Socio-economic and technological typology of avocado cv. Hass farms from Antioquia (Colombia)

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ABSTRACT: A typology of avocado cv. Hass farms was constructed based on information collected from productive units in Antioquia, Colombia. The study aimed to provide key information about the farms for those involved in the design of programs and public policies directed to growers. The data were scrutinized through Multiple Correspondence Analysis (MCA) and Cluster Analysis. The sample was made up of 214 growers of the crop. Quantitative and qualitative variables were employed for the MCA, which rendered 40 dimensions, out of which 16 accounted for 70% of the total inertia (variance) found in the data. These 16 dimensions were used as input for the Cluster Analysis, which provided the following results: 52%, 32% and 15% of the farms were located in Clusters 1, 2 and 3, respectively. The identified farm types can be associated to peasant (Cluster 1) and commercial (Cluster 3) agricultural schemes, plus a transition between them (Cluster 2). The most discriminating variables regarding such categorization were: farm size, farm registry at ICA (Colombian Agricultural Institute), Avocado cv. Hass yield, labor source, presence of crops other than avocado, existence of formal commercial alliances and technical assistance type. The percentage of farmers belonging to grower organizations was high in the three clusters. Growers in Clusters 3 and 2 had established formal commercial alliances which enabled them to access better sale prices for the crop. A trend towards establishing cv. Hass as a monocrop is observed, which may threaten both crop biodiversity and the food security of peasant growers.

Key words: farm typology, multiple correspondence analysis, cluster analysis, Colombia.

INTRODUCTION

The “Green Gold”, as avocado cv. Hass is popularly known, has already become one of the most promising cash crops of the Colombian agro-exports basket. Colombia is one of the leading producers of avocado worldwide, where it holds the third place, lagging only behind Mexico and the Dominican Republic (FAO, 2018). However, its participation in international markets is still marginal, since it is behind big exporters such as Mexico, Peru, Chile, Kenya and South Africa (TRADEMAP, 2018). Despite its negligible share of the world market, Colombia increased its avocado exports by more
than 800% in the 2014-2016 period. Furthermore, the recent lift on the ban imposed on Colombian cv. Hass exports has motivated growers and traders to conquer the American market.

Colombia has two main advantages when it comes to producing avocado cv. Hass: its strategic location, which allows quickly reaching American and European markets; and its tropical climate, which determines two yearly harvests (FRESHPLAZA, 2017). As noted by RAMÍREZ-GIL et al. (2017), avocado production in the country has grown considerably due to the existence of an unsatisfied demand in the foreign market. The department of Antioquia, which is the top Hass exporter of the country, had contributed almost half of the Colombian avocado exports by 2016 (SIERRA-SUAREZ, 2017), devoting an area of 7,644 ha to the production of this crop (GOBERNACIÓN DE ANTIOQUIA, 2015). Data provided by the Agricultural Department of Antioquia’s Governor’s office report the existence of 1,024 avocado cv. Hass growers.

Multiple programs and policies are being deployed to boost this crop in Antioquia, including technical assistance to growers, cropping research, production programs and diverse economic incentives such as soft credit and subsidies directed to growers (SIOC, 2018; FINAGRO, 2018; CORPOICA, 2017). Despite the support provided to farmers, there is little information on the different farm types currently producing avocado cv. Hass, the specific needs of which are important when it comes to assessing the impact of such interventions. It is important to take into account that the variety in question is mostly exports-driven, which forces growers to comply with specific regulations and standards required by the target markets. This is particularly critical for small growers, because of their limited access to technical assistance and the elevated costs of export certifications, which make them prohibitive when it comes to accessing foreign markets (BARRENA et al. 2013). These small growers maintain many of the peasant agriculture features mentioned by BACKER (1997), such as assigning an important fraction of the farm’s food production to household consumption, employing family labor, and having limited access to technical assistance and no formal alliances with traders/marketers.

In this context, the present study adds to the existent knowledge on avocado cv. Hass by developing a farm typology based on socioeconomic and technological aspects. This is accomplished through multivariate statistical methods applied to the characterization of the studied farms, based on a representative sample from three regions of the department of Antioquia (Colombia). These methods have often been used for the development of farm typologies in agricultural research (TITTONELL et al. 2010; KÖBRICH et al. 2003; PARDOS et al. 2008; VÁSQUEZ et al. 2011; ABAS et al. 2013; BARRENA et al. 2013; CLEVES-LEGUÍZAMO et al. 2014; GOSWANI et al. 2014; TODDE et al. 2016). This type of study allows: (a) identifying change trends in a particular production system; (b) detecting the main productivity constraints and thus targeting better agricultural innovations (TITTONELL et al. 2010); (c) establishing public policy design priorities (PARDOS et al. 2008); (d) optimizing the impact of development projects through the identification of “target groups”; and (e) providing support to advisors through key information about individual farmers, thus basing the assessment of each particular situation on known functional types (GIBON et al., 1999).

VÁSQUEZ et al. (2011) performed an initial characterization of avocado cv. Hass farms in Antioquia, in which they surveyed 83 farms in the eastern, western and northern sub regions of the department. They resorted to socioeconomic and technical variables such as grower’s age and educational level, tenure type, labor type and its monetary value, associativity between growers, access to technical assistance, and type of phytosanitary management, among others. SANGERMAN-JARQUÍN et al. (2014) also typified avocado farms in the state of Mexico (Mexico), using a similar approach to that of VÁSQUEZ et al. (2011). The former studies described some of the main features of cv. Hass farms in a general fashion, but falling short to identify a typology of productive systems with their corresponding features and needs.

Thus, the general aim of the present study was to identify a typology of the avocado cv. Hass farms of Antioquia, Colombia. Considering the dimensions with the highest inertia (variance) in the data, a set of three groups was obtained and then analyzed. The results of this study were used as input for a land zoning of the crop in question, also resorting to biophysical and environmental variables.

The present study contributed to the current knowledge on avocado cv. Hass activity in Antioquia by providing advisors, researchers and program developers with specific information about the different farm types existing in the region.

MATERIALS AND METHODS

Study area

The study area covers the eastern, southwestern and northern regions of the department
of Antioquia in Colombia. Figure 1 shows the studied area with the rural divisions where the surveyed farms are located.

