



XXIV SIMPOSIO
LATINOAMERICANO
DE CAFICULTURA

El transcriptoma del café ante el estrés por la roya



Tecnológico
de Costa Rica



TEXAS A&M
UNIVERSITY.



WORLD COFFEE
RESEARCH



TEXAS A&M
UNIVERSITY.

Echeverría-Beirute, Fabián;

Klein, Patricia E.;

Bertrand, Benoit;

Murray, Seth C.



Aquiares



USAID
FROM THE AMERICAN PEOPLE



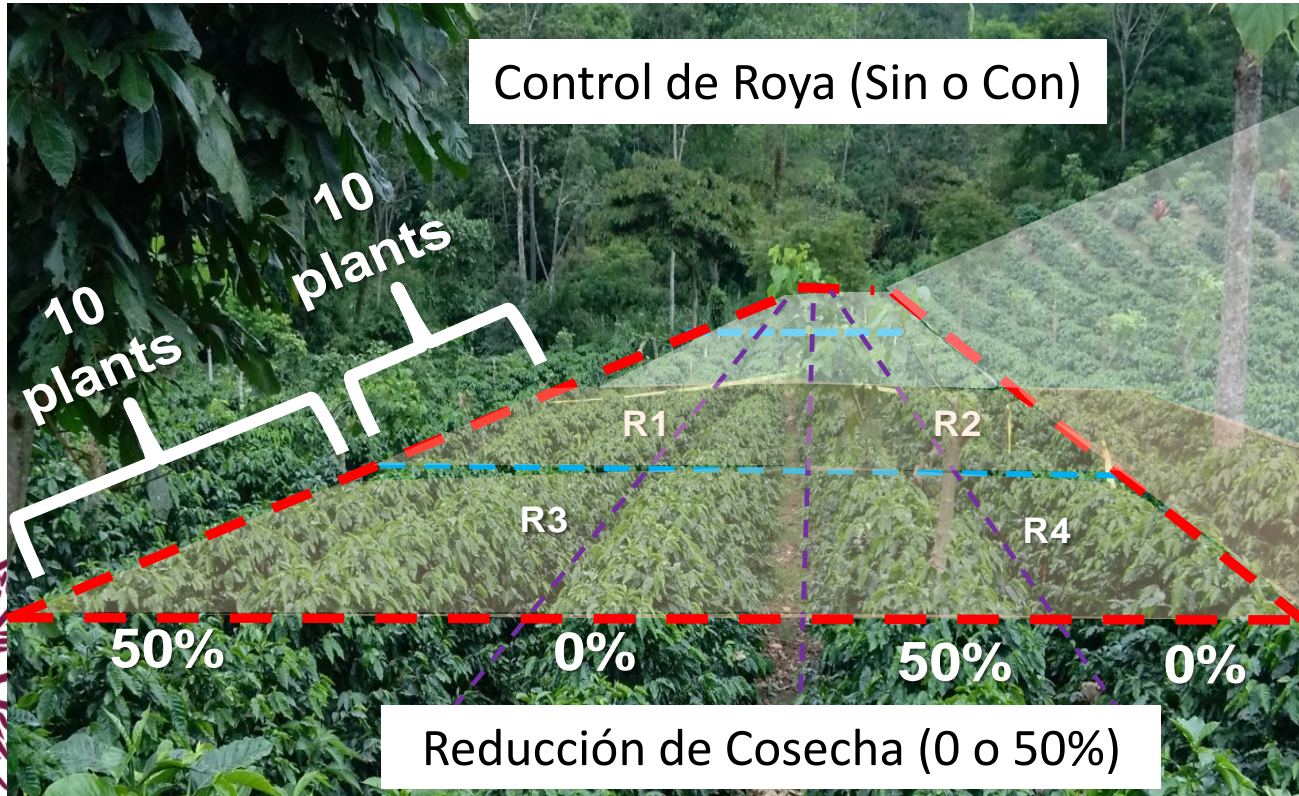


Resistente

PROBLEMA

Susceptible





		Cultivar																Main plot	
		Inbred								Hybrid								Sub-sub-plot	
		Thinning				Thinning				Thinning				Thinning					
		50%		25%		50%		25%		50%		25%		50%		25%			
1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	Row			
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	1	Rust control	1
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	2		2
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	3		3
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	4		4
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	5		5
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	6		6
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	7		7
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	8		8
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	9		9
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	10		10
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	11	11	
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	12	12	
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	13	13	
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	14	14	
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x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	24	24	
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x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	49	49	
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	50	50	
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	51	51	
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	52	52	
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	53	53	
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	54	54	
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	55	55	
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x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	60	60	
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	61	61	



XXIV SIMPOSIO
LATINOAMERICANO
DE CAFICULTURA

**0% Reducción Cosecha
Sin Control Roya**

Octubre, 2015

**50% Reducción Cosecha
Sin Control Roya**





XXIV SIMPOSIO
LATINOAMERICANO
DE CAFICULTURA

**0% Reducción Cosecha
Sin Control Roya**

Enero, 2016

**50% Reducción Cosecha
Sin Control Roya**





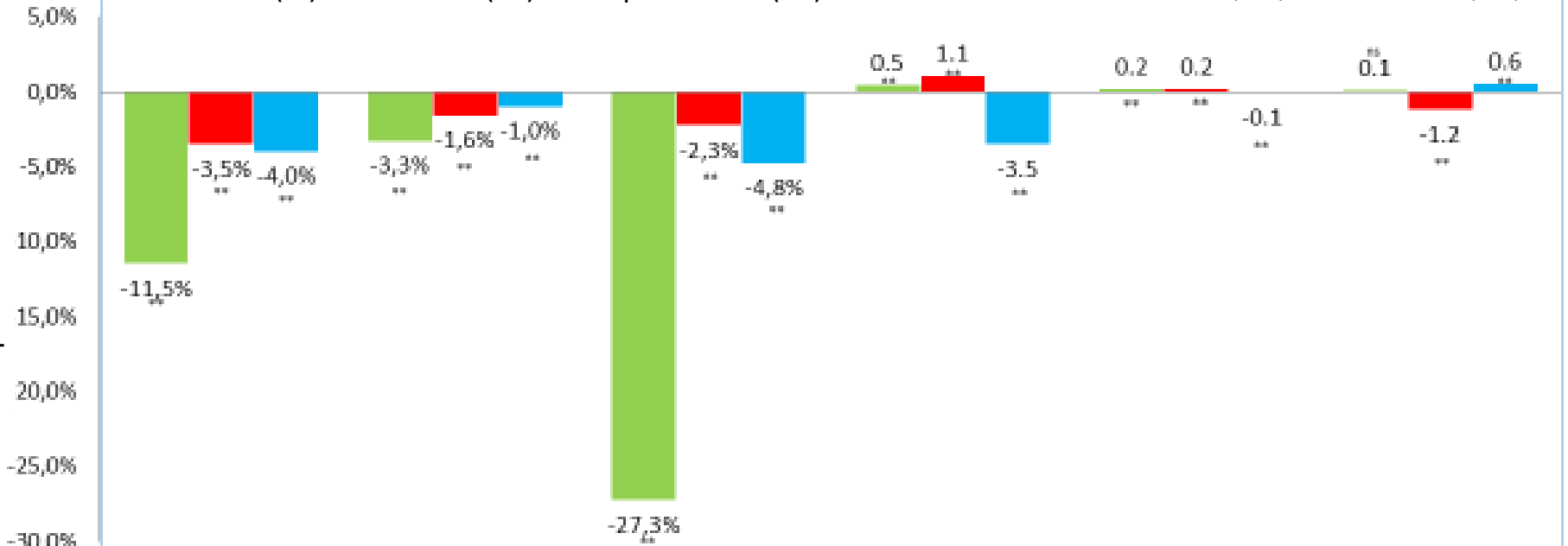
Tratamientos

■ Control de roya (si) ■ Reducción carga fructífera (50%) ■ Cultivar (híbrido F1)

