REPORT ON THE BIHAR CROP SURVEY: RABI SEASON 1943-44*

By

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PART 1. GENERAL DESCRIPTION OF THE SURVEY

SECTION 1. GENERAL INTRODUCTION

HISTORY OF THE SCHEME

First enquiry. The Government of Bihar in letter No. 13297 P. C. dated 28th September 1943 enquired whether I could undertake as early as possible a sample survey of rice in Bihar on the same lines as the survey of the jute crop in Bengal which had been going on under my guidance for several years. In my reply dated 4th October I pointed out that the season was already too far advanced for an area survey of *aghani* (winter paddy) but crop-cutting work of an exploratory nature might possibly be still undertaken. Mr. R. A. E. Williams, I.C.S. (then Secretary, Revenue Department) in his letter dated 27th October 1943 stated that Government would like me to organize crop-cutting work on paddy and requested me to submit a scheme with estimates. By this time it had become too late for even crop-cutting work on paddy. After some further correspondence it was decided that I should go to Patna for personal discussions.

2. *Discussion in Patna.* On the 16th November 1943 I reached Patna and in the afternoon of the same day had a three-hour conversation with Mr. R. A. E. Williams. In the morning of the 17th November I had the opportunity of discussing the matter personally with His Excellency Mr. (now Sir) Francis Mudie, Governor of Bihar, who after examining my proposals approved of them generally and asked me to submit a scheme as soon as possible. On the 18th and 19th November I had further talks with a number of Bihar officials, collected a good deal of material in the form of Settlement Reports, and made personal enquiries in the Survey Office about Cadastral Survey village maps.

3. *A five-year scheme.* On the basis of the information collected in this way I prepared, with the assistance of Mr. J. M. Sengupta, Statistician, who had accompanied me to Patna, a five-year scheme for the improvement of crop statistics in Bihar by the

* This Report was submitted to the Goverment of Bihar on 5th November, 1944.

method of the sample survey at an estimated cost of twenty-four lakhs of rupees exclusive of dearness allowance, and submitted this scheme at Patna on 19th November 1943. I explained that the objects of the scheme would be :—

(a) to develop an efficient sampling technique for estimating acreage, yield per acre, and total outturn of important crops such as paddy, wheat, barley, maize, gram, etc. and the total cropped area in each of the three (*bhadoi*, *aghani* and *rabi*) seasons in Bihar; and secondly,

(b) to build up the necessary human organisation on both the statistical and field sides of the work for carrying out the sample survey on standardized lines from the fifth year of the scheme.

4. The approach in a scheme of this kind must be definitely experimental. I, therefore, proposed starting with a pilot or exploratory survey on a small scale in the *rabi* season of 1943-44, and gradually expanding the scale of operations working up to a full provincial survey in the *aghani* (winter) season of 1945-46. The scheme visualized a recurring expenditure of five lakhs of rupees per year for work in three crop seasons: *bhadoi* (autumn), *aghani* (winter), and *rabi* (spring). The field work would be done under the direct control of the Government of Bihar, but the statistical and technical work was to be done in the beginning by the Indian Statistical Institute under my guidance as honorary Statistical Adviser, and was to be gradually transferred from the third year to the Government of Bihar who would take over the statistical section completely at the end of the five year scheme. A large portion of the Statistical Laboratory had been removed from Calcutta to Giridih early in 1942 as an evacuation measure; and it was suggested that the bulk of the statistical work in the Bihar crop survey scheme should be located at Giridih.

5. *Beginning of preparatory work.* The scheme submitted by me was approved in principle by the Government of Bihar within a few days, and I was asked to make necessary arrangements for the survey in the *rabi* season of 1943-44. Orders were issued by Government on the 30th November 1943 requesting all District Collectors to send two complete sets of district, *thana*, and C.S. village maps to the Giridih Branch of the Indian Statistical Institute. In his letter No. 28/1c-1/14 dated 4th January 1944 Mr. Williams assured us that Government would give the Institute full support and facilities for the work.

6. *First plan abandoned.* Government was keen that we should cover the important wheat districts in the province, and a design of the proposed survey was prepared on this basis. Unfortunately preparatory work could not be started as necessary village maps had not been received by the middle of December. It was clear that the preparatory work could not possibly be completed in time, and there was no other alternative but to abandon the original plan.

7. *Revised plan for the rabi survey.* A second series of meetings and conferences was therefore arranged at Patna on the 17th and 18th December1943 in the course of which I met Mr. E. R. J. R. Cousins, I. C. S. (Adviser to H. E. the Governor), Mr. A. P. Middleton, I. C. S. (Member, Board of Revenue), Mr.R. A. E. Williams, I. C. S. (Secretary, Revenue Department) and a number of other officials. I also had a full discussion with Rai Bahadur Sinheswar Prasad Sinha, a senior Deputy Collector, who had been appointed to the newly created post of whole-time Superintendent of Statistical Surveys. As a result of these discussions it was decided to carry out an exploratory survey in the *rabi* season of 1943-44 in the two districts Monghyr and Shahabad for which village maps had been already received.

8. *Progress of the survey.* The preparatory work for this survey was begun in the Statistical Laboratory at Giridih at the end of December 1943 and was completed after strenuous labour in the first week of Februlary 1944. The services of 78 men with experience of field work in Bengal were sent to Bihar on loan and 102 workers were locally recruited for the field survey which started on the 12th February and was completed on the 13th April, 1944. Crop-cutting work on wheat and gram started in the third week of March and was closed along with the area survey on the 13th April 1944. I went to Patna early in January 1944, and again at the end of March. I met Mr. Middleton and Mr Williams on the 23rd March; and on the 24th March I had an interview with His Excellency Mr. Mudie who examined with keen interest the preliminary results based on the material collected during the first fortnight of the survey.

9. *Surveys in the bhadoi and aghani seasons.* Although the present report is concerned with the *rabi* season of 1943-44 a brief mention may be made here of subsequent work. In the original programme it had been intended to organize the work on an expanding scale in the *bhadoi* (autumn) and *aghani* (winter) seasons of 1944-45. As a result of discussions in Patna at the end of March it was decided to have a survey of the early *makai* (maize) crop in certain portions of the districts of Purnea, Bhagalpur, and Monghyr. Not only this; the great success with which the field work in the *rabi* season had been organized gave us confidence in suggesting that a full provincial survey should be attempted in the *bhadoi* (autumn) season of this year (instead of in the *aghani* (winter) season of 1945-46 as contemplated in the original scheme),

and thereafter continue the provincial surveys in succeeding crop seasons. This proposal to expedite the work received the full support of H. E. Mr. Mudie, and Government sanction was given accordingly. The field work for the survey in the *bhadoi* season was started on the 3rd July and was completed on the 3rd October 1944. In quick succession the field work for the survey of *aghani* (winter) crops was begun on the 10th October and was in progress at the time of writing this report.

THE PRESENT REPORT

10. *Contents of the present report.* The present report gives an account of the survey in the *rabi* season and the results obtained from the material collected during the survey. The report consists of 11 sections arranged in three parts. Part 1 is mainly descriptive. The present (first) section gives a brief history of the scheme and a general introduction. Section 2 gives a general and non-technical description of the method of the sample survey of crops as developed in the course of the work in Bengal during the last 7 or 8 years. This is followed by a description of the details of the design or plan of the survey of *rabi* crops in Section 3 ; and a general account of the progress of the survey in Section 4.

11. Part 2 gives the actual results of the survey. Section 5 deals with the estimated acreages under five important crops, wheat, barley, gram, *arhar* and *khesari*. Section 6 is concerned with the rates of yield per acre of wheat and gram based on crop-cutting work done on these two crops. An attempt has also been made in this section to estimate the total outturn of these two crops. Comparison with official figures was not possible owing to difficulties in the interpretation of acreage estimates in the case of mixed crops and the unsatisfactory nature of official figures relating to outturn. A detailed discussion of the problem of mixed crops is given in Section 7. This is followed by a discussion of the cost of operations in Section 8. Finally, mistakes in preparing crop records in the method of complete enumeration are examined in considerable detail in Section 9.

12. In Part 3, Section 10 gives a general review of methods for the improvement of crop statistics with special reference to the permanently settled provinces like Bengal and Bihar. The respective advantages and disadvantages of the method of (*a*) complete enumeration and (*b*) sample survey have been considered in some detail in this section, and a general description has also been given of the Bengal scheme for complete enumeration which is scheduled to come into effect from the current *aman* paddy or *aghani* season of 1944-45. A combination of complete enumeration and sample survey is considered to offer the most promising line of advance in the immediate future. A summary of the Report is given in Section 11 of Part 3.

13. For convenience of reference, tables have been numbered separately by Sections, and inserted in the text where possible.

14. It will be noticed that the factual material is given in considerable detail in Part 2, Sections (5)—(9). This is the portion (together with the description of the design of the survey in Section 3) to be consulted by those who are primarily interested in the statistical details. Those who are interested in a more general way in the survey would find a description of the sampling method in Section 2, and an account of the survey itself in Section 4, and a summary of the results in Section 11.

ARRANGEMENTS WITH THE INDIAN STATISTICAL INSTITUTE

15. In the Bengal Crop Survey Scheme both the field and the statistical work is done by the Indian Statistical Institute for which a block grant is given by the Government of Bengal. The Institute has authority to make re-appropriations within the limits of the block grant and also to make all necessary arrangements for the work. Expenditure on field work and other charges incurred exclusively for the crop survey scheme are debited directly while overhead and joint charges are allocated on the basis of total volume of work ; and accounts audited by chartered accountants are submitted to Government.

16. *Block grant.* In the Bihar Crop Survey Scheme arrangements were made, at my suggestion, to have the field work done under the direct control of Government and the Board of Revenue was placed in charge of the scheme. The statistical work was entrusted to the Indian Statistical Institute, and a block grant was sanctioned for this purpose on the same conditions as in the case of the Bengal scheme.

17. *Contribution in lieu of the services of the Statistical Adviser.* The Government of Bihar had offered to pay a suitable remuneration to me for my work as Statistical Adviser. At my request I was, however, permitted to do this work on a purely honorary basis, but a

contribution of Rs. 15,000 per year to the Indian Statistical Institute was sanctioned with effect from 16th November 1943 in lieu of my services for which we offer our sincere thanks to the Government of Bihar.

ACKNOWLEDGEMENTS

18. The present scheme owed its inception to Sir Francis Mudie when he was Governor of Bihar ; and the personal interest taken by him in this matter was a great encouragement to us.

19. Mr. A. P. Middleton, I.C.S. (Member, Board of Revenue) and Mr. R. A. E. Williams, I.C.S. (Secretary, Revenue Department) were largely responsible for the smooth progress of the scheme in the initial stage. The organization of the field work during the *rabi* season was, as already noted, successful beyond expectation for which credit is due to Rai Bahadur S. P. Sinha (Superintendent of Statistical Surveys). Mr. Pritiranjan Sen (Registrar, Revenue Department) helped us by promptly attending to our many requirements.

20. In submitting this Report I wish to place on record our grateful appreciation of the help we received at every stage of the work from the officials of the Government of Bihar.

SECTION 2. METHOD OF THE SAMPLE SURVEY

THE JUTE SURVEY SCHEME IN BENGAL

21. A general description of the method of the sample survey for preparing crop estimates as used in Bengal during the last few years is given in this section. The method was developed in the course of a five-year scheme which was started in 1937 by the Indian Central Jute Committee (and was financed jointly by the Committee and the Government of Bengal) for the improvement of statistics relating to acreage and outturn of the jute crop in Bengal. On my advice, the Committee decided to explore the possibilities of the sampling method, and I was entrusted with the task of developing a suitable technique for this purpose with a view to securing acreage estimates with a margin of error not exceeding five per cent and at an expenditure of the order of about a lakh and a half of rupees per year (at 1937-38 level of costs).

22. The work was started with a very small scale exploratory survey in 1937, covering only about 200 square miles with a total expenditure of about six thousand rupees for the field work. The scale of operations was steadily expanded in 1938, 1939, and 1940 culminating in a survey on a full provincial scale in 1941. The results were considered entirely satisfactory by the Indian Central Jute Committee which recommended the continuance of the sample survey by Government in future. In 1942 the scheme was taken over by the Government of Bengal and the work was carried out under my guidance by the Indian Statistical Institute on behalf of Government. The method was extended to the paddy crop in 1943, and was further enlarged to cover all important crops in 1944.

23. Reports on the work done in each year from 1937 to 1943 were submitted by me to the Indian Central Jute Committee and the Government of Bengal ; some of these have been printed. A general description of the method was given in my presidential address to the section of Mathematics and Statistics of the Indian Science Congress in January 1942 ; and more recently, a full account of the theory has been given in a memoir on Large Scale Sample Surveys in the *Philosophical Transactions* Vol. 231B, No. 584, of the Royal Society of London. A non-technical description of the method is given in the present section ; for fuller details and underlying theory reference will naturally have to be made to the publications mentioned above.

THE SAMPLING METHOD

24. A classical example of the sampling method is sampling from an urn containing a large number of balls of, say, three different colours, red, white and blue, in different proportions. A handful of balls is drawn out of the urn. It is then possible, by counting the number of balls of each colour, to make an estimate of the proportion of balls of each colour in the urn itself.

25. In the case of land, instead of balls of different colours, we have a very large number of plots under different crops (or lying fallow or being utilized for other purposes). A simple technique (analogous to sampling from the urn) would be to pick up purely at random a suitable number of plots of land, and ascertain how many of these are under wheat, or gram, or any other crop. This would be quite easy if the plots were of equal size. All one would have to do would be to give serial numbers to the plots, and to select the sample plots with the help of a series of random numbers (of which large collections are available in a printed form). Unfortunately, this method can not be used as the size of individual plots in Bihar varies

widely from a fraction of an acre to several hundreds of acres. Selection by serial number of plots would not give each acre of land the same chance of being included in the sample; and samples drawn in this way would not be truly random or representative. It is no doubt possible to get over the difficulty arising from unequal size of plots but the procedure would be laborious and expensive.

26. *Use of grids.* It is convenient therefore to use not plots but sample units of a definite size like 4-acre, or 10-acre, or 50-acre in area. In my earliest publications on the sample survey of the jute crop in Bengal I had called this sample-unit a grid*, and this term is now commonly used in technical literature.

27. The use of grids or sample-units of finite size is also convenient for other reasons. In large scale surveys covering a whole province with an area of 60 or 70 thousand square miles, only a limited number of sample-units can be examined within available resources in time and money. For example, in Bengal in a full provincial survey we have been using something like 60 or 70 thousand grids or on an average about one grid or sample-unit per square mile. The grids or sample-units are thus widely scattered, and the time required for the investigator to move from one grid to another (which is called 'journey time') is not negligible in comparison with the time required for the physical examination of the crops grown within the grid. In this situation it would be clearly uneconomical to examine or survey a single plot at each locality. It would be obviously convenient to examine a group of plots or sample-units of comparatively large size at each locality visited by the investigators as the additional time required for this purpose would be very small. Considerations of economy thus suggest the use of sample-units of a fairly good size.

PLANNING OR PREPARING THE DESIGN OF A SURVEY

28. *Zoning.* For the organization of the field work (as well as for certain reasons of a technical nature) it is convenient to divide each district into a suitable number of sub-units or zone-cells each of which is a compact area roughly of an equal size. In Bihar in the *rabi* season we used zone-cells each of size about 50 square miles. In the sampling method the procedure then is to locate purely at random a suitable number of sample-units or grids within each zone-cell; and have all the plots falling within each grid examined for the proportion of land under different crops by investigators who go round from one grid to another for this purpose.

29. In planning a sample survey several things have to be settled. For example, it is necessary to decide (*a*) what should be the size or area of each sample-unit or grid (which need not be same in all zone-cells and may vary from one zone to another); (*b*) what should be the total number of grids used in each district or in the province as a whole; and (*c*) how should these grids be distributed among different zone-cells, that is, how many grids should be allotted to each zone-cell.

30. *Cost of operations.* Certain considerations which have to be kept in mind in planning a survey may be now explained. The total expenditure which can be incurred, and hence the total number of field investigators at our disposal, is fixed. If we use grids of a large size, say 50-acre or 100-acre each, then the time and hence the expense involved in the physical examination of each grid would be comparatively large, and we would be able to have only a comparatively small number of grids. They will be, therefore, widely scattered; the density (or number of grids per square mile) would be small; and comparatively greater time would be therefore spent in moving from one grid to another. On the other hand, if the grids are of a small size there can be more of them, so that they would lie closer together and would have a higher density. The time required for moving from one grid to another would, therefore, be proportionately smaller.

31. The need of working within the limits of a fixed budget places a restriction on the choice of the size (that is, the area) of each individual grid and their total number or density per square mile. Once the size (or area) of each individual grid or sample-unit is fixed, the total number which one can have also becomes fixed. On the other hand, if the total number (or density) of sample-units is fixed then the size or area of each individual sample-unit also becomes determined. It is thus not possible to choose independently both the area of each individual grid and their total number, Cost thus supplies one connexion between area and the number of sample-units. This is why a study of the 'cost function' or how the cost

* I may briefly explain the origin of the term. I visualised the whole district (or the province) as divided into a large number of cells by a system of meshes formed by two perpendicular sets of parallel lines, that is, I imagined the whole area to be covered by a system of grids. I considered a sample-unit to be one of the basic cells (or grids) picked up at random. This led to the term 'grid' being used as the name of a sample-unit in the survey of crop acreage.

depends on (*a*) the size of each individual grid and (*b*) their density or total number is essential for preparing efficient designs.

32. *Precision of results.* But cost is not the only factor. It is also necessary to consider the precision or the margin of error of the final estimate of crop acreage. The margin of error for estimates from individual sample-units or grids would be large when the size of each sample-unit is small. The precision of the estimate based on individual grids would increase as the size of each individual grid is increased.

33. The precision of the average or final value calculated from a large number of sample-units or grids is, however, not determined only by the precision of individual grids, but also depends on the total number of grids. We have already seen that working with grids of a comparatively large size would inevitably mean having fewer of them. On the other hand, one could have a large number of grids of a smaller size. We thus find that we can use grids of a comparatively large size for each of which the precision would be large but the average value would be based on a small number of grids. Working with grids of a small size, the precision of individual grids would be small, but the average value would be based on a much larger number of grids.

34. In this situation whether there is any net gain or not in the precision of the final average value would depend on whether the decrease in precision due to a reduction in the size of each individual sample-unit is or is not compensated for by the increase in precision of the average value due to the increase in the number of sample-units on which the average is based. This question has therefore to be settled experimentally by studying how the precision of the result changes as the size of each invididual sample-unit is changed. (The precision or the margin of error is usually studied in terms of what is known as 'variance' in technical language. The study of variance as a function of the size of individual sample-units is thus necessary to settle the present question).

35. *Aim of efficient planning.* To recapitulate, the sampling technique or the design of the survey has to be settled by deciding how the whole area is to be divided into a suitable number of zones, and what would be the size of individual grids in different zones, and their total number and distribution among different zones keeping in view :

(*a*) the amount of money (and hence of labour) which can be used for the sample survey ; and

(*b*) the degree of precision which is desired to be attained in the final estimate of crop acres.

36. The aim of preparing the design of the survey may, therefore, be stated in the following form :.

(A) If the total amount of money is fixed then our object would be to settle the size of each individual grid or sample-unit and their total number (or density) and distribution among different zones in such a way as to obtain the final result with the least possible margin of error.

(B) Alternatively, if the margin of error of the final estimate is determined in advance then the size, density and distribution of grids have to be settled in such a way that the sample survey can be done at minimum cost.

PREPARATORY WORK IN THE STATISTICAL LABORATORY

37. The different stages of a sample survey can now be described. The first thing to be settled is the design of the survey (including the division of the whole area into a suitable number of zones) as explained above. Once this is done the preparatory work can start in the Statistical Laboratory.

38. *Location of sample-units or grids.* For this purpose Cadastral Survey village maps (usually on the scale 16 inches to a mile printed on sheets of about $30'' \times 22''$) are used ; the boundary of each plot together with the revenue serial number of the plot is shown in these maps. A simple apparatus (called a co-ordinatograph) was devised for locating points at random on these maps. This is essentially a frame of rectangular shape made of four pieces of wood joined at right-angles at four corners. Two wooden scales (called frame-scales) are mounted on the two opposite (and longer) sides of the co-ordinatograph ; a bridge (which is simply a piece of wood of about the same width as the frame-work) rests perpendicularly to the two sides containing the scales ; and slides freely on them. A third wooden scale (which is called the bridge-scale) is mounted on the bridge on which slides freely a cursor carrying a pencil. The bridge thus moves parallel to the two longer sides of the frame while the pencil on the bridge moves in a perpendicular direction.

39. The operational procedure is simple. The co-ordinatograph is placed on a map. A pair of random numbers say (x) and (y), each consisting of three digits, is taken from avail-

able tables. The sliding bridge has an arrow mark with a notch at either end which is adjusted on the frame-scales at the reading corresponding to the random number (x) ; the sliding pencil on the bridge is adjusted at the reading (y) on the bridge-scale, and the pencil is lowered to mark the point on the map. The co-ordinates of this point (with an arbitrary origin) are thus (x) and (y) ; and as this is a pair of random numbers, the position of the point is also purely random over the map.

40. The actual location of the points on the village map is done in three successive stages. A map is prepared on a large scale of 4 miles to the inch for districts (or 16 miles to the inch for the whole province) under survey showing the division into zone-cells. Photographs are now prepared of each zone-cell on a larger scale of about one inch to the mile showing the boundaries of each *mauza* (village) sheet of map falling within each zone-cell. These maps are placed under the co-ordinatoraph, and the required number of points (one for each grid) in accordance with the design of the survey are located at random. Each *mauza* sheet thus gets a number of points located on it at random which fixes the number of grids, it being possible, of course, for some of the sheets to get no points at all, or to get one point or more than one point each. Finally, the co-ordinatograph is placed on individual mauza sheets and the appropriate number of grids are located in the way already described.

41. In the above way the position of sample-units or grids are marked at random on appropriate village maps. Grids of the appropriate size (4-acre in the *rabi* season of 1944) are then stamped on the maps with the help of engraved brass plates. Each grid is marked in a specified manner using the sample point as the south-west corner point of the square. The grids are also serially numbered as they are marked on the village maps. This finishes what is called the location of the grids on maps.

42. *Khasra or field lists.* A list is then prepared of the revenue serial numbers of all plots which lie either entirely within or partly within and partly outside each grid. A single slip of paper is used for each grid for convenience of field survey and subsequent tabulation work. At the top of each such sheet is given the serial number of the grid, its size in acres, the name of the village, police station etc., as well as the serial number of the zone-cell, and the sample (A) or (B) to which it is allotted. Necessary blank columns are provided in each sheet for entering against each plot the anna-estimate of the proportion of land under different crops as explained below. The form also contains space for the signature of the investigator and certain other particulars. The lists are supplied to the Field Branch and duplicate copies are prepared for field and laboratory work.

FIELD SURVEY

43. Each investigator is supplied with the field lists of grids allotted to him together with C. S. maps of the villages in which these grids have fallen. Each field party usually consists of four investigators in charge of a field inspector. One such party works in a certain number of zone-cells. Each party carries its own bundle of maps and other forms and takes up their residence in a village, the place where each party spends the night being called a camp. The inspector in charge distributes the work among his investigators. Each investigator then goes out to the field with the appropriate village maps, identifies the plots (of which the revenue serial numbers are given in the field lists), and makes an actual physical examination of the crops growing on each of these plots. He then enters anna-estimates of the proportion of land under different crops in the appropriate columns in the khasra or field lists.

44. As soon as the work in a particular locality is completed the whole party shifts camp to another village. Usually two or three days are spent at each camp ; but occasional haltages of six or seven days are also made. The inspector in charge of each field party keeps in touch with the investigators by moving from one camp to another. He is responsible for the accuracy of the work done by his unit, and is required to check a certain proportion of the sample-units from time to time. Investigators and inspectors are supplied with detailed instructions covering different phases of the field work.

TABULATION OF CROP RECORDS

45. *Area extraction.* In the meantime the area of each individual plot included in the grid (and hence in the field list) is measured in the Statistical Laborarory. Photographic graticules or scales are used for this purpose ; these are simply lantern slides on which a graph paper is photographed on a scale such that each small square is 0·01 acre. This photographic scale is placed over the map and the area of that portion of each plot which is included within the boundaries of the grid is directly measured by counting the numbr of squares, and entered in a column provided for this purpose in the field list.

46. *Crop records.* The field investigators hand over the field list completed by them from time to time to the inspector in charge who then despatches the whole lot directly to

the Statistical Laboratory, Giridih. As already explained, anna-estimates of the proportion of land under different crops are given in this list in appropriate columns. After the field lists are received in the Statistical Laboratory, these anna-estimates are converted into decimal figures, and entered in columns provided for this purpose in the Laboratory copy of the field list. The area of that portion of the plot which falls within the grid has been already entered in another column as explained above; multiplying the area figure by the estimated proportion of land under a particular crop, the actual area in acres under each crop is entered in a series of columns provided for this purpose in the Laboratory copy of the field list. Adding the figures in each column, the total area in acres under each crop for each sample-unit or grid is directly obtained. This finishes the stage of calculations of grid proportions or the crop acreage for each individual grid for each crop.

47. *Estimates of acreage.* For each crop, the grid proportions are then added, and in this way the average value is determined for each zone-cell. Multiplying this average value by the total area of the zone-cell, the crop acreage for each zone-cell is next directly calculated. Sub-totals are then built up for suitable administrative units, and the final estimate is obtained for each district (or the province) as a whole.

48. *Statistical analysis.* The tabulation of crop acreage is thus quite straightforward. A good deal of other statistical calculations also have to be made for the comparison of different sub-samples, estimating the margin of error, application of appropriate statistical tests, and for studies of cost and variance functions. It will not serve any useful purpose to go into these technical details for which reference must be made to the literature on the subject already cited.

PRECISION OF THE RESULTS OF A SAMPLE SURVEY

49. The precision of the results of a sample survey will depend on two things, namely, (*a*) the fluctuations or errors due to sampling; and (*b*) mistakes in the primary field records (which depend on the reliability or otherwise of the field work). Although these two different types of errors occur together in practice it is convenient to consider them separately.

50. *Errors of sampling.* One great advantage of the sample survey is the fact that, provided the sample-units or grids are located truly at random, (and more than one unit is taken from each zone-cell), it is possible to calculate the margin of error of the final result on an objective basis. It is clear that the precision of the result will increase if we increase the size (area) of each individual grid or their total number. A little consideration will also show that if fluctuations in the intensity of cultivation are large then the margin of error will also be large. In fact, the size of grids remaining constant the margin of error of the final result increases with the heterogeneity or variability in the intensity of cultivation but decreases in proportion to the square root of the total number of grids. In the matter of crop acreages it is usually found that the variability increases as the extent or size of the region under survey is increased, but the increase in variability takes place much more slowly than the increase in the area itself.

51. Two important consequences follow. The margin of error is thus roughly the same when the same number of grids is used irrespective of the fact whether the grids are scattered over a small or large area. The margin of error with say 60,000 grids (of a given size say 4-acre) would be thus not widely different when all the grids are used in one district or when they are scattered over the whole province. The total area under wheat or any other crop is however much larger in the province as a whole than within any single district. The percentage margin of error would be thus much less for the province as a whole. In other words, other things remaining the same, the wider the area covered by a sample survey, the lower will be the percentage margin of error, that is, the greater will be the relative accuracy of the results. The sample survey thus becomes more and more efficient as the scale of operations is increased.

52. The second point which deserves notice is the fact that the margin of error can in theory be reduced to any desired extent by increasing the size and the total number of grids, that is, by increasing the total sampled area. But the greater the sampled area the greater will be the cost. Reducing the margin of error thus involves incurring greater expenditure. In practice there is, therefore, a limit beyond which it is usually not possible to increase the intensity of sampling as the cost becomes prohibitive.

53. *Recording mistakes.* As already noted, the precision of the results also depends on the quality of the field work. If the primary records are unreliable, no subsequent statistical treatment can be of any real use. Unfortunately, under existing conditions in Bengal and Bihar, mistakes do occur in primary records.* Some of these are more or less

* This subject has been further discussed in Section 9.

accidental and can be treated as integral parts of sampling fluctuations. There are, however, mistakes of an altogether different kind which arise from entries being made without proper physical examination of the grids due to gross negligence or shirking of work on the part of the investigators. Such mistakes or false entries are more dangerous as they are not amenable to statistical treament. Special precautions have to be taken and suitable statistical checks and controls have to be incorporated in the design of the survey to detect (and hence to discourage) such dishonest work.

54. *Interpenetrating sub-samples.* One type of control has proved extremely useful in Bengal. The total number of grids in each zone is divided into two equal portions say, (*A*)and (*B*). The grids allotted to sub-sample (*A*) are scattered at random all over the zone; and, in the same way, the grids allotted to sub-sample (*B*) are also scattered at random over the whole area; the two sub-samples (*A*) and (*B*) are thus completely mixed up and inter-penetrate into one another. The information for the two sub-samples is collected by two entirely different sets of field investigators who work independently and at different times in the same zone so that they never meet. The two sub-samples thus supply two independent estimates of crop acreage for the same zone. How far they are in agreement immediately furnishes a good idea about the reliability (or otherwise) of the results.

55. *Duplicate grids.* In practice, a certain proportion of the grids are also intentionally made common to both samples so that they are enumerated twice by the two different parties. A detailed plot by plot comparison of the records for such twice enumerated grids then shows how far the primary field work was reliable. The field staff knows that a certain proportion of grids are surveyed twice; but is not, of course, allowed to have any information as to which particular grids are being duplicated. This very knowledge of the existence of a system of duplicated grids acts as a check on dishonest work.

CROP-CUTTING WORK

56. *Yield per acre.* So far we have considered the area survey from which we can obtain estimates of the area under different crops. Our real object however is to estimate the total production of crops. It is ,therefore, also necessary to know the rates of yield per acre. In this matter the method of complete enumeration is, in fact, impracticable so that estimates must be made by some kind of sampling process. The general procedure for this purpose is to measure and enclose a suitable area in a field in which the crop is ready for being harvested and then collect the crop within the measured enclosure and directly weigh the crop. Such crop-cutting work is in many ways more complicated than area survey. It involves careful measurement of the area of the sample-cut, the weighing of the crop as harvested and or after drying and threshing. Not only this, permission to cut the crop has usually to be secured beforehand from the cultivator or the owner of the crop, and sometimes a suitable compensation has to be paid ; information had to be collected about the variety of the crop, irrigation, use of manures etc. for which individual cultivators have to be contacted.

57. *Need of proper randomization.* The fundamental issue, however, is the proper location of the sample-cuts. In India the method often followed is to choose what is called representative fields for this purpose. Extensive experimental studies have however demonstrated beyond dispute that the attempt to select representative fields by visual examination or in other ways invariably leads to biased results. F.Yates discussed this question thoroughly in his paper on 'Some examples of biased sampling.'. (*Annals of Eugenics*, Vol.VI, 1934-35 pp.202-213), and stated :-

> 'In view of the evidence, therefore, I do not think we can escape from the conclusion that the only satisfactory method of avoiding bias is for the sampling to be random, whether it be from a wheat field or from a human population.'(*p.*213).

He has also clearly stated that :—

> 'If bias is to be avoided, the selection of the samples must be determined by some process uninfluenced by the qualities of the objects sampled and free from any element of choice on the part of the observer'. (p. 202).

58. *Design of crop cutting work.* The essential requirement in crop-cutting work therefore is to prepare a design based on the principle of random sampling. In doing this it is necessary to specify (*a*) the size of each sample-cut, (*b*) the number of plots from which such sample-cuts are to be selected in each zone, and (c) the number and manner in which the sample-cuts are to be collected from each selected plot. Once the general design of the survey is settled, a suitable number of plots (from among those falling within grids used for the area survey) are selected beforhand at random in the Statistical Laboratory, and lists of such plots are handed over to the field staff. The investigators are then instructed to collect the necessary

number of sample-cuts from the selected plots in a specified manner which has been explained in greater detail in Section 6.

59. *Multi-stage sampling.* Certain special considerations also enter in preparing the design of a sample survey depending on the human agency which is available for the work. For example, if the number of investigators is comparatively small they will have to move about a great deal from place to place for collecting the samples. In this case it is usually necessary to prepare the design according to, what is called in technical language, the multi-stage plan. For example, a certain number of zone-cells are first selected at random; within each selected zone-cell a number of villages are next selected at random; within each such village a certain number of plots are again selected at random; and finally, within each such plot the sample-cut is located at random according to specifications. These are however details of technical procedure which need not be discussed here.

60. There is one pecular difficulty in crop-cutting work which may be mentioned in this connexion. In the area survey it does not matter at all whether some or even all the plots included within a grid have no crop growing on them; this will be simply entered as having 'no crop'. A plot which has no crop growing on it (or the crop on which has been already harvested) is however quite useless for crop-cutting purposes. In selecting plots for such work, care has therefore to be taken to give a much larger number of plots than that from which the cuts would be actually collected in practice. Each investigator is instructed to go through the list in serial order, plot by plot, and stop as soon as the required number of sample-cuts have been collected. In case a plot is omitted and no crop is harvested from it, he is required to enter the reason for the omission, such as 'no crop growing', or 'crop not yet mature', or 'crop already harvested' as the case may be. In allowing plots to be omitted there is, however, risk of some bias coming in, but this cannot be avoided when the work has to be done by a comparatively small number of investigators who have to move about rapidly from place to place.

61. *Efficiency of sample surveys.* Broadly speaking, whether in the crop acreage or the crop yield survey, the essential feature of the sampling method is to select a suitable number of sample-units located purely at random over the whole region under survey. Estimates are then prepared on the basis of the information collected for the sample-units or grids. In practice, the total area actually sampled or surveyed is usually small; in acreage survey (as carried out in Bengal) it is of the order of half of one per cent or even less of the total area under survey. It has been found however that, with a proper design, even such a small fraction of sampled area can furnish final estimates of crop acreage with a margin of error not exceeding 3 or 4 per cent and this at a small fraction of the cost of a complete enumeration or plot by plot examination of the whole area. The respective advantages of the sample survey and of the complete enumeration have been discussed in Section 10.

SECTION 3. THE DESIGN OF THE SURVEY IN THE RABI SEASON : 1943-44

62. A general description of the method of the sample survey has been already given in Section 2. It will be remembered that the total budget being fixed, the object aimed at in preparing the design of a survey was to decide the size (that is, area) as well as the density of sample-units or grids in different regions or zones of the area under survey in such a way that the final results should have the highest possible precision.

63. In order to prepare an efficient design or programme of survey for this purpose it is necessary to have a good deal of preliminary information relating to the intensity of cultivation, that is, the proportion of land under different crops in different areas; variations in such intensity of cultivation from region to region; and the cost of enumeration for different sizes and densities of sample units etc.

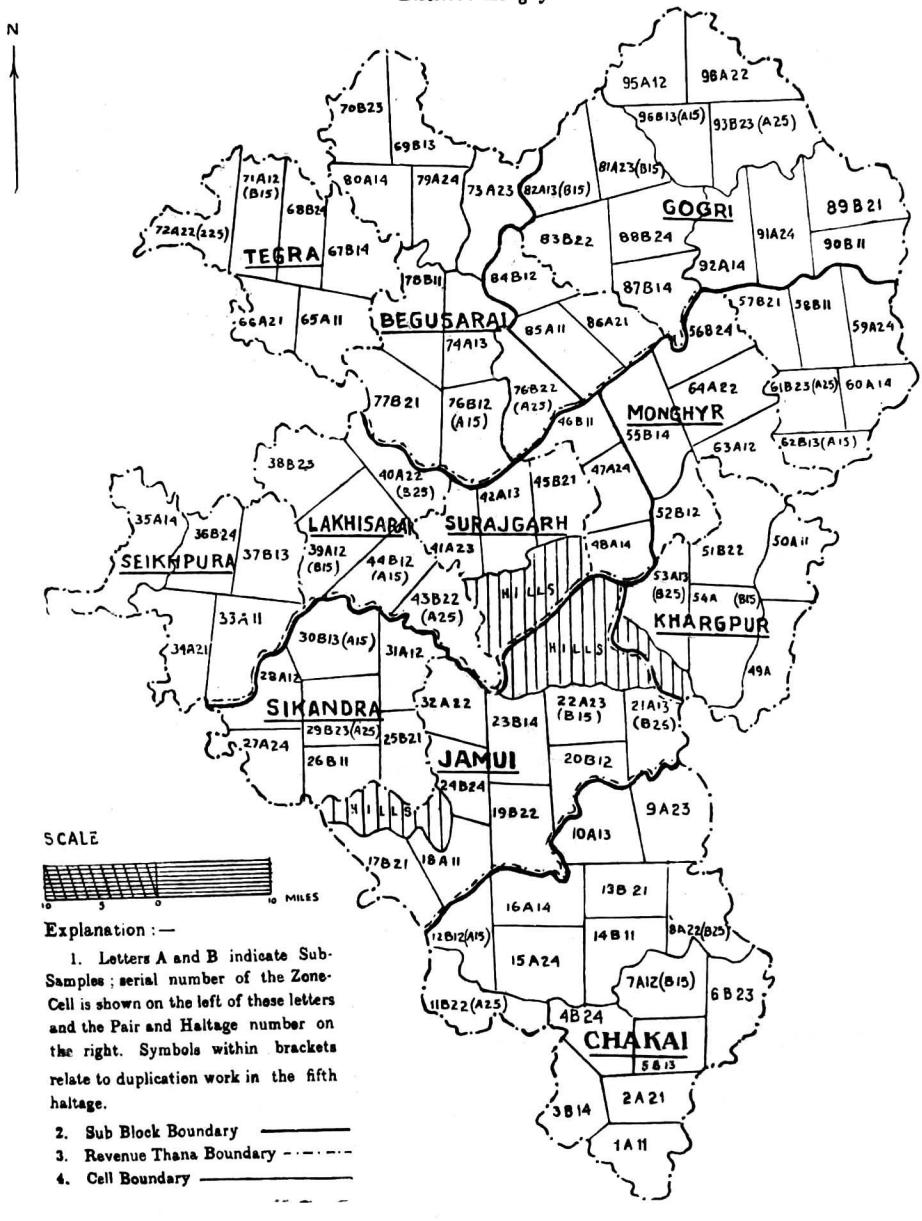
64. Practically no information was available on the above points (except such divisional or district crop acreage figures as were given in old Settlement Reports). We had, however, a good deal of experience of sample survey work in Bengal extending over several years. We decided therefore to use the Bengal information in preparing the design for the first exploratory survey in Bihar making such changes as were considered necessary for the wheat crop in particular in the two districts Shahabad and Monghyr. As the field work would have to be started at the latest in the first week of February 1944 there was very little time to complete the preparatory work in the Statistical Laboratory. It was decided, therefore, to use a comparatively simple design avioding all intricacies and complications.

