Multivariate Analysis and the Classification of Agricultural Systems in a Major Tropical Area of Cacao Production (Barlovento, Venezuela)[1]

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ABSTRACT

Production systems of the Barlovento Valley, a major area of cacao production in the tropics, were classified according to multivariate statistical methods based on cluster analysis of cases and variables. A sample of 487 surveys was selected from a total of 850 farms according to the three main components of the production systems: producer's economic rationale, technology and natural environment (10, 11). As a result of the cluster analysis, farms studied were divided into five groups, mainly characterized by an area gradient. In relation to the intrinsic characteristics of each system, it should be noted that in the Barlovento area there seems to exist a predominance of farms with agricultural systems mainly influenced by factors unrelated to potential agricultural productivity. Thus, constraints such as high production costs, limited credit, restricted use of agricultural machinery, inadequate cultural practices and reduced human labor for agricultural activities establish priorities which have overridden consideration of biological production efficiency.

COMPENDIO

Los sistemas de producción de cacao en el Valle de Barlovento, una de las principales áreas productoras de cacao en los trópicos venezolanos, fueron clasificados de acuerdo a métodos estadísticos multivariados, basados en el análisis de conglomerados de casos y variables. Se utilizó una muestra de 487 encuestas, seleccionadas de un total de 850 fincas, de acuerdo a los tres componentes principales de los sistemas de producción: Racionalidad Económica del Productor, Tecnología y Medio Natural. Como resultado del análisis de conglomerados, las fincas fueron divididas en cinco (5) grupos, principalmente caracterizados por gradiente de superficie. En relación con las características intrínsecas de cada sistema, se pudo notar que, en el área de Barlovento, parece existir una predominancia de fincas con sistemas agrícolas principalmente influenciados por factores no relacionados con la productividad agrícola potencial. Restricciones tales como los altos costos de producción, crédito limitado, insuficiencia en el uso de maquinaria agrícola, prácticas culturales inadecuadas y escasez de mano de obra para las actividades agrícolas, establecen prioridades que superan las expectativas con respecto a la eficiencia de la producción biológica.

INTRODUCTION

To understand agricultural systems as a function of their components (producer's rationale, technology and natural enviroment) entails the management of a considerable volume of information Nevertheless, relations and factors in these units could be shown through data classification of the selected production systems. Classification of these systems into groups has been traditionally based on subjective evaluations of similarity or on the presence of conspicuous, subjectively chosen elements, whereas the cluster analysis provides an objective measure of similarity and therefore a more satisfactory criteria for group division (6, 12, 25).

Although a vast amount of information is required to interpret the complex characteristics of the agricultural production systems, there are regions where complexity is relatively reduced by local peculiarities. These areas can therefore be studied as models, in a functional approach to understanding the more complex hierarchical levels of the systems (1). An example is the Barlovento Valley (State of Miranda, Venezuela), one of the tropics' major areas of cacao production, where tenure, land use and agroecological characteristics present a certain homogeneity. This valley is bordered by the Cordillera de la Costa in the north and the Cordillera del Interior in the south (Fig. 1), and the cacao plantations cover a greater extension (24% of a total of 43 751 ha) than other traditional crops in the area (7,11)

