coffee & climate
enabling effective response

Use of grafting in coffee nurseries

Case Study Background Data		
Tool Category: Adaptation on the farm		**Details:** Planting Density: - Soil Type: - Shade Regime: - Farming System: - Yield Range (kg cherry/ha): - ⦸ **rain** : 1350 mm/y
Variety: Arabica		
Climatic Hazard: • Drought • Heat stress		
Expected Outcome: • Better resilience to the drought trough improving the root system of youth coffee trees		
Implementation Date: 01.03.15 – 01.11.15	**Altitude:** 1184 **GPS:** 14.462059°N 88.909762°W	**Slope of plots:** - ⦸ **Age of trees:** <1 years
No. Farmers: 1	⦸ **Area under coffee**: 0.5 ha/farmer	Tested on de demo plots

Results

Young coffee trees are vulnerable to drought when transplanted to the fields as the roots are still poorly developed. The initiative for coffee & climate looked for alternatives to stimulate the root system and thereby reduce mortality during transplantation. Grafting is a process were the Arabica scion is put on the top of a Robusta Rootstock, in this case a variety called Nemaya. Nemaya has the origin by crossing two coffee trees (T3561 and T3751), the characteristics are high tolerance to nematodes *Meloidogyne sp and Pratylenchus sp.* and a deep rooting system which allows to improve nutrient uptake, some cases remark that this type of root system could help in poor soils and during a lack of water.

The main differences observed were the depth of the root system, grafted plants measure 28 centimeters of length while not grafted only measure 21.5 centimeters. There was no significate difference in the width of the root system.

The weight of the plants was measured without any soil, just the coffee plant, grafted plants measure in average 11.5 grams vs 8.5 of plants that were not grated.

The root system was slightly better, 1.5 grams in grated plants vs 1, this could be an advantage as a better root system will had an impact on better development of the plant, especially in height and vegetative growth.

All the results above mentioned help us to understand the benefits of grafting in coffee, the vegetative growth and root development will be key to improve plant resilience to adverse climate conditions as high temperatures and drought. It is key to highlight that grafted plants will be evaluated in the field with the impact on vegetative growth and root development.

Pros & Advantages + Learnings	Cons, Disadvantages + Things to take into account
• Better root development • Tolerance to nematodes *Meloidogyne sp and Pratylenchus sp* • Diminish water stress • Healthy plants with better growth • A better root system will improve nutrients uptake • Reduction in use of pesticides and nematicides • It can help to increase woman participation in coffee (better skills for grafting)	• Availability of seedlings of Nemaya is limited in Honduras • People who will do grafting need to be qualified • Mortality after grafting could be high if process is not correct • It is recommended as practice below 1,400 m.a.s.l., higher altitudes could reduce growth of the rootstock • Costs are higher because the purchase of the rootstock and scion

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?

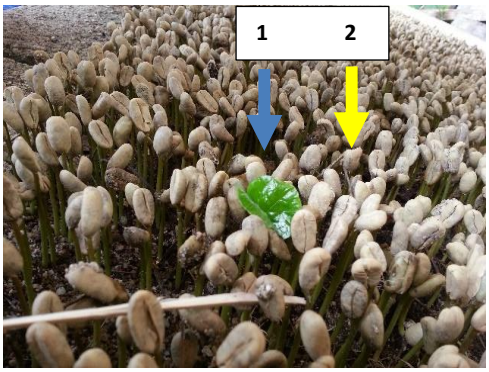
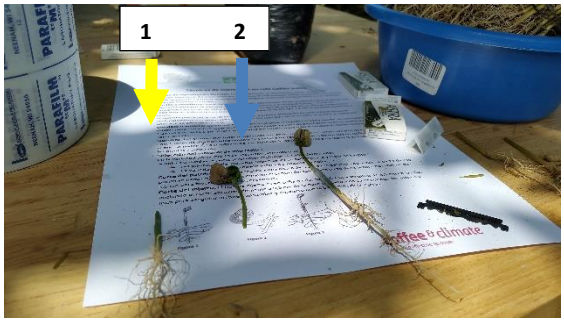
Drought and extreme temperatures are two hazards that are affecting many communities in the Trifinio region. One aspect identified in the impacts generated by these hazards is the poor root development of plants during the stage of nursery. Grafting coffee with a Robusta rootstock “Nemaya” could generate better rooting system that improve nutrient & water uptake. It is expected that grafted plants will develop better during a drought.