65. *Size of grids.* The first point to be settled was the size (that is, area) of each sample-unit or grid. In general this size need not be constant in all regions but may vary from region

CHART I. BIHAR CROP SURVEY : RABI (WINTER) SEASON, 1943-44

Field Plan showing Zone-Cells, Parties and Haltages

District : Monghyr.



Explanation :—

1. Letters A and B indicate Sub-Samples ; serial number of the Zone-Cell is shown on the left of these letters and the Pair and Haltage number on the right. Symbols within brackets relate to duplication work in the fifth haltage.
2. Sub Block Boundary ——————
3. Revenue Thana Boundary - - - - -
4. Cell Boundary ——————

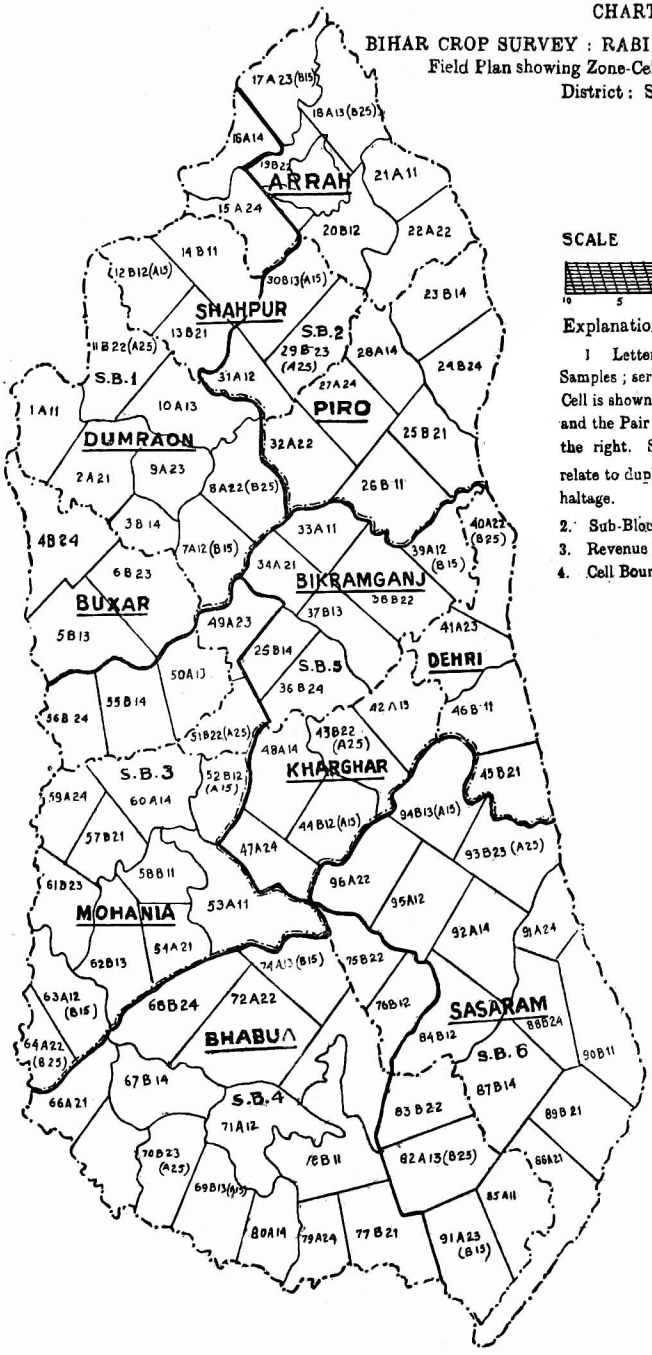
[TO FACE PAGE 10]

CHART II.

BIHAR CROP SURVEY : RABI (WINTER) SEASON, 1943-44

Field Plan showing Zone-Cells, Parties and Haltages

District : Shahabad



SCALE

10 5 0 10 MILES

Explanation :—

1. Letters A and B indicate Sub-Samples ; serial number of the Zone-Cell is shown on the left of these letters and the Pair and Haltage number on the right. Symbols within brackets relate to duplication work in the fifth haltage.
2. Sub-Block Boundary ————
3. Revenue Thana Boundary—·—·—
4. Cell Boundary ————

to region depending on intensity and variablity of conditions of cultivation. In order to aviod complications in the field survey in the very first season of work in Bihar it was decided, however, to use grids of only one size; and in the light of Bengal experience a grid of 4-acre of square shape was adopted.

66. *Density of grids.* The second point to be settled was the average density or number of grids per square mile. Here again in order to simplify the field work it was decided to avoid large variations and the average density to be aimed at in the exploratory stage was fixed at two grids or sample-units per square mile.

67. *Zoning.* I may now refer briefly to the question of zoning. Theoretical considerations show that if any particular area (in this case a district) is heterogeneous in the sense that the intensity of cultivation varies appreciably from one part to another then it is advantageous to divide the whole area into a suitable number of zones, the aim being to make each zone as homogeneous as possible. In Bengal we had found that the *thana* (or police station) was quite a convenient unit for purposes of zoning. In Monghyr and Shahabad we found however that the area of the revenue *thana* was rather large. It was therefore decided to split up each revenue *thana* into a number of smaller zone-cells roughly of the order of 40 or 50 square miles in area. In fact each of the districts was partitioned into 96 such zone-cells, the boundaries of which are shown in the accompanying Charts (1) and (2).

68. In partitioning these zone-cells advantage was taken of natural features like rivers or hills but care was taken to keep the boundaries of villages intact so that the whole of the area in each village would lie entirely within a single zone-cell. The total number of sample-units to be allotted to each zone-cell was decided on the basis of an average density of two grids per square mile. The number of grids falling to the share of each zone-cell was thus simply twice its area expressed in square miles.

69. *Interpenetrating sub-samples.* The arrangement of sub-sampling has been already explained in Section 2. In this method, the grids allotted to a region are divided into two equal inter-penetrating portions or sub-samples* called sample (A) and sample (B) respectively. The distribution of the two sub-samples can be made in various ways. For example, suppose we are allotting 4,000 sample-units to a district, we may prepare the design with 2,000 sample-units and call this sub-sample (A). We may then independently repeat the whole process over again with another 2000 grids, and thus obtain a second sub-sample (B). Another method would be to locate a pair of grids at a time and then by tossing a coin (or by some other equivalent method) allot at random one of each pair to sub-sample (A) and the other to sub-sample (B). It is clear that the preparation of the sub-samples by either of the above methods would require a good deal of time. Secondly, such inter-penetration of the two sub-samples in detail would require each of the two parties of investigators to go over the entire field. Detailed inter-penetration would thus not only require a good deal of additional preparatory work but would also increase the complexity of the field survey.

70. *Sub-samples on basis of zone-cells.* For lack of time in the preparatory stage as well as for simplifying the field work we did not think it advisable to use in the *rabi* season in Bihar such detailed or fine-grained inter-penetration of the sub-samples. Instead of detailed inter-penetration of grids we arranged the 96 zone-cells into 48 pairs of adjoining zone-cells. Each pair of adjoining zone-cells comprising about 100 sq. miles was alloted at random to either sub-sample (A) or to sub-sample (B). In the method of detailed inter-penetration, work would have been done in each zone-cell by both the parties. In the present design, work in each zone-cell was done by only one party. With detailed inter-penetration a comparison between the two sub-samples would have been possible for each zone-cell separately. In the present design, valid comparison can only be made for each sub-block or for the district as a whole.

71. In the present design we thus used the method of sub-sampling in a rather large grained fashion with inter-penetration at the stage of zone-cells instead of at the stage of grids or sample-units themselves. In Charts (1) and (2) the zone-cells have been numbered serially from 1 to 96. This serial number is followed by either the letter (A) or the letter (B) to indicate the sub-sample to which the zone-cell was allotted.

72. *Field organization.* It will be convenient at this stage to explain the structure of the field organization. Each district was divided into three blocks; and each block into two sub-blocks each of which consisted of 16 zone-cells. We thus had in each district 6 sub-blocks of 16 zone-cells each. Each block was placed in charge of a chief inspector under whom there were 4 field parties. Each field party consisted of 4 investigators under one inspector. The 4 investigators in each party worked in two groups of two, called pair (1) and (2), the two pairs

* In Bengal these are called 'half-samples' to indicate that the complete sample was made up of two half-samples.

working in two adjoining cells. Two of the four parties in each block worked in sub-block (1) and the other two parties in sub-block (2) .Of the two parties in each sub-block, one party belonged to sub-sample (A) and the other party to sub-sample (B).

73. *Haltages.* The field survey was scheduled to start early in February 1944 and to continue for a period of 60 days which was divided into 5 haltages of 12 days each. The field work actually started on the 12th February and was closed on the 13th April, the total period covered being 62 days of which 2 days were non-working days on account of the *holi* festival.

74. *Time programme.* The time programme can be best explained with the help of the two charts (1) and (2) in which suitable code-numbers are shown in the different zone-cells. As already mentioned, out of the 16 cells in each sub-block, 8 belonging to sub-sample (A) are marked with the letter (A) and the other 8 belonging to sub-sample (B) are marked with the letter (B). The first number gives the serial number of each cell. This is followed by the letter (A) or (B) showing the sub-sample to which the cell belongs. This is followed by the number (1) or (2) showing whether the work in this zone-cell was to be done by pair (1) or pair (2). The second number (running from 1 to 5) indicates the serial number of the haltage, or the 12-day period in which any particular zone-cell was to be enumerated. Thus in Chart (1) for Monghyr at the very bottom we see the zone-cell with number 1-A-1-1 which means that the serial number of this zone-cell is (1) ; it belongs to sub-sample (A) ; and the work in this cell was to be done by party No. (1) in haltage No. (1). The adjoining cell in the same chart has the number 3-B-1-4 which indicates that the serial number of this cell is (3) ; it belongs to sub-sample (B) ; and the work in this cell was to be done by party No. (1) in haltage No. (4). The time programme was arranged in such a way as to give as far as possible a fairly even distribution of enumeration work in the different haltages over the whole district.

75. *Duplicate Enumeration.* As already mentioned, it was not possible for lack of time to adopt a fine grained sub-sampling arrangement. It was therefore considered advisable to provide other statistical controls in the design ; and it was arranged that the enumeration work would be done over again in duplicate in 25 per cent of zone-cells in the fifth haltage. In each sub-block 4 zone-cells, two belonging to sub-sample (A) and two to sub-sample (B) were selected at random and arrangements were made to have these enumerated over again by the second party in the fifth haltage. Thus the zone-cell enumerated by party (A) during the main survey would be duplicated by party (B) in the fifth haltage ; and *vice versa.* The programme of work in the fifth haltage is shown in the charts within brackets. For example, in Chart (1) in Monghyr, one cell has the number 7-A-1-2 (B-1-5). This shows that the serial number of the zone-cell is 7 ; it belongs to sub-sample (A) ; in the main survey the work here was to be done by party No. (1) in haltage No. (2) ; and also that the enumeration work in this cell would be done over again in duplicate by party (B), pair No. (1) in the 5th haltage. Further controls were provided in the form of a triplicate enumeration of from 6 to 8 per cent of the sampling-units by a number of special parties of workers. These special parties were used in the third haltage to carry out an independent enumeration of the sample-units in certain selected zone-cells in which enumeration work was done once either in the first or second haltage and in which the enumeration work was scheduled to be done again during the fifth haltage.

76. *Complete enumeration of plots.* In each block a central camp was opened and a special party of 4 investigators was stationed there for certain auxiliary work. In the first haltage of 12 days the special party in each block camp was engaged on complete enumeration of a compact area of from 50 to 60 square miles in the neighbourhood of the block camp. In this complete enumeration the investigators noted for each individual plot the proportion of land under different crops, current or old fallow etc. The primary object of collecting this information was to provide material for sutdying what is called the variance function by model sampling experiments in the Statistical Laboratory

77. In the next haltage or the second 12-day period the special parties in the different block camps were interchanged so that a new party arrived at each block camp and duplicated the work done in the first 12-day period. The purpose of duplicating the complete enumeration work was two-fold. Firstly, to ensure the reliability of the primary material on which would be based subsequent studies of the variance function. Secondly, to furnish some idea regarding the degree of reliability of such primary work. (This has been discussed in Section 9).

78. In the next haltage during the third 12-day period each special party was engaged, as already mentioned, in the duplicate enumeration work in selected zone-cells. In the fourth and fifth haltages the special parties were engaged in crop-cutting work.

79. *Auxiliary parties.* Besides special parties at block camps, three auxiliary parties were used at three centres, Hilsa, Irki and Bettiah in the three districts of Patna, Gaya and Champaran respectively. Each of these parties spent 20 days at each camp in complete enumeration work. During the remaining period these auxiliary parties were engaged in crop-cutting work.

80. *Precision experiments.* Two camps for precision experiments were opened at Gogri in Monghyr district and at Bikramgunj in Shahabad district. Four technical workers (with first class M.Sc. degrees in Statistics or Mathematics) were sent from Calcutta to take charge of the work at these two centres. Harikinkar Nandi assisted by Anil Kumar Gayen was in charge of the work at Bikramgunj. Nirmal Kumar Chakravarti assisted by Gouri Sankar Chatterjee was in charge of the camp at Gogri. From five to eight investigators were posted at each of these camps ; and material was collected under close supervision for studying the technique of crop-cutting work, enumeration of mixed crops and other special problems.

81. It will be noticed that the programme of work was quite comprehensive. Unfortunately, owing to the late start of the field work, the whole programme could not be completed in detail ; but a great deal of valuable material was collected. The present report gives the results of the analysis of the above material as far as this has been completed ; but work is still proceeding.

SECTION 4. GENERAL ACCOUNT OF THE SURVEY ; RABI 1943-44

82. A general account of the crop survey in Bihar in the *rabi* season of 1943-44 is given in this Section.

STATISTICAL BRANCH

83. Shortly after my visit to Patna and personal discussions there from 16th to 18th November 1943 I was informed that the Government of Bihar had generally approved of the scheme submitted by me, and desired to have an exploratory crop survey organised in the *rabi* season of 1943-44. The statistical work was to be done by the Indian Statistical Institute under my guidance, while the field work would be done under the direct control of Government.

ARRANGEMENTS AT GIRIDIH

84. From Patna I returned to Calcutta, the headquarters of the Indian Statistical Institute, and made preliminary arrangements for starting the Bihar scheme. A portion of the Statistical Laboratory had been removed from Calcutta to Giridih as an evacuation measure early in 1942. The main library and valuable records and other equipment of the Indian Statistical Institute were housed there in premises called "Mahua" which had been handed over to the Institute free of rent for the duration of war and one year thereafter by Mrs. P. C. Mahalanobis. About 50 persons were working in the Giridih Branch at the end of November ; and it was decided that the bulk of the statistical work in the Bihar scheme should be done there.

85. I went to Giridih on the 1st December accompanied by Mr. J. M. Sen Gupta to start the work on the Bihar scheme. A good deal of material in the way of Settlement Reports, Crop and Season Reports, district maps etc. required for this purpose had been collected during my visit to Patna and had been already sent to Giridih ; orders were also issued by Government on the 30th November 1943 to have two sets of C. S. village maps sent there immediately.

86. *The first design for the survey.* Mr. Williams (Secretary, Revenue Department) was very keen that the eleven important wheat districts should be all included in the survey. As the total area proposed to be covered was large, something like 42,000 square miles, while the field staff would be comparatively small it was decided to adopt a two-stage design with the random selection of *mauza* maps in the first stage and location of grids at random within selected *mauza* sheets in the second stage. A good deal of labour was spent in the tabulation of crop records ; preparation of maps etc.; and the first design for the survey was got ready by the first week of December 1943. C. S. village maps were, however, necessary to start the actual preparatory work of locating the grids on appropriate village maps. During my visit to Patna in November I had emphasised the importance of the C. S. village maps reaching Giridih at a very early date for this purpose. Unfortunately, there was great delay in receiving the village maps. On the 15th December maps had not yet arrived from some of the important wheat districts. It was clear that the preparatory work on the scale originally proposed could not possibly be finished in time.

87. *The second design for the survey.* During my visit to Patna on the 17th December 1943 it was, therefore, decided to give up the original scheme, and to restrict the exploratory

survey to only two districts Shahabad and Monghyr for which village maps had reached Giridih. The original design of the survey had to be abandoned ; and work had to be started immediately on a new design.

88. *Lack of accommodation.* I have already mentioned that about 50 persons were working at Giridih at the end of November. A staff of at least 180 was, however, necessary to finish the preparatory work in time for the *rabi* survey. I asked Mr. N. T. Mathew (Statistician in charge of the Giridih Branch) to appoint as many local workers as he could get ; and decided to transfer the required number of men from Calcutta to Giridih.

89. *Proposal for land acquisition.* Our outstanding difficulty was, however, lack of accommodation. I had pointed this out during my visit to Patna, and I had suggested that certain pieces of land adjoining the premises in the occupation of the Institute should be acquired through the Land Acquisition Act and that the Institute should put up necessary structures at its own cost. My proposal was approved in principle by the Government of Bihar, and we were assured that full Government support would be given to us in this matter. Instructions were issued accordingly to Mr. J. S. Wilcock, I.C.S., Deputy Commissioner, Hazaribagh, to help us in securing necessary accommodation for our work. He came to Giridih on the 2nd December 1943, and on the 3rd I discussed with him our immediate requirements. Pending acquisition of land, certain premises (belonging to one Mr. Myers) adjoining the Institute premises were placed at our disposal through his good offices from the 8th December 1943.

90. This made available to us some badly needed floor space but did not solve the housing problem at Giridih. We, therefore, submitted to Government on the 15th February 1944 an application for the acquisition of certain lands. During my visit to Patna at the end of March I had the opportunity of discussing this question with H. E. Mr. (now Sir) Francis Mudie, then Governor of Bihar, who very kindly assured me that immediate action would be taken in this matter by Government. A little later notification for acquisition of land for the Institute was issued, and official enquiries by the Land Acquisition Collector were held in June and July. In the meantime we purchased a large quantity of cement and iron (with permits issued by the Government of India on the recommendation of the Government of Bihar), bricks, and other building materials ; but our construction programme has been held up as orders for land acquisition had not been issued by Government up to the time of writing this report. This is very seriously hampering the Bihar Crop Survey work.

PREPARATORY WORK

91. *General arrangements.* The new design for the survey (a description of which has been given in Section 3) was completed by the end of December 1943. Many details had to be attended to in organizing the preparatory work on a large scale. I went to Patna on the 7th January 1944 where I discussed matters with Rai Bahadur S. P. Sinha ; we then both went to Giridih. In the meantime, local recruiting of additional hands had been proceeding at Giridih ; and about 60 men were also transferred from Calcutta to Giridih. These men had not only to be housed but also fed ; at one time four different kitchens had therefore to be run by the Institute for this purpose.

92. *Location of grids and preparation of field lists.* The first task to be undertaken was the sorting and grouping of the village maps by *thanas* which itself was a large undertaking. This was followed by the location at random of eighteen thousand sample-units or grids on appropriate village maps. The preparation of field lists of more than two lakhs of plots also proceeded simultaneously.

93. After marking the grids on the appropriate village maps, these were sorted into bundles among the two samples (A) or (B), six different sub-blocks, and five haltages in accordance with the design of the survey. There were also various other items of work of a routine type in getting things ready for the survey.

94. *Special difficulties.* Unforeseen difficulties also arose from time to time. One of these is worth mentioning. Maps of certain villages in Monghyr district each consisted of a very large number of separate sheets, and in one case a single village had more than 170 different sheets. No consolidated village map showing the boundaries of the different sheets was available. It was impossible to locate the grids in the correct proportion or even to identify the grids. It was necessary therefore to prepare a map of each village as a whole showing the boundary of each individual sheet.

95. This could be done in the usual way by tracing and preparing drawings to scale which however would take an enormous amount of time. A photographic method was, therefore, devised for this purpose. Each village sheet was photographed on a small scale on cinema films with a microfile camera and contact prints were made. Each print was

out out along the actual village boundary ; and these small village contours were then fitted (something like a jig-saw puzzle) into a map of the village as a whole. This reconstructed map was then again photographed, and a print was made on an appropriate scale to fit into the *thana* map. The volume of photographic work was large as nearly 3,000 different photographs had to be made of village maps for the preparatory work in the *rabi* season alone.

96. *Completion of preparatory work.* The preparatory work had to be done at high pressure, but inspite of many difficulties it was completed in time. By the end of the first week of February 1944 all necessary maps, field lists, charts, instruction sheets etc. were ready for being despatched to the field branch according to plan.

ORGANIZATION OF THE FIELD BRANCH

97. *Preliminary arrangements.* Rai Bahadur S. P. Sinha was appointed Superintendent of Statistical Surveys just before the Christmas holidays ; but even before formally taking over charge he met me in Patna on the 17th and 18th December 1943 to discuss matters relating to the organization of the field branch. He and Mr. Priti Ranjan Sen of the Revenue Department came to Calcutta on the 25th December 1943 and stayed there for a few days to look into arrangements relating to the Crop Survey Scheme in Bengal.

98. *Loan of Bengal staff and local recruitment in Bihar.* The recruiting of the field staff was started in January 1944. Rai Bahadur Sinha suggested that as time was short it would be a distinct advantage if arrangements could be made to send on loan from Bengal a staff of experienced crop survey workers to help in giving training to the locally recruited men in Bihar and also generally in organizing the exploratory survey in the *rabi* season. I gladly agreed to this proposal, and 74 crop survey workers were sent to Bihar on loan from Bengal in charge of two field supervisors, Messrs. Dhirendra Mohan Ganguli and Pranay Kumar Chatterjee and 4 technicians, Harikinkar Nandi, Nirmal Kumar Chakravarti, Anil Kumar Gayen, and Gourishankar Chatterjee who were all first class M.Sc.'s in either Statistics or Mathematics.

99. *Strength of field staff.* It will be remembered that the field programme was divided into broadly two portions, the general or extensive scheme covering the whole of the two districts Shahabad and Monghyr ; and the special (or intensive) scheme in which work was concentrated at two centres in each of the two districts Shahabad and Monghyr, where work of a more advanced nature was done. In addition, certain areas in Patna, Gaya, and Champaran districts were also covered by moving parties for work of a preliminary nature.

100. The staff employed in the different schemes is shown below in Table (4/1). Col.(1) gives the names of districts and centres; and cols.(2) to (5) the number of different categories

TABLE (4/1). DISTRIBUTION OF FIELD STAFF BY DISTRICTS AND SCHEMES

Name of District	Staff on loan from Bengal				Staff recruited in Bihar				Total field staff			
	Chief inspectors	Inspectors	Investigators	Total	Chief-inspectors	Inspectors	Investigators	Total	Chief inspectors	Inspectors	Investigators	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
GENERAL (EXTENSIVE) SCHEME												
Shahabad	3	12	12	27	3	11	24	38	6	23	36	65
Monghyr	3	12	11	26	3	11	26	40	6	23	37	66
Total	6	24	23	53	6	22	50	78	12	46	73	131
SPECIAL (INTENSIVE) SCHEME												
Shahabad	—	1	8	9	—	—	9	9	—	1	17	18
Monghyr	—	1	8	9	—	—	10	10	—	1	18	19
Patna, Gaya, & Champaran	—	1	2	3	—	—	5	5	—	1	7	8
Total	—	3	18	21	—	—	24	24	—	3	42	45
Grand Total	6	27	41	74	6	22	74	102	12	49	115	176

of workers sent on loan from Bengal; col.(2) gives the number of chief inspectors; col.(3) the number of inspectors; col.(4) the number of investigators; and col.(5) the total number. Similar information is given for the staff recruited in Bihar in col.(6) to (9) respectively and for the combined staff in col.(10) to (13). The Bengal staff of 74 consisted of 6 chief inspectors, 27 inspectors and 41 investigators; the number of workers recruited in Bihar was 102 consisting of 6 chief inspectors, 22 inspectors and 74 investigators; the combined field staff in the scheme

was thus 176 made up of 12 chief inspectors, 49 inspectors, and 115 investigators. There were also 4 technicians (or trained statistical workers) and two field supervisors from Bengal, and the Superintendent of Statistical Surveys and his assistant in Bihar.

PROGRESS OF FIELD WORK

101. *Training of field staff.* It had been decided to give some preliminary training to the newly recruited staff in Bihar, and a training camp was opened for this purpose on the 3rd February 1944 at Gogri in Monghyr district. The six chief inspectors and a number of inspectors from Bengal in charge of two field supervisors also went there to organize the training camp, and all Bihar trainees were instructed to join there. Training was given for one week after which the field workers went to their respective centres of work. In the meantime ,the remaining workers from Bengal went to their respective camps directly from the Giridih Statistical Laboratory carrying with them all necessary maps, field lists etc.

102. *Progress of field survey.* Actual field work was started on 12th February and was continued for two months terminating on the 13th April 1944. The total period of work was 62 days out of which two days were treated as holidays on account of the *holi* festival so that the actual period of work was 60 days divided into 5 haltages of 12 days each as already noted. The field work proceeded smoothly and was completed at the scheduled times under the able supervision of Rai Bahadur S. P. Sinha. The total volume and distribution of work have been given in Section 8.

103. *Conference at Bikramganj.* I went to Patna on the 23rd March 1944 and then to Bikramganj on the 25th March and stayed there for two days for inspecting the field work. Rai Bahadur S. P. Sinha, his Assistant Supervisor, the two field supervisors from Bengal Dhirendra Mohan Ganguly and Pranay Kumar Chatterjee, had also gone there. On the statistical side Messrs. J. M. Sen Gupta (in charge of Bengal Crop Survey work), N. T. Mathew (in-charge of Bihar Crop Survey work at Giridih) and the 4 technicians, Harikinkar Nandi and Anil Gayen (in charge of the special camp at Bikramganj), Nirmal Kumar Chakravarti and Gourishankar Chatterjee (in charge of the special camp at Gogri) had also assembled at Bikramganj. We availed this opportunity to have not only a joint inspection of the field work but a series of joint discussions lasting for several hours each day on matters relating to the technique of field operations. The problem of mixed crop, and sampling procedure for crop-cutting work received special attention. Certain decisions were reached at these meetings to which reference will be made in appropriate sections.

104. *Contact between field and statistical branches.* Throughout the progress of the survey close contact was maintained between the field and statistical branches. As already mentioned, Rai Bahadur had come to Calcutta in the fourth week of December 1943; I went to Patna on the 17th January 1944; and then we both went to Giridih. Rai Bahadur came to Calcutta on the 17th February and again early in April, while I had gone to Patna and had inspected the field work at the end of March. Besides this, workers from the Statistical Laboratory went to Patna from time to time to discuss various matters.

TABULATION AND STATISTICAL ANALYSIS

105. *Original plan for tabulation of rabi records.* Instructions had been given to the field staff to send the material collected in each haltage, as soon as these were ready, directly to Giridih. At the statistical end the intention was to arrange continuous tabulation with the preparation of accumulated totals for each haltage so that up to date results of the survey would be available within a week of the receipt of the field records. As already mentioned, I went to Giridih on the 10th February and stayed there for about a week to make necessary arrangements for this purpose.

106. *Delay in arrival of field records.* The plan was however upset for two reasons. Unfortunately, there was considerable delay in the despatch of field records during the first two or three haltages owing to a very trivial hitch, namely, the lack of provision for purchasing postage stamps by the investigators. Field records began to reach Giridih in small batches from the 29th February 1944 and were tabulated as fast as possible.

107. *Change of plan.* By the third week of February certain developments had occurred which made changes in the plan inevitable. In the original scheme it had been proposed that, in case the work in the *rabi* season progressed smoothly, a survey on a somewhat larger scale would be taken up in the *bhadoi* season in which field work would start at the end of June or early July. The original plan was to complete the tabulation of the material collected in the *rabi* season by the end of April, and start the preparatory work for the *bhadoi* season sometime in early May as workers became free from *rabi* tabulation.

108. *Preparatory work for early makai (maize) survey.* Rai Bahadur S. P. Sinha had however suggested that a small scale survey of the early *makai* (maize) crop should be taken up in May in certain tracts of Monghyr, Purnea and Bhagalpur. As this would give good opportunities for strengthening the field staff I readily agreed to the proposal and Government sanction was obtained accordingly. A good portion of the Giridih staff had, therefore, to be engaged in the preparatory work for the *makai* survey.

109. *Enlarged scheme for the bhadoi survey.* Another decision made at the end of March necessitated further changes in our original plan for tabulation. The field survey in the *rabi* season had been organized so successfully that Rai Bahadur thought there would be no difficulty in attempting a survey on a full provincial scale in the *bhadoi* season of 1944 instead of waiting till the *aghani* season of 1945 as proposed in the original scheme. Examination of the *rabi* records showed that quality of field work had been quite satisfactory; and personal inspection of the field work at the end of March convinced me of the soundness of the Rai Bahadur's proposal. Government sanction was, therefore, obtained and necessary arrangements were made for starting the preparatory work for the survey in the *bhadoi* season from the begining of April.

110. *Slow tabulation of rabi records.* Thus, owing, first, to the initial delay in receiving the field records; and secondly, the starting of preparatory work for early *makai* and *bhadoi* surveys, the staff engaged at Giridih on the *rabi* material had to be reduced appreciably. Further increase of staff at Giridih was not possible for lack of accommodation. A portion of the Bihar work was therefore transferred to Calcutta which caused delays. I went to Giridih on the 12th April and stayed there for three days to see to local arrangements. As priority had to be given to the preparatory work for *makai* and *bhadoi* surveys, slowing down of the tabulaion of the *rabi* materials became inevitable.

111. *Preliminary report.* A preliminary report on the survey in the *rabi* season based on material collected in three (out of five) haltages, that is, up to 28th March was, however, submitted on the 28th April 1944.

112. *Subsequent delays.* It was my intention to submit another report in the course of a month but this was not possible for unforeseen reasons. The primary tabulation of *rabi* had been completed by the middle of May, and I started writing the report at Kalimpong on the 16th May ,1944. I was, however, obliged to go down suddenly to Calcutta on the 19th May to discuss matters relating to the Bengal Crop Survey Scheme with the Government of Bengal. Unfortunately, I had an acute attack of appendicitis at the end of May which interrupted work on the present report. I was also obliged to cancel my visit to Patna for an interview which H. E. Sir T. G. Rutherford ,Governor of Bihar, had kindly agreed to give me on the 1st June. Continued ill health as well as pressing work in connexion with the Bengal Crop Survey Scheme (which had been sanctioned in the meantime on a much enlarged scale for three years) interfered with the writing of the present report. Another difficulty was that in Calcutta I was unable to examine the primary records and tabulation sheets which were at Giridih; while, owing to my illness, I was unable to go to Giridih for several months.

113. *The present report.* I arrived at Giridih on the 2nd October and immediately started writing this report; but there was another interruption as I had to go to Calcutta in the 17th October and stay there for about a week for some urgent statistical work of the Government of Bengal. The report was, however, finished on the 31st October, much later than I had originally intended.

ACKNOWLEDGEMENTS

114. Without the ungrudging help of my fellow-workers in the Indian Statistical Institute a scheme of this kind could not have been successfully carried out. Mr. J. M. Sengupta helped me all along in the planning and the superior direction of my work; the brunt of the work fell on Mr. N. T. Mathew who was in charge of the statistical work at Giridih, and was ably assisted by the local staff, among whom Jitendranath Taluqdar, Haribhajan Choudhury, Rajendrachandra Roy, Dhirendrachandra Sarker, and Probhat Ranjan Sinha deserve special mention. Mr. Brajokishore Sinha was responsible for finishing in time the heavy photographic work at the preparatory stages. In the field branch good work was done by the two supervisors, Messrs. Dhirendra Mohan Ganguly and Pranay Kumar Chatterjee and the four technicians, Harikinkar Nandi, Nirmal Kumar Chakravarti, Anil Kumar Gayen and Gouri Shankar Chatterjee whose services were sent on loan to Bihar from the Institute.

PART 2. RESULTS OF THE RABI SURVEY

SECTION 5. AREA UNDER RABI CROPS : 1943-44

115. The present section gives the results relating to the area survey which, as already noted, began rather late in the season. The programme of work was divided into five haltages each covering a 12-day period. In certain regions harvesting started from the third haltage (between 8th and 20th March 1944) or practically from the middle of the area survey programme. Area survey along with crop-cutting work was continued during the fourth (21st March -2nd April) and fifth (3rd April -13th April) haltages, but in the latter haltage a good deal of the crop was found to have been already harvested. This naturally affected the results of the area survey; records for *masuri* were mostly missing as much of the crop had been harvested before the area enumeration could begin; and this crop has been omitted from the present report.

CROP ACREAGE BY HALTAGES

116. Table (5/1) gives the area (in thousand acres) of five important crops (wheat, barley, gram, *arhar*, and *khesari*) by districts and haltages. The serial number of the haltages is shown in col.(1); the period (date) of survey in col.(2); and the total number of grids or sample-units enumerated in col.(3). The area in thousand acres is given in successive cols. (4) to (8) for the five crops, wheat, barley, gram, *arhar*, and *khesari* respectively.

TABLE (5/1). CROP AREA IN THOUSAND ACRES BY DISTRICTS AND HALTAGES

Serial No. of haltages	Period of Enumeration	Number of grids	Area in thousand acres under				
			Wheat	Barley	Gram	Arhar	Khesari
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	DISTRICT : SHAHABAD (AREA = 2,798,000 ACRES)						
1	11 Feb - 23 Feb	1607	261·95	98·31	429·65	81·65	276·93
2	25 Feb - 6 Mar	1636	360·45	81·11	356·48	63·72	273·77
3	8 Mar - 20 Mar	1596	303·43	71·11	290·50	53·55	138·58
4	21 Mar - 2 Apl	1433	276·47	56·13	241·51	35·41	101·68
5	3 Apl - 13 Apl	1051	135·16	18·47	89·55	57·09	24·35
1-5	11 Feb - 13 Apl	7323	276·64	69·80	301·77	58·38	172·91
	DISTRICT : MONGHYR (AREA = 2,370,000 ACRES)						
1	12 Feb - 25 Feb	1408	307·22	65·49	292·81	144·30	98·91
2	26 Feb - 7 Mar	1539	244·94	71·70	190·05	109·56	22·07
3	8 Mar - 20 Mar	1413	255·71	65·42	141·37	77·64	28·17
4	21 Mar - 2 Apl	1488	327·57	65·03	149·43	83·37	42·07
5	3 Apl - 13 Apl	1181	188·16	24·41	123·23	73·70	19·20
1-5	12 Feb - 13 Apl	7029	267·96	59·77	181·64	98·67	43·00

117. The chief point to be noted in this table is the steadily decreasing area under practically all the different crops in successive haltages. This was presumably due to the increasing proportion of the crop having been harvested in the later haltages. The lesson to be learnt from the present records is that the area survey in the *rabi* season must be completed before the beginning of harvesting which in practice would mean by end of February or early March. It would, however, be obviously desirable to carry out a skeleton area survey at the time of harvesting to determine what proportion of the total area sown is actually harvested. This point has been further discussed in a later section (paragraphs 318, 319).

CROP ACREAGE BY DISTRICTS AND SUB-SAMPLES

118. For reasons explained above, the records for the first four haltages only have been taken into consideration for estimating the district crop acreage figures and their margin of error which are given in Table (5/2). Col. (1) gives the name of the crop ; col. (2) the area (in thousand acres) under each crop (together with the corresponding standard error) estimated from sample (A) ; col. (3) gives the correspending estimate based on sample (B). The difference between the two estimates (A) and (B) expressed in terms of the standard error of the difference is given in col. (4) for convenience of statistical comparison. Combined estimates of crop acreage based on both samples (A) and (B) are shown in col. (5).

Corresponding acreage figures as given in the Settlement Reports (covering the years 1907-1916 in Shahabad and 1905-1912 in Monghyr) are shown in col. (6); and corresponding official forecasts for 1943-44 (taken from the fourth wheat forecast and that dated 26th April 1944 for other crops issued by the Director of Agriculture) are shown in col.(7).

TABLE (5/2). CROP AREA IN THOUSAND ACRES BY DISTRICTS AND SUB-SAMPLES (BASED ON FIRST FOUR HALTAGES).

