SAMPLING FOR SUGARCANE STALK BORER INCIDENCE

By

RANJANA AGRAWAL[1], M.P. JHA[2] AND S.B.L. SHUKLA[3]

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SUMMARY

Attempts have been made to obtain suitable sampling unit, size and technique for recording stalk borer incidence in a field. Data on borer incidence were collected from 1500 one metre units from a compact block of 30 rows of 50 metre length. These primary units were combined to give a sampling unit leading to a normal distribution. Further analysis has been carried out using these sampling units to obtain suitable size and sampling technique.

INTRODUCTION

Stalk borer is one of the major insects affecting sugarcane crop in Uttar Pradesh. It is reported to have reduced sucrose per cent in juice by 1.7 to 3.6 and purity by 4 to 8 per cent. A reduction of 16 per cent in yield and a loss of 2 units in sugar recovery has been realised due to stalk borer. It is important to estimate stalk borer incidence in field to assess losses and thereby to plan insecticide applications. Major attempts in this direction have been made by Khanna and Bandhyopadhyay [3], Rojas [4] and Srivastava [5]. Rojas assumed incidence values following a normal distribution. Khanna and Bandhyopadhyay have taken them to be poisson while Srivastava has taken them to be Binomial. They applied suitable transformation and these transformed values were used to obtain suitable sampling techniques. Srivastava [6] obtained the actual distribution of number of bored canes and suggested sampling scheme after a suitable transformation.

In the present paper, combining of primary units has been studied to give a sampling unit leading to a normal distribution. Further analysis has been carried out using these sampling units to obtain suitable size and sampling technique.

1. 2, I.A.S R.I., Library Avenue, New Delhi-12
3. I.I.S.R., Raebareli Road, Lucknow.

MATERIAL AND METHODS

The material for the study consisted of the complete enumeration of stalk borer incidence in a compact plot of 27×50 sq.m. (net area) comprising of 30 rows of 50 metres each at the farm of the Indian Institute of Sugarcane Research, Lucknow. The variety sown was 001148. The crop was planted through conventional planting with a row to row spacing of 90 cm. Fertilizer, irrigation and other practices adopted were as per normal recommendations. Each row was divided into 50 units of one metre row length and data were collected on total number of canes and number of bored canes for each one metre unit.

To arrive at the suitable size and shape of the sampling unit, coefficients of variation were calculated and studied for different sizes and shapes of units obtained by combining the primary units along and across the rows.

Actual distributions of number of bored canes and per cent borer incidence were obtained for one metre units Normal distributions were also studied for different sizes and shapes of the units to find out the sampling unit giving normal distribution of the character under study. Using suitable sampling unit thus obtained, sample sizes for three levels of precision *viz.* 5, 10 and 15 per cent C.V. were worked out. Various sampling techniques were compared *viz.* stratified, cluster, multi-stage and systematic sampling.

RESULTS AND DISCUSSIONS

Coefficient of variation (C, V) for different sizes and shapes of units are given below in Table 1.

TABLE 1

C.V. for various sizes and shapes of the units

Unit size along the row	*Unit size across the row*			
	1R	*2R*	*3R*	*4R*
1m	58.54	45.56	36.35	31.18
2m	46.99	37.99	31.88	26.73
3m	43.01	35.90	30.07	24.53
4m	40.42	34.04	29.09	23.14

The results show that C.V. reduced considerably when rows were pooled to form unit than when unit size was increased along the row.

To study the distribution of number of bored canes per metre row length, distribution constants have been calculated. Variance (10.70) was found to be greater than mean (6.22) suggesting that the data may follow negative Binomial (NB) distribution. The NB distribution was fitted and the goodness of fit between observed and expected frequencies was tested using χ^2 test. The low value of χ^2 (χ^2=17.88) indicated that number of infested canes/metre row length follow a negative binomial distribution. To investigate the actual distribution of per cent borer incidence per metre row length, the system of Pearson's curves was tried. To get the type of the distribution, k was calculated as

$$K=\frac{\beta_1(\beta_2+3)^2}{4(4\beta_2-3\beta_1)(2\beta_2-3\beta_1-6)}$$

where β_1 and β_2 are measures of skewness and kurtosis.

Negative value of K was obtained showing that the distribution is Pearson Type I. For further confirmation, expected frequencies were calculated as :

$$Y=Y_0\left(1+\frac{x}{a_1}\right)^{m_1}\left(1-\frac{x}{a_2}\right)^{m_2}$$

where $\frac{m_1}{a_1}=\frac{m_2}{a_2}$ and origin is mode.

