PALAY CROP-CUTTING SURVEY*

by

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This paper is concerned with the estimation of the rice production in two provinces: Camarines Sur and Iloilo. The Barrios in Camarines Sur were grouped into 4 strata and those of Iloilo into 6 strata according to the estimated second crop areas. The grouping is as shown below.

TABLE I

CAMARINES SUR (cp. 60106)
PALAY CROP-CUTTING SURVEY
BARRIO GROUPING

Stratum	Reported Palay Area (hectares)		Barrio Number	
	Total	Range/barrio	Total	Sample
I	1,485	0 — 49	61	5
II	3,175	50 — 90	51	11
III	3,650	100 — 199	30	13
IV	4,385	200 & Over	15	14
Total	12,695		157	43

The number of sample barrios in Camarines Sur (Table 1) and Iloilo (Table 2 below) were allocated among the different strata according to the total second crop area in the stratum. Thus the number of sample barrios taken from stratum I of Camarines Sur had been determined to be $\frac{1,485 \times 43}{12,695} = 5$ barrios.

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TABLE 2

ILOILO (cp. 60106)
PALAY CROP-CUTTING SURVEY
BARRIO GROUPING

Stratum	Reported Palay Area (hectares)		Barrio Number	
	Total	Range/barrio	Total	Sample
I	4,361	0 — 49	194	8
II	8,486	50 — 99	68	15
III	2,465	100 — 149	22	4
IV	2,455	150 — 199	16	4
V	5,610	200 — 299	25	10
VI	2,640	300 & Over	7	4
Total	26,017		332	45

Estimates of mean yields are made for each of the different strata and those weighted by the strata second crop areas to detemine the yield in the province. By the technique of analysis of variance(on plot basis), estimates of variability of mean yield per plot, which are later converted into estimates variability of mean yield in kilograms per hectare, are made for between farms, between barrios and for the strata. The estmates stratum variances are then used to estimate the variability of mean yield in the province.

ANALYSIS OF DATA

Estimation of Yield

The sun-dried weights of the harvested palay from the sample plots were used in estimating the yield in order to eliminate from the estimate the moisture content of the fresh grains. The arithmetic mean of the plot yields was taken within each

stratum. Thus

$$\bar{x}_r = \frac{1}{bpf} \sum_{i=1}^{b} \sum_{j=1}^{f} \sum_{k=1}^{p} x_{rijk}; \qquad \begin{matrix} k = 1, 2, \ldots, p \\ j = 1, 2, \ldots, f \\ i = 1, 2, \ldots, b \end{matrix}$$

where x_{rijk} denotes the plot yield from the kth plot, jth farm and ith barrio of the rth stratum; p is the number of sample and ith barrio of the rth stratum; p is the number of sample plots in a sample farm; f is the number of sample farms in a sample barrio, and b is the number of sample barrios in the rth stratum. The mean here obtained is the mean yield in grams per plot as the data collected are in grams.

The mean yield per plot for the province is obtained by taking the weighted mean for the different strata. The weights used were the total second crop area of the strata. Thus in Camarines Sur, the mean yield x per plot (in grams) was computed by using

$$\bar{x} = \frac{1{,}485\,\bar{x}_1 + 3{,}175\,\bar{x}_2 + 3{,}650\,\bar{x}_3 + 4{,}385\,\bar{x}_4}{12{,}695}$$

$\bar{x}_1$, $\bar{x}_2$, $\bar{x}_3$ and $\bar{x}_4$ are the four strata mean yield in grams per plot. This mean yield in grams per plot for the province was converted into kilograms per hectare by introducing the multiplier $\frac{10{,}00}{5 \times 1{,}000}$ or 2. The same procedure was repeated The same procedure was repeated for Iloilo to estimate the mean yield for the province.

Variances of Estimates of Mean Yields in the Strata

A three-stage sample was used in the experiment within each of the strata. A simple random sample, without replacement, of barrios was chosen from each stratum; within the chosen barrios, farms were chosen by simple random sampling

without replacement, and within the selected farms, the experimental plots were chosen.

