Determination of optimal plot size in banana experiments.

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DETERMINACIÓN DE LA DIMENSIÓN ÓPTIMA DE UNA PARCELA EN LAS EXPERIENCIAS EN BANANOS

DETERMINATION DE LA DIMENSION OPTIMALE DES PARCELLES POUR LES ESSAIS SUR BANANIERS

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RESUME - Les auteurs recombinent diversement les 432 «unités de base» (une unité = trois touffes, de trois porteurs en principe) d'un essai d'engrais pour déterminer l'influence du nombre de souches par parcelle sur la variance des données collectées : mensurations, teneurs en K, etc. En conséquence, une probabilité de 80 p. 100, pour l'obtention de différences significatives dans la comparaison de cinq objets, nécessite cinq répétitions avec des parcelles de douze touffes.

A banana fertilization experiment was conducted with 12 fertilizer combinations during four years (1966-1970). The experiment comprised 12 treatments by 6 randomized block replicates. Each plot consisted of two rows, with 9 stools in a row (18 stools in total).

The following parameters were recorded : The number of bunches per stool (normally conducted with 3 followers), bunch weight, height of suckers and K content of blade of leaf III and petiole of leaf VII. Results were summerized in units of three adjacent stools. These units, considered as the «basic units» numbered 6 for every plot, the whole field adding up to 6 x 12 x 6 = 432 units.

Conclusions about the effect of the fertilizer treatments were published elsewhere (3). We shall deal here with the investigation of optimal plot size by calculating the changes in experimental variance when 2, 3, 4, 5, or 6 basic units are combined to one plot.

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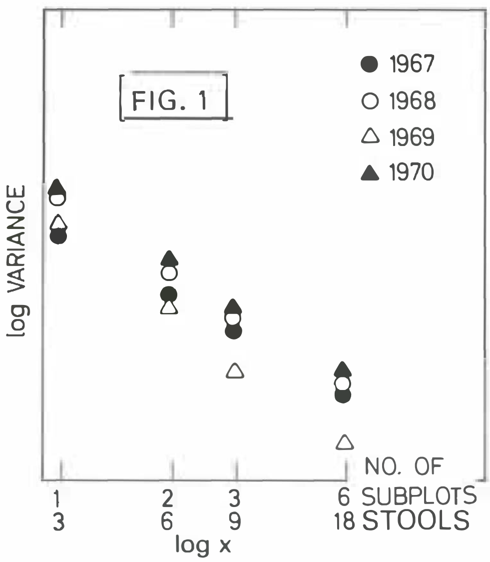
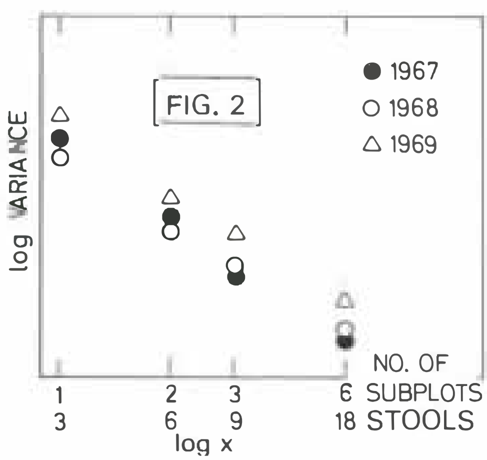
When such a uniformity trial is conducted, we have the possibility to combine all sizes and shapes of basic units. However, in the experiment described where different treatments were compared we can combine basic units only within plots which received the same treatment. This limits us as to the shape and size of plots. We can combine at most 6 adjacent basic units. With these limitations in mind, theoretical and practical conclusions can be drawn.

Each year we calculated for each of the measured variables the experimental variance among plots of different sizes (from 1 to 6 basic units). Naturally the variance was calculated without the treatment effect, but with the effect of the blocks, because the special division to blocks used in this experiment is only one of the possible divisions and is nonrelevant to the general problem in question.

