

# Technological and socio-economic analysis of the local production system of the pink Zaragoza bean (*Phaseolus vulgaris* L.) in the Caribbean of Colombia

## Análisis tecnológico y socioeconómico del sistema de producción local del frijol rosado Zaragoza (*Phaseolus vulgaris* L.) en el Caribe de Colombia



ANTONIO MARÍA MARTÍNEZ-REINA<sup>1,3</sup>  
LILIANA MARÍA GRANDETT-MARTÍNEZ<sup>1</sup>  
LILIBET TORDECILLA-ZUMAQUÉ<sup>1</sup>  
MARÍA DEL VALLE RODRÍGUEZ-PINTO<sup>1</sup>  
CARINA CECILIA CORDERO-CORDERO<sup>2</sup>  
ADRIANA PATRICIA TOFIÑO-RIVERA<sup>2</sup>

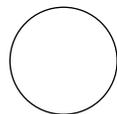
**Pink Zaragoza bean sedes.**

Photo: Agrosavia

### ABSTRACT

The objective of this study was to characterize the Zaragoza pink bean production system in the Colombian Caribbean from the technical and economic point of view. A survey was randomly applied to 32 farmers in producing areas. The data were analyzed using descriptive statistics, measurements of central tendency and contingency tables. The economic return calculations were made using a production cost pattern and economic profitability analysis techniques. The results showed that the average experience in cultivation is 12 years; the average age of the farmers is 48 years; the predominant type of tenure is property in 63% of the sample; and the mode of the area devoted to this crop is 0.5 ha. The use of family labor predominates in 65% of cases. 90% of the production is destined for the market, 8% is destined for self-consumption, and 2% is for seeds. Production costs correspond to 1,437 USD/ha, the average production is 1,700 kg ha<sup>-1</sup>, and the average sale price was 0.886 USD/kg, which generates a cost benefit ratio of 1.43% in three months of the productive cycle, from sowing to postharvest. This crop is profitable and stable inasmuch as its yields recover costs and generate profits for producers.

**Additional keywords:** Andean grains; cropping systems; peasant; food security.



<sup>1</sup> Corporación Colombiana de Investigación Agropecuaria (Agrosavia), Centro de Investigación Turipaná, Cerete (Colombia). ORCID Martínez-Reina, A.M.: 0000-0002-9312-842X; ORCID Grandett-Martínez, L.M.: 0000-0002-9755-2017; ORCID Tordecilla-Zumaqué, L.: 0000-0003-0263-6427; ORCID Rodríguez-Pinto, M.V.: 0000-0002-4820-8287

<sup>2</sup> Corporación Colombiana de Investigación Agropecuaria (Agrosavia), Centro de Investigación Motilonia, Agustín Codazzi (Colombia). ORCID Cordero-Cordero, C.C.: 0000-0003-3688-5835; ORCID Tofiño-Rivera, A.P.: 0000-0001-7115-7169

<sup>3</sup> Corresponding author. [amartinezr@agrosavia.co](mailto:amartinezr@agrosavia.co)

## RESUMEN

El objetivo de este trabajo fue caracterizar desde el punto de vista técnico y económico al sistema de producción de frijol rosado Zaragoza en el Caribe colombiano. Con datos de una encuesta aplicada a 32 agricultores según muestreo aleatorio en zonas productoras. Los datos se analizaron mediante estadística descriptiva, medidas de tendencia central y tablas de contingencia. Los cálculos del retorno económico se realizaron mediante un patrón de costos de producción y técnicas de análisis económico de rentabilidad. Los resultados demuestran que la experiencia promedio en el cultivo es de 12 años; el promedio de edad de los agricultores es de 48 años; el tipo de tenencia predominante es la propiedad en el 63 % de la muestra; la moda del área destinada a este cultivo es de 0,5 ha. Predomina el uso de mano de obra familiar en un 65% de los casos. El 90% de la producción se destina al mercado, 8 % se destina al autoconsumo y 2% para semilla. Los costos de producción corresponden a 1.437 USD/ha, la producción media es 1.700 kg ha<sup>-1</sup>, y el precio de venta promedio fue de 0,886 USD/kg, lo que genera una relación beneficio costo de 1,43% en tres meses del ciclo productivo desde la siembra hasta la postcosecha. Se concluye que este cultivo es rentable y estable por cuanto sus rendimientos permiten recuperar los costos generando ganancias para el productor.

**Palabras clave adicionales:** granos Andinos; sistemas de cultivo; campesino; seguridad alimentaria.

Received: 28-07-2020 Accepted: 27-11-2020 Published: 18-01-2021

## INTRODUCTION

Vegetables are a food source for both humans and animal species (Grings *et al.*, 2010). The Zaragoza bean (*Phaseolus vulgaris* L.) belongs to the Fabaceae family and *Phaseolus* genus. It has four cultivated species (Voyses, 2000). The greatest food impact is associated with the common bean (*P. vulgaris*), originally from America (Bautista-Zamora *et al.*, 2017). It has been a cultural form of subsistence in Latin America for the rural economy (Sangermán-Jarquín *et al.*, 2010). Its better attributes include richness in proteins, vitamins (thiamine and folic acid), minerals (potassium, magnesium, zinc, iron and phosphorus), carbohydrates and fiber (Ulloa *et al.*, 2011) in vulnerable populations, especially in developing countries (Telikicherla *et al.*, 2018).

