Simple Methods for Estimating the Actual Yield in Individual Rice Fields

By SEIZO MATSUSHIMA

Head, Department of Physics and Statistics,
National Institute of Agricultural Sciences

It is needless to say that the most accurate method for knowing the actual yield in individual fields is to harvest all the plants in the field under investigation, but it is quite laborious. In the following, therefore, some simple methods will be described.

By means of counting the number of fully ripened grains on an average hill

Selecting an average part in plant growth in the field under investigation and further selecting on that part an average hill in both the number and the weight of panicles, and counting the total number of fully ripened grains on the average hill, one can easily read the actual yield in the field at a glance from Table 1—"The ready reckoner for the yield of kernel (kg per are) based on the total number of fully ripened grains per hill and planting density".

The points in this method are to select out the average hill and to distinguish the fully ripened grains. First, the most accurate method to select out the average hill can be achieved by selecting the representative hill which will be written later, but the selection of representative hill is also a troublesome task. The average hill, however, can nearly be selected by investigating 20 hills successively on a row in the average part in plant growth and by selecting the hill which is on an average in the number of panicles as well as plant height. If one becomes skilled in the method, one can select a near average hill by eye-judgment.

Second, the most reliable method for distinguishing the fully ripened grains is to take the grains which are heavier than 1.06 specific gravity as full ripened grains. Therefore, if one uses a specimen of grains having a specific gravity of 1.06, one can easily distinguish the fully ripened grains to a fair degree with the naked eye by comparing each individual grain on the average hill with the specimen. (The method for distinguishing the fully ripened grains has been proved to be applicable to any variety in Japonica type as well as Indica type, but for glutinous varieties 1.02 specific gravity should be used.)

Recently, another convenient method for estimating the total number of ripened grains per hill has been discovered by Sugahara[2),3),4)] as follows: Dividing equally in area the field under investigation into three parts as shown in Fig. 1, and pulling a string diagonally across the field joining two corners, and sampling seven hills successively which are located on

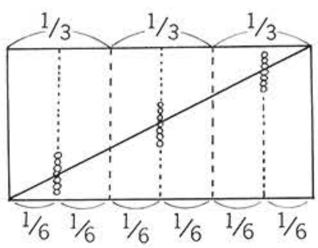

Fig. 1. A sampling method in the field under investigation.

Table 1. A ready reckoner for the yield of kernels (kg per are) based on the total number of fully ripened grains per hill and the planting density.

Number of ripened grains per hill	Number of hills per m²										
	5	8	10	13	15	18	20	23	25	28	30
200	2.3	3.7	4.6	6.0	6.9	8.3	9.2	10.6	11.5	12.9	13.8
300	3.5	5.5	6.9	9.0	10.4	12.4	13.8	15.9	17.3	19.3	20.7
400	4.6	7.4	9.2	12.0	13.8	16.6	18.4	21.2	23.0	25.8	27.6
500	5.8	9.2	11.5	15.0	17.3	20.7	23.0	26.5	28.8	32.2	34.5
600	6.9	11.0	13.8	17.9	20.7	24.8	27.6	31.7	34.5	38.6	41.4
700	8.1	12.9	16.1	20.9	24.2	29.0	32.2	37.0	40.3	45.1	48.3
800	9.2	14.7	18.4	23.9	27.6	33.1	36.8	42.3	46.0	51.5	55.2
900	10.4	16.6	20.7	26.9	31.1	37.3	41.4	47.6	51.8	58.0	62.1
1,000	11.5	18.4	23.0	29.9	34.5	41.4	46.0	52.9	57.5	64.4	69.0
1,100	12.7	20.2	25.3	32.9	38.0	45.5	50.6	58.2	63.3	70.8	75.9
1,200	13.8	22.1	27.6	35.9	41.4	49.7	55.2	63.5	69.0	77.3	82.8
1,300	15.0	23.9	29.9	38.9	44.9	53.8	59.8	68.8	74.8	83.7	89.7
1,400	16.1	25.8	32.2	41.9	48.3	58.0	64.4	74.1	80.5	90.6	96.6
1,500	17.3	27.6	34.5	44.9	51.8	62.1	69.0	79.4	86.3	96.6	103.5
1,600	18.4	29.4	36.8	47.8	55.2	66.2	73.6	84.6	92.0	103.0	110.4
1,700	19.6	31.3	39.1	50.8	58.7	70.4	78.2	89.8	97.8	109.5	117.3
1,800	20.7	33.1	41.4	53.8	62.1	74.5	82.8	95.2	103.5	115.9	
1,900	21.9	35.0	43.7	56.8	65.6	78.7	87.4	100.5	109.3		
2,000	23.0	36.8	46.0	59.8	69.0	82.8	92.0	105.8	115.0		
2,100	24.2	38.6	48.3	62.8	72.5	86.9	96.6	111.1			
2,200	25.3	40.5	50.6	65.8	75.9	91.9	101.2	116.4			
2,300	26.5	42.3	52.9	68.8	79.4	95.2	105.8				
2,400	27.6	44.2	55.2	71.8	82.8	99.4	110.4				
2,500	28.8	46.0	57.5	74.8	86.3	103.5	115.0				

Notes: 1. If 1,200 fully ripened grains are obtained per hill at the spacing of 25 hills per square meter, the yield of kernels (brown rice) per a comes to 69.0 kg. ($a=100\ m^2$).