The results are shown in figures 1 to 3, where the change in experimental variance for a basic unit (Vx) is shown, where plot size (X) is increasing from 1 to 6 (3 to 18 stools). The two scales are logarithmic and the points in most cases show a straight decreasing line and confirm the





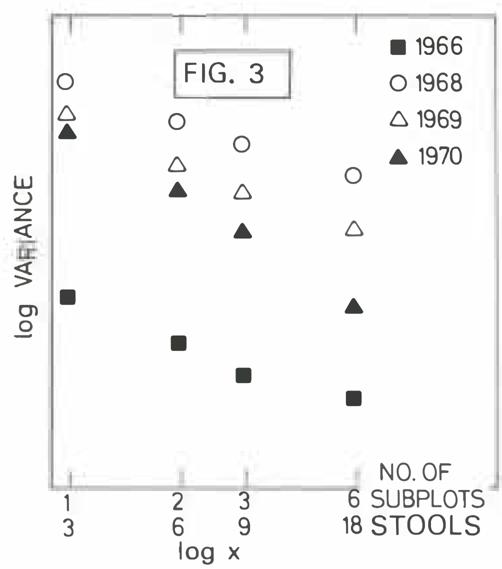


FIG. 1-2-3.
THE LOGARITHMIC RELATIONSHIPS BETWEEN NUMBER OF STOOLS IN THE EXPERIMENTAL PLOT AND THE VARIANCE OF THREE PARAMETERS • LES RELATIONS LOGARITHMIQUES ENTRE LE NOMBRE DE TOUFFES PAR PARCELLE EXPERIMENTALE ET LA VARIANCE DE TROIS PARAMETRES • LAS RELACIONES LOGARÍTMICAS ENTRE EL NÚMERO DE MATAS POR PARCELA EXPERIMENTAL Y LA VARIANZA DE TRES PARAMETROS

1. Number of bunches per stool - Nombre de régimes par touffe - Número de racimos por mata.
2. Bunch weight - Poids du régime - Peso del racimo.
3. Sucker height - Hauteur de la plante - Altura de la planta.

empirical law of FAIRFIELD-SMITH (1) which states : ($V_x = V_1/X^b$) that the variance between plots of size X is inversely proportional to a power (X^b) of plot size.

V_x = Variance (σ^2) of one subplot
b = value received experimentally (between 1 and 0)

Moreover, in each variable the exponent b is not changing much from one year to another. Therefore we calculated the average exponent from 3 or 4 years in which the parameters were taken. The exponents received were b = 0.68 for average bunch weight, b = 0.52 for average height of sucker and b = 0.85 for the average number of suckers per stool.

These b values are high enough and close to the maximal possible value b = 1 received in replicates which are completely independent. Therefore, one principle conclusion can be drawn. Under certain physical conditions the treatments can be given to comparatively large plots instead of subdividing them to many small plots and thereby increasing the number of replications. This, with but a small decrease in experimental accuracy is practicable, provided that the number of replications is sufficient to ensure a minimum of 15-20 d.f. for experimental error.

As for mineral analysis, calculations were made for K in one year only. The exponents calculated were b = 0.67 for the blade of leaf III and 0.9 for the petiole of leaf VII. Here also the values (esp. that of the petiole) are high, and we can get almost the same accuracy through increasing the number of replications and by adding to the number of suckers sampled in the plot.

If we are interested in limiting the number of suckers sampled with consequent lower accuracy in results, it is preferable to sample the blade of leaf III. However if higher accuracy is needed and we are prepared to increase the sizes of sampled plots it is preferable to sample the petiole of leaf VII. (The F values in blade and petiole were equal in plots with 15-18 suckers).

As for sucker height, a large difference was found in the variance from year to year (in 1968 the variance was 5 times higher than in 1966). This difference is accounted by the difference in desuckering between the years. In such cases it is impossible to plan an experiment with satisfactory accuracy for this parameter.

The number of suckers per stool is a parameter also depending on desuckering, a practice carried out usually by subjective criteria, and therefore we must also eliminate it while planning an experiment. We shall limit ourselves in planning the trial to the third parameter only, the average bunch weight which does not suffer from the above disadvantages.

An exemple : in a randomized block experiment comparing 5 fertilization treatments in which a 80 % probability of establishing the significance (at the 5 % level) is required, and the difference in bunch weight between treatments is 5 kg. The experimental variance among plots of four basic units was estimated as 1.9 kg. From the tables (2) we see that the minimal number of replications is 5 (table 1).

From the table we can see that the minimal number of stools and the minimal area for the experiment is received from 3 basic units (9 stools). But in such a case the number of plots is relatively high, a fact which causes additional investment in irrigation equipment. Also the area might be larger since as the plots are smaller the area of border lines is larger. Since an experiment with 4 replications is usually not recommended we can decide the optimal plot size to comprise 4 basic units = 12 stools with 5 replications.

