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Productive systems management

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Characterization of the productive units of kiwicha (*Amaranthus caudatus*) cropping in the provinces of Yungay, Huaylas and Carhuaz, department of Ancash, Peru

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Abstract

The current work was carried out with the aim of characterizing the productive units of small-scale agricultural systems of kiwicha (*Amaranthus caudatus*) in five communities of the Yungay, Huaylas, and Carhuaz provinces, Ancash region, Peru. The population sample of the production units under study was determined employing a proportional and stratified unrestricted random sampling. The information was obtained from primary (surveys and interviews) and secondary sources. The analyses were carried out by grouping qualitative and quantitative variables, and using multi-dimensional statistical techniques. Three types of producers that are similar inside each group were identified, and, at the same time, they have differences compared to other groups based on land tenure, areas sown with kiwicha and with a secondary crop, and monthly net income. The first group that included smallholding producers with 0.42 ha of arable land, possesses on average 0.14 ha cropped with kiwicha, and 0.17 ha of a secondary crop; the second group, comprised small producers with 0.53 ha of land available for their crops, have 0.30 ha of kiwicha, and 0.43 ha of a secondary crop, and the third group is composed of medium-sized producers that on average have 6.13 ha of land, of which 1.87 ha are cropped with kiwicha and 0.63 ha with a secondary crop. The monthly net income of medium producers with PEN 493.50 is higher than that of small and smallholding farmers in 176.52 % and 279.03 %, respectively.

Keywords: agricultural production, *Amaranthus*, production structure, production systems, smallholders

Caracterización de las unidades productivas del cultivo de kiwicha (*Amaranthus caudatus*) en las provincias de Yungay, Huaylas y Carhuaz, en el departamento de Áncash, Perú

Resumen

El presente trabajo se realizó con el objetivo de caracterizar las unidades productivas de sistemas agrícolas en pequeña escala de kiwicha (*Amaranthus caudatus*) en cinco comunidades de las provincias de Yungay, Huaylas y Carhuaz, región Áncash, Perú. La población muestra de las unidades de producción en estudio se determinó mediante un muestreo irrestricto aleatorio proporcional y estratificado. La información obtenida de fuentes primarias (encuestas y entrevistas) y secundarias se analizó agrupando variables cualitativas y cuantitativas, y utilizando técnicas estadísticas de análisis multidimensional. Se identificaron tres tipologías de productores que se asemejan al interior de cada grupo y, al mismo tiempo, presentan diferencias frente a otros grupos por la posesión de tierras, área sembrada de kiwicha, área sembrada de cultivo secundario e ingreso neto mensual. El primer grupo, compuesto por productores de minifundio con 0,42 ha de tierras cultivables, posee en promedio 0,14 ha de cultivo de kiwicha y 0,17 ha de un cultivo secundario; el segundo grupo, compuesto por pequeños productores con 0,53 ha de tierras disponibles para sus cultivos, cuentan con 0,30 ha de kiwicha y 0,43 ha de un cultivo secundario; el tercer grupo, compuesto por medianos productores, en promedio dispone de 6,13 ha de tierras, de los cuales 1,87 ha son de kiwicha y 0,63 ha son de cultivos secundarios. Los ingresos netos mensuales de los medianos productores con PEN 493,50 resultan mayores a los de los pequeños y los de minifundio en 176,52 % y 279,03 %, respectivamente.

Palabras clave: *Amaranthus*, estructura de la producción, pequeños agricultores, producción agrícola, sistemas de producción

Introduction

In South America, kiwicha *Amaranthus caudatus* L. (Amaranthaceae) is cultivated in marginal areas of the inter-Andean valleys in small-scale plots generally associated with maize (*Zea mays* L.) (Veneros & Chico, 2017). It is the only amaranth species that grows at altitudes greater than 2,500 meters above the sea level. (Espitia et al., 2010). In Peru, the promotion of its cultivation and its demand increased as a non-traditional export crop in the 1980s. Currently, the department of Cuzco, followed by the department of Ancash, is the highest production area of this grain (Ministerio de Agricultura y Riego [Minagri], 2016). Its cultivation within the family farming system is strategic to improve nutritional quality and family income; however, promotion, credit, and technical assistance policies are required to favor this crop (Sánchez et al., 2016).

During the 1994-2012 period in Peru, the agrarian structure has changed in terms of the number of production units, the number of farmers, and land tenure (Instituto Nacional de Estadística e Informática [INEI], 2013; Maletta, 2017; Ponce et al. al., 2015). Moreover, the agrarian structure of the department of Ancash is characterized by the diversity of productive systems and their physical, socio-economic, or technical components (Barreto, 2017). Therefore, multi-dimensional studies are required to know and characterize them (Coronel de Renolfi & Ortuño, 2005; Escobar & Berdegué, 1990).

This first approximation is useful to establish relationships between variables and economic, environmental and social indicators (Vargas & Sánchez, 2015), in such a way to facilitate a dynamic interpretation of agroecosystems and the formulation of viable recommendations with a multi-dimensional approach (Apollin & Eberhart, 1999; Carrillo et al., 2011; Coronel de Renolfi & Ortuño, 2005).