2. The yields in the table having been calculated by taking the weight of 1,000 kernels as 23.0 g, so the yields must be corrected according to the kernel size of the variety used; e.g. if the variety which has 21.0 g in the weight of 1,000 kernels is used, each value in the table must be multiplied by 0.91 (21÷23).

3. The table is applicable to not only the yield of kernels (brown rice) but also that of grains (unhulled rice). If the weight of 1,000 grains of the variety used is known, the necessary adjustment to the table is made.

the central longitudinal row in each part and nearest to the string as shown in Fig. 1, one can sample 21 (7 × 3) hills in total. From these samples one can estimate the average number of panicles per hill, so one can therefore select 12 hills, whose number of panicles is near to the average, out of these samples.

It is still a laborious task to count all the grains on these 12 hills, so the following method has been found to save labor. Selecting two representative panicles for each hill, one can select 24 representative panicles in total from these 12 hills. Counting the number of fully ripened grains on these 24 representative panicles, one can determine the average number of fully ripened grains per panicle.

Multiplying the average number of panicles per hill by the average number of fully ripened grains per panicle, one can obtain the average number of fully ripened grains per hill, on the basis of which one can read the actual yield of the field under investigation from the "Ready reckoner" mentioned above.

The key point in the method, however, is to select the representative panicles from each hill. The selection is easily done by taking out the panicle according to the order of individual culm-height in each hill referred in Table 2, i.e. the two representative panicles of

Table 2. How to select the representative panicles

No. of panicles on a sample hill	Position of representative panicle in the order of culm-height	
	From above	From below
4～ 9	2nd	2nd
10～14	3rd	3rd
14～18	4th	4th
19～23	5th	5th
24～28	6th	6th
29～33	7th	7th

a hill which has 12 panicles are third panicle from above and that from below in the order of culm-height in the hill.

By means of selecting representative hills sampling along five lines parallel to a diagonal

For accurate estimation of the actual yield in a given field it is indispensable to sample as many hills as possible from every portion of the field. For estimating the true mean (yield) with 5% precision (deviation from the true mean, shown as percentage of this mean) at 95% confidence level, it is necessary to sample randomly 64 to 196 hills, because the coefficient of variation among sampling units (i.e. hills) for the grain yield per hill generally varies from 20 to 30%[1]. (The chart for determining the size of sample has been presented in the author's book.[1])

The method of sampling the hills from every portion of the field under investigation is to pull a string diagonally across the field joining the two corners (of the two possible diagonals that one along which the larger variation in plant growth is found should be taken) and to place two points on each side of the field so as to divide each one into three equal lengths and to join pairs of points with each other with strings strung parallel to the diagonal string as shown in Fig. 2. Hills along

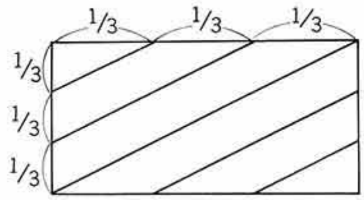

Fig. 2. A method of sampling hills along five lines parallel to a diagonal.

these five parallel lines are then selected at certain interval; in this way one can sample hills from every part of the field objectively.

When sampling, the hills located nearest to the intersection point of the longitudinal rows with these parallel lines should be selected objectively. If the paddy field under investigation is small, the hills which are nearest to the strings on every longitudinal row are selected for examination, while in a large field hills should be selected at intervals of several rows. A convenient method of determining the size of intervals (expressed by the number of rows) is to divide the total number of hills located on the five strings by the number of hills to be sampled. (i.e. 150).

The total number of hills located on the five strings can be easily estimated by multiplying the total number of longitudinal rows by 3. It is more correct to include all the edge hills which occur at both ends of each of the five strings in the sample of hills.

Classifying all the sampled hills into groups with the identical number of panicles, one can easily compute the average number of panicles per hill. All the hills with the approximately same number of panicles as the average must be selected; out of these hills with the average number of panicles that hill whose weight of panicles is nearest to the average weight of panicles per hill must be selected as the representative hill for the field.

