coffee & climate
enabling effective response

Use of Brachiaria ruziziensis and Cajanus cajan as cover crops for coffee plantations

Case Study Background Data		
Tool Category: Adaptation on the farm		**Details:** Planting Density: prod. 4300 /ha Soil Type: Clay Shade Regime: 40-50% - With Brachiaria/Gandul 31-40% - Witness Farming System: Traditional agroforestry Yield Range (kg cherry/ha): 8000- With Brachiaria/Gandul 1250- Witness ⦸ rain : 1400 mm/year
Variety: Arabica		
Climatic Hazard: • Drought • Heat stress		
Expected Outcome: • Better soil management by moderating soil temperatures, moisture loss and erosion		
Implementation Date: 01.02.14 - on going	**Altitude**: 896 m **GPS**: 14°30´18.8´´ N 88°57´.35.5´´ O	**Slope of plots**: small inclination (< 5%) ⦸ **Age of trees**: <5 years
No. Farmers: 1 farmer	⦸ **Area under coffee**: 0.36 ha/Brachiaria/Gandul 0.36 ha/Witness	Tested on demo plots

Results

Young coffee trees (younger than 2 years) are vulnerable to drought and high temperatures once they are transplanted to the field as their roots are poorly developed and high temperatures reduce water and nutrients intake trough the roots. The initiative for coffee&climate searched for alternatives to reduce the soil temperature and plant stress. *Brachiaria ruziziensis* and *Cajanus cajan* had been identified as promising tools to change the temperature of the soil and also to conserve the soil humidity.

To measure the soil temperature 'smart buttons' (SmartButton is a miniature-sized temperature logger) had been installed at 5 centimetres depth for a total of 240 days with and without cover crops and were programmed to take measurements every 3 hours.

One of the major differences seen in the maximum temperatures: Without cover, temperatures peaked well above 30°C; this temperature is regarded as an upper limit as the water, nutrient and photosynthesis of Arabica all decline. With the cover crop the temperature never rose above 30°C.

One key aspect is the incorporation of organic matter that could occur in the long term. It is estimated during one cut that Brachiara produced 14 metric tons of fresh matter/hectare. This could amount to as much as 56 metric tons during one year of fresh matter. Estimating 15% dry matter this equals to 8.4 metric tons of organic matter per hectare available to be incorporated in the long term. Further

research is needed to validate the long term effects of Brachiaria – the roots may bring up nutrients from deeper soil zones than coffe though there may also be competition if fertilization is neglected. In addition to that, increasing the distance in between rows is recommended. There will be further research regarding decomposition of the mulch generated by Brachiaria and how much can be incorporated into the soil. Cajanus generates a good effect for shading and pruning is required to give an adequate shade for coffee. Pruning of Cajanus can also be incorporated for Brachiaria. In some cases pruning a single tree can generate around 12 pounds of biomass.
Regarding soil humidity, measurements where made with an irrometer at 15, 20 and 25 centimeters depth and the results show more humidity below Brachiaria and Cajanus.
In plant development, plants below Brachiaria and Cajanus are in average 30% taller than witnessed (1.3 meters against 1.0). They also had three times more coffee beans by plant (1500 beans by plant against 500). It is recommended to keep researching in regards to interactions of cover crops (Brachiaria) and temporary shade (Gandul) in coffee development.

Pros & Advantages + Learnings	Cons, Disadvantages + Things to take into account
• Incorporates organic matter in the long term • Decreases the soil temperature • Decreases erosion • Does not necessarily mean more cutting if managed properly • Recycle of nutrients by the production of fresh vegetable matter • Improve the soil condition • Increase the humidity in the soil • Improve biological life in the soil (worms and possibly benefical fungus) • Reduces the temperature of the environment	• Seeds of the required variety were difficult to source. It is important that a sterile seed-yielding variety is used to control unwanted spread of the grass. • Resistance of farmers of adopting initially as is not common to use a grass in coffee production • If the cover crop is not properly managed it could overrun coffee trees – it must be regularly cut • Evaluate if distance between rows of coffee is enough to incorporate the cover crop (at least 1.8 m but ideally more than 2.5 m are need) • Initially farmers had a resistance to the cover crop as is not commonly used in coffee production

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?