Accordingly, the aim of the research was to characterize the productive units of kiwicha cultivation and establish the typologies of producers in five communities located in the provinces of Yungay, Huaylas, and Carhuaz, in the department of Ancash, Peru, to explore some topics that could become research topics in the Andean small grain producer sector.

Materials and methods

The study was carried out in the sphere of influence of three provinces and five districts of the department of Ancash, considered as the main kiwicha producing areas (table 1).

Table 1. Location, population, and geographical description of the study areas of the department of Ancash, Peru

Province	District	Population	Altitude (m a.s.l.)	Category	UTM coordinates	
					Latitude	Longitude
Huaylas	Mato	1,993	2,234	Village	09°02'50"	77°50'44"
	Santa Cruz	5,210	2,868	Town	08°56'55"	77°48'54"
Yungay	Yungay	22,214	2,463	City	09°09'15"	77°44'55"
Carhuaz	Pariahuanca	1,622	2,785	Town	09°21'51"	77°34'58"
	Tinco	3,285	2,581	Town	09°06'26"	77°40'55"

Source: Elaborated by the authors, adapted from Instituto Nacional de Estadística e Informática (INEI, 2017)

To define the agricultural unit (AU) sample under study, of a population of 448 producers using the probabilistic sampling technique, the total population of kiwicha producers was divided into different subgroups or strata. The methodological procedure of an unrestricted random proportional and stratified type allowed defining and dividing a sample of 115 producers (Martínez-Reyna, 2013; Pinedo et al., 2018) into the five most representative districts of kiwicha cultivation in the department of Ancash, who provided the necessary information to define the characteristics of different types of producers (Pinedo et al., 2018).

The typology of the production systems was made from the analysis of access to cropping land, cultivated area, labor availability, crop management, and yield, as well as the different combinations of cropping systems practiced by production unit. Furthermore, also including the processes of differentiated accumulation in capital (production costs, net family income), and the level of intensification of agricultural units (crop rotation practices), considering the methodological proposals proposed by Escobar and Berdegué (1990), Apollin and Eberhart (1999), and Maletta (2017).

This facilitated the development of questionnaires with structured questions (Pinedo et al., 2018), associated with 61 primary qualitative and quantitative variables, defined and coded for further processing and analysis (Coronel de Renolfi & Ortuño, 2005). Of the 61 original variables, those that could effectively contribute to the desired typification were selected (table 2).

Table 2. Variables under study selected for the characterization of the kiwicha (*Amaranthus caudatus*) productive units in chosen areas of the department of Ancash, Peru

Code	Variable	Unit of measurement
RDTOKW	Kiwicha yield	kg/ha
CASEMP	Seed/plot quantity	kg/ha
SUCULTV	Cultivated surface	ha
COSTOSE	Seed cost	PEN
INVENKW	Kiwicha sale income	PEN
COPRETER	Land preparation cost	PEN
COSPROD	Production cost per ha	PEN
COSTJOR	Labor cost	PEN
NUJORNH	No. wages per ha	No. wages
COSTOPL	Pesticide cost	PEN
COSTDER	Fertilizer cost	PEN
INGRNM	Monthly net income	PEN
INGNECS	Net income of secondary crop	PEN
NUMPEF	No. of persons per household	No.
TECNCOS	Harvest technology	No. of technologies
AREACSE	Secondary crop area	ha
ROCULTI	Rotation	Rotation scale
TENTIER	Land tenure	Surface (ha)
ACEPSIPR	Production system acceptability	Acceptance level
BPAGERE	Good agricultural practices and waste management	Level of application of Good Agricultural Practices (GAP)

Note: Exchange rate at the moment the evaluation was carried out: 1 PEN = 0.298 USD

Source: Elaborated by the authors

The characterization of the kiwicha production units was carried out based on the results of the *IV National Agricultural Census* (INEI, 2013) and the information collected from surveys applied in the field. Initially, the specific theoretical framework for the typification of the productive units was determined, and later, the variables under study were selected to know the reality of the production systems (Escobar & Berdegué, 1990).

A questionnaire format was developed with structured questions to capture information on the farming system and socio-economic aspects (Álvarez et al., 2014; Pinedo et al., 2018). The information collected through the questionnaires was ordered and systematized in a spreadsheet employing the Excel® 2013 tool. Subsequently, the data were processed with the SPSS v22 and Infostat software. For the principal component analysis (PCA), quantitative variables were used, while some categorical variables were transformed into a numerical scale.

Of the 61 variables under study, those with a coefficient of variation (CV) lower than 40 % were discarded because they lacked discriminatory power and did not contribute substantially to the multivariate analysis (Lores et al., 2008). With 20 variables selected for their higher discriminatory power, the PCA was performed using Ward's method and the Varimax rotation technique (Carrasco et al., 2017; Criollo et al., 2016; Velázquez & Perezgrovas, 2017).

