ISSN 0258-7122
Bangladesh J. Agril. Res. 40(4): 703-709, December 2015

DETERMINATION OF OPTIMUM SAMPLE SIZE FOR MEASURING THE CONTRIBUTING CHARACTERS OF BOTTLE GOURD

N. MOHAMMAD[1], M. S. ISLAM[2], K. S. RAHMAN[3]
M. M. RAHMAN[4] AND S. NASRIN[5]

Abstract

To improve efficiency in collecting data from field experiment on fruit attributes of bottle gourd (Lau), the sample size was studied for sample size at Olericulture Division, Horticulture Research Centre (HRC) of Bangladesh Agricultural Research Institute (BARI) Gazipur during 2012-13. The treatments/varieties were LS 0026-5-3, LS 0012-5-3, LS 117-F-1, LS 117-A-2 and BARI Lau-3. Fruit length, breadth and weight of bottle gourd (Lau) data were collected from the experimental plot. The data were used to design optimum sampling plan from equal number of observations per cell. The observation on fruit length (cm), breadth (cm) and weight (kg) were taken from 5 plots/treatments at random. A randomized complete block design (RCBD) with 3 replications and five treatments/varieties was used in this experiment. Five (5) plants per plot and 2 fruits per plants (10 fruits per plot) were the original sampling plan for this experiment. A sampling plan of selecting 4 plants at random and measuring 2 fruits per selected plant (8 fruits per plot and plots were 25m^2 i.e. 10m long and 2.5m wide) was found to be optimum and economical for taking measurements of fruit attributes in field experiments on bottle gourd.

Keywords: Measurement, Optimum sample size, Sampling technique and Bottle gourd.

Introduction

In any field experiments, it is necessary to determine the optimum sample size as well as optimum number of replications if researchers have to use sampling techniques for collecting data from such experiments (Islam *et al.* 2000). It is not possible to measure yield and yield contributing characteristics on the whole of each experimental unit. In any field experiment, the researcher has to face the problem in determines optimum (efficient) sample size for measuring plant characters (Federer, 1963). The researcher has to face the problem of optimum (efficient) sample size for measuring plant characters in the field experiment (Islam *et al.*2001). The optimum sampling technique depends on the variability associated with variable and the cost of reducing the variability (Kempthorne ,1952). Rigney and Nelson (1951) in cotton, Patel and Dalal (1992) in okra and Hossain *et al.* (2005) in Brinjal, Hossain *et al.* (2008) in Teasle gourd, Islam *et*

[1,3&4]Scientific Officer, ASICT Division, BARI, Gazipur-1701, [2]Principal Scientific Officer, ASICT Division, BARI, Gazipur-1701, [5]M.Sc in Statistics, Rajshahi University, Bangladesh.

al. (2012) in Sweet gourd and Islam *et al.* (2013) in Bitter gourd estimated the size of sample needed in taking measurements of plant characters. No such information is available in bottle gourd (*Lagenaria siceraria var.clavata*). This experiment deals with sample size study in bottle gourd particularly for taking measurements of fruit character like Length, Breadth and Weight. The investigation was carried out at Horticulture Research center (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur in 2012-2013. The objective of the study is to find out optimum sample size for estimating yield contributing characters of the field experiment on bottle gourd.

Material and Method

Sample size depends on the variability associated with variable and the cost of reducing that variability. For such cases, it is necessary to choose optimum sample size and number of replications. Estimation of optimum sample size and number of replications are obtained by maximizing the information for a given cost.

There were five treatments/varieties used as treatment in this experiment. The treatments/varieties were LS 0026-5-3, LS 0012-5-3, LS 117-F-1, LS 117-A-2 and BARI Lau-3. Experimental plots were 25m^2 (10m long and 2.5m wide). Fruit length, breadth and weight of bottle gourd (Lau) data were collected from the experimental plot. This data were used to calculate optimum sampling plan from equal observation per cell. The observation on fruit length (cm), breadth (cm) and weight (kg) were taken from 5 plots or treatments selected at random. The fruit length, breadth and weight of first two fruits from each selected plant utilized in this analysis. There were 10 fruits (5 plants per plot x 2 fruits per plant) per plot and 50 fruits per replication. Considering the time factor, the data of three replications were collected for deriving optimum sampling plan (Optimum in the sense of time involved in taking fruits measurements). A randomized complete block design (RCBD) with 3 replication was used for this experiment. The data were analyzed replication wise by analysis of variance (ANOVA) technique (Table 1) to estimate variance components associate with plots ($\hat{\sigma}_p^2$), plants ($\hat{\sigma}_q^2$) and fruits ($\hat{\sigma}_n^2$).

