coffee & climate
enabling effective response

Case Study - Crotalaria and Brachiaria

Case Study Background Data		
Tool category: Adaptation on the farm		**Details:** Planting Density: 3.333 /ha Soil Type: Loamy soil Shade Regime: No shade Farming System: Intensive Monoculture System Yield Range (kg cherry /ha): >10.000 ⦸ rain: 1.500 mm/year
Variety: Arabica		
Climatic Hazard: • Temperature increase • Prolonged drought periods • Rain showers • Soil erosion		
Expected Outcome: • Increase in productivity and net income per hectare • Increase in the organic matter content in the soil and moisture retention capacity • Soil temperature regulation • Soil erosion reduction		
Implementation Date: 01.10.2014 – 31.07.2015	**Altitude**: 838m **GPS:** 20º27`47 32”S 42º19`14 87”E	**Slope of plots**: 5% ⦸ **Age of trees**: 5 years
No. farmers: 14	⦸ **Area under coffee**: 2.8 ha/farmer	Tested with smallholders through Farmer Field Schools (FFS)

Results

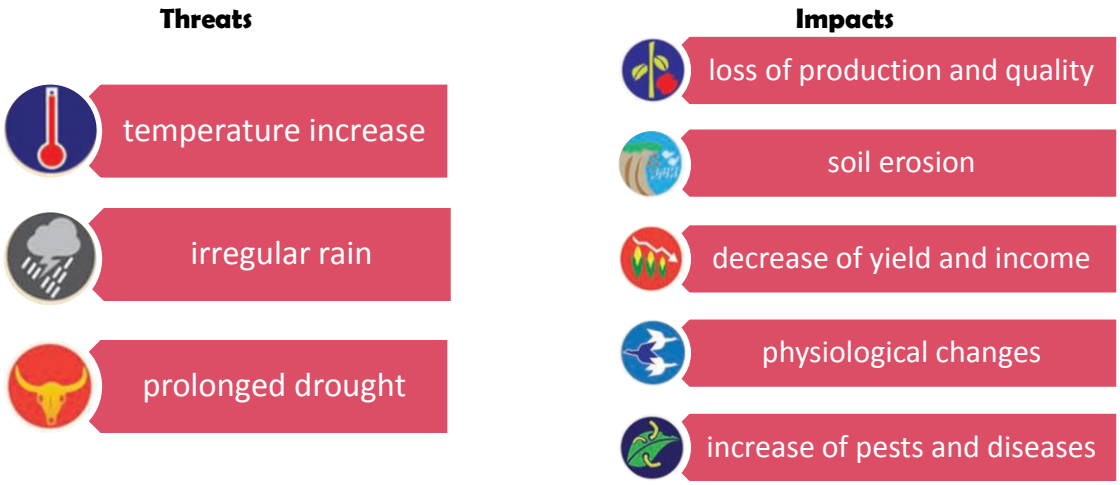
1. Coffee plots with cover crops between coffee rows presented productivity and net income per hectare increase. The coffee productivity with *Brachiaria brizantha* covering the rows was 27.8 bags/hectare, with *Crotalária spectabilis* it was 29.1 bags/hectare, while the productivity with weed chemical control was 26.4 bags/hectare. Compared to coffee that had weed chemical control, the coffee with cover crops increased an average of 2.1 bags/hectare. It was observed that the plots with cover crops had a net income of R$7,266/ha, while plots without cover crops had R$6,423. This represents a 13.1% increase in average income/hectare.
2. Other important results were the changes in the soil characteristics that are favorable to the crop development, such as the increase in the organic matter content and the moisture retention capacity. Soils with cover crops have increased by 0.4% the organic matter content and kept their field capacity longer than uncovered soils.