The statistical management of the data was carried out with the Statistical Package for the Social Sciences (SPSS). All the selected quantitative variables were standardized by transforming them into Z values to eliminate the scale and unit of measurement values (uniformity in the measurement units used); in this way, the influence of different levels of measurement units was avoided (García & Calle, 1998; Velázquez & Perezgrovas, 2017).

Influential variables in group formation, and those highly correlated with each other were identified (Tuesta et al., 2014). The components with axes whose eigenvalue was higher than 1.0, or that explained more than 60 % of the variability were selected (Álvarez et al., 2014).

For the cluster analysis, 20 discriminant variables were used employing the hierarchical grouping technique (Tovar et al., 2015), which helped to form homogeneous groups of systems with similar characteristics or typologies, with minimal variability within the group and maximal between groups (Coronel de Renolfi & Ortuño, 2005; Paz et al., 2000; Tovar et al., 2015), facilitating the understanding of the complexity of the systems (Álvarez et al., 2014).

Results and discussion

Distribution of the surveyed population by communities

Kiwicha crops were found in all the AU studied as part of the predominant diversified production system in the area. Regarding the location and percentage of farmers with kiwicha fields, the largest number of producers are located in the community of Santa Cruz (34.7 %), followed by Yungay (22.3 %), Mato (21.5 %), and Parihuanca (10.7 %), while in the community of Tinco (5.8 %) had the lowest amount of AU with this crop. In this regard, Barreto (2017) points out that, in the AU where kiwicha cultivation is found, this species is not necessarily the main crop, but part of their traditional diversified production system.

Concerning the role that men and women play, in the communities of Matos, Santa Cruz, and Yungay, the responsibility of men managing the plots compared to women is higher, while in Pariahuanca and Tinco, the AU is in charge of women (figure 1). According to INEI (2013), of the population registered in the department of Ancash, 64.8 % are men and 35.28 % are women; however, the demographic and family health survey carried out by the National Institute of Statistics and Informatics (INEI, 2014) indicated that the rural female population in Ancash is 47.5 %. The role of women is key in parcel unit management, as well as in resources conservation and income generation (Comunidad Andina de Naciones [CAN], 2011; Minagri, 2015).

Women have adapted and followed useful traditional and technological practices for each production type in which they are involved. However, despite being the backbone of food production and supply for family consumption, women face even greater limitations due to a series of cultural, traditional, and sociological factors, such as the limited openness in making decisions about the community or the occupation of managerial positions (Caselato & Amaya, 2012; González et al., 2015; Sánchez & Navarrete, 2017; Vieyra et al., 2014).

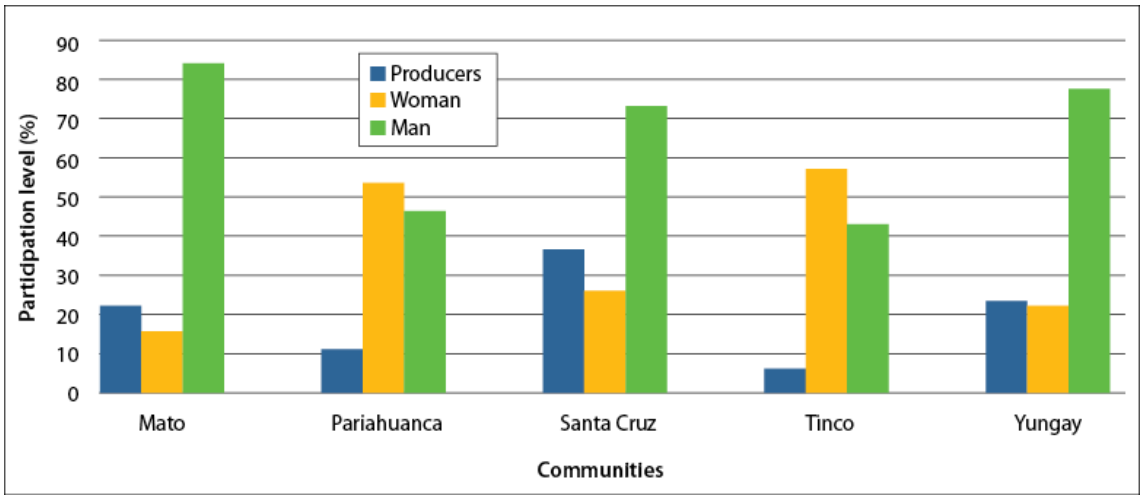

Figure 1. Percentage distribution of the population of men and women in the management tasks of kiwicha production units in the study area. Department of Ancash, 2016-2017.

Source: Elaborated by the authors

Regarding the age of the producers, in the communities of Mato, Pariahuanca, Santa Cruz, Tinco, and Yungay, 71.0 % are between 22 and 50 years old, while 15.2 % are between 71 and 89 years of age (figure 2). Currently, the proportion of working-age persons in the rural regions of the study area is 57.5 % (INEI, 2014). This information is complemented by the Regional Government of Ancash (Gobierno Regional de Ancash [Gorea], 2008), which states that 70.8 % of the population is of working age.