Parámetros evaluados

Incidencia (RI) Severidad (RS) Esporulación (RE) Hojas (TL) Condición (OC) Cosecha (TH)

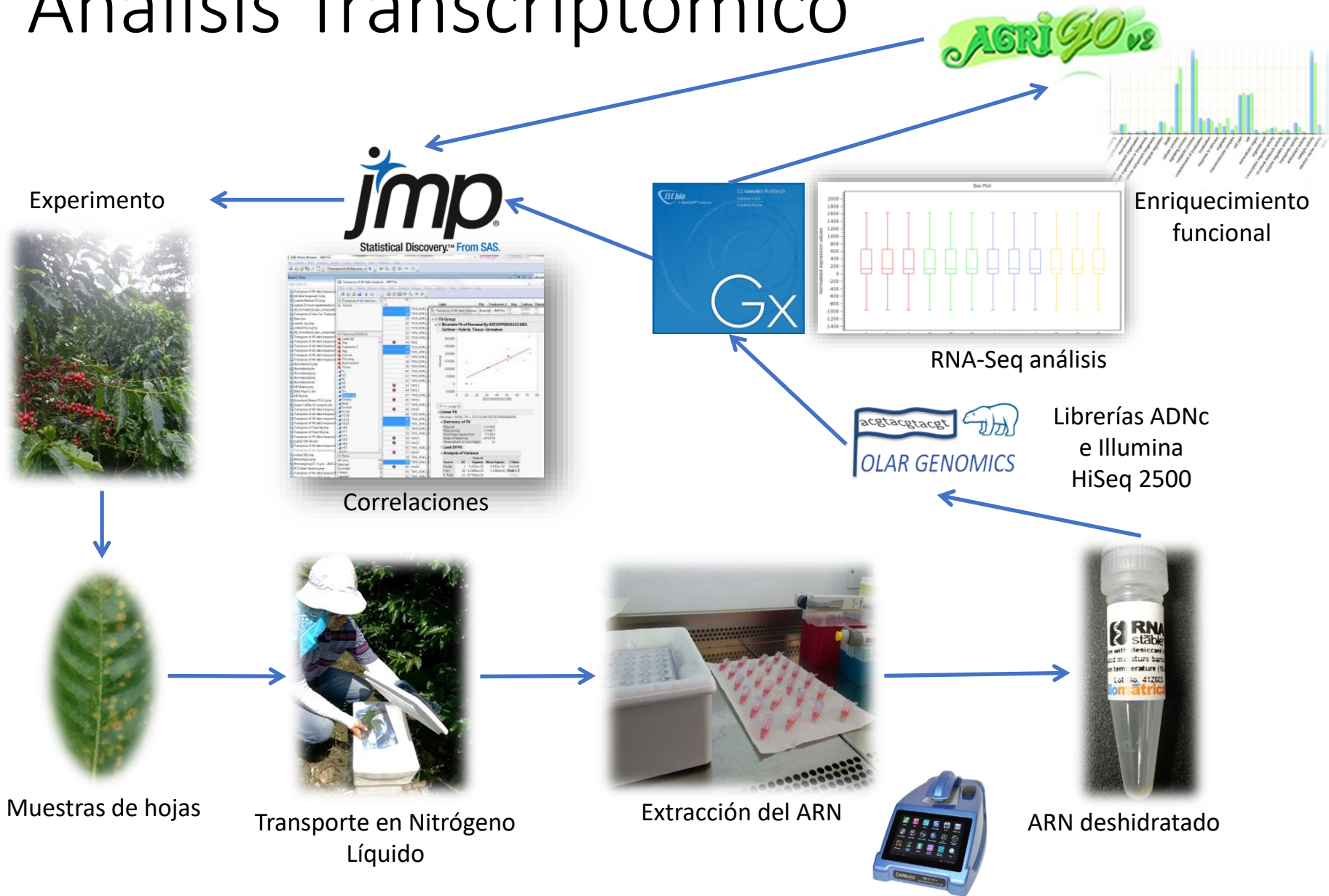
Proporción de reducción



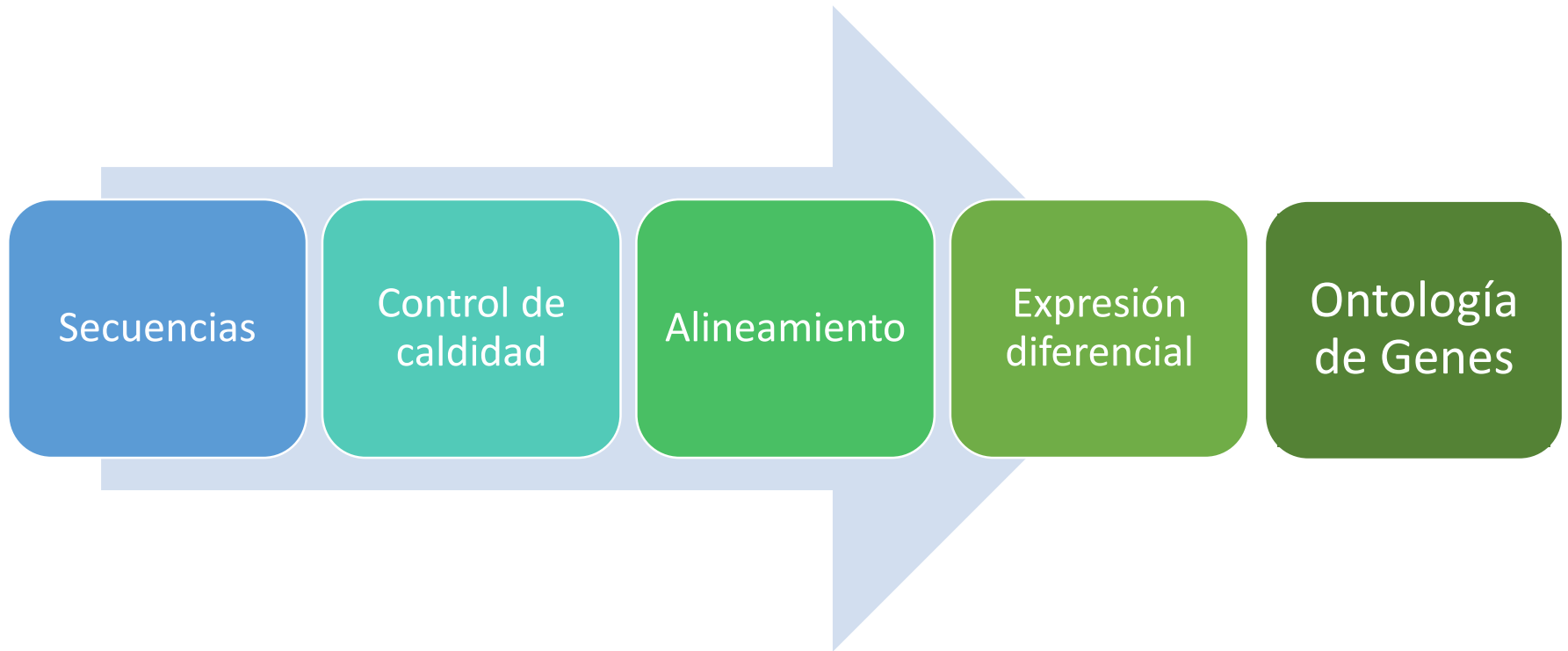
** Representa diferencias altamente significativas mediante prueba de Tukey ($p < 0,01$)