Analytical Model

We have an experiment in p treatments (plots) are taken at random, then q plants are randomly selected from each treatment. From each plant n random sampling unit is taken. The observations may be denoted by Y_{ijk} where i denote the treatments (i= 1, 2 ….. p), j the Plants (j = 1, 2, ……,q) and k the sampling unit (k = 1, 2, ….., n).

We also assume the following model:

$$Y_{ijk} = m + a_i + \beta_{ij} + \eta_{ijk} \quad (1)$$

Where

$m =$ the general mean

α_i=the treatments effect

$\beta_{ij} =$ the plants effect due to the (ij)th experimental unit.

η_{ijk} = the sampling effect due to the (ijk)th observation

For the study we suppose that the η_{ijk} 's are normally and independently distributed with variance σ_n^2, β_{ij} 's are normally and independently distributed with variance σ_q^2 and α_i 's are normally and independently distributed. The η_{ijk} 's will be independent of the β_{ij} 's and α_i 's if the sampling random.

The least square estimates are obtained as follows:

$$\hat{m} = \overline{y}\ldots$$

$$\hat{a}_i = (\overline{y}_{i\ldots} - \overline{y}\ldots)$$

$$\hat{\beta}_{ij} = (\overline{y}_{ij} - \overline{y}_{i-})$$

$$\hat{\pi}_{ijk} = (\overline{y}_{ijk} - \overline{y}_{ij.})$$

Also

$$\overline{y}_{i\ldots} = \frac{\sum_{i=1}^{p}\sum_{j=1}^{q}\sum_{k=1}^{n} y_{ijk}}{pqn}$$

$$\overline{y}_{i=} = \frac{\sum_{j=1}^{q}\sum_{k=1}^{n} y_{ijk}}{qn}$$

$$\overline{y}_{ij.} = \frac{\sum_{k=1}^{n} y_{ijk}}{n}$$

Putting these values in equation (l) and squaring and summing on both sides. Then the total sum of squares can be partitioned as:

$$\sum_{i=1}^{p}\sum_{j=1}^{q}\sum_{k=1}^{n}(y_{ijk} - \overline{y}_{\ldots})^2 = nq\sum_{i=1}^{p}(\overline{y}_{ijk} - \overline{y}_{\ldots})^2 + \sum_{i=1}^{p}\sum_{j=1}^{q}(\overline{y}_{jk} - \overline{y}_{i=})^2 + \sum_{i=1}^{p}\sum_{j=1}^{q}\sum_{k=1}^{n}(y_{ijn} - \overline{y}_{ij})^2$$

+ producttern

But product terms are usually zero.

Thus, Total (SS)= Treatment (SS) + Plant (SS)+ Sampling (SS)

With their degrees of freedom (npq-1) = (p-1) + p (q-1) + pq (n-1)

Table 1. The analysis of variance

Sources of Variation (SV)	Degrees of Freedom (D.F.)	Sum of Squares (S.S)	Mean Sum of Squares (MSS)	Expected Mean Sum of Squares (EMSS)
Plots/Treatment (Levels A)	(p-1)	$nq\sum_i \left(\overline{y_{i..}} - \overline{y_{...}}\right)^2 = S_p^2$	$\frac{S_p^2}{(p-1)} = T$	$\sigma_n^2 + n\sigma_q^2 + nq\sigma_r^2$
Plants/Plot(Level B within A)	p(q-1)	$n\sum_i\sum_j \left(\overline{y_{i..}} - \overline{y_{...}}\right) = S_q^2$	$\frac{S_q^2}{p(q-1)} = p$	$\sigma_n^2 + n\sigma_q^2$
Fruits/Plant/Plot Sampling	pq(n-1)	$\sum_i\sum_j\sum_k (y_{ijk} - \overline{y}_{ij.})^2 = S_n^2$	$\frac{S_n^2}{pq(n-1)} = S$	σ_n^2
Total	pqn-1	$\sum_i\sum_j\sum_k \left(\overline{y_{ijk}} - \overline{y_{...}}\right)^2$		

Where, p = number of plot or treatment, q = number of plants/plot and, n = number of fruits/plant/plot. Also T= The mean sum of square of Treatment, P= The mean sum of square of Plant, S= The mean sum of square of Sampling respectively.