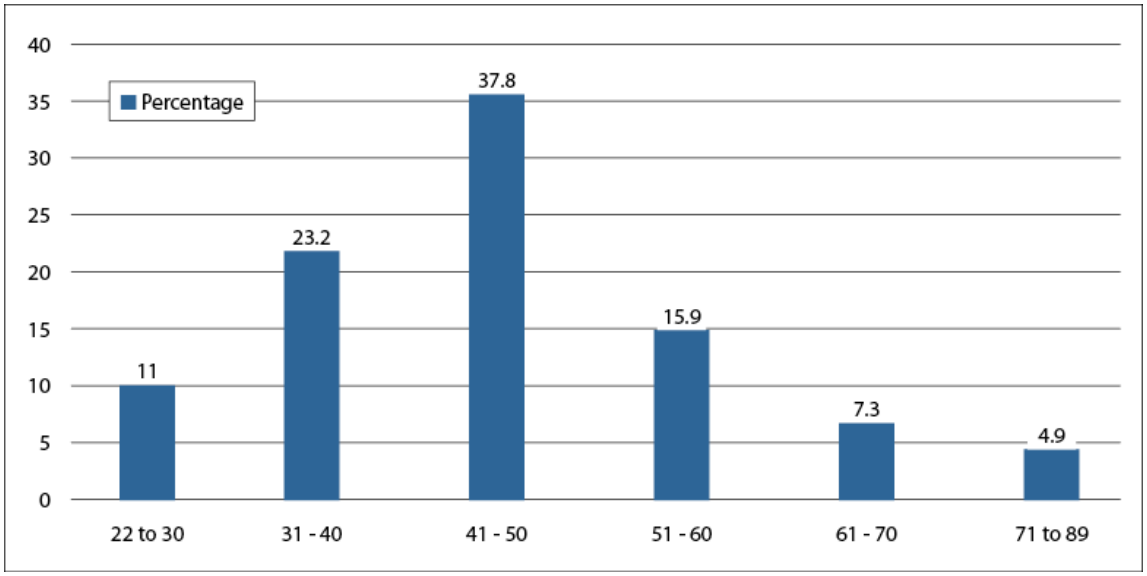

Figure 2. Groups of kiwicha producers classified by age in the provinces of Yungay, Huaylas, and Carhuaz, Ancash, 2016-2017.
Source: Elaborated by the authors

Regarding the level of education, five levels were identified: 27.0 %, with a partial or total level of higher education; 33.0 %, with incomplete and complete secondary school; 26.1 %, with some level

of primary education; 0.2 %, with initial or pre-school level, and 13.8 % are considered illiterate; therefore, 86.3 % can read and write.

Thanks to the educational policy of the governments of the last 15 years, the illiteracy rate has decreased and is reflected in a higher percentage of inhabitants of rural areas with some level of education. In the last five years, the illiteracy rate has decreased from 7.1 % to 5.9 %, among other factors, due to the increase in migration to cities or populated centers where persons have better opportunities to access educational services (Pinedo et al., 2017).

Education can be an influencing factor in the adoption of technologies (Ayora, 2015; Centro Internacional de Mejoramiento de Maíz y Trigo [Cimmyt], 1993; Pinedo et al., 2017). However, in peasant family farming contexts, the innovation of learning processes is recommended. In this regard, Pinedo (2019) mentions that the farmer field school (FFS) methodology allows information to be processed, and based on the analysis of the plots in agroecosystems, knowledge to solve crop management problems is generated due to its learning by doing principle.

The place of residence preferred by producers is associated with the age, expectations of the population, and opportunities found in their environment. Fifty-four percent of the farmers reside on the farm; 34 % in a populated center close to the farm, 15 % in the city, 5 % between the farm and the populated center, and the remaining 2 % did not specify. In this regard, Apollin and Eberthart (1999) and Pinedo et al. (2018) indicated that housing quality and the services they have is a determining factor for the permanence of producers in rural areas and close to their agricultural units.

In the AU evaluated, 43.9 % of the farmers have adobe houses in good condition; 54.9 % have adobe houses in fair conditions, while 1.20 % have dilapidated housings and in poor conditions. Likewise, 80.5 % have water, sewage, and electricity services, while 1.2 % only have water from springs. In this regard, Gorea (2008), in the population and housing studies of Ancash, found that 83.2 % of the housings located in rural areas had access to drinking water, and only 41.7 % of these had access to drainage.

Basic need satisfaction in the rural populations and its effect on the better living conditions of the inhabitants can be a key factor to encourage the permanence of producers in the field (Córdova, 2009). However, this requires promotion policies to improve the management and profitability of their AU (Pinedo et al., 2018), considering that the world market for amaranth is extending, mostly because of the possibilities of better socio-economic conditions offered by the crop (González et al., 2015; Sánchez et al., 2016).

Regarding the land tenure variable, in the five communities assessed, 67.1 % are owners, while 22 % are in the process of titling their land. In the last 15 years, the land tenure situation has changed. The number of AUs has increased in plots whose average surface reaches 0.8 ha (INEI, 2013), making it challenging to implement production plans in scale economies (Maletta, 2017).

