The comparative merits of the two practices were inve[illegible]nce into by regular experiments at the Paddy Breeding Station, Coimbato[illegible]. Three varieties of rice, a short duration *kar* crop, a medium duration *samba* crop, and a long duration *samba* crop were experimented with, and in every case transplanting was definitely found to be very much better than direct sowing. In the *samba* varieties the increased yield was brought about mainly by the bigger size of the earheads in the transplanted crop and in the *kar* crop by the bigger number of ear-heads per unit area. Even after allowing for the extra expenditure involved in the raising of seedlings and the transplanting of the same, the value of the extra produce obtained in the transplanted crop was enough to leave a clear net profit of Rs. 8 to Rs. 14 per acre.

CROP-CUTTING EXPERIMENTS.

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Introduction. One of the three factors necessary for estimating the yield of a crop, namely the "Standard or Normal yield", is admittedly susceptible of considerable improvement in many Provinces in India. The Agricultural Department in each Province is responsible for fixing the "Normal Yield" per acre for the several crops in each district. The estimate of normal yield is based mainly upon a system of crop-cutting experiments made over a number of years. Under this system, plots of land of average quality are selected in each district by the officers of the Agricultural Department and the crops grown upon them are cut and weighed before them. The results of the experiments are reported to the Director of Agriculture, who on a careful scrutiny of all the reports received by him, and after comparing with such other information as may be available from trade statistics, settlement investigations and the like, fixes the "Standard Yield" of each crop for each district. The estimates are generally revised if necessary at the end of five years.

Reliance on crop-cutting experiments, the methods adopted in carrying them out, and the agency employed in conducting them have all been subjects of criticism in the past. But no satisfactory alternative basis for calculating the normal yield has been suggested. The Board of Agriculture after a very thorough examination of the point in 1919 and 1924 recommended that crop-cutting experiments must remain the basis of estimates of "standard yield". As regards the methods in use, criticism is mainly directed to two points, viz. that the number of experiments are too few to be capable of generalisation over a large area and that they depend for their success entirely on the ability of the officer to select the average field from a large number of fields growing different varieties of a crop at different stages of maturity. In selecting the fields, it is very difficult to give proper weight to fields of very little or no productivity, and even in a normal year such yields are by no means rare. These factors make accurate selection very difficult. Another important defect of this method of selection, even though it is done on a large scale, is that it is not possible to make any generalisations from such experiments, because there is no method for determining the probable error of the results of such a "Deliberate selection" as opposed to a "Random selection". Naturally we fall back upon the method of "Random sampling" to give us a satisfactory estimate of the average yield per acre of any crop of a district.

Number of Samples. Suppose the average yield per acre of a crop from a sample is y with a standard deviation of s. Also suppose the total number of fields under that particular crop in the district is N, and that experiment is conducted in n out of the N fields. Then $X=\frac{N}{n}$ is called the sampling factor. Let $K=\frac{1}{X}$; then from a well-known formula the average yield per acre of the district is $y \pm s\sqrt{\left\{\frac{1-K}{n}\right\}}$ Hence n the frequency of the sample depends upon (1) the dispersion of the yield of the crop about the average yield; (2) the total number of fields growing that particular crop; and (3) the degree of accuracy expected as measured by the probable error of the yield. Generally 'N' is very large compared with n and so K $(\frac{n}{N})$ is insignificant. Therefore for a given degree of accuracy $\sqrt{n}$ is directly proportional to s (the standard deviation). If the crop selected is of such a character that its coefficient of variation ($100 \times \frac{\text{standard deviation}}{\text{arithmetic mean}}$) is small, the number of crop-cutting experiments necessary to give a fairly accurate result is also small, and vice versa.

To take a specific case, the coefficient of variation of the yield of rice in the several divisions of Bihar and Orissa was found to vary from 40 to 60 with an average of 48 in Mr. Hubback's crop-cutting experiments of 1925. Suppose that the standard error of any forecast should be 5% of the average

$$\therefore\ 100 \times \frac{s}{\sqrt{n} \times y} = 5$$

$$i.e.\ \frac{V}{\sqrt{n}} = 5 \text{ where V is the coefficient of variation}$$

$$\text{if } V=40 \qquad n=\frac{40^2}{5^2}=64$$

$$\text{if } V=60 \qquad n=\frac{60^2}{5^2}=144$$

Taking the upper limit, if 150 crop-cutting experiments are made per district the standard error will be about 5% of the average yield. If

225 experiments are made the standard error will be $\frac{60}{\sqrt{225}} = 4\%$. Hence to be on the safe side it is desirable to take 200 to 250 samples to get a reliable estimate of the average yield per acre.