The other way is to omit the examination of the number of panicles per hill and to proceed straight to weighing the panicles of each sampled hill and selecting that hill whose weight of panicles is nearest to the mean weight of panicles per hill for the sample and again terming the representative hill. (Of course more than one hill can be selected, and the larger the number of representative hills so chosen, the more accurate the estimation.)

When a representative hill is chosen, the following procedures are proposed for estimating the yield: Thresh it by hand, remove its rachis-branches, and dry its grains under the sun for one or two days. Select the grains using salt water with 1.06 specific gravity, wash the grains which sink in the solution with water, and dry them fully and weigh them accurately.

If you want to estimate the yield in terms of volume, say in liters per hectare, express the sunken grain weight obtained from the representative hill in grams, and multiply it by the number of hills per square meter and again multiply it by 10,000, and from the product you can estimate the weight of fully ripened dry-grains per hectare. (The constant for converting grain yield (kg) into kernel (brown rice) yield (kg) is 0.84 or 0.83 in this case.)

If you express this weight in kilograms and then multiply it by 1.01, you can get the yield of kernels (brown rice) expressed in liters per hectare. It must be noted that in this method one can estimate the yield of fully ripened kernels volumetrically without dehulling and screening. [As to the constant 1.01 for converting the weight (kg) of grains into the volume (l) of kernel (brown rice), refer to the author's book.[1] (p. 313)]

By means of using a " Yield diagnosis apparatus "

Even in the second method mentioned above it takes several days after sampling in Japan to estimate the actual yield, because two days are necessary for drying the representative hill just after sampling and further four or five days are also needed to dry the grains which sink in the solution with 1.06 specific gravity.

Hence, the actual yield can hardly be known just after sampling, which is quite inconvenient for estimating the yield. The author, therefore, invented a "Yield diagnosis apparatus" as can be seen in Fig. 3. The main parts of the apparatus are a precision balance for weighing grains, a panicle-weight balance for selecting an average hill in the panicle weight, tools for selecting grains by specific gravity, a drying apparatus which consists of a grinder and a dryer with an infrared lamp, a ready reckoner for hill number per m^2 and that for the yield of brown rich per 100 m^2. By using the apparatus one can know on the spot not only the yield of a given field, but also the magnitude of its each yield-component as follows.

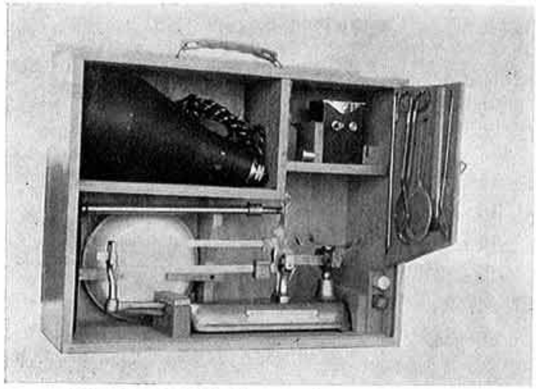

Fig. 3. Yield diagnosis apparatus.

Dry the grains obtained from a representative hill or hills for five minutes, and you will get grains with a water-content of 12~14%. Select the grains heavier than 1.06 specific gravity by using the tools for selection, and you will get fully ripened grains. Wash the fully ripened grains with water and then dry them again for 10 minutes with the infrared lamp, and you will get fully ripened grains with a water-content of 10~14%, from which you can recognize the near actual yield.

However, for accurate estimation of the yield the water-content of the dried grains must correctly be measured. For the purpose, grind a part of dried grains with the above-mentioned grinder and then take 10 g of ground grains as a sample and dry the sample again for 10 minutes with the infrared lamp, and you will be able to make any sample dry up to 0.5% in its water-content.

Knowing how much weight is reduced by drying from the sample of 10 g, you can calculate the water-content of the sample grains. Further, from the weight and the water-content of fully ripened dry-grains you can easily calculate the actual yield of a field under investigation.

For the sake of saving the calculation labor, a ready reckoner has been made on the basis of the weight of fully ripened dry-grains and the reduced weight of the sample grains of 10 g, though the yield in the chart must be corrected by the spacing density of the field under investigation.

Anyway, it should be noted that the "Yield diagnosis apparatus" makes it possible automatically in the progress of investigation to know the number of panicles per unit area, the number of spikelets per panicle, the percentage of ripened grains and the weight of 1,000 grains (or kernels), and furthermore, if it is desired, to know the number of degenerated spikelets and the percentage of non-fertilized grains, and finally, as a result of it, to point out the defects and merits in the cultivation method practiced on the field under investigation as shown in the author's book[1] (p. 317). (The apparatus is manufactured and on sale at Marui Co., Moriya-cho, Soma-gun, Ibaragi Prefecture, Japan.)

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