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EVALUATION OF SAMPLING TECHNIQUES IN ASSESSING RAT DAMAGE TO CORN

M. M. HOQUE, E. A. BENIGNO, F. G. PALIS and J. L. OLVIDA

Funded by the National Crop Protection Center, College of Agriculture, University of the Philippines at Los Baños, College, Laguna.

Researchers and Research Associate, respectively, National Crop Protection Center, College of Agriculture, University of the Philippines at Los Baños, College, Laguna.

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Three sampling methods: random (1 row x 1 hill), strip systematic (2 rows x 5 hills) and modified stratified quadrat (5 rows x 5 hills) were evaluated for rat damage appraisal in corn. The objective was to find out the most efficient sampling technique in terms of precision, least cost, least effort in the field and time spent in damage appraisal. The three methods had equal estimation of damage statistically, but strip systematic sampling method was found to be the most efficient.

INTRODUCTION

To completely assess corn losses due to rats two methods have been developed. The first one dealt with the determination of the extent of grain loss on individual damaged ears (Sanchez et al., 1975; dela Paz, 1975; De Grazio et al., 1969) and the second with the determination of the proportion of ears having at least some damage in the field (Benigno, 1980). Benigno's (1980) study showed that stratified random sampling of quadrat (i.e., five rows by five hills) is suitable for corn. The cornfield is stratified into left (20 leftmost rows) middle, and right strata (20 rightmost rows) from which the random quadrat samples were taken in a proportion of 1:4:1. Stratification was based on the observed clumped distribution of rat damage in cornfield periphery (Benigno, 1980).

Stratified sampling, however, is impractical and time-consuming for field use except when two people work together. It is also difficult to keep track of the boundaries of the 5 x 5 quadrats. Moreover, this method is not feasible if the objective of the appraisal is on a widescale estimation of national losses due to rats.

The most efficient sampling technique in terms of precision, least cost, least effort in the field and time spent, could then be selected for use in a nationwide rat damage survey. This study therefore was conducted to evaluate alternative sampling methods that are practical for field use.

MATERIALS AND METHODS

Two one-half hectare cornfields planted to UPCA Var 1 at barrio Wawa, Lumban, Laguna were appraised for rat damage one week before harvest. The opposite sides of plot 1 were adjacent to the cornfield, other sides to strip of bush sitao and riverbank. Plot 2 has two sides adjacent to corn, and the other sides to squash crops and the riverbank. There were about 10,500 hills for each plot with planting distances of 75 cm x 50 cm. All agronomic practices for corn culture were the same in both plots.

Five percent of the total number of hills were sampled for ratio damage using random, and random quadrat and 5.7% for strip systematic method. Each sampling method was performed twice for the two plots. The time spent and number of people who did the sampling were recorded. Complete counts of corn plants damaged in both plots were also conducted to compare actual damage and the estimated damage using the three estimators.

For sample hills with rat damage, the following data were recorded: length of the damaged ear from the base to the tip with kernels, average length of damage, width of damage and the type of damage inflicted. Two types of rat damage in corn were described: strip when missing kernels are on one side of the cob and circular when missing kernels are around the cob. For circular damage, length of damage was the average of the shortest and the longest length of damage. For the strip damage, the length of damaged ear was measured and the length and the width of cob with missing kernels were also measured.

The amount of grain loss in g/damaged ear was determined by using the equations derived by Sanchez et al. (1975) For the strip type: Y = 0.27 + 0.64 X; where X = the size of damage in cm^2 ; Y = weight of shelled corn in g. Table 1 shows the regression equations used to estimate losses in damaged ears in this study.

Three sampling methods were evaluated in assessing rat damage to corn: simple random, stratified quadrat, and strip systematic.

In the simple random sampling method, the hills in 23 random hills and 23 random rows were examined, this was equivalent to 525 sample hills examined for rat damage. The damaged proportion was estimated by the equation.,

$$p = \frac{\Sigma f_i x_i}{\Sigma f_i}$$

where p = damage proportion

f_i = frequency of hills with damage
x_i = damage class (x_i = 0, 1, 2, 3, . . . damaged ears)

the variance was computed as

$$s^2 = \frac{pq}{n}$$

where q = 1—p
n = total sample hills
p = damage proportion

Table 1. Regression equations and coefficients of determination showing the relationship between size of circular and strip types of simulated damage and weight of shelled corn. Ears were taken from a field near Nauhan, Mindoro (from RRC 1975 Annual Report).