In the area in question, the precipitation levels reach an annual average of 2,000 mm, whereas the altitude ranges between 200 and 3,340 m asl (CORNARE, 2015; ARAMBURO et al., 2007). The climatic and edaphological features of the three regions have allowed the development of a sound agricultural activity where crops such as plantain, coffee, panela sugarcane, potato and tree tomato play a major role (CÁMARA DE COMERCIO DE MEDELLÍN, 2014a, 2014b, 2014c). Avocado cv. Hass has been so far established in the eastern, southwestern, and northern sub regions of the department, in municipalities with moderate cold climate (BERNAL et al. 2014), which offer ideal conditions for this activity.

**Data collection and sampling**

In order to define the farm sample to be surveyed, a data base was created with information provided by several instances: list of avocado cv. Hass farms monitored by the Colombian Agricultural Institute (ICA) in Antioquia, pre-existing lists of growers of the crop available in Agrosavia (former Corpoica), and lists provided by the different UMATAS (Municipal Technical Assistance Units) of those municipalities where growers had been previously identified. This information allowed determining the approximate population of avocado cv. Hass farms of Antioquia at 1,003 productive units.

![Map of rural divisions considered in the study](image_url)
distributed in 39 municipalities, out of which 73% were located in the eastern sub region of Antioquia, 13% in the southwest sub region, and 8% and 3% in western and northern Antioquia, respectively.

Stratified random sampling with proportional affixation allowed selecting the farms, considering the 39 municipalities as strata. This methodology, which allowed establishing the representativeness of the different groups (strata) of the population, was developed in two steps: after (i) calculating the total size of the sample, (ii) the elements were proportionally assigned to each stratum (SCHAEFFER et al. 1986). Sample size was defined through the equation below. For such calculation, based on both conversations with agronomists of some UMATAS and interviews with knowledgeable experts on the crop in the department, 23% of the growers were estimated to have registered at ICA. We assumed that this parameter was directly related to farm modernization levels. Since this value could not be assessed at every studied municipality, it was extrapolated to all of them by default. A 95% confidence interval was estimated, with an error margin of 5%. Although, the sample size was set at 212 growers, two additional surveys collected in the field were incorporated to the analysis, giving a total of 214 surveys.

\[
N = \frac{\sum_{i=1}^{L} N_i^2 \cdot \frac{p_i q_i}{w_i}}{N^2 \cdot D + \sum_{i=1}^{L} N_i p_i q_i}
\]

where

- \(N\): Population Size
- \(n\): Sample Size
- \(z\): Percentile value corresponding to 95% confidence according to standard normal distribution
- \(w_i\): Stratum relative weight
- \(p_i\): Ratio of farmers registered at ICA in stratum \(i\) (this value was assumed to be the same for all strata); \(q_i = 1 - p_i\)
- \(L\): Number of strata
- \(\varepsilon\): Estimated error

The agricultural household survey designed to obtain information about the farms collected demographic, socioeconomic and production variables, together with avocado cv. Hass activity and farm household related variables. A total of 35 variables were assessed through the survey (Table 1 and 2), which was applied from October to December of 2016.

Statistical analysis

Due to the large number of variables considered in the survey, a Multiple Correspondence Analysis (MCA) was run in order to obtain a smaller group of variables (dimensions). Most of the data were qualitative in nature, which made it easier to work with categorical variables, as required by MCA (HUSSON et al. 2010). Once the qualitative and quantitative variables had been categorized, they were used for the MCA, which generated a series of synthetic variables that were later employed for the Cluster Analysis.

It is worthwhile noting that MCA is the counterpart of Principal Component Analysis (PCA). While the input of the latter are quantitative data, the former uses nominal categorical data. Nonetheless, MCA resembles its counterpart in that it searches for underlying structures in a data set and identifies those dimensions or components that contain the most variance/inertia. This is achieved by representing data points in a low-dimensional Euclidean space (GREENACRE, 2006). MCA was run on R FactoMineR software package.

Out of a number of initial variables, MCA derives a series of “synthetic” dimensions (HUSSON et al., 2010) containing those variables with higher correlation ratios (i.e., coefficients of non-linear association). The latter actually measure the relation between each one of the categorical variables and its specific dimension (HUSSON, 2016). Each dimension is analyzed in terms of the variables it contains (HUSSON et al. 2010). The MCA is often used for analyzing data obtained from surveys, wherein each question corresponds to a variable and each possible answer is a category of that variable (HUSSON et al. 2010).

In selecting the qualitative variables that were likely to facilitate greater differentiation in the MCA, an inspection of their relative frequencies was carried out through contingency tables. Those variables exhibiting homogeneous behavior in all farms were not taken into account, since they did not allow clear distinction between the productive units. In the case of the quantitative variables, Sturges law was applied in order to obtain an optimal number of groups, based on the observations of each variable. Thus, twenty-one variables were selected for the MCA: farm size and dominant land use, avocado cv. Hass planted area and yield (t ha\(^{-1}\)), type of phytosanitary control, avocado cv. Hass plantation registry at ICA, number of permanent workers at the farm, number of workers hired at harvest time, type of technical assistance, existence of commercial agreements, bookkeeping costs, application for formal credit, distance to municipality seat, main access to the farm (road type), source of economic

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resources employed for avocado cv. Hass activity, access to support or subsidies, income from avocado cv. Hass, grower’s age, educational level, avocado production experience and membership of a growers association. Out of these twenty-one variables, seven were initially quantitative in nature.

Once the main dimensions had been obtained, a Cluster Analysis was run based on them. This type of analysis allows identifying homogeneous groups (clusters) of objects and/or individuals in a particular database, by recognizing patterns in the data (KAUFMAN et al., 2005). This analysis is not guided by a priori ideas on how the groups are formed and which variables determine the distribution of the objects and/or individuals in the groups (STHDA, 2018). The farms in this study were grouped following to contrasting features (GARCÍA et al. 2010). The clusters were obtained by applying the following algorithm: (i) the main dimensions retaining most of the inertia present in the data were produced by MCA; (ii) a Hierarchical cluster with suggested groups was generated by applying “Ward”, a hierarchy criterion, and using Euclidean distance; (iii) the clusters were selected based on their internal variance/inertia, which is shown in the hierarchical tree (Figure 2). The cutoff line was traced slightly above a split in category 1, in order to avoid an important loss of inertia when passing from three to four clusters. The cutoff comes from the previously defined 0.05 significance level. This method, which starts with each observation in its particular cluster, progressively joins them until they are all included in a single cluster (CHÁVEZ et al. 2010).

