Use of Boundary Lines in Field Diagnosis and Research for Mexican Farmers

By Armando Tasistro

Better diagnostic tools that avoid the bias of the diagnostician and are more quantitative in nature are badly needed, especially in developing countries. The application of boundary lines to the databases that are routinely collected by advisers could serve as a useful alternative. Furthermore, they can provide valuable research information in a shorter time and more representative conditions than traditional experiments.

The diagnosis of field problems involves not only their identification, but also their prioritization. These are critical steps that need careful attention. Boundary lines can be used to prioritize field problems. After Webb (1972) wrote about the biological significance of boundary lines, they have been used by numerous researchers in a wide range of applications. Boundary lines have potential advantages (Shatar and McBratney, 2004) such as: the facilitation of site-specific applications because each sampled point in a field can be considered separately; the possibility of identifying a single yield-limiting variable at each location; and there is no need for a separate process of variable selection. However, they also have a number of shortcomings (Lark, 1997; Shatar and McBratney, 2004) that include: fitting boundary-line curves can be difficult; they do not provide evidence about the nature of the joint action of the factor under consideration with others; and, the potential dependence of the location of the boundary line on relatively few data points limits its robustness.

As an example of their application, the four hypothetical scattergrams in **Figure 1** show the relationship between maize yield and four variables: plants/ha, soil organic matter, soil Na, and soil EC. The database used could have typically been collected by agricultural advisers through their regular visits to farmers. As an example of the application of this approach as a diagnostic tool, we will assume that we have sampled a maize field and found the values for each of the four variables shown by the vertical lines in each graph. Each value of the four variables is associated with an expected maize yield given by the corresponding boundary line. If we arrange the expected yields in increasing order, we get the sequence soil Na < soil EC < soil organic matter < plant/ha, which suggests that in this example soil Na is the one that most limits maize yield.