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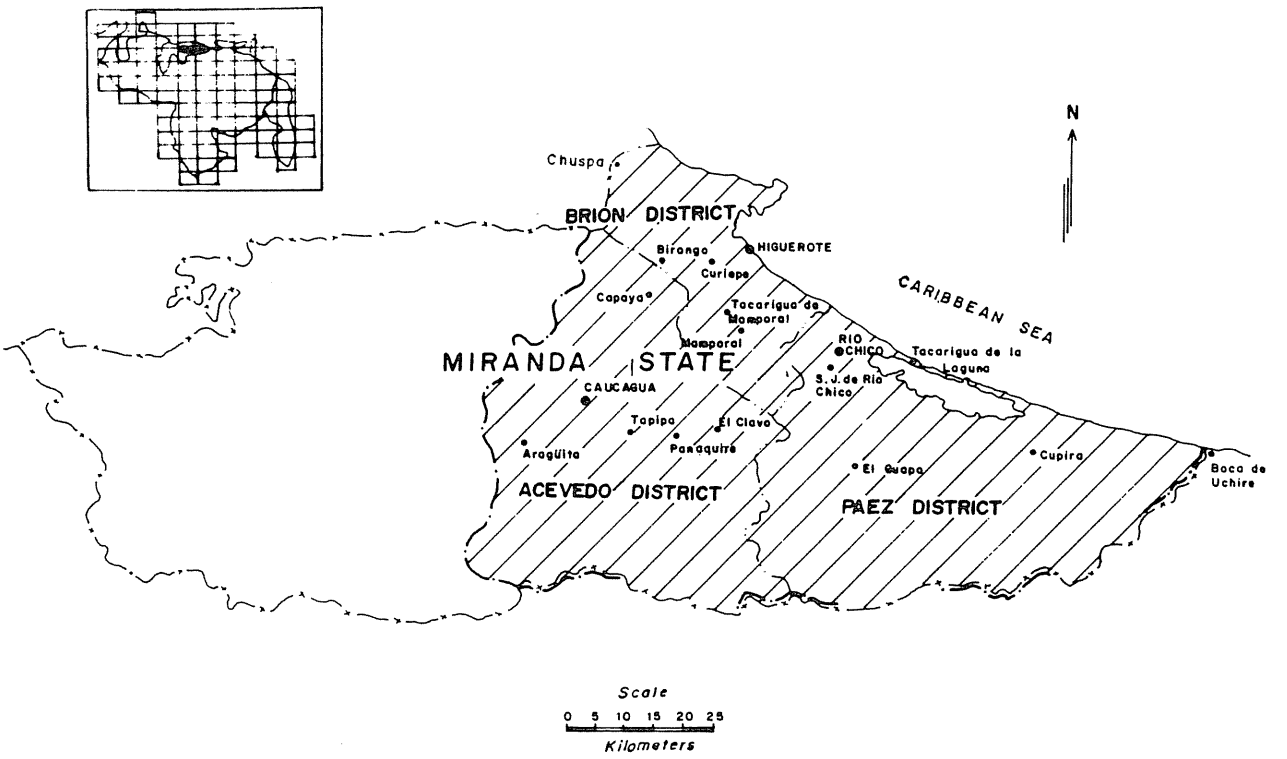

Fig. 1. Region of Barlovento (Miranda State, Venezuela) and relative position.

The purpose of this work is to classify the agricultural production systems of the Barlovento Valley according to cluster analysis techniques.

MATERIALS AND METHODS

Study area

The study area was set up in the region of Barlovento, State of Miranda, Venezuela (Fig. 1), where annual precipitation ranges from 1 500 to 3 400 mm, and the mean annual temperature is 26°C. The area is characterized by an original dry tropical forest and humid tropical forest, vegetation according to Ewel and Madriz (4). In addition to agricultural activities, human impact on the area due to touristic development has recently increased (9).

Aerial photographs (1:35000) corresponding to the photomosaic Guatire-Cabo Codera-Altagracia de Orituco/Federal District Region-State of Miranda/ Mission D-8, 1952 and photoplans (1:25000) of the 1978 aerophotographic mission Chirimena-Guatopo-Sabana de Uchire, were used to interpret the temporary changes in land use, agroecological characteristics, land tenure regimes and socio-economic structure.