According to estimation of optimum sampling plan, Snedacor and Cochran (1967), the variance component may be estimated as.

The components of variance $\sigma_n^2, \sigma_q^2 and \sigma_p^2$ estimated by $\hat{\sigma}_n^2 = S, P = \sigma_q^2 + n\sigma_p^2 and T = \sigma_n^2 + n\sigma_q^2 + nq\sigma_q^2$ i.e

$$\hat{\sigma}_q^2 = \frac{P-S}{n} and \hat{\sigma}_q^2 = \frac{T-P}{nq}$$

Thus variance of mean is

$$S_y^2 \frac{\hat{\sigma}_p^2}{P} + \frac{\hat{\sigma}_q^2}{pq} + \frac{\hat{\sigma}_n^2}{npq} \qquad (2)$$

$\hat{\sigma}_p^2, \hat{\sigma}_q^2$ and σ_n^2 for the character were obtained from the analysis of variance table.

The same variance of mean can be altered for the mean by using various combinations of q and n in equation (2)

$$S'^2_{\bar{y}} = \frac{\hat{\sigma}_p^2}{P} + \frac{\hat{\sigma}_q^2}{pq} + \frac{\hat{\sigma}_n^2}{n'p'q} \qquad (3)$$

Where q′ and n′ are the altered values of q and n respectively.

The component $\hat{\sigma}_q^2$ was assumed as constant, as it represented variation due to treatments.

Efficiency of new sampling plan,

$$E = \frac{S^2_{\bar{y}}}{S'^z_{\bar{y}}} \hat{\sigma}_q^2 \qquad (4)$$

The formula of saving the work/time load i.e time factor (TF) without sacrificing precision as compared with original plan i.e 10 fruits (5plant/plot x 2fruits/plant) per plot is defined as

$$TF\ (\%) = \frac{q'n' - qn}{q'n'} \times 100 \qquad (5)$$

Where, q′=5, n′=2, q=1,2,------,5 and n=1,2,-------,5. Since 10 fruits per plot is the original plan or control.

Results and discussion

The results of the study were utilized in arriving alternate sampling plans (i.e., altering the value of q from 1 to 5 plant per plot and from 1 to 5 fruits per plant, making total 25 sampling plants per plot) (Table-2). The relative efficiency of each plant was worded out in relation to original plan (5 plants per plot and 2 fruits per plants). Using equation-4 the relative efficiency of new alternate sampling plans is given in Table-3. The results (Table-3) indicated that the relative efficiency with the number of plants per plot and number of fruits per plant.

The other alternate plan with 4 plant per plot and 2 fruits per plant (total 8 fruits per plot) had also 99.62 percent efficiency in comparison to original plan but had 20 percent less amount field work (Using equation 5). The other plan which can be employed with same efficiency is to select 3 plants at random per plot and measure 3 fruits each selected plant (9 fruits per plot) had 94.21 but work load will be about 10 percent less than the plan with 5 plants x 2 fruits per plot.

The results revealed that work load for field operation like lagging of flowers, harvesting and measurement of individual fruit could be reduced effectively without sacrificing efficiency by selecting proper sampling plan.

Table 2. The estimated variance components for plots ($\hat{\sigma}_q^2$), plants ($\hat{\sigma}_q^2$) and fruits ($\hat{\sigma}_q^2$).

Variance component	Fruit Length			Fruit Breadth			Fruit Weight		
	R-I	R-II	R-III	R-I	R-II	R-III	R-I	R-II	R-III
$\hat{\sigma}_p^2$	26.16	28.36	24.84	0.22	0.34	0.41	0.23	0.29	0.33
$\hat{\sigma}_q^2$	38.11	33.15	23.1	0.30	0.62	0.58	0.12	0.16	0.21
$\hat{\sigma}_n^2$	1.59	2.17	1.84	0.69	0.85	0.91	0.47	0.37	0.41

Table 3. The relative efficiency for some of the alternative sampling plants.