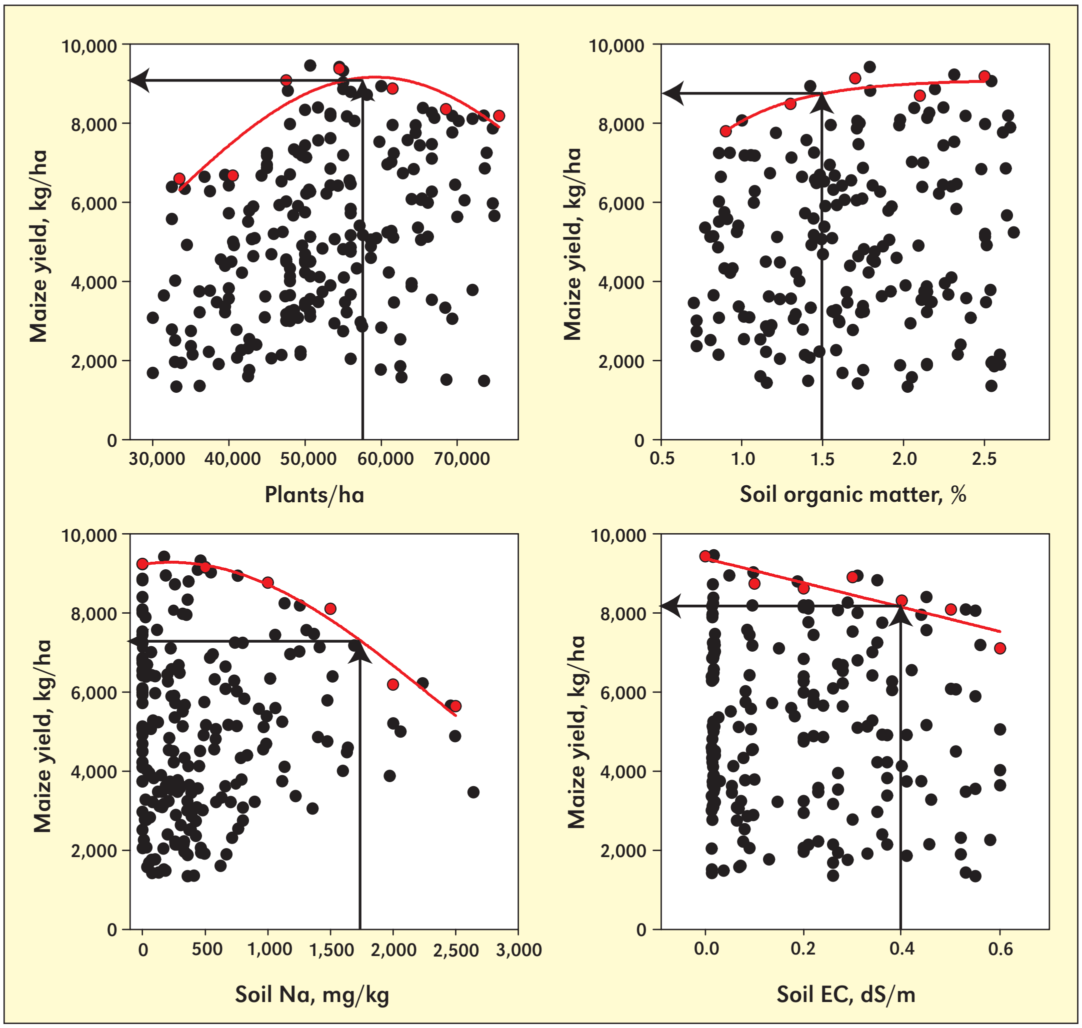

Figure 1. Scattergrams showing the hypothetical relationships between maize yield and maize plants/ha, soil organic matter content, soil Na content, and soil salinity (EC).

Examples from Mexico

Boundary lines were fitted to maize data sets made from observations taken in 1,850 farms and the results of the analysis of 38 soil samples from "La Fraylesca" region in Chiapas collected at harvest time. This sampling was carried out by private consultants as part of a training program on field diagnosis. The maize fields were sampled following the guidelines by Lafitte

Common abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; Al = aluminum; Na = sodium; EC = electrical conductivity.

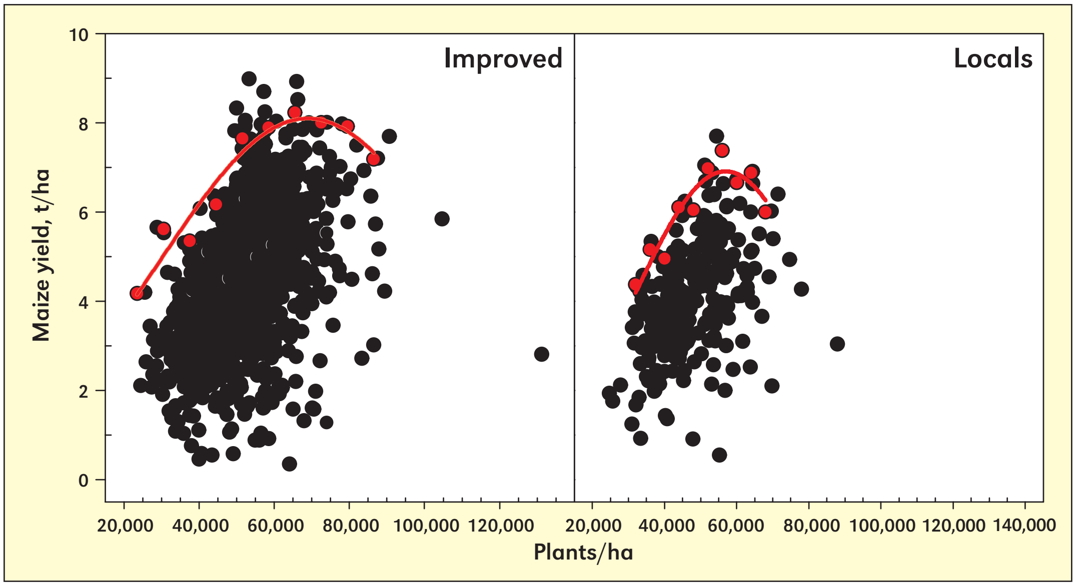

Figure 2. Maize yields of improved and local genotypes under the range in plant populations observed in Chiapas, Mexico.

