at the Institute of Plant Industry was also the Statistician to the Indian Central Cotton Committee (ICCC) and in this latter capacity Dr. Panse was asked in 1941 to make proposals for improving the statistics of cotton production. Given adequate supervision, the ICCC saw no particular difficulty in obtaining reliable statistics of acreage under cotton through existing machinery in the cadastrally surveyed areas of the country. What the Committee wanted was a sampling method of objectively estimating the yield per acre in place of the subjective method in vogue in the country.

The ICCC had before it two schemes of research for estimating yield rates, one by Panse and the other by Prof. Mahalanobis. In his scheme Panse emphasised that any sampling method must fit into the existing administrative structure and take cognizance of the fact that the departmental staff and the farmers were already familiar with crop-cutting procedures. Mahalanobis, on the other hand, following earlier work by Hubback came forward with a scheme involving experiments with plots of small sizes—three or four concentric circular plots with radius of 2′, 4′, 5′, and 7½′. The two schemes were considered by the ICCC at a meeting of experts in 1942 which

I had the privilege to attend. It was there that I first saw Panse putting forward justification for his scheme, not only based on sound statistical methodology but, what was more important, from an intimate knowledge of the difficulties one has to face when dealing with the cotton crop. The ICCC approved Panse's scheme. The approach was tried in one district to start with, and extended to two more districts in the subsequent year. The results were checked against the amount of cotton which came for ginning into the mills after making appropriate allowances for the import and export out of the selected districts. The latter data were gathered from officers specially posted for the purpose on the borders of the districts. The ICCC was satisfied with the results, approved the approach and came out with a recommendation in favour of asking the State Governments to adopt the method developed by Panse as a permanent solution for improving the forecasts of the production of cotton in the country.

It was not, however, the statistics of the cotton crop alone which benefited from the work of Panse. The method of crop-cutting surveys developed by him had a tremendous impact on the work which I.C.A.R. was asked to undertake at the time for improving statistics of acreage and yield of principal crops all over the country. So rapid was the progress of I.C.A.R. work that yield surveys based on the method became an annual routine in most States within the course of a few years. The surveys provided not only the State yields with a high degree of precision but also district yields with a reasonable margin of error. In 1951 Panse took over the direction of I.C.A.R. work himself and set out to extend the sampling technique to other crops, but the transfer of this work to National Sample Surveys (NSS) in 1952 blocked further progress. Panse thereafter devoted his energy and initiative to the development of sampling techniques in other agricultural fields, which we shall discuss later.

It must not be inferred that the progress made in estimating yield rate was easy to achieve. In particular, this work remained a matter for continuous criticism and opposition from Prof. Mahalanobis. Panse always believed that scientific work to be progressive must evoke criticism but criticism voiced through normal channels in scientific journals is one thing and criticism made through the channels of foreign expertise is another. Some of the foreign experts ostensibly invited for the purpose of lecturing in statistical theory, were deliberately involved in the controversy over matters of which

they themselves had little firsthand knowledge. The Government itself in those days, it must be said, had a weakness for the advice of a foreign expert. The story of those days will perhaps never be known to most statisticians. Fortunately for India's statistics, Panse was persuaded to remain at his post but the eventual transfer of the work to NSS in 1952 deprived I.C.A.R. of the opportunity to gain from his ability and initiative in placing agricultural statistics of yield rates on a sound basis. The truth of this statement is brought home when one sees that India's statistics of crop yields remain much at the stage where they were left in 1952 with little or no further progress in the use of objective sampling methods by the State Governments.

Space does not permit me to deal at any length with even the basic issues of this controversy but no bibliographical note on Panse's contributions can have even a sense of completeness if I fail to mention here the way Panse felt about the whole problem. Perhaps the best way of doing this is to quote a few extracts from his own writings. This is how, for example, Panse summarised his approach to the method of estimating yield (IJAS, 1948, 1951).

