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Classification of Dairy Farms According to Intensification of Production Based on a New Management Model

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Abstract

This study took place between 2011 and 2015 in order to classify dairy farms according to the scope of production intensification, based on a new management model. The study lasted five years, and it covered 90 local farms in Jimaguayú-Camagüey, and comprised 450 cases. The information was collected through interviews to farmers in their working places. Production intensification indicators were chosen for classification. Principal Component Analysis was used, which resulted in three new dimensions: areas, diversity and supplies. Finally, the sample was classified by k means clustering analysis, depending on every dimension and production intensification. Concerning the areas, the mid and mid-high categories prevailed. The opposite was observed in diversification and supplies, where the two former engulfed most cases, with low and mid values for their indicators.

Keywords:*classification, production areas, diversification, supplies, new management model*

Introduction

In Cuba, several types of classifications based on indicators to evaluate cattle systems have been developed. In that sense, Guevara (2004) and Acosta and Guevara (2009), developed some of them by assessing bioeconomic efficiency and environmental degradation. Martínez *et al*., (2015) classified private and cooperative farms, based on milk production indicators.

Those works helped define typologies that included one or several aspects. However, there are few references in Cuba regarding indicators of production intensification and their effects on agriculture today.

The Cuban Guidelines of the Economic and Social Policies (2011) recommend the adoption of a new management model for agriculture, based on farm self-management and efficiency, including the recovery of idle lands for production and yield increases through crop diversification, rotation and multi-crop systems.

Accordingly, Martín (2016) noted that a structural transformation is going on in terms of land use and management in Cuba, which calls for a new strategy into a more suitable agriculture to the potential and reality of ecosystems, and more endogenous, in concert withthe social and economic, technical and productive, and environmental realities.

Considering the above, the aim of this paper is to classify dairy farms, taking into account the real dimensions of production based on a new more flexible management model now implemented in the country, that corresponds to the goals stated.

Materials and Methods

This study was carried out between 2011 and 2015, and included 90 farms from Cooperatives of Credits and Services (CCS) in Jimaguayú, province of Camaguey, Cuba. It relied on the following criteria,creating year-stable production systems; being benefitted by the new resolutions in terms of land use and ownership (Decree 259/300); having a diversified production based on the integration of livestock and crop systems; using more than 50% of lands for livestock raising.

Characterization and farm information collection

The method suggested by Funes-Monzote (2008) was applied; the information was collected via interviews to farmers, and review of statistical records at the CCS and the Municipal Ministry of Agriculture. The form suggested by Funes, Monzote and Álvarez (2000) was used to collect the data from cattle farms. It was updated annually, according to the changes undergone in the production systems over farm follow ups throughout the study. The analyses used information from 2011-2015, so the variations were included in a sample made of 450 instances from 90 farms.

Evaluation of results

The method suggested by Escobar and Berdegué (1990) and Toro (2011) was used to classify cattle production systems, and it included three stages: selection of indicators, Principal Component Analysis, and Cluster Analysis.

According to Zeballos (2016), the indicators selected could determine the changes in the production systems considered as intensification: total farm surface (ha), usable area (ha), total grasslands (ha), total forage areas (ha), various crop area (ha), global stocking rate (LU.ha-1), number of enclosures (U), forage use (kg.ha-1), use of wastes for animal feeding (kg.ha-1), use of organic fertilizers (kg.ha-1), abundance of species (Margalef index), labor intensity hr.ha-1), energy used (MJ.ha-1), and total cost of production (pesos.ha-1).

The Principal Component Analysis was used in the second stage to reduce the number of indicators in the study and minimize variability. Varimax orthogonal rotation was applied when the components were selected, in order to link the factors selected to the factors extracted.

The sphericity test of Bartlett was run for analysis, which was highly significant ($P<0.01$). KMO (Kaiser-Meyer-Olkin) was used as well, with a resulting values of 0.65, indicating that the data met the requirements for the Principal Component Analysis. According to Pardo and Guerra (2007), three components were selected, with an accumulated explained variability equal to or higher than 70%. Within each indicator or principal component, indicators with burdens over 0.60 (Hair *et al*., 1999) were selected. Thus, three new variables (production intensification dimensions) were achieved and taken as the basis for farm classification.

In the third stage the cattle farms were classified in relation to each dimension of production intensification, using all the indicators included in them. Cluster analysis was used, k-means clustering, that split in disjoint groups. In turn, they generated farm pools, so the ones with the same features were pooled, and the different ones were placed in different groups.