(1993) where eight randomly chosen 5.0 m-long segments of crop rows were marked, and observations were carried out in the 1st, 5th, and 10th plant in each row. The results for each farm correspond to the mean of the 8 rows. Soil samples were composites of 10 to 15 sub-samples of the top 0 to 25 cm layer taken from the area of the 8 rows.

Boundary lines were adjusted following Schmidt et al. (2000) where scattergrams relating grain yield to each variable of interest were built; the data set for each scattergram was split-up in equidistant segments on the basis of the values of the x-axis variable; data points in each segment were assumed to relate to the arithmetic mean of the x-values of the respective segment; the data points in each segment were then ordered according to the dependent variable; 99% percentiles were computed and used as boundary points. A line was fitted and drawn to those boundary points.

Most of the visited farmers in Chiapas grew improved maize genotypes, which yielded more and tended to respond to higher plant densities than local genotypes (**Figure 2**). The grain yield of improved genotypes responded to the total amount of N applied showing a peak at 226 kg N/ha (**Figure 3**).

Ears with scattered grains and blank spaces in-between are indicative of possible insect damage to silks, extremely hot conditions, or drought during pollination (Lafitte, 1993). Data in **Figure 4** show that yield dropped more markedly when those symptoms were visible in more than 15% of the ears.

The partial or total absence of grain rows might be the result of several factors, including P deficiency, excessive plant population, poor plant arrangements, or that the ears showing

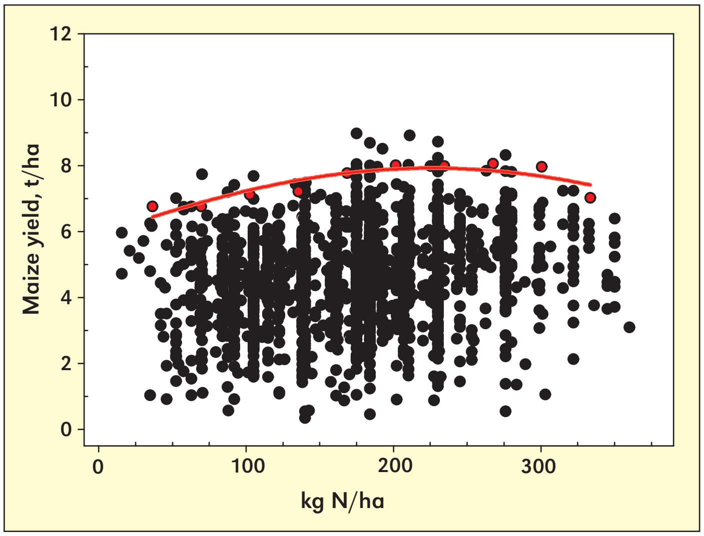

Figure 3. Maize yields of improved genotypes under the range of total N applications in Chiapas, Mexico.

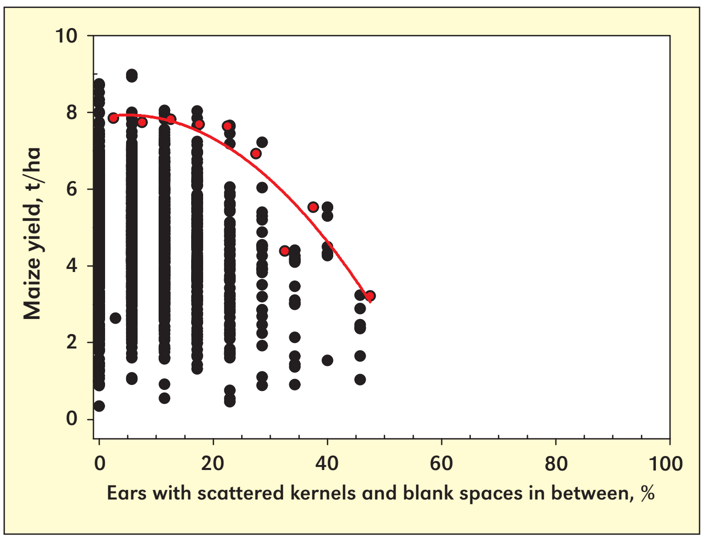

Figure 4. Effect of ears with scattered grains and blank spaces in between on maize yields in Chiapas, Mexico.