Pros & Advantages + Learnings	Cons & Disadvantages + Things to take into account
• The cover crops favour changes in the soil's characteristics that improve aspects such as fertility, organic matter and an increase in moisture retention. • The covered soil diminishes evaporation. • Diminishes (eliminates) the use of agrochemicals for weed control between coffee rows, generally prejudicial for soil and farmer's health. • Low installation and management cost – R$310 for management of *Crotalaria spectabilis* and R$493 for *Brachiaria brizantha*. • The seeds for cover crops are easily obtained. • *Crotalaria spectabilis* may reduce Meloidogyne genus nematode populations, in addition to fixing atmospheric nitrogen in the soil. • *Brachiaria ruziziensis* is a C4 species, which tend to be more drought resistant than C3 species like coffee. Besides that, it presents a deep root system that promotes the nutrient cycling from deeper layers to the soil's surface.	• The cover crops are not appropriate for high density coffee crops, because they hinder other cultural practices carried out in the coffee. • There must be a defined plan for managing the cover crops, planting it in rainy seasons and cutting/incorporating according to the phenological cultivation cycle in each locality. • *Crotalaria spectabilis* presents a fibrous stem, so the cut must be low, to avoid forming "little trunks" that can posteriorly cause damage to the harvest mats. • *Brachiaria ruziziensis* must be correctly managed, with two or three cuts during the coffee cultivation cycle. Due to its accelerated growth and form of propagating, some farmers are resistant to its use. • Both *Crotalaria spectabilis* and *Brachiaria ruziziensis* can be managed in mixed covering systems by using herbicides before the coffee harvesting.

Acceptability	High	**Effectiveness**	High
Affordability	High	**Timing / Urgency**	High

What is the objective of applying the adaptation option and how do we expect the objective to be met?

The case's objective is to diminish the productivity loss risks due to temperature increase, irregular rainfall and prolonged drought periods by using cover crops as adaptation practices to climatic changes.



Study's objective, results and indicators:

Objective	Results	Indicator
To reduce productivity loss risks due to temperature increase, irregular rainfall and prolonged drought periods, by using cover crops.	Increase in productivity and net income in coffee plots with cover crops in comparison to the local practices (witness).	• Productivity in bags/ha • Net income in R$/ha
	Increase in organic matter content and the soil's moisture retention capacity in plots with cover crops in comparison to the local practices.	• Organic matter %. • Days in soil's field capacity after the last rain.

The Operational Plan for this tool's application was:

Year	2014								2015						
Month	Mai	Jun	Jul	Ago	Sep	Out	Nov	Dec	Jan	Fev	Mar	Apr	Mai	Jun	Jul
Time															
Determination of the threat, impacts and adaptation practices	■														
Problems identification and adaptation measures definition with the farmers		■													
Planning the practice: selecting the farmer and the location of the study			■												
Soil Analysis			■												■
Planting the covering species						■									
Herbicide application						■			■				■		
Weed control with shearer								■			■		■		
Legume cut													■		
Harvest and post-harvest														■	■
Results assessment															■

Description of climatic threats and associated problems: Through the triangulation process, the main climatic threats were identified, such as: 1) temperature increase; 2) irregular rainfall; 3) prolonged drought periods; 4) strong winds; 5) hail. Also identified was the need to validate adaptation practices for soil conservation, such as improving the physical, chemical and biological characteristics, besides reducing exposure to extreme climatic factors, as rainfall increase, water loss and erosion. The impact of these events cause physiological changes in the cultivation, increase in pests and diseases, productivity loss, quality loss and income reduction for the farmers.

Description of the expected outcome: The cover crops are grass species, legumes, among other species that are planted between the coffee rows. These crops form a natural coverage, either living or dead when cut. They promote the increase in organic matter content in the soil, provide more nutrients to the coffee, increase the water retention, protect against erosion caused by heavy rain and reduce high surface temperatures of the soil. As a result, it is expected to obtain an increase in productivity and consequently increasing profit for the farmers.

How is the adaptation option applied?

Nr.	Step	Picture
1	A meeting between farmers, extensionists and researchers in the triangulation process is the first step to identify climatic threats, impacts and to define adaptation measures. Further, at that time the validation studies are planned, objectives, results and indicators identified and actions taken to the field.	
2	Once the cover species, grass or legumes are selected, it is necessary to decide the planting time and the arrangement between coffee rows. For example, *Brachiaria ruziziensis* was planted by sowing through throwing with a 50 cm spacing from the coffee projection. For the *Crotalaria spectabilis* case, the planting was made in furrows spaced in 10 cm in the center of the space between the coffee rows.	
3	The *Brachiaria ruziziensis* field must be cut periodically when the crop reaches approximately one-meter high. Depending on the climate and the rains this can happen between 60 and 90 days. The grass can be cut with manual or mechanic shearer. The cuttings should be placed near the coffee plants base (in the coffee "skirt" projection) to increase the water retention and provide nutrients as the cut leaves decompose.	