Drought and extreme temperatures are two hazards that are affecting many communities in the Trifinio region. One aspect identified in the impacts generated by these hazards is the extreme temperatures suffered by roots and foliage of the coffee that could cause major stress and decrease the water and

nutrient absorption. Brachiaria ruziziensis is a grass that is grown throughout the humid tropics. It had been used in regions of Brazil as a cover crop and on some Guatemalan farms. Cover crops can produce good quantities of fresh matter, needed to make mulching material deep enough to protect the soil and the plant, especially the feeder-root zone near the surface of the soil. Cajanus cajan (Gandul) is a shrub used as temporary shade, one advantage of Gandul is the high growth that allows it to provide shade for coffee, this shade reduces the temperature of the environment. It is required to do pruning every 6 months to structure a shade that benefits coffee. As a Fabacea it has the capacity to incorporate nitrogen in the soil that can be used by coffee.

Brachiaria and Gandul can generate better conditions in soil structures due to their root systems.

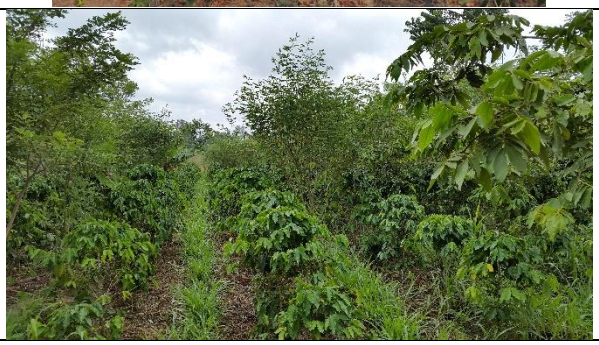
Description of climatic hazard and associated problem: Through the triangulation process (link to tool in toolbox), drought and extreme temperatures had been identified as a major climatic risk for smallholder coffee farmers in Trifinio. Drought leads to not only a high mortality of coffee seedlings in new plantations but also poor development of the plant as roots develop slowly under stress which also results in a delay of coffee production.

Description of expected outcome: Increased plant resilience against drought and heat stress through less extreme soil temperatures. Soil moisture is also conserved in the dry seasons since the grass is regularly cut and laid over the ground where it creates an insulating blanket. Quantification of the effects, short and long term is still underway. The tool may not be appropriate for all conditions, so those wishing to try this, should do so on small plots only and study the outcome closely. The current study will be continued for a further year to develop a fuller understanding of soil temperature variation and its effect on coffee.

How is the adaptation option applied?

Nr.	Step	Picture
1	Clean the field where you will plant the seedlings of Brachiaria. Coffee plantations should at least have 1.8 m in between rows but ideally more than 2.5 m are needed. Recommendation is to plant seedlings of Brachiara in coffee plantations that are younger than 2 years.	
2	Sow the Brachiaria along the length of rows, mid-way between rows of coffee trees; where necessary, plant using contour lines. Use 3 to 4 kg per hectare of Brachiaria seedlings to establish the cover crop. **Make sure it is a variety that produces only sterile seed.**	
3	Planting seedlings of Cajanus cajan (Gandul). Cleaning the field and on the coffee row plant 2 to 3 seedlings by posture. Every posture must be every 4 plants of distance and between rows planting one row with gandul and leaving one without. Usually is planted 1 pound per hectare	

4	Make sure to control aggressive weeds that could compete, taking into consideration that monitoring is required to prevent Brachiaria overrunning the coffee plantations. Always keep at least 0.25-0.5 m clear between the cover crop and the coffee branches. Cutting of weeds ideally should be done with a machete rather than chemicals.	
5	Gandul needs to be pruned starting one meter of height (around 6 months since establishment), the pruning will give structure to establish a treetop that don´t interfere with coffee development.	
6	Leave the fresh Brachiaria material after cutting between the coffee rows and where you think that coffee feeder roots are developing. Keep in mind that you should also do all the other activities of coffee production (fertilizing, pruning, shade management, spraying etc.) when necessary.	
7	If possible, measure the soil temperature. Take into consideration that most feeder roots could well be in in the first 30 cms of depth.	 

8	If possible, measure with a irrometer or other tool who reads soil humidity to establish % of water with and without cover crop to different depths.		
10	The plantation before planting the cover crop in 2014.		
11	The plantation with cover crops and Cajanus cajan (Gandul). during the rainy season in 2015.		