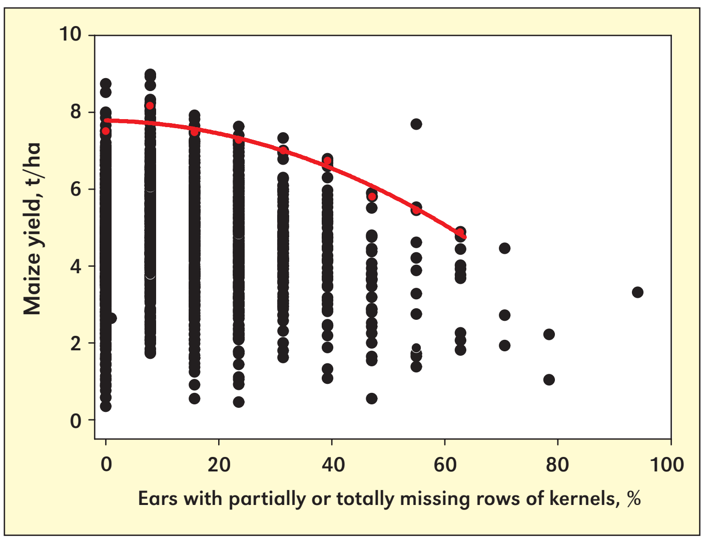

Figure 5. Effect of ears with some rows of grains partially or completely missing on maize yields in Chiapas, Mexico.

the problem are second ears in prolific plants (Lafitte, 1993). Maize yield seems to be affected less by these problems (**Figure 5**) than by those shown in **Figure 4**.

Root and stalk lodging showed low incidences, but stalk lodging seemed to affect yields more markedly than root lodging (**Figure 6**), which could be related to the more drastic effects of stalk breaking on grain filling.

Figure 7 shows the relationships between grain yield and some of the soil properties analyzed. Soil acidity is an important limitation for maize in La Fraylesca. Dominant sandy textures, humid climate, and a history of usage of ammonium sulphate as an N source, have contributed significantly to that problem. As **Figures 7a** and **7b** illustrate, maize yield is reduced 50% when exchangeable Al concentration exceeds 1.0 cmol$_c$/kg or occupies more than 20 to 30% of the cation exchange sites. Although soil K content can be severely limiting for maize yield, as indicated by the data in **Figure 7c**, the application of K is still quite limited among farmers in that region. Soil organic matter can also be a critically limiting factor (**Figure 7d**), which reinforces the need to adopt conservation agriculture practices and stop the burning or removal of crop residues.

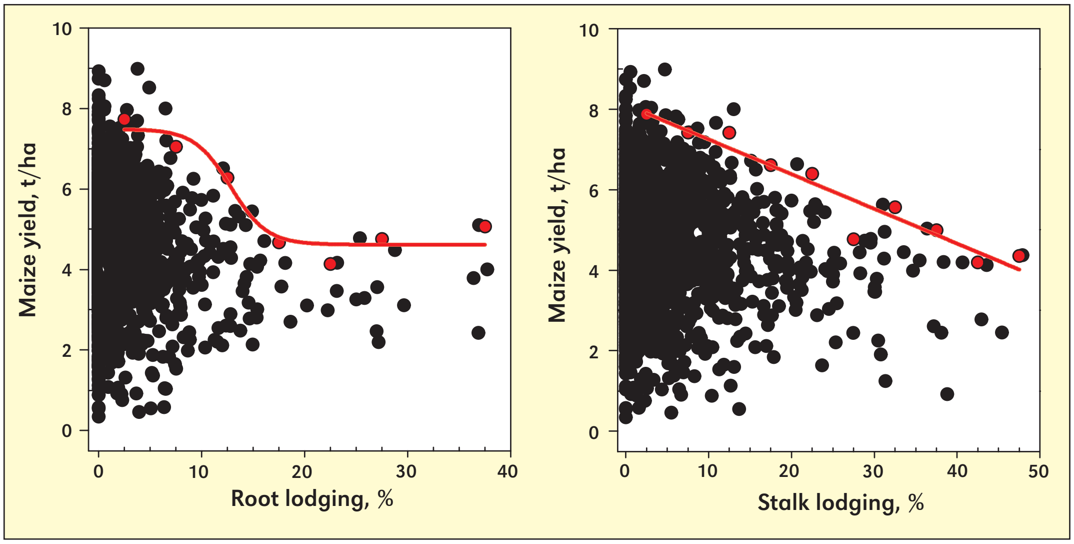

Figure 6. Effects of root and stalk lodging on maize yields in Chiapas, Mexico.