Some studies, such as phenotypic, biochemical and molecular studies on origin and domestication, have classified two groups of genes: Mesoamerican and Andean, which differ in their structures and levels of genetic diversity, both in wild and domesticated populations, where the former is the most diverse at the interpopulation level, especially in response to biotic stress (Garzón *et al.*, 2007; Hernández *et al.*, 2013).

In Colombia, the areas dedicated to bean cultivation are divided into five environmental groups; warm humid, temperate humid, cold dry, temperate dry

and very humid warm. The humid temperate group has the most favorable conditions for bean production (Barrios-Pérez and Álvarez-Toro, 2016). Beans are planted in medium and warm areas, mainly associated with Mesoamerican heritage (Voyses, 2000; Garzón *et al.*, 2007; Debouck, 2011). In Colombia, 35% of bean production comes from shrub varieties produced between 0 and 1,800 m a.s.l. (medium and hot climates), with a varietal distribution that depends on the taste of the local consumer. Production today is still based on local varieties such as the Zaragoza rose, as reported in studies carried out in Mexico (SanGermán-Jarquín *et al.*, 2010). This cultivar is characterized by its large pale pink grain with a rounded shape and is produced in the Departments of Norte de Santander, Cesar and Bolívar. It is mainly consumed in the markets of the Caribbean coast, without certified commercial seeds (Tofiño-Rivera *et al.*, 2016).

According to Agronet statistics, bean production in Colombia for 2018 was 113,887 t, cultivated in an area of 92,476 ha. The Caribbean Region participates with 18% of the domestic area with 17,055.35 ha and 11% of the domestic bean production. Within the region, the department with the largest area is Cesar, with 6,489.21 ha and a production of 5,038.78 t. The

Department of La Guajira is the second producer in the region with 2,225 t (Agronet, 2019).

In agricultural production systems, characterization studies have been carried out for beans in the different cultivars in the Caribbean Region of Colombia, such as the characterization of the production system of the yard-long bean (*Vigna unguiculata* subsp. *Sesquipedalis*), carried out by Martínez-Reina *et al.* (2019a) to build a technological and socioeconomic baseline of the production system, and the characterization of cowpea beans (*Vigna unguiculata* [L.] Walp.) by Martínez-Reina *et al.* (2020) for a description of the local production technology and evaluation of economic return indicators of the production system. These two characterizations in cultivated bean species in the Caribbean Region were done to build a technological and socioeconomic baseline. Also, Correa *et al.* (2019) indicated a low level in the local production technology for the Colombia Caribe in squash. Torres *et al.* (2013) characterized the bean production system (*P. vulgaris*) in the province of Cotopaxi-Ecuador, where they generated information on production, marketing and profitability as a base line for the promotion of production. Borja-Bravo *et al.* (2018) studied adoption and impact of bean technologies in Mexico, where they analyzed the resources invested in this species and the return to society for each monetary unit invested in research. They concluded that, given the particular economic returns, it is worth continuing to invest in research in this species. Casals *et al.* (2019) carried out a study on the common bean (*P. vulgaris*) to help conserve genetic variability, avoid erosion and guarantee adaptation processes to changes in the climate and the environment.

There is an absence of information on the production system of the Zaragoza pink bean despite its importance in the life of the horticultural communities of the Caribbean Region as an income source and contributor to the food supply. The objective was to characterize this production system because, despite its importance as a cultural form of subsistence for rural communities, it has not been characterized for the development of technical and economic competitiveness.

## MATERIALS AND METHODS

The municipalities where Zaragoza beans are grown belong to the Caribbean Region, which is located

in the northern part of Colombia. It has an area of 132,288 km<sup>2</sup>, corresponding to 11.6% of the total area of the country and spread over 132,218 km<sup>2</sup>, with an insular area of 70 km<sup>2</sup> (IGAC and DANE, 2018). According to the Population Census of Colombia, the population for the Colombian Caribbean in 2018 was estimated at 9,859,086 inhabitants, of which 73.9% were located in urban areas and 26.1% in the rural area. 15.7% of the population were Afro-descendants, 6.8% were indigenous, and 77.5% did not have ethnicity (DANE, 2019). Zaragoza bean cultivation takes place mainly in the municipalities of Rio de Oro (8°17'30"N, 73°23'14"W), in the Department of Cesar, and in Barrancas (10°57'21"N, 72°47'31"W), in the Department of La Guajira. According to the survey, the farmers had an average of 12 years of experience with this cultivation; however, 80% cultivated for less than 10 years. The longest experience was around 40. The mode for this characteristic was 5 years. The area for this crop ranged from 0.1 ha to 4.0 ha, and the mode was 2 ha. The population of farmers was small and medium.

The sample was calculated with the simple stratified sampling technique of Rodríguez (2005). The universe of data was the number of farmers who cultivate Zaragoza beans in the region, a total of 190 farmers. The data were obtained from institutions such as Secretaries of Economic Development and agro-industrial, agricultural evaluations that constituted the universe for the calculation of the sample. The sampling variable was the size of the cultivated area, that is, those who sow more than 1 ha (70%) and those who plant less than 1 ha (30%). In addition, they were bean farmers who had experience in cultivation in a bean producing area and the willingness to give the information.