RESULTS

Multiple correspondence analysis

The MCA resulted in forty dimensions containing 100% of the total inertia (variance) of the data. According to HUSSON et al. (2010), data variance content was the criterion applied to select the number of dimensions to be retained for the subsequent Cluster Analysis, which made use of 16 dimensions containing 70% of the total original variance. Figure 2 shows the sixteen dimensions in question and the corresponding variance they express.

Source: Prepared by the authors.

Table 1 - Surveyed variables describing the farms.

| Category                        | Variable                   | Description                  | Unit       |
|---------------------------------|----------------------------|------------------------------|------------|
| Demographics and socioeconomics| Grower's age               | Age of grower                | Years      |
|                                 | Grower's gender            | Gender of grower             | Female=0, Male=1 |
|                                 | Grower's educational level | Level of education of grower | None=0, Incomplete Primary school= 1, Primary school=2, Incomplete Secondary School= 3, Secondary school=3, Technical=4, Undergraduate=5, Graduate=6 |
| Farm features                   | Farm size                  | Number of ha of the farm     | Number     |
|                                 | Main access to the farm    | Farm's main access to road   | Path=0, Primary road= 1, Secondary road=2, tertiary road=3 |
|                                 | Tenure                     | Type of tenure               | Owner=0, renter=1, sharecropper=2, colonist/settler=3, other=4 |
|                                 | Distance to municipality seat | Range of distance to municipality seat | 1-5 km=0, 5-10 km=1, 10-15 km=2, more than 15 km=3 |
|                                 | Farm relief                | Main type of farm's relieve  | Flat=0, hilly=1, very hilly=2 |
|                                 | Permanent labor at the farm | Number of people working permanently at the farm | Number |
|                                 | Labor at Harvest time      | Number of people working at harvest time at the farm | Number |
| Productive activities           | Dominant land use          | Main farm's land use         | Crops=0, Pastures=1, Fallow=2, Native forest=3, Commercial forest=4, Mining=5 |
|                                 | Presence of food crops     | Existence of food crops      | Yes=0, No=1 |
|                                 | Existence of cattle        | Existence of cattle          | Yes=0, No=1 |
|                                 | Labor source               | Type of labor source         | Family labor=0, External labor=1, Mixed labor=3 |

Source: Prepared by the authors.
In the lines that follow, we detailed only three of these sixteen dimensions, considering the highest correlation ratios between variables and dimensions. Containing 13.2% of the total variance, dimension 1 is mostly explained by labor at harvest time, Avocado cv. Hass planted area, and registration at ICA, with correlation ratios of 0.54, 0.53 and 0.52, respectively. Conversely, dimension 2 is strongly connected to yield and labor at harvest time, with respective correlation ratios of 0.53 and 0.51. Finally, dimension 3 is mostly described by grower’s educational level and farm size, respectively corresponding to correlation ratios of 0.27 and 0.22. Correlation ratios between variables and dimensions are shown in table 3.

### Table 2 - Surveyed variables describing avocado cv. Hass activity in farms.

| Category | Variable                                           | Description                                      | Unit               |
|----------|----------------------------------------------------|--------------------------------------------------|--------------------|
|          | cv. Hass avocado planted/harvested area            | Number of cv. Hass avocado planted/harvested ha. | Number of Ha      |
|          | Age of cv. Hass avocado plantation                 | Orchard age                                      | Years              |
|          | cv. Hass avocado production                        | Total production of the farm                     | Kg                 |
|          | Price paid by to growers (USD $/kg)                | Price paid by 1 kg of avocado cv. Hass           | $ United Stated Dollars |
|          | Income from cv. Hass avocado (USD $/ha)            | Income derived from cv. Hass avocado             | $ United Stated Dollars |
|          | Intercropping                                      | Avocado cv. Hass intercropped with other crops   | Yes=0, No=1        |
|          | Origin of seedings                                 | Type of origin of seedlings                      | Registered nursery=0, Non registered nursery=1, Self-propagation=2 |
|          | Type of Fertilization                              | Type of Fertilization                           | Chemical=0, organic=1, both (chemical and organic)=2 |
|          | Type of Phitosanitary control                      | Type of pests and diseases management           | Chemical=0, Manual=1, Biologic=2, Other=3 |
|          | Avocado cv. Hass production experience (>5 yrs)    | Whether farmer has experience with avocado cv. Hass of more than 5 years | Yes=0, No=1        |
|          | Access to technical assistance                     | Whether having acces to technical assistance     | Yes=0, No=1        |
|          | Type of Technical Assistance                       | Type of Technical assistance                     | Independent agronomist=0, Public entity agronomist=1,Grower’s association agronomist=2, Commercial house agronomist=3 |
|          | Exports registration (ICA)                         | Whether having ICA registration                  | Yes=0, No=1        |
|          | Exports Certificate (Global GAP)                   | Whether having Global Gap Certificate            | Yes=0, No=1        |
|          | Grower's associativity                             | Whether the grower belongs to a grower's organization | Yes=0, No=1        |
|          | Formal commercial alliances with markets           | Whether having access to formal alliances with marketers/traders | Yes=0, No=1        |
|          | Access to Institutional Support                    | Whether having access to subsidies, technical assistance or other programs provided by Government | Yes=0, No=1        |
|          | Book keeping costs                                 | Whether book keeping costs                       | Yes=0, No=1        |
|          | Application to Credit in the last year             | Whether having applied to credit in the last year | Yes=0, No=1        |
|          | Constraints to avocado cv. Hass activity           | Type of main constraint                          | Commercial=0, technical=1, financial resources=2, infrastructure=3, social=4 |

Source: Prepared by authors.
Cluster analysis

Avocado cv. Hass households were clustered into three main groups, based on the sixteen dimensions derived from the MCA (Figure 3 and figure 4). The clusters are individually described below and summarized in table 4. Results of descriptive variables of each cluster are presented in table 5 and 6, the former including the mean, median and standard deviation values of the quantitative variables and the latter, the percentages of farms participating in each cluster’s variable. Figures 5 and 6 present some of the most relevant variables for each cluster.

