

Final report EG ISF DRT and IBEB project Lettuce *Fusarium oxysporum* f. sp. *lactucae* (Fol: 4) resistance - 2021



Sophie PERROT EG ISF DRT

I. <u>Background:</u>

Discovered for the first time in 1955 and described in 1967 as a novel forma specialis, *Fusarium oxysporum* f. sp. *lactucae* (Fol) is the pathogen causing "Fusarium wilt", a disease affecting lettuce. The race 1 has been identified in 1967 in Japan and then in USA, Iran, Taiwan, south of America and Europe. The races 2 and 3 have been identified in Japan in 2001 and for the moment were also reported only in Taiwan.

The test of the resistance of lettuce to *Fusarium oxysporum* f. sp. *lactucae* is used in DUS since 2013 with the races 1 and 2. This characteristic was initially described with two UPOV notes: 1 (susceptible) and 9 (resistant) (TG/13/10 Rev).

In 2012-2014, GEVES coordinated for IBEB (International Bremia Evaluation Board) a collaborative project with 11 participating laboratories to harmonize a protocol of evaluation of the resistance of lettuce to Fol: 1. The results allowed to adapt the explanation to this characteristic (definition of symptoms indicating the intermediate level) and to define good threshold varieties to distinguish between susceptibility, intermediate resistance and resistance.

The conclusions of this project were presented by GEVES and applied to update the technical protocols for CPVO (CPVO/TP-013/6-Rev) and UPOV (TG/13/11 Rev.) with three UPOV notes: 1 (susceptible), 2 (intermediate resistant) and 3 (highly resistant).

In 2016, Giraldi et al. described a new race of *Fusarium oxysporum* f. sp. *lactucae* race 4 and used several varieties to differentiate it from the previously identified races. Therefore, the following table for differentials has been proposed at the ISF DRT WG (Table 1).

	Race (ISF Code)			
Differ <mark>ential</mark> host	1 (Fol: 1)	2 (Fol: 2)	3 (Fol: 3)	4 (Fol: 4)
Patriot, Cavolo di Napoli	S	S	S	S
Costa Rica No.4	R	S	S	S
Banchu Red Fire, Lattughino biondo	ationa	l Seed	Feder	ation

Table 1: proposition for Fol: 4 differentials to ISF WG DRT based on the publication of G. Gilardi et al.

S = susceptible; R = resistant (partial resistance)

Patriot, used as differential and known to be susceptible to Fol races 1, 2 and 3 had not been described in the publication of G. Giraldi et al., 2016 and was tested by one of the DRT participants and found not to be clearly susceptible.

In 2018-2019, GEVES coordinated for ISF an interlaboratory project including 14 partners to validate, the newly identified differentials and race for use in resistance claims. Several

isolates expected as races 1, 2, 3 and 4 were tested in different laboratories including the isolate from the publication of G. Giladi. The results showed that, races 1 and 2 were validated on the differentials and if race 3 was validated requiring an aggressive test to express enough symptoms and to provide conform results. Isolates tested as race 4 were found non-conform in most laboratories (Table 2). The conclusion was the description of the race 4 required further investigation.

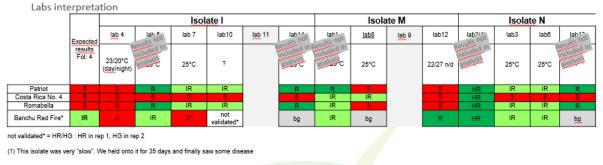


Table 2: ISF ring test results for Fol: 4 (Isolate I, M and N)

Lab X: lab who provided the isolate

R: resistant; S: susceptible; IR: intermediate resistant; Bg: bad germination

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II. ISF EG DRT / IBEB project 2021:

As the new race of *Fusarium* creates a serious threat for growers and a challenge for breeders, a harmonisation action was needed on short term. That is why ISF DRT / IBEB members decided to engage a new project coordinated by GEVES. The objectives were:

- To validate the ISF table for race 4
- Eventually to update the ISF table with new differentials in necessary
- To describe the resistance level of lettuce to Fol: 4
- **To p**ropose an interpretation rule and reference controls for the evaluation of the resistance to lettuce to FoI: 4.

To be able to meet these objectives, a new comparative test was organized to compare in controlled conditions different isolates for race 4 on a panel of varieties made up of differentials and varieties with different level of resistance. In parallel, it was decided to evaluate the same panel of varieties in a test in polytunnel to check as far as possible the correlation between results in controlled conditions and in field conditions.

a. Material and method

i. <u>Comparative test in controlled conditions:</u>

Participants:

12 Participants were involved in the comparative test in controlled conditions: BASF, Bejo, Gautier, Rijk Zwaan, Syngenta, Vilmorin, Ramiro Arnedo, Enza Zaden, ISI Sementi, Tozer, Naktuinbouw and GEVES.

Isolates:

Four isolates of Fol: 4 were selected for validation: three coming from the previous ISF project and identified as candidate isolates for race 4 and a fourth proposed by Warwick University expected with a high level of aggressivity:

- Isolate 04750888 from the Netherlands provided by AGROINNOVA (G. Gilardi et al.) (already tested in last ISF RT) coded as **isolate I**.
- 1 aggressive isolate from UK coded as **isolate W** (supplying by University of Warwick).
- 1 isolate from the Netherlands (already tested in last ISF RT) coded as isolate M.
- 1 isolate from the Netherlands (already tested in last ISF RT) coded as **isolate N.**

Isolates were provided by GEVES to partners. GEVES multiplied the isolates and sent an actively growing culture to each participant. Each participant produced the inoculum according to the UPOV protocol.

Panel:

During the setting up of the project, partners selected a panel (Table 3) made up of:

- Differentials to validate: Banchu Red Fire, Costa Rica, Patriot and Romabella.
- One resistant variety Ballerina and one susceptible variety Gisela
- Candidate controls with different levels of resistance: Cobham green, Palmos, Lomeria and 3 varieties non denominated (var_3, var_4 and var_7).

For the comparative test, four varieties were in duplicate indicated with the status "uncoded" which meant that either the denomination and the expected level of resistance were known (Banchu Red Fire and Costa Rica) or only the expected level of resistance were known (Ballerina and Gisela). These varieties were used as controls to validate the test and to help for interpretation of the other varieties.

All the varieties of the panel were also included in the comparative test, with the status "coded", which meant that the denomination and the expected level of resistance were unknown.

Code in test plan	Denomination	Expected	Code in test	Status
Banchu Red Fire	Banchu Red Fire lot CF676	CUR	Banchu Red Fire	Uncoded
var_e	Banchu Red Fire lotCF676	IR	var_11	Coded
var_g	Ballerina	R	var_g	Uncoded
var_g	Ballerina	R	var_14	Coded
Costa Rica	Costa Rica	S	Costa Rica	Uncoded
var_b	Costa Rica	S	var_02	Coded
var_d	Gisela	S	var_d	Uncoded

Table 3: panel selected for Fusarium oxysporum f. sp. lactucae race 4 comparative test

var_d	Gisela	S	var_8	Coded
var_a	Patriot	S	var_05	Coded
var_c	Romabella	S	var_13	Coded
var_f	Cobham green	R	var_01	Coded
var_h		R	var_03	Coded
var_i		R	var_07	Coded
var_j	Palmos	R	var_12	Coded
var_k	Lomeria	R	var_10	Coded
var_l		R	var _04	Coded

The seeds were collected by GEVES to be sent to each partner.

Protocol:

Each laboratory has tested all isolates on the whole panel according to UPOV guidelines for Fol: 1 (annex 1). Some steps were specified:

- Method of inoculation: soaking protocol
 - Sowing of varieties in compost or vermiculite,
 - At the good stage for inoculation, lifting the plants carefully,
 - Soaking roots in adjusted spore suspension during 5 to 15min,
 - Transplant in a new container (pots or trays).
- Quantification inoculum: concentration adjusted to 10⁶ sp/mL
- Substrate: compost
- Temperature: between 23°C and 26°C
- 20 plantlets tested
- Notation: when symptoms expressed on the uncoded S control are at note 3 (UPOV notation scale) at least
- Notation scale: observation of browning vessels for classes 0 and 1.

ii. Polytunnel test:

Participant:

1 Participant was involved in the test in polytunnel: Warwick University

Isolates:

The race 4 isolate provided by Warwick University (W) for the comparative test in controlled conditions was also used for test in polytunnel.