"An examination of the above methods of estimating crops yields by random sampling, first tried by Hubback and later elaborated by Mahalanobis, leads to the conclusion that a new approach to the problem is needed if objective methods of crop estimation are to be introduced successfully in India. We have to take into account the existing administrative machinery and the fact that experimental harvesting of sample plots or crop cutting experiments is already a familiar routine both to government officials and farmers in different States. Insistence on a very small size of the plot cut with a special apparatus and requiring a delicate technique, in place of the large plot marked by chains or measuring tape and pegs, emphasises an altogether subsidiary aspect to the problem. Employment of special moving staff required for conducting the survey by these methods would involve heavy additional expenditure to which administrations are naturally reluctant to commit themselves permanently, when departmental crop cutting experiments are being carried out by the usual staff as part of their normal duties. Crop yield surveys in Bihar and Bengal conducted by Mahalanobis have demonstrated that an ad hoc staff of travelling investigators is unsuited for crop cutting surveys. Sampling methods for estimation of crop yields to be acceptable to State Governments should, therefore, avoid any radical departure from the established departmental procedure for crop

cutting experiments, by making only essential changes to start with and the plan should be developed in such a manner that its permanent adoption will fit into the existing administrative structure and not necessitate any heavy additional expenditure on field staff. Once a start is made, however, gradual improvements in the design can always be introduced with the progress of work. These are the considerations that have guided us in developing the methods of random sampling-surveys for estimating crop yields, which we propose to describe in the present article.

To introduce a random sampling method for estimating yield, the only major change required in the traditional methods of harvesting sample plots is to ensure the selection of the plot for harvesting by a process of randomisation in place of the subjective selection by the experimenter. The problem is one of primarily convincing the administrator that a random selection of plots for crop cutting is both essential and practicable in the hands of the existing field agency. The number of plots to be harvested and their distribution over the tract as also the size of the sample plot are, however, matters to be settled by suitable experimentation. It follows that the yield survey should be so planned that while it fulfils its immediate objective, which is to give reliable estimates of yield for the tract surveyed, it should also furnish simultaneously technical information calculated to improve the efficiency of future surveys, so that yield estimates may be obtained with the requisite level of accuracy with a minimum expenditure of time and money and by maximum utilisation of available resources in the form of staff, ancillary information, etc."

What are the features of Mahalanobis' method; how did Panse evaluate them and come to formulate his own approach ? The following extracts from the same papers in the I.J.A.S. (1951) are noteworthy for the way in which he dealt with the question.

"The fieldwork is entrusted to ad hoc parties of investigators who are required to move rapidly from place to place during the harvesting season to cut sample plots The sampling is confined to those fields which are ready for harvest on the date of the investigator's visit to a place. A consequence of this method is that there is no guarantee that fields maturing at different times will be sampled for harvest in the proportion in which they occur in the population. The principle of randomisation requires that every field bearing the particular crop shall get due chance of being included in the sample. To achieve this objective, it is not only sufficient to select fields with

the help of random numbers but it is equally important to ensure that there are no subsequent omissions of fields with certain characters correlated with yield such as fields in which the crop was already harvested before the experimenter could reach the spot or those where the crop was not ready for harvest at the time of his visit. Such deviation from randomisation will introduce bias and result in an under or over-estimation of the average yield—according to whether the rejected fields were better or lower yielders than the rest. As a general rule, late maturing crops are more vigorous and yield more under normal conditions than early maturing ones. Applying this test to the surveys, proper randomisation is lacking. Rejection of fields for reasons given above was allowed and appears to be common, as investigators were supplied with lists of randomly selected fields containing many more fields than were to be actually sampled as a precaution against cases of getting fields with no crop at all or fields which had already been harvested. This difficulty and the consequent possibility of biased results has been recognised by Mahalanobis from the beginning, but is inevitable in his plan of fieldwork. The difficulty of selecting plots for sampling was mentioned in the report of the first crop cutting experiments on jute in 1939 and as an example it is stated that in one village 182 plots had to be examined to secure the required 23 plots for sampling. This difficulty is again referred to in the Bihar survey. "After struggling with the problem for many years," Mahalanobis (1946*a*) concludes that "it is becoming clear that crop cutting work to be done properly must be carried out by a comparatively larger number of investigators who could watch the crop as it grows and collect sample cuts at the right time from the fields situated in the neighbourhood of their normal places of residence."