Type of Damage	Class	Ear Length (cm)	Inches	Regression Equation (Y = a + bX)	r^2
Circular	2	8.89-10.15	3.5-4.0	- 2.26 + 4.15X	0.95
	3	10.16-11.42	4.0-4.5	- 2.12 + 4.72X	0.89
	4	11.43-12.69	4.5-5.0	- 4.15 + 5.45X	0.92
	5	12.70-13.96	5.0-5.5	- 6.48 + 5.90X	0.97
	6	13.97-15.23	5.5-6.0	- 9.75 + 6.77X	0.90
	7	15.24-16.60	6.0-6.5	-10.00 + 6.57X	0.97
Strip	2	8.89-10.15	3.5-4.0	- 0.36 + 0.68X	0.93
	3	10.16-11.42	4.0-4.5	- 0.53 + 0.69X	0.94
	4	11.43-12.69	4.5-5.0	- 0.38 + 0.69X	0.94
	5	12.70-13.96	5.0-5.5	- 0.32 + 0.61X	0.95
	6	13.97-15.23	5.5-6.0	- 0.22 + 0.64X	0.93
	7	15.24-16.50	6.0-6.5	- 0.95 + 0.63X	0.92
	2-7	8.89-16.50	3.5-6.5	- 0.27 + 0.64X	0.93

Y = weight of shelled corn in g at 14% moisture content; X = length of corn damage in cm.

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A modified stratified quadrat sampling was used as the field did not permit stratification into left, middle and right strata as described by Benigno (1980). The total 525 sample hills were divided by 25 to determine the number of 5 x 5 quadrats. The rows were grouped into five consecutive rows and hills (5 rows x 5 hills) which comprised a quadrat. A total of 21 random quadrats of 525 hills were examined per plot. The proportion of damaged hills in each quadrat was,

$$p_j = \frac{\Sigma f_j x_j}{\Sigma f_j} \qquad \text{Eqn. 1 where}$$

p_j = the proportion of hills with damage in the jth quadrat
f_j = frequency of hills with damaged ears in the jth quadrat
j = 1, 2, . . . 25 quadrats

x_j = damage class in the jth quadrat (x_j = 0, 1, 2, . . . damaged ears). The mean damage was,

$$\bar{p} = \frac{\Sigma p_j}{n} \qquad \text{Eqn. 2 where}$$

n = number of quadrats (21 quadrats)
p_j = mean damage

The variance was computed as,

$$S^2 = \frac{\Sigma(p_j - \bar{p})^2}{n - 1}$$

Both mean and variance were computed accordingly (Cochran, 1963).

In the strip systematic sampling method, a 2 row by 5 hill (2 x 5) strip sample or a total of 600 hills were examined. The first 2 x 5 sample strip was chosen by random and other samples were taken at fixed interval thereafter. The interval between strips in the row was determined by the following relationship

$$K_n = \frac{N}{n}$$

where K_n = interval between strips
N = total hills in the plot
n = sample hills

K_n, number of hills skipped between sample strips for both plots, was 20. The total sample strip (S_t) per row was obtained by the equation,

$$S_t = \frac{T_n}{K_n + 5} \quad \text{where}$$

S_t = sample strip per row
T_n = total hills in the row
K_n = interval between strips
5 = size of strip

About 70 sample hills equivalent to 7 strips for each double row were examined at each passing. The sample rows were determined by the following equation

$$K_r = \frac{n}{S_t} \quad \text{where}$$

K_r = interval between rows (e g. $r_1 = 9$, $r_2 = 9$ . . . etc.)
S_t = sample strips per row

The damage proportion for each strip and the overall mean damage was determined similarly as in the stratified quadrat method (Eqns. 1 and 2).

Total damaged ears (T) and grain loss per damage ear (G) were computed as:

$$T = \bar{p}N$$

where T = total damaged ears
$\bar{p}$ = proportion of damage
N = total ears

and $G = \bar{Y}(T)$

where G = grain loss (g)
$\bar{Y}$ = mean loss/damage ear (g)
T = total damaged ears

The damage proportion for each plot using the three sampling techniques were compared with the actual damage. The test for comparison was,

$$Z = \frac{(\bar{p} - u)}{\sigma} \text{ at } \alpha = 0.05$$

where $\bar{p}$ = mean proportion of damage
σ = population standard deviation
u = population mean

RESULTS AND DISCUSSION

The damage patterns were similar for both plots. The distribution of rat damage for the plots is shown in Figure 1. The damage was heavier at the periphery than at the center of the field i.e., in terms of number of ears damaged within an area. The different shapes in the map indicate the number of ears damaged within a given area, e.g. 20 hills x 3 rows = 60 hills or equivalent to 15 m^2. The damage intensity in the 0.5 ha plots appraised for rat damage was relatively high (12.14%). Previous observation on rat damage patterns was apparently influenced by damage intensity and surrounding habitat (Benigno, 1980). However, the damage pattern in this plot approached a uniform damage distribution.

Tables 2a and 2b summarize the results of three sampling techniques in 0.5 ha cornfields. The quadrat method estimated the most number of damaged hills (17.67%) followed by random (17%) and strip systematic with damage of 13.7% (Table 2a). The estimated mean damage of the three sampling methods did not significantly differ from one another ($\alpha = .05$) and also from the actual damage of 12.14%. The variance of the mean, V ($\bar{p}$), obtained by the different sampling methods were relatively small and close to one another suggesting that little precision is gained in shifting from one method to another.