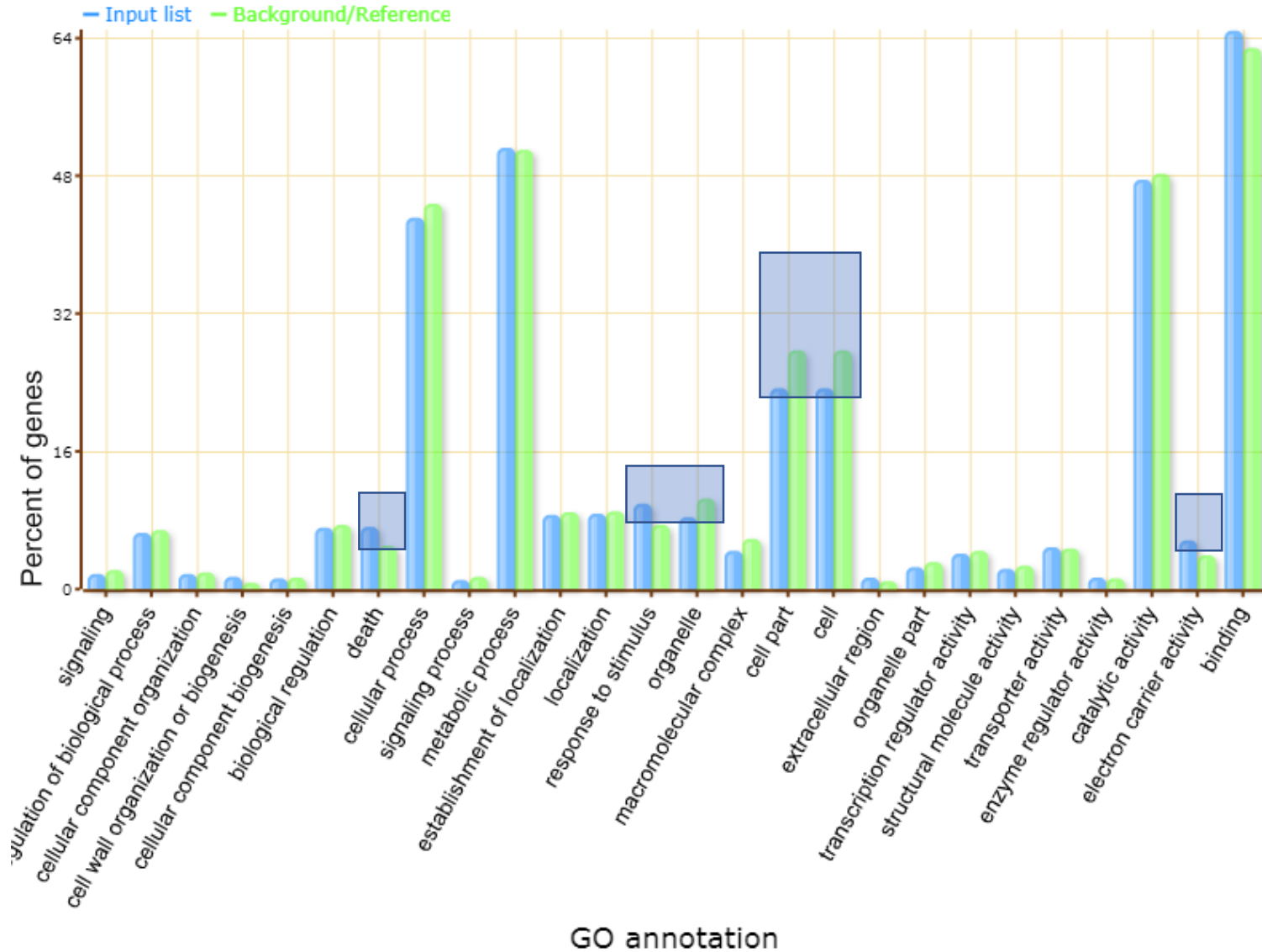
Análisis Transcriptómico



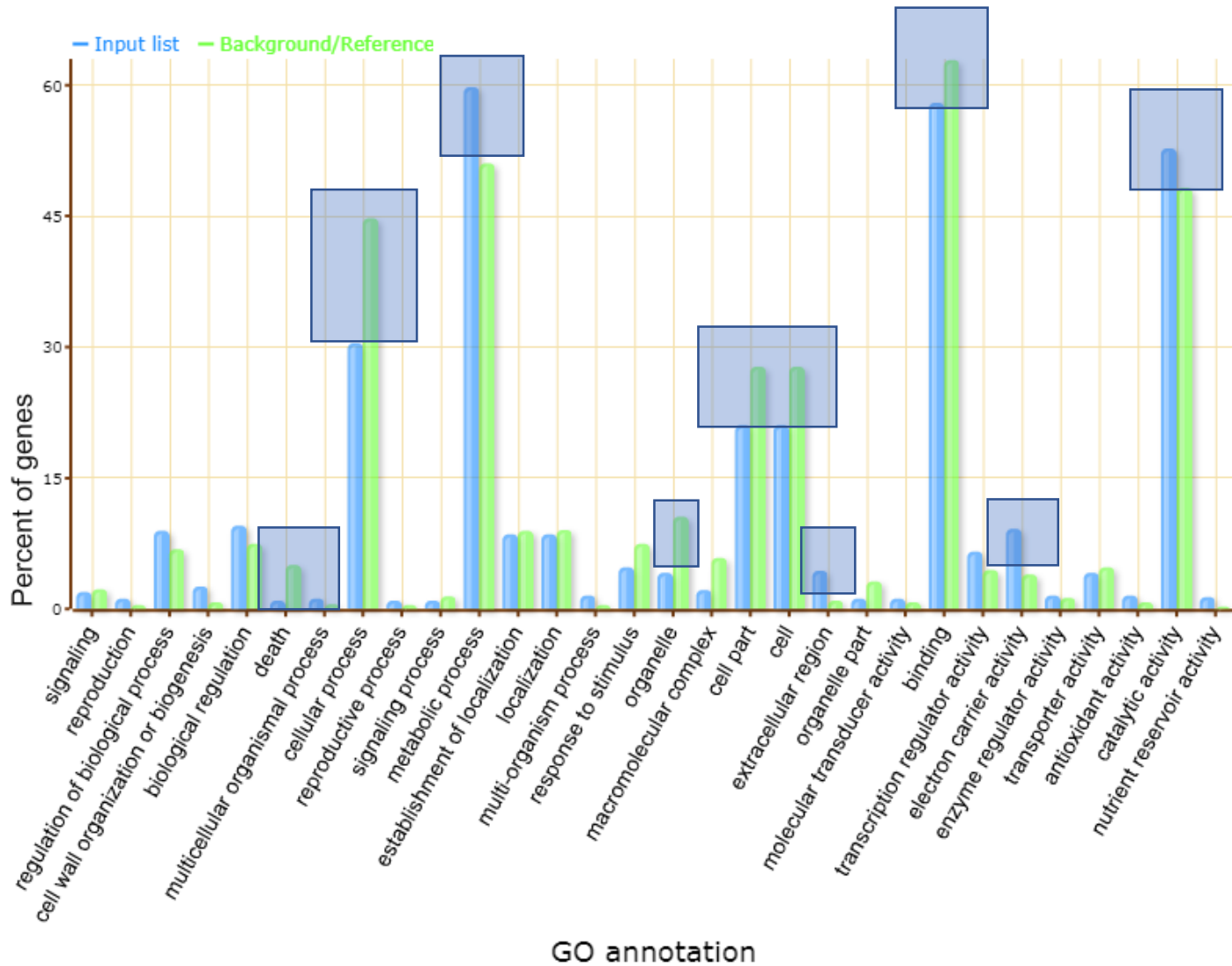
Pasos básicos del análisis RNA-Seq



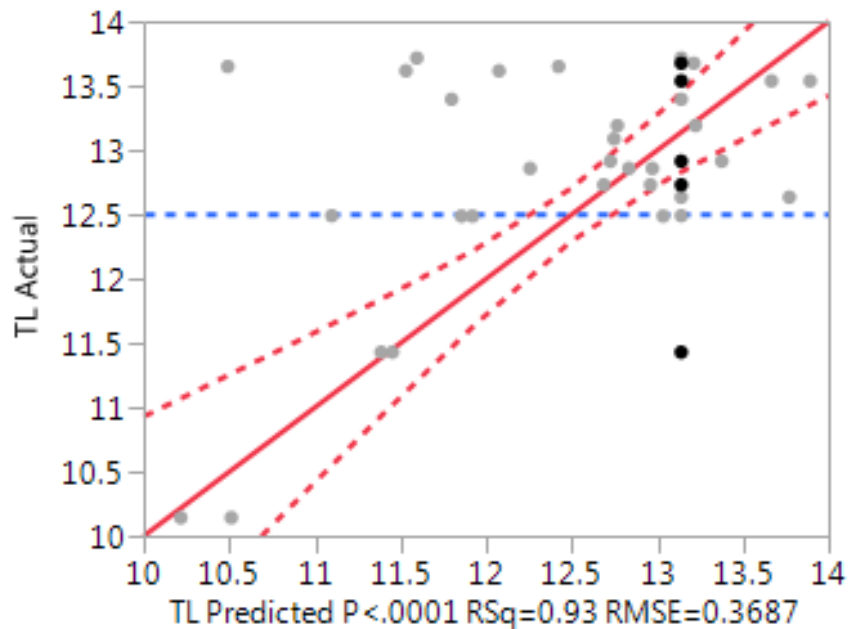
Catuaí: Control vs RT



Híbrido: Control vs RT



Híbrido - TL



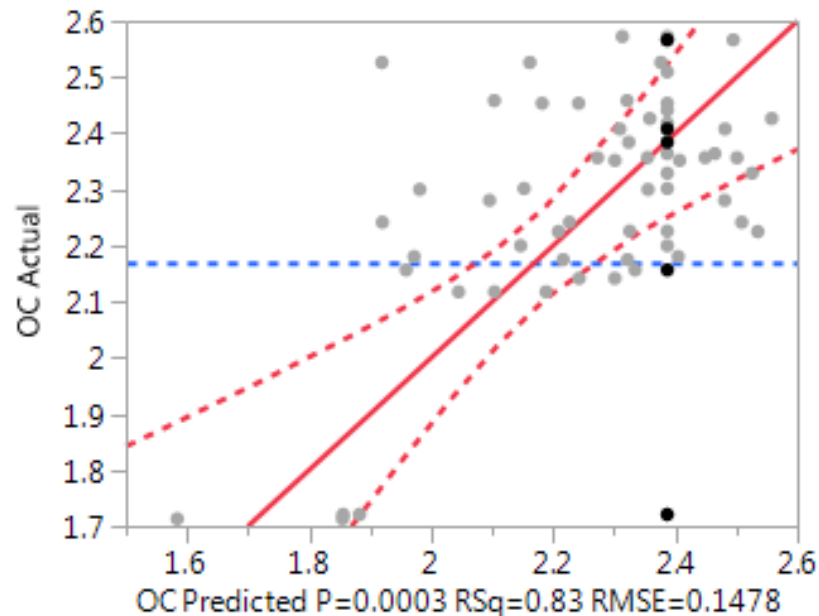
Summary of Fit

RSquare	0.927402
RSquare Adj	0.891103
Root Mean Square Error	0.368685
Mean of Response	12.50898
Observations (or Sum Wgts)	16

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	13.139737	0.443359	29.64	<.0001*