Implementation framework

The study was implemented by the initiative for coffee & climate (c&c) in collaboration with the farmer organization COCASANSEL. Brachiaria as cover crop had been establish as a demo-plot initially in Honduras. It was initially planted in a 2 year old coffee plantation with a traditional system (1.8 m between rows x 1 m between plants). Gandul was planted on the coffee row plant 2 to 3 seedlings by posture. Every posture must be every 4 plants of distance and between rows planting one row with gandul and leaving one without. Taking into consideration the experience of other farmers outside the project region, distance between rows should be at least 2.5 m. Demo-plots with that distance are currently being implemented also to evaluate results.

The Brachiaria demo-plot is located at 896 m.a.s.l. on slightly sloping ground where high temperatures and precipitation are the main hazards for coffee. Brachiaria was established in 2014. By January 2016, more than 30 farmers are incorporating Brachiaria as a cover crop using different scenarios (age of the coffee trees and distance between rows).

Measurement strategy for effectiveness

Indicator N°1 – Soil temperature

Indicator	Soil temperature with and without cover crop in °C
Definition	Soil temperature is the measurement of the warmth of the soil
Purpose	A moderate soil temperature is key for root development and for water and nutrient absorption.
Baseline	N/A
Target	Soil temperature below 30°C
Data collection	Soil temperature was measured at 5 cms of depth with mulching from cover crop and in a control group without mulching. Smart buttons were used to record data every 3 hours during 240 days.
Tool	Smart buttons
Frequency	Every 3 hours during 240 days
Responsible	Coordinador de c&c Director de Monitoreo y Evaluación
Reporting	Farmer and technician install smart buttons and retrieve them after 240 days, data was then transferred to software and then analysed by M&E. Where a camera was available, pictures were taken as evidence.
Quality control	C&C Coordinator had established procedure with the team. M&E and C&C Coordinator analysed the data to establish effectiveness.

Indicator N°2 – Tonnes of fresh matter produced from Brachiaria by hectare

Indicator	**Tonnes of fresh matter produced from Brachiaria by hectare**
Definition	Weight of fresh matter produced by the Brachiaria after cutting.
Purpose	Establish the amount of mulch that could be produced by the Brachiaria.

Baseline	N/A
Target	N/A
Data collection	After cutting the cover crop, the mulch of 10 square meters was weighted and then calculations for hectare were made.
Tool	Knife Scale
Frequency	Every cutting.
Responsible	M&E Director, c&c Coordinator
Reporting	Farmer and technician weight the mulch after cutting and data had been transferred to M&E for analysis. Where a camera was available, pictures were taken as evidence.
Quality control	C&C Coordinator had established procedure with the team. M&E and C&C Coordinator analyzed the data to establish effectiveness.

Indicator N°3 – Soil humidity with and without brachiaria

Indicator	% of soil humidity
Definition	Measure soil humidity with and without cover crop at 15, 20, 25 and 30 cms of depth
Purpose	Establish the % of humidity generated by mulch that could be produced by the Brachiaria and Gandul.
Baseline	N/A
Target	N/A
Data collection	During the dry season measure to different depth
Tool	Knife Scale
Frequency	Annual during the dry season
Responsible	M&E Director, c&c Coordinator
Reporting	Farmer and technician weight the mulch after cutting and data had been transferred to M&E for analysis. Where a camera was available, pictures were taken as evidence.
Quality control	C&C Coordinator had established procedure with the team. M&E and C&C Coordinator analyzed the data to establish effectiveness.

Measurement strategy for acceptability, affordability, timing & urgency

Interviews with farmers and cost analysis have been carried out to establish acceptability, affordability, timing & urgency.

Main findings of case study

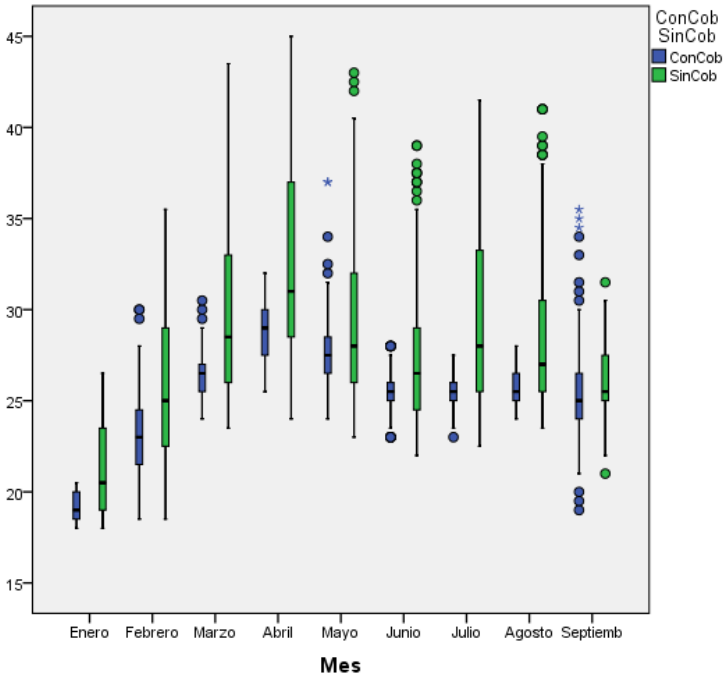
To measure the soil temperature smart buttons were installed at 5 cms depth with cover crops and without cover crops during 240 days and programing measures every 3 hours.