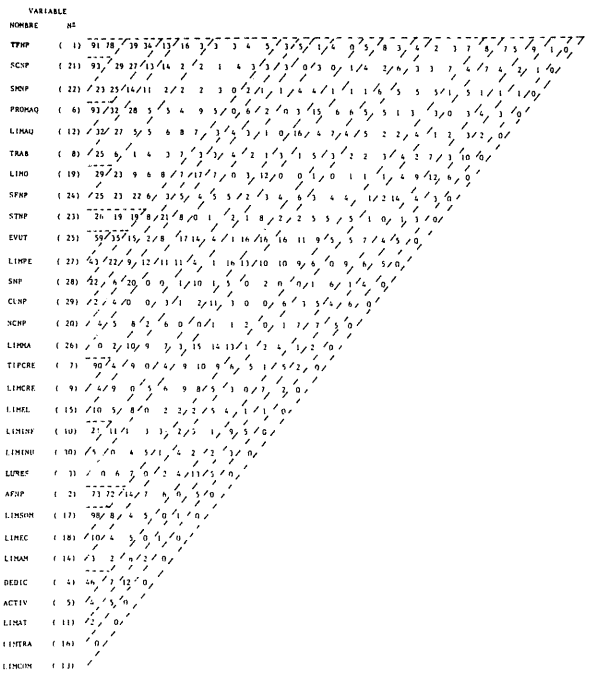

Fig. 2. Clustering tree of variable corresponding to the components of the production systems present at the Barlovento Valley (Miranda State, Venezuela.

Variables used in production systems analysis

Variables corresponding to the three main components of the production systems (economic rationale, technology and natural environment) were randomly chosen from 487 surveys carried out by the Experimental Station at Caucagua (FONAIAP) for the National Project of Bio-Socioeconomic Diagnosis of Production Systems (PNDB). Information was complemented with a survey carried out on farms representative of the sample.

Description of variables

* Variables of economic rationale/production objective

a) Size of farm (TFNP)
b) Years of farm establishment (AFNP)
c) Place of residence (LURES)
d) Dedication to farming (DEDIC)
e) Other activities apart from production (ACTIV)
f) Machinery ownership (PROMAQ)
g) Type of credit (TIPCRE)
h) Type of work (TRAB)
i) Credit limitation (LIMCRE)
j) Infrastructure limitation (LIMINF)
k) Technical assistance limitation (LIMAT)
l) Machinery limitation (LIMAQ)
m) Marketing limitation (LIMCOM)
n) Medical assistance limitation (LIMAM)
o) Electricity limitation (LIMEL)
p) Transport limitation (LIMTRA)
q) Crop age limitation (LIMEC)
r) Shading limitation (LIMSOM)
s) Manual labor limitation (LIMO)

(Source: surveys and interviews with producer.)

* Technology variables

a) Cacao surface area (SUPCA)
b) Musa surface area (SUPMU)
c) Traditional crop surface area: yam, tannia, sweet potato, cassava (SUPTRA)
d) Orchard surface: avocado, citrus, others (SUPFRE)
e) Number of crops (NCNP)
f) Evolution in land use since plot establishment (EVUT)
g) Weed limitation (LIMMA)
h) Pest and disease limitation (LIMPE)

(Source: surveys and interviews with producer.)

* Natural environment variables

a) Soil series (SNP)
b) Use capacity (CUNP)
c) Flood limitation (LIMINU)

(Source: Agroecological study maps study maps (8); Study of the agroecological units of Barlovento (13); surveys and interviews with producers.)

Classification of variables

Variables were separated into two categories: rationale and technology, and natural environment. The