Cluster 1

Containing 52% of the farms in the sample, Cluster 1 actually grouped the smallest ones (9 ha size on average), mainly located in the municipalities of Rionegro, El Retiro and Urrao. These were the most limited farms in terms of technical assistance and market access for avocado cv. Hass, and also the newest ones in this cropping activity, with orchards averaging 4 years of age and 1.9 ha in size. Most of them produced food for own consumption and had established avocado cv. Hass in association with other crops, primarily beans, maize and peas. Labor sources were almost evenly shared between family and external sources. Fertilization schemes based on chemical and organic fertilizers were applied by 70% of the farms, whereas 30% of them employed only chemical fertilizers. Phytochemical controls resorting to chemical compounds were applied in more than half of the farms. Nearly all of them (90%) had been registered at ICA and only 1% had Global GAP certification. The average price paid per kg of avocado to growers in this group was the lowest in the sample: around $0.60 USD. These growers reported the lowest educational levels, corresponding to incomplete primary school. Sixty percent of them had access to technical assistance, mainly offered by private agronomists and commercial houses. The majority of them did not have any formal commercial alliances, yet more than half belonged to a growers’ association and 75% received institutional support in the form of subsidies, seedlings or production supplies. Their major difficulties were the financial support of the crop, access to good output prices, and facing market middlemen.

Cluster 2

This cluster grouped 69 of the studied farms, which were actually medium sized (17 ha on average) and, making up 32% of the total sample, were mainly located in the municipalities of Guane, Rionegro, El Retiro, Urrao and Sonsón. More than half of the labor employed in these farms came from...
Table 3 - Squared correlation ratios between variables and dimensions.

| Variables                                      | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  | 15  | 16  |
|------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Grower's age                                   | 0.32| 0.27| 0.21| 0.04| 0.12| 0.16| 0.15| 0.11| 0.08| 0.18| 0.07| 0.37| 0.15| 0.05| 0.12| 0.17|
| Grower's educational Level                     | 0.42| 0.27| 0.27| 0.19| 0.11| 0.08| 0.11| 0.11| 0.07| 0.15| 0.14| 0.14| 0.15| 0.05| 0.12| 0.17|
| Farm size                                      | 0.29| 0.05| 0.22| 0.06| 0.24| 0.14| 0.1  | 0.03| 0.18| 0.06| 0.06| 0.06|
| Main access to the farm                        | 0.07|     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Distance to municipality seat                  | 0.04| 0.06| 0.21| 0.11| 0.22| 0.02| 0.1  | 0.04| 0.04| 0.13| 0.07| 0.12|
| Permanent labor at the farm                    | 0.3 | 0.09| 0.11| 0.03| 0.12| 0.13| 0.19 | 0.03| 0.09| 0.06|
| Labor at Harvest time                          | 0.54| 0.51| 0.14| 0.07| 0.15| 0.06| 0.11| 0.07| 0.04| 0.07| 0.05|
| Dominant Land Use                              |     |     |     | 0.07| 0.05| 0.12| 0.07| 0.1  |     |     |     |
| cv. Hass avocado planted area                  | 0.53| 0.22| 0.07| 0.18| 0.09| 0.05| 0.07| 0.05|     |     |     |     |     | 0.02| 0.05|
| cv. Hass avocado Yield (t ha⁻¹)                | 0.21| 0.53| 0.06| 0.22| 0.09| 0.08| 0.28 |     |     | 0.15| 0.08| 0.09| 0.11| 0.15| 0.05|
| Income from cv. Hass avocado                   | 0.53| 0.56| 0.21| 0.04| 0.1  | 0.33|     | 0.04| 0.03| 0.06| 0.05| 0.05| 0.19|
| Type of Phyto-sanitary control                 | 0.05| 0.06| 0.08|     | 0.16| 0.05|     | 0.02| 0.09| 0.03| 0.05|
| Avocado cv. Hass production experience (>5 yrs)| 0.18| 0.06|     | 0.03|     | 0.04| 0.06| 0.09| 0.06| 0.02| 0.07| 0.01|
| Type of Technical Assistance                   | 0.3 | 0.06| 0.12| 0.21| 0.2  | 0.04|     | 0.07| 0.09| 0.16| 0.07| 0.08| 0.1  | 0.05| 0.05| 0.14|
| Exports registration (ICA)                     | 0.52| 0.04| 0.02| 0.03| 0.03|     |     |     |     |     |     |     | 0.02|
| Grower's associativity                         | 0.04| 0.16| 0.06| 0.08| 0.07|     | 0.03| 0.02| 0.05|     |     |     |     |     |     |     | 0.02|
| Formal commercial alliances with markets       | 0.42| 0.03| 0.05| 0.02| 0.05|     |     |     |     |     |     |     |     |     |     |     | 0.02|
| Access to Institutional Support                | 0.19|     | 0.04| 0.09| 0.06|     |     |     |     |     |     |     |     |     |     |     | 0.01|
| Book keeping costs                             | 0.34| 0.04| 0.03|     |     | 0.02| 0.06|     |     |     |     |     |     |     |     |     |     |
| Origin of Economic resources for avocado cv.  | 0.07| 0.44|     | 0.02| 0.06| 0.05| 0.02|     |     |     |     |     |     |     |     |     |     |
| Hass activity                                  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Application for Credit in the last year        | 0.04| 0.33| 0.02| 0.03| 0.17| 0.02| 0.03|     |     |     |     |     |     |     |     |     |     |

Source: Prepared by authors.

external sources, but family labor had an important participation. Fewer people were working permanently and at harvest time in comparison to Cluster 3. Most of these farms produced food for the household’s own consumption. The avocado cv. Hass orchards, many of which included an associated second crop, had an average size of 4 ha, yielding about 8 tons ha⁻¹. The most common fertilization schemes were based
on chemical and organic fertilizers. Phytosanitary measures applied in more than half of these farms mixed different control modes, namely chemical, biological and organic, among others; whereas the sole application of chemical controls was observed in 42% of the orchards. More than seventy percent of the farms were registered at ICA, but fewer had received the Global GAP certificate. The price received by these growers per kg of avocado cv. Hass was around $0.80 USD, most of them having more than 5 years of experience with the crop. All of them claimed to have access to technical assistance, mainly provided by private agronomists, and many of them had already established formal links with avocado cv. Hass commercial companies. Sixty-six percent of these farmers belonged to growers’ associations, while 45% had received institutional support. The main limitations they faced were the technical management of the crop and the difficulty to steadily finance the activity.