4	The *Crotalaria spectabilis* field will be cut in the flowering stage phase when there is more biomass quantity to incorporate organic matter in the soil beyond the biological fixation of atmospheric nitrogen having achieved its apex, decreasing from this stage on. The cut can be done with manual shearer or machete as low as possible.	
5	When cut, *Briachiaria ruziziensis* forms a dead and continuous coverage that brings benefits to the soil by reducing direct impacts, such as extreme temperatures and strong erosive rains. This practice also lowers soil temperatures, reduces thermal amplitudes and conserves moisture for a longer period.	
6	Technicians and farmers evaluate the results of the cover crops in retaining soil's moisture and temperature. The image also illustrates the difference between covered soil (with decomposing *Crotalaria spectabilis*) and the soil exposed to the extreme climatic conditions. The moisture in the covered soil is higher than the exposed soil. The same is true for organic matter content.	

7	During the harvest, the farmer evaluates the productivity of the plots to reach conclusions about the effect of the adaptation practices to adapt the climatic changes performed in its property. The farmer registers all of the production costs and economically evaluates the feasibility of the practices performed in its property, by being able to visualize the productive return (bags/ha) and economic return (farmer's income).	

Implementation framework

The study on the cover crop effect over the soil's characteristics, the productivity and the income of the farmers was performed through a validation plot of Farmer Field Schools (FFS). The validation plots had a 500m² area for each of the treatments. Treatments:

- Treatment 1 – Brachiaria ruziziensis cover crop between coffee rows with three cutting times.
- Treatment 2 – Crotalaria spectabilis cover crops between coffee rows and incorporated to the soil by the time it reaches 30% flowering.
- Treatment 3 – no cover crops; conventional weed control with three herbicide applications per agricultural year.

Measurement strategy for effectiveness

Indicator	a) Productivity in bags/ha b) Net Income in R$/ha c) Organic matter % d) Days in soil field capacity after the last rain
Definition	a) Number of beneficiated coffee bags/ha b) Net income/ha c) Results of the soil analysis for organic matter calculation d) Days when the soil remains at field capacity after the last rain

Purpose	a) Selected indicator to define the impact of the cover crops as the amount of bags produced in one hectare by the coffee crop. This measure is one of the indicators that manifest the efficiency of the practices over adverse climatic events. b) The net income allows to evaluate if the practice has a positive economic return compared with the conventional practice. c) The organic matter is one of the main fertility. Additionally, the organic matter is related to the enhanced infiltration and moisture retention condition of the soil. Thus, an increase in the organic matter content means more fertility, more life, and more infiltration and moisture retention capacity. d) A soil with prolonged period at field capacity after rain guarantees water retention capacity and is in condition to provide water and nutrients to the crop for longer. This also reduces the risk that the crop evaporates and loses water quickly conducting water to a hydric stress state.
Baseline	a) 2013 - 2014 crop – 25 bags/ha b) 2013 - 2014 – crop R$ 5.750 c) 2,2% organic matter d) 2 days in field capacity after last rain
Target	a) 2014 -2015 crop – 30 bags/ha b) 2014-2015 crop – R$ 6.500 c) 2,3% organic matter d) > than 2 days at field capacity after last rain
Data Collection	a) Crop assessment performed by the farmer and the FFS comparing the productivity of the three plots established in the study. b) Net income calculation taking into account the production costs from the expenses registry and the market price in the coffee sales day for each one of the treatments considered in the study. c) Initial and final soil analysis of the plots with and without coverage taken in the field and analyzed in the laboratory. d) Measurement of the soil humidity at 40 cm depth with nominated soil tensiometer performed by the technicians and farmers.
Tool	• Field Notebook • Chemical soil analysis • Measurement with tensiometer

Frequency	a) Once – at the harvesting moment. b) Once – after finalized the melioration process. c) Twice – before planting the cover crops and after the last cut/incorporation of the soil coverage. d) Three times – in January, February and March after a rain event.
Responsible	a) Technician (Luiz Claudio) and ECA farmers b) Technician (Luiz Claudio) and ECA farmers c) Manhuaçu's Agricultural Syndicate Laboratory d) Technician (Luiz Claudio) and ECA farmers
Reporting	The data was collected in the field and posteriorly communicated to the M&E sector of the Neumann Foundation Brazil. Those in charge of the M&E along with the coordinator of coffee&climate Brazil prepared the report of results and the case study.
Quality Control	The technician and the farmers collected the information at field level. The information was validated initially by the regional technical coordinator. Posteriorly the regional technical coordinator sent to the M&E coordinator who performs the preliminary analysis that is validated by the coffee&climate coordinator.