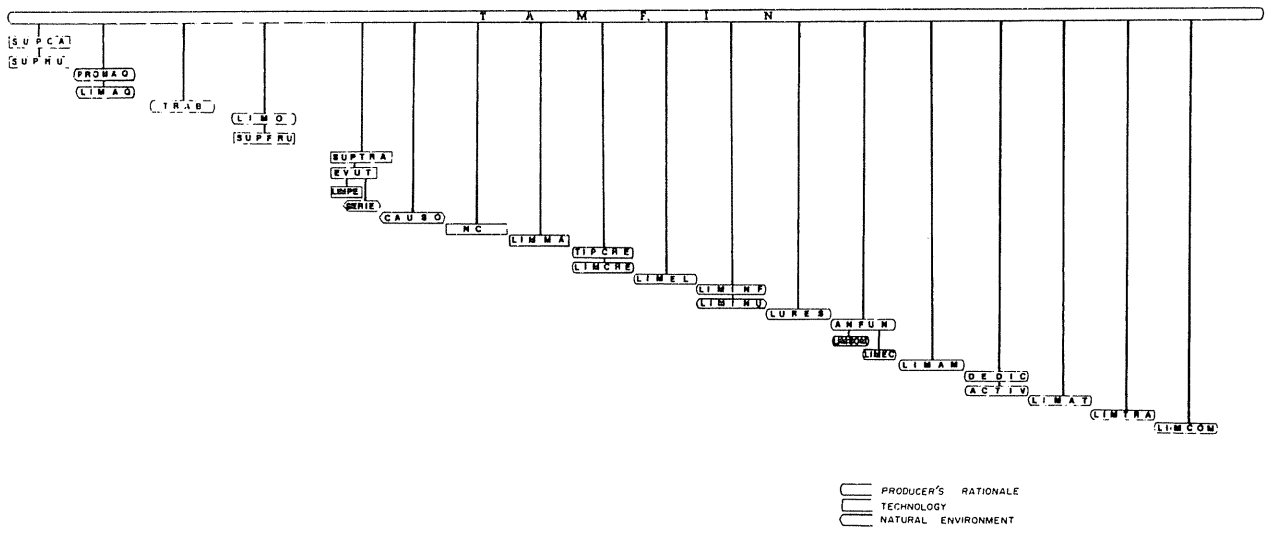

Fig. 3. Dendrogramme of the correlation matrix used to classify production systems at the Barlovento Valley (Miranda State, Venezuela).

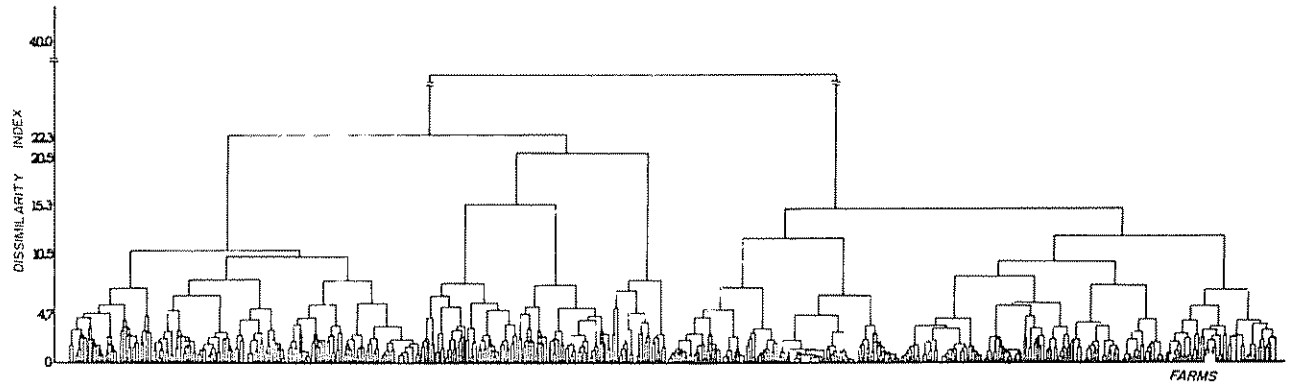

Fig. 4 Classification tree of the variables corresponding to the components of the production systems at the Barlovento Valley (Miranda State, Venezuela).

latter, referred to as the soil series and classified by use capacity, were obtained by placing each of the 82 communities studied on a MAC rural cadastral map (1:10 000), which was then superimposed on soil maps of the agroecological survey (8) (1:50 000) and the FONAIAP-CENIAP agroecological units and political division's maps (13) (1:200 000). The continuous variables (quantitative) were normalized to non-parametric variables with five different frequencies according to range. In this way, two types of non-parametric variables were obtained: dichotomical (present/absent) and multiple ordinates.

