ICO Seminar on the Coffee Berry Borer
17 March 2009

Coffee Berry Borer in Latin America and the Caribbean: Advances in Colombia

By: Gabriel Cadena Gómez Ph.D.
Director of CENICAFÉ

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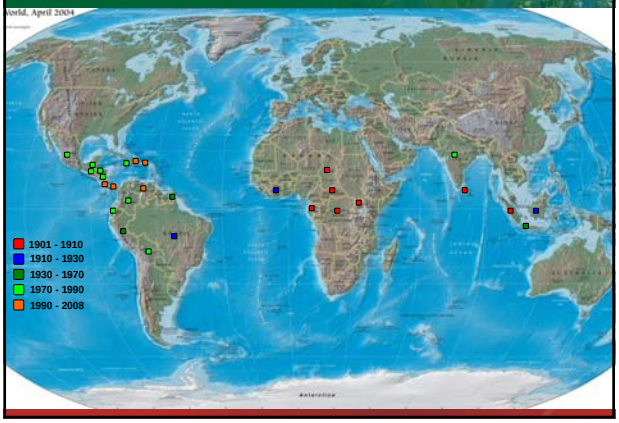
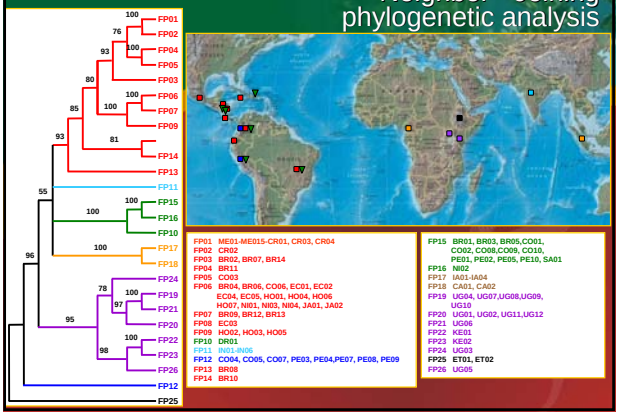


Neighbor - Joining phylogenetic analysis



FP01	ME01-ME015-CR01, CR03, CR04
FP02	CR02
FP03	BR02, BR07, BR14
FP04	BR11
FP05	CO03
FP06	BR04, BR06, CO06, EC01, EC02 EC04, EC05, HO01, HO04, HO06 HO07, NI01, NI03, NI04, JA01, JA02
FP07	BR09, BR12, BR13
FP08	EC03
FP09	HO02, HO03, HO05
FP10	DR01
FP11	IN01-IN06
FP12	CO04, CO05, CO07, PE03, PE04,PE07, PE08, PE09
FP13	BR08
FP14	BR10
FP15	BR01, BR03, BR05,CO01, CO02, CO08,CO09, CO10, PE01, PE02, PE05, PE10, SA01
FP16	NI02
FP17	IA01-IA04
FP18	CA01, CA02
FP19	UG04, UG07,UG08,UG09, UG10
FP20	UG01, UG02, UG11,UG12
FP21	UG06
FP22	KE01
FP23	KE02
FP24	UG03
FP25	ET01, ET02
FP26	UG05

Distribution of the 26 fingerprints

Molecular fingerprints

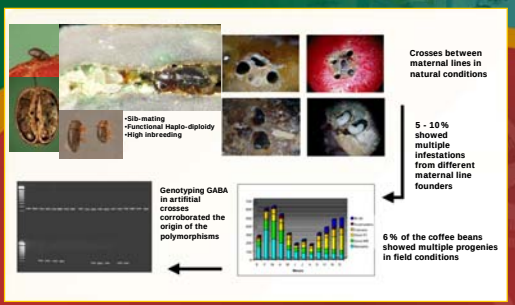
Fingerprint	Sample and country
FP01	ME01-ME015-CR01, CR03, CR04
FP02	CR02
FP03	BR02, BR07, BR14
FP04	BR11
FP05	CO03
FP06	BR04, BR06, CO06 EC01, EC02, EC04, EC05 HO01, HO04, HO6, HO07 NI01, NI03, NI04, JA01, JA02
FP07	BR09, BR12, BR13
FP08	EC03
FP09	HO02, HO03, HO05
FP10	DR01
FP11	IN01-IN06
FP12	CO04, CO05, CO07 PE03, PE04, PE07, PE08, PE09
FP13	BR08
FP14	BR10
FP15	BR01, BR03, BR05, CO01, CO02 CO08, CO09, CO10, PE01, PE02 PE05, PE10, SA01
FP16	NI02
FP17	IA01-IA04
FP18	CA01, CA02
FP19	UG04, UG07, UG08, UG09, UG10
FP20	UG01, UG02, UG11, UG12
FP21	UG06
FP22	KE01
FP23	KE02
FP24	UG03
FP25	ET01, ET02
FP26	UG05