To get these probabilities, following constants were calculated :

$$R=\frac{6(\beta_2-\beta_1-1)}{(6+3\beta_1-2\beta_2)}$$

$$a_1+a_2=\tfrac{1}{2}\sqrt{\mu_2}\,\sqrt{\{\beta_1(R+2)^2+16(R+1)\}}$$

m's are given by

$$\tfrac{1}{2}\left\{(R-2\pm R(R+2)\sqrt{\frac{\beta_1}{\beta_1(R+2)^2+16(R+1)}}\right\}$$

when the third moment μ_3 is +ve, m_2 will be +ve root.

$$Y_0=\frac{N}{a_1+a_2}\,\frac{m_1^{m_1}\,m_2^{m_2}}{(m_1+m_2)^{m_1+m_2}}\,\frac{\Gamma(m_1+m_2+2)}{\Gamma(m_1+1)\Gamma(m_2+1)}$$

$$\text{Mode}=\text{Mean}-\frac{\mu_3(R+2)}{2\mu_2(R-2)}$$

The distribution constants and χ^2 obtained are as follows :

Mean	*Variance*	*k*	χ^2_{7df}
35.83	356.25	−0.2259	12.52

The non-significant value of χ^2 confirms the goodness of fit.

Normal distributions were fitted for different sizes and shapes of the units.

TABLE 2

Fitting of Normal Distribution

Unit	*Number of bored canes*				*Per cent borer incidence*			
	β_1	β_2	χ^2	*df*	β_1	β_2	χ^2	*df*
2R×1m	.28	3.08	32.73	5	.25	3.36	14.78	5
3R×1m	.05	2.64	12.40	7	.03	3.44	8.58	4
4R×1m	.05	2.69	5.14	5	.01	2.79	1.45	3
1R×2m	.33	2.89	36.43	5	.14	2.63	24.20	5
1R×3m	.23	2.83	14.91	4	.19	2.96	19.39	4
1R×4m	.21	2.72	13.65	6	.23	3.09	15.17	4

The results indicate that both number of bored canes and per cent borer incidence are normally distributed for unit $3R \times 1m$ and $4R \times 1m$. Again increasing unit size along the row did not show any advantage.

Sample Size and Technique

Optimum sample sizes were obtained for the units $3R \times 1m$ and $4R \times 1m$ at three levels of precision *viz.* 5, 10 and 15% C.V. using

$$n = \frac{N(S_B^2 + I^2 S_T^2 - 2IS_{BT})}{S_B^2 + I^2 S_T - 2IS_{BT} + N\bar{T}^2 I^2 CV^2}$$

where n=sample size

N =Population size

I =Proportion of borer incidence (B/T)

B =Total number of bored canes in population

T = Total number of canes in the population

$$S_B^2 = \frac{1}{N-1} \sum_{i=1}^{N} (B_i - \bar{B})^2$$

$$S_T^2 = \frac{1}{N-1} \sum_{i=1}^{N} (T_i - \bar{T})^2$$

and

$$S_{BT} = \frac{1}{N-1} \sum_{i=1}^{N} (T_i - \bar{T})(B_i - \bar{B})$$

The results are given in table below :

TABLE 3

Optimum sample size for recording stalk borer incidence

Unit size	*Population size*	*Sample size (units) C.V.(%)*			*Percent area sampled C.V.(%)*		
		5	*10*	*15*	*5*	*10*	*15*
3R × 1m	500	47	13	6	9.35	2.5	1.13
4R × 1m	350	33	9	4	9.34	2.5	1.13

The results show that the precision of the estimate increases sharply as the sampled area is increased from 1 to 2.5 per cent in both unit sizes. Further, gain in precision with sampled area exceeding 2.5 per cent tended to be marginal.

Following sampling techniques have been compared for fixed sample size of 2 per cent approximately to study their relative efficiency for recording stalk borer incidence.