Putative Disease resistance protein RGA2	-0.088699	0.016007	-5.54	0.0002*
Putative disease resistance protein RGA3	0.760925	0.097556	7.80	<.0001*
Putative late blight resistance protein homolog R1B-17	-0.165443	0.029013	-5.70	0.0002*
Putative Umecyanin	-0.027269	0.007785	-3.50	0.0057*
L-ascorbate oxidase homolog	0.0341868	0.006557	5.21	0.0004*

Híbrido - OC



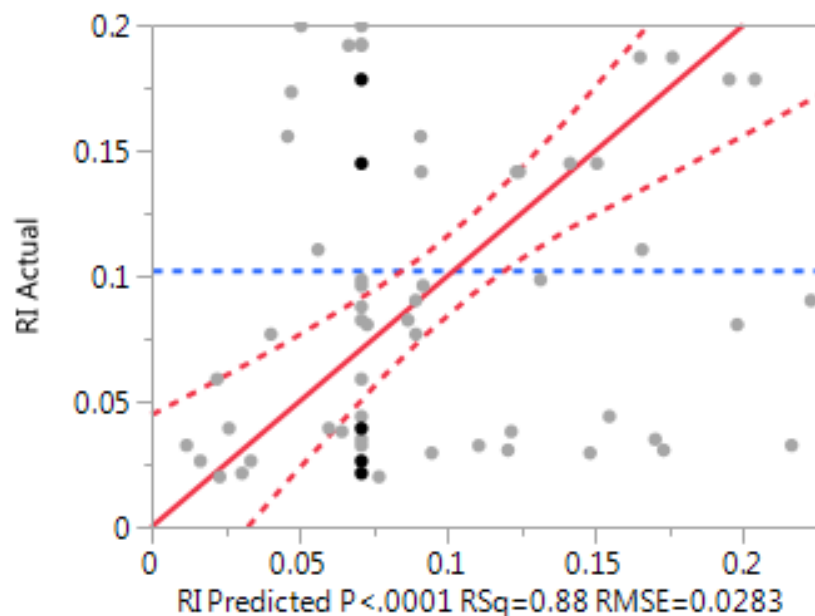
Summary of Fit

RSquare	0.832421
RSquare Adj	0.771483
Root Mean Square Error	0.147836
Mean of Response	2.170006
Observations (or Sum Wgts)	16