Regarding the generation of family employment, the study indicates that 39 % of the labor force comes directly from the family, 24.4 % are hired workers, and 35 % uses family labor as well as hired labor. Barreto (2017) indicated that in Carhuaz, 56.1 % of the families use only family labor, 22.1% use paid labor, and 21.80 % use both labor forms. Based on the results, there is a type of

family farming in the transition towards production models more integrated into the market, since a high percentage of the families hire laborers in poorly diversified production systems with a monoculture tendency, even in smallholdings (Barreto, 2017; CAN, 2011; Instituto Interamericano de Cooperación para la Agricultura [IICA], (2015); Minagri, 2015; Pinedo et al., 2017).

The predominant crops in the study area are wheat (*Triticum aestivum* L.), corn on the cob (*Z. mays* L.), potato (*Solanum tuberosum* L.), pea (*Pisum sativum* L.), and barley (*Hordeum vulgare* L.); on a smaller scale, kiwicha, quinoa (*Chenopodium quinoa* Willd.), fruits, and subsistence crops such as squash (*Cucurbita maxima* Duch.) (figure 3). According to Barreto (2017), at the Ancash department level, in production areas located between 2,650 and 2,900 m a.s.l., the four most important crops are potato, corn, beans, and forages, mainly alfalfa (*Medicago sativa* L.).

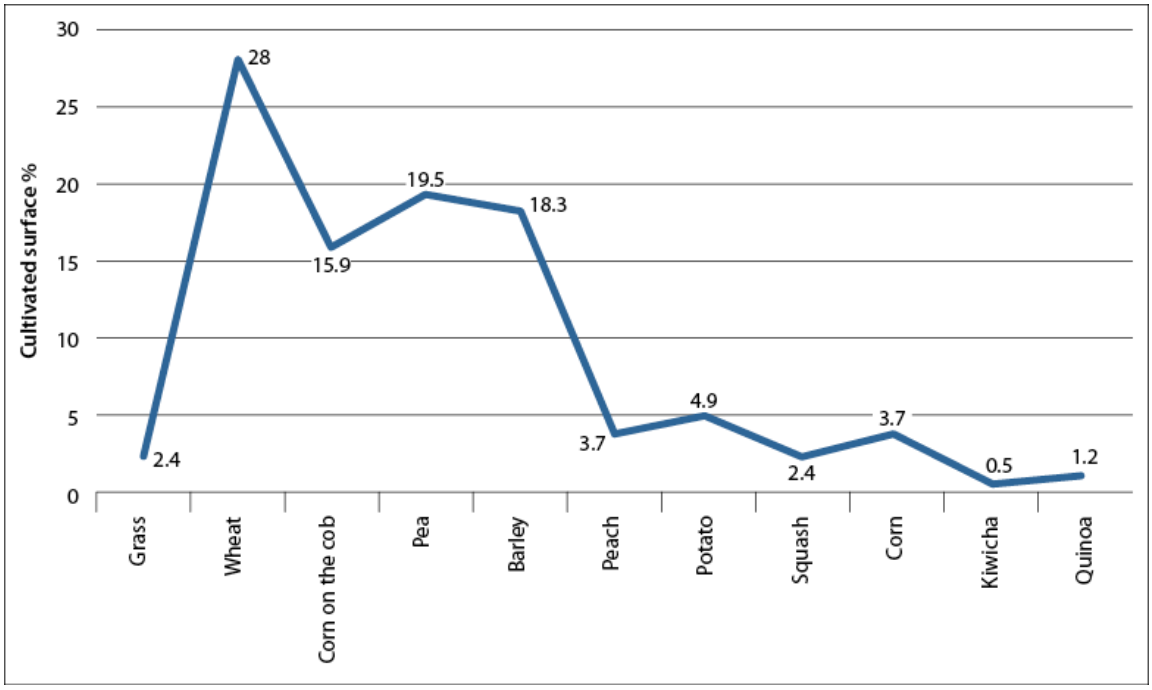

Figure 3. Area percentage dedicated to different main crops in Santa Cruz and Huaylas, in the department of Ancash.
Source: Elaborated by the author

In relation to the technological gaps, according to INEI (2013), of the 2,164,000 producers, only 10 % received some type of training and technical assistance. The study indicates that the technology used in the cultivation of kiwicha is medium to low.

As the area cultivated with kiwicha is reduced, the producers conserve traditional production models, while in areas larger than one hectare, they adopt technological packages that include the use of certified seed and agrochemicals. In very small plots, soil preparation is done manually and with animal traction. Barreto (2017) indicated that in the management of the AUs, certain traditional practices are used, including minimum tillage with traditional tools and implements, and the use of their own seed; these areas preserve their characteristics. It is evident that traditional management continues to be a viable technological alternative for the fragile agroecosystems of the inter-Andean valleys of Ancash and can be economically sustainable if the producer generates sufficient income for family maintenance (Pinedo, 2019; Sánchez et al., 2016; Sarandón, 2002).