According to Rodríguez (2005), the following formula was applied:

$$n = \frac{Z^* p^* q^* N}{[(e^2*(N-1)) + Z^2*p^*q^*]} \quad (1)$$

where,  $Z$  was 95% confidence level chosen with a margin error of 5% (1.96),  $p$  was percentage of the population whose area is less than 1 ha (proportion of farmers with area larger than 1 ha, 133),  $q$  was percentage of the population whose area is larger than one hectare,  $e$  was maximum sampling error allowed (farmers with less than 1 ha, 57 farmers), and  $N$  was population size (total farmers 190). The result indicated that 32 farmers should be surveyed for this crop.

A structured survey form was prepared containing 35 variables in 28 questions, divided into sections as follows: the first section corresponded to the economic component, and the second section consisted of questions of a technical nature, such as planting times, seeds, soil management, water management, pests, diseases, weeds and management of the harvest, post-harvest and sale of the product. Once the field work was done, the information was organized in a database in the SPSS program through descriptive statistical analyses of frequency, contingency tables, and correlation analyses.

The capture of cost information was carried out with the help of Excel, which organized the logical and sequential order of occurrence of the activities (Agreda, 1991) activity or indicator, units (in the case in which the producers handle other types of units, conversions to the metric system were used), quantities, and result of the product of the unit value and the quantity; this unit value corresponds to the market

price (in the agricultural warehouse), which must be adjusted with the cost of transportation to the farm, which is known as input at field prices.

For the economic analysis, the parameters of costs (direct, indirect and total), profitability, unit values, equilibrium point, etc. were taken into account. They were determined based on the economic theory of Krugman *et al.* (2015) (Tab. 1). From the information obtained, economic returns were calculated by identifying the constituent elements of the total cost of production, such as labor and inputs.

The performance information facilitated the calculation of unit costs and economic returns, such as net income, profitability, breakeven point, and efficiency. The labor was valued according to the monetary cost of the wage in the region and the price of the inputs according to CIMMYT (1988), that is, the price paid by the producer for the product plus the cost of transportation to the farm.

**Table 1. Parameters of production costs, economic indicators and estimated marketing margins.**

Equation	Description
$\sum_{Cd=0}^n Cd = Cd1 + Cd2 + Cd3 + \dots + Cdn$	Cd: direct costs; Cd1: seeds; Cd2: agrochemicals; Nd3: wages etc.
$\sum_{Ci=0}^n Ci = Ci1 + Ci2 + Ci3 + \dots + Cin$	Ci: indirect costs; Ci1: rental of the land; Ci2: financial costs; Ci3: others, etc.
$CP = Cd + Ci$	CP: production costs; Cd: direct costs; Ci: indirect costs
$\sum_{Rdo=0}^n Rdo = PC1 + PC2 + PC3 + \dots + PCn$	Rdo: Yield; PC,: Total dry bean production per hectare
$CU = \frac{CP}{Rdo}$	CU: unit costs; CP: production costs; Rdo: Yield
$IB = Rdo * PV$	IB: gross income; Rdo: Yield; PV: sale price of zaragoza bean production
$IN = IB - CP$	IN: net income; IB: gross income; CP: production costs
$RT = \frac{(IB-Cd)}{Cd} * 100$	RT: technical profitability; IB: gross income; Cd: direct costs
$RN = \frac{(IB-CP)}{Rdo} * 100$	RN: net profitability; IB: gross income; Cd: production costs
$Peq = \frac{CP}{PV}$	Peq: equilibrium point; Cd: production costs; PV: sale price

Continued on the next page

**Table 1. Parameters of production costs, economic indicators and estimated marketing margins.**

Equation	Description
$PPEq = \frac{CP}{IB} * 100$	PPEq: percentage of equilibrium point; Cd: production costs; IB: gross income
$Et = \frac{PV}{Cu} * 100$	Et: technical efficiency; PV: sale price; CU: unit costs
$MBC = \frac{(Pc-Pp)}{Pc} * 100$	MBC: gross marketing margin; Pc: consumer price; Pp: producer price
$PDP = 100 - MBC$	PDP: direct participation of the producer; MBC: gross marketing margin
$MNC = \frac{(MBC-Cm)}{Pc} * 100$	MNC: net marketing margin; MBC: gross marketing margin; Cm: marketing costs; Pc: consumer price

For the analysis of local production technology, the measurement of central tendency Fashion was applied, considering those activities carried out by producers in the Zaragoza bean production system in the region according to Agreda (1991).

To calculate the price of the harvested product, the regional value paid to the producer by intermediaries was considered. This value was multiplied with the average yield calculated from the information provided by the surveys and workshops to obtain the gross income, which, by subtracting the production costs, generated net income and profitability (defined as the relationship between income net and total cost). In addition, the minimum quantities of production required by producers were estimated to balance income with costs, known as the break-even point (Tab. 1).

The efficiency of the production system was calculated following Forero *et al.* (2013), who proposed the indicators: technical profitability of the crop, net profitability, technical efficiency and economic efficiency (Tab. 1).