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	2.3868648	0.064017	37.28	<.0001*
Putative Disease resistance protein At4g27190	-0.09339	0.035192	-2.65	0.0224*
Putative disease resistance protein RGA3	-0.050108	0.008335	-6.01	<.0001*
Putative uncharacterized protein (XP_010660144.1	0.2477916	0.034415	7.20	<.0001*
Putative Disease resistance protein RPM1	0.0211187	0.005847	3.61	0.0041*

Híbrido - RI



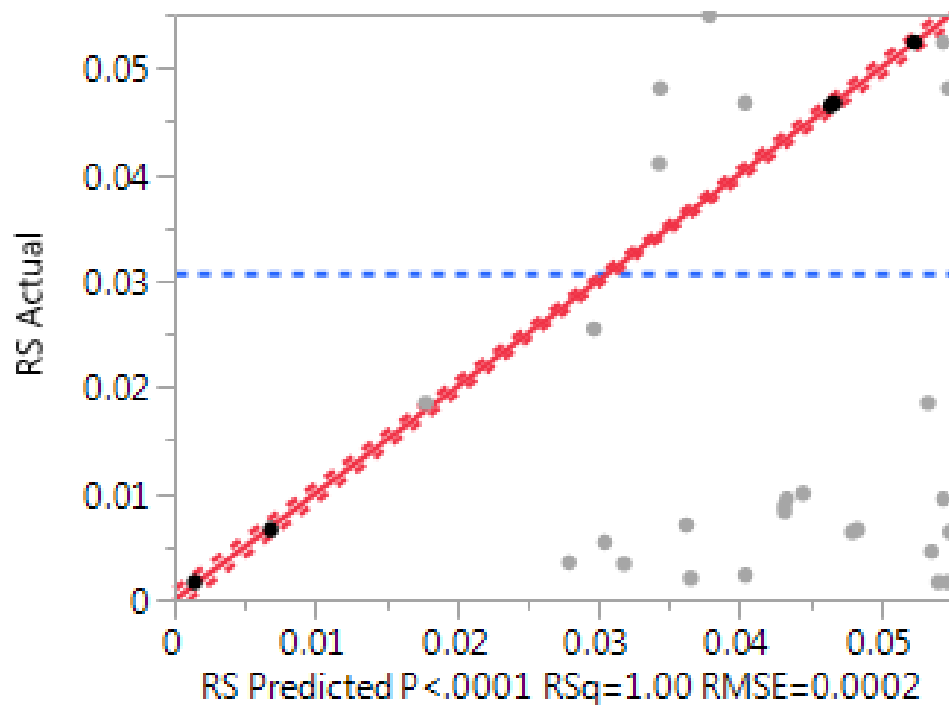
Summary of Fit

RSquare	0.880338
RSquare Adj	0.836824
Root Mean Square Error	0.028327
Mean of Response	0.102323
Observations (or Sum Wgts)	16

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob > t
Intercept	0.0709246	0.018433	3.85	0.0027*
Putative Ribosomal protein	-0.026416	0.003029	-8.72	<.0001*
Putative disease resistance protein RGA4	0.0092882	0.001407	6.60	<.0001*
L-ascorbate oxidase homolog	-0.001862	0.000469	-3.97	0.0022*
Putative Disease resistance protein (CC-NBS-LRR class) family	-0.018802	0.005011	-3.75	0.0032*

Híbrido - RS



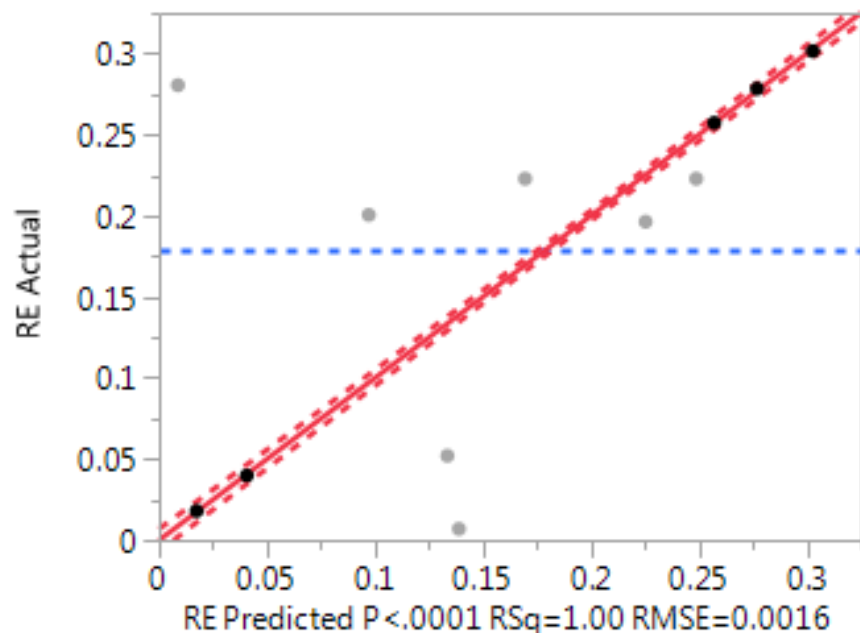
Summary of Fit

RSquare	0.999954
RSquare Adj	0.999907
Root Mean Square Error	0.000236
Mean of Response	0.030758
Observations (or Sum Wgts)	5

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	0.0585256	0.000513	114.00	<.0001*
Putative disease resistance protein RGA4	-0.000177	8.764e-6	-20.22	0.0024*
Putative Ribosomal protein	-0.001734	4.86e-5	-35.67	0.0008*

Híbrido - RE



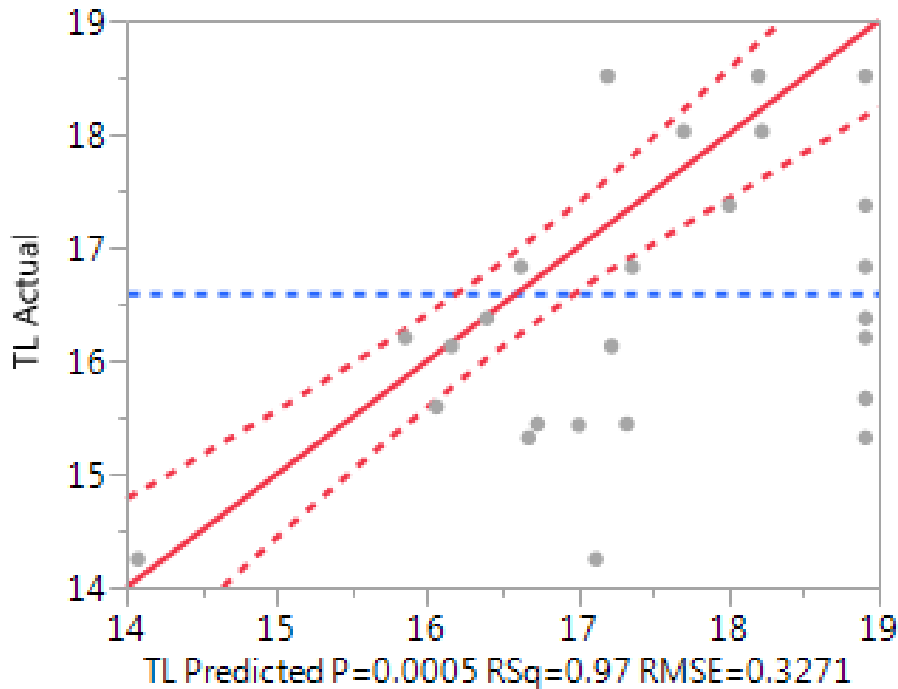
Summary of Fit

RSquare	0.999937
RSquare Adj	0.999873
Root Mean Square Error	0.001556
Mean of Response	0.17905
Observations (or Sum Wgts)	5