Principal Component Analysis (PCA)

Through a PCA and using 20 variables with the highest discriminatory power and not correlated with each other (table 1), four principal components that contribute to explain 75.5 % of the determined variance were obtained (table 3).

Table 3. Eigenvalues of the correlation matrix and contribution levels (%) of the variance of the kiwicha production units

Component	Own value	Difference	Contribution (%)	Accumulated (%)
1	11.22	5.77	51.01	51.01
2	2.35	3.52	10.70	61.71
3	1.58	1.90	7.18	68.89
4	1.46	1.81	6.66	75.54

Source: Elaborated by the authors

The readjusted values with the rotated component matrix are shown in table 4. Component 1 (C1) is the most influential and explains the typology of producers (51.01 %) and the variables that affect the production costs of kiwicha cultivation. Component 2 (C2) explains the resources and technology of producers. Component 3 (C3) refers to the levels of ecological awareness of the producer, and component 4 (C4), which contributes with 6.66 %, explains the food safety strategies of the producer in polyculture systems. Regarding components C3 and C4, Pinedo et al. (2018) and Sarandón (2002) indicated that the segments of producers who practice traditional cultivation systems show higher ecological awareness in the management of their resources and, as part of their food security strategies, they practice crop rotation, association, and productive diversification (CAN, 2011; Maletta, 2017).

Table 4. Synthetic indicator matrix of rotating components in kiwicha production units

Variables	Component				Interpretation of the components
	1	2	3	4	
Kiwicha yield	0.952	0.058	0.121	0.031	Production costs and income generation
Amount of seed/plot	0.945	0.262	0.04	0.003	
Cultivated surface	0.945	0.277	0.048	-0.012	
Seed cost	0.945	0.249	0.071	0.015	
Kiwicha sale income	0.943	0.065	0.19	0.056	
Preparation cost and terrain	0.941	0.294	0.026	-0.011	
Production cost per ha	0.937	0.291	0.107	-0.023	
Labor cost	0.849	0.362	0.104	-0.051	
No. of wages per ha	0.771	0.374	0.136	-0.077	
Fertilizer cost	0.761	0.109	-0.015	-0.006	
Monthly net income	0.664	-0.092	0.315	0.49	
Harvest technology	0.28	0.794	-0.113	-0.032	Resources and technologies of the producer
Cultivation area secondary crop	0.184	0.69	0.108	0.235	
Rotation	0.193	0.656	0.077	-0.09	
Total land (ha)	0.487	0.506	0.037	-0.061	
Production system acceptability	0.206	0.064	0.771	-0.083	Levels of ecological awareness of the producer
Pesticide costs	0.033	-0.044	0.642	-0.092	
GAP in waste management	0.048	0.094	0.615	0.243	
Net income from secondary crop	-0.055	0.116	0.236	0.85	Food strategies of the producer
No. of persons per household	-0.018	-0.079	-0.305	0.719	

Source: Elaborated by the authors

Cluster analysis

Three clusters were formed (figure 4); each group shows similar production systems inside, considering the four new synthetic variables found in the PCA (Coronel de Renolfi, & Ortuño, 2005; Paz et al., 2000), as follows: cluster 1 (CG1) includes smallholding producers; cluster 2 (CG2) comprises small producers, and cluster 3 (CG3) is composed of medium producers. The typification variables that determined the clusters were the production scale and cultivated area of kiwicha (Coronel de Renolfi & Ortuño, 2005; Maletta, 2017; Pinedo et al., 2018).