"The results of the Bengal crop survey also serve to emphasise the unsuitability of this approach to the problem of estimating crop yields. Out of the 7,680 sample cuts each aimed at for jute and aus paddy in the Bengal survey, only 1,190 cuts for jute and 2,028 cuts for paddy were actually secured. These represent about 15 per cent of the cuts planned for jute and 25 per cent for paddy. The reason given is that as the investigators had to move from one block to another, they often found that a considerable portion of the crops had already been harvested. This means that the crop actually sampled was mostly in the late maturing portion of the total crop. The extreme seriousness of the risk involved in estimating production of food crops on such data is obvious. The situation in the aman paddy

survey was better in that about two-thirds of the sample cuts planned were actually harvested although even this proportion is far from satisfactory for giving reliable and unbiased estimates of yield. Mahalanobis' (1948) own comment on these results is a repetition of his remarks on the Bihar survey : "The crux of the whole matter is that it is essential that investigators should watch the crop as it grows and cut it as soon as ready for being harvested" ; but he has now come to the conclusion that the solution he had proposed earlier, *viz.*, employing a larger number of investigators, was not practical on account of the expense involved. He adds : "Unfortunately, crop cutting work cannot be done by an ad hoc staff recruited merely for this purpose ; because careful selection of personnel is essential and the staff has to be given proper training as otherwise the work would be too unreliable to be of any value. One way would be to have a sufficient number of additional hands provided in the area survey scheme who would be available for crop cutting work at the proper season. This, however, was not feasible within the sanctioned grant. The crop cutting work had to be done, therefore, by the area survey staff as best they could manage it." One solution of this difficulty is to entrust crop cutting work to land records or agricultural agency as part of their normal duties, which precisely is the basis of our own approach to this problem."

Any discussion of the technique of crop estimation would be incomplete without a reference to the aspect concerning the size and shape of plot in crop cutting surveys. Experiments carried out by I.C.A.R. (1943, 1945, 1947) had shown that plots of small size, such as used by Mahalanobis, give an overestimation of yield. This bias resulting from plots of very small size at least under Indian conditions is recognised by all workers but there is no unanimity of opinion concerning the stage at which it becomes negligible. Of this Dr. Panse wrote in 1948 what is pertinent even today.

"There can be no difference of opinion that with training and supervision the limit at which bias becomes negligible may be reduced. In our view, however, it is not enough to demonstrate that plots of size as small as 50 sq. ft. give unbiased estimates when handled by trained statisticians, nor is it adequate to say that very small plots such as circles of radius 2′ should give much less bias than that observed in our investigations. Such results or comments, in our view, have limited value for practical application in India where the employment of a special agency of statisticians for field work in crop

sampling work is out of the question and experiments have necessarily to be carried out by the local experimental staff in course of their normal duties. In recommending a method for routine adoption it is therefore of utmost importance to ensure that the method is not susceptible to obvious source of bias in the hands of the agency handling it."

Plot size continues to remain a subject of active research in the country even today. It has become one of those prestigious question for which funds will always be found irrespective of the need and significance of this research for immediate issue before the country. One only hopes that the practical side of the question so well stressed by Panse in the above quotation will not be forgotten in further research of the problem.

3. Area Statistics. When ICCC in 1942 asked Dr. Panse to make proposals for improving statistics of yield rates it saw no particular reason to question the accuracy of the statistics of acreage under cotton in the cadastrally surveyed areas of the country. There is a detailed and accurate frame available in these areas in the form of cadastral acreage maps. Simple objective methods of enumeration are employed. The data is collected in the course of normal administration by the local Patwaris by plot to plot enumeration, which ensures their completeness, and there is provision for adequate supervision. All the same, at a later date, the Committee asked Dr. Panse to investigate whether the method worked efficiently in actual practice. Since it was considered possible that the work might suffer from lack of attention, both from the primary agency and the supervisory staff. The main purpose of the enquiry was to ascertain whether the burden of work involved was excessive to be carried out in the course of normal work by the Patwaris and if there was any possibility of reinforcing supervision on a rationalised basis using sampling methods for the purpose. Short of appointing special field agencies to collect agricultural statistics, which luxury even the advanced countries could not afford, the Committee thought that this was the only way in which the required improvement, if any, in the collection of area statistics could be brought about.

Panse carried out a number of sample surveys to check the accuracy of area statistics and brought the results together which showed that the method of plot to plot enumeration in the cadastrally surveyed areas with Patwari agency worked satisfactorily in practice.