Suppose that the yield of the kth plot in the jth farm in the ith barrio of the rth stratum be denoted by x_{rijk}. Then the model is represented as

$$x_{rijk} = \mu_r + u_{ri} + v_{rij} + w_{rijk}$$

where u_r represents the general mean yield in the rth stratum, u_{ri} the component of variation associated with the barrios in the rth stratum, v_{rij} the component variation associated with the farms in the ith barrio of the rth stratum, and w_{rijk} that component associated with the experimental plots within the jth farm in the ith barrio of the rth stratum. The components u_{ri}, v_{rij} and w_{rijk} are all assumed to be independently distributed with means zero and variances S_b^2 S_v^2 and S_w^2 respectively.

If B denotes the total number of barrios with farms planted to second crop rice, F the average number of farms in a barrio, A the average area of the farms in square meters in the sample, then the variance of the mean yield per plot (of 5 square meters area) in the rth stratum takes the form:

$$(1)\quad V(\bar{x}_r) = \left(\frac{B - b}{B}\right) \cdot \frac{S_b^2}{b} + \left(\frac{BF - bf}{BF} \cdot \frac{S_f^2}{bf}\right. + \left(\frac{BFA - bfa}{BFA}\right) \cdot \frac{S_p^2}{bfp}$$

But, since the area of the sample plot is only 5 square meters, compared to the average area of the farms, it may be considered negligible; hence, the above variance may be written as

$$V(\bar{x}_r) = \left(\frac{B - b}{B}\right) \cdot \frac{S_b^2}{b} + \left(\frac{BF - bf}{BF}\right) \cdot \frac{S_f^2}{bf} + \frac{S_p^2}{bpf}$$

The sample analysis of variance on plot basis, therefore, takes the form

Sources of Variation	d.f.	Mean Squares	E(M.S.)
Between barrios	$b-1$	s_b^2	$S_p^2 + p S_f^2 + pf S_b^2$
Between farms, within Barrios	$b(f-1)$	s_f^2	$S_p^2 + p S_f^2$
Between plots, within farms, within barrios	$bf(p-1)$	s_p^2	S_p^2
Total	$bfp-1$		

The estimates of the various population mean squares may be obtained from the analysis of variance table. Thus S_p^2 is estimated by s_p^2; S_f^2 is estimated by $\frac{s_f^2 - s_p^2}{p}$ and S_b^2 is estimated by $\frac{s_b^2 - s_f^2}{pf}$.

To get an estimate therefore of $V(\bar{x}_r)$ as given in (i), we substitute these estimates of S_p^2, S_f^2 and S_b^2 in (1). Thus, an estimate of $V(x_r)$, which will be denoted by $v(\bar{x}_r)$, is given by

$$v(\bar{x}_r) = \left(\frac{B-b}{Bb}\right) \cdot \left(\frac{s_b^2 - s_f^2}{pf}\right) + \left(\frac{BF-bf}{BF \cdot bf}\right)\left(\frac{s_f^2 - s_p^2}{p}\right) + \frac{s_p^2}{bfp}$$

or

$$v(\bar{x}_r) = \frac{B-b}{Bb} \cdot \frac{s_b^2}{pf} + \frac{F-f}{BF\ pf} s_f^2 + \frac{s_p^2}{BFP}$$

or

$$(2)\quad v(\bar{x}_r) = \frac{1}{bpf}\left[\frac{B-b}{B}\cdot s_b^2 + \frac{F-f}{f}\cdot\frac{b}{B}s_f^2 + \frac{bf}{BF}\cdot s_p^2\right],$$