Panel:

The same panel of varieties used in the comparative test in controlled conditions was also used in the polytunnel test.

iii. Statistical analyses:

Several statistical tests were used for this study to compare results and to harmonize the interpretation. A small working group was defined managed by GEVES and including Enza Zaden and Syngenta to perform the statistical analyses.

The statistical tool Pathostat (available free of charge on the GEVES Website <u>https://www.geves.fr/tools/pathostat/</u>) was mainly used for the interpretation of varieties depending on the distribution of plants per class of observation and, in comparison with controls reaction (Cochran-Armitage test for trend). Pathostat was also used to illustrate the distribution of plants per class.

ANOVA, Tukey tests on disease index, box plots (with an LSD test) and calculation of reproducibility and accuracy were also used.

b. <u>Res<mark>ults</mark></u>

i. <u>Comparative test in controlled conditions:</u>

No results were obtained for the variety Cobham green due to a lack of germination.

A first analysis of results in controlled conditions was presented by GEVES based on two interpretations. The first one was done by labs (Table 4) and a second one (Table 5) was obtained by the statistic tool (Pathostat). The interpretation done by labs showed more differences between results while interpretation with Pathostat showed less differences between labs.

Globally, differences of aggressivity were shown between isolates. The three isolates I, M, and W observed as more aggressive, and the isolate N observed as less aggressive. There was no difference of virulence between isolates and all varieties had the same interpretation regardless of the isolate.

Two differentials Patriot and Romabella confirmed the results observed in the ringtest of 2018-2019, when results were obtained that were not expected and contradicting the proposed differential table. In the present ringtest of 2021, Patriot was observed clearly resistant (intermediate resistant in few labs) when it was expected susceptible to race 4. Romabella was observed mainly intermediate resistant (sometimes resistant and rarely susceptible) when it was expected susceptible.

								Isolat	еl					Isola	ate M							Isola	ate N			Isol	ate W					
	Code in											Lab	Lab							Lab	Lab											Lab
	test	expected	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Lab 6	Lab 7	Lab 9	Lab 9	11	12	Lab 3	Lab 4	Lab 5	Lab 7	'Lab 9	Lab 9	11	12	Lab 1	Lab 4	Lab 6	5Lab 7	Lab 3	3Lab 5	Lab 6	Lab 7	/Lab 9	Lab 9	12
var_l	Var_04	R	IR	R	R	R	HR	R	R	R	R	R	R	R	IR	HR	R	R	R	R	R	IR	IR	R	R	R	HR	R	R	R	R	R
var_k	Var_10	R	HR	R	R	R	HR	R	R	HR	HR	R	R	R	R	HR	R	R	HR	R	R	IR	R	R	R	R	HR	IR	R	R	HR	R
var_h	Var_03	R	IR	IR?	R	R	HR	R	R	HR	HR	R	IR	IR	S	HR	R	R	HR	R	R	IR	IR	R	R	R	HR	R	R	HR	HR	R
var_j	Var_12	R	IR	IR?	IR	IR	HR	R	R	R/IR	R	R	R	IR	IR	HR	R	R	R	R	R	HR	IR	R	R	IR	HR	R	R	R	R	R
var_i	Var_07	R	IR	IR?	IR	S	HR	IR	IR	HR	R	R	IR	low IR	S	HR	IR	HR	R	R	R	HR	S	R	R	S	HR	IR	IR	R	R	R
var_g = Ballerina	var_g	R	S	S	low IR	S	IR	S	S-IR	S	S	R	S	IR	S	IR	S	S	HS	R	IR	IR	S	R	IR	IR	HR	S	IR	R/IR	S	R
Ballerina	Var_14	R	IR	S	IR	S	IR	S	R-IR	S	HS	R	S	IR	S	IR	IR	S	S	R	S	IR	IR	IR	R-IR	0	HR	S	R	R	IR	IR
var_e = Banchu	Var_11	IR	S	S	IR	S	HR	S	R	IR	IR/S	R	S	IR	IR	IR	R	IR	IR	R	R	IR	IR	R	R-IR	IR	IR	S	R	R/IR	R	R
Banchu Red Fire	Banchu Red Fire	IR	IR	IR?	IR	R/IR	HR	IR	IR	IR	IR/S	IR	IR	IR	IR	IR	R	IR	IR	IR	IR	IR	IR	R	R-IR	IR	HR	IR	R	R	R	R
var_a = Patriot	Vat_05	S	IR	IR?	IR	S	HR	IR	R	IR	IR	R	S	IR	S	HR	R	R	IR	R	IR	IR	IR	R	R	IR	HR	R	IR	R	HR/R	R
var_c = Romabell a	Var_13	S	S	S	low IR	S	IR	S	R	S	IR	R	IR	IR	S	IR	IR	IR/S	IR	IR	IR	IR	IR	R	IR	IR	HR	S	R	IR	IR	R
var_b = Costa Rica	Var_02	S	S	S	low IR	S	S	S	S	HS	HS	S	S	S	S	S	S	S	HS	S	IR	s	S	IR	S	S	S	S	S	IR	S	IR
Costa Rica	Costa Rica	S	S	S	S	S	S	S	S	S/HS	HS	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	HS	HS	S
var_d	Var_08	S	S	S	S	S	S	S	S	HS	HS	S	S	S	S	S	S	HS	HS	S	S	S	S	IR	S	S	S		S	S	HS	S
Var_d = Gisela	Var_d	S	S	S	S	S	S	S	S	HS	HS	S	S	S	S	S	S	HS	HS	S	S	S	S	R	S	S	S	IR	S	S	HS	S

Table 4: results of the panel of varieties for the 4 candidate isolates of Fol: 4 with internal lab interpretation

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							ls	olate	Ι								Isola	te M					Isola	te N				ls	olate	W		
Test plan	Code in											Lab	Lab							Lab	Lab											Lab
code	test	expected	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Lab <mark>6</mark>	Lab 7	Lab 9	Lab 9	11	12	Lab 3	Lab 4	Lab 5	Lab 7	Lab 9	Lab 9	11	12	Lab 1	Lab 4	Lab 6	Lab 7	Zab 3	Lab 5	Lab 6	Lab 7	'Lab 9	Lab 9	12
var_l	Var_04	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
var_k	Var_10	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
var_h	Var_03	R	R	R	R	R	R	R	R	R	R	R	R	R	S	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
var_j	Var_12	R	R	R	R	IR	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
var_i	Var_07	R	R	R	IR	IR	R	R	R	R	R	R	R	IR	S	R	IR	R	R	R	R	R	R	R	R	S	R	R	IR	R	R	R
var_g	var_g	R	IR	S	IR	S	IR	S	IR	S	IR	R	S	R	S	IR	S	S	S	R	R	IR	IR	R	IR	R	R	R	IR	IR	IR	R
var_g =			R	s	IR	s	IR	s	R	s	IR	R	s	R	s	IR	IR	s	s	R	IR		R	IR	IR		R	s	R	R	IR	R
Ballerina	Var_14	R	, N			, j	- IIX	Ŭ		Ŭ			Ŭ		Ŭ	- IIX					- IIX	R		iix.				Ŭ				
var_e =			R	s	R	IR	R	s	R	R	R	R	IR	R	R	R	R	IR	R	R	R		R	R	IR	R	IR	R	R	IR	R	R
Banchu	Var_11	IR		Ŭ																		R										
Banchu	Banchu		R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R		R	R	R	R	R	R	R	R	R	R
Red Fire	Red Fire	IR		<u> </u>																		R										
var_a =			R	R	IR	IR	R	R	R	R	R	R	IR	IR	s	R	R	R	R	R	R		R	R	R	R	R	R	IR	R	R	R
Patriot	Vat_05	S																				R										
var_c =																																
Romabell			S	S	S	IR	IR	S	R	S	IR	R	R	IR	S	IR	IR	IR	R	R	R		R	R	IR	IR	R	S	R	IR	IR	R
а	Var_13	S																				IR										
var_b =			s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	s	R		s	IR	s	s	s	s	s	IR	s	IR
Costa Rica		S						_			_			_			_		_			S				L.	_		_			
Costa Rica	Costa Rica		S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
var_d	Var_08	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	IR	S	S	S		S	S	S	S
var_d =			s	s	s	S	s	s	S	s	s	s	s	s	s	s	s	s	s	s	s		s	R	s	s	s	R	s	S	s	s
Gisela	Var_d	S	<u> </u>					Ŭ	Ŭ	Ŭ				Ŭ			Ŭ					S		Ň				, N				Ŭ

Table 5: results of the panel of varieties for the 4 candidate isolates of Fol: 4 with Pathostat interpretation

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The analysis was repeated and extended with the results in polytunnels which were assessed later than tests in controlled conditions.