The technical profitability was calculated by establishing the relationship between the difference in gross income and direct costs. For net profitability, the difference between gross income and direct and indirect costs was related to total costs, which corresponds to the same concept of profitability that is traditionally used. To calculate the technical efficiency of the crop, the difference between gross income

and direct cost was related to the cultivated area, quantifying the contribution of area to profitability (Tab. 1).

## RESULTS AND DISCUSSION

### Socio-economic and technological aspects

The characteristics of the surveyed sample, such as gender, age, education, access to services and roads, showed that the male gender predominated. There were no young farmers, they did not have basic services, and they had difficulties get products , with more costly production, as can be seen in table 2.

The sample consisted mainly of men (82%), while women represented only 18% (Tab. 2), similar to Correa *et al.* (2019) for squash and for yard-long beans (Martínez-Reina *et al.* 2019a). In this productive system, there is a lower degree of participation by young people, with an average age of 48 years (minimum value of 23 and a maximum of 77 years) (Correa *et al.*, 2019; Martínez-Reina *et al.*, 2019a, 2019b). 50% of respondents had a primary education, 27% had a high school degree, and 17% had no education. 67% of the producers had a low educational level (Correa *et al.*, 2019; Martínez-Reina *et al.*, 2019a, 2019b). For public services, 56% of the surveyed producers had basic water and electricity services, and 44% said they have no service. 88% of the farmers said the access roads are in poor condition (Correa *et al.*, 2019).

**Table 2. Sociodemographic information of the respondents.**

Sociodemographic information	Percentage
<b>Gender</b>	
Man	82
Woman	18
Age (average in years)	48
<b>Education level</b>	
Primary basic	50
High School	23
None	27
Experience time in years (mode)	17
<b>Land tenure</b>	
Owner	63
Renting	19
Other	18
Planting area (mode in ha)	0.50

Source: Calculations based on the results of surveys applied to Zaragoza bean producers in the Departments of Cesar and La Guajira (Agrosavia, 2018).

## Local technology aspects

The cultivation of the pink Zaragoza bean takes place mainly in Catatumbo and in the province of Ocaña (Department of Norte de Santander), extending to the municipalities of Rio de Oro (Department of Cesar) and throughout Serrania del Perija, up to the municipality of Barrancas in the Department of La Guajira (Méndez *et al.*, 1997).

The cropping activities carried out sequentially by the producer are presented below, classified as pre-establishment tasks such as soil preparation, crop management, and harvest and post-harvest tasks.

**Plot selection.** Producers consider different risk elements, such as susceptibility to flooding, proximity to a water source, and proliferation of root diseases from non-crop rotation. Soils for the Zaragoza bean should be sandy and clayey, well-drained, with a preference for light soils that allow good rooting; on the other hand, this crop also grows in strongly alkaline, heavy textured soils (Carvalho and Sgarbieri, 1998).

**Pre-cultivation activities.** Before starting any activity, a farmer plans how the crop should be produced, defining the sowing date as conditioned by

rain and the availability of water. Vegetable debris, such as trunks and branches, are collected, and the earth is removed in such a way that it is ready to be sown.

**Soil preparation.** Fifty-seven percent of the farmers carry out soil adaptation tasks manually, spending a total of five wages; 28% do it with equipment that consists of a plow and a rake, and 14% do it manually and mechanically, spending about four labor days in total.

**Sowing.** The sowing is done directly, spending an average of five wages per hectare. The amount of seed used on average is 35 kg ha<sup>-1</sup>, of which 53% of the sample uses recycled seed from the previous harvest, i.e., in each harvest, the farmers select and allocate the seeds according to their criteria for the next sowing session, trying to choose those with no apparent damage. About 47% of the respondents stated that they buy certified seeds in agricultural warehouses.

To define the sowing season and carry out this activity, farmers consider factors associated with the environmental offer, better commercialization possibilities, and technical and technological capacities installed by the farmer. The former delimits the dates that the Zaragoza bean producers prefer for the establishment of their crops. Most farmers choose to plant their crops taking advantage of the rainfall that occurs during the year, i.e., considering two rainy seasons. In this sense, most farmers (60%) prefer to plant in November and December, and April and October.

**Irrigation.** The irrigation scheme implemented by farmers range from pressurized, those that use large flows or floods, and manual systems. On average, a total of 9 d ha<sup>-1</sup> during the crop cycle is used, i.e., 120 d on average.

The water sources are diverse and generally correspond to permanent sources, except those that use water from rainfall.

Beans are highly susceptible crops to water deficits and excess humidity; therefore, a water supply plan is required during the field crop cycle until the pod filling stage. For the 87-90-d-cycle of the bush beans in the Caribbean area, supplementary irrigation of up to 55 d is required. About two to three efficient irrigations per week are sufficient for good seed development and production (Lardizabal, 2013).

**Fertilization.** More than 78% of the farmers fertilize chemically, regularly using fertilizers based on chemical compounds that have as active ingredients: nitrogen, phosphorus and potassium fertilizers during the first two fertilizations. As the crop production cycle progresses, the nutritional demand is higher; therefore, the farmers increase the doses of the fertilizers. Only 3% of the farmers fertilized with minor elements, while the application mechanism was use of foliar absorption products. Meanwhile, only 6% of farmers used organic fertilizer amendments (*Lombriabono* or earthworm fertilizer) as a supplementary source of crop nutrition.