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	0.3418724	0.001219	280.44	<.0001*
Putative Disease susceptibility protein	0.0020411	0.000144	14.21	0.0049*
Putative disease resistance protein RGA3	-0.011072	8.088e-5	-136.9	<.0001*

Catuaí - TL



Summary of Fit

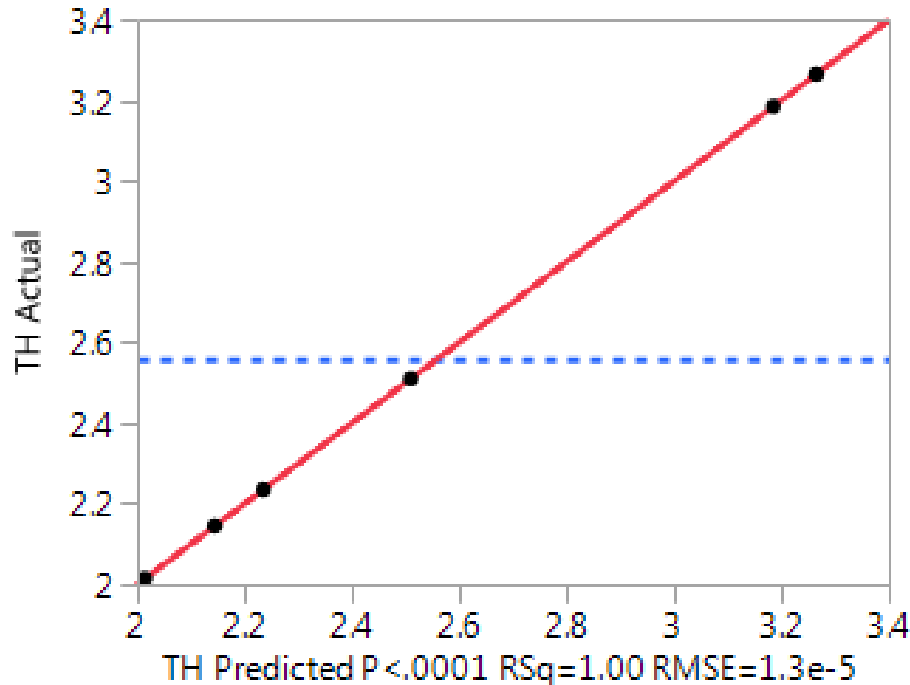
RSquare	0.965297
RSquare Adj	0.956622
Root Mean Square Error	0.327139
Mean of Response	16.59603
Observations (or Sum Wgts)	6

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	18.911636	0.25696	73.60	<.0001*
Xyloglucan endotransglucosylase/hydrolase protein 22	-0.018593	0.001763	-10.55	0.0005*

Xyloglucan endotransglucosylase/hydrolase protein 22

Catuaí - TH



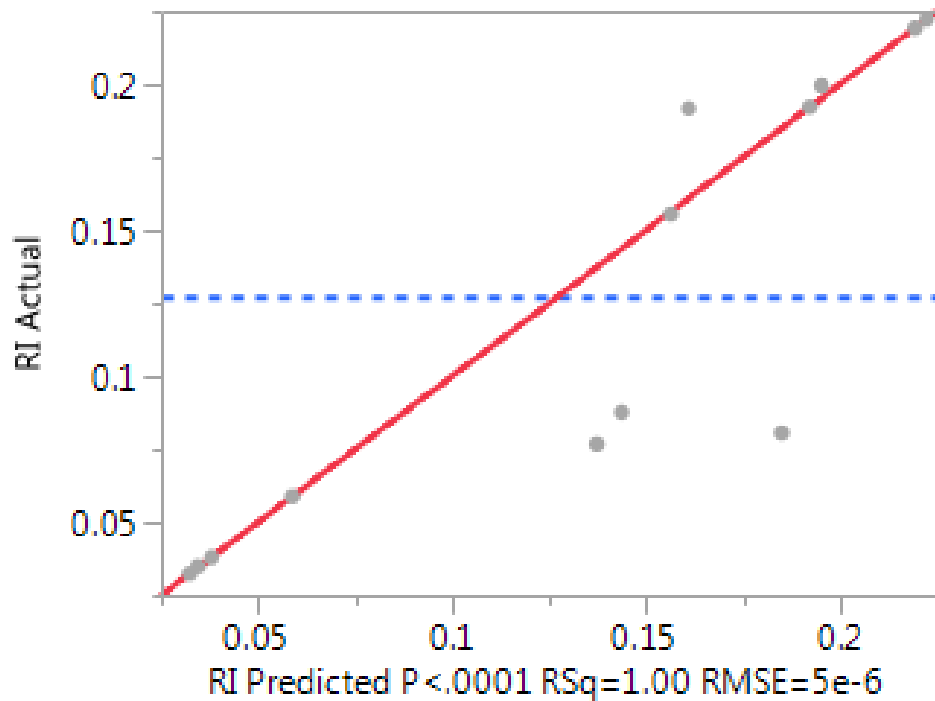
Summary of Fit

RSquare	1
RSquare Adj	1
Root Mean Square Error	1.264e-5
Mean of Response	2.559167
Observations (or Sum Wgts)	6

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	1.8689528	5.747e-5	32519	<.0001*
Acidic endochitinase	5.8765e-5	5.623e-8	1045.0	0.0006*
Probable flavin-containing monooxygenase 1	0.0006103	2.375e-8	25689	<.0001*
Alternative oxidase 1, mitochondrial	0.0015418	3.06e-7	5038.1	0.0001*
UDP-glycosyltransferase 85A1	-0.000375	4.108e-6	-91.34	0.0070*

Catuaí - RI



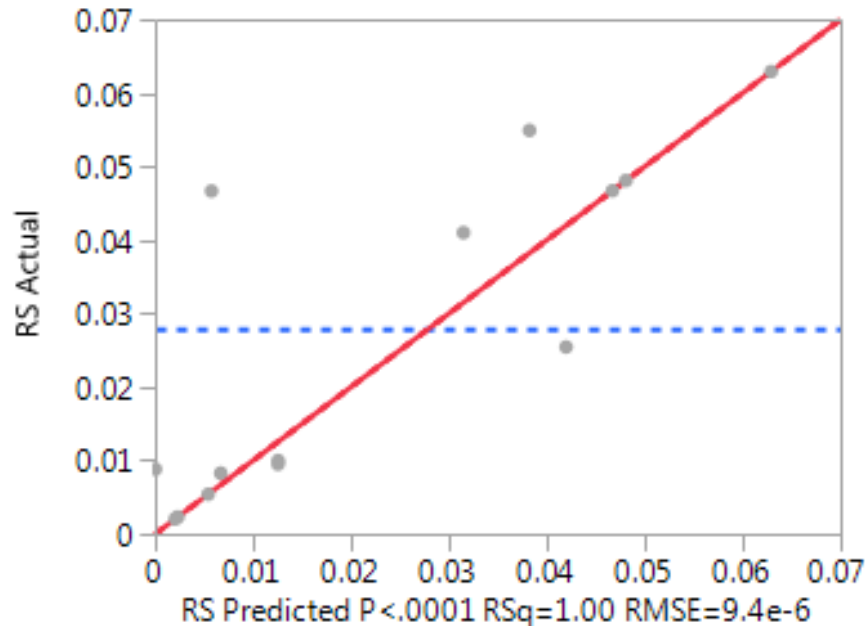
Summary of Fit

RSquare	1
RSquare Adj	1
Root Mean Square Error	5.014e-6
Mean of Response	0.127264
Observations (or Sum Wgts)	6