where

$$s_b^2 = \sum_{i=1}^{b} fp(\bar{x}_{ri..} - \bar{x}_r)^2 \Big/ (b-1)$$

$$s_f^2 = \sum_i \sum_j p(\bar{x}_{rij.} - \bar{x}_{ri..})^2 \Big/ b(f-1)$$

$$s_p^2 = \frac{\sum_i \sum_j \sum_k (x_{rijk} - \bar{x}_{rij.})^2}{bf(p-1)}.$$

Here

$\bar{x}_{ri..}$ ≡ **the mean yield per plot in the ith barrio, rth stratum.**

$\bar{x}_{rij}$ ≡ **the mean yield per plot in the jth farm, ith barrio,**

$\bar{x}$ ≡ **the mean yield per plot in the rth stratum.**

If the sampling fraction is small, $\frac{F-f}{f}$ **may be taken as unity. Hence (2) may be written as**

$$v(\bar{x}) = \frac{1}{bpf}\left[\frac{B-b}{B}s_b^2 + \frac{b}{B}s_f^2 + \frac{b}{B}s_p^2\right].$$

Following the form of the analysis of variance table presented above, we have the following "Analysis of Variance" tables for each of the strata in Camarines Sur and Iloilo.

TABLE 3

ANALYSIS OF VARIANCE
(SAMPLE PLOTS OF SQ. METERS)
CAMARINES SUR

Sources of Variation	d.f.	Sum of Squares (grams)^2	(grams)^2 Mean Squares
		STRATUM I	
Between barrios	4	3,213,968.4828	803,492.1207
Between farms, within barrios	5	471,943.7856	94,388.7571
Between plots, within farms, within barrios	10	143,383.2598	14,388.3260
T o t a l	19	3,829,295.5282	
		STRATUM II	
Between barrios	10	31,277,512.6704	3,127,751.2670
Between farms, within barrios	11	3,029,345.8336	275,395.0757
Between plots, within farms, within barrios	22	4,570,877.3200	207,767.1509
T o t a l	43	38,877,735.8240	
		STRATUM III	
Between barrios	12	7'903,657.7672	658,638.1473
Between plots, within farms,	13	1,026,057.5656	78,927.5050
Between plots, within farms, within barrios	26	300,190.4322	11,545.7858
T o t a l	51	9,229,905.7650	
		STRATUM IV	
Between barrios	13	51,711,834.7096	3,977,833.4392
Between farms, within barrios	14	1,199,621.3668	85,687.2045
Between plots, within farms, within barrios	28	738,363.0476	26,370.1088
T o t a l	55	53,649,819.1240	

TABLE 4
ANALYSIS OF VARIANCE
(SAMPLE PLOTS OF SQ. METERS)
ILOILO

Sources of Variation	d.f.	Sum of Squares (grams)^2	Mean Squares (grams)^2
		STRATUM I	
Between barrios	5	2,307,465.9204	461,493.1841
Between farms, within barrios	6	288,403.1560	48,067.1927
Between plots, within farms, within barrios	12	220,547.4950	18,378.9579
T o t a l	23	2,816,416.5714	
		STRATUM II	
Between barrios	14	7,197,674.6780	514,119.6199
Between farms, within barrios	15	1,300,282.8448	86,685.5229
Between plots, within farms, within barrios	30	4,137,130.3862	143,904.3462
T o t a l	59	12,815,087.9090	
		STRATUM III	
Between barrios	3	192,146.9036	64,048.9679
Between farms, within barrios	4	170,144.6184	42,536.1546
Between plots, within farms, within barrios	8	486,396.3512	60,799.5439
T o t a l	15	848,687.8732	
		STRATUM IV	
Between barrios	3	808,920.9480	269,640,3280
Between farms, within barrios	4	376.201.2784	94,050.3196
Between plots, within farms, within barrios	8	471.176.6594	58,897.0824
T o t a l	15	1,656,298.9218	
		STRATUM V	
Between barrios	9	1,441,585.8648	160,176.2072
Between farms, within barrios	10	1,241,065.2448	124,106.5245
Between plots, within farms, within barrios	20	1,176,637.9630	58,831.8981
T o t a l	39	3,859,289.0726	
		STRATUM VI	
Between barrios	3	427,264.2776	142,421.4259
Between farms, within barrios	4	257,766.8944	64,441.7236
Between plots, within farms, within barrios	8	346,814.9168	43,351.8646
T o t a l	15	1,031,846.0888	