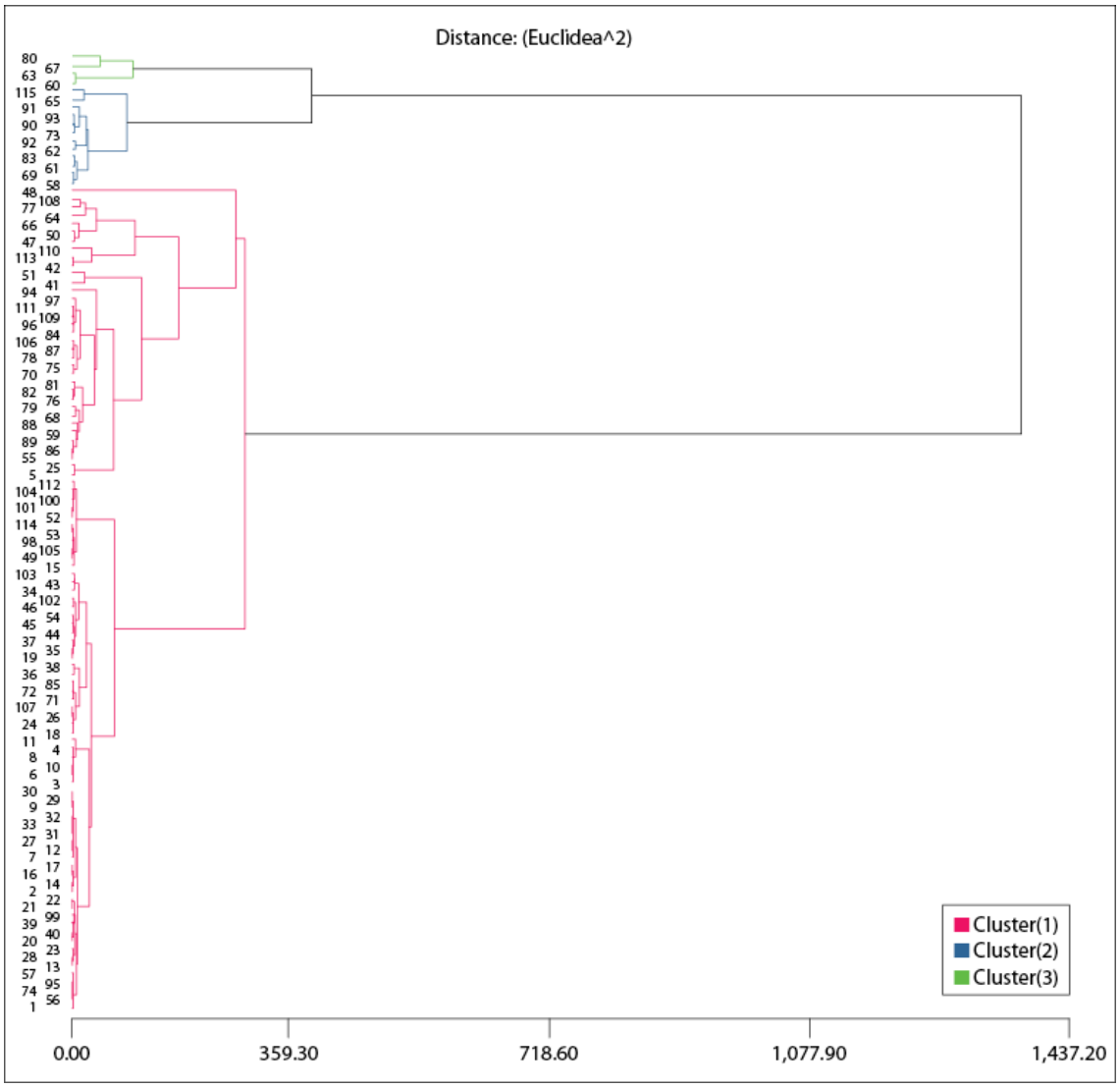

Figure 4. Typification dendrogram of smallholding, small and medium producers of kiwicha in the study area of the department of Ancash, Peru
Source: Elaborated by the authors

In the individual analysis by communities, in Mato and Pariahuanca, only smallholdings producers were recorded, while in Santa Cruz, the three types of producers were found; in Tinco and Yungay, smallholding and small producers were recorded (table 5).

Regarding the percentage of producers per community, 115 farmers who integrate kiwicha cultivation in their AU were identified, of which 36.52 % of the producers are found in Santa Cruz, 23.48 % in Yungay, 22.61 % in Mato, 11.30 % in Pariahuanca, and 6.09 % in Tinco.

Concerning land tenure, smallholding farmers own 0.56 ha of land on average, small producers 1.14 ha, and medium producers 6.13 ha. According to the classification carried out by IICA (2015), Maletta (2017), and Pinedo et al. (2017), these authors pointed out that smallholding producers own less than 1 ha, the group of small producers up to 3 ha, and the third group —medium producers— own more than 5 ha.

According to the established classification, CG1 would be considered a type of subsistence family agriculture (CAN, 2011; Escobal, 2015; Maletta, 2017). Producers in this segment, lack sufficient land, livestock, or productive infrastructure to generate monetary or non-monetary income that allows them to cover their basic food basket or minimum caloric requirements. At the same time, CG2 and CG3 could belong to the family farming group that is in transition, due to having surpluses for the market (CAN, 2011).

Table 5. Typology of producers concerning the distribution of farmers with kiwicha cropping, age, number of persons per family, experience in kiwicha cultivation, and land tenure

Community	Typology	Producers		Age	Number of persons per family	Experience (years)	Land (ha)
		No.	%				
Mato	Smallholding	26	22.61	47	5	4	0.67
Pariahuanca	Smallholding	13	11.30	48	3	9	0.14
Santa Cruz	Smallholding	2	1.74	54	5	12	0.94
	Small	36	31.30	45	4	12	2.26
	Medium	4	3.48	46	5	14	6.13
Tinco	Smallholding	6	5.22	51	3	6	0.24
	Small	1	0.87	80	4	5	0.10
Yungay	Smallholding	25	21.74	44	6	6	0.29
	Small	2	1.74	45	5	6	1.05

Source: Elaborated by the authors

The economic income and profitability of kiwicha cultivation resulted from the contribution of seven variables (table 6). The lowest economic income was found in CG1 producers with an average monthly net income of PEN 130.20. In the case of CG2, the average monthly net income is higher than CG1 by 27.05 % since they generate a monthly income of PEN 178.47. The medium-sized producers of CG3 generate the highest average economic income (PEN 493.50), and surpass CG2 and CG1 by 176.52 % and 279.03 %, respectively. None of the groups reaches the minimum living wage established by the Peruvian government (PEN 850).