The Anova showed that in controlled conditions, there was no effect of the interaction isolate x variety. This confirms that there was no difference of virulence between candidate isolates for Fol: 4 (Table 6). Only the main effects of variety and isolate are highly significant.

Table 6: analysis of variance based on the 4 isolates and the varieties of the panel in controlled conditions

Anova

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Isolate	3	10725	3575	4.45	0.004089
Variety	14	632813	45201	56.27	1.105e-115
Isolate:Variety	42	14947	355.9	0.443	0.9992
Residuals	1001	804123	803.3		

Table 5: Analysis of Variance Model

The difference of aggressivity between isolates was confirmed (Table 7). The isolate N was the less aggressive (group A) and isolates W and M were more aggressive (group B), while the isolate I bridged the gap between the two groups of aggressivity (group AB).

Table 7: Tukey tests on effect of isolate based on the disease index in controlled conditions Tukey : effect of isolate

Isolate	lsmean	SE	df	lower.CL	upper.CL	.group
Ν	43.34711	1.955845	1001	38.31403	48.38019	Α
I	49.45687	1.636378	1001	45.24589	53.66785	AB
W	51.24102	1.735430	1001	46.77514	55.70689	В
Μ	52.45476	1.682304	1001	48.12560	56.78392	В

Moreover, with the Tukey test on effect of varieties in controlled conditions, it was possible to classify globally the varieties between three groups of level of resistance (Table 8). The varieties Costa Rica and Gisela were judged as susceptible, the varieties Ballerina, Banchu Red Fire, Patriot, var_7 and Romabella were judged as intermediate resistant and the varieties var_3, var_4, Lomeria (var_10) and Palmos (var_12) were judged as resistant.

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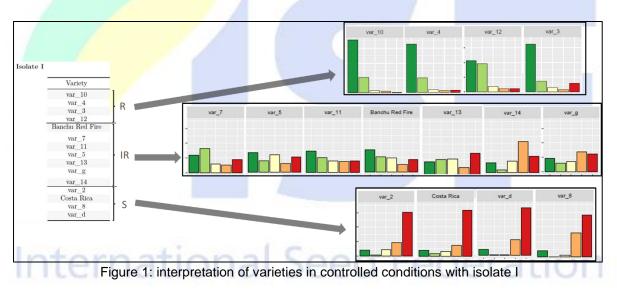
Table 8: Tukey tests on effect of variety based on the disease index in controlled conditions

Tukey : effect of variety

Variety	lsmean	SE	df	lower.CL	upper.CL	.group
Lomeria	11.27610	3.395353	1001	-0.2675194	22.81971	Α
var_4	16.83237	3.395353	1001	5.2887534	28.37598	A
var_3	22.05890	3.395353	1001	10.5152889	33.60252	Α
Palmos	23.09166	3.395353	1001	11.5480448	34.63528	AB
var_7	39.19377	3.395353	1001	27.6501517	50.73738	BC
Patriot	40.70498	3.395353	1001	29.1613650	52.24860	CD
Banchu Red Fire	43.10326	3.395353	1001	31.5596475	54.64688	CD
Banchu Red Fire	45.00846	3.395353	1001	33.4648464	56.55208	CD
Romabella	50.92054	3.395353	1001	39.3769288	62.46416	CD
Ballerina	55.81413	3.395353	1001	44.2705121	67.35774	D
Ballerina	56.49131	3.400055	1001	44.9317070	68.05091	D
Costa Rica	79.51242	3.416903	1001	67.8955368	91.12930	E
Costa Rica	82.75242	3.416903	1001	71.1355381	94.36930	E
Gisela	83.86528	3.395353	1001	72.3216652	95.40890	E
Gisela	86.24848	3.446315	1001	74.5316068	97.96536	E

R= resistant, IR= intermediate resistant and S= susceptible

This interpretation was studied isolate per isolate by a Cochran Armitage test and a pairwise comparison between varieties (Figures 1 to 4). Per isolate, GEVES illustrated for each variety the repartition of plants per class.



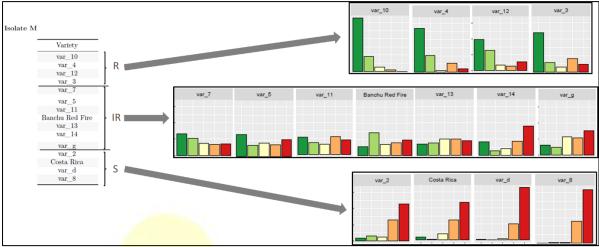


Figure 2: interpretation of varieties in controlled conditions with isolate M

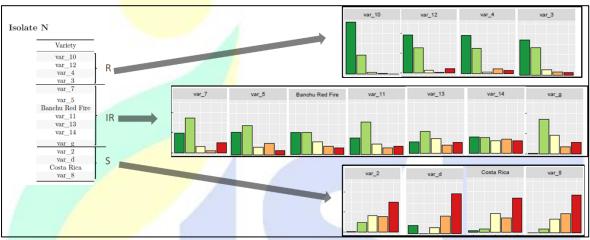


Figure 3: interpretation of varieties in controlled conditions with isolate N

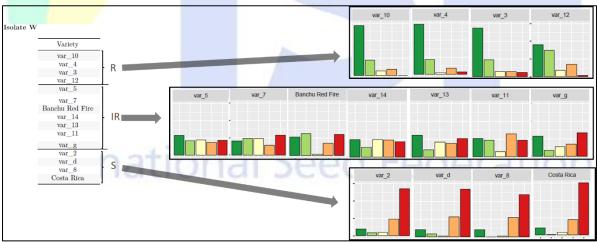


Figure 4: interpretation of varieties in controlled conditions with isolate W

The varieties had the same interpretation for the four isolates (Table 9). The distribution of plants was globally the same not depending on isolate. For resistant varieties plants were mainly in classes 0 and 1, for intermediate resistant varieties plants were in the five classes and for susceptible varieties plants were mainly in classes 3 and 4.

var_d = var_8 (Gisela)	S
Costa Rica = var_2	S
var_g = var_14 (Ballerina)	IR
var_13 (Romabella)	IR
Banchu Red Fire = var_11	IR
var_5 (Patriot)	IR
var_7	IR
var_12 (Palmos)	R
var_3	R
var_4	R
var_10 (Lomeria)	R

Table 9: interpretation of varieties in controlled condition based on the distribution of plants per class

=: same variety tested with different codes; (X): denomination of the variety when it was tested coded

ii. <u>Polytunnel test:</u>

The test in polytunnel (performed only with isolate W) was judged based on two symptoms: wilting on leaves and vascular browning (figure 5). Only two varieties Gisela and Costa Rica developed *Fusarium* wilt with severe symptoms for Gisela (also coded var_8) and with moderate symptoms for Costa Rica (also coded var_2). This confirmed the susceptibility of these two varieties to Fol: 4. The other varieties developed little or no wilt symptoms.