Measurement strategy for acceptability, affordability, timing & urgency

The Farmer Field School is a participatory methodology that generates the opportunity for farmers to learn practically the physiological and ecological phenomena that happen in the agro ecosystem due to the implementation of the management practices. The validation field plot (that is known in the FFS as the learning plot) is a living laboratory where the farmer can observe, analyze and take decisions to maintain the crop in equilibrium with the environment where it grows. Observing and understanding the organic matter function to increase fertility and maintain moisture for prolonged times is a key factor, so that the farmer takes the decision to continue its observations in its own crop field through replications.

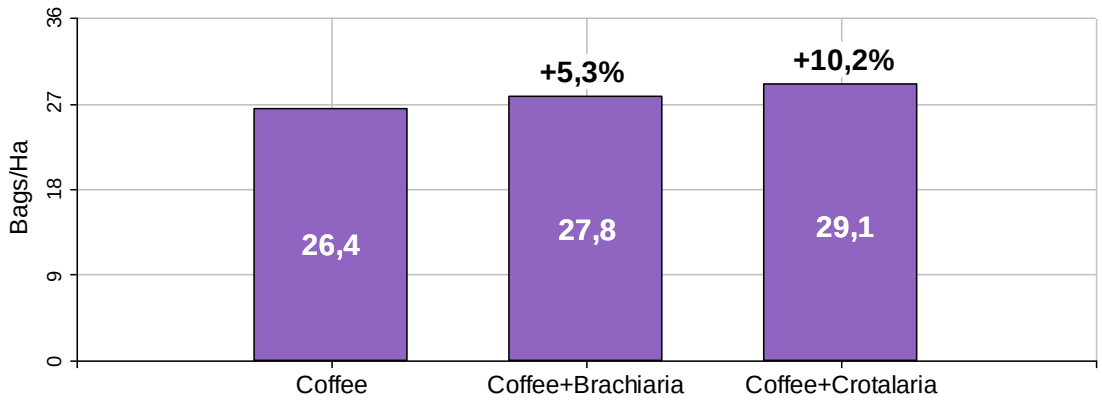
The conclusions of the observations and the analysis taken from the field are posteriorly discussed in plenary, where the facilitator (technician) identifies the satisfaction level of the results and identifies opinions about the acceptability, accessibility of the materials and any resource related to the development of the practice, as well as the time and urgency to be implemented in function of the new climatic conditions of the region.

Main findings of case study

The cover crops had a positive impact in terms of studied indicators.

a) Productivity: The coffee treatments with coverage between coffee rows had a higher productivity than the treatment without coverage in which weeds were managed by chemical method (control). The control had a productivity of 26.4 bags/ha, the *Brachiaria ruziziensis* portion had a productivity of 27.8 bags/ha and the *Crotararia spectabilis* had a productivity of 29.1 bags/ha.