Other regional studies have reported that 76% of the producers use chemical fertilizers for the Zaragoza bean, and 24% use a higher diversity of chemical and organic fertilizers, including urea, boron, triple 15, fertilizers with macro and micronutrients and vermicompost (Tofiño-Rivera *et al.*, 2018). It should be noted that the improved varieties of bush beans respond to soil fertilization, doubling their yield. Furthermore, fertilization improves their reaction against disease attacks (Pedroza *et al.*, 2013). In this sense, the pink Zaragoza bean can produce from 370.89 kg with low phosphorus to 867.25 kg with higher contributions of phosphoric fertilization (350 kg ha<sup>-1</sup> of triple superphosphate (TSP), equivalent to 45 kg of P<sub>2</sub>O<sub>5</sub>). In the seed, the phosphorus content is 55.40 ppm, and the zinc content is 21.85 ppm (Astudillo and Blair, 2008).

**Weed management.** Chemical management is carried out as well as a combination of manual and mixed methods, including manual cleaning and herbicide application. Weed management that is carried out manually spends an average of 5 d ha<sup>-1</sup>, and, in pre-emergence, chemical burning is applied using herbicides with the active ingredient glyphosate

Some regional studies have reported that the main weeds associated with the cultivation of the pink Zaragoza bean in the Caribbean are verdolaga (*Portulaca oleracea* L.), coco-grass or *pasto coquito* [Spanish] (*Cyperus rotundus* L.), gamba grass or *pasto sabanero* [Spanish] (*Andropogon gayanus* Kunth), common sowthistle or *cerraja* [Spanish] (*Sonchus oleraceus* L.), hairy crabgrass or *pluma de garza* [Spanish] (*Digitaria sanguinalis* Royle), angular winter cherry *pega pega* or *toporopo* [Spanish] (*Physalis angulata* L.), white clover (*Trifolium repens* L.), and Santa Maria feverfew or *marihuano macho* [Spanish] (*Parthenium hysterophorus* L.) (Tofiño-Rivera *et al.*, 2018).

**Pest management.** About 80% of the surveyed sample carried out chemical control, while a very low percentage applied plant-based insecticides. Moreover, it was estimated that less than 10% of the farmers did not carry out any kind of application. There were differences between the opinions of the producers regarding the identification of the pests that cause the most damage to the crops, both in the dry and in the rainy seasons, evidencing the lack of knowledge of farmers for the identification of insects and their associated damage, which include those commonly called whiteflies (the assumption is that it corresponds to the species is *Bemisia tabaci*, common in the region), the bean weevil (possibly a member of Curculionidae), the armyworm (*Spodoptera* sp.), and mites. Some regional studies have reported that mites, weevils and whiteflies are the most important pests (Tofiño-Rivera *et al.*, 2018).

**Disease management.** The diseases that attack this crop include phytophthora, alternaria, common bacterial blight, and wilting of the leaves (anthracnose). They are controlled with chemical methods by 80% of the farmers, using active ingredient fungicides and mancozeb.

Harvesting or pod recollection was carried out manually; on average, it has been calculated that about 15 wages are used for this activity, including internal transport.

**Postharvest.** The producers carried out threshing and shelling type II transformation. They packed the beans in 50-kg sacks of fique and, on average, obtained 1.7 t ha<sup>-1</sup>. They sold their product in the local market and, at a low percentage (30%), in the plot.

### Production costs and return indicators

The cost of cultivating one hectare of Zaragoza bean in Rio de Oro was COP 3,980,659, equivalent to US\$ 1,180. Of this total cost, 79% corresponded to direct costs, while 21% were indirect costs. In turn, labor was 55% of the total costs, inputs accounted for 14%, and tools took 10% of the total costs.

The calculations provided the return on investment indicators (Tab. 3). The unit cost of a 1 kg of Zaragoza beans is US \$ 8,694. First, the price of the inputs was taken as purchased by the producer individually. In the case of income, the yield of 1.7 t was taken and

multiplied by the price to obtain a gross income of US\$ 1,694.

The profitability was calculated with three approaches: The total approach was calculated at 43%, and the traditional concept was used. The technical profitability relates gross income to direct costs; here, estimated at 81%, meaning that physically, one invested monetary unit would yield an additional 81 cents. The possibility of recovering the investment is demonstrated through the 73.9% net profitability indicator, which showed that, with physical yields of 1.7 t, it is possible to generate profits. The technical efficiency was 848,070, which means that it perfectly compensates for the total costs of US\$ 1,473.

For the economic efficiency, the sale price exceeded the unit cost of production, and, for this reason, each monetary unit invested in costs was recovered, generating an additional 43 cents.

**Table 3. Production costs of one hectare of Zaragoza bean in Río de Oro, Cesar, Colombia.**

Direct costs	Value in US \$	Participation
Labors	650	55
Supplies	170	14
Tools	117	10
Subtotal direct costs	938	79
Indirect costs	243	21
Total costs	1,180	100
Return indicators		
Yield (t)	1.7	
Price/t	996	
Unit cost/t	694	
Gross income	1,694	
Net income	513	
Cost-effectiveness	43	
Technical profitability	81	
Net crop profitability	73.88	
Efficiency	1.17	
Balance point tons	1.43	
Balance point percentage	84.8	

Source: Elaborated by the authors. Workshop with producers of Río de Oro Colombia (Agrosavia, 2018).