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	0.4003137	0.000028	14319	<.0001*
Putative Thebaine 6-O-demethylase	-0.002508	0.000001	-2490	0.0003*
Ferric reduction oxidase 7, chloroplastic	-2.764e-5	3.95e-9	-6999	<.0001*
Putative UDP-glycosyltransferase 76E1	-0.002297	5.238e-7	-4386	0.0001*
Cytokinin dehydrogenase 5	-2.947e-6	2.537e-8	-116.2	0.0055*

Catuaí - RS



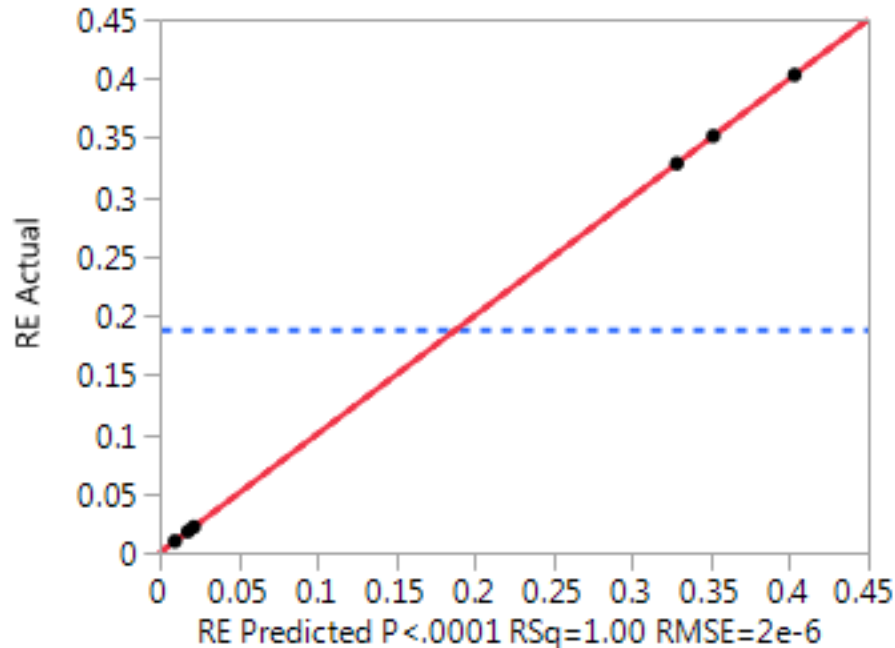
Summary of Fit

RSquare	1
RSquare Adj	1
Root Mean Square Error	9.436e-6
Mean of Response	0.027917
Observations (or Sum Wgts)	6

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob > t
Intercept	-0.022732	0.000022	-1035	<.0001*
Putative Pinene synthase	-0.000075	2.229e-6	-33.70	0.0009*
Putative methyltransferase DDB_G0268948	0.0001353	4.52e-8	2994.0	<.0001*
Putative Cytochrome P450 716B1	-0.001428	1.526e-6	-935.7	<.0001*

Catuaí - RE



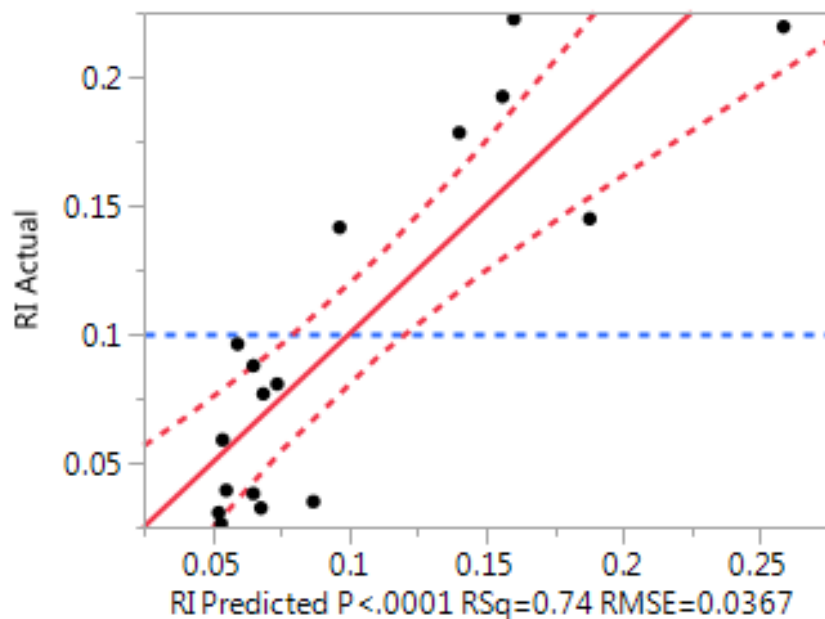
Summary of Fit

RSquare	1
RSquare Adj	1
Root Mean Square Error	2.026e-6
Mean of Response	0.188743
Observations (or Sum Wgts)	6

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-0.076403	4.178e-6	-18288	<.0001*
Putative Cytochrome P450 87A3.	-0.000133	1.942e-8	-6860	<.0001*
Putative Monothiol glutaredoxin-S5.	0.0003429	3.735e-9	91817	<.0001*
Putative Pinene synthase.	-0.007737	4.157e-7	-18613	<.0001*
UDP-glycosyltransferase 73D1	-3.154e-5	4.739e-8	-6654	0.0010*

Híbrido y Catuaí - RI



Summary of Fit

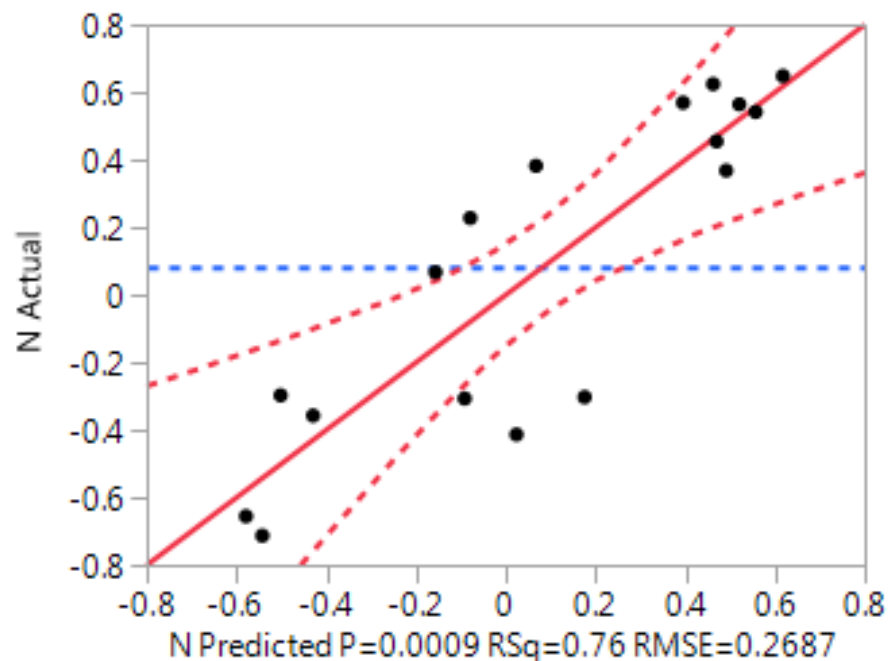
RSquare	0.737506
RSquare Adj	0.720006
Root Mean Square Error	0.036715
Mean of Response	0.100022
Observations (or Sum Wgts)	17