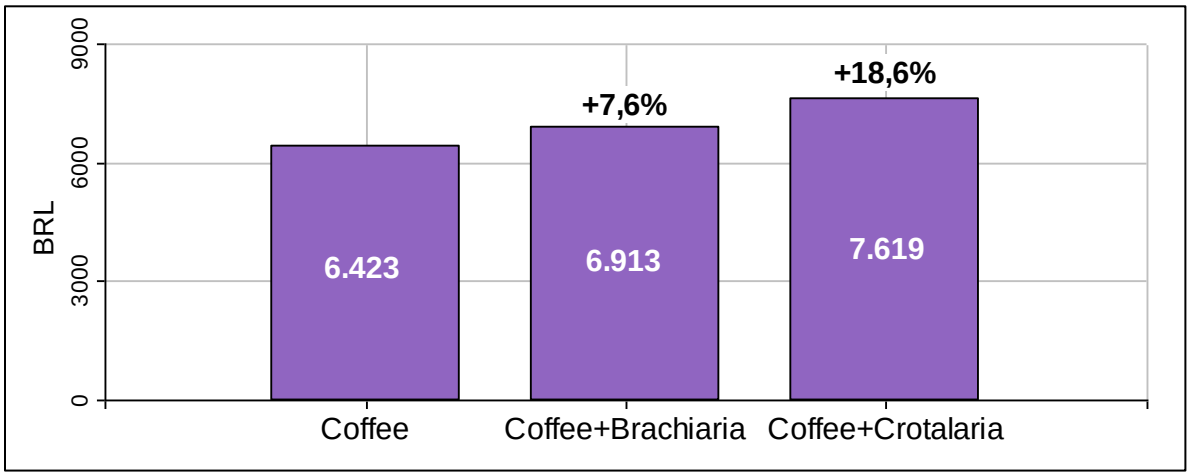
Figure 1: Productivity of the three management types between coffee rows: Weed chemical management (no coverage), coverage with *Brachiaria ruziziensis* and coverage with *Crotalaria spectabilis* between coffee rows. 2014-2015 crop.



Source: *Field Data, 2015.*

b) Net income: The coffee treatments with coverage between coffee rows have increased the productivity/ha and a higher net income/ha. The coffee plot without coverage had a net income of R$ 6,423; the coffee plot with *Brachiaria ruziziensis* coverage had a net income of R$ 6,913 and the coffee plot with *Crotalaria spectabilis* coverage had a net income of R$ 7,619.

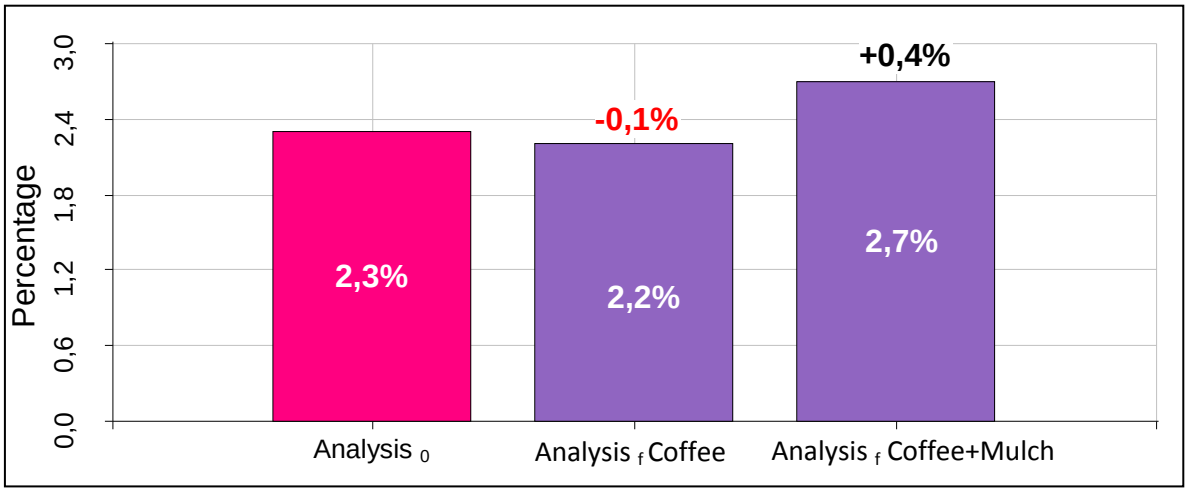
Figure 2: Net income of the three management types between coffee rows: Weed chemical management (no coverage), coverage with *Brachiaria ruziziensis* and coverage with *Crotalaria spectabilis* between coffee rows. 2014-2015 crop.



Source: *Field Data, 2015.*

c) % of organic matter. The initial analysis performed in May, 2014 showed as result that the soil from the lot had 2.3% organic matter content. In a second moment soil analysis were performed in the plot without cover crops and in the plots covered with *Brachiaria ruziziensis* and *Crotalaria spectabilis*. The result of the organic matter content in the plots without cover crops was 2.2%, and in the covered plots was 2.7% (average of both, Brachiaria and Crotalaria).