Crop	Sample(A)	Sample(B)	d(A—B)	Combined(A+B)	Settlement Report (a)	Forecast 1943-44 (b)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	DISTTICT : SHAHABAD (AREA = 2,798,000 ACRES)					
	N = 3307	N = 2965		N = 6272		
Wheat	296·36±27·13	304·37±29·16	0·20	300·35±19·87	227·9	263·80
Barley	74·63±16·10	82·08± 9·23	0·40	78·40± 9·51	105·4	102·50
Gram	369·02±42·75	305·55±33·07	1·17	337·33±26·86	339·5	282·30
Arhar	62·06±16·51	55·14±18·45	0·28	58·60±12·59	51·4	41·00
Khesari	251·85±33·18	148·75±34·25	1·56	197·81±23·78	—	—
	DISTRICT : MONGHYR (AREA = 2,370,000 ACRES)					
	N = 3165	N = 2685		N = 5848		
Wheat	242·25±35·23	325·99±40·22	1·57	284·08±31·62	144·9	219·80
Barley	44·86± 5·80	88·94± 7·11	4·80	66·90± 5·32	81·4	81·90
Gram	222·24±36·87	164·27±26·39	1·27	193·43±26·86	210·5	210·50
Arhar	105·17±25·52	102·21±29·90	0·08	103·71±23·22	(c)42·5	81·00
Khesari	45·81±16·75	49·82±19·69	0·16	47·80±15·11	—	—

(a) Settlement period : Shahabad 1907—1916 and Monghyr 1905—1912.

(b) Forecast of *rabi* crops dated 26th April 1944, and Fourth wheat forecast issued by Director of Agriculture.

(c) *Arhar* figure for North Monghyr alone in Settlement Report.

119. In Shahabad district the sample survey estimates of crop acreage (in thousand acres)are 300·35±19·87 for wheat, 78·40±9·51 for barley, 337·33±26·86 for gram, 58·60±12·59 for *arhar*, and 197·81±23·78 for *khesari*. In Monghyr district the corresponding values were 284·08±31·62 for wheat, 66·90±5·32 for barley, 193·43±26·86 for gram, 103·71±23·22 for *arhar* and 47·80±15·11 for *khesari*. We have already seen, however, that appreciable portions of the crop had been harvested during the later stages of the area enumeration; above figures must therefore be to some extent under-estimates; and are thus not comparable with official figures.

OFFICIAL FIGURES NOT STRICTLY COMPARABLE

120. There is another serious difficulty in comparing sample and official estimates. In Bihar in the *rabi* season most of the plots are sown with mixed crops; but it is not at all clear what is exactly meant by the area under any individual crop sown in mixture with other crops. The subject is full of compliactions and has been discussed in a separate section.

121. For reasons explained above a valid comparison is not possible between sample and official figures. A very rough comparison can, however, be made for just what it may be worth. In Shahabad district with a total area of 2,798,000 acres we find that sample survey gives an estimate of about 300,000 acres under wheat against a Settlement figure of about 228,000 and an official forecast of 263,800 acres in 1943-44. The Settlement figures are very old and refer to the period 1907-16 for Shahabad and 1905-12 for Monghyr. Considerable changes in crop acreage may have easily taken place since then. It is, therefore, quite possible that the area under wheat had actually increased to about 300,000acres in 1943-44, so that the official

forecast of 263,800 acres may be appreciably in defect. For barley the area during 1907-1916 was 105,420 acres according to the Settlement Report; the official estimate gives practically the same figure while the sample estimate of 78,400 acres is somewhat lower, but nothing improbable. For gram, the sample estimate of 337,330 acres is very nearly the same as the Settlement figures of 339,510 acres; the official forecast of 282,300 acres is appreciably lower. For *arhar* also the sample figure of 58,600 acres is nearer the Settlement figure of 51,440 acres than the official forecast of 41,000 acres. Neither Settlement nor official figures are available for *khesari*.

122. In Monghyr the sample estimate of the wheat area of 284,080 acres is appreciably higher than both the Settlement figure of 144,860 acres and the official forecast of 219,800; this is quite plausible. Barley with a sample estimate of 66,900 acres against Settlement figures of 81,430 acres and official forecast of 81,900 acres, shows a shrinkage as in Shahabad district. For gram the sample estimate of about 193,000 acres is somewhat smaller than the two official figures of about 211,000 acres. But for *arhar* the sample estimate of 103,710 acres is much larger and of quite a different order from the official forecast of only 1,000 acres .It is interesting to note that according to the Settlement Report(1905-07, Appendix D(ii)) the acreage under *arhar* in North Monghyr alone was about 42,000 acres so that the sample estimate for the whole district is not at all improbable.

123. On the whole, from the sample figures it looks likely that the area under wheat has increased appreciably and is greater at present than at the time of Settlement operations; area under barley has probably decreased somewhat; area under gram has remained about the same as in previous years; and area under *arhar* has increased in both districts. The official forecast of 1,000 acres for *arhar* in Monghyr is entirely wrong. Settlement figures are believed to be generally reliable, and may therefore be accepted as respresenting actual crop acreages at the time of Settlement operations. Since then changes must have taken place; but against the background of Settlement figures the sample estimates look quite plausible indicating that they have an objective foundation.

AGREEMENT BETWEEN SAMPLE ESTIMATES

124. This is all that can be said so far as the external evidence is concerned. We may now consider the internal evidence in favour of the sample survey. I have already explained in an earlier section how the whole survey was organized in two independent portions. In each district, the total number of grids or sample-units was divided into two different portions sample (A) and sample (B)—scattered over the whole district. In Shahabad out of a total number of 6,272 grids there were 3,307 grids in sample (A) and 2,965 grids in sample (B). In Monghyr district out of 5,848 grids there were 3,165 in sample (A) and 2,683 in sample (B). The grids in each of the two samples (A) and (B) were scattered over the whole district and were enumerated independently by two different sets of investigators. Each of the two samples (A) and (B) can thus furnish an independent estimate of the crop acreage for the district as a whole.

125. Let us consider actual figures. In Shahabad district according to sample (A) the area under wheat (in thousand acres) was $296{\cdot}36 \pm 27{\cdot}13$ as shown in col. (2) of Table (5/2). (The latter figure of 27·13 is the expected sampling error of the actual estimate of 296·36). According to sample (B) the area under wheat (in thousand acres) in Shahabad district was $304{\cdot}37 \pm 29{\cdot}16$ (the latter figure 29·16 again being the estimated margin of error of 304·37). These two estimates 296·36 and 304·37 are, of course, not identical. They are each based not on complete enumeration of all plots under wheat but on only a comparatively small fraction of such plots. They are therefore both subject to fluctuations due to sampling. In fact the estimated standard errors of $\pm 27{\cdot}13$ and $\pm 29{\cdot}16$ (thousand acres) for the two samples (A) and (B) respectively are statistical measures of the magnitude of such fluctuations due to sampling.

126. The difference between the two estimates 296·36 and 304·37 is 8·01 (thousand acres). The estimated margin of error in the case of either sample is, however, appreciably greater than the observed difference. We find therefore that the two sample estimates (A) and (B) for wheat acreage in Shahabad district are in agreement within the margin of error, that is, within the limits of errors of sampling. Such internal agreement must be considered to be good evidence of the reliability of the sample estimates.

127. Without entering into technical details it may be stated here that for a statistical comparison of the two sample estimates (A) and (B) it is convenient to express the difference between the two estimates in terms of the margin of error of the difference itself. These values (called 'd' for convenience of reference) have been shown in col. (4) of Table (5/2). It will be noticed that the value of 'd' is less than 1 in five cases and lies between 1 and 2 in

four cases ; only in one single case, namely, barley in Monghyr district, the value of 'd' is comparatively large. Thus, with one single exception, the two estimates based on samples (A) and (B) are in satisfactory statistical agreement.

128. For barley in Monghyr district the two estimates are $44{\cdot}86 \pm 5{\cdot}80$ and $88{\cdot}94 \pm 7{\cdot}11$ (thousand acres) for samples (A) and (B) respectively. The difference is admittedly large and a value of 'd' of 4·80 cannot be neglected. It is necessary however to recall at this stage that the division into the two samples (A) and (B) was made on the basis of comparatively large zone-cells (each of area 50 square miles approximately), and was not carried to individual sample-units. As already explained in an earlier section, this rough and course grained structure of the two interpenetrating sub-samples makes it possible for real geographical differences in the different zone-cells having been shown up in the two sample estimates. That is, the two estimates (A) and (B), although mixed up for the district as a whole, refer to fairly big patches in geographically distinct areas. The observed difference for barley in the two estimates (A) and (B) may therefore be due to real regional differences in the intensity of cultivation in the big patches into which the samples were divided. It is thus not unreasonable to conclude that the two sets of results based on the two samples (A) and (B) are in satisfactory agreement and hence the sample estimates are on the whole reliable (within, of course, respective limits of sampling errors.)

129. In view of the importance of the question, we may also consider the agreement between the two samples (A) and (B) in closer detail separately for each sub-block in each district. Relevant material is given in Table (5/3) in which col. (1) gives the serial number of the sub-block ; cols. (2) and (3) give for Shahabad district the number of grids or sample-units in samples (A) and (B) respectively ; cols. (4) and (5) the crop acreage with corresponding standard errors based on samples (A) and (B) respectively ; and col. (6) the value of 'd', that is, the difference between the two estimates (A) and (B) divided by the standard error of the difference. Similar data for Monghyr district are given in cols. (7) to (11).

130. It will be noticed that for individual sub-blocks the agreement between estimates based on samples (A) and (B) are generally satisfactory as judged by the values of 'd'. Out of a total number of 60 values of 'd' given in cols. (6) and (11) we notice that 51 are less than 1, and the remaining 9 lie between 1 and 2. We also find that 5 out of 6 values of 'd' are greater than 1 for barley in Monghyr district ; the differences in the sub-blocks are not unduly large ; but sample (B) is usually giving higher estimates with the result that the difference for the district as a whole is quite large indicating the possible existence of real differences in the intensity of cultivation of barley between different zone-cells of Monghyr.

ANALYSIS OF VARIANCE FOR AREA SURVEY

131. Certain technical data relating to the precision of the results of the area survey are given in Table (5/4) in which the name of the crop is shown in col. (1). This is followed by figures relating to sample (A) in cols. (2) to (5), and corresponding data relating to sample (B) in cols. (6) to (9), and finally for the two samples combined together in cols. (10) to (13). Cols. (2), (6) and (10) give the mean proportion of land under each crop ; cols. (3), (7) and (11) the variance between (mean proportion of) zone-cells ; and cols. (4), (8) and (12) the variance within zone-cells. Finally the ratio of the variance between zone-cells to the variance within zone-cells (V_1/V_2) is shown for sample (A) in col. (5), for sample (B) in col.(9), and finally for the two samples (A) and (B) combined together in col. (13). It is worth noting that the ratio of the two variances given in cols. (5), (9) and (13) is on the whole large showing that the greater part of the fluctuation in the intensity of cultivation occurs from one zone-cell to another.

132. Based on the data given in Table (5/4) the standard deviations for different stages calculated by the appropriate two-stage formula are given in Table (5/5). The name of the crop is shown in col. (1). This is followed by the mean proportion of land under each crop for sample (A) in col. (2) ; calculated standard deviation of fluctuations between cell-means (S_1) in col. (3), and the standard deviation of fluctuations within zone-cells (S_2) in col. (4). Corresponding figures for sample (B) are given in cols. (5), (6) and (7) respectively. The mean proportion of land under cultivation (with standard error) for each crop for the two samples (A) and (B) combined together is given in col. (8) ; and the percentage variability of the combined proportion in col. (9). It will be noticed that the over-all margin of error for the estimates of crop acreages for individual districts lie between roughly 7 and 12 per cent for wheat, barley and gram ; but are appreciably higher for *arhar* and *khesari*.

TABLE (5/3). COMPARISON OF CROP AREA (IN THOUSAND ACRES) BY SUB-SAMPLES AND SUB-BLOCKS

Serial No. of sub-block	District Shahabad					District Monghyr				
	Number of grids		Estimated area with standard error		Diff. d(A-B)	Number of grids		Estimated area with standard error		Diff. d(A-B)
	(A)	(B)	Sample (A)	Sample (B)		(A)	(B)	Sample (A)	Sample (B)	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
WHEAT										
1	513	528	62·90±16·48	68·82±15·74	−0·26	517	632	1·50±19·56	6·53±17·08	−0·19
2	579	489	61·84±14·21	62·82±15·82	−0·05	614	511	13·68±16·13	17·74±17·92	−0·17
3	594	552	40·54±13·56	60·83±14·50	−1·03	654	569	57·76±18·02	46·95±19·68	+0·41
4	677	379	36·47±15·23	33·21±22·85	+0·12	508	426	59·56±20·03	85·84±22·53	−0·87
5	354	540	69·85±19·60	65·57±14·85	+0·17	423	234	44·68±21·81	76·24±28·43	−0·88
6	590	477	24·76±16·37	13·12±19·22	+0·46	449	311	65·07±21·90	92·69±25·18	−0·83
	3307	2965	296·36±27·13	304·37±29·16	−0·20	3165	2683	242·25±35·23	325·99±40·22	−1·57
BARLEY										
1	513	528	19·28± 5·12	23·74± 4·94	−0·63	517	632	1·65± 4·33	9·13± 3·86	−1·29
2	579	489	17·20± 4·46	15·41± 4·90	+0·27	614	511	5·10± 3·59	12·07± 4·02	−1·29
3	594	552	9·14± 4·25	7·21± 4·50	+0·31	654	569	3·10± 4·07	2·59± 4·41	+0·09
4	677	379	4·66± 4·77	9·22± 7·10	−0·53	508	426	9·19± 4·51	16·52± 5·04	−1·08
5	354	540	15·71± 6·09	13·08± 4·62	+0·34	423	234	3·20± 4·88	15·06± 6·40	−1·47
6	590	477	8·64± 5·08	13·42± 6·00	−0·61	449	311	22·62± 4·88	33·57± 5·64	−1·46
	3307	2965	74·63±16·10	82·08± 9·23	−0·40	3165	2683	44·86± 5·80	88·94± 7·11	−4·80
GRAM										
1	513	528	81·53±14·29	86·23±13·64	−0·24	517	632	1·46±15·82	9·05±13·86	−0·37
2	579	489	82·06±12·34	52·97±13·72	+1·58	614	511	12·14±13·04	22·26±14·51	−0·59
3	594	552	63·23±11·76	59·80±12·57	+0·20	654	569	80·75±14·59	64·38±15·91	+0·76
4	677	379	54·09±13·21	42·59±19·77	+0·48	508	426	75·72±16·20	28·33±17·77	−1·96
5	354	540	54·14±16·97	44·03±12·86	+0·47	423	234	32·07±17·64	34·73±23·02	−0·02
6	590	477	33·97±14·19	19·93±16·73	+0·66	449	311	20·10±17·71	5·52±20·34	+0·54
	3307	2965	369·02±42·75	305·55±33·07	+1·17	3165	2683	222·24±36·87	164·27±26·39	+1·27
ARHAR										
1	513	528	32·78± 9·50	24·40± 9·03	+0·64	517	632	0·16±15·55	10·86±13·62	−0·52
2	579	489	18·27± 8·20	15·86± 9·09	+0·20	614	511	2·16±12·82	3·41±14·20	−0·07
3	594	552	3·17± 7·81	6·18± 8·32	−0·26	654	569	15·48±14·34	10·69±15·65	+0·22
4	677	379	3·16± 8·76	0·83±13·16	+0·15	508	426	1·73±15·92	9·47±17·93	−0·32
5	354	540	0·26±11·27	2·07±10·02	−0·12	423	234	56·66±17·36	57·63±22·63	−0·03
6	590	477	4·42± 9·41	5·80±11·03	−0·10	449	311	28·98±17·43	10·15±21·98	+0·67
	3307	2965	62·06±16·51	55·14±18·45	+0·28	3165	2683	105·17±25·52	102·21±29·90	+0·08
KHESARI										
1	513	528	26·21±19·65	16·02±18·76	+0·38	517	632	0·00	0·00	0·00
2	579	489	56·76±16·97	47·44±78·84	+0·37	614	511	1·18± 8·44	11·21± 9·38	−0·79
3	594	552	40·41±16·13	41·96±17·29	−0·07	654	569	22·60± 9·42	22·52±10·31	+0·01
4	677	379	25·75±18·13	8·29±27·25	+0·53	508	426	9·15±10·48	3·71±11·81	+0·34
5	354	540	84·31±23·40	29·18±17·70	+1·88	423	234	1·29±11·43	0·47±14·91	+0·04
6	590	477	18·41±19·48	5·86±22·93	+0·58	449	311	11·59±11·47	11·91±13·15	−0·02
	3307	2965	251·85±33·18	148·75±34·25	+0·28	3165	2683	45·81±16·75	49·82±19·69	−0·16

TABLE (5/4). PROPORTION OF LAND UNDER DIFFERENT CROPS BY SUB-SAMPLES : ANALYSIS OF VARIANCE BETWEEN AND WITHIN ZONE-CELLS.

Name of crops	Sample (A)				Sample (B)				Combined (A & B)			
	Mean proportion (p)	Between cells (v_1)	Within cells (v_2)	Ratio (v'_1) (v_2)	Mean proportion (p)	Between cells (v_1)	Within cells (v_2)	Ratio (v'_1) (v_2)	Mean proportion (p)	Between cells (v_1)	Within cells (v_2)	Ratio (v'_1) (v_2)
(1)	(2	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	DISTRICT : SHAHABAD (NUMBER OF GRIDS = 6272)											
Wheat	·1059	·2904	·0228	12·73	·1088	·2980	·0276	10·72	·1073	·3005	·0251	11·97
Barley	·0267	·1019	·0044	23·16	·0293	·0319	·0051	6·25	·0280	0·663	·0048	13·81
Gram	·1319	·7190	·0294	24·46	·1092	·3803	·0243	15·65	·1206	·5514	·0270	20·42
Arhar	·0222	·1068	·0047	22·72	·0197	·1192	·0089	13·39	·0209	·1122	·0079	14·20
Khesari	·0900	·4332	·0249	17·40	·0514	·4034	·0176	22·92	·0707	·4207	·0214	19·66
	DISTRICT : MONGHYR (NUMBER OF GRIDS = 5848)											
Wheat	·1022	·6431	·0248	25·93	·1375	·6691	·0308	21·72	·1199	·6527	·0276	23·65
Barley	·0189	·0183	·0042	4·36	·0375	·0220	·0077	2·86	·0282	·0230	·0058	3·97
Gram	·0938	·7034	·0212	33·18	·0695	·2875	·0149	19·30	·0816	·4994	·0183	27·29
Arhar	·0444	·3367	·0149	22·60	·0431	·3702	·0146	25·36	·0438	·3521	·0148	23·79
Khesari	·0193	·1479	·0072	20·54	·0210	·1608	·0072	22·33	·0202	·1528	·0072	21·22

TABLE (5/5). MULTI-STAGE ESTIMATES OF THE STANDARD DEVIATION OF MEAN PROPORTION OF LAND UNDER CROPS BY SUB-SAMPLES.

Name of crops	Sample (A)			Sample (B)			Combined (A+B)	
	Mean proportion (p)	Between cells (s_1)	Within cells (s_2)	Mean proportion (p)	Between cells (s_1)	Within cells (s_2)	Mean proportion with standard error (p)	Percentage variability
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	DISTRICT : SHAHABAD (NUMBER OF GRIDS = 6272)							
Wheat	·1059	·0628	·1500	·1088	·0660	·1661	·1073± ·0071	6·62
Barley	·0267	·0380	·0663	·0293	·0200	·0714	·0280± ·0034	12·14
Gram	·1319	·1000	·1717	·1092	·0762	·1559	·1206± ·0096	7·96
Arhar	·0222	·0380	·0887	·0197	·0425	·0943	·0209± ·0045	21·53
Khesari	·0900	·0768	·1716	·0514	·0795	·1327	·0707± ·0085	12·02
	DISTRICT : MONGHYR (NUMBER OF GRIDS = 5848)							
Wheat	·1022	·0970	·1575	·1375	·1073	·1755	·1199± ·0113	9·42
Barley	·0189	·0148	·0648	·0375	·0167	·0877	·0282± ·0019	6·74
Gram	·0938	·1020	·1476	·0695	·0700	·1221	·0816± ·0096	11·76
Arhar	·0444	·0700	·1221	·0431	·0800	·1208	·0438± ·0083	18·95
Khesari	·0193	·0061	·0848	·0210	·0053	·0848	·0202± ·0054	26·73

DECREASE IN CROP AREA ENUMERATED IN SUCCESSIVE HALTAGES

133. The gradual decrease in the area under practically all the crops in successive haltages has been pointed out in an earlier paragraph. It was also noted that this was probably due to the fact that harvesting had commenced in the middle of the area survey so that much of the crop had already been harvested before the area enumeration work could start in the fourth and fifth haltages. A second factor also might have been in operation. Owing to failure of rain, damage caused by pests or animals, and other accidental causes, portions of the area sown go out of cultivation and are not harvested. The area harvested in fact must be always less than the area sown. This gap between the area sown and the area harvested may be large for paddy according to Sir John Hubback and has been further discussed in a later section. I have no knowledge, and I have not been able to secure any reliable information as to the extent to which the harvested area falls short of the area sown in the *rabi* season in Bihar. If this gap is considerable then the observed decrease in acreage-estimates in the later haltages may have also to be partly ascribed to this factor.

134. Although it is not possible from the available material to disentangle how far the observed decrease in area estimates is due (*a*) to previous harvesting of the crop or (*b*) to fields having gone out of cultivation through the operation of natural causes, it is of some interest to consider the facts as observed. Relevant material is given in Table (5/6) in which col. (1) gives the serial number of the haltage; col. (2) the actual period of survey. The observed crop acreage (in thousand acres) is given in col. (3) for wheat and in cols. (5), (7), (9) and (11) for barley, gram, *arhar* and *khesari* respectively.

TABLE (5/6). ESTIMATED CROP AREA IN THOUSAND ACRES BY HALTAGES

Serial No. of haltage	Period of survey	Wheat		Barley		Gram		Arhar		Khesari	
		observed	graduated	observed	graduated	observed	graduated	observed	graduated	observed	graduated
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	DISTRICT : SHAHABAD										
1	11 Feb - 23 Feb	262	335	98	102	430	452	82	73	277	298
2	25 Feb - 6 Mar	360	301	81	83	386	370	64	65	274	230
3	8 Mar - 20 Mar	303	267	71	65	290	288	54	58	139	163
4	21 Mar - 2 Apl	276	233	56	46	242	205	35	50	162	95
5	3 Apl - 13 Apl	135	200	18	23	90	123	58	43	24	27
	DISTRICT : MONGHYR										
1	12 Feb - 25 Feb	307	296	65	76	293	255	144	132	99	70
2	26 Feb - 7 Mar	245	280	72	67	190	217	110	115	22	53
3	8 Mar - 20 Mar	256	265	65	58	141	179	78	98	28	42
4	21 Mar - 2 Apl	328	249	65	49	149	141	83	81	42	28
5	3 Apl - 13 Apl	188	234	60	40	182	103	99	64	43	14

135. The observed acreages were graduated by simple straight lines, and the graduated values are given in cols. (4), (6), (8), (10) and (12) of the same table for wheat, barley, gram, *arhar* and *khesari* respectively. The graduating equation in each case was of the form: $y=a+b(x)$, where (y) is the graduated value of crop acreage and (x) is the serial number of the haltage. The values of (a) and (b) for the different crops are shown in Table (5/7) separately for the two districts Shahabad and Monghyr.

TABLE (5/7). LINEAR GRADUATION OF CROP AREA : $y=a+b(x)$

y = AREA UNDER CROP IN THOUSAND ACRES
x = SERIAL NUMBER OF HALTAGES

Name of crop	Estimated values of parameters			
	'a'		'b'	
	Shahabad	Monghyr	Shahabad	Monghyr
(1)	(2)	(3)	(4)	(5)
Wheat	368·60	311·30	−33·80	−15·50
Barley	120·30	48·90	−18·50	−8·90
Gram	534·80	293·30	−82·40	−38·10
Arhar	80·60	148·50	− 7·60	−16·90
Khesari	360·00	84·00	−67·80	−14·00

SAMPLE FIGURES PROBABLY UNDER-ESTIMATES

136. On account of the progressive decrease in crop acreage in successive haltages it is clear that the average estimate based even on the first four haltages must necessarily be under-estimates of the total area sown. If the decrease in crop acreage is mainly due to the crop having been harvested before the area enumeration had taken place (which is likely) then the average sample estimates considered here must also be under-estimates of the area harvested. One could perhaps use the graduated values for the first haltage as adjusted crop acreages free from the decreasing tendency noticed in the observed values. On this

basis, the area under wheat would be 335,000 acres against an average observed value of 300,000 acres in Shahabad; and 296,000 acres against observed average of 284,000 acres in Monghyr district. For barley we get adjusted values of 102,000 and 76,000 acres against average values of 78,000 and 67,000 acres; for gram the adjusted values of 452,000 and 255,000 acres against average values of 337,000 and 193,000 acres; for *arhar* adjusted values of 73,000 and 132,000 acres against average values of 59,000 and 104,000; and finally adjusted values of 298,000 and 70,000 acres for *khesari* against average values of 198,000 and 48,000 acres in the two districts Shahabad and Monghyr respectively. These adjusted values may be accepted as upper limits of 'area sown'; but much reliance cannot be placed on these results in the absence of factual knowledge regarding shrinkage of area sown with the progress of the crop season.

SECTION 6. RATE OF YIELD AND OUTTURN OF WHEAT AND GRAM: 1943-44

137. Crop-cutting work started in some of the sub-blocks in the third haltage, that is, between 8th and 20th March and was carried on in full swing during the last two haltages, that is, from 21st March to 13th April, 1944.

138. *Work on two crops, wheat and gram.* During preliminary discussions with the Government of Bihar I had enquired whether at least portions of the crop-cutting work could be done by (or under the supervision of) the staff of the Agriculture or Co-operative Departments, but I was informed that this was not possible. The whole of the work had to be done within the limited resources (in men and money) of the present scheme. It was decided, therefore, to restrict the crop-cutting work to only two crops, namely, wheat and gram. Even with two crops the total volume of work which could be done was strictly limited. There were only two alternatives, either to reduce the total number of cuts or to reduce the size (area) of each cut. The total number of cuts could not, however, be reduced too much as the margin of error of the average yield for the district would be too high.

139. *Size of cuts.* Extensive crop-cutting work in Bengal had shown that sample-units of a comparatively small size were more efficient in the sense that a higher precision could be attained in the final results with less expenditure of labour (and hence at lower cost). The advantage of using comparatively small cuts had also been fully established by a classical series of crop-cutting experiment conducted in Bihar by Sir John Hubback between 1923 and 1925. He had used small triangular cuts of size 1/3200 acre (=13.6 sq. feet) each; and in his paper on "Sampling for Rice Yield in Bihar and Orissa" (Government of India, 1927) he had very clearly stated (p. 9) that there was no need of taking large samples instead of the handy samples used by him; and had explained that this was due to the fact that, the existence of high correlation in the yield of contiguous pieces of land, "made the ordinary rule that the standard deviation of the mean was the standard deviation of the population divided by the square root of the numbers of samples quite inapplicable".

140. It is true that Sir John Hubback's work was done on paddy; but his arguments are equally valid for other crops. In fact, the existence of high correlation between the yield of contiguous portions of land has been conclusively established for wheat and other crops by the work of Fairfield Smith (*Jour. of Agri. Sc.* Vol. 28, 1938, pp. 1-23) and others. Extensive crop-cutting work on wheat in England had also directly shown that cuts of a comparatively small size were convenient and suitable. For example, F. Yates in his articles on "Crop estimating and forecasting: Indications of the sampling observations on wheat" in the *Journal of the Ministry of Agriculture of the United Kingdom* (Vol. 43, 1936-37, p. 161) stated :—

> "……In order to provide objective estimates of yields of commercial fields ……a very simple sampling technique was adopted, only about 5 square yds. in all of any field being sampled. This amount of sampling proved amply sufficient when the purpose of sampling is that of estimating the mean yield of a district, sampling errors being small in relation to the variability between fields."

141. For reasons explained above it was decided to work with sample-cuts of 25 sq. feet each and to take two such cuts from each plot included in the sample. (This gave a sampled area of 50 square feet against a sampled area of 5 sq. yds or 45 sq. feet in the United Kingdom in the work described by Yates). The plots (from which the crop was to be cut) were selected beforehand at random in the Statistical Laboratory from among the plots which were included in the grids or sample-units used in the area enumeration. Within each selected grid two plots, one of gram and one of wheat, were picked up at random for this purpose and within each selected plot two cuts (called a doublet) were actually harvested by the worker in the way explained below.

142. *Location of cuts.* The workers were supplied with tables of random numbers out of which two numbers were picked up in serial order for each selected plot. The first random number gave the number of steps the worker was to measure along the length of the plot from one corner, and the second random number gave the number of steps which he was required to walk into the plot perpendicular to the length of the plot and parallel to the other sides. The point located in such a way formed one of the vertices of the triangular apparatus described below.

143. *Crop-cutting procedure.* Instead of using pegs and ropes a simple portable apparatus was used in Bihar during this survey. This apparatus was a modified form of the one used by Sir John Hubback in his crop-cutting work in Bihar. It consisted of three flat iron rods which formed a right-angled isosceles triangle. The longer (hypotenuse) piece was placed on the ground with one end lying over the point located at random within the plot in the way explained above. The two shorter sides were pushed through grooves fitted at the two ends of the long piece (forming the hypotenuse) at an angle of 45° until they meet at right-angles. The procedure of pushing the two side pieces through the plants was deliberately adopted by Hubback to prevent any bias coming in through the inclusion (or exclusion) of individual plants occuring on the border line.

144. The plants enclosed in this way within the triangular iron frame were then cut and weighed. In the case of wheat, the ears were clipped off and weighed giving the weight of the crop as harvested (called for convenience the weight of 'ears'). Each cutting was put into a numbered bag and dried for a few days ; the grains were then separated and weighed again giving what is called the weight of grain. In the case of gram, the pods were collected and weighed which gave the weight of pods as harvested while the grains separated from the pods after they were dried gave the weight of grain. The area enclosed within the triangular piece was 12.5 sq. feet ; two cuts were obtained on either side of the hypotenuse giving two sub-cut readings for each sample-unit of area 25 sq. feet. Two such sample units (called a doublet) were cut in every selected plot.

YIELD OF WHEAT AND GRAM PER ACRE

145. The mean yield in maunds of grain per acre of wheat and gram is shown in col. (4) and col. (8) respectively of Table (6/1) separateiy for each sub-block the serial number of which is given in col. (1). The mean yield of wheat varied from 3·48 maunds in sub-block No. (2) to 8·40 maunds per acre in sub-block No. (1) in Shahabad district ; and from 4·15 maunds in sub-block No. (2) to 10·43 maunds per acre in sub-block No. (1) in Monghyr district. In the same way, the mean yield of gram varied from 3·25 maunds in sub-block No. (6) to 6·38 maunds per acre in sub-block No. (1) in Shahabad district ; and from 3·44 maunds in sub-block (No. 2) to 7.68 maunds in sub-block No (1) in Monghyr district. The variation from one sub-block to another was thus quite appreciable in each district.

THE CONVERSION FACTOR

146. The yield of both wheat and gram has naturally to be given in terms of grain after extraction from ears and pods respectively. The process of drying the crop and extracting the grains is a complicating factor and takes time. It would simplify the field work quite appreciably if the weight of the crop could be taken immediately after harvesting and later on converted into the equivalent weight of grain. It will be remembered that this is what is done in the case of paddy which is directly weighed, and this weight later converted into weight of rice (not in husk) with the help of a conversion of factor the value of which is usually accepted as two-thirds. With a view to study the possibility of using a similar method in the case of wheat and gram the cuttings in the present survey were weighed twice, as already noted, once immediately after harvesting and a second time after the extraction of the grain.

147. From the theoretical point of view the best method of finding the relation between the weight of ears of wheat or of pods of gram as harvested and corresponding equivalent weight of grain would be to fit a linear regression equation $y=b(x)$ where 'y' is the weight of grain, and 'x' the weight of crop as harvested. All available material was graduated in this way, and relevant data are given in Tables (6/1) and (6/2). In Table (6/1) col. (1) gives the serial number of the sub-block, col. (2) the number of sub-cuts ; col. (3) the mean weight in maunds per acre of the crop as harvested ; and col. (4), as already noted, the corresponding weight in maunds per acre of dry grain.

TABLE (6/1). RELATION BETWEEN WEIGHT OF CROP AS HARVESTED AND WEIGHT OF GRAIN OF WHEAT AND GRAM

Serial No. of sub-blocks	Wheat				Gram			
	Ears as harvested		Weight of grain in maunds per acre		Pods as harvested		Weight of grain in maunds per acre	
	No. of sub-cuts	Weight in maunds per acre	Observed values	Graduated values	No. of Sub-cuts	Weight in maunds per acre	Observed values	Graduated values
(1)	(2)	(3)	(4)	(5)	(6)	(6)	(8)	(9)
				DISTRICT : SHAHABAD				
1	274	11·81	8·40	7·83	135	9·13	6·38	6·06
2	179	5·31	3·48	3·32	204	9·17	5·89	6·09
3	233	12·07	7·27	8·00	115	8·32	5·54	5·52
4	54	10·30	4·66	6·83	37	7·23	5·15	4·80
5	255	8·71	5·56	5·77	160	5·34	3·55	3·55
6	50	8·91	5·97	5·91	48	5·03	3·25	3·34
				DISTRICT : MONGHYR				
1	24	17·97	10·43	10·84	20	21·67	7·68	13·89
2	324	6·84	4·15	4·12	214	5·44	3·44	3·49
3	183	7·51	5·02	4·53	174	6·62	4·60	4·24
4	248	9·60	7·06	5·79	105	7·06	4·98	4·53
5	136	7·67	4·68	4·62	102	6·10	3·78	3·91
6	169	17·05	8·90	10·28	20	5·66	4·19	3·63

TABLE (6/2). COEFFICIENT OF CORRELATION AND REGRESSION BETWEEN WEIGHT OF CROP AS HARVESTED AND WEIGHT OF GRAIN OF WHEAT AND GRAM

Serial No. of sub-blocks	Wheat			Gram		
	Number of sub-cuts	Coefficient of Correlation (r)	Coefficient of Regression (b)	Number of sub-cuts	Coefficient of Correlation (r)	Coefficient of Regression (b)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
			DISTRICT : SHAHABAD			
1	274	0·9055	0·7682	133	0·9497	0·7124
2	179	·8710	·6241	204	·8231	·6292
3	233	·9210	·6104	115	·9700	·6691
4	54	·9365	·5552	37	·8894	·7152
5	255	·9508	·6224	160	·9599	·6571
6	50	·9780	·6688	48	·9255	·6219
Total	1,045	·9108	·6627	697	·9234	·6643
			DISTRICT : MONGHYR			
1	24	0·8896	0·5369	20	0·9921	0·3488*
2	324	·9169	·5867	214	·9536	·5970
3	183	·9519	·6648	174	·9528	·6728
4	248	·9662	·7519	105	·9626	·7202
5	136	·9215	·6043	102	·7751	·5568
6	169	·8767	·5256	20	·8332	·7215
Total	1,084	·9108	·6031	635	·8752	·6410

* This has been omitted in forming the pooled estimate.

148. The coefficients of correlation for each sub-block are shown in Table (6/2) in which col. (1) gives the serial number of the sub-block ; col. (2) the number of sub-cuts, and col. (3) the co-efficient of correlation between the two weights for wheat in Shahabad district ; the corresponding co-efficient of regression 'b' (or factor of conversion) is given in col. (4). In the same way, the number of sub-cuts, the coefficient of correlation, and the factor of conversion are given in cols. (5), (6) and (7) respectively for grams. It will be noticed that the coefficients of correlation are all high showing a close physical connexion between the two weights.

149. The conversion factors for wheat and gram given in cols. (4) and (7) of Table (6/2), show a good deal of fluctuation from sub-block to sub-block in both districts. This may be partly due to real differences in maturity or other conditions under which the crop was harvested in different regions. Part of the observed fluctuations must also have arisen from personal factors or even careless or dishonest work on the part of the investigators. In one case, for example, for gram in sub-block (1) of Monghyr district the value of the conversion factor is extremely low, only about 0·35, while the coefficient of correlation is above +0·99 and is the highest observed value. The size of the sample is very small, only 20, but even then the results look suspicious ; and the material has been rejected in calculating pooled values of the conversion factor for each district (based on the pooled data for all sub-blocks) which are shown at the bottom of each half of the Table.

150. The pooled values are 0·663 and 0·603 for wheat and 0·664 and 0.641 for gram in the two districts Shahabad and Monghyr respectively. These pooled values were used to convert the weight of crop as harvested into corresponding weight of grain which are shown for wheat in col. (5) and for gram in col. (9) of Table (6/1). There is reasonably good agreement between these graduated values and the directly observed values of the weight of grain shown in cols. (4) and (8) for wheat and gram respectively.

151. The important point to note is that in spite of variations the values of the conversion factor are not widely different. This is encouraging as it indicates the possibility of the conversion factor being something really stable (like the factor for conversion of weight of paddy into weight of husked rice). The subject clearly deserves further study. A good plan would be to collect necessary material for this purpose at a number of selected Government farms in different parts of the province where the work can be relied upon to be done with the requisite accuracy ; the active co-operation of the Agriculture Department is essential for this purpose. Controlled experiments would also have to be made under proper supervision in cultivator's own fields for studying the factor under conditions in which the conversion actually takes place.

PRECISION OF THE RESULTS

152. I shall now examine briefly the precision of the results of crop-cutting experiments which was actually attained in this survey, and also which it is possible to attain in future.