Cluster 3

It contains the largest farms, but also the fewest farms in the sample, with an average size of 136 ha, a median size of 51 ha, and an average age of 6 years. They were mainly located in the municipalities of Sonsón, Abejorral and San Vicente de Ferrer, most of them already constituted as agricultural companies. A number of variables registered their highest values in this cluster: grower’s educational level, orchard size, avocado cv. Hass yield, number of people working permanently and at harvest time in the productive units, and avocado cv. Hass price ($1.09 USD per kg). The majority of these farms applied chemical fertilization and had integral phytosanitary control schemes consisting in manual

Figure 3 - Hierarchical tree showing three farm groups resulting from the Cluster Analysis of avocado cv. Hass productive units in the department of Antioquia (Colombia).
practices and both chemical and biological inputs. All the growers in this cluster had access to technical assistance from private agronomists, had their farms registered at ICA, and had received the Global GAP certificate. The main economic resource to sustain the plantation was growers’ own income. Most of these farmers belonged to an avocado cv. Hass growers’ association and had established formal commercial alliances to sell the crop. The main constraints they faced were the lack of labor to work in the plantations and the difficulty to find qualified avocado cv. Hass technical assistance.

DISCUSSION

The present study characterized different avocado cv. Hass farms in Antioquia, Colombia, aiming to identify technical management and market orientation patterns. Due to the cross-sectional nature of the data, the results presented here can be read as a snapshot of such farms. The three identified farm clusters differed mainly regarding farm size, farm registry at ICA, avocado planted area, farm labor at harvest time, avocado cv. Hass yield per farm, labor source, technical assistance type, farmer’s experience with the crop larger than five years, and existence of formal commercial alliances (Figure 5 and figure 6). As pointed out by TITTONELL et al. (2010) agricultural household categorization is a key element, not only to direct agricultural technologies, but also to improve agricultural policy design (PARDOS et al. 2008). The farms in Cluster 3 were the most organized ones of them all, having already ruled out many of the constraints faced by those in Clusters 1 and 2, as it was the case of access to formal markets. Yet, all the farms in the sample would certainly benefit from agricultural research and development.

Cluster 1 grouped more than half of the farms (52%) of the sample and also the smallest ones. It contained the largest fraction of productive units employing family labor in the crop and producing food for own consumption. These features bring Cluster 1 close to peasant agriculture (BACKER,
Table 4 - Typology of avocado cv. Hass farms.

| Farm Type | Product orientation | Main Characteristics |
|-----------|---------------------|----------------------|
| 1         | Small farmer. New in avocado cv. Hass production. Subsistence and market oriented. | Containing 52% of the farms under study, this group was mostly composed of mid-aged farmers who were novice to avocado cv. Hass activity. They worked in small farms and small orchards also producing food for household consumption. Intercropped avocado cv. Hass with important participation of family labor. No formal connection to markets or Global Gap certification for the crop. Main limitations are financial support for the crop and access to good sell prices (associated to price control by middlemen). |
| 2         | Medium farmer. Experienced in avocado cv. Hass production. Semi-commercially oriented. | This group contained 32% of the farms, which were large in size and also produced food for household consumption. Mainly mid-aged farmers with more than five-years of experience cultivating avocado cv. Hass, which, being rarely intercropped, was cultivated by mixed family and external labor force. Most of the farmers had formal connections with avocado cv. Hass commercial/exporting enterprises. The main constraints were financial support for the crop and managing the technical aspects of the crop. |
| 3         | Entrepreneurial farmer. Experience in avocado cv. Hass production. Market oriented. | Fifteen per cent of the farms corresponded to this group, which contained the largest farms and orchards growing avocado cv. Hass as a monocrop. The youngest growers in the sample, managed their avocado cv. Hass activity in an entrepreneurial fashion and did not produce food for their own consumption. Labor force employed at the farm was predominantly external. Most of the farms had established formal agreements with avocado cv. Hass commercial/exporting companies. Their main restrictions were the access to labor and qualified technical assistance. |

Source: Prepared by the authors.

Table 5 - Quantitative farm descriptors. Frequency, mean, median and standard deviation where applicable.

| Items                                      | Cluster 1 (n= 112) | Cluster 2 (n= 69) | Cluster 3 (n= 33) |
|--------------------------------------------|--------------------|-------------------|-------------------|
| Quantitative Variables                      | Mean (SD)          | Mean (SD)         | Mean (SD)         |
| Grower’s age (yr)                          | 50.78 (12.90)      | 56.53 (10.73)     | 49.54 (11.84)     |
| Farm size (ha)                             | 9.35 (11.30)       | 17.14 (10.00)     | 136.2 (235.21)    |
| Permanent labor at the farm                | 1.80 (2.00)        | 2.869 (2.00)      | 19.99 (12.48)     |
| Labor at Harvest time                      | 3.22 (2.69)        | 7.49 (7.00)       | 21.17 (15.00)     |
| Age of avocado cv. Hass plantation (yr)    | 4.06 (2.78)        | 6.60 (3.24)       | 6.42 (3.84)       |
| Number of avocado cv. Hass trees           | 448 (312)          | 1201 (800)        | 6914 (4500.0)     |
| Avocado cv. Hass planted area (ha)         | 1.95 (1.32)        | 4.898 (3.831)     | 22.38 (15.79)     |
| Avocado cv. Hass harvested area (ha)       | 1.37 (1.02)        | 3.247 (2.390)     | 24.275 (11.64)    |
| Avocado cv. Hass yield (t ha⁻¹)            | 6.20 (6.58)        | 8.32 (7.09)       | 9.899 (7.812)     |
| Price paid to growers ($USD/kg)            | 0.60 (0.21)        | 0.81 (0.38)       | 1.09 (1.07)       |
| Income from avocado cv. Hass ($USD/ha)     | 1,863 (3,043)      | 6,298 (4316)      | 8863 (6454)       |