Variance of Etimates of Mean Yields in the Two Provinces

By weighting the strata mean yields by the second crop areas of the strata, an estimate of the mean yield for the province was obtained. Thus for Camarines Sur, the mean yield in grams per plot was obtained by using the formula

$$\bar{x} = \frac{w_1\bar{x}_1 + w_2\bar{x}_2 + w_3\bar{x}_3 + w_4\bar{x}_4}{w_1 + w_2 + w_3 + w_4},$$

where w_1, w_2, w_3, w_4 are the second crop areas in hectares in the first, second, third and fourth strata, respectively.

From the above relation, therefore, the estimate of the variance of the estimate of the mean yield for Camarines Sur was obtained as

$$v(\bar{x}_r) = \frac{w_1^2 v(\bar{x}_1) + w_2^2 v(\bar{x}_2) + w_3^2 v(\bar{x}_3) + w_4^2 v(\bar{x}_4)}{(w_1 + w_2 + w_3 + w_4)^2}$$

where $v(x_1)$, $v(x_2)$, $v(x_3)$ and $v(x_4)$ are the estimates of the variances of the mean yields for the first, second, third and fourth strata, respectively. Applying this formula, therefore, the variance of the estimate of the mean yield in grams per plot for Camarines Sur is estimated to be 37,327.2083 $(\text{grams})^2$/plot.

Following the same procedure, to estimate the variance of the estimate of mean yield for Iloilo, Table 5 shows the estimates of these variances together with the estimates of the variance of the estimate of the mean yields for the strata and and for different units at the three sampling stages.

TABLE 5
ESTIMATES OF VARIANCE OF MEAN YIELDS

Provinces	Estimate of Variances of mean Yield in (grams)^2/ plot	Standard Error of Estimate	Estimate of Variances of mean Yield in (kgs.)^2/ha.	Standard Error of Estimate kgs./ha.	Mean Yield in kgs./ha.	Coeff. of Variation $\frac{SE}{\bar{x}} \times 100$
I. CAMARINES SUR			22,358.7177	149.5283	1,637.1350	9.13
Stratum I	37,327.2083	193.2025	149,308.8332	386.4050	1,549.0670	24.94
Between barrios	35,455.1682	188.2954	141,920.6728	376.5909	6,196.2680	6.08
Between farms, within barrios	4,002.5215	63.2655	16,010.0860	126.5310		
Between plots. within farms, within barrios	716.9163	26.7753	2,867.6652	53.5506		
Stratum II	58,121,5843	241.0842	232,486.3372	482.1684	1,908.4650	25.26
Between barrios	64,826.2771	254.6100	259,305.1084	509.2201	7,633.8600	6.67
Between farms, within barrios	1,536.9983	39.2046	6,147.9932	78.4091		
Between plots. within farms, within barrios	4,721.9807	68.7167	18,887.9228	137.4333		
Stratum III	7,931.4111	89.0585	31,725.6444	178.1169	1,307.0272	13.63
Between barrios	11,148.2816	105.5854	44,593.1264	211.1708	5,228.1092	4.04
Between farms, within barrios	1,295.8023	35.9972	5,183.2092	71.9945		
Between plots. within farms, within barrios	222.0343	14.9008	888.1372	29.8016		
Stratum IV	6,603.1385	81.2596	26,412.5540	162.5194	1,745.2768	9.31
Between barrios	69,502.6107	263.6335	278,010.4428	527.2670	6,981.1072	7.55
Between farms, within barrios	1,059.2345	32.5459	4,236.9380	65.0918		
Between plots. within farms, within barrios	470.8948	21.7001	1,883.5792	43.4002		
II. ILOILO			6,564.2236	81.0198	1,750.9886	4.63
Stratum I	13,912.5808	117.9516	55,650.3232	235.9032	1,276.0484	18.49
Between barrios	17,226.0830	131.2482	68,904.3320	262.4963	5,104.1934	5.14
Between farms, within barrios	1,237.0098	35.1711	4,948.0392	70.3423		
Between plots. within farms, within barrios	765.7899	27.6729	3,063.1596	55.3458		