According to Segura (2014), four pools were codified for each dimension of production intensification: The first group was named "low intensification" (I); the second was "mid intensification" (II); the third one was named "mid-high intensification" (III); and the fourth was "high intensification" (IV). The groups had not been previously defined by the analyst, but later, according to the data. The system characterization was done based on their means.

RESULTS AND DISCUSSION

Table 1 shows the principal component analysis, and the definition of three variables which accounted for 72.2% of total accumulated variance. The first resulted in 29.60% and was associated to the areas and their distribution, so it was called "areas"; the second and third were 21.37% and 21.29%, respectively, and they integrated indicators associated to diversification and inputs.

These dimensions were considered strategic by Suset (2013) as part of the rearranging of Cuban agriculture, based on land concession, diversification and input reduction, as key elements of sustainability. Moreover, Ortiz and Alfaro (2014), pointed out that sustainable intensification processes must also integrate knowledge and resources, ethnic and cultural heritage, preferences, species and local diversity. It also made reference to area dimensions (large or small agriculture), two important aspects of system analysis.

Tables 2, 3, and 4, show the mean indicator values per category, according to the dimensions from the previous analysis. Table 2 shows the statistical summary for "Areas". The low group represents 17%, whereas the mid-high group share the largest number of cases (132 and 164), which represents between 29 and 36% of the sample and prevalence in those categories. The high group gathered the same number of cases as the low group (77%), for 17%.

Analysis of the elements revealed that the usable area is more than 90% of the total area for the four categories, pointing to a high value (Muñoz *et al*., 2013) for the indicator (52%). It demonstrated the use made of this resource on the farms, regardless of the category.

A comparison of the other indicators of usable area made by categoriesto the usable area, concluded that the total grass area varied from 10.1 ha (78%) in the low, to 52.0 ha (90%) in the high. The latter being more specialized in livestock raising, though forages accounted for about 6% in all the cases. It revealed greater dependence on this resource for the low category in terms of grass production. Therefore, a larger number of enclosures were required (3.3), contrary to the more livestock-specialized areas, with 5.4 for the mid, to 7.7 enclosures for the high.

Analysis of diversification had the two first categories grouping 75% of the sample, characterizing the low and mid-levels for this dimension. This condition was marked for the area studied, with a vulnerability before climatic change and the local economic and productive stability (MOA, 2014). In addition to it, the mid-high category had 84, and the high had 28, for 25% of the cases.

Four indicators were included in the dimension. The first was varied crop areas, which ranged from 0.60 ha to 6.05 ha. Blanco *et al*. (2014) referred to them as critical to consider a livestock system as high in biodiversity. It was even related to the production of organic fertilizers and residues for feeding. However, they did not contribute with an exact value in relation to the total area, and it fit to the particular needs of each farmer, with a great variability depending on the categories.

Analysis of organic fertilizers revealed that the amounts used in the four categories are below the ones found in livestock-crop systems (Funes-Monzote and Monzote, 2008), who applied between 4 and 6 t/ha. Furthermore, residues, as in the previous indicator, were below the potential for production reported by Reyes-Muro *et al.*(2013), in terms of crop areas. It proves the poor use made of the two indicators to restore soil fertility and recycle the system.

Concerning species variety according to the Margalef index, it reaches 2.22 and 2.82 for the mid and low categories. However, the mid and high groups were very similar (3.30). In that sense, Salmón *et al*., (2012) found indexes that ranged from 3.9 to 8.8; the latter considered as high biodiversity. These values show that the species included in the systems are few, even when they were placed in the mid-high and high diversity categories. It must be taken into account, considering the working goals of the sector, which stimulates diversification as an efficient way to make good use of lands (ANAP, 2015).

Table 4 shows the values of the variables grouped in inputs. The first two categories accounted for 89% of the cases, with 254 and 148, respectively. In turn, the third (mid-high values) accounted for 10%; and finally, the high values included two cases, with a very low percent compared to the others (0.5 %).

The total costs coincided with those of Funes-Monzote *et al.* (2009), who found values between 1.87 and 4.86 thousand of pesos/ha-1.year; on farms with different diversification levels, it even wend beyond the high category. It was related to stages where certain farms have spent on setting new areas for agriculture; they also used variable amounts of inputs (herbicides, fuel, electricity and concentrated supplements), tied to the generally high prices set by MINAG, which increase total costs.

On the contrary, in terms of energy, the results were lower than the reports made by Funes-Monzote (2016) in the four categories. They determined them in a program for implementation of integrated livestock-crop systems over three years, ranging from 5000 to 3000 MJ/ha/year. Llanos (2013), considered that this indicator is associated to farm intensification, more discreet in low-mid levels.