153. *Precision of district rates of yield.* The weighted average rate of yield of wheat (ears as harvested) is $10{\cdot}30 \pm 0{\cdot}49$ maunds per acre in Shahabad, and $9{\cdot}05 \pm 0{\cdot}43$ maunds per acre in Monghyr. The two figures $\pm 0{\cdot}49$ and $\pm 0{\cdot}43$ are the standard errors of the two respective mean values. The weighted average rate of yield of gram (pods as harvested) is $7{\cdot}68 \pm 0{\cdot}45$ maunds per acre in Shahabad and $5{\cdot}93 \pm 0{\cdot}54$ maunds per acre in Monghyr district ; the two figures $\pm 0{\cdot}45$ and $\pm 0{\cdot}54$ again being the respective standard errors. It is interesting to note that standard error of the district mean yield is in every case just about half a maund per acre. Dividing the standard errors by respective mean values we also notice that the percentage standard error was 4·7% and 4·8% or just under five per cent for wheat in the two districts, and somewhat higher 5·9% and 9·1% respectively in Shahabad and Monghyr for gram. This is not unsatisfactory ; but even with the same number of cuttings the margin of error can be reduced appreciably by improving the pattern or design of the survey. No useful purpose will be served by entering into details of technicalites, but certain basic data are being given below for a general appreciation of the position and convenience of reference.

154. *Multi-stage analysis of variance.* The design of the crop-cutting experiments was of the multi-stage type. The appropriate analysis of variance for the mean yield of crop as harvested in maunds per acre is shown in Table (6/3) in which col. (1) gives the source of variation ; col. (2) the degree of freedom of the material for wheat ; col. (3) the sum of squares of deviations ; col. (4) the variance (which is obtained simply by dividing the figure in col. (3) by the corresponding figure in col. (2) ; col. (5) gives the calculated multi-stage standard deviation ; and col. (6) the corresponding coefficient of variation which is obtained

by dividing the figure in col. (5) by the general mean yield of 10·30 maunds per acre in Shahabad district and 9·05 maunds per acre in Monghyr district. Similar data for gram are given in col. (7) to (11); the general mean yield for conversion of standard deviations into coefficients of variation being 7·68 and 5·93 maunds per acre in Shahabad and Monghyr respectively.

TABLE (6/3). MULTI-STAGE ANALYSIS OF VARIANCE : YIELD IN MAUNDS PER ACRE OF WHEAT AND GRAM AS HARVESTED.

Source of Variation	Wheat					Gram				
	Degrees of freedom	Sum of squares	Variance	Multi-stage: Standard deviation	Multi-stage: Coefficient of variation	Degrees of freedom	Sum of squares	Variance	Multi-stage: standard deviation	Multi-stage: Coefficient of variation
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
DISTRICT : SHAHABAD										
	Mean Yield = 10·30±0·49					Mean Yield = 7·68±0·45				
Between zone-cells	29	4183·72	144·33	2·51	24·4	30	2151·06	71·70	2·22	28·9
Within cells between plots	274	4951·96	18·08	2·94	28·5	156	2065·42	13·25	2·33	30·3
Within plots between cuts	302	226·69	0·75	0·86	8·4	187	443·31	2·37	1·54	20·1
Total between cuts	605	9362·37	15·46	(3·94)	(35·3)	373	4659·79	12·49	(3·53)	(46·0)
DISTRICT : MONGHYR										
	Mean Yield = 9·05±0·43					Mean Yield = 5·93±0·54				
Between Zone-cells	27	2649·78	98·13	2·09	23·1	26	2319·81	89·24	2·3	42·3
Within cells between plots	239	3687·52	13·41	2·70	29·8	128	2125·87	16·62	2·59	43·7
Within plots between cuts	267	259·44	0·96	0·98	10·8	155	513·84	3·32	1·83	30·9
Total between cuts	533	6595·74	12·37	(3·53)	(38·9)	309	4959·52	16·04	(4·00)	(67·5)

155. *Design of crop-cutting experiments:* Without entering into technicalities it may be mentioned here that the values of the standard deviations given in col.(5) and(10) indicate that nothing is to be gained by increasing the number of sample-cuts within each plot nor by increasing the number of plots within each zone-cell. The precision of the results would be increased by scattering the sample-cuts as widely as possible over different zone-cells rather than on a large number of plots within particular zone-cells, and over plots rather than on cuts within plots. This is just what one would expect as the more widely the sample-cuts are scattered the more representative are likely to be the result.

156. The multi-stage standard deviations 'between zone-cells' and 'within zone-cells between plots' are roughly of the same order for both crops showing that the fluctuations in yield from one zone-cell to another or from one plot to another within zone-cells are about the same for both wheat and gram in each district. The standard deviation within plots is however greater for gram showing that the yield of this crop is more variable from one part to another of the same plot. But the important point to note is that the standard deviations for both crops are roughly of the same order so that the same design of survey would serve quite well for both crops.

POSSIBILITIES OF IMPROVEMENT IN PRECISION

157. *District rates of yield:* It will be noticed from col.(6) of table. (6/3) that the overall or total standard deviation is 3·94 maunds per acre for wheat for the Shahabad material and 3·52 maunds per acre for the Monghyr material. The corresponding values for gram are 3·53 and 4.00 maunds per acre in the two districts respectively. We may, therefore, adopt say 4 maunds per acre as a convenient value of the standard deviation for purposes of illustration.

If 256 cuts are collected purely at random (in the form of uni-stage sampling) from all over the district then the satndard error of the mean yield of the district would be reduced to one quarter of a maund per acre so that in 19 cases out of 20 the observed mean value would not be out by more than half a maund per acre. We can express the same results in terms of percentage margin of error. From col.(6) of Table (6/3) we notice that the coefficient of variation for wheat is practically same, 38·25% and 38·89% in Shahabad and Monghyr respectively. For gram the values are 45·96% in Shahobad and 67·45% in Monghyr. The proportionate variability is thus somewhat higher for gram as compared to wheat. For purposes of illustration we may adopt say 40% for wheat and 64% for gram. With 256 cuttings spread purely at random all over the district the mean yield would have a standard error of 2·5% for wheat and 4% for gram.

158. *Margin of error of provincial rates of yield.* The use of multi-stage (instead of simple random or uni-stage) sampling is, however, usually more convenient in practice although the margin of error is somewhat larger. With the values of the standard deviation (or coefficient of variation) for different stages given in Table (6/3) it is possible to calculate the margin of error for different patterns of sampling. The coefficient of variation for wheat, it will be noticed from col. (6) of table (6/3), lies between 23·09% and 29·83%. If the fluctuation of yield in other districts are of the same order then we may use 25% as a convenient value for purposes of illustration. For gram the values lie between 28·91% and 43·68%, and we may adopt 40% for numerical calculations. If 4 cuts were obtained from each of 625 zone-cells then with 2500 cuts the standard error of the mean yield for the province as a whole would be about 1·1% for wheat and 1·8% for gram which would be adequate for all practical purposes. We thus find that 2500 or 3000 sample-cuts distributed in the proper way would enable the provincial mean yield of wheat being determined with a standard error of something like one per cent, and of gram with a margin of error of 2% or less. As the physical uncertainty itself is of the same magnitude nothing would be gained by trying to reduce the sampling error below this limit.

159. The actual pattern of sampling has however to be setteld from consideration of cost and practical convenience of field work. The values of the standard deviations and coefficients of variation at different stages of sampling given in Table (6/3) in conjunction with considerations of cost and convenience enable the sampling technique being settled on a scientific basis. The values of the standard deviations obtained during the present survey show, however, that working with handy cuts of the kind used here there would be no difficulty in determining the district or provincial mean rates of yield with all necessary or desired precision.

EFFECT OF PREMATURE HARVESTING

160. A preliminary study was made of the effect on the rate of yield due to harvesting the crop before it was fully mature. One plot under wheat at Sasaram and another plot under gram in Mohania were selected for this purpose. Within these plots a grid of size 20′ × 20′ was marked out; and within this enclosure 10 plants were picked up at random at intervals of 3 days until the plot was harvested by the owner. Weights were taken of individual ears from which the mean weight of ears at harvesting was calculated. Later on the crop was dried and the weight of grain was also determined, and the ratio of the weight of grain to weight of ears of wheat (or pods of gram) was calculated.

161. Table (6/4) shows the results of the work on wheat in Sasaram; col.(1) gives the date of collecting the plants; col.(2) the number of plants; col.(3) the number of ears. The mean

TABLE (6/4). WEIGHTS (IN TOLAS PER EAR) OF WHEAT.

Date of cutting plants from field	Number of plants of wheat	Number of ears of wheat	Mean weight in tolas per ear with standard error		Ratio of weight of crop as harvested to weight of grain
			crop as harvested	grain after extraction	
(1)	(2)	(3)	(4)	(5)	(6)
28 March 1944	10	71	0·132±0·008	0·057±0·001	0·372±0·054
31 March 1944	10	75	0·163±0·012	0·064±0·002	0·432±0·083
3 April 1944	10	73	0·155±0·009	0·090±0·003	0·579±0·132
6 April 1944	10	71	0·134±0·007	0·067±0·002	0·503±0·091
9 April 1944	10	66	0·122±0·006	0·084±0·003	0·071±0·176
12 April 1944	10	55	0·127±0·006	0·077±0·003	0·591±0·146

weight of the crop in tolas per ear as harvested is given in col.(4); the mean weight of grain in tolas per ear in col.(5); and the mean ratio of the weight of grain of wheat to weight of ears

as harvested is shown in col.(6). In the same way results for work on gram are shown in Table (6/5). As before, cols.(1) and (2) give the date of cutting and number of plants respectively. The weight of pods as harvested in tolas per plant is given in col.(3); the weight of gram (after extraction from pods) in tolas per plant in col.(4); and the ratio of the above two weights in col.(5).

TABLE (6/5). WEIGHTS (IN TOLAS PER PLANT) OF GRAM.

Date of cutting of plants from field	No. of plants	Weight in tolas pods as harvested	Per plant of grain after extraction	Ratio of weight of pods to weight of gram
(1)	(2)	(3)	(4)	(5)
29 March 1944	10	10·0	6·5	0·65
3 April 1944	10	10·0	6·5	0·65
6 April 1944	10	6·5	4·0	0·62
9 April 1944	10	6·5	4·0	0·62

162. It will be noted that the weight of wheat ears decreased with increasing maturity while the grain gained in weight. The ratio of weights therefore increased with increasing maturity. In the case of gram both weights decreased with increasing maturity so that the ratio was more or lesss steady.

163. The above experiment was undertaken to see whether it was possible to make any corrections for premature harvesting of the crop. As pointed out in another section, one great difficulty of working with a comparatively smaller number of investigators in a crop-cutting survey is the fact that the investigators have to move rapidly from one place to another in order to cover the whole province in an adequate manner. It is therefore often inevitable that an investigator should reach a village when the crop on the plots (which were selected beforehand at random for crop cutting work) was not yet ripe for harvesting. If the investigator has to wait until the crop becomes ripe, a good deal of time may be wasted. On the other hand, if he leaves the village without collecting the crop, a large number of gaps would occur in the sample. In this situation, if it were possible to cut the crop even when it was not fully mature and use suitable adjustments to obtain the estimated crop at maturity, then the efficiency of crop-cutting work could be increased appreciably. The results obtained in the present preliminary study are not adequate for this purpose, but show that it may be worth while exploring the possibilities in this direction.

MEAN RATES OF YIELD PER ACRE OF WHEAT AND GRAM

164. We may now consider the full material comprising all cuts for which the weight of the crop as harvested was available. The data are given in Table (6/6) in which col.(1) shows the serial number of the sub-block; col.(2) the number of sub-cuts of wheat ; and col.(3) the mean weight in maunds per acre. These were then converted into weight (in maunds per acre) of dry grain by multiplying by appropriate conversion factors based on linear regression; these values are shown in col.(4). In the same way, the number of sub-cuts of gram as harvested is shown in col.(5); the corresponding weight in maunds per acre in col.(6); and the converted weights (in maunds per acre) of dry grain in col.(7).

165. Results of crop-cutting work in the special camps at Mohania and Sahpur in district Shahabad and at Gogri and Kanui in district Monghyr have not been given in Table (6/6) ; owing to their highly local character these values have neither been taken into consideration in calculating the district averages.

166. It will be noticed from col.(3) of Table (6/6) that there were considerable variations in the yield from sub-block to sub-block, that is, from one geographical region to another within each district. In Shahabad the yield of wheat (as harvested) varied from 7·60 maunds per acre in sub-block (2) to 12·42 maunds per acre in sub-block (1). In Monghyr the variation was even larger; from 6.84 maunds per acre in sub-block (2) to 17·97 maunds per acre in sub-block (1).

167. The variation was also quite large for gram (as pods at the time of harvesting) from 4.62 maunds per acre in sub-block (6) to 8·74 maunds per acre in sub-block (1) in Shahabad district as shown in col.(6) of Table (6/6). Omitting a very high value of 21·67 maunds per acre in sub-block (1) in Monghyr district (which is unreliable as it was based on only 24 sample-cuts), the mean yield of gram was more steady and remained between 5.26 and 6·80 maunds per acre in the different sub-blocks.

TABLE (6/6). MEAN YIELD IN MAUNDS PER ACRE OF WHEAT AND GRAM

Serial No. of sub-blocks	Wheat			Gram		
		Weight in maunds per acre			Weight in maunds per acre	
	No. of sub-cuts	ears as harvested	converted into grain	No. of sub-cuts	pods as harvested	converted into grain
(1)	(2)	(3)	(4)	(5)	(6)	(7)
		DISTRICT : SHAHABAD				
1	296	12·42	8·23	148	8·74	5·80
2	270	7·60	5·04	248	8·56	5·68
3	236	11·86	7·86	116	7·97	5·29
4	64	8·95	5·93	37	7·23	4·80
5	348	8·36	5·54	226	5·22	3·47
6	52	8·82	5·85	56	4·62	3·07
		DISTRICT : MONGHYR				
1	24	17·97	10·81	20	21·67	13·89
2	324	6·84	4·12	115	5·26	3·37
3	183	7·51	4·53	179	6·25	4·01
4	268	9·62	5·80	117	6·80	4·36
5	148	7·01	4·23	115	5·73	3·67
6	169	17·05	10·28	20	5·66	3·63

DISTRICT OUTTURN OF CROP

168. Having obtained estimates of crop acreage and also of yield per acre it was easy (in theory) to calculate the total outturn. Multiplying the estimated acreage by the estimated rate of yield per acre for each sub-block, the outturn for each sub-block was directly obtained. From these the district totals were built up by straightforward addition, and are shown in Table (6/7). The serial number of the sub-block is given in col. (1); the total geographical area of the sub-block in thousand acres in col.(2) ; the sample estimate of the area of wheat (in thousand acres) in col. (3) ; and the yield of grain in maunds per acre of wheat in col.(4). Multiplying these two figures we get the total outturn of wheat in thousand maunds of grain in col. (5). In the same way, the area under gram is given in col. (6) ; the yield of grain in maunds per acre in col.(7); and the outturn of gram in thousand maunds of grain in col.(8) of table (6/7) for each sub-block separately.

169. Adding the outturn for individual sub-blocks we get in col. (5) of table (6/7) the total outturn of wheat grain of 1947·1 thousand maunds in Shahabad and 1832·9 thousand maunds in Monghyr district. Dividing these figures by the corresponding sample estimates of crop acreage from col. (3), namely, 300·35 and 284·08 thousand acres respectively, we get the adjusted average rates of yield of wheat grain of 6·48 and 6·45 maunds per acre for Shahabad and Monghyr respectively as shown within brackets in col. (4) of Table (6/7). In the same way, we get the total outturn of gram (extracted from pods) of 1680·6 and 822·4 thousand maunds for Shahabad and Monghyr as shown in col. (8) of Table (6/7). The corresponding adjusted average rate of yield for gram was 4·98 maunds per acre in Shahabad and 4.25 maunds per acre in Monghyr.

OFFICIAL ESTIMATES OF YIELD AND OUTTURN

170. *District figures.* It is difficult to make any comments on the above figures. Rates of yield and outturn are not given separately for districts in official publications of the Agriculture Department but can be calculated in the way explained below. In the fourth wheat forecast the condition factor for outturn is given as 69 per cent in Shahabad and 77 per cent in Monghyr district. It is also stated that the standard rate of yield is 12 maunds per acre ; multiplying this by the respective condition factors of 69 per cent and 77 per cent one gets the calculated rates of yield of 8·28 maunds per acre in Shahabad and 9·24 maunds per acre in Monghyr shown within brackets (to indicate that these are derived figures) in col. (4) of Table (6/7). Multiplying these calculated rates by corresponding official acreage figures of 263·8 and 219·8 thousand acres shown in col. (3) of Table (6/7), we get the calculated outturn in thousands of maunds of 2184 and 2051 in Shahabad and Monghyr respectively shown within brackets in col. (5) of Table (6/7).

TABLE (6/7). CALCULATED OUTTURN IN THOUSANDS OF MAUNDS OF GRAIN OF WHEAT AND GRAM

Serial No. of sub-blocks	Geographical area in thousand acres	Wheat			Gram		
		area in thousand acres	yield in maunds per acre	Outturn in thousand maunds	Area in thousand acres	yield in maund per acre	Outturn in thousand maunds
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			DISTRICT : SHAHABAD				
1	463·6	65·84	8·23	541·9	83·90	5·8	486·6
2	445·5	62·32	5·04	314·1	67·54	5·6	383·6
3	429·0	50·71	7·86	398·6	61·52	5·2	325·4
4	518·1	34·87	5·93	206·8	48·34	4·8	232·0
5	431·7	67·67	5·54	375·0	49·08	3·4	170·3
6	508·5	18·92	5·85	110·7	26·95	3·0	82·7
	2796·4	300·35	(6·48)	1947·1	337·33	(4·98)	1680·6
Calculated (official sources)		263·8	(8·28)	(218·4)	(282· 3)	(9·71)	(27·41)
			DISTRICT : MONGHYR				
1	393·6	3·95	10·84	42·8	5·64	13·89	78·3
2	359·2	15·76	4·12	64·9	17·38	3·37	58·6
3	424·1	52·33	4·53	237·0	72·56	4·01	291·0
4	403·0	72·70	5·80	421·7	52·03	4·36	226·9
5	390·2	60·48	4·23	255·8	33·03	3·67	121·2
6	399·7	78·86	10·28	810·7	12·79	3·63	46·4
	2369·8	284·08	(6·45)	1832·9	193·43	(4·25)	822·4
Calculated (official sources)		219·8	(9·24)	(2031)	210·5	(9·97)	(2099)

171. For gram the calculation is a little more involved. The outturn for the province as a whole is given as 541,800 tons, and the total area under gram as 1,459,600 acres in the forecast of *rabi* crops issued on the 26th April 1944 by the Director of Agriculture. Dividing 541,800 tons by 1,459,600 acres one gets 10·1 maunds per acre as the provincial rate of yield. Dividing by the condition factor of 78 per cent for the province as a whole (as given in the *rabi* forecast) the standard yield is apparently 12·95 maunds per acre. The condition factors for gram are given (in the *rabi* forecast) as 75 per cent and 77 per cent for Shahabad and Monghyr respectively ; multiplying 12·95 maunds per acre by these two factors the calculated rates of yield are 9·71 and 9·97 maunds of grain per acre for Shahabad and Monghyr respectively and are shown within brackets in col. (7) of Table (6/7). Finally, multiplying the above rates of yield by corresponding official estimates of area under gram in thousand acres of 282·3 and 210·5 we get the calculated outturn of 2741 and 2099 thousand maunds of gram for Shahabad and Monghyr respectively which are shown within brackets in col. (8) of Table (6/7).

172. *Provincial figures :* Official figures relating to rates of yield and outturn are, however, of extremely doubtful value. For example, for wheat the estimated acreage for the province as a whole in 1943–44 is given as 1,220,800 acres and the outturn as 452,700 tons in the fourth wheat forecast issued by the Director of Agriculture ; dividing the latter by the former we get the rate of yield as 10·09 maunds per acre (which it may be noted incidentally is practically the same as the yield of gram). The condition factor for the whole province is given as 76 per cent. (We have checked this by direct calculation ; it is the average value based on the condition factor for each district weighted by the respective crop acreage). Dividing 10·09 maunds per acre by this provincial condition factor of 76 per cent we obtain a calculated standard rate of yield of 13 28 maunds per acre instead of the quoted standard figure of 12 maunds per acre. No explanation has been given of this discrepancy. In fact the position has been made even more confusing by a remark added in a footnote in the fourth wheat forecast that the Departmental estimate of the provincial condition factor is 85 per cent. Dividing the calculated provincial yield rate of 10·09 maunds per acre by this 'departmental' condition factor 85 per cent one gets a standard yield of 11·87 aunds per acre which is very nearly the same as the quoted figure of 12 maunds per acre. But this does not explain anything as the provincial outturn was probably obtained by using the condition factor of 85%. The real point is how was the 'departmental' estimate of 85 per cent obtained ? Nothing has been stated in this regard.

173. To study this question a little further the provincial rates of yield and the standard yield for wheat, barley and gram for the four crop seasons from 1940–41 to 1943-44 were calculated from information given in official publications. The results of such calculations are shown in Table (6/A) in which col. (1) gives the crop season, col. (2) the area under each crop in acres in the province as a whole and col. (3) the total outturn in tons both as stated in official reports. Dividing the outturn figure in col.(3) by the corresponding acreage figure in col. (2) we get the calculated provincial rate of yield in maunds per acre shown in col.(4). The provincial condition factors as given in official reports are shown in col. (5). Dividing the calculated yield rate in col. (4) by the corresponding condition factor in col. (5) we get the calculated 'standard' rates of yield per acre shown in col. (7). In certain instances what are called 'departmental' estimates are also given of the condition factor; these are shown in col. (6). Using these condition factors it is possible to obtain a second set of calculated standard rates of yield which are shown in col. (8) headed 'departmental' rates.

TABLE (6/A). CALCULATED RATES OF YIELD BASED ON OFFICIAL SOURCES

Crop season	Area under crop in acre (official)	Produce in tons (official)	Yield in maunds per acre (calculated)	Official condition factor		Standard yield in maunds per acre	
				Provincial average	Departmental average	Provincial	Departmental
(1)	(2)	(3)	(4)	(5)	(6)	7))	(8)
			WHEAT				
1940-41	10,96,400	4,05,500	10·07	84	—	11·99	—
-42	13,00,000	4,84,600	10·14	85	—	11·93	—
-43	12,80,000	5,81,200	12·36	91	—	13·58	—
-44	12,20,800	4,52,700	10·09	76	85	13·28	11·87
			BARLEY				
1940-41	12,98.200	4,46,000	9·35	87	—	10·75	—
-42	12,84,300	4,46,300	9·46	88	—	10·75	—
-43	12,69,100	4,16,000	8·93	70	83	12·76	10·76
-44	12,79,100	4,95,000	10·54	82	99	12·85	10·65
			GRAM				
1940-41	14,44,300	4,67,700	8·81	82	—	10·74	—
-42	14,48,600	5,29,500	9·95	85	—	11·71	—
-43	14,46,500	4,68,000	8·81	69	82	12·77	10·74
-44	14,59,600	5,41,800	10·10	78	94	12·95	10·74

174. For 1940—41 and 1941—42 figures of accreage (col.2), ond produce(col.3) endition factor (cols. 5 and 6) are taken from Appendix III and V of the Season and Crop Report, Bihar, 1941–42. For 1942–43 and 1943–44, figures are taken from the 'Fourth forecast of the wheat crop of Bihar 1943–44' and 'Forecast of the *Rabi* crop of Bihar 1943–44' dated 26th April 1944 isssued by the Department of Agriculture. The standard or normal rate of yield of wheat is given as 12 maunds per acre in the 'Fourth forecast of the wheat crop in Bihar 1943–44."

175. It will be noticed that for wheat the "standard" yield was 11·99 and 11·95 maunds per acre in 1940-41 and 1941-42 but jumped to 13·58 maunds in 1942-43 and 13·28 maunds per acre in 1943-44. For barley the standard yield was 10·75 maunds per acre in 1940-41 and 1941-42 but suddenly increased to 12·76 and 12.85 maunds per acre in 1942-43 and 1943-44 respectively. For gram the standard rate was 10·74 maunds per acre in 1940-41, 11·71 maunds in 1941-42, 12·77 maunds in 1942-43 and 12·95 maunds in 1943-44. Such sudden changes in the "standard" yield is certainly curious. It would be also noticed that the so-called "departmental" estimates of the condition factor, given in col. (6) of Table (6/A), bring down the "standard" yield of wheat in 1943-44 to 11·87 maunds per acre as already noted, and of barley and gram to about 10¾ maunds per acre in 1942-43 and 1943-44.

176. In view of the conflicting nature of estimates based on official publications I made personal enquiries from Mr. A. P. Cliff of the Bihar Agriculture Department. In his D. O. No. 228 dated Patna the 16th July 1944 he wrote :

"There have been no crop cutting experiment by this department on wheat and gram. The normal outturn of wheat is taken to be 12 maunds per acre over the whole province vide p. 16 para 58 of the Crop Statistics Manual of Bengal 1908. The provincial

normal outturn of gram is similarly taken as 10¾ maunds per acre. I am unable to give you any 'evidence' for these figures and doubt very much if any, worth the name, exists."

It is clear that standard rates of yield used by the Agriculture Department are purely conventional and have no basis in experimental observations. We have already noted that official acreage figures relating to "mixed crops" are extremely ambiguous. Comparison of our figures with official estimates is, therefore, not possible.

SPECIAL STUDIES

177. *Mixed crops.* Certain special studies were also attempted in connexion with the determination of yield and total outturn. For example, a preliminary study was made of the yield per acre of wheat from plots which were sown with different proportions of wheat in mixture with other crops ; the results have been discussed in the next section 7.

178. One point may however be noted here. In the present survey the crop acreage given is the net or effective area which would have been covered by a crop if it had been sown "pure" by itself, that is, without any mixture with other crops. The rates of yield per acre is, however, based on the gross or total geographical area covered by all crops in the mixture. To calculate the outturn by multiplying the above two figures would obviously lead to under-estimation. Official crop acreages are probably net areas (although nothing is known definitely about this), while standard rates of yield are presumably based on gross area; it is likely, therefore, that official outturn figures are also under-estimates.

179. *Variance function and border effect.* A certain amount of material was collected to study in what way the variance of yield decreased with the increase in the size of the sample-cut ; but the material was too meagre to give any clear indication. There is urgent need of a critical study of the variance function and also of the border effect, that is, whether any bias is being introduced or not due to inclusion (or exclusion) within the sample-cuts of plants occurring on the border of the cuts. This bias, if it exists, is naturally likely to be comparatively more important in cuts of a small size as the proportion of the perimeter to the total area of the cut is large.

180. *Eye-estimation of yield per acre.* In Bengal in 1943 and in previous years very encouraging results had been obtained in controlled experiments in eye-estimation by physical examination of the yield per acre of paddy and jute crops. A number of investigators were found capable of doing this with close approximation to results based on direct crop-cutting work. An attempt was made to carry out a similar experiment on wheat in Bihar, but owing to shortness of time the investigators could not be given necessary training and the material collected was not of much value.

181. It will be noticed there are many problems requiring critical study in connexion with the determination of yield per acre and outturn of *rabi* crops in Bihar. A good begining has, however, been made in the pilot survey in 1943-44 which must be followed up in future.

SECTION 7. THE PROBLEM OF 'MIXED' CROPS

182. In the *rabi* season in Bihar the outstanding difficulty was undoubtedly the occurence of mixed crops of many different types. Wheat, gram and barley are usually sown in mixtures of two, three or more crops ; and plots under a single crop are rare except for *arhar*. It is therefore necessary to enquire what is the exact meaning of the area sown under mixed crops, and how is one to estimate the area separately for each component crop.

TWO WAYS OF OCCURRENCE OF 'MIXED' CROPS

183. So far as an individual plot is concerned the word 'mixed' may have two different meanings. For example, one portion say, 4-anna proportion of a plot may be entirely under wheat ; another portion say, 6-anna, entirely under barley ; and the remaining portion, say 6-anna entirely under gram. In such cases there is, of course, no ambiguity as to how much area has to be allotted to each individual crop.

184. There is however a second way in which mixed crops can occur. For example, the sample plot may be sown with a mixture of wheat, barley and gram scattered all over the plot. In this case, in one sense, each crop covers the whole or 16-anna of the plot. Should then each crop be credited with the full 16-anna of the land ? The total anna estimate would then obviously total up to 16+16+16=48 anna or three times the actual geographical area of the plot itself. A second method would be to make an estimate of the net anna-proportion of the land which would have been covered by, say, wheat if it had been sown separately from the other two crops. In this method the net or effective proportion of land

under each crop has to be estimated, and the total for each plot (inclusive, of course, of land not under cultivation) would be invariably 16-anna or exactly equal to the geographical area.

VARIATIONS IN COMPOSITION OF 'MIXED' CROPS

185. A complication is, however, introduced by the fact that when the same two or the same three crops are sown mixed in the second way (that is, covering the same identical portion of the plot), the intensity or relative proportion of the different crops do not remain the same but vary widely from region to region, and even from plot to plot. Results of certain sample studies for wheat are shown in Tables (7/1) and (7/2) in which the anna composition of different types of mixed crops are shown based on the analysis of records relating to 16,564 plots in Shahabad district and 16,724 plots in Monghyr district. In Table (7/1) the first three columns show the anna composition of the crop under three heads, wheat, gram, and other crops respectively. Thus 16-0-0 indicates plots entirely under wheat, 0-16-0 means plots entirely under gram, or 0-0-16 plots entirely under other crops (which themselves may be mixed). In the same way, 1-5 anna (under wheat), 11-15-anna (under gram) means a mixed crop of wheat and gram in which the anna proportion of wheat lies between 1-anna and 5-anna and the anna-proportion of gram between 11-anna and 15-anna and so on. Col. (4) shows the number of plots of each type occurring in the sample in Shahabad district; col. (5) gives the percentage of all plots; and col. (6) the percentage in terms of cultivated plots only. Similar information is given in cols. (7), (8) and (9) for Monghyr district.

186. It is clear from Table (7/1) that plots under wheat or gram alone are rather rare being only 3·2 per cent of all plots or 6·2 per cent of cultivated plots in Shahabad, and 3·1 per cent of all plots and 8·0 per cent of cultivated plots in Monghyr. Wheat and gram in mixture occur in 12·9 per cent of cultivated plots in Shahabad, and in 15·0 per cent of such plots in Monghyr; wheat occurs in mixture with gram and other crops in 22·1 per cent of cultivated plots in Shahabad and in 15·7 per cent of such plots in Monghyr; finally, wheat occurs in mixture with crops other than gram in 5·4 per cent of cultivated plots in Shahabad and 8·1 per cent of such plots in Monghyr. Gram occurs with crops other than wheat in Shahabad in 14·5 per cent and in Monghyr in 7·9 per cent of cultivated plots. Wheat thus occurs in mixture with some crop or other in Shahabad in 40·4 per cent, and by itself only in 3·8 per cent of all cultivated plots; in Monghyr wheat occurs in mixture in 38·8 per cent, and by itself in only 5·2 per cent of all cultivated plots. In the same way, gram occurs in mixture with other crops in 49·5 per cent and by itself in 2·4 per cent of cultivated plots in Shahabad; and in mixture in 38·6 per cent and by itself in 2·8 per cent of cultivated plots in Monghyr. It will be noticed that the composition of mixed crops of wheat and gram thus differs quite appreciably from plot to plot.

187. The position so far as a particular component crop, say wheat, is concerned can be seen better if the material is tabulated in a different way as in Table (7/4) in which col. (1) shows the type of composition in terms of anna proportion of intensity of cultivation of wheat alone, namely, plots having effective anna-proportion of wheat between 1-anna and 5-anna, 5.3-anna (*i.e.* roughly equal mixture of 3 crops), between 6-anna and 10-anna, between 11-anna and 15-anna, and 16-anna or entirely under wheat; col. (2) gives the number of plots observed in each category; and col. (3) the same information expressed in the term of percentages of the total number of plots studied. It will be seen from col. (3) of Table (7/4) that in Shahabad district 6·5 per cent of plots had usually between 1-anna and 5-anna effective intensity of cultivation in mixed crops; 50·0 per cent had one third (or 5·3-anna) effective composition of wheat in mixed crops of wheat, gram and some other crop; about 20·4 per cent of plots had from 6-anna to 10-anna or a medium effective intensity of cultivation of wheat; and 14·3 per cent of plots had from 11-anna to 15-anna or a heavy proportion of wheat in mixed crops. Finally, the proportion of plots entirely under wheat (among all plots having wheat) was only 8·8 per cent. In Monghyr district the position was broadly similar; 8·1 per cent of plots had an effective anna-composition of 5-anna or less under wheat; 35·7 per cent had one third (or 5·3-anna) composition; 34·3 per cent between 6-anna and 10-anna composition; 10·1 per cent with between 11-anna and 15-anna composition of wheat; while only 11.8 per cent of plots were entirely under wheat.

GROSS AND NET AREA UNDER INDIVIDUAL CROPS

188. This is the actual position. How then is the total area under wheat (or other crops) to be estimated? Our first reaction naturally was to adopt existing standards in use in the Bihar Agricultural Department so that our sample estimates would be directly

TABLE (7/1). DISTRIBUTION OF PLOTS UNDER WHEAT AND GRAM BY TYPE OF MIXTURE OF CROPS.

Anna-composition of type of mixed crop			Shahabad			Monghyr		
			Number of Plots	Percentage of plots to		Number of plots	Percentage of plots to	
Wheat	Gram	Others		total	cultivated		total	cultivated
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(8)
			(1) Single Crop (wheat or gram)					
16	0	0	322	2·0	3·8	341	2·0	5·2
0	16	0	200	1·2	2·4	185	1·1	2·8
	Total		522	3·2	6·2	526	3·1	8·0
			(2) Wheat and Gram					
1— 5	11—15	—	94	0·6	1·1	102	0·6	1·6
6—10	6—10	—	607	3·6	7·3	763	4·6	11·6
11—15	1— 5	—	377	2·3	4·5	115	0·7	1·8
	Total		1078	6·5	12·9	980	5·9	15·0
			(3) Wheat and Others (not gram)					
1— 5	—	11—15	148	0·9	1·8	133	0·8	2·0
6—10	—	6—10	149	0·9	1·8	226	1·4	3·4
11—15	—	1— 5	153	0·9	1·8	175	1·0	2·7
	Total		450	2·7	5·4	534	3·2	8·1
			(4) Gram and Others (not wheat)					
—	1— 5	11—15	370	2·2	4·4	156	0·9	2·4
—	6—10	6—10	481	2·9	5·8	264	1·6	4·0
—	11—15	1— 5	361	2·2	4·3	97	0·6	1·5
	Total		1212	7·3	14·5	517	3·1	7·9
			(5) Wheat, Gram and others					
5·3	5·3	5·3	1847	11·2	22·1	1029	6·2	15·7
			(6) Other crops (not wheat or gram)					
—	—	16	3255	19·6	38·9	2975	17·8	45·3
	Cultivated plots		8364	50·5	100·0	6561	39·3	100·0
			(7) Not cultivated					
0	0	0	8200	49·5	—	10163	60·7	—
	All plots		16564	100·0	—	16724	100·0	—

TABLE (7/2). SUMMARY DISTRIBUTION OF PLOTS UNDER WHEAT AND GRAM BY TYPE OF MIXTURE OF CROPS

	Shahabad			Monghyr		
	Number of Plots	Percentage of plots to		Number of Plots	Percentage of plots to	
		total	cultivated		total	cultivated
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 Single crop (wheat or gram)	522	3·2	6·2	526	3·1	8·0
2 Wheat and gram	1078	6·5	12·9	980	5·9	15·0
3 Wheat and others	450	2·7	5·4	534	3·2	8·1
4 Gram ad others	1212	7·3	14·5	517	3·1	7·9
5 Wheat gram and others	1847	11·2	22·1	1029	6·2	15·7
6 Other crops	3255	19·6	38·9	2975	17·8	45·3
Total cultivated	8364	50·5	100·0	6561	39·3	100·0
(Not cultivated)	8200	49·5	—	10163	60·7	—
All plots	16564	100·0	—	16724	100·0	—

comparable with departmental figures. I made enquiries in the matter, and also requested Rai Bahadur S. P. Sinha to discuss the subject with the officers of the Agricultural Department and to ascertain what methods were actually being used for estimating the area allotted to individual crops in the case of plots with mixed crops. No definite information could be secured but I was given to understand that the Agricultural Department was not using any standard method for this purpose. The area figures for individual *mauzas* are supposed to be supplied by local officers, and nothing was known as to how the acreage for individual crops was actually estimated.

189. The Settlement Reports also failed to make the position clear. In the Gaya Report (1911-1918) by Mr. E. L. Tanner, I.C.S., it is stated in para 136, p. 81 :—

"If in any particular plot wheat and barley mixed were recorded as having been grown, the area was proportionately divided between them".

This, of course, is the method of using net or effective acreages. In the same Report in para 140, p. 82, it is, however, again stated :—

"In the first year's area an attempt was made to reduce all the results to a 16-anna crop by estimating, what the actual crop was in terms of a bumper crop (16-anna). The result was so inaccurate that this was dropped and only actual results recorded..... and in giving the results of the experiment only actual outturns have been given".

The attempt to make adjustments for the variation in the yield due to differences in the effective composition of wheat in mixed crops was thus apparently abandoned.