TABLE 5 (Continued)

Provinces	Estimate of Variances of mean Yield in (grams)^2/ plot	Standard Error of Estimate	Estimate of Variances of mean Yield in (kgs.)^2/ha.	Standard Error of Estimate kgs./ha.	Mean Yield in kgs./ha.	Coeff. of Variation $\frac{SE}{\bar{x}} \times 100$
II. ILOILO (Continued)						
Stratum II	7,526.2715	86.7641	30,105.0860	173.5082	2,102.3666	8.25
Between barrios	7,123.9016	84.4032	28,495.6064	168.8064	8,129.1506	2.08
Between farms, within barrios	953.6470	30.8812	3,814.5880	61.7623		
Between plots. within farms, within barrios	2,398.4058	47.9735	9,593.6232	97.9470		
Stratum III	4,449.5006	66.7046	17,798.0024	133.4091	1,603.9738	8.32
Between barrios	1,344.5508	36.6681	5,378.2032	73.3362	6,415.8950	1.14
Between farms, within barrios	1,141.4618	33.7855	4,565.8472	67.5710		
Between plots. within farms, within barrios	2,398.4058	47.9735	9,593.6232	97.9470		
Stratum IV	15,029.1935	122.5936	60,116.7740	245.1872	1,709.8226	14.34
Between barrios	10,794.3755	103.8960	43,897.5020	209.5173	6,839.2900	3.06
Between farms, within barrios	2,197.0773	46.8730	8,788.3092	93.7460		
Between plots. within farms, within barrios	3,681.0676	60.6718	14,724.2704	121.3436		
Stratum V	4,232.0273	65.0540	16,928.1092	130.1081	1,660.0790	7.84
Between barrios	901.7421	30.0290	3,606.9684	60.0580	6,640.3160	.90
Between farms, within barrios	1,631.8657	40.3964	6,527.4628	80.7928		
Between plots. within farms, within barrios	1,470.7974	38.3510	5,883.1896	76.7019		
Stratum VI	7,664.6306	87.5479	30,658.5224	175.0957	1,774.8050	9.86
Between barrios	4,873.7314	69.8121	19,494.9256	139.6242	7,099.2200	1.97
Between farms, within barrios	1,318.1162	36.3059	5,272.4648	72.6117		
Between plots. within farms, within barrios	2,709.4915	52.0528	10,837.9660	104.1055		

Averegae Yields and their Precisions

Camarines Sur. The average yield ranges from about 360 kilograms per hectare to about 8,265 kilograms per hectare with a mean of about 1,637 kilograms per hectare and median of about 1,107 kilograms per hectare. A study of Table 7 reveals that about 10 per cent of the sample barrios had an average mean yield of less than or equal to 500 kilograms per hectare, about 27 per cent of the sample barrios had an average mean yield of 500 — 1,000 kilograms per hectare or about 47 per cent of all the sample barrios had an average mean yield of less than or equal to 1,000 kilograms per hectare. About 16 per cent of the sample barrios had an average mean yield between 100 — 1,500 kilograms per hectare or about 63 per cent of all sample barrios had an average mean yield of less than or equal to 1,500 kilograms per hectare. About 12 per cent of sample barrios had an average mean yield between 1,500 — 2,000 kilograms per hectare or about 74 per cent of the whole sample barrios had an average mean yield of less than or equal to 2,000 kilograms per hectare. About 26 per cent of sample barrios had average mean yield of more than 2,000 kilograms per hectare.

Table 6 shows the precision attained in each stratum. Among the four strata into which the province is divided, the highest precision achieved is about 9 per cent in stratum IV and the lowest is about 25 per cent in stratum II and stratum III.