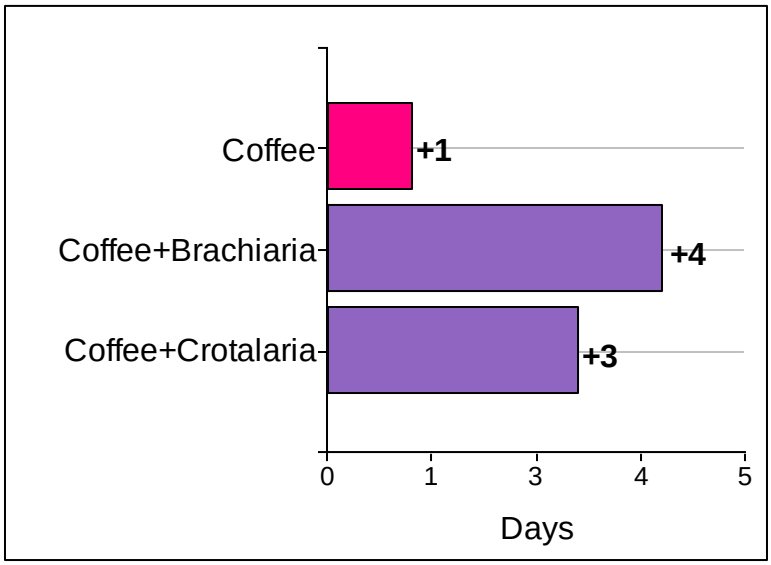
Figure 3: Variation in organic matter content (%) in covered and uncovered soils, analyzed through soil analysis in the beginning and in the end of the 2014-2015 crop.



Source: *Field Data, 2015.*

d) Days at soil field capacity after the last rain[1]. Once cover crop treatments were set up, moisture retention analysis were performed using as a measure, the number of days after rain where the soil remains with a tension measurement of between 20 and 50 centibars, a range that indicates that the soil is at or near field capacity. Through the utilization of tensiometers it was proven that soils with cover crops remain for longer at field capacity than uncovered soils. In other words: cover crops help to conserve the water retained in the soil.

Figure 4: Number of days of soils at field capacity (< to 50 centibars) from three management treatments of the soil between coffee rows: Weed chemical management (no coverage), coverage with *Brachiaria ruziziensis* and coverage with *Crotalaria spectabilis* between coffee rows. 2014-2015 crop.



Source: *Field Data, 2015.*

[1] A safra 2014-2015 se caracterizou por apresentar chuvas irregulares ao inicio do ciclo agrícola e uma seca entre os meses de dezembro e janeiro que impactou em alterações fenológicas, como floração atrasada e fraco enchimento de frutos. No entanto, precipitações acima da média acorreram entre fevereiro e março que contribuiu a diminuir a quebra da colheita.

Acceptability					
Leading Question: To what extent did farmers readily accept this tool as useful for implementation and implement it as planned?					
High	X	**Low**		**Don't Know**	
High: The farmers easily accept to execute this tool and it continues to be implemented as planned.					

Please Comment:	
If there was resistance to adopting this tool, why?	No resistance.
If farmers discontinued tool implantation later on in the process, even though they initially accepted it, why?	n.a.
Did this tool have any external issues or impacts (positive or negative) which influenced its acceptability? (community, value chain?)	The cover plants helped to retain rainwater, diminishing soil erosion and flash flood, which damage roads and promote silting of streams.
Any other comments:	There are other grasses and legumes that must be tested. The farmers, helped by the Project, test other high seed production legumes to continue the soil management with coverage.

Affordability					
Leading question: Are the costs of the tool affordable to the farmers, taking into account the initial investment, maintenance cost and the availability of inputs?					
High	X	**Low**		**Don't know**	X
High: The initial investment and the maintenance costs of this tool are affordable to farmers from their regular operations and the times it takes to recover the investment is reasonable to farmers.					

Please comment:	
Are there any external costs? (to society or environment?)	n.a.
If costs are high because inputs are not available, what inputs? And why?	In Brazil there are several cover crop seeds providers. The companies offer certified seeds and deliver them wherever the requester wants.
Any other comment:	It is necessary to test other cover crops species, especially the ones that can be multiplied in the own community to eliminate the dependency of buying seeds.