4. The Census of Agriculture. Panse made a significant contribution to the programme and progress of the decennial census of agriculture sponsored by FAO. Realizing that lack of basic data constituted a serious handicap to most of the developing countries in the preparation of their development plans, Panse saw in the census the first step in planning. At the same time he kept in mind the possible impact of census on the evolution of a sound and permanent system of current agricultural statistics. For two years, 1960-61, he worked as Regional Adviser for Agricultural Census in Asia and the Far East, visited a number of countries in the region to observe the agricultural census in operation and discussed the problem of census-taking with field workers, directors and other technicians engaged in planning, organising and conducting the agricultural census. He incorporated this experience and his thinking on the subject in a manual he wrote for FAO on the problems of agricultural census taking, with special reference to developing countries. In this manual Panse extended the concept of the agricultural census itself as an integrated system of surveys. The manual is available in all the official languages of FAO.

It would be rash to conclude that Panse favoured complete enumeration to sampling method for collecting information on items other than land use in the cadastrally surveyed areas. I cannot do better than quote his views from the same manual on agricultural census taking. Panse wrote :

"A view is sometimes expressed that an agricultural census by complete enumeration is a desirable undertaking even if the results are likely to be of imperfect quality and have a limited scope. This view, however, cannot be accepted lightly, for a supposedly complete enumeration census which is in reality substantially incomplete, would produce results of poor quality and is liable to present a distorted picture of the agriculture structure if carried out under conditions of difficult communications, an ignorant and suspicious peasantry providing biased information and an unmanageable larger number of qualified and illtrained field staff that must necessarily be employed. Non-sampling errors, such as biased responses, are likely to be appreciable even where the census is substantially complete and it may turn out that the results are consequently less accurate than those of a well-conducted sample census subject to responsibly small sampling errors. It is against this background that a decision whether to carry out a complete enumeration or to project a sample survey will need to be taken. It will also depend upon the level at which the results are required, that is, whether the results will be tabulated for the entire

country, for individual provinces, for individual districts or even for their administrative subdivisions. Of course, this decision need not be either a complete enumeration or a sample survey as the only alternative but could well be a combination of both."

5. *Extension of Sampling Techniques to Other Fields.* As mentioned earlier, Panse extended the application of sampling techniques to a number of other fields. Cost of production studies, estimation of catch of fish, estimation of livestock and their products, and evaluation of the intensive agricultural district programmes are a few examples of these fields. Space does not permit us to describe these applications beyond mentioning principal features of one or two of them.

The analysis and control of respondent bias were the principal features of his studies on cost of production. Results of the investigations carried out in different regions of India for three years under the auspices of the Research Progress Committee of the Planning Commission to compare two methods for collecting data for estimating cost of production on crops have con firmed this need for controlling non-sampling errors. One method consisted in locating an investigator in a selected village on a whole time basis to record on sample farms field operations and other items by daily physical observation. In the other method the investigator paid periodical visits, three or four times a year, to selected villages and interviewed farmers of selected holdings to oblain data for cultivation and other operations since his previous visit. The investigators who did the field work were trained men with an agricultural background. The investigators employed for the interview method had an additional qualification in agricultural economics. The interview method gave appreciably higher estimates of total inputs and components like human and bullock labour, and underestimated the items of total output. The conculsion was that when ad hoc staff visit the selected farms periodically and obtain information by interview the input factors are inflated and output factors are underestimated. However, when the field agency is stationed on a group of farms and watches the operations over the seasons, this bias largely disappears. The results of these studies are brought together in a book entitled *The Techniques of Cost Production Studies* which illustrates in a remarkably lucid style the need and importance of controlling non-sampling errors in surveys.