Iloilo. The average yield ranges from about 303 kilograms per hectare to about 3,289 kilograms per hectare, with a mean of about 1,751 kilograms per hectare and median 1,716.6667 kilograms per hectare. A study of Table 7 reveals that about 5 per cent of the sample barrios have average mean yield of less than or equal to 500 kilograms per hectare; about 5 per cent of sample barrios had average mean yields below 1,000 kilograms per hectare. About 26 per cent of sample barrios had average mean yield between 1,000.0001 — 1,500 kilograms per hectare or about 35 per cent of sample barrios had average mean yield of 500 — 1,500 kilograms per hectare. About 35 per cent of the sample barrios had average mean yield of

1,500.0001 — 2,000 kilograms per hectare or about 70 per cent of the sample barrios had average mean yield below 2,000 kilograms per hectare. About 30 per cent of the sample barrios had average mean yield above 2,000 kilograms per hectare.

The mean yields for the 6 strata in Iloilo range from 1,276 kilograms per hectare to about 2,102 kilograms per hectare. A look at Table 6 shows the precision attained in each stratum. Among the six strata into which the province is divided, the highest precision achieved is about 8 per cent in stratum V and the lowest is about 18 per cent in stratum I.

TABLE 6

ESTIMATES OF MEAN YIELDS AND STANDARD ERRORS OF ESTIMATES

Province	Reported Palay Area (ha.)	Estimated Mean Yield in kg. ha.	Standard Error of Mean Yield	Coefficient of Variation
CAMARINES SUR	12,695	1,637.1350	149.5283	9.13
Stratum I	1,485	1,549.0670	386.4050	24.94
Stratum II	3,175	1,908.4650	482.1684	25.26
Stratum III	3,650	1,807.0272	178.1169	13.63
Stratum IV	4,385	1,745.2768	162.5194	9.31
ILOILO	26,017	1,750.9886	81.0198	4.61
Stratum I	4,361	1,276.0484	235.9020	18.49
Stratum II	8,486	2,102.3666	173.5082	8.25
Stratum III	2,465	1,603.9738	133.4091	8.32
Stratum IV	2,455	1,709.8226	245.1872	14.34
Stratum V	5,610	1,660.0790	130.1081	7.84
Stratum VI	2,640	1,774.8050	175.0957	9.86

TABLE 7

RELATIVE FREQUENCY (%) OF MEAN YIELDS IN KGS./HA.

Mean Yields in kgs./ha.	Camarines Sur			Iloilo		
	Freq.	Relative Frequency	Cumulative Frequency	Freq.	Relative Frequency	Cumulative Frequency
500 and below	4	9.30	9.30	2	4.65	4.65
500.0001 -- 1,000	16	37.21	46.51	2	4.65	9.30
1,000.0001 -- 1,500	7	16.28	62.79	11	25.58	34.88
1,500.0001 -- 2,000	5	11.63	74.42	15	34.89	69.77
Above 2,000	11	25.58	100.00	13	30.23	100.00
T o t a l	43	100.00		43	100.00	

It appears from the results of the study that Iloilo has a greater yield per hectare than Camarines Sur; the former has a mean of about 1,751 kilograms per hectare with a standard error of about 80 kilograms per hectare while Camarines Sur has a mean yield of about 1,637 kilograms per hectare with a standard error of about 150 kilograms per hectare. The mean yields are more scattered for Camarines Sur than those for Iloilo. The greater mean yield in Iloilo could be accounted for by the irregation projects started in the province recently.

Comparison of Mean Yields

Application of Bartlett's test for homogeneity of variances of the 4 strata into which Camarines Sur is divided shows that the 4 strata differ highly in their variances.

However, by the application of the F-test, the variances of the following strata were found not to be significantly different at the 5 percent significance level:

Camarines Sur: Strata I and II
Strata III and IV

On the basis of these findings and assuming that the mean yields are approximately normal, the t-test was used to compare the mean yields of the above strata.