Source: Prepared by authors.
The farmers in this group had the lowest education level of them all, the most limited access to technical assistance, and were also the newest ones in the avocado cv. Hass activity (less than five years of experience). These factors probably account for the lower yields of these farms. The fertilization schemes applied by these farms, based on organic and chemical inputs, differed from those featuring Cluster 3. Technical assistance for the crop typically advises not to use organic matter unless it is very well composted. The phytosanitary control of this crop requires integral management of pests and diseases (ALARCÓN et al., 2012), which was not being applied in these farms, since they mostly relied on agrochemical inputs. The limited access of these farms to formal markets may be linked to their lower technological level and lack of both ICA registration and Global Gap certification. The latter is probably explained by the elevated cost of this certificate (which particularly affects small growers) and the fact that these were the youngest plantations and, therefore, their production had not stabilized. As stated by BARRENA et al. (2013), when it comes to fruit production, exporters seek to ensure a minimal level of good agricultural practices, so as to have access to a wider range of markets. However, this usually implies more restrictions for peasant growers. This group of farms were facing major difficulties to get economic benefits from avocado cv. Hass cultivation, which are not only associated to limited access to information via technical assistance, but to the lack of the necessary formal alliances and export certifications to access international markets and, hence, better prices. Consequently, the production of these farms is circumscribed to the domestic market, since the European one (actually the main purchaser of Colombian avocado exports) requires the Global GAP certification (BAIN, 2010). This is disadvantageous since, at the national level, they do not negotiate with formal commercial partners. Most of these farms claimed to be at the mercy of middlemen who controlled the prices paid for the crop in municipal markets. One additional concern that stands out for this group is the trend towards Table 6 - Qualitative descriptors of the farms.

| Qualitative variables                                                                 | Cluster 1 (n= 112) | Cluster 2 (n= 69) | Cluster 3 (n= 33) |
|--------------------------------------------------------------------------------------|-------------------|-------------------|-------------------|
| Dominant Land use (%): 0 = crops, 1 = pastures, 2 = fallow, 3 = native forest, 4 = commercial forest | 65 28 0 6 1 63 21 10 4 1 75 9 0 9 6 | 30 2 70 | 58 0 42 |
| Type of fertilization (%): 0 = chemical; 1 = organic; 2 = both (chemical and organic) | 60 40 | 100 0 | 100 0 |
| Access to technical assistance (%): 0 = yes (1) otherwise                           |                   |                   |                   |
| Type of phytosanitary control (%): 0 = chemical; 1 = manual; 2 = biologic; 3 = organic; 4 = integral (using two or more of the previous types) | 66 9 0.9 4 20 42 4 1 0 52 21 0 0 3 76 |                   |                   |
| Exports registration (ICA Instituto Colombiano Agropecuario) (%): 0 = yes; 1 = otherwise | 90 10 | 79 21 | 85 15 |
| Exports certificate (Global GAP) (%): 0 = yes; 1 = otherwise                        | 1 99 | 23 77 | 57 43 |
| Food production for household consumption (%): 0 = yes; 1 = otherwise                | 81 19 | 71 29 | 42 58 |
| Origin of Economic Resources: 0 = own resources, 1 = formal credit, 2 = informal Credit | 45 30 2 23 | 39 20 0 40 | 53 19 0 28 |
| Institutional support (subsidies, programs, other): 0 = yes; 1 = otherwise          | 75 25 | 45 55 | 21 79 |
| Growers’ associativity: 0 = yes; 1 = otherwise                                       | 51 49 | 66 33 | 61 39 |

Source: Prepared by authors.
establishing avocado as a monocrop, which may affect both crop biodiversity and food production for household consumption. This farm cluster needs to be assisted in the financial support of their cropping activity, naturally aiming at a higher productivity (TITTONELL et al. 2010) as a result not only of better access to supplies, credit and institutional support programs, but also of an adequate guidance on accessing formal national or international markets. Due to the fact that many of these growers still rely on other crops for household food consumption, it would be necessary to study the coexistence of the avocado cv. Hass production system with other crops, in order not to affect the food security of these farms. With a better access to qualified technical assistance, these farms would be able to implement a more integral management of pests and diseases which, in turn, would allow them to reduce costs (agrochemical supplies), thus taking advantage of available family labor. Technical assistance could also provide information on how to deal with soil erosion, which is likely present in most of the farms, since they are located on hilly sites. Nonetheless, as suggested by TITTONELL et al. (2010), farms exhibiting these characteristics may have economic constraints that hinder their engagement in technological innovation and extension activities.

The farms in Cluster 3 did not face the same obstacles as those in Cluster 1, since they had access to technical assistance, Global GAP certification and formal alliances with exporting companies. As a consequence, the farmers in this group appear to have benefited the most from these conditions when compared to those of the other clusters. Contrary to the observations of BARRENA et al. (2013) in Chile, export certifications have enabled these Colombian growers to access new markets and obtain better prices in the domestic market.

Figure 5 - Boxplots a) Farm size (Ha) b) avocado cv. Hass planted area (Ha) c) avocado cv. Hass yield d) Price paid to growers ($USD/kg).
Most of the farms in Cluster 3 had established avocado as a monoculture. They employed external labor and had five or more years of experience with the crop, bookkeeping costs and access to technical assistance. These factors indicated that these farms have a rather commercial agricultural profile (BACKER, 1997). Research and development for these farms should focus on capitalization and less labor-intensive agricultural technologies in order to cope with the lack of workforce in the surroundings. Just as well, it should provide training facilities for technical assistants to specialize in avocado cv. Hass technical management.

The farms in Cluster 2 share some features with those of Cluster 1, such as the use of family
and external labor, food production for household consumption, and fertilization and phytosanitary schemes. This group also shares some of the characteristics of Cluster 3 in terms of avocado cv. Hass yield, type of technical assistance, and access to formal commercial alliances. These farms need better technical assistance aimed to access better seedlings and improving phytosanitary management, therefore increasing their yields.

The current results revealed considerable homogeneity in parameters such as type of tenure, distance from the farm to municipality seats and growers’ associativity, all of which are important for the development of avocado cv. Hass cultivation. As pointed out by VÁSQUEZ et al. (2011), tenure security is especially relevant to this crop, not only because it is semi-perennial and; therefore, requires long-term investments, but also because the plantations can be used as collateral to apply for formal credit. Just as well, proximity to markets benefits cv. Hass growers as a result of the quick dispatch of the product from the farms, which, in turn, reduces transport costs and preserves fruit quality by avoiding long travelling distances along non-paved roads. Finally, associativity was found to be a common feature of the three farm types, resulting in numerous benefits such as access to technical training and institutional support in the form of subsidies, increased bargaining power of small and medium growers to negotiate with middlemen, and new possibilities to establish commercial alliances with big marketers.