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 risks for smallholder coffee farmers in Trifinio. Drought leads to a high mortality of coffee seedlings in new plantations but also poor development of the plant as roots develop slowly under stress and this could also delay coffee production.

Description of expected outcome:
Improve plant resilience to drought through a better root system.

How is the adaptation option applied?

Nr.	Step	Picture
1	Establish seddlings of the robusta Nemaya 7 to 14 days before the one that you would like as scion. Scion should be established 7 to 14 days later than the rootstock	
2	After 60 to 70 days of planting the rootstock and 50-60 days of the scion, grafting process will happen. The rootstock (nemaya) must be with leaves (first leaves) - #1 in the picture. The scion (productive part) must be inside the coffee parchment - #2 in the picture	
3	With the rootstock, you cut the stem around 5 cms above were the root begins. Just in the middle of the stem you cut two centimeters with direction to the root - #1 in the picture The scion, you cut it at 5 cms below the bean. With the stem from opposite side of the bean you do a cutting of 2 cms creating a wedge #2 in the picture	

4	Joining the two separate plants (rootstock and scion) with a budding tape called parafilm (a biodegradable material that is not required to remove after the process) or any material that don´t allow water to access the junction. During grafting process plants already grafted should not let to dehydrate before transplanting.	
5	Root system of a robusta rootstock “nemaya”	
6	Before planting in the field it is recommended to clean the soil were you will plant by your most effective method. You plant the grafted coffee tree into the bag and continue the management in the nursery	

7	Grafting is an activity that generate woman participation. Some cases in Guatemala highlight that woman had won grafting competitions. Number of plants grafted by day can vary depending on the expertise of the grafter between 200 to 1000 grafting's/day.	
8	Grafted plant (left) vs Not grafted plant (right)	
9	Scale to measure the weight of coffee plants and compare between grafted and not grafted	

Implementation framework

The study was developed by the initiative Coffee&Climate (c&c) in cooperation with the Cooperative Flor del Pino in Ocotepeque, Honduras. The cooperative is located at 1,184 m.a.s.l. Through the assessment with farmers about different conditions that increase their vulnerability to climate change, poor root development in youth coffee trees was identified as a condition. Grafting was carried on in all the stages, since the planting of seedlings until planting the grafted plants in the field. A research made

by c&c establish that grafted plants could improve the quality of the plants and especially the root system (using robusta rootstock Nemaya).

Seedlings was purchased at ANACAFE in Guatemala, to warranty the quality (Robusta has a lot of cross pollination and a bad propagation could generate that not all the characteristics required are attributed in the Nemaya variety). Farmers were trained in grafting skills.

Measurement strategy for effectiveness

Measurements were made at different stages of plant development, the first was carried after 60 days of planted and second measurement was made finalizing the nursery stage, just before sending to the field.

Seedbed – This was prepared in the traditional way using sand of river and covering with dry grass for germination period. After 60 days when the coffee plant is ready to be grafted measurements were taken, length of root was measured.

Nursery – After making the grafting plants are send to the field in individual bags, all the activities (irrigation, fertilization, spraying for nutrition and pest and control disease was accomplish according to management plan). After 5 months in the bag, coffee trees were measured to compare grafted and not grafted, both were washed to clean to evaluate the root system.