To illustrate, on the basis of the null hypothesis that the mean yields of strata I and II of Camarines Sur are equal, the t-statistic is given as

$$t = \frac{\bar{x}_1 - \bar{x}_2}{S_{\bar{x}_1 - \bar{x}_2}}$$

where $\bar{x}_1$ and $\bar{x}_2$ are the estimates of the mean yields of strata I and II, respectively and $S_{\bar{x}_1 - \bar{x}_2}$ is the estimate of the standard error of $(\bar{x}_1 - \bar{x}_2)$. The estimate of the standard error of $(\bar{x}_1 - \bar{x}_2)$ is obtained by using the formula

$$S_{\bar{x}_1 - \bar{x}_2} = \sqrt{\frac{N_1 S_1^2 + N_2 S_2^2}{N_1 + N_2}\left[\left(\frac{1}{n_1}\right) + \left(\frac{1}{n_2}\right)\right]}$$

where S_1^2 and S_2^2 are the estimates of the variances of the estimates of the mean yields for strata I and strata II, respectively and N_1 and N_2 are corresponding degrees of freedom, n_1 and n_2 are the total number of plots in strata I and II, respectively.

Here S_1^2 and S_2^2 are obtained from the analysis of variance tables with $N_1 = 10$ and $N_2 = 22$.

Substituting the values of these in the above formula, we can get $S_{\bar{x}_1 - \bar{x}_2} = 122.5467$.

$$\bar{x}_1 = 1{,}549.0670; \quad \bar{x}_2 = 1{,}908.4650$$

Hence

$$t = \frac{1{,}908.4650 - 1{,}549.0670}{122.5467}$$

$$t = \frac{359.3980}{122.5467} = 2.9327$$

$$t_{22.05 \text{ d.f.}} = 1.695.$$

Therefore it can be seen that the mean yields of these two strata differ significantly.

Applying the same test to stratum III and stratum IV it was also found that the mean yields differ significantly.

Using the t-test, the mean yield of strata II and VI, I and IV differ significantly at 5% level.

Summary of Results

The paper attempted to make estimates of palay mean yield per hectare in two provinces: Camarines Sur in Luzon and Iloilo in the Visayas. The average yield for stratum was obtained as the sample arithmetic mean of the yields within the selected farms, within selected barrios which are within the stratum. The strata means were then conbined in proportion to the second palay crop areas to give the mean yield for the province. The mean yield in grams per plot (measuring 5 square meters in area) were then converted to kilograms per hectare by using the multiplier $\frac{10{,}000}{5 \times 1{,}000}$ or 2.

The sampling error of the mean yield for the stratum was estimated from the analysis of variance table. This sampling error provides an index of accuracy of the mean yield estimates and that broadly the chances are one in twenty that the unknown actual yield does not differ from the estimated yield by a margin exceeding twice the sampling error.

The average yield in kilograms per hectare in the 4 strata of Camarines Sur is about 1,300 kilograms per hectare in stratum III to about 1,900 kilograms per hectare in stratum I

to about 2,100 kilograms per hectare in stratum II. The variability of the mean yields of the 14 barrios in stratum IV of Camarines Sur is the greatest among the four strata of the province with a range of mean yields equal to about 7,905 kilograms per hectare, with a mean of about 1,745 kilograms per hectare. Stratum II in the same province, with 11 barrios and with a mean yield of about 1,908 kilograms per hectare, has a range of barrio mean yields equal to about 2,300 kilograms per hectare.

In Iloilo, among the 6 strata, stratum II with 15 barrios and with a mean yield of about 2,102 kilograms per hectare appears to have the greatest variability; the range of the barrio mean yields being equal to 2,985 kilograms per hectare; stratum III, with 4 barrios and with a mean yield of about 1,604 kilograms per hectare, appears to have the least variability with a range of about 610 kilograms per hectare. The coefficients of variation for the four strata of Camarines Sur as indicated in Table 6 range from 9.13 to 25.26.

