



1 **ECONOMIC AND ENVIRONMENTAL ANALYSIS OF CITRUS BASED**
2 **INTERCROPPING SYSTEMS IN COSTAL TABLELANDS**

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4 CARLOS ROBERTO MARTINS ¹, GERALDO STACHETTI RODRIGUES ², INÁCIO DE
5 BARROS ³

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7 **INTRODUCTION**

8 Modern cultivation practices of fruit have shown that there is a need for improvements
9 towards increasing biodiversity in production systems. The incorporation of more crops and
10 plant species within the orchards may favor better biological balances and consequently
11 decreasing the growing problems with pests and diseases observed in sole crop fields. A
12 biodiversity based farming system makes better use of ecosystems services, therefore
13 reducing the dependency on external inputs of the farm (DURU et al., 2015). The require,
14 however, a systemic view of the agricultural activity and sets up to oppose to monocrops that
15 induces the decline in biodiversity and reduction of ecosystems services, like nutrient cycling,
16 climate mitigation, and water quality (GABA et al., 2015).

17 Intercropping fosters the intensification of environmental processes and functions in
18 perennial cropping systems through diversification of productive design, and favors the
19 expression of the beneficial effects of biodiversity in the production systems (ALTIERI,
20 1999). The possibility to explore the environment with agricultural activities, together with
21 biodiversity, is based upon a diversified arrangement of crops, within both time and space
22 scales, in replacement to mono-cropping.

23 Although intercropping is being increasingly adopted by growers, the cultivation of
24 cash and staple food crops together with citrus is basically carried on by small and medium
25 farmers of the North coast of Bahia and South of Sergipe States. By means of intercropping
26 they aim at making better use the limited availability in land, inputs, machinery and labor
27 necessary for manuring; weed, pest and disease control; irrigation; among others (MARTINS
28 et al., 2014).

29 The objective of this study is to evaluate citrus based intercropping systems through
30 indicators of economic and environmental performances aiming at identifying the best
31 combinations for the Coastal Tablelands region.

¹ Dr., Embrapa Clima Temperado, e-mail: carlos.r.martins@embrapa.br;

² Ph.D., Embrapa Meio Ambiente, e-mail: geraldo.stachetti@embrapa.br;

³ Ph.D. Embrapa Tabuleiros Costeiros, e-mail: inacio.barros@embrapa.br;

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MATERIAL AND METHODS

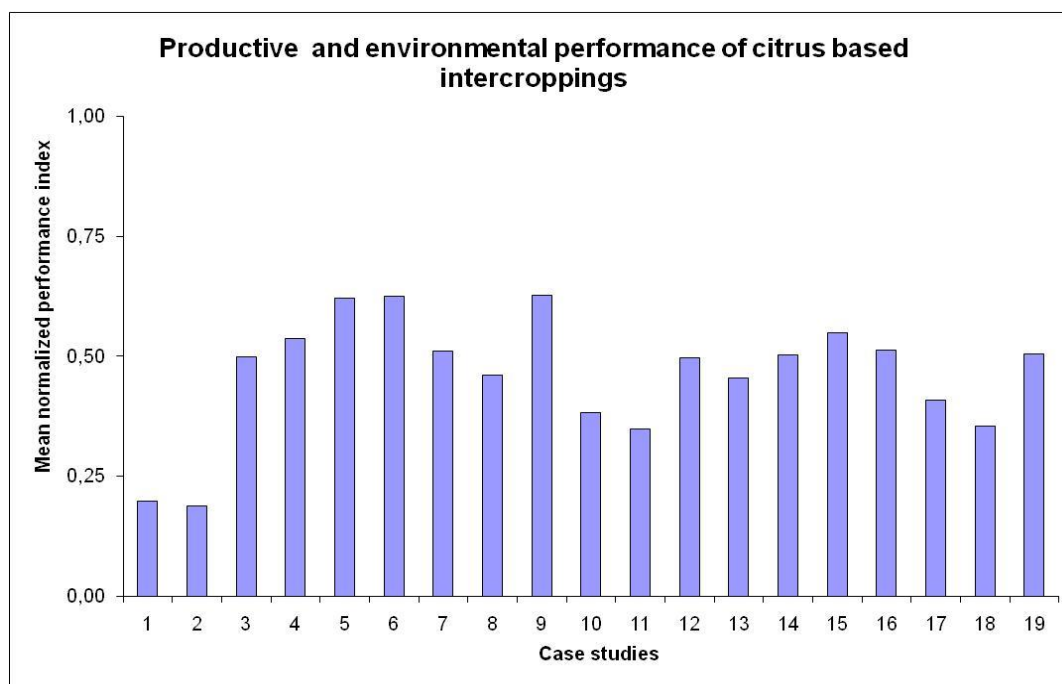
A field survey was carried out in 19 fruit farms that adopt intercropping in their orchards in the Coastal Tablelands area of South Sergipe and North of Bahia. All needed information were collected with the help of a previously prepared questionnaire and the data organized into an Excel TM template based “Matrix of indicators of economic and environmental performances of citrus based intercropping systems” developed specially for this study.