GROSS AREA WITH ANNA COMPOSITION

190. In the absence of any standard method the Field Branch was provisionally instructed to try to estimate the net or *effective* anna proportion of the plot covered by individual crops. On the 25th and 26th March 1944, when I was at the special camp at Bikramgunj in Shahabad district, this question was discussed in considerable detail at a conference with the technicians and the supervising staff of the Field Branch. It was agreed that the proper course would be to record both (*a*) the gross area as well as (*b*) the estimated effective composition of each component crop either in anna terms or in certain standard broad categories such as 'low wheat and heavy gram', 'medium wheat and medium gram', etc. By direct experiment we found that there was no difficulty in classifying plots under mixed crops in such broad categories.

YIELD RATES FOR MIXED CROPS

191. It was also decided that if crop-cutting experiments could be carried out on a sufficient number of plots of each of the different types of mixed crops then it would be possible to determine how the rate of yield per acre of each individual crop depended on its composition in the mixture. These rates of yield could be then used to calculate the total production or outturn from plots in different categories. It was too late in the season to carry out this programme in full but a certain amount of material was secured from which results of considerable interest have been extracted.

192. From available crop-cutting records an attempt was made to classify the plots under mixed crops by the proportion or anna-estimate of effective composition of wheat. Unfortunately, the anna composition of the crop was, as a rule, not mentioned in the crop-cutting record itself; the serial number of the grid (from which the plot was selected) was also not given. The serial number of the plot was, however, available in the original *khasra* or field records for area survey ; it was possible, therefore by searching through these lists, to trace the corresponding effective anna-composition of wheat in the given plot as recorded at the time of the area survey in the field *khasra* books. The procedure was extremely laborious. Relevant information was however traced for 189 plots in Shahabad district and for 247 plots in Monghyr district.

193. The yield of wheat in maunds per acre was calculated separately for plots in different anna-categories. The results are shown in Table (7/3) in which the anna-composition of the plots is given in col. (1) in two-anna intervals, that is, with estimated compositions of 1 and 2-anna, 3 and 4-anna, 5 and 6-anna, ...15 and 16-anna under wheat. The number of plots in each category is given in col. (2) ; and the observed mean yield in maunds of wheat grain per acre is shown in col. (3). In the same way, the number of plots in each class in Monghyr district is shown in col. (5) ; and the observed yield of wheat in col. (6).

TABLE (7/3). RELATION BETWEEN YIELD IN MAUNDS OF GRAIN PER ACRE AND ANNA PROPORTION OF INTENSITY OF CULTIVATION OF WHEAT IN MIXED CROP

Anna proportion of intensity of cultivation of wheat in mixed crops (sample plots)	District Shahabad			District Monghyr		
	No. of plots in sample	Mean yield in maunds per acre		No. of plots in sample	Mean yield in maunds per acre	
		observed	graduated		observed	graduated
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1-anna to 2-anna	9	4·0	4·3	11	5·6	4·2
3-anna to 4-anna	17	5·7	4·9	23	4·5	4·8
5-anna to 6-anna	30	5·1	5·5	24	4·2	5·3
7-anna to 8-anna	32	5·7	6·1	55	5·4	6·0
9-anna to 10-anna	35	7·1	6·6	35	6·6	6·6
11-anna to 12-anna	19	6·9	6·9	35	6·4	7·2
13-anna to 14-anna	10	7·1	7·2	14	9·6	7·8
15-anna to 16-anna	37	7·5	7·4	50	8·1	8·4
Total	189	6·3	6·3	247	5·5	5·5
All sub-cuts	1266	6·21	—	1112	5·58	—

194. It will be noticed that, on the whole, the yield increased, as one would expect, with increasing intensity of anna-composition. A second degree parabola was used for graduating the material for Shahabad district, and a simple straight line for the Monghyr material. The graduating equations are :—

$$y = 3{\cdot}66 + 0{\cdot}41(x) - 0{\cdot}011(x^2) \quad \ldots \quad \ldots \quad \ldots \text{ for Shahabad;}$$

$$\text{and } y = 3{\cdot}71 + 0{\cdot}30(x) \quad \ldots \quad \ldots \quad \ldots \text{ for Monghyr,}$$

where y is the yield of grain of wheat in maunds per acre, and x the anna-composition of wheat in mixed crops. It may be mentioned here that the value of the coefficient of correlation was +0·269 for the Shahabad material and +0·370 for the Monghyr material; standard deviations of x (the anna-composition) were 4·22 and 4·18 for the two districts respectively; and standard deviations of y were 3.39 and 3.14 maunds per acre for the two districts respectively. The graduated values are given in col. (4) for Shahabad and in col. (7) for Monghyr.

195. One point deserves notice in Table (7/3). The rate of yield per acre does not increase in equal proportion with the increase in the anna-composition of cultivation. For example, in Shahabad district, the graduated yield is 4·3 maunds per acre for an anna-composition of 1 and 2-anna proportion of wheat in mixed crops; 6·1 maunds per acre for an anna-composition 7 and 8-anna; and 7·4 maunds per acre for an anna-composition of 15 and 16-anna. In the same way the corresponding yields are 4·2, 6·0 and 8.4 maunds per acre in Monghyr district. Thinner compositions evidently give proportionately greater yields which is probably the reason for their popularity.

CALCULATION OF OUTTURN FROM MIXED CROPS

196. From a knowledge of the way in which the rate of yield per acre depends on the anna-composition of wheat it is possible to calculate the total outturn without any difficulty. We had seen in Table (7/4) that 6·5 per cent of wheat plots in Shahabad had been recorded as having an effective anna-composition of 5-anna or less. The mid-value of the composition in this category is 3-anna which may be adopted as the average composition. The total area of 300·3 thousand acres under wheat in Shahabad and 284·1 thousand acres under wheat in Monghyr can now be allocated to each category in proportion to the respective percentage of sample plots shown in col. (3) of Table (7/4). For example, the allocated area in the category "1-anna to 5-anna" (with mid-value 3-anna) is 21·1 thousand acres. The corresponding gross area must be, of course, much higher; and can be reconstructed by multiplying the net effective area 21·1 by 16/3 which gives 112·5 thousand acres as shown in col. (5) of Table (7/4). In the same way for the class of 6 to 10-anna (with an average composition of 8-anna) the multiplying factor will be 16/8; and for the class of 11 to 15-anna (with an average com- position of 13-anna) the multipllying factor will be 16/13. It is thus possible to pass from the estimated net or effective area to the gross area under wheat.

TABLE (7/4). RECONSTRUCTED VALUES OF GROSS AREA UNDER WHEAT IN THOUSAND ACRES AND OUTTURN OF WHEAT IN THOUSAND MAUNDS

Anna proportion of intensity of cultivation of wheat in mixed crops (sample plots)	Plots under wheat		Area under wheat in thousand acres		Yield in maunds per acre	Estimated outturn in thousand maunds
	Total number	percentage	effective (observed)	gross re-constructed)		
1	2	3	4	5	6	7
DISTRICT SHAHABAD						
1-anna to 5-anna	242	6·5	21·1	112·5	4·79	539
5.3 anna	1847	50·0	150·1	453·1	5·52	2501
6-anna to 10-anna	756	20·4	59·7	119·4	6·24	745
11-anna to 15-anna	530	14·3	42·0	51·7	7·13	369
16-anna	322	8·8	27·4	27·4	7·40	203
Total	3697	100·0	300·3	764·1	5·70	4357
DISTRICT MONGHYR						
1-anna to 5-anna	235	8·1	22·6	120·5	4·61	556
5·3-anna	1029	35·7	91·1	275·0	5·30	1458
6-anna to 10-anna	989	34·3	89·8	179·6	6·11	1097
11-anna to 15-anna	290	10·1	35·3	43·4	7·61	330
16-anna	341	11·8	45·3	45·3	8·51	386
Total	2884	100·0	284·1	663·8	5·77	3827

197. Results of such calculations are shown in Table (7/4) in which col. (4) gives the estimated net or effective acreage under wheat in different anna classes. Multiplying these by appropriate factors shown in col.(3) we get the gross acreage under wheat shown in col.(6). It will be noticed that in Shahabad district a net or effective acreage of 300·3 thousand acres would be roughly equivalent to a gross area of 764·1 thousand acres. In the same way, a net or effective wheat area of 284·1 thousand acres would be equivalent to a gross area of 663·8 thousand acres in Monghyr district.

198. The method for calculating the total outturn is also shown in Table (7/4) in which col. (6) gives the graduated value of the yield in each anna-class of composition of wheat. Multiplying these rates of yield by the corresponding reconstructed gross acreage given in col. (5) we get the total estimated production of wheat grain in thousand maunds for each category of plots as shown in col. (7). Adding up the figures in col. (7) we get the reconstructed outturn of 4357 and 3827 thousand maunds for the two districts Shahabad and Monghyr respectively.

NEED OF FURTHER STUDIES

199. These figures are much higher than the two previous figures of outturn, namely, 1947 and 1833 thousand maunds respectively in the two districts which we had obtained in Section 6. The method of calculation adopted in the present section should give more correct results; but, owing to paucity of the data on which these particular calculations are based it is not certain how much weight can be attached to the present figures. Calculating the outturn of plots under mixed crops by multiplying the net or effective acreage by the rate of yield for a "pure" crop (*i.e.* sown by itself without mixture) would lead to under-estimation as plots with thinner compositions of wheat give proportionately higher yields than plots with heavier compositions. Owing to the fact that wheat in Bihar is usually sown in mixture with widely varying compositions it is also clear that lumping together of all plots under mixed crops would lead to wrong results. Calculations given in this Report illustrate the many pitfalls arising from the occurrence of mixed crops in the *rabi* season in Bihar.

200. In view of the difficulties in the interpretation of estimates relating to mixed crops it must be emphasized that no valid comparison is possible at present between sample estimates and official figures. Further experimental studies are required before a satisfactory method can be found for dealing with mixed crops of the widely varying kind which occur in Bihar. The subject is of great importance and carefully designed experiments should be undertaken preferably in collaboration with the Agricultural Department.

SECTION 8. COST OF OPERATIONS

201. I have already explained that one of the chief objects of the exploratory survey in the *rabi* season in 1944 was to collect information which would enable the running cost of the survey being reduced in future by more efficient planning of the sampling technique. Records were, therefore, kept of the amount of time required for enumeration of the grids and other items of work. Certain results based on these records are discussed in the present section.

FIELD BRANCH

202. The total number of workers and their distribution among different sub-blocks have been given in Table (4/1) in Section 4. In order to assess the total volume of work it is not enough to give the number of workers ; it is also necessary to give the number of days on which they had actually worked. Here a distinction has to be made between what may be called 'working-days' and 'pay-days'. By 'working day' is meant a day which is actually spent in some kind or other of field work. On the other hand, a 'pay day' is a day for which salary was paid irrespective of whether any actual field work was done or not. It is clear that, owing to minor illnesses and cessation of work through inclement weather and other unforeseen reasons, the number of 'working days' will be less than the number of 'pay-days'. For cost studies it is, however, convenient to use the 'pay-day' as the unit of measurement.

203. A second point must be explained before going into further details. It is clear that there are different types or grades of working days, namely, the working day of a chief inspector or that of an inspector or that of an investigator. Strictly speaking, the whole of the primary work is actually done only by the field investigators, the duty of the chief inspectors and inspectors being simply to see that the work is done properly. It is therefore necessary to distinguish carefully between the two types of work. In fact the most convenient plan is to look upon the 'working day' of the investigators as the fundamental unit of measurement, and treat the 'working-day' of the inspecting staff as overhead.

204. To recapitulate, in the present report one 'working-day' means one day of actual field work done by an investigator and is the fundamental unit of measurement ; but for cost studies, the 'pay-day' of an investigator, namely, a day for which salary is paid to one investigator is adopted as the basic unit throughout the present report.

205. In converting investgator-days or pay-days into money values it is of course necessary to add the whole of the over-head in the way of pay-days of the inspecting and supervising staff as well as all other expenses incurred for travelling and contingent charges. Such conversion of investigator-days into money values is however of importance only for budget purposes. So far as the technical problem or preparing the design of the survey is concerned it is clear that results in terms of pay-days are fully adequate.

TOTAL VOLUME OF WORK

206. The number of investigators and the number of pay-days (as defined above) spent in different operations of the survey are shown in Table (8/1) for the extensive scheme separately for each sub-block in the two districts Shahabad and Monghyr. Col. (1) gives the serial number of the sub-block ; and col. (2) the number of investigators working in each sub-block. The total number of pay-days spent in area survey work is given in col. (3), and that in crop-cutting work in col. (4) ; the total number of pay-days consumed is shown in col. (5). The number of grids actually enumerated in the area survey is shown in col. (6) ; the number of sample-cuts harvested is shown for wheat in col. (7) and for gram in col. (8) ; and the total number in col. (9).

207. It will be noticed that the total number of investigators employed in the extensive scheme was 73, and that they spent a total number of 4,882 pay-days consisting of 4,565 days of work in area survey, and 317 days of work in the crop-cutting scheme. The total number of grids actually enumerated in the area survey was 14,438 ; and the total number of sample-cuts of crop collected was 3,875 of which 2,378 were of wheat and 1,497 of gram.

208. In the same way, the number of investigators and pay-days spent in the special (intensive) scheme in the block camps and special camps in Shahabad and Monghyr districts, and also in the preliminary work in certain adjoining districts are shown in Table (8/2). It will be remembered that the work done in the intensive scheme was located near a number of camps names of which are given in col. (1). The number of investigators and the total number of pay-days spent are given in cols.(2) and (3) respectively. The number of grids enumerated in duplicate for checking is shown in col. (4) ; and the number of sample-cuts of crop collected in col.(5). The total number of plots surveyed in the complete enumeration of all plots in selected areas is shown in col. (6) ; the number of plots which were surveyed twice in col. (7) ; and the total number of plots surveyed in col. (8).

209. In addition to the pay-days shown in Table (8/2) certain precision experiments on crop-cutting work were also done in the two special camps at Gogri and Bikramgunj. In the intensive scheme the total number of pay-days spent was 1999 ; and in the extensive scheme, as already noted, 4565, so that the total number of pay-days used in the whole survey was 6564.

TABLE (8/1). DISTRIBUTION OF INVESTIGATORS AND PAY-DAYS BY SUB-BLOCKS (EXTENSIVE SCHEME).

Serial No. of sub-blocks	No. of investigators	Pay-days spent			grids (area survey)	Number surveyed		
		area survey	crop-cutting work	total		Sample-cuts (crop-cutting) wheat	gram	total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
			DISTRICT : SHAHABAD					
1	6	428	50	478	1268	296	148	444
2	6	432	33	465	1231	270	248	518
3	6	429	29	458	1359	236	116	352
4	6	345	9	354	1295	64	37	101
5	5	376	35	411	944	348	226	574
6	7	360	21	381	1280	52	56	108
District	36	2370	177	2547	7377	1266	831	2097
			DISTRICT : MONGHYR					
1	6	424	7	431	1325	24	20	44
2	7	378	34	412	1433	324	215	539
3	6	441	26	467	1368	180	179	359
4	6	331	27	358	970	268	117	385
5	6	298	22	320	1002	148	115	263
6	6	323	24	347	963	168	20	188
District	37	2195	140	2335	7061	1112	666	1778
Two Districts	73	4565	317	4882	14438	2378	1497	3875

TABLE (8/2). DISTRIBUTION OF INVESTIGATORS AND OF PAY-DAYS BY CAMPS (INTENSIVE SCHEME)

Name of camp	Number of		Area survey : no. of grids	Crop-cutting no. of cuts	Number of plots in complete enumeration		
	investigators	pay-days			single survey	duplicate survey	effective total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
			BLOCK CAMP PARTIES				
Jamui	4	119	—	786	6009	1855	7864
Lakhisarai	3	100	186	—	3792	772	4564
Khagaria	3	53	—	—	6575	—	6575
Shahpur	3	219	—	2040	5871	1608	7479
Mohania	4	220	318	914	2781	860	3641
Sasaram	4	217	—	—	3254	1073	4327
Total	21	928		3740	28282	6168	34450
			SPECIAL CAMP PARTIES				
Gogri	7	401		1380+957*	27654	50	27704
Bikramganj	7	267		736*	7177	—	7177
Total	14	668		1380+1693*	34831	50	34881
			MOVING CAMP PARTIES				
Hilsa, Bettiah, Jahanabad	7	403	—	—	28,517	—	38,517
Total	42	1999	—	5120+1693*	91,630	6218	97,848

* multiple cuts of different sizes.

DISTRIBUTION OF PAY-DAYS BY SUB-BLOCKS AND HALTAGES

210. Having considered the total volume of work we may now look to the distribution of pay-days by sub-samples and sub-blocks in the two districts Shahabad and Monghyr which is shown in Table (8/3). Col.(1) gives the serial number of the sub-block. For sample (A) the total number of grids enumerated is shown in col. (2), and the number of pay-days consumed in col. (3). Dividing the number of pay-days by the number of grids surveyed is obtained the number of pay-days consumed per grid which is shown in col. (4). In the same way, the number of grids surveyed, the number of pay-days consumed, and the number of pay-days per grid are shown in cols. (5), (6) and (7) respectively for sample (B). Finally, similar data are given for the two samples (A) and (B) combined in cols. (8), (9) and (10) respectively.

It will be noticed that the number of pay-days consumed per grid, that is, the average number of grids enumerated was nearly the same in each of the sub-blocks in both districts.

DISTRIBUTION OF GRIDS AND PAY-DAYS BY SUB-SAMPLES AND HALTAGES

211. The distribution of grids and pay-days is shown by sub-samples and haltages in Table (8/4) in which col. (1) gives the serial number of haltages instead of the serial number of sub-blocks as in Table (8/3); otherwise the arrangement is identical with that in Table (8/3). Thus for sample (A) the total number of grids surveyed, the number of pay-days consumed, and pay-days consumed per grid are given as before in cols. (2), (3) and (4) respectively. Corresponding figures for exsample (B) are given in cols. (5), (6) and (7); and for the two samples (A) and (B) combined together in cols. (8), (9) and (10) respectively.

TABLE (8/3). DISTRIBUTION OF GRIDS AND PAY-DAYS BY SUB-SAMPLES AND SUB-BLOCKS

Serial No. of sub-blocks	Sample (A)			Sample (B)			Combined Samples (A+B)		
	Number of		pay days per grid	Number of		pay days per grid	Number of		pay days per grid
	grids	pay days		grids	pay days		grids	pay days	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				DISTRICT : SHAHABAD					
1	628	210	·33	640	218	·34	1268	428	·34
2	647	230	·36	584	202	·35	1231	432	·35
3	624	214	·34	735	215	·29	1359	429	·32
4	808	207	·26	487	138	·28	1295	345	·27
5	392	161	·41	552	215	·39	944	376	·40
6	762	205	·27	518	155	·30	1280	360	·28
District	3861	1227	·32	3516	1143	·33	7377	2370	·32
				DISTRICT : MONGHYR					
1	517	208	·40	808	216	·27	1325	424	·32
2	745	200	·27	688	178	·26	1433	378	·26
3	765	225	·29	603	216	·36	1368	441	·32
4	566	172	·30	404	159	·39	970	331	·34
5	597	176	·29	405	122	·30	1002	298	·30
6	544	173	·32	419	150	·36	963	323	·34
District	3734	1154	·31	3327	1041	·31	7061	2195	·31

212. The only point to be noted in this table is the fact that the number of pay-days consumed per grid was appreciably higher (or the number of grids surveyed per day was appreciably lower) in the fifth haltage in each of the samples (A) and (B) in both districts. This is also true of the fourth haltage but to a smaller extent. This is due to the fact that in the fourth and to a greater extent in the fifth haltages the investigators were also required to do crop-cutting work in addition to area enumeration. This naturally slowed down the output.

TABLE (8/4). DISTRIBUTION OF GRIDS AND PAY-DAYS BY SUB-SAMPLES AND HALTAGES.

Serial No. of halt-ages	Sample (A)			Sample (B)			Combined Samples (A+B)		
	Number of		Pay days per grid	Number of		Pay days per grids	Number of		Pay days per grid
	grids	pay days		grids	pay-days		grids	pay-days	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				DISTRICT : SHAHABAD					
1	854	263	·31	753	243	·32	1607	506	·31
2	816	235	·29	820	227	·28	1636	462	·28
3	883	244	·28	713	229	·32	1596	473	·30
4	781	260	·33	704	232	·33	1485	492	·33
5	527	225	·43	526	212	·40	1053	437	·42
Total	3861	1227	·32	3516	1143	·33	7377	2370	·32
				DISTRICT : MONGHYR					
1	795	242	·30	613	182	·30	1408	424	·30
2	805	246	·31	734	207	·28	1539	453	·29
3	778	222	·29	635	201	·32	1413	423	·30
4	805	244	·30	715	238	·33	1520	482	·32
5	551	200	·36	630	213	·34	1181	413	·35
Total	3734	1154	·31	3327	1041	·31	7061	2195	·31

RELATION BETWEEN COST AND DENSITY OF GRIDS

213. It has been explained in previous sections that a very simple design was intentionally used for the present survey, and no provision was made for detailed studies of the cost of operations for different patterns of field organisation. The over-all density of grids was kept more or less the same, that is, an equal number of sample units was allotted to each zone-cell of equal size. Village maps were, however, not available in certain instances and also for other unforeseen reasons some of the grids had to be abandoned. The number of grids actually enumerated was thus reduced in some of the zone-cells. This introduced variations in the effective density, that is, in the actual number of grids enumerated per square mile. Advantage was taken of such gaps to determine approximately how the cost of operations varied with changes in the density of sample-units.

214. Material relating to the time consumed for different effective densities of grids is shown in Table (8/5). For this purpose the different zone-cells were grouped in accordance with the effective density, that is, the number of grids actually surveyed per square mile. The class range for such grouping is shown in col. (1) ; and the midpoint of the range in col. (2). Thus the ranges for classification were effective densities of 0·21 to 0·40, 0·41 to 0·60,..2·41 to 2·60 with respective midpoints 0·305, 0·505,..2·505. The respective number of zone-cells in each class in district Shahabad is shown in col. (3) from which we find, for example, that the number of zone-cells having effective densities of grids actually enumerated between 1.41 and 1 60 (with a mid-value of 1·505) was 12 ; and so on. The average number of pay-days consumed per grid for each class of effective density in district Shahabad is shown in col. (4). In the same way, the number of zone-cells in each category and the corresponding number of pay-days consumed per grid for district Monghyr are given in cols. (6) and (7) respectively ; and similar data for both districts combined in cols. (9) and (10) respectively.

215. It will be noticed from col. (10) of Table (8/5) that for an effective density of 0·705 the time consumed was 0·34 pay-day per grid, while it is appreciably lower and only 0·27 pay-day per grid for an effective density of 2·505 grids per square mile. Speaking generally, the number of pay-day per grid decreased as the density of grids increased. This is just what one would expect. When the density of grids is high, that is, when there are a large number of grids per square mile, it is obvious that the time spent in moving from one grid to another would be less per grid than when the density is lower and the grids are more widely scattered.

216. The observed values of pay-day per grid were then graduated by a straight line. The calculated parameters are given in Table (8/6). The total number of zone-cells used for purposes of graduation was 96 for Shahabad district. The average cost in terms of pay-day per grid was 0·3142, and the average density of grids per square mile was 1·4925. For Shahabad the regression equation was

$$C = 0{\cdot}3811 - 0{\cdot}0515\,(D) \ldots . \quad (1)$$

where (C) is number of pay-days per grid, and (D) the effective density or number of grids surveyed per square mile. The ratio of variance due to linear regression was 17·83 indicating that the observed decrease in cost (pay-day per grid) with increasing density of grids was statistically significant and must be considered to be real.

217. The graduated values of cost (pay-day per grid) for Shahabad district is shown in col. (5) of Table (8/5). Considering the nature of the material the graduation is not unsatisfactory.

218. The graduation parameters for Monghyr and for the two districts taken together are also given in Table (8/6). For Monghyr also the linear regression is statistically significant ; and this is true for the two ditricts taken together. The two regression equations are :—

$$C = 0{\cdot}3714 - 0{\cdot}0422\ (D) \ldots \quad \ldots \quad (2) \text{ for Monghyr ; and}$$
$$C = 0{\cdot}3788 - 0{\cdot}0465\ (D) \ldots \quad \ldots \quad (3)$$

for the two districts taken together, where (C) as before is the cost in pay-day per grid and (D) the effective density of grids surveyed.

219. Graduated values of cost (pay-day per grid) are shown in col. (8) for Monghyr district, and for both districts taken together in col. (11) of Table (8/5). The agreement between observed and graduated values is on the whole satisfactory.

220. Previous work in Bengal had shown that the cost of operations increases with decreasing density, that is, with increasing scatter of the grids. This has been also found to be true in Bihar in the survey in the *rabi* season. The relation between cost and density in Bengal was not however strictly linear, but within the limited range of present observations in Bihar a straight line fit appears to be good enough for all practical purposes.

TABLE (8/5). OBSERVED AND GRADUATED VALUES OF COST (PAY-DAYS PER GRID) FOR DIFFERENT DENSITIES OF GRIDS

Density or number of grids surveyed per square mile		District : Shahabad			District : Monghyr			Both Districts		
		No. of Zone-cells	Pay-days per grid		No. of Zone-cells	Pay-days per grid		No. of Zone-cells	Pay-days per grid	
Range	Mid-point		Observed	Graduated		Observed	Graduated		Observed	Graduated
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
0·21-0·40	0·305	3	0·3667	0·3651	1	·4400	0·3583	4	·3850	0·3644
0·41-0·60	0·505	—	—	·3548	—	—	·3498	—	—	·3551
0·61-0·80	0·705	4	0·3375	·3445	5	·3500	·3414	9	0·3444	·3458
0·81-1·00	0·905	10	·3220	·3342	15	·3173	·3329	25	·3192	·3365
1·01-1·20	1·105	9	·3544	·3239	8	·3200	·3244	17	·3382	·3271
1·21-1·40	1·305	10	·3820	·3136	7	·3014	·3160	17	·3488	·3178
1·41-1·60	1·505	12	·3317	·3033	10	·3480	·3075	22	·3354	·3085
1·61-1·80	1·705	23	·2713	·2930	7	·3389	·2991.	30	·2857	·2992
1·81-2·00	1·905	17	·2924	·2827	10	·2650	·2706	27	·2822	·2899
2·01-2·20	2·105	4	·3070	·2724	17	·2741	·2822	21	·2792	·2806
2·21-2·40	2·305	2	·3060	·2621	5	·2720	·2737	7	·2713	·2714
2·41-2·60	2·505	2	·3151	·2518	9	·2678	·2652	11	·2737	·2620

TABLE (8/6). CALCULATED PARAMETERS FOR GRADUATION OF COST (PAY-DAYS PER GRID) ON DENSITY OF GRIDS.

Name of parameter	District : Shahabad	District : Monghyr	Both districts combined
(1)	(2)	(3)	(4)
Total number of Zone-cells	96	94	190
Mean cost in pay-day per grid (C)	0·3142±0·0060	0·3033±0·0051	0·3088±0·0040
Mean density (or number) of grids per sq. mile (D)	1·4925±0·0482	1·6092±0·0559	1·5503±0·0096
Coefficient of correlation between cost (C) and Density (D)	−0·4107	−0·4938	−0·4505
Standard deviation of cost (Sc) and of Density (SD)	=0·0592 ; SD=0·4720	Sc=0·0498 ; Sd=0·5820	Sc=0·0549 ; SD=0·5320
Ratio & Variance for test of linear regression	17·8275	29·6510	48·1566
Regression of cost (c) on Density (D)	C= ·3811− ·0515(D)	C= ·3714− ·0422(D)	C =3788− ·0465(D)

PRACTICAL VALUE OF RESULTS

221. It is worth while pointing out the importance and practical value of the above study. In preparing the design for the *bhadoi* season it was possible to calculate in advance (with the help of the above results) the time which would be required for an area survey with different densities of grids. Information relating to cost of operations collected in the *rabi* season was thus of immediate and direct practical use in preparing the programme of work in the *bhadoi* season.

EXPENDITURE IN THE FIELD BRANCH

222. *Worker-months.* We may now consider briefly the expenditure in money incurred in the field branch for the survey in the *rabi* season of 1943-44. This is shown in Table (8/7) in which col. (1) gives the heads of broad groups of expenditure. Col. (2) shows the number of months of work put in by different categories of workers ; from this column we find that the total number of months of work done by investigators was 158·3, that done by inspectors was 37·0 months, and that by chief inspectors 13·4 months in all. The corresponding volume of work done by each category of field staff in the Bengal Crop Survey of 1943-44 (in two crop seasons, namely, *bhadoi* or jute and *aus* paddy, and *aman* paddy) is shown for comparison in col. (3) from which we find that the total number of months of work done by investigators was 2000 in round numbers, that done by inspectors 430 months, and by chief inspectors 103 months. The next two columns give the proportion of inspecting staff per investigator-month ; from cols. (4) and (5) we notice that in Bihar the effective proportion of inspectors was 0·24 per investigator-month, that is, one inspector per 4 investigators against 0·22 or some thing between 1 in 4 and 1 in 5 in Bengal. The proportion of chief inspectors in Bihar was 0·09 or 1 chief inspector per 11 investigators against 0·05 or 1 in 20 in Bengal.

TABLE (8/7). COMPARATIVE FIELD EXPENDITURE IN BENGAL AND BIHAR.

Head of expenditure	Number of worker-months		Rate per investigator month		*Total expenditure in Rupees		Rate in rupees per investigator month	
	Bihar *rabi*	Bengal 1943-44	Bihar *rabi*	Bengal 1943-44	Bihar *rabi* 1943-44	Bengal 1943-44	Bihar *rabi* 1943-44	Bengal 1943-44
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1. Investigators	155·3	2000	1·00	1·00	6270	72000	40·50	36·00
2. Inspectors	37·0	430	0·24	0·22	2330	30100	15·00	15·05
3. Chief Inspectors	13·4	108	0·09	0·05	998	18900	6·30	9·45
4. Sub-total (1 to 3)	205·7	2538	1·33	1·27	9598	121000	81·80	60·50
5. Dearness allowance					2092	34000	13·50	17·00
6. Leave salary & Provident fund				—	—	6400	—	3·20
7. Sub-total (5+6)					2092	40400	13·50	20·20
8. Field staff sub-total (4+7)					11,680	101,400	75·30	80·70
9. Supervising staff					5603	6500	36·00	3·25
10. Headquarters					4183	7100	27·00	3·55
11. Sub-total (9+10)					9786	13600	63·00	6·80
12. Staff sub-total (8+11)					21478	175000	138·30	87·50
Other expenses								
13. Travelling allowance					2798	20000	18·00	10·00
14. House rent					332	2400	2·10	1·20
15. Contingent (with peon)					6270	25800	40·50	12·90
16. Other expenses sub-total					9400	48200	60·60	24·10
17. Grand Total					30,876	223,200	198·90	111·60

* excludes non-recurring expenditure on training.

223. *Total expenditure.* The total expenditure incurred in Bihar, correct to the nearest rupee, is shown in col. (6); and the corresponding expenditure incurred in the Bengal scheme, in round figures in col. (7). In Bihar there was also an amount of about Rs. 9052 spent on account of pay and travelling allowances of the field staff sent on loan from Bengal;

this has not been included in Table (8/7) as it was an extra-ordinary item of expenditure incurred for the training of the Bihar staff. In the same way one item of about Rs. 10,000 in Bengal spent for giving training to new workers has been omitted.

224. The total expenditure for the full provincial survey in two seasons in Bengal was about 2·23 lakhs of rupees. The expenditure of Rs. 30,876 for one single survey in only two districts in Bihar was naturally higher in comparison owing to the fact that certain preliminary expenses of a non-recurring nature were incurred in the pilot survey, and also because overhead costs were proportionately much higher on account of the small scale of operations.

225. *Cost per investigator-month.* Dividing the total expenditure by the number of investigator-months we get the "cost per investigator-month" in Bihar and Bengal as shown in cols. (8) and (9) respectively of Table (8/7). We notice that in Bihar the cost of salary of investigators was Rs. 40·5 against Rs. 36 per month in Bengal in 1943-44 ; the proportionate share of the cost of salary of inspectors was Rs. 15 per investigator-month in both provinces ; the proportionate cost of the salary of chief inspectors was Rs. 6·3 in Bihar against Rs. 9·45 in Beugal. The total cost on account of salary of field staff was Rs. 61·8 in Bihar against Rs. 60·5 in Bengal per investigator-month. Adding dearness allowance of Rs. 13·5 (which includes the allowance not only for the investigators but also a proportionate share of the allowance for inspectors and chief inspectors) the total expenditure on account of staff salary was Rs. 75·3 per investigator-month in Bihar. The dearness allowance was higher, Rs. 17 in Bengal ; there was also an additional item of Rs. 3·2 as contribution to leave salary and provident fund per investigator-month. The total expenditure on account of salary of field staff was thus appreciably higher, Rs. 80·7 per investigator-month in Bengal.

226. There was not much difference in the salary of the supervising staff, Rs. 5,603 in Bihar against R.s 6,500 in Bengal. But the per capita expenditure was naturally very much higher (because of the small number of investigators) in Bihar, Rs. 36 against Rs. 3·25 in Bengal. Big differences naturally again occured on a per capita basis in expenditure incurred for staff at headquarters with Rs. 27 per investigator-month in Bihar against only Rs. 3·55 in Bengal. Among other expenses, travelling allowance consumed Rs. 18 in Bihar against Rs. 10 in Bengal ; house rent was Rs. 2·1 in Bihar against Rs. 1·2 in Bengal. Contingent charges (including pay and allowance of peon) were proportionately much higher in Bihar, Rs. 40·5 per investigator-month against Rs. 12·90 in Bengal, again because of the small scale of operations. The total expenditure under heads other than salary was thus much higher, Rs. 60·6 per investigator-month in Bihar against Rs. 24·10 in Bengal. The total cost per investigator-month was Rs. 198·9 in Bihar against Rs. 111·60 in Bengal.

227. *Expenses for crop-cutting work.* It is of interest to note that crop cutting work consumed only 317 pay-days out of a total of 6700 pay-days in the whole survey. It will be remembered that the precision in estimating crop acreage and average yield per acre for the province as a whole was about the same. The area survey work thus required about 14 times more labour than crop-cutting work to attain the same precision in the final results. Also 317 pay-days mean about 10½ investigator-months. As the overall rate of expenditure was Rs. 198·9 per investigator-month the marginal share of expenditure for crop-cutting work was only a little over Rs. 2100. Crop-cutting work is thus not at all expensive.

EXPENDITURE IN THE STATISTICAL BRANCH

228. The total amount of money received by the Indian Statistical Institute up to 31st March 1944 on account of the Bihar Crop Survey scheme was Rs. 61,986 out of which Rs. 5,666-11-0 was credited as contribution in lieu of the Statistical adviser's services.

229. *Cost per computer-month.* In the statistical branch also the real unit of measurement is the computer-month, that is, the work done by one computer in one month. The total volume of statistical work actually consumed for the survey in the *rabi* season was 241 computer-months between practically January and March 1944. This is the net amount of time spent by primary computers ; on an average about 50 per cent of additional staff is required for the inspecting and supervising work in the computation section and in office and general administrative work. For the portion of the work done before 31st March 1944 the adjusted rate of expenditure was about Rs. 150 per computer-month made up of Rs. 95·7 for staff salary (inclusive of pay of primary computers, inspectors, and office and other staff) and Rs. 54·3 for other expenses.

230. It will be noticed that the staff salary per computer-month of Rs. 95·7 was somewhat higher than Rs. 87·5 per investigator-month in the field branch in the Bengal scheme ; *pro rata* expenditure on heads other than salary was also higher, Rs. 54·3 per computer-month against Rs. 24·1 per investigator-month in the filed branch. Expenses

were naturally higher on the statistical side because men with higher qualifications, as also calculating machines, photographic and other more expensive apparatus were required for the work.

231. In the Bihar *rabi* survey scheme the total volume of work in the statistical branch was larger than the total volume of field work, 241 computer-months against 155·3 investigator-months. The cost per computer-month, Rs. 150, was somewhat lower than the cost per investigator-month, Rs. 198·9 in the field branch. It must be remembered, however, that so far as the Government of Bihar was concerned, there was also the contribution of Rs. 5666-11-0 in lieu of the services of the Statistical Adviser. If this is taken into consideration, there would be an additional cost of Rs. 23·5 per computer-month bringing up the total cost to Rs. 173·5 per computer-month. Making allowances for the larger volume of the statistical work, the cost per primary worker in the field and the statistical sides of the Bihar crop survey scheme was not very dissimiliar.

232. A good deal of statistical work has also been done in connexion with the *rabi* survey scheme since 1st April 1944, but detailed figures of cost accounting are not yet available. It may be, however, stated broadly that the total volume of work (inclusive of 241 computer-months consumed upto 31st March 1944) has probably exceeded the estimated figure of 300 computer-months given in the budget.

SECTION 9. ACCURACY OF AREA ENUMERATION

233. A good deal of material was collected in the intensive schemes for special studies for the improvement of the technique of the crop survey. Some of the results of such special studies are given in the present section. It may be mentioned, however, that work is still proceeding in certain directions but progress has been and is still slow as a sufficient number of men cannot be put on to this work for lack of accommodation at Giridih.

STUDY OF COMPLETE AREA ENUMERATION

234. Compact areas were completely enumerated plot by plot in the neighbourhood of the special block camps by a number of field parties employed exclusively for this purpose. In this scheme detailed plot by plot records were prepared showing what crop was grown on what proportion of land in each plot and what proportion was fallow or was being used for other purposes. A complete record was thus prepared for each plot showing in detail how it was being utilized.

235. In certain areas the complete enumeration work was duplicated independently by a second party of investigators. In the original programme the area to be surveyed in each camp was to be covered in sectors, one sector each being alloted to one investigator so that all the sectors would be duplicated in turn in a balanced pattern. Unfortunately, owing to unforeseen difficulties, only a fraction of the field programme relating to the second survey could be completed.