Camarines Sur has an estimated mean yield of about 1,637 kilograms per hectare with a standard error of about 150 kilograms per hectare. That means that the chances are 1 to 20 that the unknown actual mean yield in the province is between 1,343 kilograms per hectare and 1,931 kilograms per hectare. Iloilo has an estimated mean yield of approximately 1,751 kilograms per hectare with a standard error of about 81 kilograms per hectare.

Status of Crop-Cutting in the Philippines

Crop-cutting as an objective method of estimation is still at its "infant" stage in the Philippines. The palay-cutting experiment started by the A.E.D., D.A.N.R. during the fiscal year 1959-1960 was just a pilot project. As far as the writer is aware, the results and anlysis of the result of this project are to date not yet available; so, the presentation of the results and analysis of the results of Camarines Sur and Iloilo is the first to be made. Perhaps using the same methods of estimation

described in this paper, estimate of mean yields and their precision in the other provinces can be made.

It is the belief of the writer that there is still a long way to go before crop-cutting as an objective method of crop estimation will be adopted in the Philippines. It is a stupendous undertaking not to mention the considerable research to be done in the sampling techniques to be used for more precise yield estimates. As can be noted in Table 6, the precisions of the estimates are very low, ranging from 9.31 to 25.26% for Camarines Sur and 7.84 to 18.49% for Iloilo. Much have to be done along crop-cutting before judgement can be passed on the necessity and feasibility of adopting crop-cutting as an objective method for obtaining production data in the Philippines.

Conclusion and Recommendations

The importance of crop forecasting cannot be overemphasized. Accurate crop forecasts are useful to the consumers and to those engaged in trade since such forecasts greatly help to stabilize prices and facilitate trade operations. Their importance to the administration is obvious as such forecasts are used in decisions on matters of food policy, particularly under present conditions when it is an issue whether or not to import so much of rice and corn.

In view of the importance of crop forecasts, particularly rice and corn, estimates of mean yield from year to year should be precise. Therefore attempts should be made by all those concerned to improve the precision of the estimates made of mean yields.

As noted in the result of the crop-cutting experiment in Camarines Sur and Iloilo, the precision achieved is very low. This low precision may be due to the inadequate scale of ex-

perimentation, to the wide variability of the sizes of the farms, the sampling techniques used and the absence of ancillary information that could be used in the estimates.

Precision in the experiment could be improved by increasing the scale of experimentation. More barrios could be taken to improve the precision of the mean yield estmate. However, owing to inadequate transportation facilities between barrios, this would introduce more administrative difficulties and would cost more time and money, as it is not practicable to visit more than one barrio during the day. Perhaps, due to wide variations in the size of the farms, more farms should be taken in each barrio. However, before definite plans of action can be followed along this line, information on sizes of farms in each barrio should be taken in order to have an idea to what extent this source of variation dominates the sampling variance of estimates.

The method of farm to farm enumeration for obtaining acreage statistics depends on adequate and effective supervision. At present this does not seem feasible for lack of funds and lack of trained personnel. But, since it is very important to have acreage measures, random sampling of farms for obtaining acreage as an interim measure may be resorted to. For, desirable as it is to aim at complete statistics of acreage, the surveying of unsurveyed areas and the setting up of the necessary agency for complete enumeration would be both costly.

In addition to acreage, perhaps it would help in improving precision of estimates of mean yields if such other information as manuring, irrigation, use of improved seeds, crop rotation and soil type are taken. Having information on these agricultural practices, the survey designers may be guided in the use of an appropriate sample design.

A large bias may have been intrdouced in the estimates by the technique used in the choice of experimental plots within

chosen farms in the exepriment. The scheme of randomly selecting points along the largest diagonal of a chosen parcel of selected farms gives zero probability to the non-diagonal points of the parcels to be chosen for the sample. A scheme should be devised whereby as much as possible all points of a chosen parcel should have equal probability of being selected as a corner or center of the sample plot.

Further lines of work will yet have to be done in determining the most efficient sampling design to use. For example, the efficiency of stratification relative to one without stratification has yet be determined, how farms for the sample have to be allocated to the barrios, optimum allocation of the sampling units at the different stages of sampling have yet to be determined.