September 1988: Tumaco
May 1989: Ancuyá
October 1989: La Plata
March 1990:Ansermanuevo
June 1990: Vegachí
July 1990: Páez
September 1990: Pradera

1991: Coffee Central Region

Advances on the biology of CBB

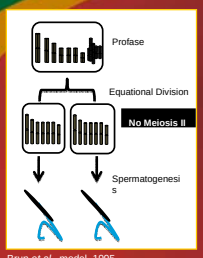
outbreeding



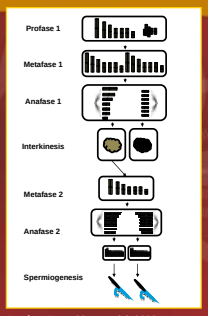
These results indicate out-crossing events in natural conditions in Colombia and would allow the use of a genetic control approach

MEIOSIS IN THE CBB EVALUATED BY MEANS OF CYTOLOGICAL ANALYSIS:

Meiosis in CBB males indicates no visible recombination and the presence of every stage of the Meiosis II. These results are controversial from what was previously reported

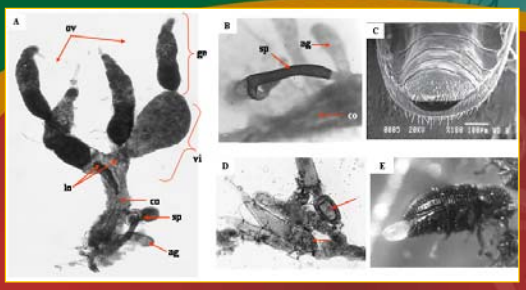


Brun *et al.*, model, 1995



Berrío & Benavides, model, 2008

The Reproductive Tract of *Hypothenemus hampei*



JD Rubio, AE Bustillo, LF Vallejo, JR Acuña, P Benavides. 2007.

Dispersal of *Hypothenemus hampei* During Coffee Plant Renovation

Castaño *et al.* 2002

Mean coffee berries per site (0,5m²) and CBB infestation, according to the ripe stage of the coffee berries during coffee plant renovation

Coffee berry stage	Total coffee berries	Infested coffee berries	CBB infestation level
Unriped	538,8 a	56,4 a	10,5 a
Riped	40,3 b	18,0 b	44,7 b
overripped	19,3 b	7,8 c	40,4 c

* Mean followed by different letters indicates statistical difference under a 5% Tukey comparison Test

Mean CBB individuals per berry per site (0,5m²) at different coffee berry ripeness during the renovation of coffee plantations

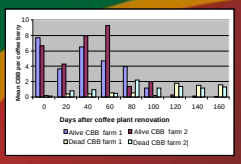
	CBB individuals			
Coffee berry stage	Eggs	Larvae	Pupae	Adults
Unriped	1,5a	1,5a	1,3ª	1.5a
Riped	1,6a	2,3b	1,6b	1.6a
Overripped	1,9b	1,7a	1,5ab	1,6a

* Means followed by different letters indicates statistical difference under a 5% Tukey comparison test

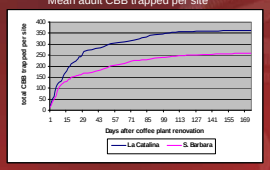
Dispersal of *Hypothenemus hampei* During Coffee Plant Renovation

Castaño *et al.* 2002

CBB individuals into coffee berries on the ground after coffee plant renovation



Mean adult CBB trapped per site



2'575,667 y 3'617,000 CBB adults trapped per hectare

Impact of The CBB Infested Coffee Berries on the Ground Over the CBB Levels in the Trees

TREATMENTS

T1: 1 infested coffee berry on the ground (TTO 1)

T2: 5 infested coffee berry on the ground (TTO 5)

T3: 10 infested coffee berry on the ground (TTO 10)

T4: 15 infested coffee berry on the ground (TTO 15)

T5: 20 infested coffee berry on the ground (TTO 20)

T0: Control (TTO 0)

15 replications per treatment

LOCATION

Paraguaicito, Quindío, 1218 m.a.s.l.