Data treatment: multivariate analysis techniques

Data of the variables were processed with BMDP statistical programs (Biomedical Pack elaborated by Dixon and Brown (3), implemented on the Burroughs 6 700 system, at the School of Computer Studies of the Central University of Venezuela, and modified for the purposes of the present work. Values of the farm (samples or cases) variables were stored on a 487 x 30 matrix (samples vs. variables) as a BMDP data file of fixed format. The variables of the previously described normalization presented numerical values.

Classification according to the cluster analysis

The data matrix was processed with the PIM routine to obtain correlations between operational variables (measure of similarity). Maximum similarity criteria were used to combine two groups or clusters of variables.

Systems were classifed with the P2M routine (cluster analysis of cases) using the operational variables chosen for the analysis. In this case, the chi-square statistical analysis was used as a measure of similarity, and the mean distance as a criteria for group linkage.

RESULTS AND DISCUSSION

Photointerpretations confirmed that land use patterns have not changed over the last 26 years. Thus, the area under cacao cultivation was similar in surface area and distribution, with cacao occupying a greater surface area in relation to other crops (11). However, important changes in land tenure have occurred as a result of a) agrarian reform programs related to improvements in the legal conditions of established producers and b) a relative improvement in wealth distribution. This is possibly a result of greater community participation in agricultural activity due to the allotment of undivided plots of land to each settler (11).

It is important to point out that despite the homogeneity of this area in relation to other land use patterns, changes in the coastal area may be observed (7, 9, 11). These changes include tourist recreational facilities such as buildings and equipment which, in the last few years, have induced modifications in characteristic aspects of the area such as the socio-economic structure. This growth in tourism-oriented activities has prompted migration towards the construction area of a percentage of the active agricultural commnity, negatively affecting production of this traditionally agricultural area (9).

The classification tree, with the correlation coefficients between variables and the corresponding dendrogram of the correlation matrix appear in Figs. 2 and 3, respectively. The highest significant correlation can be observed between farm size and other variables, especially cacao and *Musa* surface area, which are the main crops in the area under study. It was also obser-

ved that machinery limitations and ownership correlated highly with the previously mentioned variables, a probable result of facilitated agricultural activities in relation to f .rm size and mechanization.

A high correlation was also obtained with manual labor limitations, possibly explained by difficulties due to the movement of workmen toward other areas of occupational activity (9).

Regarding the variables selected in accordance with the methodological approach of Arias *et al.* (1), soil series, usage capacity and flood limitation presented a significant mean correlation with farm size, cacao surface area and *Musa* surface area; whereas the variables infrastructure, shading, and crop age limitation and type of credit showed a smaller significant correlation with the remaining variables.

Fig. 4 shows the classification tree for the operational variables. Five groups of farms were formed. The first group consists mainly of farms where cacao is cultivated in association with *Musa* in surface areas varying in size between 0.5 and 150 hectares (29 percent of total farmlands). Since the farms were founded less than 30 years ago, they are apparently exempt from problems of crop senescence. The activities of producers are mainly farming without the use of machinery. The second group represents 16 percent of the total, with a surface area varying between 0.25 and 225 hectares. Sixty-nine percent of the crops in this group are orchards, either associated with traditional crops or growing as monocultures and associations of cacao with *Musa* are also included. Fifty percent of the producers are totally dedicated to crop farming, whereas others may carry out different activities which represent an additional income. The third group includes the largest farms, varying in size between 40 and 900 hectares, covered with new plantations of cacao-*Musa* as the dominant association. Producers are fully dedicated to farming and they use machinery in their activities. The farms in the fourth group (20 percent of the total) were founded more than 30 years ago and vary in size between 0.5 and 15 hectares. Cacao and cacao-*Musa* associations are the dominant crops and the fifth plantation senescence does affect yield. The farms in the fifth group (13 percent of the total) range in size between 0.5 and 120 hectares, although 95 percent are 12 hectares or less. The cacao *Musa* association is dominant, but in approximately 20 percent of the plots, other associations of orchards and traditional crops are found.

A classification tree (Fig. 5) based on previously discussed group classifications was elaborated defining the determinant variables for each level (1, 2, 5).