The calculation of the marketing margins elucidated the price movements when it passed from one actor

in the chain to another. In this case, when it leaves the farm of the producer, it passes to the intermediary and the final consumer through the gross marketing margin (GMM), which showed that, for every US\$ 1 that the consumer pays, US\$ 0.16 is captured through intermediation. This movement is moderate in that, by just marketing the product, a portion of less than 20% of what the consumer pays is taken.

In the case of the intermediary, this margin was higher, with a value of 30%, indicating that for every US\$ 1 that the consumer pays, US\$ 0.30 is captured by the intermediary. This means that the second link in the chain obtains a higher benefit by marketing the product, i.e., 30% of the difference between the price of the producer and the final price of the consumer.

The direct participation of the producer was estimated at 6.02%, which means that for each monetary unit paid by the consumer, the producer receives 6 cents, and the rest (94%) goes to intermediation.

Similar studies, such as the one by Martínez-Reina *et al.* (2019a) on long beans, have shown a gross marketing margin of 50%, much higher than what was found in the current study on the Zaragoza bean. In this case, the intermediary received a gross margin of 25%. For the Zaragoza bean study, it was 0.6%. It is a shorter marketing chain and only two actors intervene.

For the indicators of return, there were differences; for example, in Nigeria, labor participated with 72% of the total costs, meanwhile, for the dry Caribbean Region assessed in this study, it was 55%; moreover, when compared with the net income for Nigeria, the value was US\$ 792.34, meanwhile for the Caribbean Region, it was US\$ 513. It should be noted that the efficiency of the Zaragoza bean production system was evidenced by its profitability, explained by the fact that the income exceeds the costs. Other studies reported by Martínez-Reina *et al.* (2019b) had return indicators in the case of the eggplant production system for the humid Caribbean Region, with profitability values 51% higher than the one found in this study.

When analyzing the dynamics of the production chain around the distribution of surpluses of the difference between the price paid to the producer and the price paid to the consumer, it was observed that the indicators, marketing margins, and direct

producer participation were lower than in other studies. Perhaps this can be explained because the marketing chain for the Zaragoza bean is shorter, and only two actors intervene, making the difference in the producer price and the consumer price lower than in the other species reported in several studies.

The aging of the rural sector, the field and agriculture is a reality. This situation was evidenced when studying the production of zaragoza beans in the municipalities of Rio de Oro in the Department of Cesar and Barrancas in La Guajira. According to the World Health Organization, in recent years, the proportion of people over 60 years of age has been increasing faster than any other age group in almost all countries (WHO 2015). For Colombia, DANE reported that the percentage of rural inhabitants with ages close to 60 years has increased from 7% in 1985, which increased to 10% in 2014, and it is estimated that it will reach 23% by 2050 (DANE, 2014). The data agreed with López *et al.* (2018) for the municipality of Chinavita in the Department of Boyaca. This phenomenon of aging for the Zaragoza bean study had an average age of 48 years, with maximum ages of 70. This puts at risk not only the production of beans but agriculture in general, along with the the low availability of public services and road infrastructure, which make production more expensive.

## CONCLUSIONS

The Zaragoza bean requires research studies on issues related to agronomic management and marketing plans to allow this horticultural species to play an important role, achieving high yields with low production costs and encouraging consumption because of its nutritional benefits. Besides these studies, strategies allow the adoption of technology by producers.

The cultivation of beans is a cultural form of subsistence under the family farming system and, despite the fact that its areas are small, contributes greatly to the supply of food with great nutritional value that, for years, has provided food to families in the Caribbean region.

However, the socioeconomic conditions of farmers, such as low schooling, poor access to services, poor infrastructure, and low technological levels, were higher than the national average and could be better if technologies are incorporated into the system of production.

The stability of the production system, both economically and environmentally, was evident throughout the study; the possibility of recovering the investment with average yields of 1.7 t ha<sup>-1</sup> and the participation of labor in 55% of total production costs also demonstrates economic sustainability. Therefore, major investments in equipment are not required, and it is grown by farmers with little capital in a region with abundant labor.

## ACKNOWLEDGMENT

The authors thank the Corporación Colombiana de Investigación Agropecuaria (AGROSAVIA) for their support in carrying out the project “Socioeconomic, technological and market analysis of the main vegetables grown in the Caribbean Region of Colombia”, which provided the data used in this study. This project is part of the research agenda of the Vegetable Network. Thanks are also given to the Ministerio de Agricultura y Desarrollo Rural of Colombia (MADR) for financing this study.

**Conflict of interests:** The manuscript was prepared and reviewed with the participation of the authors, who declare that there exists no conflict of interest that puts at risk the validity of the presented results.