Naranjal, Caldas, 1381 m.a.s.l.

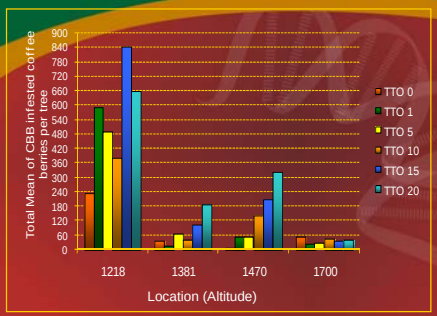
La Bella, Quindío, 1470 m.a.s.l.

Santacruz, Risaralda, 1700 m.a.s.l.

CBB trapped every 10 days using sticky traps

CBB infestation level and total number of infested coffee berries every 30 days

Total mean CBB infested berries per tree during a six month period in four locations



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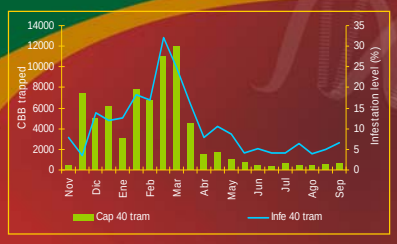
Alcohol traps to monitor CBB in the field: Ethological approach



Total adult CBB trapped and tree infestation level

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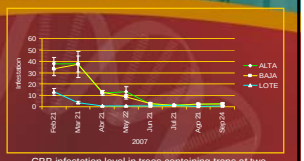
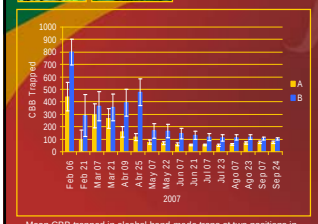
Alcohol traps to monitor CBB in the field: Ethological approach



CBB infestation level in trees containing traps at two positions: 1.5m and 0.40m and CBB infestation level in the experimental plot



Mean CBB trapped in alcohol hand-made traps at two positions in the trees : 1.5m (A) and 0.40m (B) throughout a calendar year
A:125 ± 8
B: 247 ± 13

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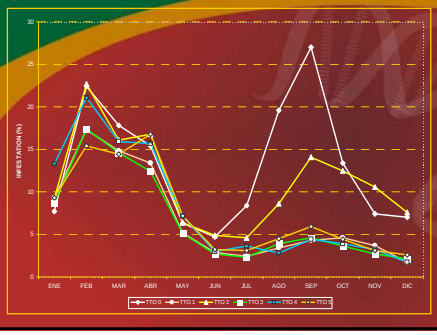
Contribution of Cultural, Chemical and Biological Approaches in the Control off CBB

CBB LEVEL IN THE FIELD



T0:Control (traditional harvest)

T1:Cultural control

T2: Chemical control

T3:Cultural + Chemical

T4:Cultural + *B. bassiana*

T5:Cultural + Chemical + *B. bassiana*

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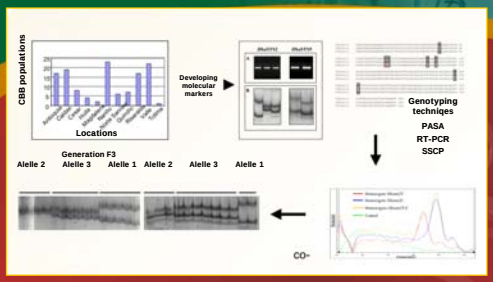
Molecular techniques to develop CBB markers in advancing biology, genetics and ecology



There are eight molecular markers being used in addressing biological and genetic issues of the coffee berry borer, and two being developed to address dispersal patterns in the field

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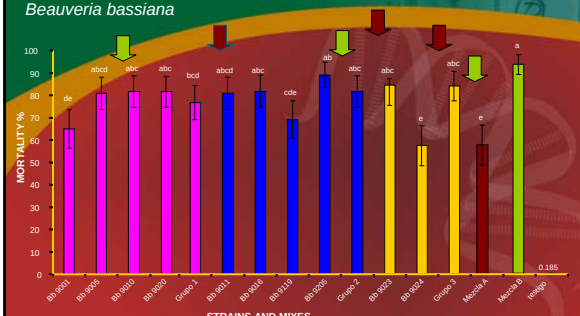
IPM approaches: Biological control

