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Article

Technical and economic viability of the cultivation of coriander (Coriandrum sativum L.) in Orinda, Chihuahua

Viabilidad técnica y económica del cultivo de cilantro (Coriandrum sativum L.) En Orinda, Chihuahua

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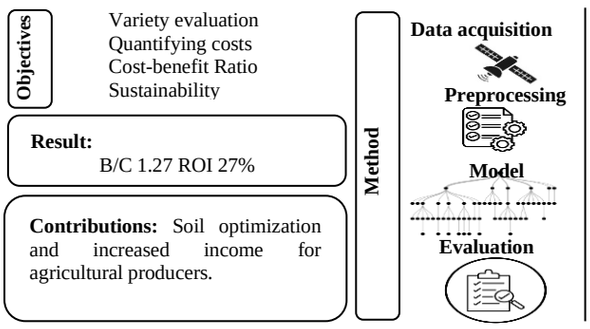
Abstract

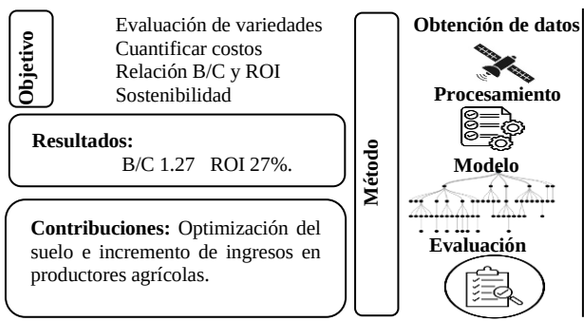
Cilantro is marketed worldwide for its aromatic and gastronomic properties. The aim of this study was to evaluate five cilantro varieties grown under pecan walnut coverage. The variables analyzed included yield, height, stem thickness, number of petioles, and economic performance, aiming to identify the best variety. It consisted of a completely randomized experimental design with five treatments (varieties), and an agro-cost scheme and financial indicators were used to analyze the economic viability of cultivation. The main results revealed that the American Long Standing variety stood out with a yield of 13.1 tons per hectare and a cost-benefit ratio of 1.27. This variety allows for environmental contribution by optimizing soil use through crop association and economically by improving producers' incomes.



Crop association, Agro-costs, Carya Illinoinensis, Economic indicators, Varieties

Resumen

El cilantro, es comercializado a nivel mundial por sus propiedades aromáticas y gastronómicas. El objetivo de este estudio consistió en evaluar cinco variedades de cilantro cultivadas bajo cobertura de nogal pecanero (*Carya illinoinensis*), las variables analizadas incluyeron rendimiento, altura, grosor de tallo, numero de peciolos y rendimiento económico, con el propósito de identificar la mejor variedad. Consto de un diseño experimental completamente al azar con cinco tratamientos (variedades), además se empleó un esquema de agrocostos e indicadores financieros para el análisis de la viabilidad económica del cultivo. Los principales resultados revelaron que la variedad American Long Standing destacó con un rendimiento de 13.1 toneladas por hectárea y una relación beneficio-costo de 1.27. Esta variedad permite una contribución ambiental al optimizar el uso del suelo mediante la asociación de cultivos y económicamente al mejorar los ingresos de los productores.



Asociación de cultivos, Agrocostos, Carya illinoinensis, Indicadores económico, Variedades

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Introduction

The species Coriandrum sativum L., more commonly known as coriander, has its roots in ancient Egypt and various regions of the Mediterranean, being widely recognised for its medicinal and aromatic properties by the pharaohs of the time (Chavez Hernandez, 2018).

The term "coriander" derives from the Greek koriannon, a combination of koris (insect with an unpleasant aroma) and annon (an aromatic aniseed), alluding to the unpleasant smell emanating from its still-green fruits, which transforms into a more pleasant aroma as they mature (Apolo Romero and Basurto Jimbo, 2017). Globally, coriander is widely traded and used in the preparation of a variety of foods (FAO, 2015), including liqueurs, pickles, sausages, sauces, sweets and soups, among other gastronomic dishes (Holmes Naranjo and Bermeo Salvatierra, 2017).