CONCLUSION

Three types of avocado cv. Hass farms were identified in Antioquia, Colombia. They differed mainly regarding farm size, farm registry at ICA, avocado planted area, farm labor at harvest time, avocado yield per farm, labor source, technical assistance type, and farmer’s experience with avocado cv. Hass. One of the observed farm types was found to be related to peasant agriculture, while another one came close to commercial agriculture, and a third one shares features with both of them.

The results of this study may contribute to increasing the positive impact of future agricultural innovations and public policies and programs aimed at avocado cv. Hass farms. Most of the current programs intended to support the production of this variety do not rely on sound information such as the one provided by the current farm typology in terms of the different profiles and needs of avocado cv. Hass productive units. Such information is valuable when it comes to deciding which programs may be more beneficial for a particular farm type, thus enhancing the impact of any intervention. Particularly, the farms in Cluster 1 should be targeted by special support policies and development programs in order to sustain their activity.

DECLARATION OF CONFLICT OF INTERESTS

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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AUTHORS’ CONTRIBUTIONS

The authors contributed equally to the manuscript.

REFERENCES

ABAS, Z. et al. The environmental profile of dairy farms in Central Macedonia (Greece). Procedia Technology. 2013. vol. 8. 378 – 386. Available from: <https://www.sciencedirect.com/science/article/pii/S2212017313001126>. Accessed: Mar. 13, 2018. doi: 10.1016/j.protcy.2013.11.050.

ALARCÓN RESTREPO, J. J., et al. Manejo fitosanitario del cultivo del Aguacate Hass. ICA.2012. Available from: <https://www.ica.gov.co/getattachment/4b5b9b6f-ecfc-46e1-b9ca-b35e11ee2e2/>. Accessed: Mar. 13, 2018.

ARAMBURO, C. et al. Desarrollo regional: una tarea común universidad-región. Instituto de Estudios Regionales, Iner.2007.

BACER, T. La Agricultura Empresarial Campesina y el Combate de la Pobreza Rural Andina. Instituto Interamericano de Cooperación para la Agricultura. 1997.

BAIN, C. Governing the global value chain: GLOBALGAP and the Chilean fresh fruit industry. 2010. International Journal Sociology. Agr. Food 17: 1-23. Available from: <https://www.courseshero.com/file/12286694/Bain-C-2010-Governing-The-Global-Value-Chain-Global-GAP-and-Chilean-Fresh-Fruit-Industry/>. Accessed: Mar. 13, 2018.

BARRENA, J. et al. Heterogeneity of farms entering export supply chains: the case of fruit growers from central-south Chile. 2013. Spanish. Journal of Agricultural Research. 11(2), 281-293. Available from: <http://www.researchgate.net/publication/273691618_Heterogeneity_of_farms_entering_export_supply_chains_The_case_of_fruit_growers_from>

Ciência Rural, v.50, n.7, 2020.
central-south, Chile>. Accessed: Apr. 04, 2018. doi: 10.5424/sjar/2013112-3469.

BERNAL, J.; DÍAZ, C. Manejo del cultivo de Aguacate. In: Bernal, J., et al. (Eds.), Actualización Tecnológica y Buenas Prácticas Agrícolas (BPA) en el Cultivo de Aguacate, Manual técnico CORPOICA. 2014. Centro de Investigación la Selva, Rionegro, Antioquia, Colombia, pp.11e151. Available from: <http://repository.agrosavia.co/bitstream/handle/20.500.12324/12616/68164_64855.pdf?sequence=1&isAllowed=y>. Accessed: Apr. 04, 2018.

BLOOMBERG (2018). USDCOP Spot Exchange Rate. Available from: <https://www.bloomberg.com/quote/USDCOP:CUR>. Accessed: Mar. 28, 2018.

CLEVES-LEGUÍZAMO, J.; JARMA-OROZCO, A. Characterization and typification of citrus production systems in the department of Meta. 2014. Revista Agronomía Colombiana, 32(1), 113-121. Available from: <http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S0120-99652014000100015>. Accessed: Mar. 28, 2018. doi: 10.15446/agronom. v32n1.42164.

CÁMARA DE COMERCIO DE MEDELLÍN. Perfil socioeconómico de la subregión del Oriente. 2014a.

CÁMARA DE COMERCIO DE MEDELLÍN. Perfil socioeconómico de la subregión del Norte. 2014b.

CÁMARA DE COMERCIO DE MEDELLÍN. Perfil socioeconómico de la subregión del Suroeste. 2014c.

CHÁVEZ, M. D. et al., Creating a typology of tobacco farms according to determinants of diversification in Valle de Lerna (Salta Argentina). Spanish Journal of Agricultural Research. 2010, vol(82), 460-471. Available from: <https://www.researchgate.net/publication/48168216_Creating_a_typology_of_tobacco_farms_according_to_determinants_of_diversification_in_Valle_de_Lerna_Salta-Argentina>. Accessed: Apr. 14, 2018. doi: 10.5424/sjar/2010082-1201.

CORNARE, 2015. Análisis socioeconómico del Oriente Antioqueño Anexo 1. Plan de Crecimiento Verde y Desarrollo Compatible con el Clima para el Oriente Antioqueño.

CORPOICA, 2017. Trabajamos para que el aguacate Hass, se convierta en el cuarto producto agrícola colombiano de exportación. Available from: <http://www.corpoica.org.co/noticias/generales/sgr-aguacate-antioquia/>. Accessed: Feb. 22, 2017.

FINAGRO, 2018. Información Sectorial Aguacate. Available from: <https://wwwFINAGRO.com.co/informacion%C3%B3n-sectorial/aguacate2017/>. Accessed: Jul. 09, 2018.

FRESHPLAZA. Colombia: Hass avocado production to double in 3 years. 2017. FreshPlaza, Available from: <http://www.freshplaza.com/article/180377/Colombia-Hass-avocado-production-to-double-in-3-years>. Accessed: Mar. 07, 2018.