Beauveria bassiana



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Biological Control

Treatment	CBB Mortality by *B. bassiana*	
	Mean (%)	C. V. (%)
Bb 9020	53.14 b	8.70
Bb 9023	55.49 ab	16.20
Bb 9205	59.60 ab	11.41
Bb 9001	54.13 ab	15.51
Bb 9119	58.28 ab	16.41
Bb 9024	55.10 ab	21.91
Mix A (Bb 9020 + Bb 9023 + Bb 9205)	60.22 ab	11.52
Mix B (Bb 9001 + Bb 9119 + Bb 9024)	**66.63 a**	**15.82**
Commercial strain	56.63 ab	17.67
Control within the plot	19.46	63.89
Control outside the plot	8.37	63.72

EXPERIMENT I
Cárdenas et al. 2007

CBB Mortality in the field by *B. bassiana* (2 x 10^7 espores/branch)

EXPERIMENT II
Bastidas et al. 2007

CBB Mortality in the field by *B. bassiana* (2 x 10^7 espores/branch)

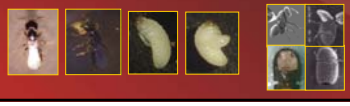
Treatment	CBB Mortality	
	x	SE
Prepared 3	25,5bc*	3,6
Prepared 4	**32,3b**	3,9
Commercial control (on rice)	**62,2a**	**4,9**
Pure spores	**15c**	3,3
Control within the plot	4,2d	0,8
Control outside the plot	4d	0,9

EXPERIMENT III *Bernal et al. 1999*
30% mortality of adult CBB from infested coffee berries on the ground

Biological Control

Parasitoids as a CBB control strategy

Municipality	Number of released individuals in the field in Colombia *C. stephanoderis* Oct 1994 - Sep 2000	*P. nasuta* Nov 1997 - Sep 2000	*P. coffea* Oct 1999 - Sep 2000
Antioquia	73.860.108	25.079.000	-
Boyacá	8.342.820	2.400.000	-
Caldas	870.961.127	324.997.000	916.925
Caquetá	1.550.800	800.000	-
Cauca	46.629.892	32.950.000	-
Cesar	3.024.060	-	-
Cundinamarca	64.532.180	12.000.000	-
Huila	49.042.540	15.600.000	-
Magdalena	5.669.144	3.320.000	-
Meta	6.132.930	1.480.000	-
Nariño	10.858.008	600.000	-
Quindío	205.390.906	23.217.000	202.500
Risaralda	218.837.910	27.050.000	718.550
Santander	158.117.498	31.518.000	-
Norte de Santander	1.628.340	80.000	-
Tolima	39.517.351	2.650.000	-
Valle	80.928.517	12.500.000	-
Total	**1.845.024.131**	**516.241.000**	**1.837.975**



Biological Control

Genetic Variability and Biological Performance of *Prorops nasuta* in samples collected in Colombia

State	Municipality	present/total sampled	Parasitism
Norte de Santander 80.000 ind	Pamplonita	2/2	0,74% - 3,78%
	Chinácota	2/3	1,02% - 3,25%
	Bochalema	0/1	0%
	Total	**4/6**	**66,67%**
Caldas 324.997.000 ind	Palestina	6/8	0,49% - 10,2%
	Chinchiná	1/1	1,85%
	Manizales	1/2	1,20%
	San José	1/3	0,25%
	Risaralda	0/3	0%
	Total	**9/18**	**50,00%**
Risaralda 27.050.000 ind	Pereira	2/7	0,5% - 1,38%
	Marsella	0/5	0%
	Total	**2/12**	**16,67%**
Quindío 23.217.000 ind	Pueblo Tapao	0/1	0%
	Quimbaya	4/10	0,5% - 3,5%
	Buenavista	1/2	0,50%
	Montenegro	1/1	3,75%
	Total	**6/14**	**42,86%**
Nariño 600.000 ind 12.500.000 ind	Sandoná	11/11	13,43% - 29,9%
	Consacá	10/10	1,5% - 50%
	Ancuyá	10/10	2,36% - 21,63%
	Total	**31/31**	**100,00%**
Valle	Pance	1/1	-
Cesar	Jagua de Ibirico	2/2	-
	Gran Total		**65,06%**