Likewise, it is estimated that world production is between 300,000 and 335,000 MT annually (FAO, 2015). According to data from the Servicio de Información Agroalimentaria y Pesquera (SIAP) in 2022, agricultural producers in Mexico generated around 114,245.24 tonnes of coriander, cultivated on an area of 7,809.86 hectares.

The state of Puebla leads production at national level, contributing 46,747.18 tonnes on an area of 3,311.05 hectares. It should be noted that most of this production is destined for the international market, mainly the United States (SIAP, 2018).

In the state of Chihuahua, only 8.5 hectares of coriander area was recorded in 2022, with a production of 67.68 tonnes. In comparison, the area dedicated to walnut cultivation reached 101,272.04 hectares for the same year (SIAP, 2023).

It is worth noting that numerous producers, especially those dedicated to walnut production, have implemented the incorporation of crops such as alfalfa, clover, oats and pasture among their walnut orchards, to provide soil cover and other benefits (Osman, 2022), which can be agronomic and economic (Tamayo Ortiz and Alegre Orihuela, 2022).

According to SIAP (2022), from 2000 to 2021, 16.66% of arable hectares in Mexico were no longer sown, with only 18,151,034.91 ha currently being sown, due to population growth (Badii et al., 2015), drought and the desertification process (Bolaños González et al., 2016), FAO 2024 warns that, in addition to the growing demand for food and the exploitation of natural resources, it will be difficult to achieve food security, and stresses the importance of sustainable agriculture to counteract the current challenges of agricultural and food production.

According to Tamayo Ortiz and Alegre Orihuela (2022), the combination of crops makes it possible to increase yields per arable area, which helps to conserve soil, use water more efficiently and generate greater economic gains.

This approach, supported by the agro-costing scheme (FIRA, 2023) and the use of financial indicators, makes it possible to assess the economic viability of the crop (Molina De Paredes, 2017), by structuring production costs and thus making informed decisions in the agricultural sector. In the municipality of Rosales, Chihuahua, there is a lack of information about which variety of coriander adapts and performs best under the cover of pecan walnut and an analysis of production costs for the same.

However, as it is an autumn-winter cycle crop, it presents two difficulties for its production in the municipality: first, the low availability of irrigation water in the crop cycle; second, in the spring-summer cycle, the crop presents "premature sprouting", which means that it does not meet the quality characteristics demanded by the market. These difficulties motivate the development of studies on its association with the pecan nut crop and to determine its yields in the spring-summer cycle.

This approach will not only serve as an integral production system, but will also offer small producers an alternative crop that they can implement in their walnut orchards. In this sense, the objectives of this research are: 1) To compare the productivity of five coriander varieties established under pecan nut cover 2) To quantify the establishment costs of the coriander variety with the highest productivity 3) To calculate the return on investment of the coriander variety with the highest productivity.

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Materials and methods

Location of the study area

A field experiment was established in 2023, in an orchard with 15-year-old walnut trees. The orchard is located in the community of Orinda, municipality of Rosales, in the state of Chihuahua, Mexico, at coordinates 28°25'86.49" North Latitude and 105°55'42.54" West Longitude. The study area has a mostly semi-warm climate, with an average annual temperature range of 14-20º C. However, there are extreme values in the winter months (December-February) with minimum temperatures that can reach -10°C and maximum values in the summer months (June-August) with temperatures that can exceed 40°C.

The average annual rainfall is 200 to 500 mm from June to September. Occasionally, light snowfall may occur in December or January. The prevailing winds come from the southwest (INEGI, 2010) and the soil type according to the taxonomy of the United States of America is of the order of aridisols.

Agronomic management

The experiment used the following five coriander varieties: Long national (T1), Morocco (T2), Turko (T3), Líder (T4) and American long standing (T5). Six replications were used and set up in a randomised complete block design. Cultural practices were as follows. Sowing was carried out on 29 March, by hand, three rows per furrow and a useful plot of 300 plants was considered. For the variables fresh foliage weight (kg) and number of bunches, 50 cm were considered for each replicate. Once the treatments were sown, a fertiliser dose of 80-100-120 and a rooting agent (ROOTEX-1 kg $^{ha-1}$) were applied.