Again, only the two varieties Gisela and Costa Rica showed high level of vascular browning, while Banchu Red Fire (also coded var_11), var_13, Ballerina (also coded var_14) were observed with lower level of vascular browning. The varieties var_3, var_4, Patriot (also coded var_5), var_7, Lomeria (var_10) and Palmos (var_12) developed no or very few vascular browning

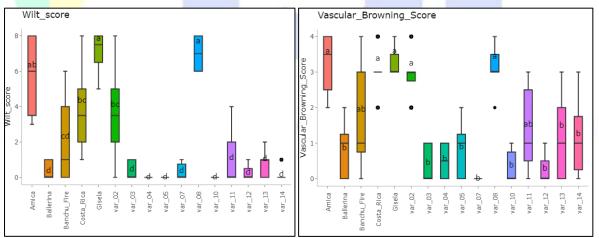


Figure 5 : *Fusarium* wilt score and vascular browning score in polytunnel test for the panel of varieties with isolate W

Analysis of results in polytunnel confirmed globally the classification of varieties in the three groups of resistance (table 10).

Variety	Wilt score	Vascular browning score	Interpretarion
Costa Rica = var_2	bc	а	S
var_d = var_8 (Gisela)	а	а	S
var_g = var_14 (Ballerina)	d	b	IR
Banchu Red Fire = var_11	cd/d	ab	IR
var_13 (Romabella)	d	b	IR
var_5 (Patriot)	d	b	R
var_5 (Patriot) var_7	d d	b b	R R
	d d d	1	
var_7	d d d d	b	R
var_7 var_3	d d d d d d	b	R
var_7 var_3 var_4	d d d d d d d	b b b	R R R

Table 10: classification of varieties in the resistance level depending on polytunnel results

=: same variety tested with different codes; (X): denomination of the variety when it was tested coded; grey: varieties with a different interpretation between tests in controlled condition and polytunnel.

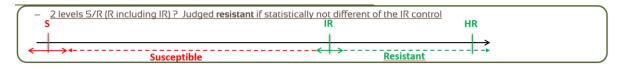
Only the varieties Patriot and var_7, judged as intermediate resistant in controlled conditions, were judged differently resistant in polytunnel test. That confirmed the "sufficient" correlation with results obtained in controlled conditions with the four isolates.

The importance of symptoms of brown vessels for market was discussed and it appeared that it has not the same importance depending on companies. If only wilt symptoms are considered, it was possible to distinguish only two levels of resistance (susceptible and resistant). But taking into account of vascular browning and results in controlled conditions, three levels of resistance were observable with the presence of intermediate resistance (low level of vascular browning in polytunnel or distribution of plants between the classes in controlled conditions).

c. Scenarios of decision rules

Based on the results, different scenarios of interpretation were discussed by partners to evaluate if an interpretation in two notes (susceptible and resistant) or in three notes (susceptible, intermediate resistant and resistant) could be proposed for a DUS protocol. The data of the comparative test were used by GEVES to continue the analysison two

scenarios of decision rules selected by partners (Figure 9). It was decided to test the scenario with candidates of intermediate resistant and resistant controls with different levels of resistance to obtain interpretations from the less to the more restrictive.



3 levels S/IR/R ? V	Vith an IR control as lower t	threshold of IR			
Not different from S control → judged S S	Between the S and the IR controls → judged S	Not different from IR control → judged IR IR	Between the IR and the HR controls → judged IR	IR I	Not different from HR control → judged HR HR
	Susceptible		termediate resistant	- + •	Highly resistant

For the first scenario with only two levels Susceptible and Resistant, one susceptible candidate control (Gisela), three intermediate resistant candidate controls (lower border of resistance) (Ballerina, Banchu Red Fire and Patriot), and two resistant candidate controls (Palmos and Lomeria) were chosen by partners. The interpretation of the varieties according to the first scenario and with the comparison of all the combinations of candidate controls was defined with the Pathostat tool (detailed results in annex 2).

For all the combinations of controls tested:

- A good correlation between labs was observed with a reproducibility around 0.8.
- The four varieties expected as resistant (var_3, var_4, Lomeria and Palmos) were well interpreted as resistant.
- The interpretation of varieties expected with an intermediate resistant level were judged differently depending on the intermediate resistant and the resistant controls selected. Ballerina being the intermediate resistant control given the most of varieties interpreted as resistant. And Patriot the one given the most of varieties interpreted as susceptible.
- Lomeria and Palmos had less effect than lab conditions.

For the second scenario, with three level of resistance (Susceptible, intermediate resistant and highly resistant) it was decided to keep Gisela as susceptible candidate control, to include two intermediate resistant control: Ballerina (with the lower level of intermediate resistance) and var_7 (with the higher level of intermediate resistance) and to compare two highly resistant candidate controls (Palmos and Lomeria). The interpretation of the varieties according to the second scenario and with the comparison of the two highly resistant candidate controls was defined with the Pathostat tool (detailed results in annex 3). For both combinations, isolate I showed the higher level of accuracy and the best reproducibility between laboratories (around 0.6).

d. Decisions and conclusion

During the meeting of presentation of results of the different scenarios, GEVES and ISF organized a system of pool to simplify the decisions to answer to the objectives of the project. The vote of partners not present during the meeting was collected by GEVES before the meeting and included in the answers. The principle of the majority was retained for the selection of the decision rule and the reference material (isolate and controls) for the evaluation of the resistance of lettuce to Fol: 4 (Figure 10) and for the validation of the differential table (Table11).

<u>Interpretation rule</u>: the second scenario with **three levels of resistance (**susceptible, intermediate resistance and highly resistance) was retained by the majority.

<u>Reference isolate for *Fusarium oxysporum* f. sp. *lactucae* race 4: the **isolate I**, isolate 04750888 provided by G. Gilardi (AGROINNOVA) was unanimously selected.</u>

Reference controls:

- Gisela was selected as susceptible reference control. This variety is expected to be • susceptible to the four races of *Fusarium* but it has to be validated on races 2 and 3.
- Ballerina was selected as lower level of intermediate resistant control.
- Patriot was selected as higher level of intermediate resistant control
- Lomeria and Palmos were selected as highly resistant controls.



Figure 7: interpretation rule and controls for evaluation of resistance of lettuce to Fol: 4

During the discussion, Naktuinbouw made a point of noting that the selection of an interpretation in 3 classes (S, IR, and HR) made by the partners of the project is for market claims, and that the CPVO protocol may still have only 2 classes (S and R) (proposal supported by Naktuinbouw). This simplification proposal, which does not correspond to the decision made in this project and the choice of a lot of breeding companies regarding market claims, will have to be discussed at CPVO level by the examination offices at the time of the proposal to add the Fol: 4 characteristics in the Technical protocol for DUS.

Differentials table: the selected controls were added to the differentials table (Table 11). The interpretations of Patriot and Romabella for race 4 were updated (from susceptible to intermediate resistant) following the results of the project. The resistant level observed during the project was identified as HR (highly resistant) in the differentials table to comply with the terminology.

Differ <mark>ential</mark> host	Fol: 1	Fol: 2	Fol: 3	Fol: 4
Gisela	S	ND	ND	S
Patriot	S	S	S	IR
Costa Ri <mark>c</mark> a N°4	HR	S	S	S
Romabella	HR	HR	S	IR
Banchu Red Fire	S	HR	S	IR
Ballerina	C S	ND	ND	IR
Lomeria	DISEL	ND	ND	HR
Palmos	HR	ND	ND	HR

Table 11: Table of differentials selected and validated in the project

S: susceptible, IR: intermediate resistant, HR: highly resistant, ND: no data

Follow up this project, complementary tests will be conducted by two partners and GEVES to complete the differentials table for missing results for races 2 and 3. If Gisela was found not to be susceptible to all races, a new search for a susceptible control to all races should

be carried out. Moreover, a choice between the two varieties Lomeria and Palmos could be done depending on results on races 2 and 3 not yet known.

The availability of the reference material (differentials, controls and isolate I) was checked with the owner which confirmed that this material can be used for DUS and the material will be integrated in MATREF.

Partners discussed about the communication to plan with the conclusion of this project. The differential table was proposed for validation to ISF website. Partners will share the conclusions by social media, Newsletter, etc... An abstract has been accepted for the IHC 2022 congress (poster) and an article will be written by John Clarkson (University of Warwick).