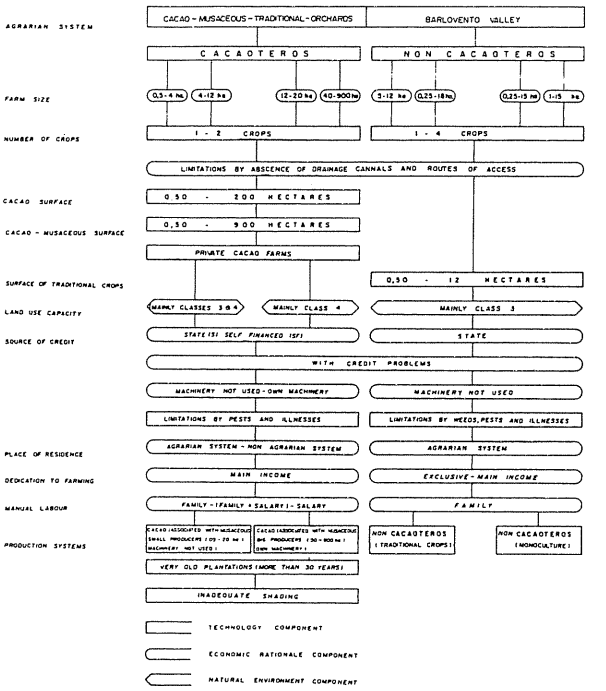

Fig. 5. Classification tree of the production system at the Barlovento Valley (Miranda State, Venezuela).

Two levels are described, the first one involving: a) all producers of cacao as a monoculture or associated with *Musa* (approximately 60 percent of total producers) and b) non-cacao producers (39 percent of the total) mainly dedicated to the production of mono-and multiple crops of cassava, yam, tannia and orchards of citrus and avocado. The second level includes four categories of producers. The first consists of farms owned by small producers cultivating cacao associated with *Musa* on a surface area of 0.50 to 20 ha where machinery is not used. They are financed by state agencies and generally have problems with loans. These farms (55 percent of the total area) are located on waterlogged lands of types three and four according to their use capacity system. The second category includes farms owned by large producers cultivating cacao associated with *Musa* on a surface and of 50 to 900 ha mechanized under a high input technology. These producers are generally self-financed, live within the agrarian system on private lands of types two and three, and represent five percent of the total. The third group are non-cacao producers, mainly dedicated to cultivating traditional associated crops on plots between 0.25 and 17 hectares of type three land, and represent 23 percent of all producers. Associations of traditional crops with orchards such as avocado and citrus are usually present, which means greater diversification. The producers are state-financed, and family labor

predominates. The last group consists of non-cacao producers dedicated to monoculture (*Musa*, orchards or traditional crops) planted without specific location in the area on farms oscillating between 0.25 and 10 ha. These producers are exclusively dedicated to subsistance agricultural farming with domestic manual labor, and represent approximately 17 percent of the total. The farms of this group are mainly located on type three land.

Results of the above classification indicate that in the Barlovento area there is a predominance of farms with a production system hampered by constraints mainly influenced by factors unrelated to primary production potential. This situation seems to be associated with: a) high production costs and an inadequate system of credits which does not respond to the needs of cacao production in the area; b) scarce use of agricultural machinery and adequate technology due to very limited technical assistance to the producers, which has contributed to maintain the traditional farming system of low yield; c) a decrease in manual labor for agriculture, mainly due to emigration towards urban centers and to the construction of recreational tourist complexes in the area. This emigration of labor is a reflection of inadequate living conditions and the scarcity of resources in the agricultural areas, discouraging producers from remaining in the area. However, potential land use for agricultural activities in the Barlovento area is very high, as observed in certain farms of the area managed under intensive agriculture. Therefore, the development of an appropriate technology for maximum crop yield is necessary. The design of such a technology should entail a knowledge of the main problems affecting the production systems of the area, which to a greater or lesser extent have been detected through the present classification.

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