- Soil temperature *below the cover crop* averaged 25.9°C at 5 cm
- Soil temperature *without the cover crop* averaged 28.6°C at 5 cm

The measurements every 3 hours give the following results:

Range of temperatures	5 cm - woc	5 cm - wcc
15 - 25 °C	21%	26%
25 - 30 °C	47%	71%
30 °C y arriba	31%	3%
woc= without cover crop, wcc= with cover crop Aprox. 1,800 readings		

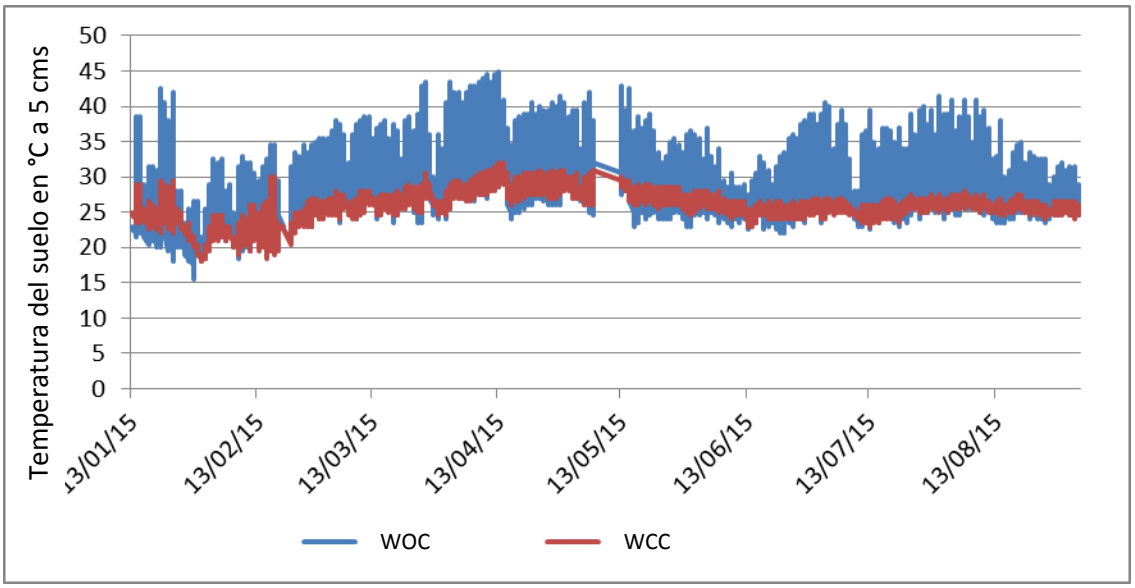
Graphic comparing soil temperature with and without cover crop:



The graph show the advantages of using cover crops to reduce the soil temperature and to maintain soil temperature below 30° Celsius.

Regarding soil temperature: Even a short period of high soil temperature can result in irreversible damage to a coffee plant. Two hours a day with a soil temperature above 33°C is enough to result in a pronounced decrease in the weight of the root system. The same exposure to temperatures of 38°C and above not only adversely affects the roots of the tree, but also their height. A constant temperature of above 33°C, similar to what we find in our validation plots without cover crops, aggravates these adverse effects on the coffee plant. (Franco 1982).

One of the biggest differences was the maximum daily temperatures, without cover crops the temperature arise many times the 30°C, the soil temperature is a critical point for water and nutrient absorption by the plant.



It is important to establish the impacts generated by maximum and minimum temperatures of the soil in coffee quality; it is possible to incorporate that variable in a feature study.