GEVES and all the partners of the ISF project wish to thank Giovanna Gilardi and AGROINNOVA for the supplying of *Fusarium oxysporum* f. sp. *lactucae* race 4 material and for the confirmation of the availability of the reference isolate for a future use for disease resistance testing.

SEED IS LIFE

International Seed Federation

Organisation of the project

Preparation, participation, and coordination of the project

GEVES coordinated this project.

Participants:

Table 12: Participants in the ISF lettuce/Fol: 4 project
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Company	Contact name	Email
GEVES	Valerie Grimault	valerie.grimault@geves.fr
	Sophie Perrot	sophie.perrot@geves.fr
Naktuinbouw	Wim Sangster	w.sangster@naktuinbouw.nl
	<mark>Diederik Smil</mark> de	d.smilde@naktuinbouw.nl
BASF	Bart Geraats	bart.geraats@vegetableseeds.basf.com
Bejo Zaden	J <mark>ordi Boshove</mark> n	jordi.boshoven@bejo.nl
Enza Zaden	Mathieu Pel	M.Pel@enzazaden.nl
	Jim Carlos Cervantes	j.cervantes@enzazaden.fr
	Flores	
Gautier	Marion Cordier-Demissy	marion.cordier@gautiersemences.com
	Gael Briand	Gael.briand@gautiersemences.com
ISI Sementi	Franco Donati	f.donati@isisementi.com
Ramiro Arnedo	Marisol Arnedo	marnedo@ramiroarnedo.com
	Javier Pena Asin	jpa@ramiroarnedo.com
Rijk Zwaan	Eelco Gilijamse	e.gilijamse@rijkzwaan.nl
Syngenta	Michel de Lange	
Tozer	Geoff Denton	geoffrey.denton@tozerseeds.com
University of	John Clarkson	John.Clarkson@warwick.ac.uk
Warwi <mark>ck</mark>		
Vilmo <mark>rin</mark>	Bertrand MONSIMIER	bertrand.monsimier@vilmorin.com

Meetings of the project:

Kick-off meeting online on 01 July 2021 Meeting on controlled condition results online on 06 October 2021 Working group meeting on analysis of results on 18 November 2021 Final meeting online on 15 December 2021

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Annex 1

TG/13/11(proj.4) Lettuce, 2016-11-29 40

Ad 53: Resistance to Fusarium oxysporum f.sp. lactucae (Fol) race 1

1. Pathogen 2. Quarantine status	Fusarium oxysporum f.sp. lactuca EPPO alert list	e
	lettuce - Lactuca sativa L.	
3. Host species 4. Source of inoculum	NIAS Genebank ⁷ (JP), CREA-SCS GEVES ¹⁰ (FR)	S ⁸ (IT), Naktuinbouw ⁹ (NL),
5. Isolate	Fol: 1	
6. Establishment isolate identity	use microscope and inoculation to	lettuce susceptible standard
7. Establishment pathogenicity	use lettuce susceptible standard	
8. Multiplication inoculum		
8.1 Multiplication medium	inoculation by sowing on contamin	nated soil: Wheat bran-soil medium
	inoculation by soaking seedlings:	
	Potatoes Dextrose Broth)	
8.6 Harvest of inoculum	inoculation by sowing on contamin inoculation by soaking seedlings:	
Format of the test		
9.1 Number of plants per genotype	at least 30, in case of doubt 60	
9.2 Number of replicates	at least 2	
9.3 Control varieties	susceptible: Cobham Green, Patri	ot (Cobham Green is slightly less
	susceptible than Patriot)	Natavia (Natavia is the lawse laws) of
	moderate resistance)	Natexis (Natexis is the lower level of
	resistant: Costa Rica No.4, Romas	
9.4 Test design	include control varieties	301
9.5 Test facility	greenhouse or climate room	
9.6 Temperature	25-28 °C (day) / 20 °C (night)	
9.7 Light	under natural day length	
10. Inoculation	two methods can be used for inoci	ulation:
	sowing seeds on contaminated soil	soaking seedlings
10.1 Preparation inoculum	wheat bran-soil medium culture	soaking of roots and of
	mixed with sterilized soil	hypocotyl axis for 5 to 15 min in
		the inoculum suspension
10.2 Quantification inoculum	soil : culture = 20 : 1	spores are harvested and
		adjusted to 10 ⁶ to 10 ⁷ sp/ml
10.3 Plant stage at inoculation	seeds stimulated to emerge	cotyledons to 2 or 3 leaves
	(remark: avoid seeds rotted by	appearing
	factors other than pathogen)	
10.4 Inoculation method	two methods can be used, as des	cribed above
10.5 First observation	7- 10 days post inoculation	clined above
10.6 Second observation	14 days post inoculation	
10.7 Final observations		ng or soaking). One or two of these 3
	observations may be sufficient. Th	
	soaking is destructive since stems	
	vessels.	
11. Observations		
11.1 Method		plants with symptom; as information
	calculate a disease index.	

⁷ genebank@nias.affrc.go.jp

⁸ scs.sa@crea.gov.it

⁹ resistentie@naktuinbouw.nl

10 matref@geves.fr

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	41	
11.2 Observation scale	inoculation by sowing seeds on contaminated soil	inoculation by soaking seedlings
	0: healthy	0: plant without symptoms and healthy vessels
	1: slightly stunting, growing reduction	1: plant with brown vessels only below the cotyledon without yellowing and wilting
	2: severely stunting	2: plant with brown vessels above the cotyledon, without yellowing and wilting
	3: die	3: plant yellowing and wilting, brown vessels
	25	
	TG/13/11(proj.4) Lettuce, 2016-11-29 42	
11.3 Validation of test	of the aggressiveness of the test a the categories. a disease index may be helpful (e: by soaking seedlings: DI= (0A + 1 E), where A to E are number of pla	
 Interpretation of data in terms of UPOV characteristic states 	compare the distribution over the o controls.	ategories with the result of the