## BIBLIOGRAPHIC REFERENCES

- Agreda, V. 1991. Metodología para el análisis económico. pp. 93-124. In: Quijandría, B. and M.E. Ruiz (eds.). Aspectos metodológicos del análisis social en el enfoque de sistemas de producción. IICA; RISPAL, San Jose.
- Agronet. 2019. Área cosechada, producción y rendimiento de frijol 2007-2018. In: Ministerio de Agricultura y Desarrollo Rural of Colombia, <http://www.agronet.gov.co>; consulted: december, 2020.
- Astudillo, C. and M. Blair. 2008. Contenido de hierro y cinc en la semilla y su respuesta al nivel de fertilización con fósforo en 40 variedades de frijol colombianas. *Agron. Colomb.* 26(3), 471-476.
- Borja-Bravo, M., E.S. Osuna-Ceja, S. Arellano-Arciniega, R.V. García-Hernández, and M.A. Martínez-Gamiño. 2018. Competitividad y eficiencia en la producción de frijol en condiciones de temporal con tecnología tradicional y recomendada. *Rev. Fitotec. Mex.* 41(4), 443-450. Doi: 10.35196/rfm.2018.4.443-450
- Barrios-Pérez, C. and P. Álvarez-Toro. 2016. Caracterización agroambiental de sistemas de producción de maíz y frijol en Colombia. CCAFS Working Paper no. 184. CGIAR Research Program on Climate Change,

- Agriculture and Food Security (CCAFS), Copenhagen, Denmark.
- Bautista-Zamora, D., C. Chavarro-Rodríguez, J. Cáceres-Zambrano, and S. Buitrago-Mora. 2017. Efecto de la fertilización edáfica en el crecimiento y desarrollo de *Phaseolus vulgaris* cv. ICA Cerinza. *Rev. Colomb. Cienc. Hortic.* 11(1), 122-132. Doi: 10.17584/rch.2017v11i1.5496
- Casals, J., A. Rivera, A. Rull, R. Romero, J. Sabsaté, S. Sans, S. Soler, M.J. Diez, F. Casañas, J. Prohens, and J. Simó. 2019. Improving the conservation and use of traditional germplasm through breeding for local adaptation: The case of the Castellfollet del Boix common bean (*Phaseolus vulgaris* L.) landrace. *Agronomy* 9(12), 889. Doi: 10.3390/agronomy9120889
- Carvalho, M.R. and V.C. Sgarbieri. 1998. Relative importance of phytohemagglutinin (lectin) and trypsin-chymotrypsin inhibitor on bean (*Phaseolus vulgaris* L.) protein absorption and utilization by the rat. *J. Nutr. Sci. Vitaminol.* 44(5), 685-696. Doi: 10.3177/jnsv.44.685
- CIMMYT, Centro Internacional de Mejoramiento de Maíz y Trigo. 1998. La formulación de recomendaciones a partir de datos agronómicos: Un manual metodológico de evaluación económica. Mexico, DF.
- Correa, E.M., A.M. Martínez, A.R. Orozco, G.E. Silva, L. Tordecilla, and M.V. Rodríguez. 2019. Análisis de un sistema productivo agrícola en el Caribe: tecnología de producción, patrón de costos e indicadores económicos de la producción de ahuyama. *Rev. Econ. Caribe* 23, 47-70. Doi: 10.14482/ecoca.23.3033
- DANE, Departamento Administrativo Nacional de Estadística of Colombia. 2019. Censo Nacional de Población y Vivienda 2018 y desafíos socioeconómicos para la región Caribe. Bogota.
- DANE, Departamento Administrativo Nacional de Estadística of Colombia. 2010. Estudios postcensales: proyecciones nacionales y departamentales de población 2005-2020. Bogota.
- Debouck, D.G. 2011. Frijoles (*Phaseolus* spp.). In: *La agricultura en Mesoamérica – Cultivos Andinos*. FAO, [http://www.fao.org/tempref/GI/Reserved/FTP\\_FaoRlc/old/prior/segalim/prodalim/prodveg/cdrom/contenido/libro09/Cap2\\_2.htm#21](http://www.fao.org/tempref/GI/Reserved/FTP_FaoRlc/old/prior/segalim/prodalim/prodveg/cdrom/contenido/libro09/Cap2_2.htm#21); consulted: February, 2020.
- Forero, J., L.J. Garay, F. Barberi, C. Ramírez, D.M. Suárez, and R. Gómez. 2013. Reflexiones sobre la ruralidad y el territorio en Colombia. Problemáticas y retos actuales. pp. 69-111. In: Garay, L.J., R. Bailey, J. Forero, F. Barberi, C. Remírez, and D. Suárez (eds.). *La eficiencia económica de los grandes, medianos y pequeños productores agrícolas colombianos*. Oxfam, Bogota.
- Garzón, L., M. Blair, and G. Ligarreto. 2007. Uso de selección asistida con marcadores para resistencia a antracnosis en frijol común. *Agron. Colomb.* 25(2), 207-214.
- Grings, E.E., S.A. Tarawali, M. Blummel, A. Musa, C. Fatokun, S.J. Hearne, and O. Bouka. 2010. Cowpea in evolving livestock systems. pp. 322-333. In: Boukar, O., O. Coulibaly, C.A. Fatokun, K. Lopez, and M. Tamo (eds.). *Proc. 5<sup>th</sup> World Cowpea Conference Innovative Research Along the Cowpea Value Chain*. Saly, Senegal.
- Hernández-López, V.M., M.L.P. Vargas-Vázquez, J.S. Muruaga-Martínez, S. Hernández-Delgado, and N. Mayek-Pérez. 2013. Orígenes, domesticación y diversificación del frijol común. *Avances y perspectivas*. *Rev. Fitotec. Mex.* 36(2), 95-104.
- IGAC, Instituto Geográfico Agustín Codazzi; DANE, Departamento Administrativo Nacional de Estadística of Colombia. 2018. Atlas estadístico de Colombia. In: <https://geoportal.dane.gov.co/servicios/atlas-estadistico/>; consulted: February, 2020.
- Krugman, P., R. Wells, and K. Granddy. 2015. *Fundamentos de economía*. 3<sup>th</sup> ed. Reverté, Barcelona, Spain.
- Lardizabal, R., S. Arias, and R. Segura. 2013. *Manual de producción de frijol*. USAID, La Lima, Honduras.
- López, E.P., L.M. Martínez, C.A. Martínez-Cañas, and A. Vargas-Prieto. 2018. Desarrollo rural y envejecimiento: caso de estudio municipio de Chinavita, Boyacá, Colombia. *Rev. Investig. Desarro. Innov.* 8(2), 193-206. Doi: 10.19053/20278306.v8.n2.2018.7959
- Martínez-Reina, A.M., L. Tordecilla-Zumaqué, C. Cordero-Cordero, and L. Grandett-Martínez. 2019a. Entorno tecnológico y socioeconómico de la habichuela larga en el caribe húmedo de Colombia. *Cien. Agri.* 16(2), 7-24. Doi: 10.19053/01228420.v16.n2.2019.9114
- Martínez-Reina, A.M., L. Tordecilla-Zumaqué, L. Grandett-Martínez, M. Rodríguez-Pinto, E. Correa, A. Orozco, C. Cordero, J. Romero-Ferer, and G. Silva. 2019b. Análisis económico de la producción de berenjena (*Solanum melongena* L.) en dos zonas productoras del Caribe colombiano: Sabanas de Sucre y Valle del Sinú en Córdoba. *Cien. Agri.* 16(3), 17-34. Doi: 10.19053/01228420.v16.n3.2019.9514
- Martínez-Reina, A., E. Correa, J. Romero, A. Tofiño, C. Cordero, L. Grandett, L. Tordecilla, M. Rodríguez, Y. Rozo, Y. Romero, J. Sierra, A. Orozco, and G. Silca. 2020. El cultivo de hortalizas en la región Caribe de Colombia: Aspectos tecnológicos, económicos y de mercado. Agrosavia, Mosquera, Colombia. Doi: 10.21930/agrosavia.investigation.7404074
- Méndez, H., A.L. Arguello, J. Mantilla, J. Bobrek, H. Castro, F.A. Pabón, G. Hernández, J. García, L. Vergel, and C.T. Araque. 1997. Análisis de los sistemas agropecuarios del departamento de Norte de Santander. Corpoica, Villavicencio, Colombia.
- Pedroza, A., R. Trejo, J.A. Chávez, and J. Samaniego. 2013. Tolerancia al estrés hídrico y fitosanitario mediante indicadores agronómicos y fisiológicos en diferentes variedades de frijol (*Phaseolus vulgaris* L.). *Rev. Mex. Fitopatol.* 31(2) 91-104.
- Rodríguez, J. 2005. *Métodos de muestreos, casos prácticos*. Centro de Investigaciones Sociológicas, Madrid.