Fish catches are made all the year round by almost innumerable small units operating along the sea coast of India. The illiteracy and

Nevertheless, criticism continued to be made about the Patwari system and the reliability of the acreage statistics obtained by them. Some critics even went to the extent of condemning the system as being incapable of providing reliable statistics. The principal critic was Prof. Mahalanobis. Using the field agency of the National Sample Survey, he conducted a check on the work of the Patwaris in four northern States of India in 1949 and 1950 and showed that Patwaris over-estimate acreage under wheat to the extent of 10-26 per cent in the different States with an average overestimate of 15 per cent. On the other hand, cash crops like sugarcane, linseed and other oil seeds were shown to have been underestimated, usually more than 50 per cent. The results of this enquiry caused concern in the Government of India. Careful examination, however, of the results showed that the discrepancies between the Patwari records and those of the NSS investigators were due to *the differences in concepts and definitions used by the two agencies.* Sugarcane, for example, although planted in the months of January to March, is entered in the Patwari register only at the time of crop inspection during September/ October. This is in accordance with the Land Records Manual of Instruction for recording crop acreage. The NSS investigator, on the other hand, noticing the crop in the field during his inspection in April and finding no entry by the Patwari recorded it as a mistake. Again, linseed and other oil seeds grown mixed with wheat and other cereals are not recorded, the entire area being shown against the cereals. This is in accordance with the Land Records Manual. At the time of final computation of crop acreage, however, an appropriate allowance is made in the area under cereals for this omission. These facts were found to account for the observed discrepancies in acreage under wheat as well as oil seeds. Clearly, the sample check conducted by Prof. Mahalanobis was not valid in critically assessing the efficiency of the administrative enumeration procedures.

A number of independent sample checks were subsequently conducted by Panse himself which confirmed that leaving aside questions of concepts and definitions, the acreage statistics derived from the Patwari census were on the whole satisfactory. All over the world in many advanced countries statistics of crop acreage are in fact collected by annual census throught the available administrative machinery, such as village or municipal committees. Human nature is also the same everywhere. It is ridiculous to suggest that an agency belonging to one department is more trustworthy than that belonging to another. As Panse put it, the integrity of our statistics

like our activities will develop with our national character. Given adequate supervision there is therefore nothing in the census method of plot enumeration in cadastrally surveyed areas to doubt the accuracy of acreage statistics. Panse was therefore rightly concerned that the country should spend its energies in condemning the Patwari system instead of attempting to strengthen it and to extend it to unsurveyed areas where it did not exist. In any case, when the data is needed for very small administrative units as a basis for regional planning or in order to provide benchmark information for current agricultural statistics, sampling methods may be uneconomic and complete enumeration inevitable except for items which do not lend themselves to complete enumeration. This is not to say that Panse did not recognise the role of sampling method in improving acreage statistics. Indeed, in his view, sampling had an indispensable role in controlling and improving the quality of fieldwork of the primary enumerators and in speeding up the availability of the results of the census. In particular, sampling had a great role in rationalising the supervision of Patwari work and in improving the reliability of early forecasts of crop acreage. A coordinated scheme for the purpose was drawn up by I.C.A.R. in agreement with the States but after transfer of the work to NSS it was not possible to implement it.

Panse also welcomed the use of sampling method for areas which were not cadastrally surveyed, which did not have a Patwari agency and which, in consequence, could not possibly use a census method of plot enumeration. Indeed, he himself gave a lead by organizing an area survey based on sample method in the unsurveyed State of Orissa. However, to condemn what had been developed over decades in the States having Patwari system, without trying to improve it with the help of sampling methods, such as randomised supervision, was to waste the limited sources available for the improvement of statistics. It was his hope that the NSS Organisation would exercise a healthy influence on the Patwari system by supplementing the efforts of the State Governments by providing the needed supervision on a sampling basis. With its federal system of government and the main responsibility for agriculture lying with the States, he maintained that what India needed most was agreement on methods of collecting statistics using available field agency reinforced by supervision by the centre on a sampling basis. If NSS could only achieve this, a great step forward would have been taken in improving the much needed statistics of production for facilitating the food administration of the country.

ignorance of the fishermen of the quantitative aspect of their work and ingrained suspicion of any enquiry make the data on catches, secured through verbal enquiry, too unreliable to be of much use. Complete enumeration under these conditions is ruled out as impracticable. The total amount of the fish catch has, therefore, to be estimated by sampling in both time and space and employing objective method of enumeration, *viz.*, as physical measurement of the sampled catch. The solution to the various problems in sampling theory and practice raised by the enquiry makes one of the most fascinating readings and I can do no better than refer the reader to the original report (I.C.A.R., 1950) and the subsequent publication of the results in *Biometrics* (1958).