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	0.0181395	0.01544	1.17	0.2584
Putative Stellacyanin	6.5668e-5	1.012e-5	6.49	<.0001*

A gene encoding stellacyanin is induced in *Capsicum annuum* by pathogens, methyl jasmonate, abscisic acid, wounding, drought and salt stress

Híbrido y Catuaí – Consumo de Nitrógeno



Summary of Fit

RSquare	0.764935
RSquare Adj	0.68658
Root Mean Square Error	0.268673
Mean of Response	0.08251
Observations (or Sum Wgts)	17

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	0.7334542	0.155154	4.73	0.0005*
Laccase-2.	-0.026366	0.005829	-4.52	0.0007*
Laccase-4.	0.0072639	0.001513	4.80	0.0004*
Laccase-17.	-0.023593	0.005317	-4.44	0.0008*
Putative Stellacyanin.	-0.000434	0.000111	-3.91	0.0021*

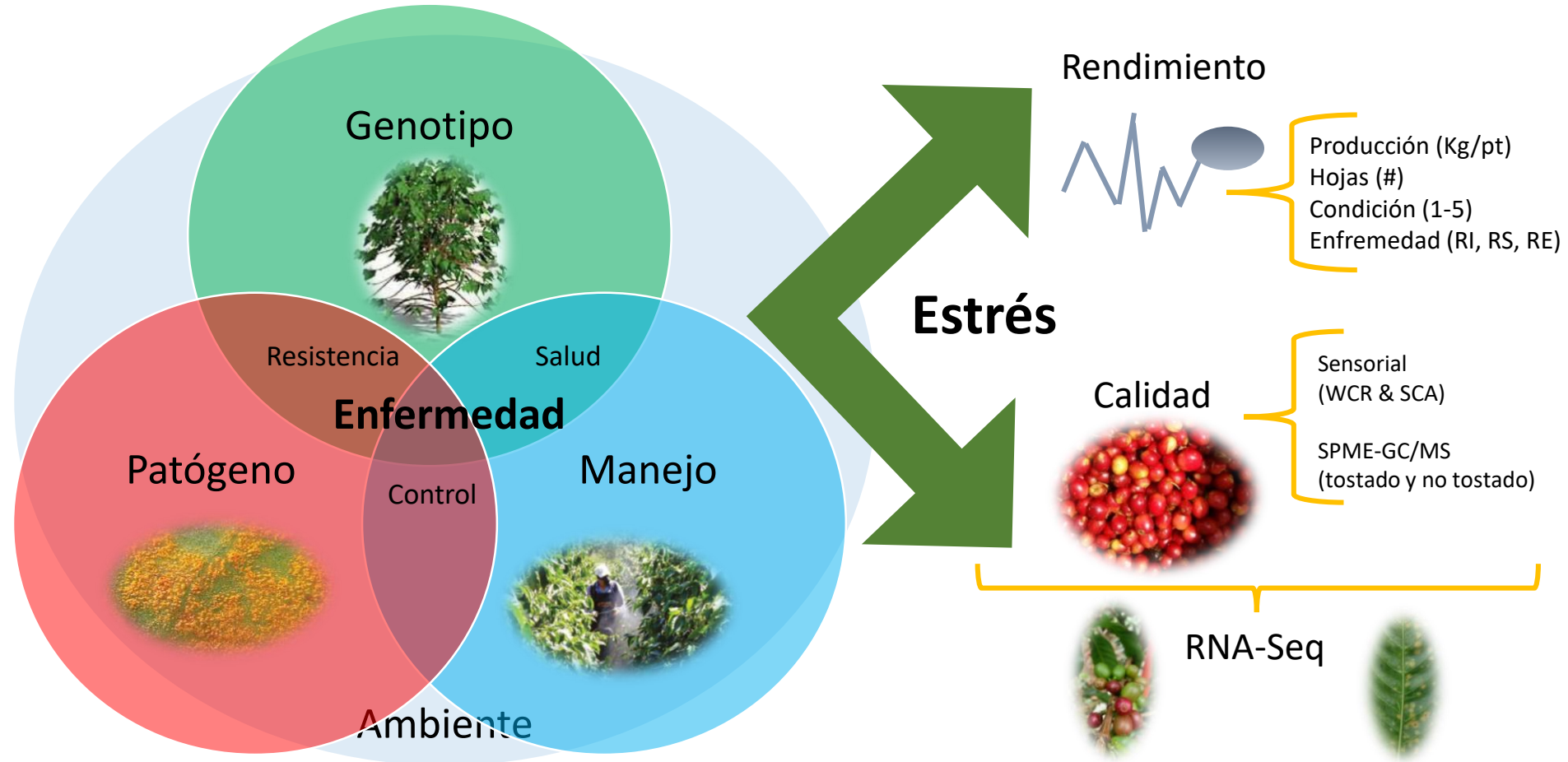


Conclusiones

- La reducción de un 50% en la carga fructífera influye en una disminución del 3,5% y 2,3% la incidencia y esporulación de la roya bajo condiciones de campo, para ambos cultivares, respectivamente.
- La aplicación de controles químicos influye en una disminución del 11,5% y 27,3% la incidencia y esporulación de la roya bajo condiciones de campo, para ambos cultivares, respectivamente.
- Alrededor de 500 genes fueron relacionados con cambios de expresión genética en respuesta a la condición fisiológica de la planta.
- Es posible crear modelos de predicción de genes con mayor efecto ante el estrés mediante el análisis del transcriptoma del café.



Parte de un estudio integrado





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Agradecimiento

FINANCIAMIENTO



"Revitalizing the Central American, Caribbean and Peruvian Coffee Sectors after the Rust Crisis of 2012 through Applied Research and Development". USAID APS: APS-OAA-13-000003



"Yield, quality and coffee leaf rust"



<https://worldcoffeeresearch.org/work/yield-quality-and-coffee-leaf-rust/>



<http://agriliferesearch.tamu.edu/>

<http://coffee.tamu.edu/>

BECA



Instituto Tecnológico de Costa Rica

<http://www.tec.ac.cr/Paginas/index.html>

COOPERACIÓN



Agricultural Research for Development

<http://www.cirad.fr/en>



Hacienda Aquiaries Coffee Farm

<http://aquiaries.com/>

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**¡GRACIAS A USTEDES,
PROMECAFE Y
PATROCINADORES!**

fabianeotec@gmail.com