TABLE 1 - Number of stools per plot, replications, plots and stools needed for an 80 % probability of establishing a 5 % range of significance when the difference (between the 5 treatments) in bunch weight is 5 kg.

TABLEAU 1 - Nombres de touffes par parcelle, de répétitions, de parcelles et de touffes par essai, nécessaires à une probabilité de 80 % d'obtenir une signification au niveau 5 %, quand la différence de poids de régime (entre 5 traitements) est de 5 kg.

TABLA 1 - Números de matas por parcela, de repeticiones, de parcelas y de matas por experimento. necesarios para una probabilidad de 80 % de obtener una significación al nivel de 5 %, cuando la diferencia de peso de racimo (entre 5 tratamientos) es de 5 kg.

number of subplots	number of stools	number of replications	total number of plots in experiment	total number of stools	total area required (hectar)
3	9	6	30	270	0.36
4	12	5	25	300	0.40
5	15	5	25	375	0.50
6	18	5	25	450	0.60
7	21	4	20	420	0.56
8	24	4	20	480	0.64

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DETERMINATION DE LA DIMENSION OPTIMALE DES PARCELLES POUR LES ESSAIS SUR BANANIER

Dans un essai de fertilisation comparant douze traitements, on a relevé les paramètres suivants : nombre de régimes par touffe, poids des régimes, hauteur de la plante, teneur en potassium du limbe de la feuille III et du pétiole de la feuille VII. L'essai était disposé en six répétitions constituées de blocs randomisés. Chaque parcelle, comportant dix-huit touffes, était subdivisée en six «unités de base» de chacune trois touffes (menées théoriquement à trois porteurs), et les données ont été relevées séparément sur chacune des 432 unités.

Ces unités de base ont été combinées en parcelles de différentes dimensions (une à six unités). Pour chaque dimension, la variance expérimentale entre de telles parcelles (en éliminant l'effet des traitements) a été estimée. Le graphique de ces variances en fonction de la dimension des parcelles (x) sur une échelle logarithmique confirme la loi empirique de H.F. SMITH, selon laquelle la variance entre parcelles de dimension x est inversement proportionnelle à une puissance (x^b) de cette dimension. L'exposant (b) a été estimé pour chacun des paramètres (figures 1 à 3).

En utilisant ces résultats, on peut calculer les combinaisons optimales de dimension de parcelle et de nombre de répétitions. Par exemple, dans un essai en blocs randomisés comparant cinq traitements (tableau 1), où l'on veut une probabilité de 80 p. 100 d'obtenir des résultats significatifs au seuil de 5 p. 100, la combinaison optimale consiste en cinq répétitions avec des parcelles de quatre unités de base (12 touffes).

DETERMINACIÓN DE LA DIMENSIÓN ÓPTIMA DE UNA PARCELA EN LAS EXPERIENCIAS EN BANANOS

En una experiencia de fertilización, en la que se compararon 12 tratamientos, fueron registrados los siguientes parámetros : número de racimos por planta madre, peso del racimo, altura del seudo-tallo y contenido de potasio de la hoja III y del pecíolo VII.

La experiencia fué diseñada en 6 repeticiones en bloques al azar. Cada parcela, conteniendo 18 plantas madres, fué subdividida en seis unidades de base de 3 plantas madres (teoricamente conducidas con tres hijos por planta) cada una, y se hicieron mediciones por separado en cada una de las 432 unidades.

Las unidades básicas se combinaron en parcelas de diferentes tamaños (1-6 unidades). Para cada dimensión de parcela, se determinó la varianza experimental entre tales parcelas (eliminando el efecto de tratamiento). La representación gráfica de estas varianzas en función de la dimensión de la parcela (x) sobre escala logarítmica confirmó la ley empírica de H.F. Smith, el cual manifiesta que la varianza entre las parcelas de dimensión x es inversamente proporcional a una potencia (x^b) de la dimensión de la parcela. El exponente b fué calculado para cada uno de los parámetros (figure 1-3).

Usando estos resultados, se pueden calcular las combinaciones óptimas de tamaño de la parcela y número de repeticiones. Por ejemplo, en un experimento en bloques al azar comparando 5 tratamientos (tabla 1) en los que se requiere un 80 % de probabilidad de establecer la significación al nivel del 5 %, la combinación óptima es de 5 repeticiones con parcelas de 4 unidades básicas (12 plantas madres).