- Sangermán-Jarquín, D.M., J.A. Acosta-Gallego, R. Schwenstesius, M.A. Damián, and B.S. Larqué. 2010. Consideraciones e importancia social en torno al cultivo del frijol en el centro de México. *Rev. Mex. Cienc. Agríc.* 1(3), 363-380.
- Telikicherla, M., M. Naika, A. Kandangath, and S. Vadakkoot. 2018. *In vitro* therapeutic properties of different fractions of *Phaseolus vulgaris* seeds as affected by the distribution of phytochemicals. *J. Food Biochem.* 42, e12485. Doi: 10.1111/jfbc.12485
- Tofiño-Rivera, A.P., A.D. Velásquez-Agudelo, and M.A. Zapata-Tamayo. 2016. Indicadores edafológicos del cultivo de fríjol en el Caribe seco colombiano: una estrategia *in situ*. Corpoica, Mosquera, Colombia.
- Tofiño-Rivera, A.P., Y. Rozo-Leguizamón, D.A. Gómez-Latorre, L.F. Gómez-Ramírez, and P.J. Tamayo-Molano. 2018. Modelo productivo de frijoles para el Caribe húmedo colombiano. Agrosavia, Mosquera, Colombia.
- Torres, E., D. Quisphe, A. Sánchez, M. Reyes, B. González, A. Torres, A. Cedeño, and A. Haro. 2013. Caracterización de la producción de frijol en la provincia de Cotopaxi Ecuador: caso comuna Panyatug. *Cienc. Tecnol.* 6(1), 23-31.
- Ulloa, J.A., P. Rosas, J.C. Ramírez, and B.E. Ulloa. 2011. El frijol (*Phaseolus vulgaris*): su importancia nutricional y como fuente de fitoquímicos. *Revista Fuente* 3(8), 5-9.
- Voysest, O. 2000. Mejoramiento genético del frijol (*Phaseolus vulgaris* L.): Legado de variedades de América Latina 1930-1999. CIAT, Cali, Colombia.
- WHO, World Health Organization. 2015. World report on ageing and health. Geneva.