Effectiveness					
Leading question: Does the tool provide the expected benefits to farmers?					
High	X	**Low**		**Don't Know**	
High: The objective of the tool has been met for the farmers.					

Please, comment:	
What benefits did farmers expect from this tool?	The farmers expected productivity and net income increase due to increases in organic matter content, fertility, soil's physics and microbiology. Characteristics that improve physiological and productive conditions, guaranteeing higher productivity and aptitude to adapting to climatic changes.
If the objective has not been met, why?	The objective was fully achieved.
Have there been any significant external issues which influenced the effectiveness (positive or negative) of this tool? Please explain.	The climatic conditions with irregular rainfall and drought periods helped to prove the efficiency of the cover crops when comparing to regular weed management.
Any other comments about effectiveness?	The cover crops were effective in controlling broad-leaf weeds and bindweed by competing for space and sunlight.

Timing /Urgency					
Leading Question: Is the amount of time that this tool takes to implement (from starting implementation until benefits accrue) reasonable to farmers?					
High	X	**Low**		**Don't Know**	
High: The tool is short/mid-term (taking into account the productive cycle of the coffee, needed inputs, preparation and execution time).					
Please, comment:					
If implementation takes too long, why?		n.a.			
Any other comments about timing?		The production systems with conventional weed management can be quickly transformed into alive/dead coverage management. It only takes the farmer's decision and the technical assistance to access the technology's knowledge.			

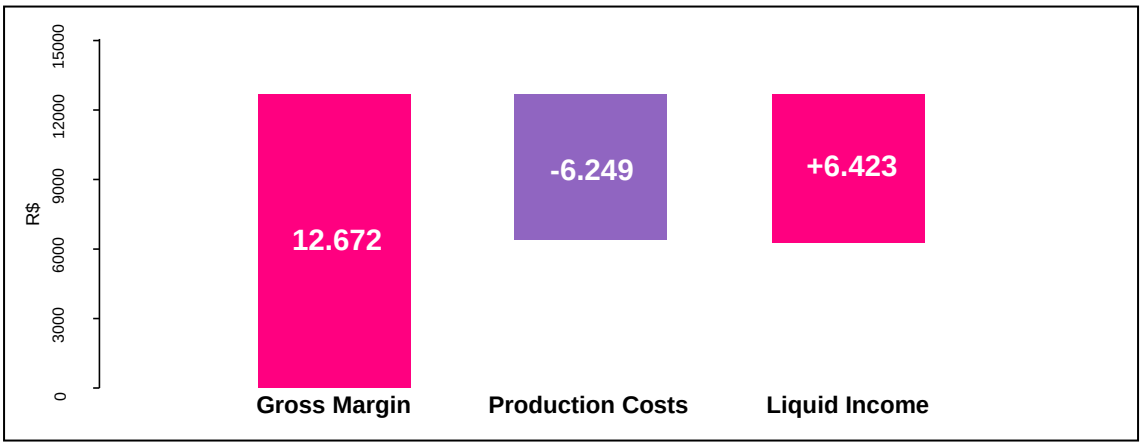
Attachment

Attachment 1: Economic analysis of the three management types between the coffee rows: Weed chemical management (no coverage), coverage with *Brachiaria ruziziensis* and coverage with *Crotalaria spectabilis* between coffee rows. 2014-2015 crop in BRL.

	Coffee without coverage (control)	Coffee with *Brachiaria ruziziensis* coverage	Coffee with *Crotalaria spectabilis* coverage
Benefit	*1.698*	*1.707*	*1.714*
Harvest	*1.901*	*2.002*	*2.095*
Fertilizing	*765*	*765*	*765*
MIP	*191*	*191*	*191*
Planting	*382*	*382*	*382*
Pruning	*319*	*319*	*319*
General Works	*573*	*573*	*573*
Weed/cover crop management	*420*	*493*	*310*
Total Production Costs	*6.249*	*6.431*	*6.349*
Productivity	*26*	*28*	*29*
Sales Price	*480*	*480*	*480*
Gross Income	*12.672*	*13.344*	*13.968*
Net Income	*6.423*	*6.913*	*7.619*