The matrix of economic and environmental performance indicators was built as an Excel TM template and is based on 4 main premises: I) Profitability – represented by the indicators: Profit (LC); Profit evenness (ER) and Seasonality (S); II) Production efficiency – represented by the indicators: Area Equivalent Index (IEA), Efficiency in the use of water (EH), Efficiency in the use of N (EM), Efficiency in the use of P (EP), Efficiency in the use of K (EK), Return on investment in fossil fuel energy (RIEF), Return on investment in labor (RIT); III) Conservation of productive capacity – represented by the indicators: Soil Organic Matter (OM), (pH), Phosphorus (P), Potassium (K), Calcium plus Magnesium (Ca + Mg), Cation Exchange Capacity (CTC), Sum of Basis (SB) and Basis Saturation (V); and IV) Biological regulation – represented by the indicators: Plant health control impact level (NICF) and Productive diversity (PD).

RESULTS AND DISCUSSION

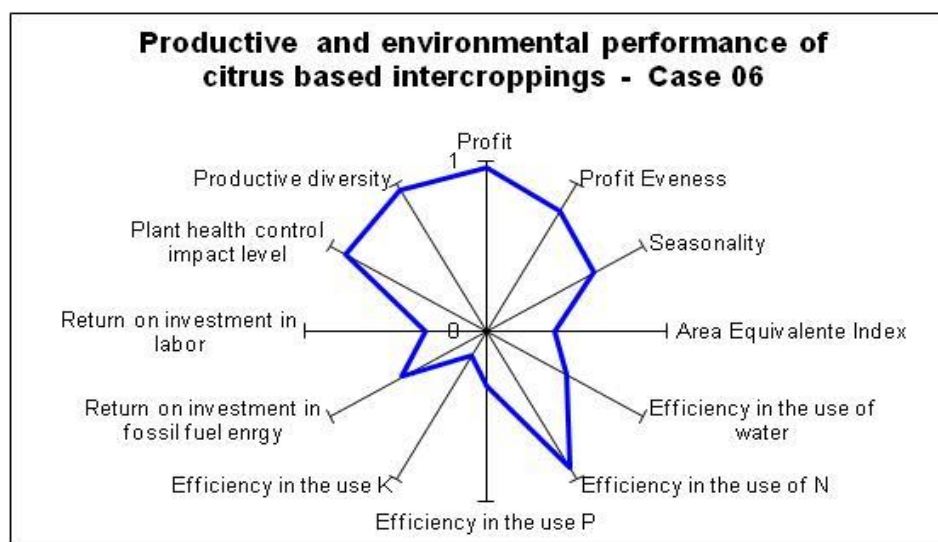
The economic-environmental performances of citrus monocrop (cases 1 and 2) and intercropping (cases 3 to 19) in the cases studies in the Coastal Tablelands of Sergipe and Bahia are shown in Figure 1. According to the results of the surveys, monocrop orchards have lower economic-environmental performances compared to intercropping. The average index of all intercropping farms is above 0.5 and the best results were observed almost exclusively in farms where cassava or maize (for grain or sweet corncobs) as intercrop in the citrus orchards.

Among the intercrop farms with low performance index are those that used okra, cowpea, cucumber, papaya and passionfruit. The average index for monocrop orchards was 0.19, lower than any result with intercropping case study. Individual analysis of each fruit farm reveals the indicators that contributed most for the economic-environmental performance of the best grading farms (above index 0.63), as it is shown in Figure 2 for case study number 6 where cassava, beans and corn were used as intercrop.



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Figure 1: Economic-environmental performances of citrus monocrop (cases 1 and 2) and intercropping (cases 3 to 19) in Coastal Tablelands of Sergipe and Bahia



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Figure 2: Economic-environmental performance of the intercropping systems with citrus, cassava, cowpea and corn in case study n° 6.

75 The results of the present study shows that the combination of citrus with cassava, corn,
76 cowpea, yam, fava beans, cucumber, okra, peanuts, watermelon, papaya and passionfruit in
77 intercrop farming systems design brings economic and environmental benefits to fruit farms. It
78 is important to highlight however, that the economic and environmental performance of an
79 intercropping system depends upon how the different crops cope together for

80 complementarity in the use of resources (DIMA et al., 2007). Based upon the concept of niche
 81 complementarity and facilitation, intercropping systems may favor symbiosis and reduction in
 82 the dependency of external inputs (GLIESSMAN, 2001).

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CONCLUSIONS

85 The ‘Integrated Indicator System for Economic-Environmental Performance
 86 Assessment of Citrus Based Intercropping Designs in Costal Tablelands’ has shown to be a
 87 suitable tool for evaluating citrus farming systems according to the principles of the
 88 Ecological Intensification. The best economic-environmental performances are obtained by
 89 combining citrus with cassava; cassava, maize and cowpea (or brown beans?); maize and
 90 cucumber. The indicators most positively influenced by the intercropping are Plant health
 91 control impact level, Productive diversity, Profit, Profit evenness, Return on investment in
 92 fossil fuel energy, Efficiency in the use of water, nitrogen and phosphorus.

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