For weed control, Trifluralin was applied pre-emergence and Diler 120 EC post-emergence, both at a dose of 1 L $^{ha-1}$. Pest control was carried out with the application of the insecticide Toreto applying 0.15 L $^{ha-1}$ and disease control with the application of Prontius® (Methyl Thiophanate) and Agrimycin 100® (Oxcitetracycline + Steptromycin) both at a dose of 1 L $^{ha-1}$.

Variables evaluated

The agronomic variables evaluated were plant height (cm) from stem base to tip, plant stem thickness (mm), number of petioles, number of primordia, fresh foliage weight (kg) and number of bunches. In addition, the average monthly temperature under the shade of the pecan trees was recorded. In economic terms, the rate of return on total income and the benefit/cost ratio were calculated.

Experimental design and statistical analysis

For the statistical analysis, an analysis of variance (ANOVA) was implemented under unstructured treatments (Rubio and Jimenez, 2012) using the statistical package SAS version 9.4 (SAS Insittute Inc. 2016). When the ANOVA declared statistical significance between treatments, the Tukey's mean comparison test was used. All analyses considered a significance level of 95%, i.e. α=0.05.

Economic management

Through the agrocost methodology used by Fideicomisos Instituidos en Relación con la Agricultura (FIRA, 2024), which consists of a digital register of production costs in an agrocost of production scheme for agricultural crops in specific areas. The production cost structure considers the actual expenses incurred by the producer during the production cycle, such as cultural work, labour, irrigation, inputs (fertilisers and chemicals) and harvesting processes. Subsequently, for the economic analysis, economic viability was evaluated using the financial indicators ROI and B/C Ratio according to Ortega et al (2023).

Results

Agronomic variables

Temperature

The temperature was recorded using two Elitech RC-51 devices, one located under the shade of pecan nut trees and the other in the open field. The readings were recorded from 23-04-2023 to 27-05-2023, obtaining an average temperature of 20.6 ˚ C under the cover of pecan nut trees and 25.1 ˚ C in the open field.

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Plant height (PA)

ANOVA showed statistical differences between the varieties evaluated with respect to the PA parameter (P<0.05). Figure 1 shows that the variety Morocco obtained the greatest height with 33.2 cm followed by the variety Turko with 32.3 cm. Tukey's test showed that these two varieties are statistically equal with respect to this variable and different with respect to the other three varieties. Similarly, the varieties Líder (30.8 cm), Long national (30.7 cm) and American long standing (30.1 cm) were statistically similar to each other. The results of the present study are different from those reported by Duwal et al. (2019) who evaluated eight coriander varieties at the Institute of Agriculture and Animal Science in Nepal and found no statistical difference in PA parameter. These researchers reported plant heights ranging from 39.1 cm in the variety Khusboo to 46.7 cm in the variety IKO-BR-50, which are higher than those found in the study reported here. Vega Diaz (2012) reported that the five varieties evaluated in the region of Araucania, Chile, did not present statistical differences in the PA parameter, however the heights were similar to those obtained in the present study, reporting values ranging from 29.925 for the santos variety to 30.9 for the Moggiano and Comun varieties. Researchers Peneva and Krilov (1977) pointed out that the growth of coriander is affected by the length of the day rather than by temperature, suggesting that studies should be carried out to determine this effect under the conditions in which the present study was carried out.

Box 1

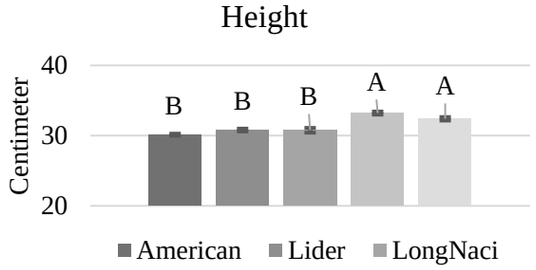

Figure 1

Final height (cm) of five coriander varieties produced in a pecan nut orchard

Source: Own elaboration

Stem thickness

The ANOVA showed statistical differences for the stem thickness variable in the five varieties evaluated (P<0.05).