Biological performance

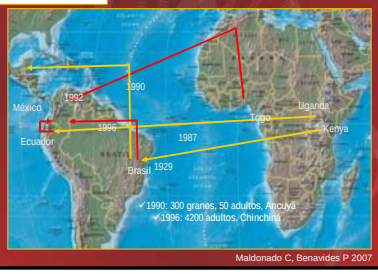
Locality	Predatorism Parasitism	Eggs	Longevity adults	Larvae	Adults
Sandoná	Low	High	High	High	Middle
Consacá	Low	Middle	Middle	Low	Middle
Quindío	Low	Low	High	Middle	Low
Caldas	Low	Low	High	Middle	Middle
Norte de Santander	Middle	Middle	Low	Middle	Low
Cenicafé	High	Middle	High	High	High

Molecular fingerprints of *P. nasuta* sampled in Colombia

Maldonado C, Benavides P 2007

Biological Control

Correspondence analysis



Maldonado C, Benavides P 2007

Collecting parasitized CBB infested coffee berries

Ensure the establishment of the parasitoids in the field: *Prorops nasuta*

Biological Control

Native Predators

***Monanus* sp.**
(Col: Cucujidae)

Two native predator species with potential as CBB control strategy

***Crematogaster* sp.**
(Hym: Formicidae)

NEXT: Biology aspects

Vera L, Gil Z, Benavides P 2007

Chemical Control

Biorational insecticides for the Control of Coffee Berry Borer in Colombia

Main characteristics of biorational insecticides

- Lethal effect under low dosis
- Very specific
- Decompossed quickly
- Low levels of toxicity
- Low environmental impact

Chemical Control
Mean CBB Mortality in Field Conditions

Treatment		Mortality days after spraying		
No.	Code	1	3	8
1	ENTBIO 1	98.5 A	97.1 A	96.6 A
2	ENTBIO 2	61.0 B	54.0 B	57.8 C
3	ENTBIO 3	98.2 A	98.6 A	96.1 A
4	ENTBIO 4	66.6 B	69.4 B	74.0 B
5	ENTBIO 5	6.4 C	13.0 D	5.78 D
6	Control	1.3 C	1.54 E	1.44 D

Villalba D. 2007

Chemical Control
Efficacy of the ENTBIO 6 Insecticide for the control of CBB

Treatment		Mean Mortality* Days after spraying			
No.	Code	1	3	8	15
1	ENTBIO6 - 500*	90.43 A	95.04 AB	79.93 B	75.79 C
2	ENTBIO6 - 1.000	94.09 A	84.13 C	94.61 A	85.52 BC
3	ENTBIO6 - 1.500	94.76 A	93.25 AB	92.79 A	88.30 AB
4	ENTBIO6 - 2.000	95.19 A	88.59 BC	94.13 A	93.56 AB
5	ENTBIO6 - 2.500	93.27 A	99.80 A	97.00 A	89.59 AB
6	ENTBIO6 - 4.000	95.62 A	96.81 A	97.67 A	98.75 A
7	Lorsban 4 EC	96.03 A	97.94 A	87.95 AB	87.11 ABC
8	Control	2.58 B	3.42 D	1.40 C	2.52 D

* Dosis: cc/ha

PROYECTIONS
- Dosis
- Residual effect
- Commercial Plots
- Residues
- Side effects

Villalba D, Yandar S 2007

Traits of interest in Colombian Coffee breeding


Yield


Cup quality




Coffee Berry Borer control



Resistance to *Colletotrichum kahawae*


Resistance to Coffee Rust

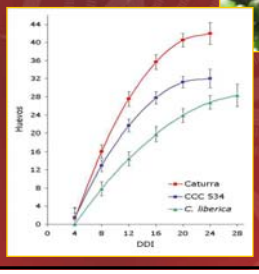
Coffee Berry Borer resistance

Genomic Strategies To Detect Genes Involved In Resistance To The Coffee Berry Borer *Hypothenemus hampei*

Evaluation of resistant sources in *Coffea* >900 accessions were field evaluated.