Indicator N°1 – Length of root

Indicator	Length of root
Definition	a. Measurement of length (in cms) of root during seedbed after 60 days of planting b. Measurement of length (in cms) of root in the nursery after 150 days of planted in the bag comparing plants grafted and not grafted
Purpose	Improve the root development to increase capacity of the plant to uptake water and nutrients
Baseline	N/A first evaluation
Target	The root system is equal or better than plants without grafting
Data collection	The data was collected through demonstration plots with a control group (no grafting) and treatment (grafting): **Seedbed:** Plants for rootstock and plants without grafting

	Nursery: Before planting in the field, measure plants with grafting and no grafting
Tool	Measuring tape Data collection template (length, wide and weight)
Frequency	**Seedbed:** After 60 days of planted (or when transplanting to nursery bag) **Nursery:** After 150 days in the nursery comparing plants with and without grafting – measure was before transplanting to the field
Responsible	c&c Coordinator c&c Technician
Reporting	Farmer and technician measure the root system and fill the data collection template to compare the results between seedbed and nursery of plants with and without grafting. Where a camera was available, pictures were taken as evidence. The results are share through farmer fieldschools and trainings in the farm
Quality control	c&c Coordinator had established procedure with the team. c&c Coordinator analyzed the data to establish effectiveness.

Indicator N°2 – Wide of root

Indicator	Wide of root
Definition	a. Measurement of wide (in cms) of root in the nursery after 150 days of planted in the bag comparing plants grafted and not grafted
Purpose	Improve the root development to increase capacity of the plant to uptake water and nutrients
Baseline	N/A first evaluation
Target	The root system is equal or better than plants without grafting
Data collection	The data was collected through demonstration plots with a control group (no grafting) and treatment (grafting): **Nursery:** Before planting in the field, measure plants with grafting and no

	grafting
Tool	Measuring tape Data collection template (length, wide and weight)
Frequency	**Nursery:** After 150 days in the nursery comparing plants with and without grafting – measure was before transplanting to the field
Responsible	c&c Coordinator c&c Technician
Reporting	Farmer and technician measure the root system and fill the data collection template to compare the results between seedbed and nursery of plants with and without grafting Where a camera was available, pictures were taken as evidence. The results are share through farmer fieldschools and trainings in the farm
Quality control	c&c Coordinator had established procedure with the team. c&c Coordinator analyzed the data to establish effectiveness.

Indicator N°3 – Weight of root

Indicator	Weight of root
Definition	a. Measurement of weight (in grams) of root in the nursery after 150 days of planted in the bag comparing plants grafted and not grafted
Purpose	Improve the root development to increase capacity of the plant to uptake water and nutrients
Baseline	N/A first evaluation
Target	The plants grafted are heavier than without grafting
Data collection	The data was collected through demonstration plots with a control group (no grafting) and treatment (grafting):

	Nursery: Before planting in the field, measure plants with grafting and no grafting
Tool	Scale Data collection template (length, wide and weight)
Frequency	**Seedbed:** After 60 days of planted (or when transplanting to nursery bag) **Nursery:** After 150 days in the nursery comparing plants with and without grafting – measure was before transplanting to the field
Responsible	c&c Coordinator c&c Technician
Reporting	Farmer and technician measure the root system and fill the data collection template to compare the results between seedbed and nursery of plants with and without grafting Where a camera was available, pictures were taken as evidence. The results are share through farmer fieldschools and trainings in the farm
Quality control	c&c Coordinator had established procedure with the team. c&c Coordinator analyzed the data to establish effectiveness.

Measurement strategy for acceptability, affordability, timing & urgency

The information will be discussed with farmer organizations and farmers to evaluate their perception on the results of grafting coffee.

Costs:

Seedbed – 1000 plants in 1 square meter of Nemaya rootstock and 1000 plants of traditional variety in 1 square meter