COMPARISON BY INDIVIDUAL PLOTS

236. Duplicate records were however obtained for 6,188 plots by different investigators working independently. This material is of considerable interest as it throws much light on the accuracy with which complete enumeration work can be actually carried out in practice by investigators of the present type appointed *ad hoc* for this purpose.

237. Results of a detailed comparison of the two independent enumerations of the same identical set of individual plots are shown in tables (9/1)—(9/5). In Table (9/1) the records have been tabulated in a two-way form. An actual example will make the procedure clear. Let us consider, for example, table (9/1f) which gives a comparison of the two sets of records for 1,855 plots surveyed in thana Jamui of district Monghyr, once between 12th and 24th February and a second time between 25th February and 6th March. Entries relating to the wheat crop have been analysed in this particular table. The figures 0-anna, 1-anna, 2-anna, 3-anna....16-anna at the top of columns represent the anna-estimate of the proportion of land sown with wheat as recorded in the first enumeration carried out between 12th and 24th February. In the same way the figures 0-anna, 1-anna, 2-anna....16 anna given in the first column of the table represent for each row the anna-estimate of land under wheat as recorded during the second enumeration carried out between 25th February and 6th March 1944. The figures given in the different cells represent actual number of plots recorded to have the anna-proportions under wheat as shown in the marginal anna figures in the top row and in the first column.

238. Thus we find in the left hand corner cell belonging to '0-anna' row and '0-anna' column the figure 1573. This means that 1573 plots were recorded as having '0-anna', that is as being without any wheat in both the enumerations. Just below this figure, in the

column headed '0-anna' and in the row marked '1-anna', we have the figure 7 which shows that 7 plots were recorded as having 'no wheat' in the first enumeration but were recorded as having 1-anna proportion of land under wheat in the second enumeration. In the same way we have the figure 126 in the column headed '0-anna' and row marked '16-anna' showing that these 126 plots were recorded as having 'no wheat' during the first enumeration but were shown as having a 16-anna wheat crop in the second enumeration. At the bottom of the first column we have the figure 5 giving the total number of plots which were recorded to have 'no wheat crop' in the first enumeration.

239. Let us now follow the first row marked '0-anna' on the extreme left. The first number is 1573 which, as already noted, gives the number of plots shown to have 'no wheat' in both enumerations. To the right of this we have the number 13 in the column headed '1-anna' (and the row marked '0-anna') giving the number of plots which were recorded as having 1-anna under wheat in the first enumeration, but were entered as having no wheat at all in the second enumeration, and so on. In the '0-anna' row we have in the column headed '16-anna' the figure 18 giving the number of plots which were recorded as having a 16-anna wheat in the first enumeration but were shown as having no wheat at all in the second enumeration. On the extreme right in the '0-anna' row we have the figure 1637 giving the total number of plots which were recorded as having no wheat at all in the second enumeration.

DISCREPANCIES IN ANNA-ESTIMATE

240. From the way in which table (9/1a) has been prepared it is clear that if the two enumerations were in complete agreement then entries would have occurred only in the diagonal cells, that is, in the 0-0, 1-1, 2-2....16-16 cells. That is, the number of plots shown to have no wheat would have been the same in both enumerations. The number of plots shown to have 1-anna under wheat, 2-anna under wheat etc. up to 16-anna under wheat would also have been identical in both enumerations. A glance at tables (9/1a)—(9/1f) shows that in actual fact this was not so ; and in an appreciable number of cases plots were recorded to have different proportions of land under wheat in the two enumerations. As already pointed out, among 1751 plots shown as not having any wheat in the first enumeration, only 1573 were recorded as having no wheat in the second enumeration ; the remaining 178 plots (which were recorded as having no wheat in the first enumeration) were shown to have different proportions of land from 1-anna to 16-anna under wheat in the second enumeration.

241. It is clear therefore that results of complete enumeration carried out by *ad hoc* investigators of the present type are subject to appreciable mistakes in recording. This is fully borne out by the other tables (9/1a)—(9/1f). Considerable variations occur in the anna estimates of the area under the same crop made by different investigators. This would not have been very serious if the anna estimates had differed by a comparatively small amount. For example, the same plot might easily be estimated to have a 4-anna crop of wheat bn one investigator and to have a 5-anna or 6-anna crop by a second investigator. The positioy as revealed by tables (9/1a) to (9/1f) is more serious. We found that plots recorded as having been sown completely with wheat in the first enumeration were shown as having no wheat at all in the second enumeration. Such discrepancies could have only arisen either through a mistake in the identification of the plot or in the identification of the crop, or through the work having been fudged altogether.

DISCREPANCIES IN CROP RECORDS

242. To investigate the matter in greater detail it was considered advisable to tabulate the duplicate records of the same set of individual plots in a different way in Table (9/2). Instead of classifying under anna-estimates of the proportion of land under the same crop, the material is now classified simply according to the particular crop shown to be growing on the plot irrespective of the proportion of land under different crops. Thus in Table (9/2a) the column headings at the top are simply 'wheat', 'gram', 'wheat and gram', 'wheat, gram, and others', 'gram and others', 'other crops', and 'no crop' (the last one signifying that the plots were either kept fallow or were being used for purposes other than cultivation). The same headings also occur in the extreme left against each row.

243. In this Table (9/2) also, if the results of the two enumerations are in complete agreement, then entries would occur only in the diagonal cells, that is, in the cells which are marked both ways as being 'under wheat', or 'under wheat and gram' etc. A glance at Tables (9/2a) to (9/2f) shows that quite a large number of entries occur outside the diagonal cells. We thus find that, apart from discrepancies in anna-estimates, appreciable discrepancies had also occurred in recording the crops grown on the same individual plots enumerated by different sets of investigators.

Table (9/1). Comparison of duplicate anna estimates of proportions of land under wheat

Table (9/1a). Thana Jamui, District Monghyr

Anna estimates of proportion of land under wheat made in 2nd enumeration from 25 Feb. to 6 March 1944	Anna estimates of proportion of land under wheat as recorded in first enumeration between 12 February and 24 February 1944																
	0-anna	1-anna	2-anna	3-anna	4-anna	5-anna	6-anna	7-anna	8-anna	9-anna	10-anna	11-anna	12-anna	13-anna	14-anna	15-anna	16-anna	Total
0-anna	[1573]	13	8	1	3	—	3	1	7	—	3	—	5	2	—	—	18	1637
1-anna	7	[—]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7
2-anna	9	1	[—]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10
3-anna	—	—	—	[—]	—	—	—	—	—	—	—	—	—	—	—	—	—	—
4-anna	2	—	1	—	[—]	—	1	—	—	—	—	—	—	—	—	—	—	4
5-anna	3	—	—	—	1	[—]	—	—	—	—	—	—	—	1	—	—	—	5
6-anna	2	—	—	—	—	—	[—]	—	—	—	—	—	—	—	—	—	—	2
7-anna	1	—	—	—	—	—	—	[—]	1	—	—	—	—	1	—	—	—	3
8-anna	3	—	—	—	2	—	—	—	[1]	—	—	—	2	—	—	—	1	9
9-anna	—	—	—	—	—	—	—	—	—	[—]	—	—	1	—	—	—	1	2
10-anna	5	—	—	—	—	—	1	—	—	—	[—]	—	1	—	—	—	—	7
11-anna	2	—	—	—	—	—	—	—	1	—	—	[—]	—	—	—	—	—	3
12-anna	8	—	—	—	—	—	2	—	1	—	—	—	[1]	—	1	—	1	14
13-anna	1	—	—	—	—	—	—	—	—	—	—	—	—	[—]	1	—	—	2
14-anna	6	—	—	—	—	—	—	1	—	—	—	—	3	1	[—]	—	1	12
15-anna	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	[—]	—	3
16-anna	126	—	1	—	—	—	1	—	4	—	—	—	1	—	—	—	[2]	135
Total	1751	14	10	1	6	—	8	2	15	—	3	—	14	5	2	—	24	1855

Table (9/1b). Thana Shahpur, District Shahabad

Anna estimates of proportion of land under wheat made in 2nd enumeration from 23 February to 6 March 1944	Anna estimate of proportion of land under wheat as redcorded in first enumeration between 13 February and 23 February 1944																
	0-anna	1-anna	2-anna	3-anna	4-anna	5-anna	6-anna	7-anna	8-anna	9-anna	10-anna	11-annaz	12-anna	13-anna	14-anna	15-anna	16-anna	Total anna
0-anna	[1389]	10	11	13	11	3	6	8	4	3	1	—	—	—	—	—	—	1459
1-anna	10	[2]	1	—	1	—	1	—	—	—	—	—	—	—	—	—	—	15
2-anna	21	1	[1]	1	1	—	—	1	—	—	—	—	—	—	—	—	—	26
3-anna	22	1	—	[1]	2	1	—	—	—	—	—	—	—	—	—	—	—	27
4-anna	23	3	3	—	[—]	—	1	1	—	—	1	—	1	—	—	—	—	33
5-anna	8	—	—	1	2	[—]	1	—	—	—	1	—	—	—	—	—	—	13
6-anna	7	2	1	1	—	—	[1]	3	—	—	1	1	—	1	—	—	—	18
7-anna	4	—	—	1	—	—	—	[—]	—	—	—	—	—	—	—	—	—	5
8-anna	4	—	—	—	1	1	—	1	[1]	—	—	—	—	—	—	—	—	8
9-anna	—	—	—	—	—	—	—	—	—	[—]	—	—	—	—	—	—	—	—
10-anna	2	—	—	—	—	—	—	—	—	—	[—]	—	—	—	—	—	—	2
11-anna	—	—	—	—	—	—	—	—	—	—	—	[—]	—	—	—	—	—	—
12-anna	—	—	—	—	—	—	—	—	—	—	—	1	[—]	—	—	—	—	1
13-anna	—	—	—	—	—	—	—	—	—	—	—	—	—	[—]	—	—	—	—
14-anna	1	—	—	—	—	—	—	—	—	—	—	—	—	—	[—]	—	—	1
15-anna	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	[—]	—	—
16-anna	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	[—]	—
Total	1491	19	17	18	18	5	10	14	5	3	4	2	1	1	—	—	—	1608

TABLE (9/1c). THANA SASARAM, DISTRICT SHAHABAD

Anna estimates of proportion of land under wheat made in 2nd enumeration from 25 February to 6 March 1944

Anna estimates of porportion of land under wheat as recorded in first enumeration between 11 February and 23 February 1944

	0-anna	1-anna	2-anna	3-anna	4-anna	5-anna	6-anna	7-anna	8-anna	9-anna	10-anna	11-anna	12-anna	13-anna	14-anna	15-anna	16-anna	Total
0-anna	[773]	5	4	1	3	—	6	2	8	1	5	1	3	—	5	2	5	824
1-anna	2	[1]	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	5
2-anna	3	1	[—]	—	2	—	1	—	2	—	—	—	—	—	—	—	—	9
3-anna	—	—	—	[—]	1	2	—	1	1	—	—	—	—	—	—	—	—	5
4-anna	1	—	1	1	[—]	—	1	—	—	1	—	—	—	—	—	—	—	5
5-anna	1	—	1	—	2	[1]	1	—	1	2	—	—	1	—	—	—	—	10
6-anna	3	—	1	1	2	2	[1]	1	1	2	1	1	—	—	—	—	—	16
7-anna	1	—	—	—	—	1	2	[—]	—	1	4	—	—	1	—	—	—	10
8-anna	7	—	—	—	—	3	1	1	[3]	3	2	1	—	—	2	3	—	26
9-anna	1	—	1	—	1	—	2	—	5	[—]	3	—	1	—	—	—	—	14
10-anna	2	—	1	—	—	2	—	2	5	3	[2]	3	2	—	1	—	—	23
11-anna	—	—	—	—	1	1	1	—	1	1	9	[2]	1	—	1	—	1	19
12-anna	2	—	—	—	2	4	—	—	7	—	8	2	[3]	1	—	—	—	29
13-anna	1	—	—	—	—	—	1	1	2	4	2	—	6	[3]	2	—	1	23
14-anna	—	—	—	—	—	—	—	—	1	1	1	—	—	—	[1]	—	—	4
15-anna	2	—	—	—	—	—	—	1	—	—	—	—	1	—	1	[—]	4	9
16-anna	8	1	1	—	—	—	1	—	—	—	—	—	—	—	2	7	[22]	42
Total	807	8	11	3	15	16	18	9	37	19	37	10	18	5	15	12	33	1073

TABLE (9/1d). THANA LAKHISARAI, DISTRICT MONGHYR

Annna estimates of proportion of land under wheat made in 2nd enumeration from 25 February to 6 March 1944

Anna estimates of proportion of land under wheat as recorded in first enumeration between 12 February and 24 February 1944

	0-anna	1-anna	2-anna	3-anna	4-anna	5-anna	6-anna	7-anna	8-anna	9-anna	10-anna	11-anna	12-anna	13-anna	14-anna	15-anna	16-anna	Total
0-anna	[724]	—	2	—	9	—	1	—	6	—	—	—	1	—	—	—	6	749
1-anna	1	[—]	—	—	1	—	—	—	—	—	—	—	1	—	—	—	—	3
2-anna	1	—	[—]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
3-anna	2	—	—	[—]	—	—	—	—	—	—	—	—	—	—	—	—	—	2
4-anna	—	—	—	—	[1]	—	—	—	—	—	—	—	—	—	—	—	—	1
5-anna	—	—	—	—	1	[—]	—	—	—	—	—	—	—	—	—	—	—	1
6-anna	1	—	—	—	—	—	[—]	—	—	—	—	—	—	—	—	—	1	2
7-anna	—	—	—	—	—	—	—	[—]	1	—	—	—	—	—	—	—	—	1
8-anna	—	—	1	—	—	—	—	—	[1]	—	—	—	—	—	—	—	—	2
9-anna	—	—	—	—	—	—	—	—	—	[—]	—	—	—	—	—	—	—	—
10-anna	1	—	—	—	—	—	—	—	—	—	[—]	—	—	—	—	—	—	1
11-anna	1	—	—	—	—	—	—	—	—	—	—	[—]	—	—	—	—	—	1
12-anna	—	—	—	—	—	—	—	—	—	—	—	—	[—]	—	—	—	—	—
13-anna	—	—	—	—	—	—	—	—	—	—	—	—	—	[—]	—	—	—	—
14-anna	2	—	—	—	—	—	—	—	—	—	—	—	—	—	[—]	—	—	2
15-anna	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	[—]	—	—
16-anna	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	[—]	2
Total	735	—	3	—	12	—	1	—	8	—	—	—	2	—	—	—	7	768

TABLE (9/1e). THANA GOGRI, DISTICT MONGHYR

Anna estimates of proportion of land under wheat as recorded in first enumeration between 26 February and 7 March 1944

Anna estimates of proportion of land under wheat made in 2nd enumeration from 8 Mar. to 20 Mar. 1944

	0-anna	1-anna	2-anna	3-anna	4-anna	5-anna	6-anna	7-anna	8-anna	9-anna	10-anna	11-anna	12-anna	13-anna	14-anna	15-anna	16-anna	Total
0-anna	[27]	—	—	—	—	—	2	1	1	—	—	—	—	1	1	—	3	36
1-anna	—	[—]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2-anna	—	—	[—]	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3-anna	1	—	—	[—]	—	—	—	—	—	—	—	—	—	—	—	—	—	1
4-anna	—	—	—	—	[—]	1	1	—	—	—	—	—	—	—	—	—	—	2
5-anna	—	—	—	—	1	[—]	—	—	—	—	—	—	—	—	—	—	—	1
6-anna	—	—	1	—	—	—	[—]	—	—	—	—	—	—	—	—	—	—	1
7-anna	—	—	—	—	—	—	—	[—]	—	—	—	—	—	—	—	—	—	—
8-anna	—	—	—	—	—	—	—	—	[—]	—	—	—	—	—	—	—	—	—
9-anna	—	—	—	—	—	—	—	—	—	[—]	—	—	—	—	—	—	—	—
10-anna	—	—	—	—	1	—	—	—	—	—	[—]	—	—	—	—	—	—	1
11-anna	—	—	—	—	—	—	—	—	—	—	—	[—]	—	—	—	—	—	—
12-anna	—	—	—	—	—	—	—	—	—	—	—	—	[—]	1	1	—	1	3
13-anna	1	—	—	—	—	—	—	—	—	—	—	—	—	[—]	1	—	—	2
14-anna	1	—	—	—	—	—	—	—	—	—	—	—	—	—	[—]	—	2	3
15-anna	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	[—]	—	—
16-anna	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	[—]	—
Total	30	—	1	—	2	1	3	1	1	—	—	—	—	2	3	—	6	50

TABLE (9/1f). THANA MOHANIA, DISTRICT SHAHABAD

Anna estimates of proportion of land under wheat as recorded in first enumeration between 13 February and 23 February 1944

Anna estimates of proportion of land under wheat made in 2nd enumeration from 25 Feb. to 6 Mar. 1944

	0-anna	1-anna	2-anna	3-anna	4-anna	5-anna	6-anna	7-anna	8-anna	9-anna	10-anna	11-anna	12-anna	13-anna	14-anna	15-anna	16-anna	Total
0-anna	[745]	5	3	3	10	1	7	1	9	—	—	—	—	—	1	—	1	786
1-anna	8	[1]	1	3	1	1	—	—	—	—	—	—	—	—	—	—	—	15
2-anna	7	—	[2]	1	1	—	—	—	—	—	—	—	—	—	—	—	—	11
3-anna	4	—	—	[—]	—	2	1	1	1	—	—	—	—	—	—	—	—	9
4-anna	4	—	—	—	[1]	1	—	—	1	—	—	—	1	—	—	—	—	8
5-anna	1	—	—	1	—	[—]	—	—	1	—	1	—	—	—	—	—	—	4
6-anna	1	—	—	—	1	—	[—]	—	—	1	1	—	1	—	—	—	—	5
7-anna	2	—	—	—	—	—	—	[1]	—	—	—	—	—	—	—	—	—	3
8-anna	4	—	—	1	—	—	1	1	[—]	—	—	—	1	—	—	—	—	8
9-anna	—	—	—	—	—	—	—	—	2	[—]	1	—	—	—	—	—	—	3
10-anna	1	—	—	—	—	—	—	—	—	1	[1]	—	—	—	—	—	—	3
11-anna	—	—	—	—	—	—	—	—	—	—	—	[—]	—	—	—	—	—	—
12-anna	—	—	—	—	—	—	—	—	—	—	—	—	[—]	—	—	—	—	—
13-anna	—	—	—	—	—	—	—	—	1	—	—	—	—	[—]	—	—	1	2
14-anna	—	—	—	—	—	—	—	—	—	—	—	1	1	—	[—]	—	—	2
15-anna	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	[—]	—	—
16-anna	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	[—]	1
Total	777	6	6	9	14	5	9	4	15	2	4	1	5	—	1	—	2	860

TABLE (9/2). COMPARISON OF DUPLICATE CROP RECORDS

Crop records in second enumeration	Crop records in first enumeration							
	Wheat	Gram	Wheat & gram	Wheat, Gram & Others	Gram & others	Other crops	No crops	Total
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

TABLE (9/2a). POLICE STATION MOHANIA, DISTRICT SHAHABAD
PERIOD OF FIRST ENUMERATION : 13 FEBRUARY TO 23 FEBRUARY 1944

Period of 2nd enumeration: 23 Feb. 6 March 1944									
	Wheat	[—]	—	—	1	—	1	—	2
	Gram	—	[20]	—	1	6	1	2	30
	Wheat & Gram	1	—	[17]	2	10	5	4	39
	Wheat, Gram & others	—	1	3	[16]	18	2	3	43
	Gram & Others	—	31	2	17	[212]	10	13	285
	Other crops	—	8	1	2	6	[111]	38	166
	No Crop	—	1	1	4	5	8	[277]	296
	Total	1	61	24	43	257	138	377	861

TABLE (9/2b). POLICE STATION SASARAM, DISTRICT SHAHABAD
PERIOD OF FIRST ENUMERATION : 11 FEBRUARY TO 23 FEBRUARY 1944

Period of 2nd enumeration : 25 Feb. to 6 March 1944									
	Wheat	[22]	—	—	2	1	13	4	42
	Gram	—	[—]	—	—	1	—	1	2
	Wheat & Gram	1	1	[1]	3	—	2	—	8
	Wheat, gram & others	1	—	23	[98]	1	23	5	151
	Gram & Others	—	—	—	12	[8]	5	1	26
	Other crops	6	—	3	15	3	[145]	39	211
	No crop	3	—	—	6	2	57	[565]	633
	Total	33	1	27	136	16	245	615	1073

TABLE (9/2c). POLICE STATION SHAHPUR, DISTRICT SHAHABAD
PERIOD OF FIRST ENUMERATION : 11 FEBRUARY TO 23 FEBRUARY 1944

Period of 2nd enumeration: 25 Feb. to 6 March 1944									
	Wheat	[—]	—	—	—	—	—	—	—
	Gram	—	[8]	—	—	12	—	1	21
	Wheat & Gram	—	—	[—]	—	—	—	1	1
	Wheat. Gram & others	—	1	—	[38]	68	22	2	131
	Gram & others	—	7	—	13	[184]	122	25	351
	Other crops	—	1	—	4	39	[240]	31	315
	No crop	—	4	—	3	12	93	[667]	779
	Total	—	21	—	58	315	477	727	1598

244. The two-way tables discussed above show the details of the comparison of duplicated records for individual plots. A more summary form of the tabulation is, however, convenient for a general appreciation of the position. This is shown in Table (9/3a) in which the results of the comparison between records obtained during the first and the second enumerations are shown in a condensed form for each camp or centre separately and also for the the districts separately, and finally for the two districts taken together. In this Table col. (1) gives the name of the camp, and cols. (2) and (3) the dates of the first and the second enumeration, respectively. Col. (4) gives the number of 0-0 entries, that is, the number of plots which were recorded as having no wheat in both enumerations. In col. (5) is given the number of plots for which anna-estimates of the proportion of land under wheat was the same in both the enumerations. For these plots the two enumerations were therefore in complete agreement. The number of plots for which the records of the first and second enumerations were not in agreement is shown in col. (6). The total number of plots compared is given in col. (7) of Table (9/3a).

245. Instead of actual numbers, for purpose of comparison, it is more convenient to use percentage figures which are shown in cols. (8), (9) and (10). Col. (8) gives the percentage of 0-0 plots, col. (9) the percentage of plots recorded as having wheat in both enumerations and finally col. (10) of Table (9/3a) shows the percentage of plots for which records in the two enumerations were not in agreement.

TABLE (9/2). COMPARISON OF DUPLICATE CROP RECORDS(contd.)

Crop records in second enumeration	Crop Redords in first enumeration							
	Wheat	Gram	Wheat & Gram	Wheat, Gram & Others	Gram & others	Other Crops	No Crops	Total
(1)	(2)	(2)	(4)	(5)	(6)	(7)	(8)	(9)

TABLE (9/2d). THANA JAMUI DISTRICT MONGHYR
PERIOD OF FIRST ENUMERATION : 12 FEBRUARY TO 24 FEBRUARY 1944.

Period of 2nd enumeration: 25th Feb to 8th Mar. 1944									
	Wheat	[4]	—	6	1	1	50	47	109
	Gram	1	[24]	4	—	1	16	20	66
	Wheat & Gram	5	—	[12]	4	3	3	6	33
	Wheat, gram & others	—	—	4	]1]	4	3	12	24
	Gram & others	4	1	4	5	[14]	6	27	61
	Other crop	6	3	5	9	17	[28]	108	276
	No crop	4	9	7	9	26	77	[1154]	1286
	Total	24	37	42	29	66	283	1374	1855

TABLE (9/2e). THANA LAKHISARAI DISTRICT MONGHYR
PERIOD OF FIRST ENUMERATION : 12 FEBRUARY TO 24 FEBRUARY 1944

Period of 2nd enumeration : 25thFeb to 6th Mar. 1944									
	Wheat	[—]	—	3	—	—	—	2	5
	Gram	—	[—]	—	—	—	—	1	1
	Wheat & gram	—	1	[5]	—	—	—	2	8
	Wheat gram & others	2	—	—	[—]	—	—	3	5
	Gram & others	1	—	5	2	[—]	4	14	26
	Other crops	2	—	3	1	1	[2]	12	21
	No Crop	2	3	5	—	1	3	[692]	706
	Total	7	4	21	3	2	9	726	772

TABLE (9/2f). THANA GOGRI : DISTRICT MONGHYR
PERIOD OF FIRST ENUMERATION : 26 FEBRUARY TO 7 MARCH 1944.

Period of 2nd enumeration: 8th Mar. to 20th Mar. 1944									
	Wheat	[—]	—	—	—	—	—	—	—
	Gram	—	[—]	—	—	—	—	—	—
	Wheat & Gram	2	—	[3]	—	—	—	2	7
	Wheat, Gram & others	1	—	—	[1]	—	4	1	7
	Gram & others	—	—	—	—	[—]	—	—	—
	Other crops	—	—	—	—	—	[—]	—	—
	No crops	3	—	2	2	—	4	[25]	36
	Total	6	—	5	3	—	8	28	50

246. Looking at col. (10) of Table (9/3a) it will be noticed that the proportion of plots not in agreement varied from 6 per cent in Lakhisarai to 46 per cent in Gogri in Monghyr district. The over-all proportion of discrepant plots was 16·5 per cent in Shahabad and 13·0 per cent in Monghyr with a combined proportion of 15·0 per cent for the two districts taken together. Records of the two complete enumerations were thus discrepant in something like one-sixth of the total number of plots surveyed. This is by no means negligible.

247. It will be remembered that in preparing Table (9/3a) agreement was interpreted in the sense that the actual anna estimate of the proportion of land under wheat should be identical in both the enumerations. This is, however, a very stringent definition. For example, a plot recorded as having 5-anna under wheat in one enumertion and 6-anna under wheat in the other enumeration, would be, according to this definition, considered as discrepant. It is possible to adopt other definitions of agreement. For example, a plot recorded as having wheat in it in both enumerations may be considered to be in agreement irrespective of the fact whether the respective anna-estimates were in agreement or had differed widely. Thus, according to this definition, a plot recorded as having one anna under wheat in one enumeration and as 16-anna under wheat in the other enumeration would

be considered to be in agreement. This is the most liberal interpretation of agreement which one could possibly adopt. Results of the comparison on this basis are shown in Table (9/3b) in which the arrangement of the different columns is exactly similar to that in Table (9/3a); col.(10) as before, gives the percentage of plots for which the records were not in agreement,

TABLE (9/3a). PROPORTION OF PLOTS IN EXACT AGREEMENT IN ANNA ESTIMATE

Name of Camp	Period of survey		Number of Plots			Total No. of plots compared	Percentage of plots for which both records are		
	first survey	second survey	Zero-Zero (no wheat in both surveys)	agreement in anna estimate	discrepancy in anna estimate		in agreement		not in agreement
							Zero-zero	with wheat	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
District : Shahabad									
Mohania	13/2—23/2	25/2—6/3	745	6	109	860	86·6	0·7	12·7
Shahpur	11/2—23/2	25/2—6/3	1389	6	213	1608	86·4	0·4	13·2
Sasaram	11/1—23/2	25/2—6/3	773	39	261	1073	72·0	3·6	24·4
Total	11/2—23/2	25/2—6/3	2907	51	583	3541	82·1	1·4	16·5
District : Monghyr									
Lakhisarai	12/2—24/2	25/2— 6/3	724	2	46	772	93·7	0·3	6·0
Gogri	26/2— 7/3	8/3—20/3	27	0	23	50	54·0	0·0	46·0
Jamui	12/2—24/2	25/2— 6/3	1573	4	278	1855	48·7	0·2	15·1
Total	12/2— 7/3	25/2—20/3	2324	6	347	2677	86·8	0·2	13·0
Two Districts	11/2— 7/3	25/2—20/3	52231	57	930	6218	84·1	0·9	15·0

TABLE (9/3b). PROPORTION OF PLOTS IN AGREEMENT AS TO OCCURRENCE OF WHEAT

Name of Camp	Period of survey		Number of plots			Total No. of plots compared	Percentage of plots for which both records are		
	first survey	second survey	Zero-zero (no wheat in both surveys	having wheat in			in agreement		not in agreement
				both surveys	only one survey		Zero-zero	With wheat	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	10)
District : Shahabad									
Mohania	13/2—23/2	25/2—6/3	745	42	73	860	86·0	4·9	8·5
Shahpur	11/2—23/2	25/2—6/3	1389	47	172	1608	84·4	2·9	10·7
Sasaram	11/2—23/2	25/2—6/3	773	215	85	1073	72·1	20·0	7·9
Total	11/2—23/2	25/2—6/3	2907	304	330	3541	82·1	8·6	9·3
District : Monghyr									
Lakhisarai	12/2—24/2	25/2— 6/3	724	12	36	772	93·7	1·6	4·7
Gogri	26/2— 7/3	8/3—20/3	27	11	12	50	54·0	22·0	24·0
Jamui	12/2— 7/3	25/2— 6/3	1573	40	242	1855	84·70	2·2	13·1
Total	12/2— 7/3	25/2—20/3	2324	63	290	2677	86·8	2·8	10·8
Two districts	11/2— 7/3	25/2— 6/3	5231	367	620	6218	84·1	5·9	10·0

which, in the present case, means the percentage of plots which were recorded as having wheat in one enumeration but not having wheat at all in the other enumeration. It will be noticed that the proportion of discrepancy defined even in this most liberal way was so high as 10 per cent.

248. Other definitions of agreement intermediate between the two used above are also possible. For example, plots for which the anna estimate of proportion under wheat agreed within 4-anna may be considered to be in agreement; or the proportion of plots the anna-estimates of which in the two enumerations agreed within 8-anna may be considered as being in agreement, and so on. Results of comparison on the basis of two such definitions, with latitudes of 4-anna and 8-anna respectively, are shown in summary form in Table (9/4). The arrangement in this table is broadly similar to that in table (9/3). Col. (1) now gives the latitude or margin of agreement. The percentage of plots for which records were discrepant (according to different definitions) are shown in col. (8) of table (9/4).

TABLE (9/4). SUMMARY OF COMPARISON OF DUPLICATE RECORDS OF PLOTS UNDER WHEAT

Latitude of comparison	Number of plots			Total No. of plots compared	Percentage of plots		
	in agreement		not in agreement		in agreement		not in agreement
	Zero-zero	with wheat			Zero-zero	with wheat	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1-anna	5231	57	930	6218	84·1	0·9	15·0
4-anna	5231	164	823	6218	84·1	2·6	13·3
8-anna	5231	239	748	6218	84·1	3·9	12·0
16-anna	5231	367	620	6218	84·1	5·9	10·0

249. For facility of comparison, results of the comparison with the most stringent definition (that is, agreement within 1-anna) and the most liberal definition (agreement only in the presence or absence of wheat, that is, with a latitude of 16-anna) are also shown in the same table (9/4). We notice that with the most stringent definition (requiring complete agreement in the anna-estimate) the over-all proportion of discrepant blots was 15 per cent. Allowing a latitude of 4-anna, this is reduced to 13·3 per cent; and allowing a latitude of 8-anna, to 12 per cent. Using the most liberal interpretation (namely, either presence or absence of wheat irrespective of the estimated proportion of land under the crop) the number of discrepant plots is 10 per cent which is still not negligible. We find then that whatever definition is adopted the results of two *ad hoc* complete plot-by-plot enumerations had differed in the case of wheat from 10 to 15 per cent of the total number of plots surveyed.

COMPARISON IN TERMS OF ACREAGE

250. So far the records of the two enumerations have been compared in terms of individual plots. A second procedure is also open, namely, a comparison of the total area under wheat (or under any other crop) in any given area as recorded in the two enumerations. Results on this acreage basis of comparison are shown in table (9/5) in which col. (1) gives the name of the police stations, and col. (2) the Jurisdiction List serial number of the village. Col. (3) gives the area in acres under wheat as recorded by the first worker (symbolically represented by W_1); i and col. (4) the corresponding area entered under wheat in the same village as recorded by the second investigator (W_2). Thus we find from the first line of the table that in police station Sasaram, J. L. No. 121, the area under wheat was recorded as 3.90 acres by the first worker, but the second worker did not find any wheat at all in this particular *mauza*. In the same way, in the second police station in J. L. No. 122/1 the area under wheat was recorded as 2·91 acres by the first and 8·64 acres by the second worker respectively.

251. The actual magnitude of the discrepancy is shown in the next two columns (5) and (6) of Table (9/5). Any area which is recorded to have wheat in the first enumeration but not in the second may be called a positive discrepancy. On the other hand, any area recorded as having no wheat in the first enumeration but as having wheat in the second enumeration may be called a negative discrepancy. The total number of acres with positive and negative discrepancies (defined in the way explained above) are shown in cols. (5). and (6) respectively of Table (9/5). For example, in Sasaram J. L. No. 121 the positive discrepancy is 3·90 acres. In the same way in Sasaram J. L. No. 122/1 the positive discrepancy is 0.87 acre which means that this amount of land was recorded as being under wheat in the first enumeration but not having any wheat in the second enumeration. The negative discrepancy in the same case was 6·60 acres which was the area recorded as being under wheat in the second enumeration but was recorded as having no wheat in the first enumeration.

252. The next two cols. (7) and (8) of Table (9/5) give the sum of dsicrepancies in two different ways. If we add positive and negative discrepancies retaining their algebraic signs we get the algebraic sum shown in col. (7). In this procedure we allow the positive

TABLE (9/5). COMPARISON OF CROP RECORDS IN TERMS OF ACREAGE : WHEAT

Name of Police Station	J. L. No	Area in acres estimated by		Actual discrepencies (difference between two records)		Sum of discrepancies		Discrepancies as percentage of estimate by first worker	
		first worker (w_1)	second worker (w_2)	positive	negative	algebraic (counting sign of difference	accumulated (neglecting sign of difference)	algebraic	accumulated
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mohania	134	18·10	10·22	9·96	2·08	7·88	12·04	43·54	66·52
	535/1	55·20	61·94	8·17	14·91	−6·74	23·08	−12·21	41·81
	535/2	22·17	18·64	9·22	5·69	3·53	14·91	15·92	67·25
	537	1·78	1·09	0·79	0·10	0·89	0·89	38·76	50·00
Total		97·25	91·89	28·14	22·78	5·36	50·92	5·51	52·36
Shahpur	146	—	7·26	—	7·28	− 7·28	7·28	−100·00	100·00
	147/2	7·86	4·50	4·97	1·61	3·36	6·58	44·55	86·36
Total		7·86	11·78	4·97	8·89	− 3·92	13·86	−50·00	180·91
Sasaram	121	3·90	—	3·90	—	3·90	3·90	100·00	100·00
	122/1	2·91	8·64	0·87	6·60	− 5·73	7·47	−196·91	256·70
	123	2·78	—	2·78	—	2·78	2·78	100·00	100·00
	125	17·98	16·22	3·83	2·07	1·76	5·90	9·79	32·81
	139	21·68	11·31	11·27	0·90	10·37	12·17	47·83	36·13
	140	9·26	13·64	1·65	6·03	− 4·38	7·68	−47·30	82·94
	141/1	74·22	94·17	12·30	32·25	−19·95	44·55	−26·88	60·02
Total		132·73	143·98	36·60	47·85	−11·25	84·45	− 8·48	63·63
Lakhisarai	125/1	6·39	6·59	4·60	4·80	− 0·20	9·40	−3·13	147·10
Gogri	325/1	13·79	11·66	6·51	4·38	2·13	10·89	15·45	78·97
Jamui	10/1	4·75	7·53	1·87	4·65	− 2·78	6·52	−58·53	137·26
	10/2	16·84	6·32	12·07	1·55	10·52	13·62	62·47	80·80
	20	5·43	3·86	4·86	3·29	1·57	8·15	28·91	150·09
	22/2	0·83	14·60	0·83	14·60	−13·77	15·43	−1651·07	1859·03
Total		27·85	32·31	19·63	24·09	− 4·46	43·72	− 16·01	150·99
All Police Stations		285·87	298·21	100·45	112·79	12·34	213·24	4·32	74·59

and negative errors to cancel out as far as possible. In Sasaram J. L. No. 122/1 we had a negative discrepancy of −6.60 acres, adding the positive discrepancy of 0·87 acre we get an algebraic sum of −5·73 acres which is the net discrepancy in the final result. A second procedure is to add the positive and negative discrepancies ignoring their signs. In Sasaram J. L. No. 122/1 we then get 6·60+0·87=7·47 acres shown in col. (8).

253. For convenience of comparison these two discrepancies are converted into percentages of the area under wheat as recorded in the first enumeration as given in col. (3) of Table (9/5). The percentage algebraic discrepancy is shown in col. (9); and percentage absolute or accumulated discrepancy in col. (10). The algebraic percentage discrepancy is naturally smaller because the positive and negative errors are allowed to cancel out in this case. But, for individual *mauzas* even this algebraic discrepancy can be quite high. For police stations, some of the positive and negative errors for *mauza* as a whole again have the

chance of cancelling out and the percentage algebraic discrepancy naturally becomes still smaller. But here also we find in Sasaram algebraic discrepancy of -8·48 per cent or in Jamui -16·01 per cent and so on. For the total material further compensations between positive and negative discrepancies would occur, but even then a residual discrepancy of + 4·32 per cent had still remained.

254. The absolute percentage discrepancy, on the other hand, is based on the accumulated total positive and negative errors which are not permitted to cancel out. In one sense, this is a better measure of the real magnitude of discrepancies in the two enumerations. For the whole material relating to wheat we notice that it was so high as 74·59 per cent.

255. Similar results of the comparison of the area under gram are given in Table (9/6) in which the arrangement of the columns is exactly the same as that in Table (9/5).