Figure 2 shows that the American long standing variety obtained the greatest stem development with 6.68 mm followed by the Long national variety with 6.4 mm, Líder with 6.25 mm, Morocco with 6.2 mm and finally the lowest thickness was noted in the Turko variety with 5.4 mm. The Tukey test identified that the American long standing variety was superior to all the other varieties with respect to this variable, while the Turko variety was the least thick of this group. It is important to mention that Hernández (2003) reported a significant genotype-environment interaction between four coriander materials (Criollo de Ramos, Marroqui, Sun master and Slow bolt). This author mentioned that leaf area and stem thickness were similar in the first 45 days of growth in the four genotypes evaluated; however, from that date onwards, there was a clear difference between the genotypes evaluated. On the other hand, Balanta Lara (2017) in his evaluation of the variety Unapal precoso, without and with fertilisation, the plant showed an average thickness of 5.29 and 5.79 mm respectively, highlighting the benefits of fertilisation.

Box 2

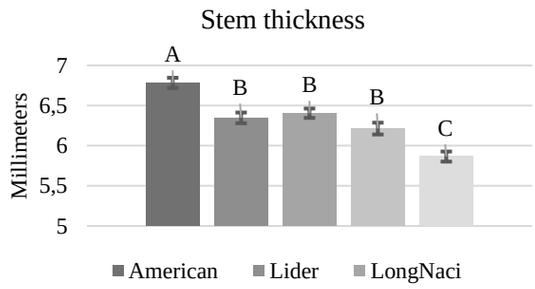

Figure 2

Stem thickness (mm) of five coriander varieties produced in a pecan orchard

Source: Own elaboration

Number of petioles

ANOVA identified statistical differences among the five coriander varieties evaluated (P<0.05). Figure 3 shows that the highest number of petioles was found in the variety Morocco with 7.38, followed by the varieties Long Nacional with 7.28 and American long standing with 7.23. The Tukey test confirmed that these three varieties are statistically equal with respect to this variable, while the varieties Líder (6.78 petioles) and Turko (6.53 petioles) obtained the lowest number of stems.

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Vega Diaz (2012), in his evaluation of five cultivars (varieties) of coriander, reports that there were no significant differences, however, presents values similar to those obtained in this study, with the Bonanza variety registering the lowest number with 6 petioles per plant and the common variety the highest number with 7 petioles per plant.

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Box 3

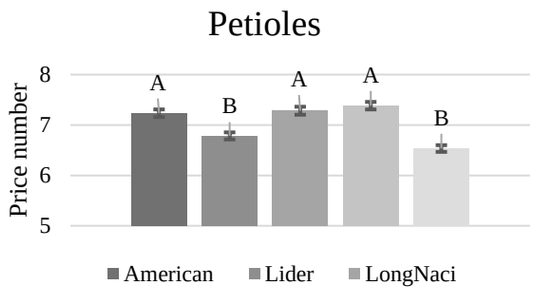

Figure 3

Number of petioles in five varieties of coriander produced in an orchard with pecan nut

Source: Own elaboration

Fresh weight yield of coriander

ANOVA detected significant differences for the yield obtained by five coriander varieties (P<0.05) evaluated in a pecan nut orchard. For the estimation per hectare, a total area of 0.8 hectares was considered, because the remaining 0.2 hectares of land is dedicated to walnut cultivation. Figure 4 clearly shows that the variety American long standing averaged the highest yield with 13.1 t ha-1 and the variety Líder came second with 12.0 ton ha-1. The variety with the lowest yield was Turko with 10.9 ton ha-1 and with average yields were the national Long variety (11.4 ton ha-1) and the variety Morocco (11.8 ton ha-1).

Researchers Duwal et al. (2019) evaluated eight coriander varieties at the Institute of Agriculture and Animal Science in Nepal and found that the variety IKO-BR-50 produced the highest yield with 15.46 ton ha-1, which is higher than that obtained in this study. However, these researchers also evaluated the variety American long standing and reported a yield of 12.66 ton ha-1 which is similar to the yield reported for this variety, in the present study (13.1 ton ha-1). Surya et al., (2018) tested four genotypes (CO-1, CO-2, CO-3 and Cr-4) of coriander and one variety (Arka Isha) under two conditions; open field and protected.