One of the key aspects using cover crops is the incorporation of organic matter as a condition who could be improved in the long term, during different cuttings of Brachiaria it has been estimated that can generated 14 tons of biomass (fresh matter), this would be around 56 tons by year, with an estimation of 15% of biomass transformed to dry matter this could be around 8.4 tons of dry matter/hectare that would be incorporated.

Brachiaria biomass generation is linked to rainfall, it is observed that during dry seasons Brachiaria diminish the biomass production.

Regarding soil humidity, measuring had been performed during February 2016, the results are:

% of soil humidity			
Depth in the soil	With Brachiaria	Without Brachiaria	Difference
15	49.7	43.7	+6
20	52.6	46.8	+5.8
25	52.7	51.8	+0.9
30	68.4	54.3	+14.1

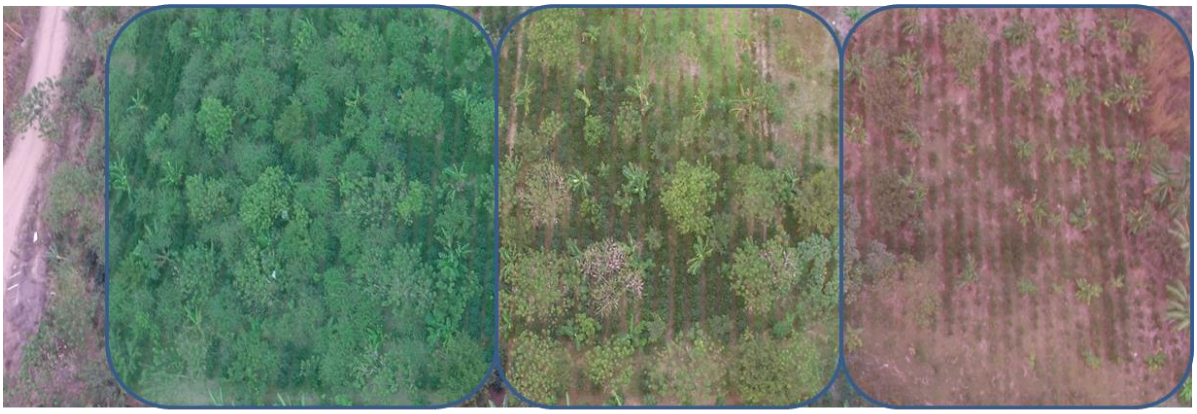
There can be a correlation between soil temperature and soil humidity, this fact had not been analyzed due to limitations in the equipment, but there is signs that cover crops could reduce evapotranspiration in the soil. c&c has recently purchase more equipment to understand this conditions.

Regarding temperature of the environment, measurements were made to understand the influence of Gandul in the temperature of the environment:

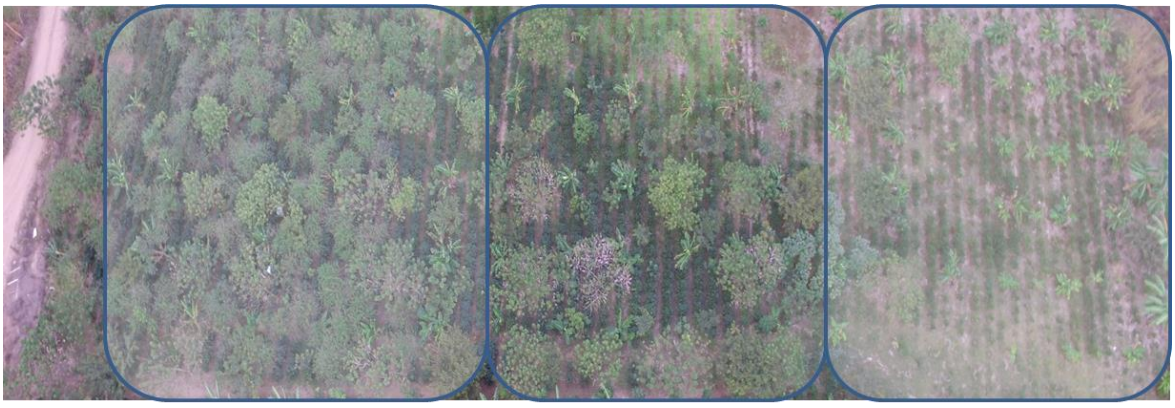
Date	Hour	With Gandul °C	Without Gandul °C	Difference
27/1/2014	2.30 p.m.	21	26	-5
18/2/2014	10.40 a.m.	19	28	-9
16/9/2015	1.20 p.m.	33	38	-5

It is suggested through the use of smartbuttons to establish the effects of temporary shade as gandul in the temperature and relative humidity.