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12/Palmos R	var 03	_					LabL	abl	LabL								Labl	ab La	bLa			k				b La	bLa	b La						.ab I	LabL	ab L	.ab L		1	re	producibility
var_05/Patriot IR R	_	R					LabL	abl	LabL			1					Labl	ab La	bLa			1				b La	bLa	b La		2	1			.ab I	LabL	ab L	.ab L		_	re	producibility 1
var_1/Banchu Red Fire IR R <td> var_04</td> <td>R R</td> <td></td> <td></td> <td></td> <td></td> <td>LabL</td> <td>abl</td> <td>LabL</td> <td></td> <td></td> <td>1</td> <td></td> <td></td> <td></td> <td></td> <td>Labl</td> <td>ab La</td> <td>bLa</td> <td></td> <td></td> <td>1 1</td> <td></td> <td></td> <td></td> <td>b La</td> <td>bLa</td> <td>b La</td> <td></td> <td>2</td> <td>1 1</td> <td></td> <td></td> <td>.ab I</td> <td>LabL</td> <td>ab L</td> <td>.ab L</td> <td></td> <td>1</td> <td>re</td> <td>producibility 1 1</td>	 var_04	R R					LabL	abl	LabL			1					Labl	ab La	bLa			1 1				b La	bLa	b La		2	1 1			.ab I	LabL	ab L	.ab L		1	re	producibility 1 1
var_g/ Ballerina IR R	var_04 var_10/Lomeria	R R R					LabL	abl	LabL			1 1 1					Labl	ab La	bLa			1 1 1 1				b La	bLa	b La		2	1 1 1			.ab I	LabL	ab L	.ab L		1 1	re	producibility 1 1 1 1
Banchu Red Fire IR R	var_04 ar_10/Lomeria 12/Palmos	R R R R					LabL	abl	LabL			1 1 1 1					Labl	ab La	bLa		. 12 R R R R	1 1 1 1 1				b La	bLa	b La		2	1 1 1			.ab I	Lab L 7 R R R R	ab L	.ab L	12 R R R R	1 1 1		producibility 1 1 1 1 1
var_07 IR R </td <td>var_04 ar_10/Lomeria r_12/Palmos var_05/Patriot</td> <td>R R R IR</td> <td></td> <td></td> <td></td> <td></td> <td>LabL</td> <td>abl</td> <td>LabL</td> <td></td> <td></td> <td>1 1 1 1 1</td> <td></td> <td></td> <td></td> <td></td> <td>Labl</td> <td>ab La</td> <td>bLa</td> <td></td> <td>12 R R R R R R</td> <td>1 1 1 1 0.62</td> <td></td> <td></td> <td></td> <td>b La</td> <td>bLa</td> <td>b La</td> <td></td> <td>2</td> <td>1 1 1 1 1</td> <td></td> <td></td> <td>ab 5 R R R R R</td> <td>Lab L 7 R R R R S</td> <td>.ab L 9 R R R R R</td> <td>.ab L</td> <td>12 R R R R R</td> <td>1 1 1 0.71</td> <td></td> <td>producibility 1 1 1 1 0.84</td>	var_04 ar_10/Lomeria r_12/Palmos var_05/Patriot	R R R IR					LabL	abl	LabL			1 1 1 1 1					Labl	ab La	bLa		12 R R R R R R	1 1 1 1 0.62				b La	bLa	b La		2	1 1 1 1 1			ab 5 R R R R R	Lab L 7 R R R R S	.ab L 9 R R R R R	.ab L	12 R R R R R	1 1 1 0.71		producibility 1 1 1 1 0.84
var_13/Romabella IR S S R	var_04 var_10/Lomeria var_12/Palmos var_05/Patriot var_11/Banchu Red Fire	R R R R IR e IR					LabL	abl	LabL			1 1 1 1 1 1	1 R R R R R R				Labl	ab La	bLa		12 R R R R R R	1 1 1 1 0.62 0.80				b La	bLa	b La		2 2 2 2 2 2 2 4 4 4 4 4 4 4 4 4 4 4 4 4	1 1 1 1 1 1 1			ab 5 R R R R R	Lab L 7 R R R R S	.ab L 9 R R R R R	.ab L	12 R R R R R	1 1 0.71 0.52		producibility 1 1 1 0.84 0.84
var_14/Ballerina IR S R S S S R R S S S S R S R S R R S O.38 var_02/Costa Rica S	var_04 var_10/Lomeria var_12/Palmos var_05/Patriot var_11/Banchu Red Fire var_g/ Ballerina	R R R R IR e IR IR					LabL 6 R R R R R R S/R	ab L 7 R R R R R R R R	LabL		11 12 R R R R R R R R R R R R R R	1 1 1 1 1 0.80	1 R R R R R S/F				Labl	ab La	bLa		R R R R R R R R	1 1 1 0.62 0.80 0.47				b La	bLa	b La		2 2 2 2 2 2 2 2 2 2 2 2 2 2	1 1 1 1 1 1 1 1 1	1 R R R R R R R		ab 5 R R R R R	Lab L 7 R R R R S	.ab L 9 R R R R R	.ab L	I2 R R R R R R R	1 1 0.71 0.52 1		producibility 1 1 1 0.84 0.84 0.78
var_02/Costa Rica S	var_04 var_10/Lomeria var_05/Patriot var_11/Banchu Red Fire var_g/ Ballerina Banchu Red Fire	R R R IR IR IR IR IR					Lab L 6 R R R R R R S/R R	ab L 7 R R R R R R R R S	LabL		11 12 R R R R R R R R R R R R R R	1 1 1 1 1 0.80 0.64	1 R R R R R S/F				Labl	ab La	bLa		12 R R R R R R R R R	k 1 1 1 0.62 0.80 0.47 0.80				b La	bLa	b La		2 () () () () () () () () () ()	1 1 1 1 1 1 1 1 1	1 R R R R R R R		ab 5 R R R R R	Lab L 7 R R R R S	.ab L 9 R R R R R	.ab L	12 R R R R R R R R	1 1 0.71 0.52 1 0.71		producibility 1 1 1 0.84 0.84 0.78 0.79
Costa Rica S	var_04 var_10/Lomeria var_05/Patriot var_11/Banchu Red Fire var_g/ Ballerina Banchu Red Fire var_07	R R R IR IR IR IR IR IR IR		3 R R R R R R R R R			Lab L 6 R R R R R S/R R R R	ab L 7 R R R R R R R R S	LabL		11 12 R R R R R R R R R R R R R R	1 1 1 1 1 0.80 0.64 0.80	1 R R R R R S/F R R	3 R R R S R R R S	4 R R R R R S/R R R		Labl	ab La	bLa		R R R R R R R R R R R	t 1 1 1 0.62 0.80 0.47 0.80 0.80				b La	bLa	b La			1 1 1 1 1 1 1 1 1 1 1	1 R R R R R R R R R R		ab 5 R R R R R	Lab L 7 R R R R S	.ab L 9 R R R R R	.ab L	12 R R R R R R R R R	1 1 0.71 0.52 1 0.71 0.52		producibility 1 1 1 0.84 0.84 0.78 0.79 0.79 0.79
var_d/Gisela S <t< td=""><td>var_04 var_10/Lomeria var_05/Patriot var_05/Patriot var_11/Banchu Red Fire var_g/ Ballerina Banchu Red Fire var_07 var_13/Romabella</td><td>R R R IR IR IR IR IR IR IR IR</td><td>1 R R R R R R R R R R R R R R</td><td>3 R R R R R R R R S</td><td></td><td></td><td>Lab L 6 R R R R R S/R R R R</td><td>ab L 7 R R R R R R R R S</td><td>LabL</td><td></td><td>11 12 R R R R R R R R R R R R R R R R R R R R R R R R R R R R</td><td>1 1 1 1 0.80 0.64 0.80 0.53</td><td>1 R R R R R S/F</td><td>3 R R R S R R R R S S S</td><td>4 R R R R R S/R R R R R</td><td>5 R R R R R R R R R R</td><td>Lab I 6 R R R S/R S/R S/R S/R S/R S/R</td><td>ab La 7 9 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1</td><td>bLa 9 8</td><td>11 R R R R R R R R R R R</td><td>R R R R R R R R R R R R</td><td>t 1 1 1 0.62 0.80 0.47 0.80 0.80 0.80 0.47</td><td>R F R F R F R F R F R F R F R F R F</td><td></td><td></td><td>b Lal 7 R R R R R R R R R</td><td>bLa 9 R R R R R R R R R R R R</td><td>b La</td><td></td><td></td><td>1 1 1 1 1 1 1 1 1 1 57</td><td>1 R R R R R R R R R R</td><td></td><td>ab 5 R R R R R</td><td>Lab L 7 R R R R S</td><td>ab L 9 R R R R R R R R R R S</td><td>abl 9 R R R R R R R R R R R</td><td>12 R R R R R R R R R R</td><td>1 1 0.71 0.52 1 0.71 0.52 0.52</td><td></td><td>producibility 1 1 1 0.84 0.84 0.78 0.79 0.79 0.55</td></t<>	var_04 var_10/Lomeria var_05/Patriot var_05/Patriot var_11/Banchu Red Fire var_g/ Ballerina Banchu Red Fire var_07 var_13/Romabella	R R R IR IR IR IR IR IR IR IR	1 R R R R R R R R R R R R R R	3 R R R R R R R R S			Lab L 6 R R R R R S/R R R R	ab L 7 R R R R R R R R S	LabL		11 12 R R R R R R R R R R R R R R R R R R R R R R R R R R R R	1 1 1 1 0.80 0.64 0.80 0.53	1 R R R R R S/F	3 R R R S R R R R S S S	4 R R R R R S/R R R R R	5 R R R R R R R R R R	Lab I 6 R R R S/R S/R S/R S/R S/R S/R	ab La 7 9 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1	bLa 9 8	11 R R R R R R R R R R R	R R R R R R R R R R R R	t 1 1 1 0.62 0.80 0.47 0.80 0.80 0.80 0.47	R F R F R F R F R F R F R F R F R F			b Lal 7 R R R R R R R R R	bLa 9 R R R R R R R R R R R R	b La			1 1 1 1 1 1 1 1 1 1 57	1 R R R R R R R R R R		ab 5 R R R R R	Lab L 7 R R R R S	ab L 9 R R R R R R R R R R S	abl 9 R R R R R R R R R R R	12 R R R R R R R R R R	1 1 0.71 0.52 1 0.71 0.52 0.52		producibility 1 1 1 0.84 0.84 0.78 0.79 0.79 0.55