Simple Random Sampling

Under S.R.S. variance of the estimate has been obtained as :

$$V(I) = \frac{N-n}{Nn\bar{T}^2} (S_B^2 + I^2 S_T^2 - 2IS_{BT})$$

Stratified Sampling

To use stratified sampling group of rows were taken as strata. Variance of the estimate was calculated by

$$V_{St}(I)=\frac{1}{NLT^2}\sum_{h=1}^{L}\frac{N_h-n_h}{n_h}\left(S_{Bh}^2+I^2S_{Th}^2-2IS_{BT_h}\right)$$

where L is number of strata

h is stratum identification

N_h =Total number of units in the h-th stratum

n_h =Numher of units sampled from the h-th stratum

I_h =Proportion borer incidence in the h-th stratum

$$S_{Th}^2=\frac{1}{N_h-1}\sum_{i=1}^{N_h}(T_{ih}-\bar{T}_h)^2$$

$$S_{Bh}^2=\frac{1}{N_h-1}\sum_{i=1}^{N_h}(B_{ih}-\bar{B}_h)^2$$

$$S_{BT_h}=\frac{1}{N_h-1}\sum_{i=1}^{N_h}(B_{ih}-\bar{B}_h)(T_{ih}-\bar{T}_h)$$

Cluster Sampling

Clusters were obtained by grouping units of one metres on length across the rows. Variance is obtained as

$$V_{C_1}(I)=\frac{M-m}{mM(M-1)}\sum_{k=1}^{M}(I_k-\bar{I})^2$$

where M=Total number of clusters in the population

m =number of clusters sampled

I_k =Proportion of borer incidence in the k-th cluster

Two-Stage Sampling

(*a*) *Both stage random.* Two stage sampling has been used taking group of rows as first stage units and one metre row length as second stage units. Variance of the estimate is calculated as

$$V_{TS}(I)=\frac{1}{T^2}\left(\frac{1}{l}-\frac{1}{L}\right)(S_{bB}^2+I^2S_{bT}^2-2IS_{bBT})$$
$$+\frac{1}{l}\left(\frac{1}{m}-\frac{1}{M}\right)(\bar{S}_{WB}^2+I^2\bar{S}_{WT}^2-2I\bar{S}_{WBT})$$

where L and M are number of first and second stage units in the population and l and m are the corresponding units in the sample.

$$S_{bB}^2 = \frac{1}{L-1} \sum_{h=1}^{L} (\bar{B}_h - \bar{B})^2$$

$$S_{bT}^2 = \frac{1}{L-1} \sum_{h=1}^{L} (\bar{T}_h - \bar{T})^2$$

$$S_{bTB}^2 = \frac{1}{L-1} \sum_{h=1}^{L} (\bar{T}_h - \bar{T})(\bar{B}_h - \bar{B})$$

$$\bar{S}_{WB}^2 = \frac{1}{L} \sum_{h=1}^{L} \frac{1}{M-1} \sum_{i=1}^{M} (\bar{B}_{ih} - \bar{B}_h)^2$$

$$\bar{S}_{WT}^2 = \frac{1}{L} \sum_{h=1}^{L} \frac{1}{M-1} \sum_{i=1}^{M} (T_{ih} - \bar{T}_h)^2$$

$$S_{WBT} = \frac{1}{L} \sum_{h=1}^{L} \frac{1}{M-1} \sum_{i=1}^{M} (T_{ih} - \bar{T}_h)(B_{ih} - \bar{B}_h)$$

Various combinations of first and second stage units forming total sample size 2.0% were tried and $l=L/2$ and $m=2$ was found to be giving maximum precision.

(*b*) *Systematic Sampling for Selection of First-Stage Units.* An increasing trend in per cent borer incidence towards centre across the rows, suggested the use of systematic sampling for selection of first stage units. Therefore, two stage sampling with systematic sampling for selection of first stage units and SRS for selection of second stage units was tried. Variance of the estimate is obtained as :

$$V(I)_{MSsys} = \frac{1}{k} \sum_{i=1}^{k} (I_i - \bar{I})^2 + \frac{1}{l\bar{T}^2} \left(\frac{1}{m} - \frac{1}{M} \right) (\bar{S}_{WB}^2 + \bar{S}_{WT}^2 I^2 - I^2 \bar{S}_{WBT})$$

where $K=L/l$.

The C.V.'s under different sampling schemes and sampling units are given in Table 4.

TABLE 4

C.V. under different sampling techniques

Sampling technique	*Unit size*			
	3R × 1m		*4R × 1m*	
	Sample Size	*C.V.*	*Sample Size*	*C.V.*
S.R.S.	10	11.20	7	11.23
Cluster sampling	10	14.85	7	14.85
Stratified sampling	10	10.47	7	11.01
Two stage sampling (random at both stages)	10	11.29	8	10.49
Two stage sampling (Systematic at I stage)	10	10.57	8	10.36

Perusal of Table-4 indicates that cluster sampling is not advisable. The performance of other sampling schemes was at par but for operational convenience, two stage sampling using systematic sampling at first stage can be recommended.

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