TABLE (9/6). COMPARISON OF CROP RECORDS IN TERMS OF ACREAGE: GRAM

Name of Police Station	J. L. No	Area in acres estimated by		Actual discrepancies (difference between two records)		Sum of discrepancies		Discrepancies as per centage of estimate by first worker	
		first worker (w_1)	second worker (w_2)	positive	negative	algebraic (counting sign of difference)	accumulated (neglecting sign of difference)	algebraic	accumulated
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mohania	134	113·98	120·58	10·95	17·55	−6·60	28·50	−5·99	25·00
	535/1	146·41	130·67	22·22	6·48	15·74	28·70	10·75	19·60
	535/2	140·19	121·54	24·73	6·08	18·65	30·81	13·30	21·98
	537	19·20	18·65	2·32	1·77	0·55	4·09	2·86	21·30
Total		419·78	391·44	60·22	31·88	28·34	92·10	6·75	21·94
Shahpur	146	29·16	24·02	9·14	4·00	5·14	13·14	17·63	45·06
	147/2	49·80	53·20	12·75	16·15	−3·40	28·90	− 6·83	58·03
Total		78·96	77·22	21·89	20·15	1·74	42·04	2·20	53·24
Sasaram	121	113·63	13·02	102·27	1·66	100·61	103·93	88·54	91·46
	122/1	1·93	57·59	0·62	56·28	−55·66	56·90	−2883·94	2948·19
	123	1·06	0·73	0·40	0·07	0·33	0·47	31·13	44·34
	125	0·23	—	0·23	—	0·23	0·23	100·00	100·00
	139	11·71	13·11	3·04	4·44	− 1·40	7·48	11·96	63·88
	140	5·02	3·96	1·89	0·81	1·06	2·72	21·12	54·18
	141/1	45·40	28·32	25·68	8·60	17·08	34·28	37·62	75·51
Total		178·98	116·73	134·13	71·83	62·25	206·01	34·78	115·10
Lakhisarai	125/1	9·97	9·63	6·76	6·42	0·34	13·18	3·41	132·20
Gogri	325/1	1·33	3·09	0·36	2·12	−1·76	2·48	−132·33	186·47
Jamui	10/1	8·99	12·42	3·05	6·48	− 3·43	9·53	−38·15	106·01
	10/2	12·46	14·02	2·96	4·52	− 1·56	7·48	−12·52	60·03
	20	14·91	2·26	14·03	1·38	12·65	15·41	84·84	103·35
	22/2	4·90	9·34	0·33	4·77	−4·44	5·10	−90·61	104·08
Total		41·26	38·04	20·37	17·15	3·22	37·52	7·80	90·94
All Police Stations		730·28	636·15	243·73	149·60	94·13	393·33	12·89	53·86

Here we find that the over-all algebraic percentage discrepancy was 12·89 per cent and the absolute or accumulated discrepancy 53·86 per cent.

256. For convenience of reference the results for each police station are given in a more condensed from in Table (9/7). From col. (8) of this table we notice that the algebraic percentage discrepancy varied from -50·0 per cent in police station Shahpur to −3·1 per cent cent in police station Lakhiserai with an over-all net discrepancy of+4·3 per cent for wheat. The net discrepancy varied from -132·3 per cent in Gogri to + 2·2 per cent in Shahpur with

TABLE (9/7). SUMMARY OF COMPARISONS OF DUPLICATE CROP RECORDS IN TERMS OF ACREAGE : WHEAT

Name of Police Station	Number of		Estimated area under crops in acres		Sum of discrepancies in crop acreage		Percentage discrepancy in crop acreage	
	villages	plots	first survey	second survey	algebraic (counting sign of difference)	accumulated (neglecting sign of difference)	algebraic (counting sign of difference)	accumulated (neglecting sign of difference)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Area under wheat in acres								
Mohania	4	860	97·2	91·9	+ 5·4	50·9	+ 5·5	52·4
Shahpur	2	1608	7·9	11·8	− 3·9	13·9	−50·0	180·9
Sasaram	7	1073	132·7	144·0	−11·2	84·4	− 8·5	63·6
Lakhisarai	1	772	6·4	6·6	− 0·2	9·4	− 3·1	147·1
Gogri	1	50	13·8	11·6	+ 2·1	10·9	+15·4	79·0
Jamui	4	1855	27·9	32·3	− 4·5	43·7	−16·0	157·0
Total	19	6218	285·9	298·2	+12·3	213·2	+ 4·3	74·6
Area under gram in acres								
Mohania	4	860	419·8	391·5	+28·3	92·1	+ 6·8	21·9
Shahpur	2	1608	79·0	77·2	+ 1·7	42·0	+ 2·2	53·2
Sasaram	7	1073	179·0	116·7	+62·3	206·0	+34·8	115·1
Lakhisarai	1	772	90·0	9·6	+ 6·4	13·2	+ 3·4	132·2
Gogri	1	50	1·3	3·1	− 1·8	2·5	−132·3	186·5
Jamui	4	1855	41·2	38·0	+ 3·2	37·5	+ 7·8	90·0
Total	19	6218	730·3	636·1	+94·1	393·3	+12·9	53·9

an over-all value of + 12·9 per cent for gram. The accumulated discrepancies (neglecting their signs) were much higher, and varied from 52·4 per cent in police station Mahania to 180·9 per cent in Shahpur with an over-all value of 74·6 per cent for wheat. The values varied from 21·9 per cent in Mohania to 186·5 per cent in Gogri with an over-all discrepancy of 53·9 per cent for gram.

PART 3. GENERAL REVIEW AND SUMMARY

SECTION 10. GENERAL REVIEW OF METHODS FOR THE IMPROVEMENT OF CROP STATISTICS

257. Agricultural statistics in India especially in the permanently settled provinces like Bengal and Bihar have been known for a long time to be thoroughly unreliable. MacDonnel had complained in 1876 of 'a great want to an administrator in Bengal (which at that time included Bihar), the want of agricultural statistics'. (*Report on the Food-grain Supply of Bengal and Bihar, introduction, p.iii*). Since then nearly half a century has passed and the subject has been reviewed over and over again. The Royal Commission on Agriculture (1928) under the chairmanship of Lord Linlithgow was of opinion that existing agricultural statistics "are admittedly often mere guesses and not infrequently demonstrably absurd guesses" (*Report, p* 605). Dr. A. L. Bowley and Mr. D. H. Robertson were of opinion that "the annual statistics of area are almost worthless" (*Report on a Scheme for the Economic Census of India*, 1934, pp.35–39). The Bengal Paddy Enquiry Committee (1938) fully endorsed these views (*Report, Vol.* 1. *p.* 88). The Bengal Land Revenue Commission (1940) observed that "no dependable statistics existed in Bengal....to show the yield of the various crops' (*Report, Vol.* 1, p.76).

258. Although the need of improvement of crop statistics has been always fully recognized, no definite action, except the five-year sample survey scheme in Bengal initiated in 1937 for the improvement of Jute forecasts and later extended to the paddy crop, had been taken for a long time. The acute food crisis in Bengal in 1943 and general food shortage in North-East India under war conditions, however , brought things to a head ; and large schemes have been and are being sanctioned by Provincial Governments as well as the Government of India for the improvement of crop statistics. It would be useful, therefore, to give a general review of the subject with special reference to permanently settled provinces like Bengal and Bihar in the light of the experience gained in the course of the work on the jute and paddy crops in Bengal from 1937 to 1943 and the pilot survey of *rabi* crops in Bihar in 1943–44.

259. *Subjective and objective methods.* Methods of preparing crop statistics may be broadly classified into two groups, namely, (a) subjective, or (b) objective. Official forecasts in Bengal and Bihar have been so far and are still based on the subjective method. Local officers supply estimates of crop acreage and what is called the 'condition factor' for outturn from a general subjective appreciation of prevailing conditions ; and the total produce is calculated by the formula, area × standard yield × condition factor. In the 'Report on the Marketing of Wheat in India' (Government of India , 1937) it is explained (pp.8–9) :

> 'In the temporarily settled areas where the basis of assessment for land revenue is revised periodically, e.g., the Punjab, the United Provinces etc., the first factor, namely , area, is known with reasonable accuracy. The second factor, namely, standard yield, is not known with the same degree of accuracy since it is frequently based on old and doubtful data. The effect of seasonal condition is the most difficult to gauge as under the present system reliance is placed on the opinions of the local *patwaries* and village *chaukidar* or *thanadar*.
>
> 'The estimate of standard yield is understood to represent the average outturn on average soil in a year of average character as deduced from the information obtained from experiments made up to the period under review. Revisions are made from time to time in the standard figures.....
>
> 'There is no revenue staff in the districts of premanently settled provinces in Bengal and Bihar and the difficulties of estimating the correct seasonal factor are much greater than in the temporarily settled areas.'

After reviewing existing methods the Report states (p.10) 'the general opinion seems to be that little reliance can be placed on estimates based on primary material collected as at present.'

260. Under existing conditions official forecasts based on the subjective or , as it is often called, the reporting, method have been usually under-estimates. This is due to a large extent to the natural desire of the cultivators to make crop estimates lean towards short supply, as under-estimates would help in keeping down assessment of revenue in the temporarily settled areas and also in maintaining higher prices generally everywhere.

261. *Objective methods.* In objective methods estimates of crop acreage would be based on actual physical examination of growing crops and eastimates of yield per acre on actual crop-cutting experiments. In this method the condition factor would be completely eliminated, and the annual production would be directly calculated each year by the formula: area × rate of yield per acre. Scientific opinion for a long time has been agreed that this objective (or survey method as it may be called) is to be preferred to the subjedctive or reporting method.

THE AREA SURVEY

262. *Complete enumeration and sample survey.* So far as the area survey is concerned two different procedures are open, namely, (a) a complete enumeration or (b) a sample survey. In the complete enumeration a complete inventory is prepared by actual physical examination of each individual plot showing the proportion of land under each crop in each plot. In the sample survey similar records are prepared not for all plots but only for a comparatively small number of sample-units located at random over the area under survey. Each method has its advantages and disadvantages. It is not possible to give a categoric verdict in favour of one or the other. In fact, a combination of the two methods, where this can be arranged, may offer the best line of advance.

263. *Comparative merits in the abstract.* The three basic factors which have to be considered in this connexion are (1) the nature of the information, (2) precision of the results, and (3) cost of the operations in two methods. Auxiliary administrative consideration may also be important. It will be useful to start with a brief statement of comparative merits of the two methods in an abstract form.

264. *Nature of information.* The complete enumeration (if it can be carried out without mistakes) would give not only the total area under any particular crop in the province as a whole but would also supply fullest possible information regarding crop acreages separately for districts, sub-divisions, police stations, individual villages, or even individual plots. In wealth of detailed information the complete enumeration thus represents the highest goal of statistics. The sample survey on the other hand can only supply over-all estimates for comparatively large areas like the province as a whole, or individual districts, or even possibly sub-divisions, but not for *thanas* or villages unless the cost is to be disproportionately high. In fact the more detailed the information required the higher will be the cost in the sample survey.

265. *Margin of error.* The total margin of error is made up of three different kinds of components, namely, (a) sampling errors due to fluctuations from sample to sample; (b) recording errors arising from mistakes in the preparation of crop records or at other stages of the work; and (c) margin of uncertainty or variation arising from physical factors. In the complete enumeration the first or (a) sampling errors cannot occur. If we ignore (b) recording or (c) physical errors, then the results of a complete enumeration are theoretically perfect. In the sample survey, on the other hand, the results can never be perfectly accurate. A certain margin of error is inherent in the sampling method because of the fact that the estimate is based not on the entire universe but only on a comparatively small fraction of it picked up at random.

266. *Cost of operations.* Against this, the cost of a sample survey and the labour required are comparatively small. For example, for Bengal, it has been found that a sample survey can give an estimate of the total area under a crop like jute for the province as a whole with a sampling error of something like 3 per cent at a cost of about one tenth or one-fifteenth of that of a complete enumeration. In the abstract, the choice between complete enumeration and sample survey thus depends purely on what information is desired to be collected and what price one is prepared to pay for the same.

EFFECTIVE ACCURACY

267. *Recording errors.* It is however not possible to ignore the recording errors. Mistakes always occur at the stage of recording the anna-estimate of the crop (and also at other stages of the work) in both sample survey and complete enumeration. These arise from chance errors of observation, and also from what is often far more serious, gross negligence or dishonesty on the part of the investigators. Experience in Bengal has shown that such recording mistakes are in practice more important than sampling errors.

268. During the last 7 years we arranged for certain compact areas being surveyed in detail independently by two (or some times three or more) sets of investigators. In this

way a large mass of crop records were prepared in duplicate independently by different sets of workers. A comparison of such duplicate crop records invariably showed large discrepancies between crop entries made by different investigators for the same identical plots. Such material for Bengal has been discussed in various reports submitted to the Indian Central Jute Committee and the Government of Bengal, and also in a memoir on Large Scale Sample Surveys in the *Phylosophical Transactions* of the Royal Society, Vol. 231, No. 584,1944. The proportion of plots for which the records were discrepant was often so high as 20 to 30 per cent.

269. In Bihar, in the *rabi* season of 1944, with investigators receiving Rs. 40/- per month (plus cost of living and travelling allowances on usual scales) and working under close supervision, we found in Section (9) that the proportion of plots for which records in two successive enumerations were discrepant varied from 10 per cent to 15 per cent of the total number of plots surveyed depending upon the stringency of comparison. In terms of acreage we found that, even when positive and negative errors are allowed to cancel out, the over-all residual error was quite appreciable. The absolute or accumulated discrepancy (when the positive and negative errors are not allowed to cancel) was surprisingly high and over 54 per cent for gram and nearly 75 per cent for wheat as shown in Table (9/5). We thus find that the results of a complete enumeration as carried out under existing conditions in either Bengal or Bihar are not entirely free from errors but are subject to appreciable recording mistakes arising from either accidental errors or gross carelessness and shirking of work on the part of the field staff.

270. *Margin of error.* Once it is admitted that the results of a complete enumeration are not free from mistakes, the margin of error of the results requires consideration. In this matter the method of complete enumeration suffers from a great disadvantage. Once any mistake has been made in a complete enumeration there is no possibility (short of a repetition of the enumeration) to detect it. It is therefore not possible (short of a second enumeration) to make any valid estimate of the margin of error of a complete enumeration.

271. *Scientific control in the sample survey.* The sample survey stands on an entirely different footing. Fluctuations in the results must occur in the sample survey owing to the fact that a fraction and not all the units are included in the survey. But these very fluctuations make it possible (by methods based on the theory of probability) to calculate a valid estimate of the margin of error of the final result. This is a distinct advance in scientific method. The sample survey can thus supply not only an estimate of the acreage under a given crop but also the margin of error of the estimate. The prime necessity for this purpose is, of course, that all sample-units which are actually surveyed should be picked up purely at random. Additional controls such as the interpenetrating sub-samples or duplicated enumeration of grids can also be easily provided as explained in previous sections. It is, of course, not possible to guarantee that a sample survey would give accurate results; this must ultimately depend on the reliability of the field records. But controls can be provided in such a way that if a sample goes wrong then this can be detected.

272. *Physical error.* It would be useful at this stage to consider what I have called the margin of uncertainty due to physical causes. The area sown, for example, is not a mathematical quantity which is fixed throughout the season; crops continue to be sown on new fields till quite late in the season; plants die for lack of rain or are destroyed by pests or animals. The total area under any crop thus varies from day to day or even from hour to hour throughout the crop season. The area harvested also has its physical margin of error depending on the limit of accuracy with which the area of a field can be determined. For example, there is a good deal of uncertainty in the area of *ails* (field ridges serving as boundaries between fields). Sir John Hubback in his bulletin on "Sampling for Rice Yield in Bihar and Orissa" (pp. 9-10) discussing the harvested area writes. :

> "It.....excludes the field ridges (*ails*), which are usually measured in with the fields at a cadastral survey. Since the cadastral survey figure is the basis for the cropped area of the year, this.....point is of importance. No very satisfactory determination of the area occupied by ridges has yet been made, but it would appear to vary beetween nearly 10 per cent in a hilly country to scarcely more than 2 per cent in level country. It is usually taken as 5 per cent."

273. The weight of harvested crop itself is subject to fluctuations due to physical causes. For example, the weight of wheat depends on the humidity of the atmosphere; according to the "Report on Marketing of Wheat in India" (p. 215) the natural shrinkage may be about "1 per cent between the time the wheat is harvested and the onset of the monsoon"; the gain in weight during the monsoon may be 1% or 2%, or in particularly humid regions even "as much as 5% by the end of September" Whatever be the accuracy of the

results of crop-cutting experiments a good many factors of variation come in at the stage of harvesting, threshing, and winnowing under actual conditions of work in the cultivators' own fields or homes. In considering utilization of the crop other uncertainties are brought in, such as loss during cartage and storage (due to vermins, insects, fungus etc.), wastage in processing and cooking or even as food.

274. In fact, not only crop acreage or crop outturn but every physical quantity has its own margin of uncertainty. For example, the weight of say a grown up man is not something absolutely fixed ; it changes when he takes food or a drink of water, or even when he inhales or exhales air. It is clearly meaningless to try to give the weight of an adult human being correct to say a few grains. In the same way, there must be a certain limit beyond which it is physically meaningless to go in estimating the acreage, the rate of yield per acre, or the total outturn of a crop. In the case of wheat or paddy, the uncertainty due to purely physical factors can be scarcely less than 2 or 3 per cent. To try to reduce the margin of error due to sampling fluctuations below this physical limit is, therefore, meaningless.

THE PATWARI SYSTEM

275. *Temporarily settled provinces.* The lack of accuracy in primary field work discussed above has however reference only to work under existing conditions in Bengal and Bihar. I have no information regarding the accuracy attained in practice in the acreage estimates made by *patwaries* in the temporarily settled provinces like Madras, Punjab, United Provinces etc. It is generally believed that crop estimates prepared by *patwaries* are fairly reliable, and it is quite conceivable that this is so. It must be remembered that the *patwari* is an important link between the village and the Government machinery for collecting land revenue ; he is indeed a man of importance in the village and enjoys great social prestige. I understand that in practice the office is often hereditary. He has intimate knowledge of both cultivators and cultivation conditions. Estimates prepared by the village *patwaries* are therefore much more likely to be reliable than estimates made by *ad hoc* investigators employed from season to season.

276. There is also a second factor of importance. The cultivator is interested in keeping down estimates of production to as low a level as possible for a variety of reasons. In temporarily settled areas there is the question of periodic revision of rent ; a short crop is more likely to keep up prices ; there is the natural tendency to be conservative in estimating chances of gain, of not tempting providence ; and so on. The Government of the province, on the other hand, is interested in collecting as much revenue as possible ; and the *patwari*, as the representative of Government, is interested in increasing his crop estimates to as high a level as possible. It is the balancing of these two forces in opposing directions that make the *patwari* keep to some kind of middle truth.

277. *Permanently settled provinces.* In permanently settled provinces like Bengal and Bihar the *patwari* system does not however exist. To appoint a large number of *ad hoc* investigators, and to give them the name of *patwaries* would not and cannot immediately create a *patwari* system as it exists in the temporarily settled provinces. The *ad hoc* investigator would not have, at least in the beginning, the social prestige of the real *patwari*. He would not have and cannot immediately acquire the same intimate knowledge of village conditions. Finally, the *ad hoc* investigator would not have any connexion with the collection of revenue so that the inter-play of opposing forces noted above would be lacking in the permanently settled provinces.

278. In this situation it cannot be expected that an *ad hoc* staff of investigators would be capable of supplying crop estimates with as much reliability as real *patwaries*. This does not mean that in the course of time a real *patwari* system cannot be built up in either Bengal and Bihar. Four conditions are however essential for success. First of all, workers (whatever they may be called) must be given practically permanent appointments as otherwise Government would not have any hold on them ; and the quality of work would be doubtful. Secondly, they must be given an adequate salary ; it is well known that men on poor pay like village chowkidars can not be relied upon to collect accurate information. Thirdly, the number of *patwaries* must be sufficiently large to be able to do the work in an adequate manner. Finally, they should be associated with responsible Government work other than the preparation of crop estimates. Linking with the revenue system would of course be the desirable thing ; but, as long as the Permanent Settlement is in existence, this may not be possible. Other suitable work of sufficient importance and prestige should therefore be allotted to make the *patwari* an important link between the village and the Government of the province.

279. Given these four conditions it should be, of course, possible to build up, in the course of time, a really dependable *patwari* system in Bihar and Bengal. From the statistical point of view this would be certainly desirable. This would also have obvious advantages from an administrative point of view. It would be therefore sound policy to organize a *patwari* system in Bengal and Bihar. Two points, however, require to be emphasized, namely, the need of fulfilling the four conditions mentioned above ; and secondly, the fact that a real *patwari* system would take an appreciable amount of time to build up. It is, therefore, necessary and desirable in the transitional stage to use the sample survey for obtaining reliable crop statistics. The best line of advance thus lies in the combination of the *patwari* system and the sample survey. Before discussing the advantages of this combined system it will be convenient to describe the essential features of an actual scheme for complete enumeration.

THE BENGAL SCHEME FOR COMPLETE ENUMERATION

280. The Government of Bengal have recently sanctioned a scheme for complete enumeration of acreage under different crops in which work is expected to begin in the *aman* (winter) paddy season of 1944-45. The whole of the province of Bengal is to be covered in the scheme ; the total area to be surveyed (exclusive of reserve forests) would be thus about five crores of acres comprising about nine and a half crores of plots in round numbers.

281. *Object of the scheme.* The object of the present scheme is to prepare a complete inventory of all crops grown on each individual plot. The investigators will go round the fields and after actual physical examination of growing crops note against each plot in appropriate columns in the *khasra* lists the anna-proportion (taking the area of the whole plot as 16-anna) of the plot under each crop ; entries will also be made of different kinds of fallow land. This primary field enumeration work will be repeated in each of the three principal agricultural seasons, namely, *bhadoi* (monsoon), *aghani* (winter) and *rabi* (spring).

282. *Primary investigators.* The province is divided for administrative purposes into 612 Police Stations and 5786 or say 6,000 Unions in round numbers. Since 1941 a large semi-permanent organisation is in existence in Bengal for the issuing of licenses for growing jute under the Bengal Jute Regulation Act. In this Jute Regulation Department (as it is called) there is one primary licensing assistant in each Union, and his part-time services will be utilized for the crop census work. This primary licensing assistant or recorder in each Union will be given the assistance of two literate and active villagers (or *patwaries* as they are being called) for inspecting the plots and noting in the *khasra* or field lists the name and extent of cultivation of each crop against each plot.

283. *Compilation.* The field *khasras* (or crop records) would be sent to compilation offices, one of which would be set up in each circle of six Unions on an average as in the Jute Regulation Department. In these compilation offices the anna proportion of the plot under each crop will be multiplied by the total area of the plot ; and the actual area (in acre) under each crop in each plot will be noted. Adding these figures for all plots in a *mauza* the area under each crop would be directly obtained for each *mauza* ; and totals for higher units such as *thanas*, sub-divisions, districts etc. would be gradually built up.

284. *Budget.* Each investigator (who is to be called a *patwari*) will be given a consolidated pay of Rs. 100/- per year. The Bengal Scheme states that "this will be a retainer and the *patwari* will live in his own home and be permitted to follow his own pursuits subject to the exigencies of the crop census work. In each Union an area of about 10 or 12 square miles will have to be traversed at least thrice in the year and each plot under crop will have to be inspected". As there are 6,000 Unions, and there will be two village investigators (or *patwaries*) in each Union each on Rs. 100/- per year, the total cost of the primary field staff would be $6,000 \times 2 \times$ Rs. 100 = Rs. 12,00,000 (twelve lakhs of rupees) per year.

285. For compilation work there will be 1,000 compilers getting between Rs. 50 and Rs. 60 per month ; the total cost would be about Rs. 6,30,000 per year inclusive of dearness allowance at 1944 rates. Rent of camp offices would cost Rs. 3,60,000 and contingency and other expenses about Rs. 2,00,000 so that the total cost of the scheme would come to Rs. 23,90,000 per year. This is exclusive of a preliminary non-recurring expenditure of Rs. 3,15,000 in the first year for the preparation of the plot lists. The above estimates of about twenty-four lakhs of rupees per year is also exclusive of the cost of the part-time services of the Jute Regulation staff which will function as the inspecting and supervising staff in the scheme.

286. *Effective time for enumeration.* Two or three points require notice in the above scheme. It is necessary to remember that sowings continue over a considerable span of time

in each season ; and that enumeration of areas in which sowings have not been completed would necessarily lead to under-estimation. The area survey work cannot therefore start in any region until sowings have been practically completed. It is also clear that area enumeration would again become unreliable after harvesting has started. The effective time for area survey work thus lies between the completion of sowings on one hand and the beginning of harvesting on the other. The net time available for area enumeration would not therefore be 12 months but appreciably less, possibly about 7 or 8 months in the year in each region. Even a wholetime worker would thus be able to do area survey work for only from 210 to 240 days in the year.

287. Now in both Bengal and Bihar our experience has been that it takes on an average about 10 investigator-days of work for the complete enumeration of plots in one square mile. On this basis, each Union with an area of about 10 or 12 square miles would require about 100 or 120 investigator-days of work in each season, or from 300 to 360 investigator-days of work for three seasons per year. One investigator per Union is thus not sufficient for complete enumeration work. It is worth noting that in the original form of the Bengal Scheme the proposal was to employ only one local investigator in each Union ; but in the revised scheme, as already noted, two local investigators would be employed in each Union so that, so far as the number of investigators is concerned, the staff would not be inadequate.

288. *Pay of investigators.* The real weakness to my mind lies in their pay and status. Although the annual salary of Rs. 100 is called a 'retainer' in the Bengal scheme, and it is stated that the *patwari* would be "permitted to follow his own pursuits subject to the exigencies of the crop census work", in practice he would have little time left to do other work. The real question then is whether a pay of Rs. 100 per year would attract the kind of person who can be relied upon to do the crop census work with the requisite accuracy. For reasons already explained this appears to be doubtful.

289. *Part-time inspecting arrangements.* Adequate inspection and supervision of the primary field work is indispensable for success. In the Bengal scheme this is intended to be done by the part-time services of the Jute Regulation staff. This may be feasible in the off-season when they are not busy with jute licensing work ; but it would be difficult to manage this work during the licensing season and at the time of the checking of the licensed area, which means roughly during 6 or 7 months in the year. The plan to get the inspecting work in the complete enumeration scheme done by the part-time help of the Jute Regulation staff may, therefore, turn out to be another weak point in the scheme.

290. *Independent cost.* If a separate inspecting staff has to be provided the cost would come to roughly fifty per cent of the cost of the primary field staff or say about six lakhs of rupees. The total cost of a scheme like the one sanctioned in Bengal with an independent inspecting staff of its own would be thus something like thirty lakhs of rupees per year. If the village investigators (or *patwaries*) have to be paid not Rs.100 per year but a higher salary then the cost would be much greater. For example, if they are given Rs. 25 per month or Rs. 300 per year the additional cost would be 24 lakhs of rupees, or including inspecting cost at a proportionately higher rate say 30 lakhs of rupees. At 1944 level of wages and prices the independent cost of a scheme of complete enumeration like the Bengal one may thus easily come to about sixty lakhs of rupees per year. In any case, if work is done as in the Bengal scheme the cost would be about twentyfour lakhs of rupees per year. To have anything cheaper may mean that the information gathered would be unreliable and not worth collecting.

OUTTURN OF CROP

291. We have been considering so far the problem of the area survey, i.e. of estimating the crop acreage. There is also the problem of estimating the outturn per acre (and hence, by multiplying with the area, the total production) of the crop. Under certain conditions the determination of the yield per acre of a given crop is much easier than estimating the crop acreage ; it is also much less expensive.

HUBBACK'S EXPERIMENTS IN BIHAR : 1923-1925

292. The subject of crop-cutting experiments has received a good deal of attention in recent years. The basic principles were, however, established nearly 20 years ago in India by a series of experiments (which truly deserves to be called classical) carried out in Bihar by Sir John Hubback between 1923 and 1925. He gave an account of his work in a bulletin on 'Sampling for Rice Yield in Bihar and Orrissa' published by the Government of India in 1927. By direct experimental studies on an extensive scale he showed that by an expendi

ture of a sum of money, that was not excessive in view of the importance of the matter, it was possible to replace the normal yield and the condition factor (used in the ordinary method of calculating total outturn) by a scientific estimate in which the possibility of error could be gauged.(p.2).

293. *Need of random samples.* First, as to the need of randomization, he described the existing method and commented on it in the following way (pp.3–4) :–

> 'An officer of some standing visits the tract, of whose yield he is required to form an estimate, and selects a fairly large area, usually 1–10th of an acre, as containing an average crop. This he cuts and carries and in due course threshes and weighs. If he has time he makes two or more experiments, but it is obvious that he cannot usually manage to make a large number of such experiments. There are two main objections to this method : the first is that it depends entirely for its accuracy on the ability of the officer to select. He has to make his selection from a large number of fields growing different varieties at different points of maturity. It is very easy to be misled as to yield by the strength of straw, heavy straw being by no means always correlated with heavy yield of grain. Again it is difficult to give proper weight to the fields which will give little or no yield at all, and even in a normal year such fields are by no means rare. These factors make accurate selection very difficult. The second objection is even more important, viz., that there is no possible way of estimating what is the probability that the result of such selections is within a given range from the true mean yield. The method is comparable to estimating the average income of the population of a town by watching the streets for a few days and then picking out a man, who looked to be in average circumstances and discovering what his income is.'
>
> 'The only way in which a satisfactory estimate can be formed is by as close an approximation to random sampling as the circumstance permits, since that not only gets rid of the personal element of the experimenter, but also makes it possible to say what is the probability that the result of a given number of samples will be within a given range from the true mean. To put this in definite language, it should be possible to find out how many samples will be required to secure that the odds are at least 20 to 1 on the mean of the samples being within one maund of the true mean.'

294. The above statement still remains a masterly discussion of the subject. I have already referred to Yates's paper which fully confirmed Hubback's conclusions. Scientific opinion now is united in insisting upon the need of using random samples. The credit for recognising and emphasizing this principle in India 20 years ago must go to Hubback.

295. *Zoning.* In Hubback's method the work was organized on the basis of subdivisions averaging nearly 1000 square miles in extent. In each such tract 12 centres were to be fixed, spread as evenly as possible over the whole tract (p.8). In each centre the sampler would go out a fixed distance in one direction and circling round return from another direction so as to cover approximately the same area on each day. Crop-cutting work was to be done at each centre for 12 days, the actual dates of harvesting at different centres being spread over the whole period of harvest (p.8). As Hubback points out 'the aim was to distribute the sampling as regularly as possible both in *time* throughout the period of harvest and in *space* over the area sampled' (p.6). At least 20 sample-cuts (which were of quite small size) were expected to be collected per day on an average ; with 12 centres Hubback expected to get 'at least 240 cuttings, but probably as many as 300' in each tract of about 1000 sq. miles. It would be noticed that without making any explicit mention of the fact Hubback had in fact used the principle of zoning in a most effective manner.

296. *Small size of cuts.* As already mentioned in Section 6, Hubback had clearly realized the comparative efficiency of cuts of small size. He had explicitly stated :

> 'It is no advantage to take a large number of samples from places very close together, where the crops will naturally be very much the same on the same day. The degree of accuracy is not seriously improved by such practice. This explains why there is no need to take large samples instead of the handy samples obtained by my method. A sample of one-tenth of an acre is merely 320 of my samples taken in juxtaposition. It simply gives a determination of the mean yield of that particular field, which is not more effectively accurate than that given by say four small samples. Even four samples instead of one are not worth while, because in the great majority of cases they do not differ among themselves enough to affect the mean

> or the standard deviation of the whole set of samples. ....Technically speaking, there is very high correlation between the individuals of such groups of samples, which makes the ordinary rule, that standard deviation of the mean was the standard deviation of the population divided by the square root of the number of samples, quite inapplicable' (p.9).

This has been fully confirmed by the work of Yates and others already cited in Section 6, and also by our own work on the jute and paddy crops in Bengal. (It is worth noting that Hubback had also recognized the departure of the standard deviation of the mean from 'the inverse square root' rule long before other workers).

297. *Precision of results.* Hubback had given considerable attention to the precision of the results. He had carefully studied the frequency distribution of the sample-yields and found that the standard deviation varied from 4 maunds to 12 maunds per acre (with an average value of about 6 maunds per acre). Hubback pointed out that with 240 cuttings the mean yield of a tract (of about 1000 sq. miles) would be out by only one maund per acre in only one case out of twenty. As each district would consist of about 4 such tracts the above margin of error would be reduced from one maund to about half a maund per acre for individual districts; and with 16 districts, the margin of error of the mean yield for the province as a whole would be reduced to about one-eighth of a maund or five seers per acre.

298. It is easy to express the same results in the form of percentages. From Hubback's data I find that the coefficient of variation for different *thanas* varied mostly from 30% to 60% with an average value of about 43%. Accepting 43% as a representative figure, we find that the margin of error would be about 5% or 6% for the mean yield of tracts of 1000 sq. miles each; 2% or 3% for the mean yield of individual districts; and less than one per cent for the mean yield of the province as a whole.

299. It is of interest to recall here a fact already mentioned in Section 6, namely, that the coefficient of variability of mean yield was about 38% or 39% for wheat, and 46% and 67% for gram in the two districts. These compare quite favourably with 43% for paddy found by Hubback. As already mentioned, from 2500 to 3000 cuttings of the handy size used in the present survey (if these can be picked up at random in a suitable manner) would enable the provincial rate of yield with a standard error of about one per cent for wheat, and a little less than two per cent for gram. Hubback's recommendation of using cuts of a small size is thus fully justified by our work on wheat and gram in Bihar in 1943–44.

300. Hubback had emphasized the applicability of his method to small or large tracts. He explained that 'the same number of centres would give a slightly greater degree of accuracy for smaller and slightly less degree for a larger tract, because the standard deviation on the whole increases with the size of the tract, though not at all rapidly' (p.8). Here also he anticipated a good deal of recent findings in this matter. One interesting technical point is also worth noting. Hubback had perceived that his method of randomization did not exactly conform to the requirements of the theory of 'simple' sampling (p.12) or uni-stage random sampling; he appears in fact to have felt in a vague way the need of using what would be now called the theory of multi-stage sampling.

301. *A special difficulty in crop-cutting work.* There is one peculiar difficulty in crop-cutting work which requires consideration at this stage. The area survey can be done at any time between sowings and harvesting. As this interval lasts for at least several weeks, there is no difficulty in arranging an investigator to reach the village and plots (selected beforehand at random) while the crop is still standing on the field. In crop-cutting work the crop has however to be collected just when it is ready for being harvested; and this harvesting period is usually short and may last for only a few days in each locality. The actual time of harvesting also fluctuates quite widely from one place to another. The result is that, when villages and plots are selected beforehand at random, it often happens that an investigator reaches a particular village when the crop has been already harvested or is yet not ready for harvesting.

302. Hubback had clearly recognized this difficulty. He referred to some work done by Mr. Dobbs (then Director of Agriculture, Bihar and Orissa) in 1921 in Nawada *thana* in Gaya. Dobb's 'method was to divide up the map in equal squares, in order to pick out the villages in which samples were to be taken, and then to sample the fields bearing the survey number 50, or the nearest fields planted with rice'. Hubback pointed out, however, that 'for this method it was necessary to find out the date on which the crop in each field would be ready for harvest and to arange to visit the village on that date' (p.6) which of course presented great practical difficulties.

303. *Hubback's achievement.* I have dwelt at some length on Hubback's work because of its immediate relevance to the present problem, and also because of what he had achieved nearly 20 years ago at a time when the whole subject was in an undeveloped stage. He had carried out careful experiments extended over three crop seasons (1923–1925) and over the greater part of the province in the Orissa deltaic tract, Chota Nagpur plateau, Santal Parganas and Manbhum, the alluvial Gangetic plain and Gaya; and was of opinion that conclusions drawn from his figures could be 'applied with safety to the whole province except perhaps the North-Gangetic tract' (p.8).

304. He had thus succeeded in working out (with the help of extensive field experiments covering the greater part of a province) a complete method based on the principle of random sampling for estimating the mean yield of paddy with a margin of error of one per cent or less for the province as a whole. He himself had stated that 'the method could also be applied to other crops, especially cereals' (p.9).

TYPE OF FIELD STAFF : STATIONARY OR MOVING

305. *Stationary investigators.* It may be asked, therefore, why could not Hubback's method be directly adopted? This brings us to the crux of the problem, namely the human agency. Hubback had suggested using the 'existing revenue and agricultural staff', and was of opinion that with their help 'there would be no serious difficulty in substituting this (i.e. his) method for the unscientific method of sampling now prescribed' (p.11).

306. The subject may be considered in general terms. Let us assume that the part-time services of a large number, say 1000 persons (to be called 'samplers'), who are scattered more or less uniformly over the whole province, are available for the survey. A number of plots can then be picked up at random in advance and assigned to each 'sampler' in the immediate neighbourhood of his usual place of residence. Each sampler can then keep a watch on the crop growing on the plots allotted to him, and can collect the sample-cuts at the proper time when the crop is ready for being harvested. At full harvesting time there would be no difficulty in each sampler collecting 4 or 5 cuttings on an average in one day. If each sampler works for one day or two at a stretch (or a part of the day for a few days) there would be no difficulty in collecting from eight to ten thousand cuttings which would be quite sufficient for all practical purposes.