var_08/Gisela S S S S S S S S S S S S S S S S S S S	var_04 var_10/Lomeria var_05/Patriot var_11/Banchu Red Fire var_g/ Ballerina Banchu Red Fire var_07 var_13/Romabella var_14/Ballerina	R R R IR IR IR IR IR IR IR IR IR	1 R R R R R R R R R R R R R R	3 R R R R R R R R S			Lab L 6 R R R R R S/R R R R	ab L 7 R R R R R R R R S	LabL		11 12 R R R R R R R R R R R R R R R R R R R R R R R S R R R S	1 1 1 1 0.80 0.64 0.53 0.40	1 R R R R R S/F S/F	3 R R R S R R R R S R S S R S	4 R R R R S/R S/R	5 R R R R R R R R R R R R	Lab I 6 R R R S/R S/R S/R S/R S/R S/R S/R	ab La 7 9 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1	Ib La 9 9 8 9	11 R R R R R R R R R R R R	12 R R R R R R R R R R R R	1 1 1 0.62 0.80 0.47 0.80 0.47 0.80 0.47 0.20	1 3 R F R F R F R F R F R F R F R F R F R F S F			b Lai 7 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	bLa 9 R R R R R R R R R R R R	b La 9 R R R R R R R R R R R R R	12 12 12 12 12 12 12 12 12 12	2	1 1 1 1 1 1 1 1 1 1 57 .57	1 R R R R R R R R R R		ab 5 R R R R R	Lab L 7 R R R R S	ab L 9 R R R R R R R R R R S	abl 9 R R R R R R R R R R R	12 R R R R R R R R R R	1 1 0.71 0.52 1 0.71 0.52 0.52 0.43		producibility 1 1 1 0.84 0.78 0.79 0.79 0.79 0.55 0.38
	var_04 var_10/Lomeria var_05/Patriot var_11/Banchu Red Fire var_g/ Ballerina Banchu Red Fire var_07 var_13/Romabella var_14/Ballerina var_02/Costa Rica	R R R IR IR	1 R R R R R R R R R R R R R R	3 R R R R R R R R S			Lab L 6 R R R R R S/R R R R	ab L 7 R R R R R R R R S	LabL		11 12 R R R R R R R R R R R R R R R R R R R R R R S R S R S R S R	1 1 1 1 0.80 0.64 0.53 0.40 0.53	1 R R R R R S/F S/F S/F	3 R R R S R R R R S R S S R S S S S	4 R R R R S/R S/R S/R S/R	S R R R R R R R R R R R R R S	Labl G R R R R S/R S/R S/R S/R S/R S	ab La 7 9 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1	bLa 9 9 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 9	11 R R R R R R R R R R R R S	12 R R R R R R R R R R R R R R	1 1 1 0.62 0.80 0.47 0.80 0.47 0.80 0.47 0.20 0.24	1 3 R I R I R I R I R I R I R I R I R I R I R I S I S S			b Lai 7 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	bLa 9 R R R R R R R R R R R R	b La 9 R R R R R R R R R R R R R	12 12 12 12 12 12 12 12 12 12	2 1 1 1 1 1 1 1 1	1 1 1 1 1 1 1 1 1 57 .57	1 R R R R R R R R R R		ab 5 R R R R R	Lab L 7 R R R R S	ab L 9 R R R R R R R R R R S	abl 9 R R R R R R R R R R R	12 R R R R R R R R R R	1 1 0.71 0.52 1 0.71 0.52 0.52 0.43 0.71		1 1 1 0.84 0.78 0.79 0.79 0.79 0.55 0.38 0.57
0.839 0.644 0.898 0.810 0.789	var_04 var_10/Lomeria var_05/Patriot var_11/Banchu Red Fire var_g/ Ballerina Banchu Red Fire var_07 var_13/Romabella var_14/Ballerina var_02/Costa Rica Costa Rica var_d/Gisela	R R R IR IR IR IR IR IR IR S	1 R R R R R R R R R R R R R R	3 R R R R R R R R R S S	4 R R R R R R R R R R S S S	5 R R R R R R R R R R R S S	Lab L 6 R R R R R S/R R R R	ab L 7 R R R R R R R R S	LabL	9 R R R R R R R R R R R S S	11 12 R R R R R R R R R R R R R R R R R R S R S R S R S R S R	1 1 1 1 1 0.80 0.64 0.53 0.40 0.80 0.80 0.80	1 R R R R R R R S/F S/F S/F S/F	3 R R R S R R R R S R S S R S S R S	4 R R R R S/R S/R S/R S/R	S R R R R R R R R R R R R S S	Labl G R R R R S/R S/R S/R S/R S/R S	ab La 7 9 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1 S 1 S 1 S 1 S 1	bLa 9 9 8 9	111 R R R R R R R R R R R R S S	12 R R R R R R R R R R R R R R S	1 1 1 0.62 0.80 0.47 0.80 0.47 0.80 0.47 0.20 0.24 0.23	1 3 R I R I R I R I R I R I R I R I R I S I S I S I	3 4 3 4 3 7 4 7 7 7 8 7 7 7 8 7 7 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7 8 7	6	b Lai 7 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	bLa 9 R R R R R R R R R R R R	b La 9 R R R R R R R R R R R S S	12 R R R R R R R R R R R R R	2	1 1 1 1 1 1 1 1 57 .57 .57 1	1 R R R R R R R R S R S S S		ab 5 R R R R R	Lab L 7 R R R R S	ab L 9 R R R R R R R R R R S	abl 9 R R R R R R R R R R R	12 R R R R R R R R R R	1 1 0.71 0.52 1 0.71 0.52 0.52 0.43 0.71 1		1 1 1 0.84 0.78 0.79 0.79 0.79 0.55 0.38 0.57 0.73
	var_04 var_10/Lomeria var_05/Patriot var_11/Banchu Red Fire var_g/ Ballerina Banchu Red Fire var_07 var_13/Romabella var_14/Ballerina var_02/Costa Rica Costa Rica var_d/Gisela	R R R IR IR IR IR IR IR IR IR IR S S	1 1 R R R R R S S S S S S S S S S S S S S S	3 R R R R R R R R R R S S S S	4 R R R R R R R R R R R R R S S S S S	5 R R R R R R R R R R R S S S S	LabL 6 R R R R R R S/R S S/R S S/R S S/R	ab L 7 R R R R R R R R S S S S S S S	LabL 9 R R R R R R R R R R R R R S S S S	9 R R R R R R R R R R R R S S S	11 12 R R R R R R R R R R R R R R R R R R S R S R S R S R S R S S S S	1 1 1 1 1 0.80 0.64 0.80 0.53 0.40 0.80 0.80 0.80 0.80	1 R R R R R R S/F S/F S/F S/F S/F S/F	3 R R R S R R R R S R S S S S S S S S S	4 R R R R S/R S/R S/R S/R S/R	S R R R R R R R R R R R R S S S	Labl G R R R R S/R S/R S/R S/R S/R S	ab La 7 9 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1 R 1 S 1 S 1 S 1 S 1	bLa 9 9 8 R 8 R 8 R 8 R 8 R 8 R 8 R 8 R 8 R 8 R 8 R 8 R 8 R 8 S 8 S 9 S	11 R R R R R R R R R R R R S S S	12 R R R R R R R R R R R R R	t 1 1 1 1 0.62 0.80 0.47 0.80 0.47 0.20 0.24 0.33 0.47	1 3 R I R I R I R I R I R I R I R I R I S I S I S I S I S I	3 4 3 4 3 7 4 7 7 7 8 7 7 7 8 7 7 7 8 7 8 7 8 7 8 7 9 <td>G R R R R R R R R R R R R R R R R R R R</td> <td>b La 7 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8</td> <td>bLa 9 R R R R R R R R R R S S S</td> <td>b La 9 7 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8</td> <td>12 R R R R R R R R R R R R R R R</td> <td>2 </td> <td>1 1 1 1 1 1 1 1 1 1 1 5 7 5 7 1 .75 1</td> <td>1 R R R R R R R R S R S S S</td> <td></td> <td>ab 5 R R R R R</td> <td>Lab L 7 R R R R S</td> <td>ab L 9 R R R R R R R R R R S</td> <td>abl 9 R R R R R R R R R R R</td> <td>12 R R R R R R R R R R</td> <td>1 1 0.71 0.52 1 0.71 0.52 0.52 0.43 0.71 1 1</td> <td></td> <td>1 1 1 0.84 0.78 0.79 0.79 0.55 0.38 0.57 0.73 0.73</td>	G R R R R R R R R R R R R R R R R R R R	b La 7 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	bLa 9 R R R R R R R R R R S S S	b La 9 7 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8	12 R R R R R R R R R R R R R R R	2	1 1 1 1 1 1 1 1 1 1 1 5 7 5 7 1 .75 1	1 R R R R R R R R S R S S S		ab 5 R R R R R	Lab L 7 R R R R S	ab L 9 R R R R R R R R R R S	abl 9 R R R R R R R R R R R	12 R R R R R R R R R R	1 1 0.71 0.52 1 0.71 0.52 0.52 0.43 0.71 1 1		1 1 1 0.84 0.78 0.79 0.79 0.55 0.38 0.57 0.73 0.73