Thus from a knowledge of the coefficient of variation of the yield of any crop the number of experiments for each sample can be fixed. For most of the important crops the coefficient of variation is not likely to be more than 60, and hence it is enough if for each crop 200 to 250 cuttings are taken to find the average yield.

Technique of Selection. It is very well-known that even in the compact area of a district, several crops are grown on a variety of soils of varying degrees of fertility, under different methods of cultivation (irrigated or unirrigated, intensive or light, and so on). To add to this there is a large number of varieties of the same crop including those of improved seeds. So if we want to divide the district into a number of homogeneous areas and then take a number of samples from each variety of the crop, the work will be impossible because it is almost certain that such homogeneous areas cannot be delimited with sufficient accuracy, and even then the number will be too large for investigation. Even if this could be done, it would be impossible to compute the probable error of such experiments. (In certain crops like cotton, where the cassification of separate varieties is of very great importance, the sampling method for different varieties could be applied).

So it is necessary to devise a method by which every unit in the aggregate shall have an equal chance of being included. In the present case the question arises whether the unit for sampling should be a village or a field comprised in a survey number. The defect of the former method is that we can select only a few villages, and in each village a selection has again to be made of a few plots. This restricts the scope for all varieties of plots being represented in the sampling because there is a very high correlation between the soil conditions, varieties of the crop and their yields in the same village as compared with the whole district. In fact this method is analogous to selecting 50 strips of 10 units each instead of a random sample of 500 units. (Vide F. L. Engledow and G. U. Yule, " The Principles and Practice of Yield Trials Section "). It is shown there that the standard deviation of such a method is greater than that of the random sampling method. So the best way of doing the whole thing is to prepare a list of the fields in the district, arranging the villages in a geographical or alphabetical order and in each village arranging the fields according to the survey number. Now suppose there are ' N ' fields (i. e. total of the survey numbers) and we want to select ' n ' fields. Let X be the nearest integer of the fraction $\frac{N}{n}$. Now mark the 1st, $(x+1)$; $(2x+1)$, $(3x+1)$; ....and so on, numbers in the ordered list and conduct the crop-cutting experiments in those fields. Of course it is better to select the first field at random rather than selecting the first survey number of the first village in the list. Also if it is felt necessary, there is no objection to arranging the villages according to the different soils and types of cultivation. But this should be done before the selection is made from the ordered list. Thus due weight will be given to tracts where a large percentage of fields grow the same crop, and also the different types of cultivation and soil receive adequate representation. Of course if in the survey number selected the particular crop is not grown the nearest field growing the crop should be taken.

After the selection is made the adequacy and the randomness of the sample can be tested by computing the area of the crop of the whole district from the sample, as well as the land revenue assessed; and seeing whether the estimates differ from the facts by more or less than the computed probable error. A rough test can also be made by dividing this big sample into two, one comprising the sample of odd numbers and the other the even, and observing how the results of these two sub-samples agree.

Mr. J. A. Hubback in his "Sampling for Rice Yield in Bihar and Orissa" observed that the practical difficulties involved in the above method require a method which is more automatic in the distribution of sampling in time and space. The only difficulty pointed out by him is the necessity to find out the date on which the crop in each field would be ready for harvest and to arrange a visit to the village on that date. The alternative method suggested by him was to divide a tract of nearly 1,000 square miles into 12 regions. "It is necessary to fix 12 centres spread as evenly as possible over the area and to put down against each centre the day on which sampling is to be done. These days should be spread evenly over the period of harvest. The sampler should go out a fixed distance in one direction and, circling round, return from another direction, so that it is secured that he covers approximately the same area on each day. He could cut one sample from each field, where he finds harvesting in progress. He will be able ordinarily to get from 30 to 40 samples in a day when the harvest is in full swing and 10 to 20 when it is slack." Any officer could do the work quite well.

