

# Optimum Allocation of Plots into Years, Seasons, Locations and Replications for Once-Over Harvest Trials of Cucumber

Todd C. Wehner

Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609

William H. Swallow

Department of Statistics, North Carolina State University, Raleigh, NC 27695-8203

This research was supported by a grant from the North Carolina Pickle Producers Association

Many cucumber breeders test large numbers of lines before discarding them or releasing them as cultivars. Lines that perform well over a wide range of environmental conditions are useful to growers and seed companies, because such lines have a high probability of being useful in future (untested) years, and in many production areas. Since, it is possible to test lines in trials over years, seasons, locations, and replications, the question arises as to the most efficient way to distribute resources in the planning of trials. The question of optimum sample size has been recently reviewed (5).

Optimum sample size and distribution has been examined for nested designs (2), and for crossed designs with tobacco (1), cotton (3) and maize (4). Generally, it was concluded that additional locations and years were more efficient in providing cultivar performance data than additional replications within locations or years.

Data analysis. Cucumbers were grown in 2 years (1984, 1985), 3 seasons (spring, summer, fall), 4 North Carolina locations (Clayton, Clinton, Castle Hayne, and stress conditions of low fertilizer, irrigation and pest control), and 2 replications. Twenty-two genotypes in each of 2 crop types (pickle, slicer) were grown. The genotypes represented a diverse sample of available cultivars and lines (gynoecious vs. monoecious, dwarf vs. tall, indeterminate vs. determinate, disease resistant vs. susceptible, hybrid vs. inbred, adapted to southern vs. northern U.S.A., newly released vs. outdated).

Cucumbers were harvested once-over when the check plots ('Calypso' and 'Poinsett 76') had 10% oversized fruits. Data were collected on total fruit number, and average fruit quality (scored 1 to 9, where 1=poor, 5=average, 9=excellent).

The variance for a genotype mean can be expressed as in equation (A).

$$(A) V_{\bar{x}} = \frac{\sigma^2_{GY}}{y} + \frac{\sigma^2_{GS}}{s} + \frac{\sigma^2_{GL}}{l} + \frac{\sigma^2_{GYS}}{ys} + \frac{\sigma^2_{GYL}}{yl} + \frac{\sigma^2_{GSL}}{sl} + \frac{\sigma^2_{GYSL}}{ysl} + \frac{\sigma^2_e}{rysl}$$

for data collected over y years, s seasons, l locations, r replications and g genotypes, with all factors viewed as random.

For each crop type, the variance components for total yield and average quality score were estimated (Table 1) using Type I estimates from the VARCOMP procedure of the Statistical Analysis System (SAS Institute, Cary, North Carolina).

Table 1. Estimates of variance components for effects of genotype and environment.

Crop and Variable	Variance component							
	$\sigma^2_{GY}$	$\sigma^2_{GS}$	$\sigma^2_{GL}$	$\sigma^2_{GYS}$	$\sigma^2_{GYL}$	$\sigma^2_{GSL}$	$\sigma^2_{GYSL}$	$\sigma^2_e$
Pickle								
Yield	17.13	0.25	-2.60	11.92	3.07	8.20	15.58	67.64
Quality	0.020	0.035	-0.015	-0.013	-0.045	0.061	0.033	0.821
Slicer								
Yield	11.65	7.79	2.83	6.67	3.71	6.89	6.58	64.20
Quality	0.009	0.099	-0.017	-0.007	-0.011	0.013	0.141	0.741

Estimated variances of genotype means were calculated for each of 5 designs (combinations of  $y$ ,  $s$ ,  $l$  and  $r$ ), using equation (A) with the variance components replaced by their estimated values. The basic design took  $y=s=l=r=2$ . The other designs increased, in turn, the number of levels of one factor to 3, while holding the others at 2. We then compared the estimated variances of a genotype mean across designs in order to provide insight on the relative benefit (variance reduction) of increased allocation of resources in one direction or another.

Results. Comparing estimated variances of genotype means across the designs (Table 2) showed that the response was similar for pickling and slicing cucumber lines. The following conclusions can be made. If total yield is of principal interest, allocating resources in favor of more years will be most beneficial in reducing the variance of a genotype mean. Increasing the number of replications will be least effective. If increasing the number of years is impractical, increasing the number of seasons is second best, followed by locations. If average quality is considered instead, increasing number of seasons of data collection will produce the greatest benefits.

Considering yield and quality together for either pickling or slicing cucumbers, the best allocation of resources is to use tests over years and/or seasons, rather than locations or replications. For initial testing in a breeding program, it would be easiest to use a spring and summer (or fall) test to sample the effect of seasons. Tests over years would be better mainly for advanced lines, since additional years of testing in early stages will slow the progress in a breeding program.

Table 2. Estimated variances of genotype means for total yield and average quality score of pickles and slicers using 5 designs for performance trials<sup>2</sup>.

Model					Total yield		Average quality	
Increased	<u>r</u>	<u>l</u>	<u>s</u>	<u>y</u>	<u>Pickle</u>	<u>Slicer</u>	<u>Pickle</u>	<u>Slicer</u>
Base	2	2	2	2	19.4	20.3	0.076	0.108
Reps	3	2	2	2	18.0	19.0	0.059	0.093
Locations	2	3	2	2	16.8	17.3	0.059	0.090
Seasons	2	2	3	2	15.6	16.2	0.048	0.070
Years	2	2	2	3	13.2	15.9	0.059	0.087

<sup>2</sup>Variances estimated for trials run with r replications, l locations, s seasons and y years (using 2 of each for the base model).

#### Literature Cited

1. Jones, G. L., D. F. Matzinger and W. K. Collins. 1960. A comparison of flue-cured tobacco varieties repeated over locations and years with implications on optimum plot allocation. Agron. J. 52: 195-199.
2. Marcuse, S. 1949. Optimum allocation and variance components in nested sampling with an application to chemical analysis. Biometrics 5: 189-206.
3. Miller, P. A., J. C. Williams and H. F. Robinson. 1959. Variety X environment interactions in cotton variety tests and their implications on testing methods. Agron. J. 51: 132-134.
4. Sprague, G. F. and W. T. Federer. 1951. A comparison of variance components in corn yield trials: II. Error, year X variety, location X variety, and variety components. Agron. J. 43: 535-541.
5. Trout, J. R. and R. P. Marini. 1984. Estimating sample size to achieve efficient experiment designs. HortScience 19: 355-358.