韓土肥誌 2卷 1號 (1969)

A Study on the Number of Sample Units for Yield Components (I)

W. K. Oh

Institute of Plant Environment
Office of Rural Development, Suwon

S. H. Chang
H. C. Lee

United Nations Special Fund for
Korean Soil Fertility Project

收量構成要素를 爲한 標本數에 對한 硏究 (第1報)

吳 旺 根
農村 振興廳 植物環境硏究所

張 錫 煥·李 熙 哲
國際聯合 韓國土壤肥沃度事業機構

要 約

1967年 및 1968年度에 얻은 成績을 利用하여 株當 數穗調査에 必要한 標本數를 計算한 바 他道에 比하여 標本誤差가 큰 江原道와 全羅南道에서 더 많은 標本을 取하여야 하는것으로 생각된다.

收量構成要素를 爲한 標本數는 緯度에 따라 다른 것이 아니라 道內에서의 이들 收量構成要素의 變異性에 따라 左右된다고 보며 5%의 標本을 取함으로서 約 75% 乃至 85%의 相對的 情報를 얻을수 있다고 생각된다.

1. Introduction

In field experiments it is frequently required to estimate the number of samples which should be taken in order to determine some the values of certain population parameters with a specified precision based on appropriate agronomic characters.

Abraham (1966) indicated with a sample size of 5% when the plot size is 28 m^2 about 60 to 70 percent of the relative information could be obtained. Frey and Rodgers (1961) worked on the optimum number of heads for spikelet counts in oats, taking the cost into account, and prescribed that the optimum number of samples will vary with year and location, cost ratio and experimental precision desired. In these two studies the sampling units were small units of area taken from experimental plots or the number of panicles of oats from a certain length of sowing bed.

It is common to transplant paddy in hills of 3-5 seedlings each, so that the ultimate sampling unit for measuring average number of panicles per hill would naturally be the hills in a plot. From this agronomic point of view, an attempt has been made, in this paper, to determine, with a specified precision, the number of hills for tiller or panicle count in a plot at different stages of paddy growth.

2. Materials and statistical analysis

a. Materials

Recently a large number of experiments have been carried out in farmers' fields adopting 3×3×3 confounded factorial design in representative soils

in each province. The size of a plot was 27 m² and the spacing 15 cm × 30 cm of between hills and between rows accomodating 416 hills per plot. The agricultural practices remained same as the farmers'. From these experiments four replications have been taken from a soil group for this study at harvsting stage in Kangwon Do, Chungchong Nam Do, Kyongsang Nam Do and Chulla Nam Do in 1967, at maximum tillering stage in Kyonggi Do and Kangwon Do and at ear formation stage in Kyonggi Do, Kangwon Do and Chungchong Nam Do in 1968. From these experiments 12 hills composed of three hills at the end of each of the predetermined rows were taken in 1967 and 4 hills at radonm in 1968 after having discarded the border rows.

b. Statistical analysis

Experience has shown that the distribution of the number of panicles or tillers follows normal distribution, so that the following model may be considap pr opriate to express the number of tillers or anicles. Let there be r replicates with t treatments and s samples from each plot. Then, the linear model for the number of tillers or panicles, y_{ijkl}, may be written as

$$y_{ijkl}=\mu+\gamma_i+b_{ij}+t_k+e_{ijk}+\eta_{ijkl}$$

Where μ = Over all mean

γ_i = The effect of the i^{th} replicate

b_{ij} = Contribution of the j^{th} block within the i^{th} replicate

t_k = Effect of the k^{th} treatment

e_{ijk} = Experimental error

η_{ijkl} = Sampling error

$E(e_{ijk})=0$, $E(\eta_{ijkl})=0$

Assuming that the experimental error, e_{ijk} and sampling error, η_{ijkl} are normally and independently distributed with variances σ_e^2 and σ_s^2, respectively, the analysis of variance will be as follows.

Analysis of Variance

source of variation	D.F.	M.S.	Expected M.S.
Replications	r-1		
Blocks within replication	r(b−1)		
Treatments	t-b		
Replications X Treatments	(r-1)(t-b)	Ee	$\sigma_s^2+s\sigma_e^2$
Sampling Error	rt(s-1) or by subtraction	Es	σ_s^2
Total	(rts-1)		

Obviously the estimated sampling error term will be Es and true plot error will be $(Ee-Es)/s$ and the variance of a treatment mean when s samples are taken is given by

$$\frac{\sigma_e^2}{r}+\frac{\sigma_s^2}{rs}$$

and the percentage of plot error will be

$$\frac{\sqrt{\frac{\sigma_e^2}{r}+\frac{\sigma_s^2}{rs}}}{\bar{y}}\times 100$$

Letting P be the specified percentage of error with which the average is to be estimated, the minimum number of samples to be taken are given by

$$S=\frac{\sigma_s^2}{\frac{rp^2\bar{y}^2}{100^2}-\sigma_e}=\frac{(\text{Percentage sampling error})^2}{rp^2-(\text{Percentage true plot error})^2}$$

Further, the efficiency of s sampling is given in terms of ratio of two variances: Variance for treatment means with s samples and that when the whole plot is taken as sample.

$$E=\frac{\frac{\sigma_e^2}{r}+\frac{\sigma_s^2}{rN}}{\frac{\sigma_e^2}{r}+\frac{\sigma_s^2}{rs}}$$

Where $\frac{\sigma_e^2}{r}+\frac{\sigma_s^2}{rN}$ is the variance when the whole plot is taken as a sample.