These authors reported statistical differences between growing conditions and between genotypes/variety. The highest yields were in the treatments under protected conditions and the highest yield was with the variety Arka Isha with 14.13 g plant-1.

Box 4

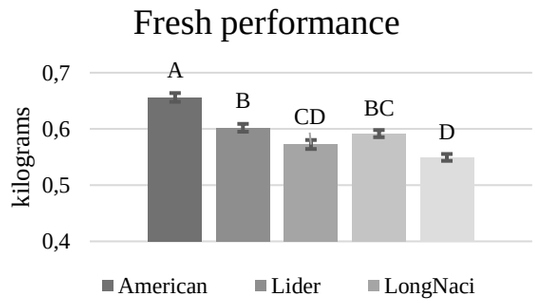

Figure 4

Fresh yield of five coriander varieties evaluated in a walnut orchard

Source: Own elaboration

Number of bunches

ANOVA identified statistical differences between the five coriander varieties evaluated (P<0.05).

For the estimation per hectare a total area of 0.8 hectares was considered, for the variety American Long Standing 108,698.26 bunches were estimated, presenting the highest yield, while the variety Turko presented the lowest yield with 80,818.70 bunches.

Box 5

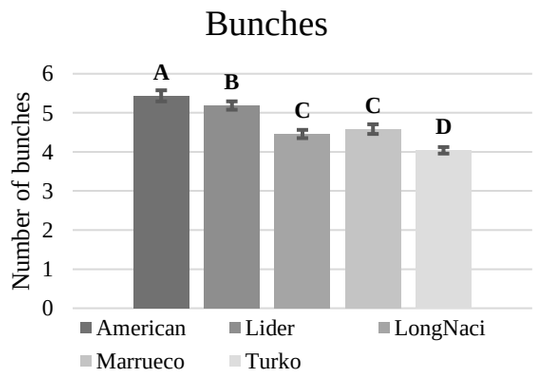

Figure 5

Number of bunches of five coriander varieties evaluated in a walnut orchard

Source: Own elaboration

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Table 1 shows the costs associated with the concepts and activities carried out in relation to the establishment, growth, development and harvest of the coriander variety that presented the highest fresh yield and number of bunches, which based on the agronomic results was the American Long Standing variety with 13.1 ton $^{ha-1}$ and 108,698.26 bunches $^{ha-1}$.

The total cost is also shown in table 2, considering an interest rate of 11.25% per annum, applied to the amount described as bankable, giving a total production cost of $127,959.00.

Box 6

Table 1

Production Costs per Ha

Concept	Finan.	No finan	Total
Land preparation	7200	0	7200
Sowing	9800	0	9800
Fertilization	7210	0	7210
Irrigation	4500	0	4500
Crops	1600	0	1600
Pest, weed, and disease control	12929	0	12929
Harvesting, selection, and packing	38039	0	38039
Goods transportation	0	14756	14756
Miscellaneous	2500	20000	22500
Total	83778	34756	118534

Source: Own elaboration

Box 7

Table 2

Production Costs

Date	Financeable	Interes rate	Interests	Non financeable	Total
jan-dec 2023	83778	11.25%	9425	34756	127959

Source: Own elaboration

Economic profitability

FIRA's agro-cost methodology was used to determine the profit ($/ha), considering the commercial presentation of coriander (bunches).

Three estimates were made based on variable prices and yields (minimum, probable and maximum).

The prices considered correspond to those usual in a normal harvesting season, while the most probable yield was determined in this study, considering a range of plus or minus one tonne for maximum and minimum. The prices established are: minimum price per bunch of coriander is $1, representing the lowest extreme under supply and demand conditions. The likely price is set at $1.5 per bunch, reflecting the most realistic estimate under typical market circumstances. Finally, the maximum price is $2 per bunch, indicating the highest value it could reach under favourable conditions.

In relation to yields, the following quantities are established: 99,570 bunches, equivalent to a yield of 12 ton/ha; 108,698 bunches, corresponding to a yield of 13.1 ton/ha; and 116,165 bunches, associated with a yield of 14 ton/ha. Table 3 shows the profits ($/ha) based on yield and table 4 shows the profits ($/ha) based on production costs, generating a profit of $35,088.00 in the most likely price and yield scenario.