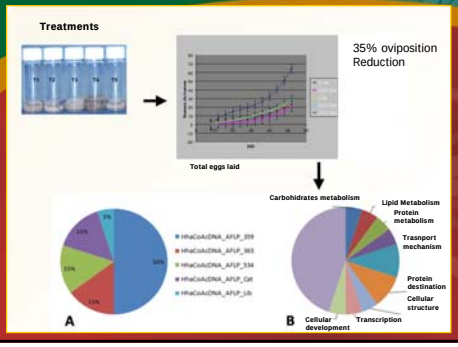
Seven wild accessions of *Coffea liberica* and *C. arabica* showed antibiosis against the insect (Decreased fecundity 27% - 35% vs. control).

Similar results have been obtained using artificial diets developed by CENICAFE.

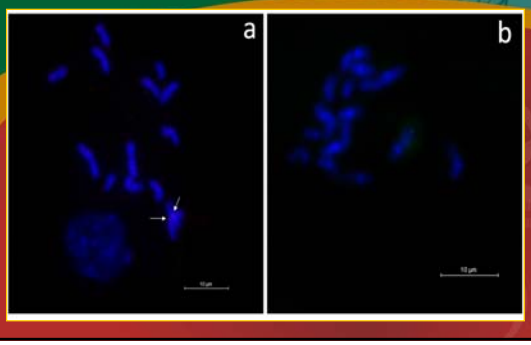


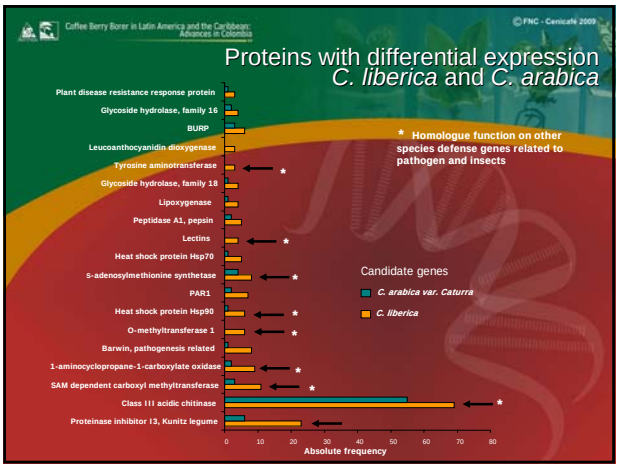
Coffee Berry Borer resistance

CBB Gene Expression to Antibiosis Compounds from coffee seeds



FISH on CBB chromosomes indicating the presence of *Mannanase* in *H. hampei* and it is absence in *H. obscurus*

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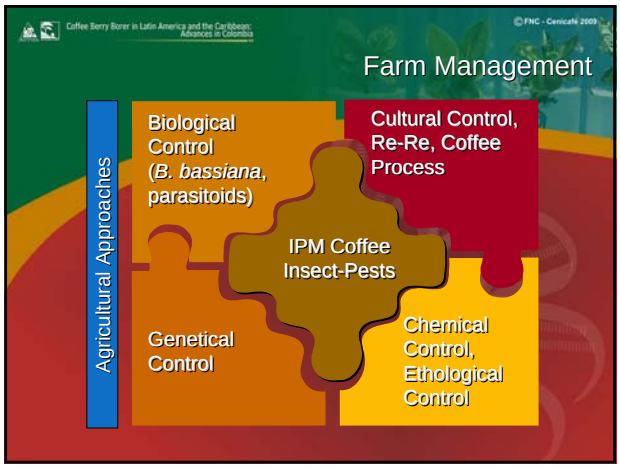
Proteins with differential expression
C. liberica and C. arabica
Plant disease resistance response protein
Glycoside hydrolase, family 16
BURP
Leucoanthocyanidin dioxygenase
Tyrosine aminotransferase
Glycoside hydrolase, family 18
Lipoxygenase
Peptidase A1, pepsin
Lectins
Heat shock protein Hsp70
s-adenosylmethionine synthetase
PAR1
Heat shock protein Hsp90
O-methyltransferase 1
Barwin, pathogenesis related
1-aminocyclopropane-1-carboxylate oxidase
SAM dependent carboxyl methyltransferase
Class III acidic chitinase
Proteinase inhibitor I3, Kunitz legume
* Homologue function on other species defense genes related to pathogen and insects
Candidate genes
C. arabica var. Caturra
C. liberica
0 10 20 30 40 50 60 70 80
Absolute frequency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Farm Management
Agricultural Approaches
Biological Control (B. bassiana, parasitoids)
Cultural Control, Re-Re, Coffee Process
IPM Coffee Insect-Pests
Genetical Control
Chemical Control, Ethological Control


Thank you