Table 6. Variables of influence on the economic sustainability of the agricultural units of kiwicha production

Community	Cluster	V1	V2	V3	V4	V5	V6	V7
Mato	Smallholding	0.17	103.70	7	476.47	1,193.91	0.10	81.81
Pariahuanca	Smallholding	0.08	41.92	6	458.47	2,507.00	0.08	120.62
Santa Cruz	Smallholding	0.16	96.00	6	430.38	860.00	0.33	82.00
	Small	0.56	335.00	14	1,199.79	905.48	0.55	184.92
	Medium	1.87	1,122.00	40	380.25	961.67	0.63	493.50
Tincos	Smallholding	0.23	114.71	9	699.71	414.29	0.14	254.43
	Small	0.23	125.00	10	910.00	1,800.00	0.14	255.00
Yungay	Smallholding	0.08	45.72	5	366.56	1,981.99	0.18	112.08
	Small	0.10	60.00	4	318.83	760.42	0.43	95.50

Note: cultivation area (V1), land preparation cost (V2), No. of wages (V3), production cost (V4), yield in kg/ha (V5), surface of secondary crop in ha (V6), and monthly net income (V7). (figures in PEN). Exchange rate = 3.35 USD (1 PEN = 0.298 USD).
Source: Elaborated by the authors

Smallholding producers show the lowest levels of V7, reflected by small-scale agriculture with an average area of 0.14 ha, while medium-sized producers, with 0.30 ha, use their production for self-consumption and the scarce surplus for sale in the local market. Possibly, these two segments of producers can increase their cultivation areas, but there is little evidence of promotion to cultivate this crop. Hence, the trend in the coming years will be for a smaller cultivated area of kiwicha (Minagri, 2017). The highly fragmented type of agriculture limits scaling up producer economies (CAN, 2011; Maletta, 2017); on the contrary, small and medium-sized producers may have better possibilities of negotiation and integration into the market (IICA, 2015; Pinedo et al., 2018; Sánchez et al., 2016).

According to the United Nations Development Programme (PNUD, 2017), in Peru, the economy grew by 87 %, and poverty fell from 58.7 % to 22.7 % between 2004 and 2015, classifying it as a country with a high human development index (0.73). Nonetheless, structural inequalities persist in the study area, especially between the poor and the vulnerable, with the highlands being the most vulnerable with a poverty rate of 49 %. According to INEI (2016), the average monthly cost of the family food basket in the rural area of the Sierra region (montane) is PEN 234, and the average monthly per capita income in the rural area of this same region is PEN 417. The average monthly income of the three clusters, i.e., smallholdings, small- and medium-sized producers, reach an average of PEN 130.20, PEN 178.47, and PEN 493.50, respectively. These values reflect a level of monetary poverty (PNUD, 2017) compared to the economic income of the producers.

Possibly only medium producers will remain in this productive activity in the following years. Finally, producers of the three typologies identified in light of their monthly net income levels are inferred to contribute very little to the sustainability of kiwicha cultivation. A system must generate sufficient economic income, facilitate access to goods and services, and contribute to the proper use of natural resources to be sustainable (Sarandón, 2002).

Therefore, considering that kiwicha is widely recognized for its high protein content and nutritional qualities (Caselato & Amaya, 2012), as well as its ability to adapt to various climatic and environmental conditions, it is an alternative to face the challenges imposed by climate change (Ponce et al., 2015). Furthermore, kiwicha is a feasible strategy to contribute to national food security (CAN, 2011; Minagri, 2015), while remaining a viable alternative to ensure sustainable economic income (González et al., 2015; Maletta, 2017; Sánchez & Navarrete, 2017; Sánchez et al., 2016).

Conclusions

The analysis carried out to the 115 kiwicha production units allowed the identification of three types of producers comprised of groups of relatively nearby farms, according to the criteria of the variables used. On the other hand, a set of observations was obtained on the production and financing structures of the farms and the composition of the variables that characterize them.

Women play an essential role in driving and generating family income in the units evaluated. However, their role is only limited to primary production, wasting the potential of kiwicha grains. Due to its high protein content (14 % to 17 %), this crop can be a great opportunity to revalue the

role of women by integrating their knowledge and cultivation practices with the generation of added value through rural community industries.

Kiwicha production is minimal within the cultivation certificate of the producer, i.e., its importance is significant from the point of view of family food security. On the other hand, in the global context of the productive unit, it is an activity characterized by its low profitability and little contribution to the generation of income for the families dedicated to its cultivation.

However, given the current climate change context (recurrent presence of adverse climatic phenomena such as drought and heatwaves caused by the increase in temperatures) and due to the agronomic characteristics of the crop, it is a viable alternative to improve local food security and the socio-economic situation of producers.

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All the authors made significant contributions to the document, agree to its publication, and state that there are no conflicts of interest in this study.

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