Number of		Fruit Length			Fruit Breadth			Fruit Weight			Average over traits	Work/Time Load (%)
Plants /plot	Fruits /plant	R-I	R-II	R-III	R-I	R-II	R-III	R-I	R-II	R-III		
1	1	51.31	55.10	59.26	24.79	27.51	29.47	45.12	51.82	58.42	44.76	90
1	5	62.40	56.66	61.06	45.59	44.07	47.78	83.33	81.10	89.22	63.47	50
2	3	74.41	77.48	80.38	61.85	62.90	63.64	100.45	98.45	110.26	81.09	40
2	4	67.45	77.64	80.56	65.75	65.85	68.79	102.86	102.10	114.13	82.79	20
2	5	74.58	77.73	80.65	68.33	67.75	71.33	109.72	104.42	116.59	85.68	0
3	2	86.49	88.25	89.81	68.96	72.34	74.59	106.22	108.49	118.50	90.41	40
3	3	86.68	88.52	90.01	75.63	77.67	79.49	114.82	110.54	124.56	94.21	10
3	4	86.78	88.66	90.23	79.47	82.54	82.45	111.63	103.58	127.83	94.80	20
5	2	100	100	100	100	100	100	100	100	100	100	0
5	1	99.24	98.79	98.90	71.77	78.54	79.09	106.32	107.32	122.24	95.80	50
5	3	99.85	99.90	99.72	92.02	95.64	96.67	129.67	122.59	138.98	108.33	50
4	2	94.23	95.07	95.64	78.68	82.82	83.73	116.07	112.95	137.46	99.62	20
4	3	94.48	95.31	95.88	85.10	88.01	86.65	123.67	117.78	133.20	102.23	20
4	1	93.78	94.38	94.93	64.17	70.38	89.25	98.01	100.59	114.43	91.10	60
3	5	86.84	88.74	90.32	81.96	82.54	84.33	122.78	115.48	129.87	98.09	50

Conclusion

Among different sampling plans a plan with 5 plants per plot and 1 fruits (total 5 fruits per plot) had on an average 95.80 percent efficiency i.e., almost equal efficiency when compared with original sampling plan of 5 plants/plot and 2 fruits per plant (10 fruits per plot). By adopting this new plan 50 percent work load (time) could be saved without sacrificing precision.

Then we conclude that sampling of selecting 4 plants at random per plot and measuring 2 fruits each selected plant (total 8 fruits per plot) appeared optimum and efficient(closed to original sampling plan i.e. 10 fruits per plot).

References

Federer W. T. 1963. Experimental design. Theory and application, Oxford and IBH Publishing Co. New Delhi, India.

Hossain,M.I.; Islam, M.S.; Hossain, M.A; Nasrin, S. and Yesmin, S. 2005. Determination of optimum sampling plant characters of brinjal. *International Journal of Sustainable Agricultural Technology*, 1(6): 25-29.

Hossain,M.I.;Muhammad Shuaib; Kabita; Muhammad Tareq; M.S. Kabir and M. A. Uddin. 2008. Optimum sampling for measuring different plant characters of Teasle gourd. *Eco-friendly Agril. J.* **1**(3): 172-175.

Islam, M.S.; Mohammad.N.; Rahman.K.S, Rahman.M.M. and Hoque.A.K.M.A. 2013. Optimum sampling for measuring different plant characters of bitter gourd. *Eco-friendly Agril. J.* **6**(11): 234-237, 2013.

Islam, M.S.; Mohammad.N.; Rahman.K.S, Rahman.M.M. and Hoque.A.K.M.A. 2012. A study of optimum sampling for measuring different plant characters of sweet gourd. *J. Bangladesh Soc. Agril. Sic. Tecnol.* **9**(1&2):195-199.

Islam, M.S.; Sen, K. and Rahim, K. 2000. Estimation of optimum sample size and number of replications in RCBD with unequal observation per cell. Dhaka University Journal of Science, **48**(1): 89-94.

Islam, M. S. 2001. Statistical development of field plot technique for agronomic experiments. Unpublished Ph. D. thesis, Dhaka University, Dhaka, Bangladesh.

Kempthorne, O. 1952. Design and analysis of experiment, John Wiley and Sons, Inc, New York, USA.

Patel, J.N. and Dalal, K.C. 1992 Sampling technique for measuring pod characters of okra. *Gujarat Agricultural University Research Journal*, **18**(1): 81-84.

Rigney.J.A. and Nelson. WI L. 1951. Some factors affecting the accuracy of sampling cotton for fibre determinations. *Agronomy Journal* **43:** 531-535.