3. Results and discussion

Table 3. Average number of tillers of panicles per plot and percentage of errors obtained from the results.

	Kyonggi	Kangwon	Chungnam	Kyongnam	Chunnam
	At maximum tillering stage				
Mean per sampling unit	18.6	16.1	—	—	—
Percentage of sampling error	19.5	20.6	—	—	—

Percentage of true plot error	9.2	9.3	—	—	—
Efficiency	48.8	47.0	—	—	—
	At ear formation stage				
Mean per sampling unit	17.8	14.0	17.3	—	—
Percentage of sampling error	18.7	19.8	26.5	—	—
Percentage of true plot error	7.8	9.6	8.2	—	—
Efficiency	42.4	46.7	30.4	—	—
	At harvesting stage				
Mean per sampling unit	—	12.7	15.8	16.7	18.4
Percentage of sampling error	—	29.4	24.3	23.2	25.2
Percentage of true plot error	—	5.7	4.8	3.1	6.4
Efficiency	—	54.8	68.0	46.0	63.0

As given in Table 3, average number of tillers at maximum tillering stage have appeared to be more or less same in Kyonggi Do and Kangwon Do, northern part. At ear formation stage there is no difference between Kyonggi Do and Chungchong-Nam-Do but much lower number of tillers were observed in Kangwon Do, as compared to the other two provinces and it is decreasing with the stages of growth.

Table 4. Minimum number of hills

Provinces	r = 2			r = 3			r = 4			r =5		
	p=3	p=5	p=10	p=3	p=5	p=10	p=3	p=5	p=10	p=3	p=5	p=10
	1. At maximum tillering stage											
Kyonggi	—	—	4	—	—	2	—	24	2	—	10	1
Kangwon	—	—	4	—	—	2	—	31	2	—	11	2
	2. At ear formation stage											
Kyonggi	—	—	3	—	22	2	—	9	2	—	6	1
Kangwon	—	—	4	—	—	2	—	19	2	—	9	1
Chung nam	—	—	6	—	90	4	—	22	3	—	13	2
	3. At harvesting stage											
Kyonggi	—	—	—	—	—	—	—	—	—	—	—	—
Kangwon	—	49	6	—	21	4	227	13	3	68	10	2
Chungnam	—	—	5	—	26	3	—	13	2	—	9	2
Kyongnam	61	14	3	31	9	2	21	6	2	16	6	2
Chunnam	—	69	6	—	19	3	—	11	2	149	8	2

r: replication
p: percentage of error.

Difference in percentage of sampling error is small being 1.1% in Kangwon Do and Kyonggi Do at the maximum tillering stage and at ear formation stage in Chungchong Nam Do. It is found considerably higher as compared to the other two provinces, while at harvesting stage they are in the following order; Kyongsang Nam Do, Chungchong Nam Do. Chulla Nam Do and Kangwon Do.

Percentages of true plot error at maximum tillering stage in Kyonggi Do and Kyongwon Do, northern part, are in same order, but that at earformation stage is higher in Kangwon Do as compared

to Kyonggi Do and Chungchong Nam Do mean while the percentages of true plot errors at harvesting stage are in same order of percentages of sampling error.

The minimum number of hills obtained accordingly by the help of the formulae above are given in Table 4. Large number of hills should be taken with p 3 and 5 in Kangwon Do and Chulla Nam Do, which seems to be due to considerably high sampling error in those provinces.

In Table 4, the number of hills to be included in the sample for tiller counts were found to be same at maximum tillering stage in Kangwon Do and Kyonggi Do, and were larger in Chungchong Nam Do and Kangwon Do at ear formation and harvesting stages, respectively. At these places the sampling errors were high.

Consequently, the number of samples to be taken are varying at different stages and depend upon the number of replicaions.

In this paper it has been found that about 2% sampling is necessary for about 50 to 60 percent of efficiency and about 75-85% of efficiency can obtained with 5% sampling, which are higher than what Abraham obtained.

On the basis of true plot error systematic sampling may be examined whether or not it can be applied not only for estimating the yield components but also for simplification of field work with out disturbing precision.

4. Summary

The necessary number of hills for panicle counts have been obtained, and are more in Kangwon-Do and Chulla Nam-Do where the variability of sampling error is higher as compared to other provinces.

It seems that number of samples do not depend on the latitude but on the variabilities of yield components within the province and it is considered that about 5% sampling fraction gives about 75 to 85% of relative information on the average.

References

1. Frey K.J. and Rodgers P.: Agri. J. Vol. 53, 28-29, (1961)
2. Kempthorne O. The design and analysis of experiments. New York John Wiley and Sons, Inc. (1962)
3. Abraham. T.P. Indian J. of Agri. Sci. Vol. 36, Aug. (1966)