307. Three points require to be emphasized in this method. First of all, that each investigator or 'sampler' would do his work in the immediate neighbourhood of his normal place of residence so that he would not have to undertake any long journeys for collecting the samples. This may, therefore, be called the system of '*stationary investigators or samplers*'. Secondly, the crop could be collected just when it is ripe for harvesting so that there would be no wastage of samples or gaps. Thirdly, each sampler would do the work along with his regular occupation, and in fact would put in only one or two days of work so that the cost of field work would be practically negligible, and in any case marginal. We thus find that, given the part-time help of a large number of stationary investigators (like the revenue or agricultural staff of a province), crop-cutting work can be carried out in accordance with the the principles of random sampling in a perfectly satisfactory manner at practically negligible cost. Hubback had established this on a firm experimental basis twenty years ago.

308. *Moving investigators.* But, unfortunately, the part time services of a large number of investigators are not always available. For example, in my letter dated 8th November, 1943 addressed to Mr. R. A. E. Williams, I. C. S. (at that time Secretary, Revenue Department, Bihar) I had specifically enquired whether the agricultural and or other Government staff could be made available (of course, on a part-time basis) for crop survey work in Bihar; but I was given to understand that this was not possible and that the work had to be done by investigators appointed under the scheme.

309. When a suitable human agency (like that of the *patwaries* in the temporarily settled provinces)is not, or cannot be made available for the sample survey then there is no other alternative but to get the work done by a comparatively small number of whole-time investigators appointed *ad hoc* for this purpose. As they have to be employed on a full-time basis for the whole season, the area survey has naturally to be spread over the whole season, that is, over say three months normally in each crop season. The primary staff required for this purpose is some thing like 250 or 300 investigators. The area commanded by each investigator would then have to be necessarily some thing like 200 or 250 square miles, or, if the double sub-sample plan is adopted, something like 400 or 500 square miles. The investigators cannot any longer be kept stationary but have to move about a great deal to cover

their respective allotted area in an adequate manner. This introduces one complication, namely, the waste of time in moving from one grid or sample-unit to another. The time taken for such journeys (called 'journey time') is by no means negligible, and is usually greater than the total time spent in actual enumeration work. This may be called the system of *moving investigators*. Considerations of cost of field operarions now become of paramount importance; and have been considered in earlier sections.

310. *Possibilities of air-surveys.* I have assumed so far that the primary sample enumeration would be done directly by investigators. It is possible, of course, to use the method of air-survey with the help of photographs taken from aeroplanes. In Bengal this possibility had been considered several years ago in connexion with the jute forecast and actual trial photographs were taken. The difficulty at that time was that the growing jute crop could not be distinguised from other crops. A little later, in 1938, having come to know that similar experiments were being made in U. S. A. I made enquiries but was informed that the difficulties had not been overcome. This subject was again considered by the Jute Census Committee at its third meeting held on the 26th October 1938 (p.5 of preceedings printed by the Indian Central Jute Committee in 1938). My own idea was in fact to try special color sensitizers for this purpose. A grant was actually sanctioned by the Indian Central Jute Committee for photographic experiments; but unfortunately, the beginning of hostilities made it impossible to carry out any work. My personal view has always been that the possibilities of air-survey (using specially sensitized films) deserve serious study, but I regret I have no definite knowledge to give any advice in this matter.

CHOICE OF DIFFERENT METHODS

311. *Choice of the sample survey.* The choice of the sample survey scheme with work done by patries of moving investigators (as in Bihar in 1943–44 or in Bengal since 1937–38) was thus not based on any categoric superiority of the method but because of certain contingent facts. First of all, the sample survey is much less expensive than a complete enumeration. It is capable of supplying, at a small fraction of the cost of complete enumeration, crop acreages for the province as a whole (and possibly districts) with a margin of error of about three per cent. The physical margin of uncertainty, as already pointed out, is also probably of this magnitude. There is, therefore, no point in trying to reduce the sampling error below this limit so that the sample survey is fully adequate so far as provincial (or district) estimates of crop acreages are considered.

312. Secondly, where a *patwari* system (or a similar agency) is not in existence as in Bengal and Bihar it is much easier and quicker to organize a sample survey. A full scheme for complete enumeration in a province like Bengal or Bihar would require an army of several thousand investigators scattered over the whole province. Recruiting and training such a large number of workers is not only difficult but is bound to take a good deal of time. Making adequate arrangements for inspection and supervision (which are essential for success) also present many difficulties. The sample survey, on the other hand, requires only from two to three hunderd primary investigators with an inspecting staff of from 60 to 80 persons for work on a full provincial scale. Problems of organization are therefore much simpler. There is much greater chance of securing say 300 reliable workers than several thousands. Another advantage of the sample survey already noted is the possibility of calculating a valid estimate of the margin of error of the results and of providing controls at the point of collection of the primary material. Finally, in a sample survey it is possible to have progressive estimates of the crop-acreage almost from the begining of the survey and right through the crop season; the final estimate can also be got ready within 10 or 12 days of the termination of the area survey. The administrators can, therefore, maintain practically continuous touch with developments all through. These are considerations in favour of the sample survey.

313. The sample survey, however, has its own limitations. It is unable to supply information for crop acreages for small units of area like *thanas*, villages etc. There are also definite disadvantages in carrying out crop-cutting work by a comparatively small number of moving 'samplers'. As already pointed out, crop-cutting work can be done much better by *patwaries* or some similar agency of 'stationary samplers'.

314. *Advantages of a patwari system.* Where a reliable *patwari* system is in existence it would be in fact possible to utilize its help not merely for crop-cutting work but also for a sample survey of crop acreage. In the area survey, as at present organized in Bengal or Bihar, the total number of investigator-days spent in each season is something like 25,000 in round numbers. As already pointed out, a good deal of this is consumed in moving from

one grid to another and other miscellaneous work. The net time required for actual physical examination of the grids and for preparing crop records is about 12,000 investigator-days. If stationary investigators were available then they would be able to finish the whole field work in these 12,000 investigator-days. With 2000 investigators the whole field work for a full scale sample survey can therefore be finished in about 6 or 7 days.

315. The same thing can be easily seen in a slightly different way. In the *bhadoi* season in Bihar about 60,000 grids (each of size 4-acre) were used for the area survey. With 2000 investigators each would have an allotted area or cell of about 30 or 35 square miles so that each investigator would be able to do the enumeration work within his own cell without leaving his usual place of residence. In these circumstances each investigator would be able to survey 5 or 6 grids per day ; 2000 *patwaries* (or stationary investigators of a similar type) would therefore be able to finish 60,000 grids in 6 or 7 days. With 4000 or 6000 *patwaries* the total time required would be proportionately less and only 2 or 3 or 4 days. Even these few days of work could be done either at a stretch or could be spread over a month or more to suit the exigencies of the more regular work of the *patwaries*.

316. A sample survey of crop acreage can be thus carried out very easily with only a few days of work in each crop season by *patwaries* or other workers of a similar type. Crop-cutting work can also be done by them in the same way. Even if only four or five cuts are taken by each sampler per day on an average then work for only a day or two by each of 2000 samplers would enable eight thousand or more sample-cuts being collected for the province as a whole which would be ample for all practical purposes.

317. If *patwaries* (or a large number of stationary investigators) happen to be available then a sample survey of both crop acreage and rate of outturn per acre can therefore be easily carried out with only a few days of work in each crop season. As the primary work would be done by permanent employees of Government its accuracy is likely to be much greater than that of work done by *ad hoc* investigators employed from season to season.

318. The total volume of work in the sample survey is only a fraction of that required for complete enumeration. For a province like Bihar or Bengal with an effective area of say 60,000 square miles to be surveyed (leaving out hilly and forest tracts), at the rate of 10 investigator-days per square mile, the time required for complete enumeration would be 6,00,000 (six lakhs) of investigator-days. For a provincial survey 60,000 grids of 4-acre each would be sufficient, and would require only about 12,000 investigator-days (for stationary investigators) ; that is, only about one-fifteenth of the time required for complete enumeration. Fairly reliable district figures could be given with say four times as many, or 240,000 grids. Even then the total time required would be only about one-twelfth of that of a complete enumeration. With a system of stationary investigators the cost of a sample survey would be thus extremely small, and in any case marginal and practically negligible. As already noted, the cost of crop-cutting work would be again only a small fraction, one-tenth or one-fifteenth of that of the area survey.

319. *Complete enumeration.* If more detailed information is required about the crop acreage of small units like *thanas* or villages then recourse must be had to the method of complete enumeration. Where *patwaries* are available, a complete inventory of crop acreage can be prepared by them as a part of their routine duties. Where *patwaries* are not available (as in Bengal or Bihar) a suitable system of stationary or local investigators must be organized for this purpose. This, as already pointed out, is partly a matter of expense and partly one of time. Provided enough money is sanctioned for this purpose it would be certainly possible and desirable to build up a *patwarie* system in Bengal or Bihar.

ADVANTAGES OF A COMBINED SYSTEM

320. *Superposed sample survey.* I have already noted that where possible a combined system would offer the best line of advance. In such a combined system, a sample survey of crop acreage as well as crop-cutting work on a restricted scale would be superposed on the work done by the *patwaries* or other local investigators. This would give two independent sets of estimates of crop acreage as also of rate of outturn per acre for the province as a whole or for individual districts ; and would supply a most valuable check on the reliability of the results. The superposed sample survey would in fact function in the combined system in a manner analogous to the financial audit in ordinary administration.

321. *Gap between 'area sown' and 'area harvested'.* The sample survey has another important use. The area harvested is not the same as the 'area sown or planted' since practically every year some of the fields bear no crop worth cutting. The harvested area must always be less than the area sown as some of the plants would die or be destroyed by pests

or vermin or animals. In provinces with good irrigation facilities there is naturally much less risk of the crop failing for lack of rain ; and the gap between 'harvested area' and 'area sown' may be quite small. On the other hand, in provinces in which irrigation facilities are meagre there is always a good deal of risk of the crop failing through lack of rain. As it happens, the permanently settled provinces like Bengal and Bihar are also provinces which are backward in irrigation. It is in these provinces that the gap between 'area harvested' and 'area sown' is therefore likely to be quite appreciable. In fact Sir John Hubback after discussing this subject stated that the difference between the planted (or sown) area and the harvested area of paddy might, in a bad year, "well be over 50 per cent all over a sub-division" in Bihar (p. 10 of his bulletin already cited).

322. It is, therefore, clearly necessary to estimate the gap between the 'area sown' and the 'area harvested'. This cannot, however, be done by the method of complete census as enumeration of crop acreage would continue throughout the season. In the sample survey, a quick area survey early in the season would give a good idea of the area sown. A second survey *carried along with crop-cutting work* would supply an objective estimate of the area harvested. This would enable an estimate being made of the gap between the two, and would hence enable suitable adjustments being made in the crop acreage obtained from complete enumeration. The need of estimating the gap between 'area sown' and 'area harvested' is thus by itself a sufficient reason for the continuance of the sample survey along with complete enumeration. A combined acreage and yield survey would also enable the total outturn being estimated directly instead of by multiplying the total acreage by the average rate of yield per acre. This has important theoretical advantages.

323. *Frame-work for sample survey.* In the combined system, when the *patwaries* or local investigators have once become well organized, the sample survey would have chiefly a supplementary function. The scale of operations may, therefore, be reduced to below that at present in use in Bihar and Bengal. But even then in order to organize and carry out the sample survey work it is essential to have a strong frame-work of inspecting and supervising staff. Bengal experience shows that from 60 to 80 inspectors and 20 or 25 chief inspectors would be required for this purpose. If such an inspecting staff is maintained, they would be able to conduct independent area surveys and crop-cutting experiments on a restricted scale which would supply a most valuable check on the reliability of the whole scheme. The existence of such a nuclear staff trained in sample survey work would indeed be a valuable asset to the province. It would be then possible to mobilize this staff at short notice to collect such information relating to rural areas as may be required by Government from time to time.

324. *Safeguard against future set backs.* Maintaining such a nucleus of trained inspecting staff would also be a safeguard against setbacks in statistical matters in future. The food crisis of 1943 showed how Government was hampered at every step for the lack of reliable crop statistics. This, coupled with conditions brought about by the war situation in North East India, made Government willing to spend large sums of money for collection of crop statistics. In the face of impending famine and pestilence, expenditure however large, is quite rightly, of no consideration, But if by any mischance complete enumeraion does not work quite satisfactorily or has to be abandoned at any time in future the one possible alternative would be, of course, to fall back on the sample survey. This, however, would be only possible if a nucleur inspecting staff is available ready at hand for this purpose.

325. The cost of maintaining a skeleton frame-work of sample survey will be small. On the scale visualized above, the inspecting staff may be maintained as an integral part of the complete enumeration (or *patwari* system) without involving any additional expenditure. The real additional cost of the sample survey would thus be the expenditure required for the statistical portion of the work. On the reduced scale indicated above, the total cost would probably be something of the order of a lakh or a lakh and a half of rupees per year. This would be a very moderate expenditure for ensuring continuity of work in future. It would also supply independent estimates based on the sampling method and furnish an excellent check on the accurary of complete enumeration.

SECTION 11. SUMMARY OF THE REPORT

326. For convenience of reference a general summary of the Report is given below

SECTION 2. METHOD OF THE SAMPLE SURVEY

327. A general account is given in this section of the method of the sample survey as developed in the course of a five-year scheme (1937-1941) for the improvement of the acreage estimates of the jute crop in Bengal, and later extended to the paddy crop by the Government of Bengal in 1942, 1943 and 1944.

328. *Use of random samples.* The essential feature is to use about sixty or seventy thousand sample units called 'grids' which are small units of square shape and usually of size from 2 to 5-acre each. The whole of the province is divided into a suitable number of zone-cells. (In Bengal, 960 zone-cells of 64 square miles each are being used at present; in the *rabi* survey in Bihar, 96 zone-cells each of about 50 square miles were used in each of the two districts Shahabad and Monghyr) A certain number (depending upon the design of the survey) of such grids are located purely at random on cadastral survey *mauza* maps within each zone-cell. Field lists (*khasra*) are prepared showing the revenue serial number of all plots falling within each grid. Investigators then go out to the field with these lists and appropriate C. S. village maps, identify the plots, examine the crops growing on the plots, and record in the field lists the anna-estimates of the proportion of land under different crops on each plot. The field lists are then sent to the Statistical Laboratory where the records are tabulated, and estimates are prepared of the crop acreage based on the information collected for the sample plots.

329. *Planning of the sample survey.* The precision of the results naturally depends on the size (area) of each individual grid and their total number. The larger the size and/or the larger the total number of grids the greater is the precision. The object of efficient planning of a large scale sample survey is to settle the size of each individual grid, and their total number and distribution among different zones in such a way as to obtain the final result with the least possible margin of error.

330. *Margin of error.* The margin of error of the results of a sample survey is made up of two parts; one due to fluctuations of sampling (which is inherent in the sampling method and which can be calculated on the basis of the theory of probability), and the other due to mistakes in the primary records arising from careless or even dishonest work on the part of investigators. Under existing conditions recording mistakes are quite as important as sampling fluctuations. It is, therefore, necessary to incorporate in the sample survey suitable statistical checks and controls.

331. *Sub-samples.* One type of control has proved extremely useful in Bengal. The total number of grids in each zone is divided into two equal portions, say (A) and (B). Grids belonging to each set are located at random all over the area in each zone-cell, and information is collected for the two sets of grids by two different parties of field investigators who work independently and at different times in the same zone so that they never meet. The two sub-samples thus supply two independent estimates of crop-acreage for each zone and also for higher units like districts or the province as a whole. How far these two estimates based on the two sub-samples are in agreement with each other immediately supply a good idea about the reliability (or otherwise) of the results.

332. *Crop-cutting experiments.* The yield per acre has to be determined by direct crop-cutting work in which the crop grown on a suitable measured area is harvested and directly weighed. Extensive experimental studies in India and abroad have shown conclusively that the attempt to select so-called representative fields always introduces bias. Scientific opinion in every country is united on the need of the sample-cuts being located in a purely random manner without leaving any choice to the investigators.

SECTION 3. THE DESIGN OF THE SURVEY

333. *Aim.* The object of the pilot survey in the *rabi* season was two-fold, namely, to obtain some information for the *rabi* crops in the two important wheat districts of Shahabad and Monghyr; and secondly, to collect basic information necessary for efficient planning of the sample survey in subsequent seasons.

334. *Size and density of grids.* Partly for lack of adequate time of preparatory work and partly to avoid complications in the exploratory stage it was decided to use grids of a square shape and one uniform size, namely four-acre. It was also decided to have, on an average, a density of two grids per square mile.

335. *Zone-cells and sub-samples.* Each of the districts was divided into 96 zone-cells roughly of a square shape and from 40 to 50 square miles in area; and from 80 to 100 grids were allotted to each zone-cell. For lack of time a detailed inter-penetration of grids was not attempted. The 96 zone-cells in each district were however divided into 48 pairs of adjoining cells. Among these 24 pairs of zone-cells were allotted at random to sub-sample (A), and the remaining 24 pairs to sub-sample (B). One party of field investigators worked in each zone-cell so that the information was collected independently for sub-samples (A)

and (B) for each pair. With detailed inter-penetration of grids a comparison between the two sub-samples would have been possible for each zone-cell separately. In the present design, valid comparison can, however, be made only for the district as a whole.

336. *Sub-blocks.* Each district was divided into three blocks and each block into two sub-blocks each consisting of 16 zone-cells. Each block was placed in charge of a chief inspector under whom there were four field parties. Each field party consisted of four investigators under one inspector. Of the two parties in each sub-block one party belonged to sub-sample (A) and the other to sub-sample (B).

337. *Complete enumeration.* Arrangements were also made for the complete enumeration of all plots in certain compact areas; portions of these areas were subsequently surveyed independently by a second party. The object of collecting such plot to plot information was two-fold: firstly, to carry out special studies by model sampling experiments, and secondly, to furnish some idea as to the degree of reliability of the primary field work.

SECTION 4. GENERAL ACCOUNT OF THE SURVEY

338. *Preparatory work.* Planning of the survey started in the third week of December 1943, and was completed within a few days. The work of locating at random 18,000 sample units or grids on appropriate village maps, preparing field lists (*khasra*) comprising more than two lakhs of individual plots and making other necessary arrangements for the survey was completed by the end of the first week of February 1944.

339. *Organization of the field branch.* Seventy-four experienced crop survey workers in charge of two field supervisors were sent to Bihar on loan from Bengal. The local field staff in Bihar, recruiting of which started in January 1944, consisted of 74 investigators, 22 inspectors and 6 chief inspectors. A training camp was opened at Gogri in Monghyr district on 3rd February 1944, where the newly recruited Bihar staff was given actual training in field work by the inspecting and supervising staff sent on loan from Bengal.

340. *Progress of field work.* Field work started on 12th February and terminated on 13th April 1944. The total period of work was 62 days out of which 2 days were treated as holidays on account of *holi* festival; the actual period of 60 days of work was divided into 5 haltages of 12 days each. A special conference was arranged at Bikramgunj and was attended by the whole of the supervising staff and technicians. Various problems relating to mixed crops and crop-cutting experiments were discussed and decisions relating to future procedure were made.

341. *Tabulation and statistical analysis.* Arrangements were made for despatching the material collected in each haltage directly to Giridih. The original plan was to have the whole field data tabulated within a week or so of the receipt of the material. This plan however had to be changed owing firstly to the delay in receiving the field records during the first two haltages, and secondly because of the need of starting preparatory work for the early *makai* (maize) survey which was decided to be taken up in May. A further change in plan was necessitated by the decision to organize a full scale survey in the *bhadoi* season for which preparatory work had to be started on a very large scale.

342. *Reports.* A preliminary report on the survey in the *rabi* season based on material collected in 3 (out of 5) haltages was submitted on the 28th April 1944. Partly due to heavy pressure of work in connexion with the *bhadoi* survey and partly to the sudden illness of the Statistical Adviser the writing of the present report was unduly delayed, and was completed at the end of October 1944.

CHIEF RESULTS OF THE RABI SURVEY

343. The pilot survey in the *rabi* season, although it was confined to only two districts, has supplied a great deal of valuable information relating to crop statistics.

SECTION 5. THE AREA SURVEY

344. The present survey has shown that a sample survey of this kind can supply district estimates of acreage under wheat with a sampling error of about five per cent and a provincial estimate with a sampling error of one or two per cent. For gram the sampling error for the province as a whole would be something like two or three per cent (Section 5).

345. *Estimated crop acreages.* In Shahabad district the sample estimates of crop acreage (in thousand acres) are $300{\cdot}35 \pm 19{\cdot}87$ for wheat, $78{\cdot}40 \pm 9{\cdot}51$ for barley, $337{\cdot}33 \pm 26{\cdot}86$ for gram, $56{\cdot}60 \pm 12{\cdot}95$ for *arhar* and $197{\cdot}81 \pm 23{\cdot}78$ for *khesari*. In Monghyr district crop acreages (in thousand acres) are $284{\cdot}08 \pm 31{\cdot}62$ for wheat, $66{\cdot}90 \pm 5{\cdot}32$ for barley, $193{\cdot}43 \pm$

26·86 for gram, 103·71±23·22 for *arhar* and 47·80±15·11 for *khesari*. The estimated margin of error generally varied between 10 and 30 thousand acres for the different crops in the two districts. This is reasonably small and is quite satisfactory for a pilot survey.

346. In the area survey the internal agreement between different sub-samples is on the whole satisfactory showing that the results are quite reliable.

347. Owing to the late start of the survey, acreage figures are, however, probably under-estimates as portions of the crop had been already harvested during the later stages of the area enumeration. Adjustments based on the observed decrease in successive haltages indicates higher acreages (in thousand acres) of 335, 102, 452, 73 and 298 for wheat, barley, gram, *arhar* and *khesari* in Shahabad district; and 296, 76, 255, 132 and 70 respectively for the five crops in Monghyr district. These adjusted values are probably upper limits for the area sown.

348. *Settlement figures.* Settlement figures are generally believed to be reliable and may be accepted as representing actual conditions at the time of settlement operations (1907-1916 in Shahabad and 1909-1912 in Monghyr). Crop acreages according to Settlement Reports were (in thousand acres) 228, 145 for wheat; 105 and 81 for barley; and 340 and 211 for gram in the two districts respectively. Sample estimates are not strictly comparable to official figures owing to the ambiguity in the interpretation of acreage under mixed crops. But a general examination of the sample estimates against the background of Settlement figures suggests that in recent years the cultivation of wheat has increased appreciably, the area under barley has decreased somewhat, while that under gram has remained much the same in both Shahabad and Monghyr districts. The area under *arhar* is certainly much greater than 1000 acres in Monghyr district as given in official forecasts.

SECTION 6. OUTTURN OF WHEAT AND GRAM

349. *Hubback's work* Sir John Hubback had carried out an extensive series of crop-cutting experiments on paddy covering the greater part of Bihar and Orissa about 20 years ago (1923-25) using, as far as is known, for the first time in India, the method of random samples for this purpose. He had used cuts of a handy size of 1/3200 acre (=13·6 sq. feet) each, and had shown that such small cuts gave satisfactory results. It appears that by his method with 3000 sample-cuts the mean yield of paddy for the province as a whole could be determined with a sampling error of about one per cent (Sections 6 and 10).

350. *Yield per acre of wheat and gram.* Hubback had expressed the opinion that his method would be easily applicable to cereals. This has been confirmed by the crop-cutting work on wheat and gram done in the present survey. The adjusted average yield of wheat grain was 6.48 and 6.45 maunds per acre for Shahabad and Monghyr respectively. The rate of yield of gram (extracted from pods) was 4.98 and 4.25 maunds per acre for Shahabad and Monghyr respectively. The percentage standard error is estimated at 4·7 per cent and 4·8 per cent for wheat in Shahabad and Monghyr respectively and 5·9 per cent for gram in Shahabad and 9·1 percent in Monghyr district.

351. *Margin of error.* The work done shows that about 3000 sample-cuts of a convenient size (30 square feet per plot) located at random in an appropriate manner would enable the provincial mean rate of yield per acre being determined with a sampling error of about one per cent for wheat and a little less than two per cent for gram. It is clear, therefore, that given a suitable human agency for doing the crop-cutting work there is no difficulty in determining the provincial or even district rates of yield with sufficient precision for all practical purposes (Section 6).

352. *District outturn.* The total outturn, in theory, can be obtained simply by multiplying the crop acreage figure by the mean rate of yield per acre. The estimated outturn of wheat (in thousands of maunds of extracted grain) calculated in this way is 1947·1 in Shahabad and 1832·1 in Monghyr; and of gram 1681·6 and 1822·4 thousand manuds in the two districts respectively.

353. *Unreliability of official estimates.* Comparison of above estimates with official figures is not possible for two reasons. As already noted, acreage figures for mixed crops are ambiguous. Secondly, official figures relating to rates of yield, 'condition factor', and outturn are conflicting and of doubtful value. Actual calculations based on official reports for the four crop-seasons from 1940-41 to 1943-44 show that "standard" rates of yield have changed suddenly from year to year although no crop-cutting experiments on *rabi* crops appears to have been done by the Department of Agriculture in recent years. Different sets of condition factors are given for the same crop in the same year, but nothing has been stated

reconcile the discrepancies. Enquiries made from departmental officers made it clear that the present position is unsatisfactory, and careful experimental study is essential for progress.

SECTION 7. PROBLEM OF MIXED CROP

354. *Ambiguity about mixed crops.* Mixed crops may have two different meanings. In the same plot one portion of the land may be sown with one crop, and another portion with another crop and so on ; in such cases there is no ambiguity in the area under each individual crop. It is also possible for the same portion of land to be sown with a mixture of two or more crops. In this case each crop covers the whole geographical area under mixed crops. If each crop is credited with the gross area then the total land recorded to be under cultivation would be much greater than the actual geographical area. Estimates may also be made of the net proportion of land which have been covered by each crop if it had been sown separately ; the total net area would be now equal to the geographical area covered by mixed crops.

355. *Frequent occurrence of mixed crops.* Sample studies show that wheat or gram is sown by istelf (or 'pure' as it is called) in only a small proportion (about 10 per cent) of the land under wheat or gram alone ; in the remaining 90 per cent wheat (or gram) is sown in mixture with other crops.

356. *Variations in mixture.* In Bihar the relative proportions of the different crops in mixture do not remain the same but fluctuate widely from region to region or even from plot to plot in the same region. Proper assessment of area under mixed *rabi* crops is thus a matter of great importance in this province. As far as could be ascertained, no standard procedure is being used at present for this purpose in Bihar. The Settlement Reports also fail to make the position clear.

357. *Variations in rate of yield of mixed crops.* The rate of yield of wheat was determined for plots with different compositions of wheat sown in mixture with other crops. The rate of yield increases, as one would expect, with increasing composition of wheat in the mixture. But the increase in yield does not take place in equal proportion with the increase in the intensity of wheat. For example, the graduated yield is 4.32 maunds per acre for one and two-anna proportion of wheat, and is 7·4 maunds per acre for a 15 and 16--anna proportion. Thinner compositions thus give relatively higher yields which probably explains their popularity.

358. *Gross acreage and calculated outturn.* In the present survey estimates had been made on the basis of net or effective acreages. Converting these net or effective acreages into gross acreages and multiplying by rates of yield appropriate to different compositions the estimated total outturn in thousand maunds of wheat (as extracted grain) was 3860 for Shahabad and 4486 for Monghyr against calculated values of about 1947 and 1832 as given in Section 6. The wide gap shows the urgent need of critical studies.

359. It is suggested that the best plan would be to record two things in the case of mixed crops, namely, (a) the gross (or geographical) area under all combined crops in the mixture, and (b) the effective or net anna proportion of composition of each crop, that is, the estimated proportion of the land which would be covered by the crop if sown by itself without mixture. Crop-cutting experiments should also be conducted to determine the rate of yield per acre (on the basis of gross or actual geographical area) for plots with different proportions of the crop in the mixture. The outturn can be then calculated directly by multiplying the gross area by the rates of yield appropriate to the particular anna-composition of the crop.

SECTION 8. COST OF OPERATIONS

360. *Volume of labour used in the survey.* In the present survey payment was made to investigators for a total of 6564 days of work out of which 4565 were spent in area survey (inclusive of 317 in crop-cutting work), and 1999 in special studies. The amount of time required for crop-cutting work thus represented only about 7 per acent of the time required for area survey work. The sampling errors of estimates of crop acreage and of rates of yield per acre were about the same ; this shows that area survey work requires about fourteen times more than crop-cutting work to attain the same precision in the results.

361. *Relation between cost and density of grids.* It is found that, as one would expect, the time taken for enumeration of grids increased when the density of grids was small that is, when there were fewer grids per square mile because proportionately more time was consumed in moving from one grid to another. The actual relation between cost and density of grids was similar to that previously observed in Bengal.

362. The above studies were directly useful in preparing the plan for the survey in the *bhadoi* and succeeding seasons as it enabled calculations being made in advance of the time (and hence expenditure) which would be required in working with grids of different densities.

363. *Analysis of costs.* The total expenditure in field branch as well as the proportionate cost per investigator-month under different heads in the *rabi* survey have been analysed and compared with corresponding costs in the Bengal crop survey in 1943–44. Expenditure and cost per investigator-month in the statistical branch have been also discussed.

SECTION 9. ACCURACY OF AREA ENUMERATION

364. *Recording mistakes.* In certain compact areas complete inventories were made of the proportion of land under each crop in each individual plot. This work was repeated independently a second time in certain areas by entirely different parties of workers. A comparison of such duplicate records for the same identical plots showed that the two sets of record were discrepant in the case of from 10 per cent to 15 per cent of plots compared depending upon the stringency of the definition of agreement.

365. Comparison in terms of acreage showed that both positive and negative discrepancies (i.e. errors of both commission and omission) occurred in appreciable numbers. In building up totals for higher units like villages, *thanas*, districts etc. the possitive and negative discrepancies would cancel out to a large extent, and the residual discrepancy would become gradually smaller. For the material under comparison this residual discrepancy was, however, still appreciable and greater than 4 per cent. If the discrepancies are added together neglecting their signs one gets the accumulated discrepancy which was surprisingly high,—about 75 per cent for wheat and 54 per cent for gram.

SPECIAL STUDIES

366. A number of special studies were also undertaken to collect information for improving the technique of the crop survey; and some of the results are mentioned below.

367. *Weight of crop as harvested.* Studies were made to find the relation between the ears of wheat as harvested and the weight of grain extracted from the dried ears as also the relation between the weight of pods of gram as harvested and the weight of extracted grain. If a stable ratio can be found between these two weights then it would be possible to simplify the crop-cutting work by recording only the weight of ears of wheat (or pods of gram) as harvested, and later converting these into equivalent weight of grain. Preliminary results were encouraging as the observed ratio was found to be fairly stable but further investigations are necessary. Preliminary studies were also made of the effect of premature harvesting on the weight of crop (section 6).

368. *Analysis of variance.* There was considerable variation in the yield of both wheat and gram from one region to another and also from plot to plot. Valuable information relating to such variations has been collected which indicates that sample-cuts should be scattered over as many localities as possible rather than on many plots within the same locality, and within each locality on as many plots as possible rather than on many cuts within the same plot. With the help of numerical data calculated from experimental observations it is possible (in conjunction with considerations of costs) to arrange the pattern of sampling in such a way that the highest precision in results may be attained with a minimum expenditure of time or money (Section 6).

SECTION 10. REVIEW OF METHODS FOR IMPROVEMENT OF CROP STATISTICS

369. Section 10 gives a general review of methods for improvement of crop statistics with special reference to permanently settled provinces like Bihar and Bengal.

370. *Existing methods unreliable.* Existing methods of preparing crop statistics are based on subjective estimates made by local officers of both crop acreage and the so-called 'condition factor' of outturn. In the permanently settled provinces figures collected in this way have been known from a long time to be unreliable.

371. *Need of an objective method.* Scientific opinion is united regarding the need of using an objective method based on actual physical examination of growing crops.

372. For acreage surveys two procedures are open, namely, (a) complete enumeration and (b) sample survey. In the complete enumeration a detailed inventory is prepared by direct physical examination of the proportion of land under different crops in each individual plot in the province.

373. For crop-cutting work, complete census of weighing of the crop on each individual plot is out of question, and recourse must be had to the method of random samples.

374. *Sample survey.* In this method a suitable number of sample-units or grids are located purely at random, and the proportion of land under different crops in the plots included within these grids is recorded by direct physical examination. Estimates are then prepared for the area under survey on the basis of such sample information.

375. *Stationary investigators.* The procedure of the sample survey itself takes two different forms depending upon the kind of human agency which may be available for the field work. If the part-time services of a large number of investigators (like *patwaries* in temporarily settled provinces) happen to be available then each investigator can be allotted a small compact area or cell so that he can enumerate a suitable number of grids within his own cell without leaving his usual place of residence. This may be called a system of stationary investigators. If the part-time help of say, 2000 investigators happen to be available then the whole work of area survey can be finished in 5 or 6 days in each season ; with a large number of investigators the work would take still less time.

376. Crop-cutting work becomes extremely simple with a system of stationary observers. A suitable number of villages and plots can be selected at random beforehand and assigned to each investigator within his own cell so that he can collect the samples just when the crop on the selected plots happen to be ready for harvesting. With one or two thousand investigators the whole work can be finished in a day or two practically at negligible cost.

377. *Moving investigators.* If the part-time help of stationary investigators is not available (and it may be mentioned here, that this was not available in the Bihar scheme) then the work must be done by a comparatively small number of whole-time investigators appointed *ad hoc* for this purpose. The area allotted to each investigator in this system must necessarily be large, several hundred square miles in extent. Each investigator has ,therefore, to move about from place to place for both area survey and crop-cutting work. A good deal of time is consumed in such journeys, and considerations of cost become important in deciding the pattern or design of the sampling technique.

378. *Advantage of complete enumeration.* A complete enumeration (when it can be carried out without mistakes) represents in wealth of detailed information the highest goal of statistical science. Against this, the sample survey can only give crop acreages for large units like the province or districts or perhaps sub-divisoins, but not for small units like *thanas* or villages.

379. *Margin of error.* Once, however, any mistake is made in the complete enumeration there is no possibility of detecting it except by a second (or possibly a third) enumeration. The sample survey possesses a great advantage in this matter ; provided the sample-units are taken at random, it is possible to estimate the margin of error on a valid and scientific basis. It is also possible in the sample survey to incorporate internal statistical checks and controls. Although a sample survey cannot be guaranteed to give accurate results, if it goes wrong, this can be detected.

380. *Relative costs.* The cost of a complete enumeration is necessarily high. Experimental studies in both Bihar and Bengal show that about 10 investigator-days are required per square mile to do the work satisfactorily. On this basis, 6,00,000 (six lakhs) of investigator-days would be required for the complete enumeration of 60,000 square miles. For provincial estimate of crop acreage the use of about 60,000 grids of about 4-acre each would be sufficient for which the time required for actual enumeration would be about 12,000 or 15,000 investigator-days at the most. With stationary investigators a sample survey of area would thus require one-fortieth or one-fiftieth of the labour of complete enumeration. With moving investigators more time would be required but even then it would be something like one-twentieth of that of complete enumeration.

381. *Recording mistakes.* In actual practice, one difficulty in the method of complete enumeration under existing conditions in Bengal and Bihar is that large mistakes are made in the preparation of crop records and also at other stages. For crop acreage, the effective accuracy of a complete enumeration therefore is not likely, in the immediate future, to be higher than that attained in the sample survey in practice. Organizational difficulties in working with a large staff are also naturally greater in the complete enumeration.

382. *Choice between the two systems.* The choice between complete enumeration and sample survey is thus primarily a question of expense, and depends entirely upon in how much detail information is desired to be collected and how much expenditure and trouble one is prepared to incur for this purpose.

383. *The patwari system.* If a real *patwari* system can be built up (or where it is in existence) it should be possible to get quite reliable estimates of crop acreage. This system has distinct advantages over a sample survey (carried out by a small rapidly moving staff) in crop-cutting work. A *patwari* system has also many administrative advantages; but in order to be effective it must have a sound organization as in the temporarily settled provinces.

384. *A combined system.* In Bengal and Bihar the building up of such a *patwari* system will take time. In the transitional stage it is desirable to continue the sample survey in order to secure reliable crop statistics in the immediate future.

385. Even when a *patwari* system is fully organized it would be desirable to incorporate the sample survey as an integral part of the scheme of complete enumeration. In such a combined system both sample survey of area and crop-cutting work would be done with the part-time help of the *patwaries* for which only a few days of work would be required in each crop season.

386. *Gap between area sown and area harvested.* The area harvested is always less than the area sown. The gap may be large in a province like Bihar in which crops are usually rain-fed; according to Hubback this gap may be so large as 50% for paddy in large tracts of Bihar. In a combined system, an early sample survey of acreage would be carried out in the middle of the season to estimate the 'area sown'; and a second sample survey of area would be carried out *along with crop-cutting work* to estimate the 'area harvested'. It would be then possible to make necessary adjustments for the gap between the two. This combined acreage and yield survey would also enable the total outturn being estimated directly for the grids and zones and hence for districts or the province as a whole.

387. *Sample checks.* The sample survey would in any case supply valuable checks on the results obtained through complete enumeration.

388. *Marginal cost.* In the combined system it would not be necessary to have a separate body of investigators for the sample survey; but a small trained staff of inspectors would be maintained for general supervision of the work. The cost of a sample survey integrated with a scheme of complete enumeration would be thus marginal and small, probably of the order of a lakh and a half of rupees per year in a province like Bihar.

389. *Safeguard against future set-back.* The maintenance of a nuclear staff for sample survey would be useful in case by any mischance the scheme of complete enumeration is not entirely satisfactory or has to be abandoned in future as it would be then possible to fall back on the sample survey for securing crop statistics of sufficient accuracy for practical purposes.