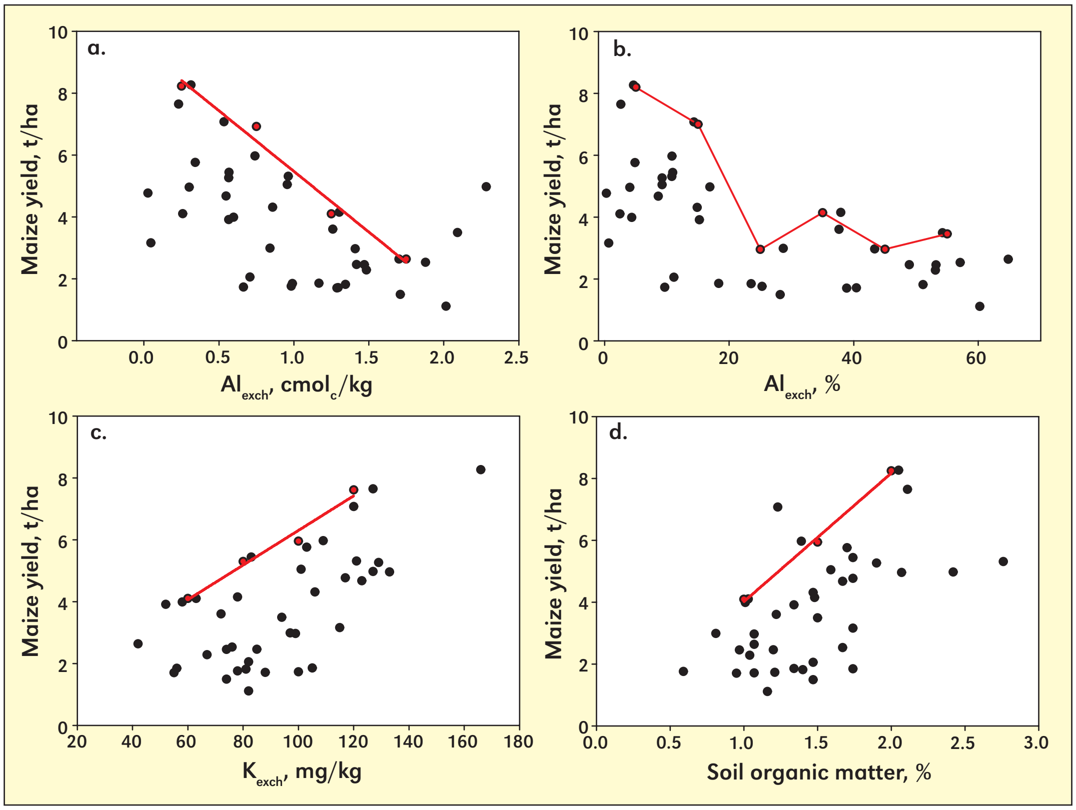

Figure 7. Effects of soil exchangeable Al (a) and (b), soil K (c) and soil organic matter (d), on maize yields, Chiapas, Mexico.

Prior to this work, the knowledge about the effects of plant population, N rates, or other management components on maize yield in the region was limited to results taken from conventional research plots. Given the limited nature of these studies in terms of geographical areas or environmental conditions, the application of their results can be limited by uncertainty about the variability between the conditions under which the results were obtained and those under which they will be applied. This brings attention to the potential of data collection and analysis through boundary lines as a research tool. As evidenced by the results of this study, properly planned surveys can efficiently provide representative data to compliment conventional research plots.

The increasing use of surveys in agriculture as well as of precision agriculture tools are providing greater opportunities to develop databases amenable to analysis through boundary lines. BC

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