AUTOMATIC MAPPING OF THE SPREAD OF AFRICAN CASSAVA MOSAIC VIRUS

R. Lecoustre, C. Fauquet, and D. Fargette

First author, Laboratoire de Biomathématiques et Statistiques, IRHO/ CIRAD La mé, 01BP1001 Abidjan, Ivory Coast; second and third authors, Laboratoire de Phytovirologie, ORSTOM, BP V 51, Abidjan, Ivory Coast.

The automatic mapping technique of cartography employed here uses the application of the theory of regionalized variables (2). Some examples of regionalized variables are: densities of human population in a given geographic zone, a mineral concentration in an ore-bearing earth ... The cumulative percentage of cassava contaminated plants is an adequately defined regionalized variable of density.

Let us consider the two following A and B linear sequences of numbers:

A: 1 - 2 - 3 - 4 - 5 - 6 - 5 - 4 - 3 - 2 - 1
B: 1 - 4 - 3 - 6 - 1 - 5 - 4 - 2 - 3 - 5 - 2

In case A we can see an obvious symmetrical structure; in case B the structure, if there is one, is unaccented; however, these two sequences of 11 numbers have the same variance. So these two mathematical values are insufficient to describe the structure and the main characteristics of a natural phenomenon.

The two main characteristics of a regionalized variable are the continuity and the isotropy in the considered space. If the continuity, in general, is unrespected we are in the case of an irregular repartition named "pure nugget effect;" the clearest example being the gold nugget field.

For a local estimation, the structural information needed is totally summarized by the semi-variogram study. Each point of this semi-variogram (G) represents for a given h distance (H), the mean (E) of the squared value of the deviation between the values of the regionalized variable in every point of the space studied [Z(X+h);Z(X)].

$$G(H) = 1/2\ E[Z(X+h) - Z(X)]^2$$

Practically, this semi-variogram is adjusted to a modelized variogram. The different types of adjustment of the regionalized variables are likely to enable the deduction of spreading patterns of, for instance, the mineral element or the species, or the disease considered. In the case of ACMV, the experimental semi-variogram is likely to be adjusted to a straight line, showing a precise gradient effect in the structure of the variable within the considered trials. Furthermore, in the case of oriented variables, it is possible to calculate the semi-variogram in each direction and to find a prevalent direction. In these circumstances, the contamination is essentially a primary contamination (coming from outside the field) ("Spatial pattern of ACMV spread," same issue), following the direction of the prevailing wind and with a border effect as it was found in field experiments ("Primary and secondary spread of ACMV," same issue).

Knowing the modeled semi-variogram of a given variable it is possible to calculate a local estimation of the regionalized variables from a sample collected experimentally.

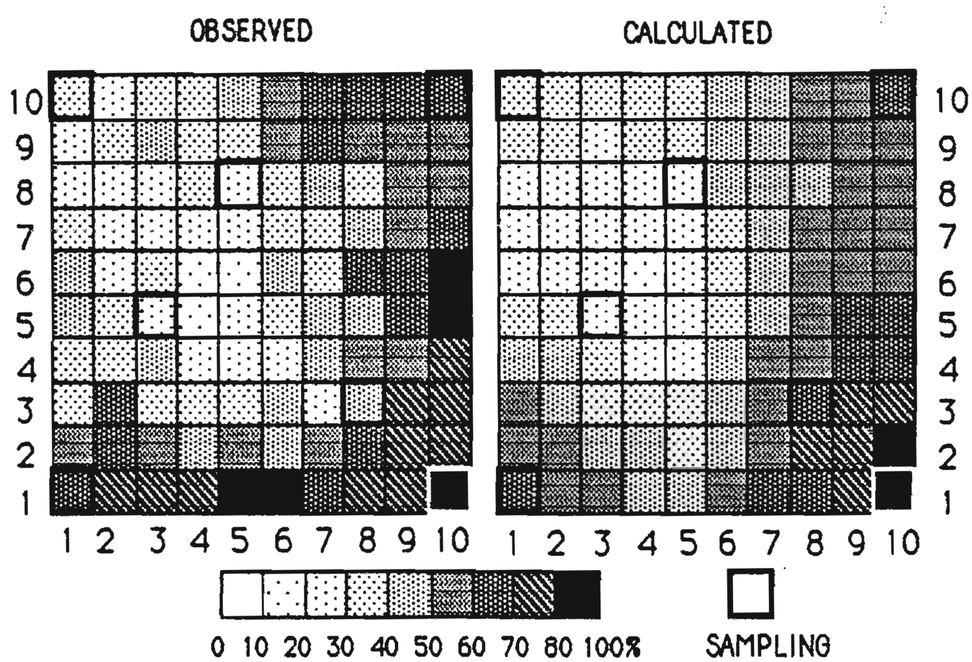
A theory of a local estimation, without any shift, was adjusted by Krige (1). This theoretical method calculates again the values of the sampled points, restoring the distribution in mean and variance; this method is known as the kringing method.

The calculation of a Z(Xo) value in an Xo of any point surrounded by n sampled points is obtained by the formula:

$$Z(Xo) = \sum^{n} Li\ Z(Xi)$$

where $\sum^{n} Li = 1$ and Z(Xi) represents the variable value of a sampled point Xi; Li is the calculated balancing coefficient of the value of the sampling in Xi. The Li values are calculated with the modeled semi-variogram, so that the expected value of the variance, in Xo, is minimum.

The studies comparing the calculated values obtained from a given sample and from a h max distance from which the Xi values are considered to have no more influence upon this Xo calculation, show that in the case of ACMV, a sample of 7% (7 blocks of 25 or 100 plants in a trial of 50 to 100 blocks) and a h max distance near 5 blocks (25 to 50 meters) give the best estimates.



The figure above visualizes the results obtained with the automatic mapping with a cassava field of 1 ha, 6 months after planting, with a sampling of 7%. . The correlation between the observed and the calculated cartography is 0.81. Nevertheless, the knowledge of a border effect, particular to the spread of the ACMV disease, implies that a structured sample collection rather than a random sample collection should be chosen.

The kringing method enables the reduction of about 14 times the field observation work, while correctly giving the necessary structural information needed to study the spread of the ACMV viral disease in the experimental trials.

REFERENCES

1. Krige, D. G. 1966. J. South Afric. Inst. Mining and Metallurgy 66:13-38.

2. Matheron, G. 1965. Cahiers du Centre de Morphologie. Fascicule 5. Ecole des mines de Paris.