Box 8

Table 3

Profit per ha based on yield

UTILITY ($/HA)

YEAR 1	Selling price ($/ton)						
YIELD (BUNCHES/HA)	1.00	1.17	1.33	1.50	1.67	1.83	2.00
99570	-28389	-11462	4469	21396	38323	54254	71181
102308	-25651	-8259	136070	25503	42895	59265	76657
105046	-22913	-5055	139711	29610	47468	64275	82133
108698	-19261	-782	144568	35088	53567	70958	89437
110606	-17353	1450	147106	37950	56753	74450	93253
113344	-14615	4653	150748	42057	61325	79461	98729
116165	-11794	7954	154499	46289	66037	84623	104371

Source: Own elaboration

Box 9

Table 4

Profit per ha per Cost of Production

UTILITY ($/ha)

Year 1	Selling price ($/ton)						
Total cost ($/ha)	1.00	1.17	1.33	1.50	1.67	1.83	2.00
108459	239	18718	36109	54588	73067	90458	108937
114959	-6261	12218	29609	48088	66567	83958	102437
121459	-12761	5718	23109	41588	60067	77458	95937
127959	-19261	-782	16609	35088	53567	70958	89437
134459	-25761	-7282	10109	28588	47067	64458	82937
140959	-32261	-13782	3609	22088	40567	57958	76437
147459	-38761	-20282	-2891	15588	34067	51458	69937

Source: Own elaboration

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Based on the total costs and probable income obtained, we proceeded to calculate the benefit-cost ratio and other concepts, which show the economic viability for the American Long Standing variety, generating as a result a B/C ratio of 1.27 and an ROI of 27%. These values indicate a positive economic viability, although the B/C ratio is lower than that reported by Cuvi Ramírez (2023) in his study on the evaluation of coriander cultivation with different fertilisers and nitrogen levels. In this study, the following B/C ratios were obtained: 1.50 for fertilisation with UREA, 1.47 for ammonium nitrate, 1.49 for Ferthigue, under a medium fertilisation level, and 1.22 for the control.

Thus, the author shows that there is a way to improve economic efficiency through the optimisation of fertilisation and agronomic management practices.

Box 10

Table 5

Compendium of economic viability information, American Long Standing variety.

Concept	Valor
Probable yield (Ton/ha)	13.10
Probable yield (Bunches/ha)	108698
Probable price ($/Bunch)	1.50
Weight per bunch (gr)	120
Probable income ($/ha)	163047.00
Total cost ($)	127959.00
Cost-benefit ratio	1.27
Probable utility ($/ha)	35088.00
Cost (Ton/ha)	9767.86
Return on Investment (ROI)	27%

Source: Own elaboration

Conclusions and recommendations

From the present study it is concluded that there are differences in the agronomic performance of the evaluated varieties, being superior the performance of the variety American long standing. In addition, this variety showed a positive economic viability, confirming that coriander has potential as an alternative crop under the cover of pecan nut. It is recommended to continue with research that adds value to the coriander crop, taking advantage of its medicinal and nutritional benefits, in order to expand and diversify the economic opportunities offered by this crop.

Declarations

Conflict of interest

The authors declare that they have no conflicts of interest. They have no known competing financial interests or personal relationships that might have appeared to influence the article reported in this paper.

Authors' contribution

Ontiveros-Gómez, Guadalupe: I contributed the project idea and research development.

Guigón-López, Cesar: I contributed with the development of the research, data analysis, revision and editing.

Magaña-Magaña, José Eduardo: I contribute with revision and editing.

Olivas-García, Jesús Miguel: I contribute with the research method, data analysis.

Availability of data and materials

Data sets used or analysed during the current study are available from the corresponding author upon reasonable request.

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Abbreviations

FIRA	Fideicomisos Instituidos en Relación con la Agricultura (Trusts related to agriculture)
CANACO	National Chamber of Commerce
ROI	Return of Investment (Retorno de la Inversión)
B/C	Benefit-Cost Ratio
SIAP	Agri-food and Fisheries Information System
FAO	Food Agriculture Organization

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