Work intensity showed no significant differences by categories, with values below the reports made by Suarez (2007) in a livestock-crop system, with values (hours/man/days) that went from 6.4 to 6.8, for eight years. It evidenced that intensification still falls short, caused by the little time used for agricultural work.

Global stocking rate for all the categories was above 1.5 AU.ha-1, considered by Valdés (2013), as critical for the local agroecosystem. It must be evaluated, especially in the mid-high and high categories, considering the environmental and production implications for the systems, also adding the increased costs of keeping animal excess on the farms.

Finally, forage use was presented (mostly *P. purpureum* CT-169, and *Saccharum* ssp. In a lower proportion). If the results achieved by Martínez (2013) and García *et al.* (2014), for these crops (up to 170 t DM/ha/year in the same working area), are observed, then there is poor use of the resources (including the high category). Mileras *et al.* (2011) noted the need to use pasture and forages in tropical livestock raising; however, the former elements are the most important ones, which indicates the need to have a balance in forage inclusion and use, thus cutting down on other inputs and providing sustainability and benefits for production systems.

CONCLUSIONS

The farms were classified according to the size of their intensification processes, based on a new management model now developed in Cuba. It was determined by the area, diversification, and inputs. The mid and mid-high categories were more frequently observed for the area; diversification and inputs were different, as the two former encompassed most of the cases, with low and mid values, for the indicators in them.

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Table 1. Results of principal component analysis

Components	1	2	3
Autovalue	4.144	2.992	2.981
Explained variance %	29.603	21.371	21.292
Accumulated variance %	29.603	50.974	72.265
Indicators	Areas	Diversification	Inputs
Usable surface	0.887	0.047	-0.353
Total farm surface	0.867	-0.002	-0.395
Total grazing area	0.867	-0.116	-0.373
Total forage area	0.806	0.247	0.204
Number of enclosures	0.724	0.137	0.248
Various crop area	0.018	0.948	-0.069
Use of organic fertilizers	0.326	0.864	0.097
Use of residues	-0.381	0.842	0.135
Species variety	0.179	0.647	0.037
Total production costs	0.010	-0.017	0.848
Energy used	-0.269	0.205	0.678

Forage use	0.369	0.278	0.655
Global stocking rate	-0.069	-0.055	0.648
Work intensity	-0.430	-0.039	0.629

Table 2. Mean values found for the indicators included in the area dimension

Indicators	Categories							
	Low (n=77)		Mid (n=132)		Mid-high (n=164)		High (n=77)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total farm area, ha	13.6	1.70	26.3	3.67	41.6	5.30	59.9	5.15
Usable area, ha.	13.0	1.42	24,3	3.26	39.3	4.12	58.1	5.97
Total grazing area, ha	10.1	2.48	20,3	3.69	34.2	4.77	52.0	5.57
Total forage area, ha	0.8	0.96	1.7	1.75	2.6	2.06	3.6	2.96
No. of enclosures, U	3.3	1.42	5,4	2.16	6.8	3.03	7.7	3.43

Table 3. Mean values and typical deviation of indicators included in the diversification dimension

Indicators	Categories							
	Low n=149		Mid n=189		Mid-high n=84		High n=28	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Area of various crops	0.63	0.48	2.02	0.97	4.44	2.08	6.05	2.98
Use of organic fertilizers	137.3	125.4	297.3	186.1	463.7	219.0	674.1	234.9
Use of residuals on the farms	333.9	247.5	1 360.9	441.6	3 595.0	999.7	8 822.2	765.6
Species variety	2.22	0.77	2.82	0.79	3.30	1.00	3.29	0.90

Table 4. Mean values and typical deviation of indicators in the input use dimension for the stage studied

Indicators	Categories							
	Low (n=254)		Mid (n=148)		Mid-high (n=46)		High (n=2)	
	Mean	Sd	Mean	SD	Mean	SD	Mean	SD
Total costs,pesos.ha^{-1}	1515.7	672.32	2239.8	1220.75	2406.8	662.66	5805.8	3501.45
Energy used. MJ.ha^{-1}	1660.7	443.55	2012.46	890.31	2125.58	334.14	2653.75	283.48
Working intensity. hr.ha^{-1}.d^{-1}	0.67	0.33	0.72	0.34	0.73	0.30	1.0	0.00
Global stocking rate. AU.ha^{-1}	1.5	0.48	1.5	0.50	1.8	0.63	2.8	0.96
Use of forage. kgMF.ha^{-1}	2227.8	1377.70	6586.5	1469.38	12997.5	1674.45	26424.2	276.27