But this method will not be strictly random on account of the fact that however carefully the dates for sampling may be arranged, all the different units have not an equal chance of coming into the sample because only those fields which are homogeneous in certain respects will be ready for harvest during a particular period and so the fields having different varieties produced on different soils under different conditions will not all stand equal chance. Hence the random sampling method proposed above is the best, provided arrangements can be made for the investigators to visit those particular fields when they are just ready for harvest.

Details of the Experiment. After selecting the field the next question is whether the average yield per acre of the whole field should be found out or again only a random sample of that crop should be taken or any other method should be adopted. The objection to finding out the average yield per acre of the whole field is that all the survey numbers are not of the same extent in area, and secondly that it is impracticable considering the cost and time that it takes. An alternative method is to follow the "*Danabandi*" (appraisement) system of rent payment followed in some parts of the country. It consists of the tenant cutting a small area where the crop is thinnest and the landlord where the crop is heaviest, mixing the two together and taking the result as a fair sample. But Mr. Hubback's objection to this method is that it presupposes that the true mean lies midway between the highest and lowest sample, which is very rarely found in practice. He says that in fact this method always gives an over-estimate. An alternative method is to take 4 or 5 samples from each field and find the average of those to get the average yield of the field. But it was found by experience in Bihar and Orissa that 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 (vide Hubback's "Sampling for Rice Yields in Bihar and Orissa," p. 9).

Hence it is enough if a small plot of land (the area being constant for all sample) is chosen at random, under definite directions, and the average yield of that is taken to typify the field. For example the sampler may be instructed to go to the centre of the boundary of the field parallel to the line in which the harvest is proceeding and take a plot of area at a few steps say 5, 10, from that place. Of course for finding the absolute yield of that field that sample is not sufficient; but in the case of a large number of samples positive and negative errors cancel and the average yield of the whole district will not be disturbed. In this connection the question, what is the reasonable area of the plot of land for each sample, arises. In Mr. Hubback's experiment a mechanical device, by which a plot of land in the form of an equilateral triangle comprising an area of 13200 of an acre is formed, was used. But it is very difficult to find the area and to weigh the quantity of grain produced in such a small plot very accurately and even small errors in measurements and weights magnify the errors of the average yield per acre. So from practical considerations it will be better if a plot of land whose area is 1150 or 11100 of an acre is chosen, i. e. a plot of ground in the form of a square of side 10 yards or 7 yards roughly.

Conclusion. To sum up, the standard yield of any crop in any district can be estimated by cutting the crop on about 200 to 250 plots of land each of area 1,100 or 1,50 of an acre, the plots being selected on a purely random basis. Of course every effort should be made to compare the results of the experiments with such other information as may be available from trade statistics, settlement investigations and the like.

ON SOME PARASITES FOUND IN ASSOCIATION WITH THE STEM WEEVIL PEST OF COTTON IN SOUTH INDIA (*Pempheres affinis*, F.) & THEIR ROLE IN ITS BIOLOGICAL CONTROL*

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It is now over two decades since the cotton stem weevil *Pempheres affinis*, F. began to attract some attention as a fairly important pest of cotton in South India, and the first paper (1) on the general features and life history of this insect was published by the senior author. Since then, this pest, which was in the early years confined chiefly to the cambodia variety of cotton, has been directing its attentions to other cottons and distributing itself fairly widely in the cotton areas of South India. As a consequence, special attention has had to be paid to this insect along with other important pests of cotton viz., the boll worms, and even the help of legislation had to be resorted to for the control of these important pests. Side by side, intensive studies on the different aspects of the problems connected with this insect have also been carried out by the Government Entomologist and by a special staff appointed for this work by the Indian Central Cotton Committee. The peculiar habits of this weevil as an internal feeder in its destructive stages have made it rather difficult to tackle it by means of the ordinary mechanical or insecticidal methods of control, and it is found that the only possible means of keeping the pest under some control must mainly consist of prophylactic cultural means and plant sanitation, the breeding of resistant strains of cotton, or by trials in biological methods by the use of parasites or predators. Speaking of biological methods and the agencies in that direction, with which this paper is mainly concerned, it is needless to add that it is in the first place essential to find out whether any such natural enemies really exist and get some definite ideas regarding their potentiality before any control measures in that direction are attempted. With a view to find out if the pest is subject to the attacks of such natural enemies the authors have been carrying on some work, and the experience of the past two or three years has so far shown that this insect, unlike some of our common insect pests, is not commonly subject to

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