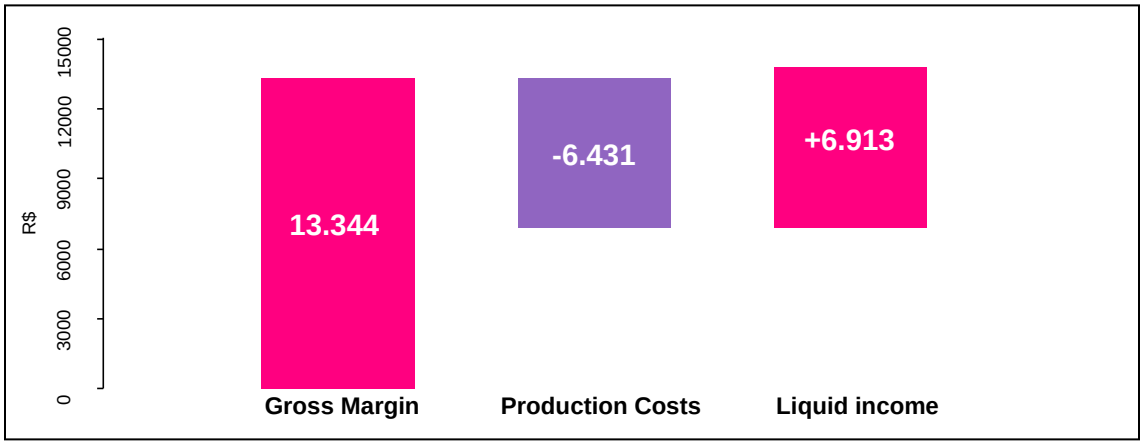
Source: *Field Data, 2015.*

Attachment 2: Income from coffee treatment with chemical weed management (no coverage).



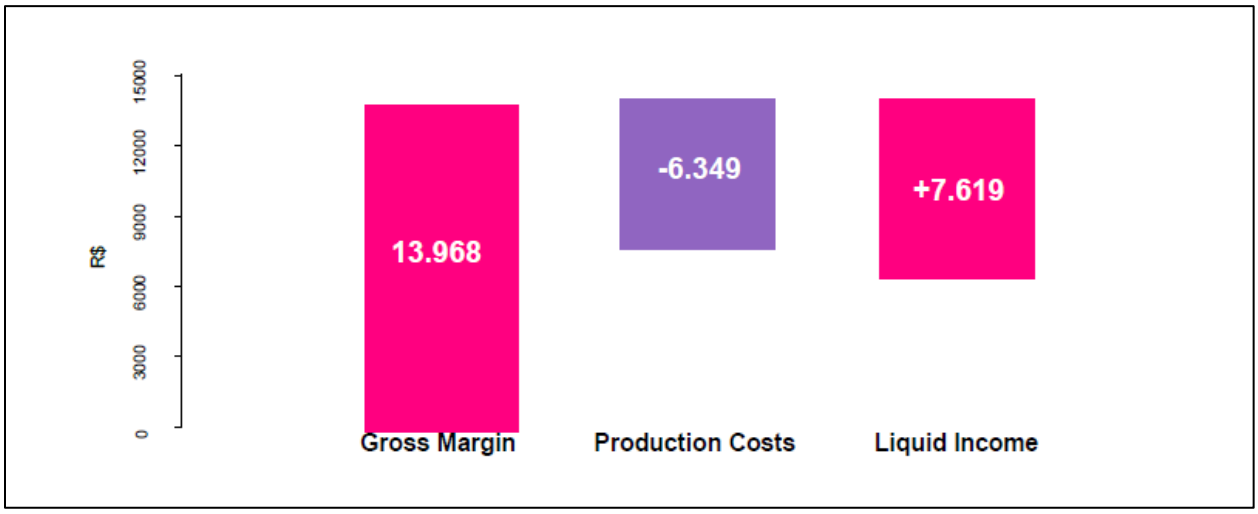
Source: *Field Data, 2015.*

Attachment 3: Income from coffee treatment with *Brachiaria ruziziensis* between coffee rows as cover crop.



Source: *Field Data, 2015.*

Attachment 4: Income from coffee treatment with *Crotalaria spectabilis* between coffee rows as cover crop.



Source: *Field Data, 2015.*