GARCÍA, A.; et al., Structural characterization of extensive farms in Andalusian dehesas. Archivos de Zootecnia. 2010. 59 (228): 577-588. Available from: <https://pdfs.semanticscholar.org/9661/144514f86756ee45a3710066399f6a41.pdf>. Accessed: Mar. 07, 2018.

GIBON, A.; et al. Livestock farming systems research in Europe and its potential contribution for managing towards sustainability in livestock farming. 1999. Livestock Production Science. 61. 121–137. Available from: <https://www.sciencedirect.com/science/article/pii/S0301622699000627>. Accessed: Mar. 07, 2018. doi: 10.1016/S0301-6226(99)00062-7.

GREENACRE, M (2006). Multiple Correspondence Analysis and Related Methods. Chapman & Hall.

GOSWANI, R. et al., Farm types and their economic characterization in complex agro-ecosystems for informed extension intervention: study from coastal West Bengal, India. 2014. Agricultural and Food Economics, 2014, 2:5. Available from: <https://link.springer.com/article/10.1186/s40100-014-0005-2>. Mar. 07, 2018. doi: 10.1186/s40100-014-0005-2.

HUSSON, F.; et al., Principal Component methods – hierarchical clustering - partitional clustering: why would we need to choose for visualizing data? 2010. Technical Report- Agrocampus. Available from: <https://pdfs.semanticscholar.org/0433/5d99d40a3370f5aeb26228ecf127d3f1ce.pdf?_ga=2.244818917.514399630.1587398786-2098095952.1586381283>. Accessed: Mar. 07, 2018.

HUSSON F., [Francois Husson]. Multiple Correspondence Analysis with FactoMine R. [Video File]. (2016, November 30). Available from: <https://www.youtube.com/watch?v=SllUYD6iac>. Accessed: Mar. 07, 2018.

KAUFMAN L.; ROUSSEEUW, P. Finding groups in data. John Wiley & Sons, Inc., Hoboken, New Jersey. 2005. 9th edition.

KÖBRICH, C et al., Typification of farming systems for constructing representative farm models: two illustrations of the application of multi-variate analyses in Chile and Pakistan. 2003. Agricultural Systems: vol. 76, pp. 141-157. Available from: <https://www.sciencedirect.com/science/article/pii/S0308521X000136-6>. Accessed: Mar. 07, 2018. doi: 10.1016/S0308-521X(02)00013-6.

RAMÍREZ-GIL, J. G.; et al., Economic impact of the avocado (cv. Hass) wilt disease complex in Antioquia, Colombia, crops under different technological management levels. 2017. Crop protection. 101, 103-115. Available from: <https://www.revistas.unal.edu.co/index.php/efame/article/view/66465/70962>. Accessed: May, 17, 2018. doi: HTTP://dx.doi.org./10.15446/rfna.v71n2.66465

PARDOS, L.; et al., The diversity of sheep production systems in Aragón (Spain): characterization and typification of meat sheep farms. 2008. Spanish Journal of Agricultural Research, 6(4), 497-507. Available from: <http://revistas.inia.es/index.php/sjar/article/view/344/341>. Accessed: May, 17, 2018. doi: 10.5424/sjar/2008064-344.

SANGERMAN-JARQUÍN, D.; et al., Tipología del productor de aguacate en el estado de México. 2014. Revista Mexicana de Ciencias Agrícolas Vol 5 p. 1081-1095. Available From: <http://www.scielo.org.mx/pdf/remexca/v5n6/v5n6a14.pdfSCHAEFFER, R.; MENDENHALL, W.; OTT, L. Elementos de Muestra. 1986. Editorial, Iberoamérica.

SIERRA SUAREZ, J. F; (December 23, 2017). El aguacate: esperanza de países para exportar más. El Colombiano. Available from: <http://www.elcolombiano.com/especiales/antologia-periodistica/aguacate-hass-esperanza-de-antiqueunos>

Ciencia Rural, v.50, n.7, 2020.
para-exportar-mas-GY6346679 on 06.07.2018>. Accessed: May, 17, 2018.

SIOC, 2018. Cadena de Aguacate, Indicadores e Instrumentos May 2018. Available from: <https://sioc.minagricultura.gov.co/Aguacate/Documentos/002%20-%20Cifras%20Sectoriales/002%20-%20Cifras%20Sectoriales%20-%202018%20Mayo%20Aguacate.pdf>. Accessed: Jul. 09, 2018.

STDHA Statistical tools for high-throughput data analysis. Types of Clustering Methods. Overview and Quick Start R Code. Available from: <http://www.sthda.com/english/articles/25-cluster-analysis-in-r-practical-guide/111-types-of-clustering-methods-overview-and-quick-start-r-code/2018>. Accessed: Feb 20, 2018.

TITTONELL, P. et al., The diversity of rural livelihoods and their influence on soil fertility in agricultural systems of East Africa – A typology of smallholder farms. 2010. Agricultural Systems. 103 (2010) 83-97. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S0308521X09001061>. Accessed: May, 17, 2018. doi: 10.1016/j.agsy.2009.10.001

TODDE, G. et al., A multivariate statistical analysis approach to characterize mechanization, structural and energy profile in Italian dairy farms. 2016. Energy Reports, 2 (2016) 129–134. Available from: <https://www.sciencedirect.com/science/article/pii/S235248716300191>. Accessed: May, 17, 2018. doi: 10.1016/j.egyr.2016.05.006.

TRADEMAP, 2018. Available from: <https://www.trademap.org/Country_SelProduct_TS.aspx?nv pm=1|||080440|||6|1|1|2|2|1|2|1|1>. Accessed: Feb. 02, 2018.

VÁSQUEZ, G. L. A. et al., Caracterización biofísica y socioeconómica del sistema de producción de aguacate cv. Hass en los departamentos de Antioquia, Caldas, Risaralda y Quindío. 2011. Corporación Colombiana de Investigación Agropecuaria, CORPOICA, Centro de Investigación La Selva, Rionegro, Antioquia, Colombia. Boletín divulgativo. Rionegro (Antioquia): CORPOICA - Centro de Investigación La Selva, 201 1. 97p. Available from: <https://repository.agrosavia.co/handle/20.500.12324/13547>. Accessed: May, 17, 2018.