So interesting and novel was the application of sampling technique to fishery catch that FAO invited Panse to visit a number of countries for advising them on the improvement of fishery statistics of catch. In particular, Panse assisted the Governments of the United Arab Republic and Uganda in evolving an appropriate technique for the purpose. The results of the work are described in the report published by FAO (1964).

6. *Other Contributions to Economic And Planning Statistics.* Panse's interests have been much wider. His papers published in the Indian Journal of Agricultural Economics on the index numbers of agricultural production and on trends of crop yields provide two illuminating examples of his interest in developing procedures for evaluating the progress of development plans in the country. The latter paper in particular illustrates in a striking manner the contribution which statistical method can make to the development of evaluation procedures. It is common knowledge that comparison of annual yields suffers from seasonal variation. The difficulty is sought to be got over by comparing the average yields over several years. Even so, it is not possible to rid the average yields completely of seasonal disturbances, such as rust epidemic on wheat in consecutive years. There are a multitude of weather factors which influence crop yield and have to be allowed for in judging the progress of yield. Clearly, the total variation observed among annual yields for different districts in the country needs to be partitioned into variation (*a*) between the two plan periods, (*b*) between individual years within each period, (*c*) between districts, (*d*) representing interaction between periods and districts, and (*e*) representing interaction between individual years within periods with districts. It is only after such partitioning that a

comparison of components (*a*) and (*e*) will show whether the differences in the average yield level between the two plan periods is statistically significant or is only such as can arise from random fluctuation of seasonal yields and can therefore be reasonably ascribed to the latter. The analysis was without any effect on wheat but the adjusted rice yields showed an overall increase of 8 per cent during the first plan period as compared to the pre-plan period. Clearly, weather factors had adversely affected yield during the first plan period compared to the pre-plan period.

Panse's contributions to the development of yardsticks to assess the progress of agriculture have been particularly important. He brought together and analysed the massive data of field experiments on crop response to fertilisers and other inputs in a series of publications entitled *Index of Experiments*. These voluminous publications, one each for the different States of the country, were prepared under the guidance of an Expert Committee with Panse as Member-Secretary. They contain a wealth of information of great value for planning. It is this work which provided the basic data for developing yardsticks for judging the possibilities of increasing agricultural production in the country and enabled Panse to probe deeply into the technical aspects of India's plan for the development of agriculture. The assessment of the Intensive Agricultural District Program (IADP) in the country which he carried out for the Sen Committee of the Planning Commission provides an excellent example of this work by Panse.

His most recent article in June 1966 published in the Economic Times under the heading *The New Strategy in Agriculture* provides another example. In this article Panse scrutinised the claims of the new strategy in a manner which focussed the attention of the public and the Planning Commission alike. When the new strategy for the development of agriculture was announced in 1964, one was given to understand that one could expect an additional yield of one ton/acre on the average with a fertiliser dose of the 100 lbs. of Nitrogen and 50 lbs. of Phosphate. Panse was all in favour of the new strategy but he did not find the available evidence justified the claim of the response of 1 ton/acre. With forthright candour characteristic of him, Panse showed that the available evidence did not justify an assumption of more than half the figure put forward by the Planning Commission. He feared that the tall claim of 1 ton/acre might lead to over-optimism in the country and insistence on large dose may lead

to disappointment considering that fertilizers were in short supply and a scarce resource and needed to be used at doses which gave the maximum additional response per unit of application. Without the support of essential scientific data the strategy was like a 'big lead forward' and he was afraid that unless appropriate steps were simultaneously taken it may meet the same fate. This article which Panse wrote in the Economic Times sometimes after he had retired from I.C.A.R., unfortunately lost Panse a good deal of his popularity in Government circles for the forthright way in which he expressed his criticism on the strategy. But that has always been the way in which Panse worked and wrote. He resented doing anything to please anybody, however highly placed. As the Vice-President of I.C.A.R. said at the farewell address, "Panse believed in the use of the hammer and not persuasion." Panse's reply was that his experience of over 35 years had taught him that persuasion led nowhere in India and it was his experience which taught him gradually harden in his approach and eventually in the use of the hammer. Panse never sought for himself any advantage out of any controversy. It has been my greatest privilege in life to enjoy his friendship Not a month had passed when he and I did not exchange views on some technical topic or another.