1 pound of Nemaya – USD 5 – by plant is 0.05 USD

1 pound of traditional variety – USD 4 – by plant is 0.04 USD

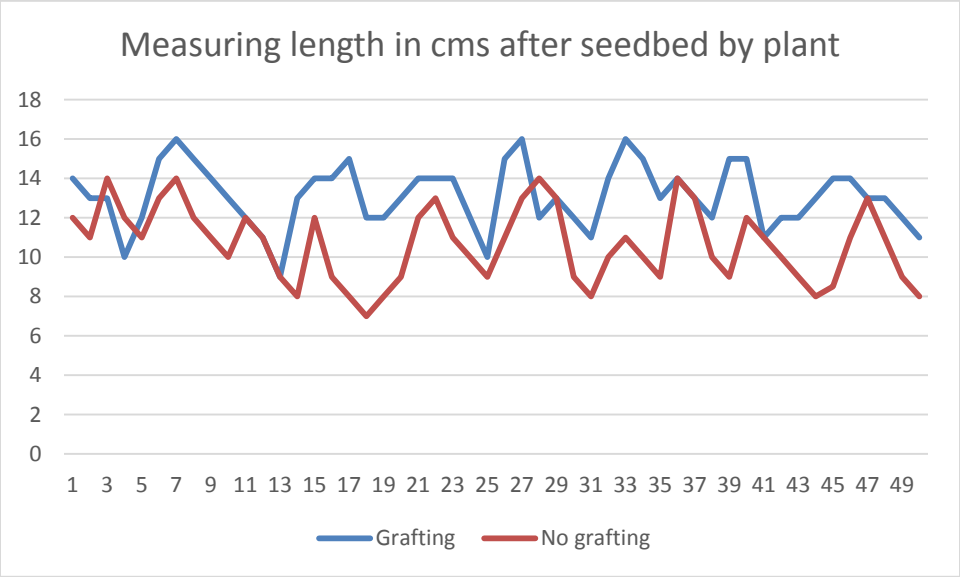
Nursery

Labour for grafting is USD 15 per 1000 plants, each plant cost is 0.015 USD

Cost of seedling and labour for grafting is USD 0.02

Main findings of case study

Variables compared are height, wide and weight. In the case of height the results after 60 days in the seedbed:



The plants grafted (Nemaya) were in average 2.5 longer than without grafting during seedbed. One aspect to consider is that plants below 9 cms of height were discard by quality reasons, 16% of plants without grafting were lost.

During nursery two plants were measured by washing the root system:

		Height of the plant- cms.	wide planta- cms.	Height of the root- cms.	Wide of the root- cms.	Weight total - grs	Weight foliage - grs	Weight of root - grs
Grafting	1	21	26	28	17.5	12	10	2
	2	21	25	29	13.5	11	10	1
No grafting	1	20	25	19	13	9	8	1
	2	20	27	24	17	8	7	1

The main differences were the height of the root system, grafted plants measure 28.5 cms vs 21 without grafting and the wide of the root values are similar. Other variables are weight of the plants, plants

grafted measure 11.5 grams vs 8.5 without. Foliar weighted 10 for grafted plants and 7.5 without grafting, root system measure 1.5 with grafting and 1 without grafting. This could be key as a better root system will help to develop better the plant, especially in height and vegetative growth.

All the results mentioned above will help us to understand how grafting will help to develop better plants with more resilience to climate hazards, especially to high temperatures and drought. It is key to highlight that this plants will continue to be evaluated in the field, variables as vegetative growth and root system will be measured.

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?			No, but trainings were required on the practice as it has not been tested before in the region		
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?)			IHCAFE and c&c are currently testing grafting in the research center in Copán. This generate expectations by technicians and farmers with this tool. The impacts of climate hazards as ENSO will generate a better acceptability of this practice because farmers look for alternatives due to impacts of climate hazards		
Any other comments:			Quality of seedlings especially of Robusta Nemaya must be warranty		

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?)			No, the practice could even decrease the cost of applying nematicides, this could even have an impact in the environment		
If costs are high because inputs are not available, what inputs? And why?			-		
Any other comments:			-		

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?			A better root system will help to: Reduce the stress of a drought Improve water and nutrient uptake Reduce the attack of nematodes		
If the objective has not been met, why?			It is important to continue research once that plants are transfer to the field. It is recommended to include more evaluations with statistical analysis.		
Have there been any significant external issues which influenced the effectiveness (positive or negative) of this tool? Please explain.			-		
Any other comments about effectiveness			More analysis on plant development 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:			Further research required, especially at field level.		