Table 2a.Statistical comparisons of the three sampling methods in estimating damage in 2 one-half hectare cornfields in barrio Wawa, Lumban, Laguna.

Factors	Strip Systematic (2 rows x 5 hills)	Random Hills (1 row x 1 hill)	Modified Stratified Quadrat (5 rows x 5 hills)
No. of test	4	4	4
No. of sample hill/test	600	525	525
Est'd. % mean damage (100 $\bar{p}$)	13.78 (11.8-20.6)	17.56 (14.5-21.3)	17.67 (9-22.2)
Variance of the mean (V $\bar{p}$)	.002	.0003	.001
Actual % damage (100 μ)	12.14	12.14	12.14
Actual variance (s^2)	.00167	.00167	.00167
Error (%)[a]	13.5	40.03	44.73
Z computed	.40[ns]	1.32[ns]	1.35[ns]

[a] $100 \times \frac{\text{(Mean estimated damage — Actual damage)}}{\text{Actual damage}}$

ns = not significant at 5%

Table 2b. Comparison of three sampling methods with respect to precision and time spent in assessing rat damage on corn.

Factors	Strip Systematic (2 rows x 5 hills)	Random Hills (1 row x 1 hill)	Modified Stratified Quadrat (5 rows x 5 hills)
Est'd. total damaged ears	1772	2105	2132
Actual damaged ears	1558	1558	1558
Est'd. total grain loss (kg)	77.353	91.890	93.068
Actual loss (kg)	68.011	68.011	68.011
Errors (%)	13.74	35.11	36.84
Mean time spent (man-hours)			
Sampling	3.51	6.15	16.86
Data sheet preparation	2.0	3.0	2.0
Total	5.51	9.15	18.86

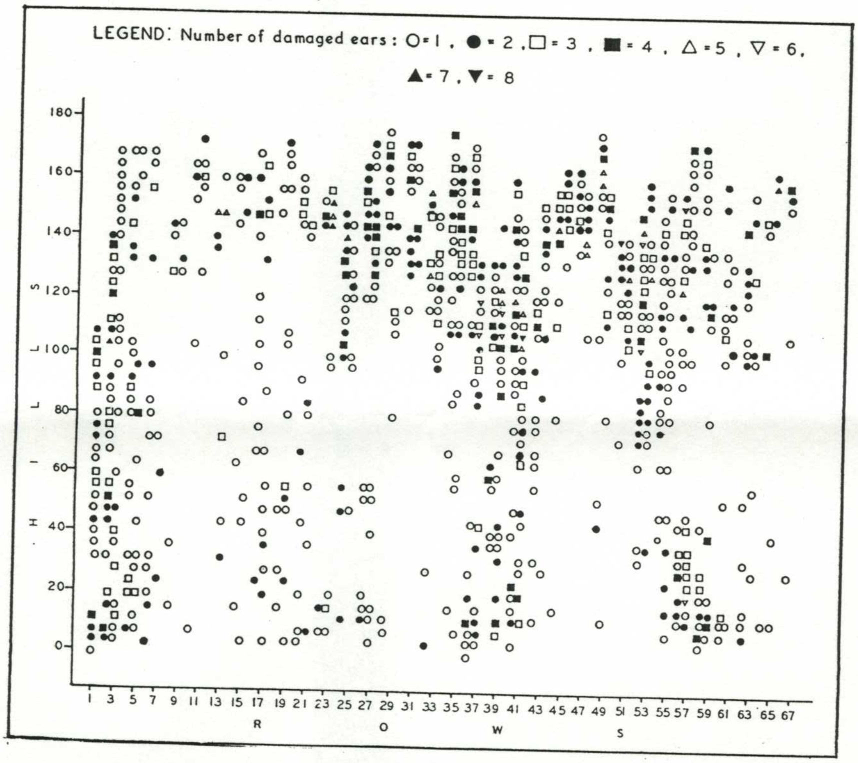

Fig 1. Rat damage distribution in a 0.5 ha. cornfield at one week before harvest in Barrio Wawa, Lumban, Laguna. The shapes represent the number of rat damaged ears within the area.

No significant differences were observed between the plots in terms of grain loss (Table 2b). Quadrat method estimated the highest mean grain loss per plot at 93.06 kg, 91.89 kg for random and 77.35 kg for strip systematic method. The latter appeared to be the most precise with the least percent error (13.74%) and also gave the closest approximation to the true total grain loss with 13.74% error. Considering the time spent, strip systematic sampling has the advantage. A total of 8.86 man-hours was spent with the quadrat method, 9.15 man-hours for random and 5.51 man-hours with the systematic method.

Based on the results, strip systematic was the most efficient sampling technique for assessing rat damage to corn. The tendency for damage to be clumped along the field periphery suggests that stratified systematic sampling using strips (2 rows x 5 hills) rather than quadrats may be used. The area may be stratified as described previously by Benigno (1980) and sample strips taken systematically in each stratum. Time spent in sampling could be further reduced if the activity of taking the measurements of damage in damaged ears is disregarded. A study is underway to further improve the method.

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