Some images using drones had been take, in green you can find the treatment Brachiaria + Gandul, yellow you can find only Brachiaria and red without Brachiaria and Gandul:



With Brachiaria & Gandul | With Brachiaria | Without Brachiaria & Gandul



With Brachiaria & Gandul | With Brachiaria | Without Brachiaria & Gandul

Measuring plant development during September 2015 the results achieved:

Adaptation practice	Height mts	Wide mts	# beans by coffee branch	Branch with coffee /plant	Branch without coffee /plant	# coffee beans / plant
Without cover crop	1.0	0.9	26	22	6	582
With Gandul/ Brachiaria Ruziziensis	1.3	1.1	44	35	9	1541

Linking results between soil &environment temperature, soil humidity and others it is clear that plants with adaptation practices have better development. The plants with Brachiaria and Gandul are 30% taller (an average in meters of 1.3 vs 1.0), with branches better developed (in average in meters 1.1 vs 0.9 by plant). The treatment without Brachiaria and Gandul lost many plants, maybe due to high temperatures and soil humidity.

The cost for establishment and management of Brachiaria and Gandul:

Costs:

- Cost by 1 kg of Brachiaria ruziziensis : USD 20
- Cost of implementing Brachiaria by hectare: USD 60-80
- Cost of planting Brachiaria: USD 15 – 1 a 1.5 manday
- Cost for weeding without cover crop: USD 120 – 12 mandays*
- Cost for weeding with cover crop: USD 80- 8 mandays*

*For plantations of coffee below 3 years, were coffee and permanent shade do not generate enough shade to the soil and this makes that more weeding is required.

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: Farmers readily accepted this tool for implementation and continue to implement it as planned.			**Low:** Farmers generally did not accept this tool; *Or* the tool was met with resistance later on, even though farmers initially accepted it.		
Please comment:					
If there was resistance to adopting this tool, why?			It is a new practices in the region, farmers are starting to adopt it, and the ones who had work with it they are satisfied.		
If farmers discontinued tool implementation later on in the process, even though they initially			-		

accepted it, Why?	
Did this tool have any external issues or impacts (positive or negative) which influenced its acceptability? (community, value chain?)	Some producers and farmer organizations who are not part of the Project are interested in adopt the practice, also because it can decrease erosion.
Any other comments:	We are collecting data to show farmers more results and increase adoption. Further research will be conducted.

Affordability					
Leading question: Are the costs of the tool affordable to farmers taking into account the initial investment, maintenance costs and the availability of inputs?					
High	x	**Low**		**Don't know**	
High: The initial investment and the maintenance costs of this tool are affordable to farmers from their regular operations and the time it takes to recover the investment is reasonable to farmers. *Inputs (e.g. labor, electricity..) are available when they are necessary so that no extra costs are incurred from timing related issues.*			**Low:** The initial investment or the maintenance costs of this tool go beyond what is affordable to farmers from their regular operations *or the amount of time it takes to recover the investments are unreasonable to farmers*.		
Please comment:					
Are there any external costs? (to society or environment?)			None reported to the date. The biggest impact could be to not control weeding's in Brachiaria because it can spread. Monitor is required.		
If costs are high because inputs are not available, what inputs? And why?			As a new practice it has not been implemented before in the Project region, because of this is not available but some agro-services are interested in distribute it.		
Any other comments:			In general farmers had invest less in weeding's using cover crops. Further research is required.		

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.			**Low:** The tool did not fulfill its objective entirely.		
Please Comment:					
What benefits did farmers expect from this tool?			Reduce soil temperature Increase organic matter Improve soil conditions Reduce impacts of climate		
If the objective has not been met, why?			-		
Have there been any significant external issues			None during the testing		

which influenced the effectiveness (positive or negative) of this tool? Please explain.	
Any other comments about effectiveness:	Further research is required.

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 takes a reasonable amount of time to implement (taking into account the coffee growing season, inputs necessary, preparation time and implementation time); *And* this tool accrues the effects expected within a reasonable amount of time.			**Low:** It takes too long to implement this tool (taking into account the coffee growing season, inputs necessary, preparation time and implementation time); *Or* it simply takes too long for this tool to accrue benefits.		
Please comment:					
If implementation takes too long why?			-		
Any other comments about timing:			After more than one year of testing it has shown promising results.		