Annex 2: interpretation of the varieties done by Pathostat based on the first scenario of decision rule with two levels of interpretation

Figure 8: interpretation with Balleria as intermediate resistant candidate control and Lomeria (var_10) (top table) and Palmos (var_12) (bottom table) used as candidate controls

					ls	solat	el									is	olate	- M								is	olat	e N							i	sola	te W				
	La I	.ab La	ab La	ab I				Lab I	Lab I	abl		Lab	Lab	Lab	Lab			Lab I	ab I	ab I	əbl		Lab	Lab	Lab				Lab	Lab		Lab	Lab	o Lal					b Lab	h	
	b 1		1	5	6	7	9		11			1	3	4	5	6	7	9		11 1		[1	3	4	6	7	9	9	12		1	3	4	5	7	9	9			
var 04 R	R	RF	2	R	R	R	R	R	R	R	1	R	R	R	R	R	R	R	R		R	1	R	R	R	R	R	R	S	R	0.75	R	R	R	R	R	R	R	R	1	0.94
var 12 (Palmos) R		R	ŝ	R	R	R	R	R	R	R	0.80	R	R	R	R	R	R	R	R	R	R	1	R	R	R	R	R	R	R	R	1	R	R	R	R	R	R	R	R	1	0.94
var 03 R	R	RF	2	R	R	R	R	R	R	R	1	R	R	S	R	R	R	R	R	R	RC	0.80	R	R	R	R	R	R	R	R	1	R	R	R	R	R	R	R	R	1	0.94
10/lomeria R	R	RF	२	R	R	R	R	S	R	R	0.80	R	R	R	R	R	R	R	R	R	R	1	R	R	R	R	R	R	R	R	1	R	R	R	R	R	R	R	R	1	0.94
Banchu Red Fire IR	R	RF	R	R	R	R	R	R	R	R	1	R	R	R	R	S/R	R	R	R	R	RC	0.80	R	R	R	R	R	R	R	R	1	R	R	R	R	R	R	R	R	1	0.94
var 05/Patriot IR	R	S S	S	R	R	R	R	R	R	S	0.53	R	S	S	R	S/R	R	R	R	R		0.49	R	R	R	R	R	R	R	R	1	R	R	R	R	S	R	R	R	0.75	0.67
var 07 IR	R	s s	S	R	R	R	R	R	R	R	0.64	R	S	S	R	R	S	R	R	R	RC	0.53	R	R	R	R	R	R	R	R	1	R	S	S	R	S	R	R	R	0.46	0.64
var 11/Banchu Red Fire IR	R	R S	S	R	S	R	R	R	R		0.53	R	R	R	R	S/R	R	S	R	R	RC	0.62	R	R	R	R	S	R	S	R	0.57	R	R	R	S	R	S	R	R	0.57	0.60
var 13/Romabella IR	S	S S	S :	S	s	R	S	R	R	R	0.47	S	S	S	R	R	S	S	R	R	RC	0.44	S	S	R	R	S	R	S	R	0.43	S	S	R	R	R	S	S	R	0.43	0.49
var_g/Ballerina IR	R	S S	5	S	S	R	S	S	R	S (0.53	S	R	S	R	S	S	S	S	R	s c	0.53	R	R	R	S	S	R	S	S	0.43	R		R	R	R	R	S	R	0.71	0.49
var_14/Ballerina IR	S	S S	S :	S	S	S	S	S	R	S (0.80	S	R	S	R	S	S	S	S	R	RC	0.47	S	R	S	R	S	R	S	R	0.43	R	R	R	R	S	S	S	R	0.46	0.51
var_d/Gisela S	S	S S	5	S	S	S	S	S	S	S	1	S	S	S	S	S/R	S	S	S	S	s c	0.80	S	S	S		S	S	S	S	1	S	S	S	S	S	S	S	S	1	0.94
var_02/Costa Rica S	S	S S	5	S	S	S	S	S	S	S	1	S	S	S	S	S	S	S	S	S	RC	0.80	S	S	S	S	S	S	S	S	1	S	S	S	S	S	S	S	S	1	0.94
var_08/Gisela S	S	S S	5	S	S	S	S	S	S	S	1	S	S	S	S	S	S	S	S	S	S	1	S	S	S	S	S	S	S	S	1	S	S	S	S	S	S	S	S	1	1
Costa Rica S	S	S S	S :	S	S	S	S	S	S	S	1	S	S	S	S	S	S	S	S	S	S	1	S	S	S	S	S	S	S	S	1	S	S	S	S	S	S	S	S	1	1
										0	.794				1						0	.749									0.829)								0.814	0.790
				-	Isol	late	1					Т				isola	ate N	Λ			Т				-	isola	ate l	١							isol	ate	N				
	Lak	Lab	Lab					o Lab) Lab	Lab		La	b La	b La	b La			/I Lab	Lab	Lab I	ab		Lab	Lab				-	b Lab	Lab	,	Lab	o Lak	b La				o Lal	b Lab]	
	Lab 1	Lab 3	Lab 4					o Lab 9		Lab 12		La 1			b La 5					Lab I 11			Lab 1	Lab 3				-	o Lab 9	Lab		Lab 1	b Lab 3	b La 4				o Lal 9)	
var 04 R	1		Lab 4 R					o Lab 9 R			1				b La 5 R							1	I					-			1	Lab 1 R		b La 4 R			D Lak			1	1
var_04 R var 10/Lomeria R	1 R		Lab 4 R R					o Lab 9 R R							b La 5 R R								I					-				Lab 1 R R		b La 4 R R			D Lak				1 1
	1 R R		Lab 4 R R R					o Lab 9 R R R			1				b La 5 R R R								I					-			1	Lab 1 R R R		b La 4 R R R			D Lak			1	
var_10/Lomeria R	1 R R R		Lab 4 R R R R					o Lab 9 R R R R			1				b La 5 R R R R								I					-			1	Lab 1 R R R R		b La 4 R R R R			D Lak			1 1	1
ar_10/Lomeria R 12 (Palmos) R	1 R R R R		Lab 4 R R R R R R					D Lab 9 R R R R R R			1 1 1				5 R R R							1 1 1	I					-			1	Lab 1 R R R R R		b La 4 R R R R R			D Lak			1 1 1	1 1
var_10/Lomeria R 12 (Palmos) R Banchu Red Fire IR	1 R R R R R R		Lab 4 R R R R R R R					D Lab 9 R R R R R R		12 R R R R R	1 1 1 1	1 R R R R R		4 R R R R	5 R R R						R R R R R R	1 1 1 1	I					-			1	Lab 1 R R R R R R		b La 4 R R R R R R			D Lak			1 1 1 1 1	1 1 0.94 0.94
var_10/Lomeria R 12 (Palmos) R Banchu Red Fire IR var_03 R	1 R R R R R R	3 R R R R R	Lab 4 R R R R R R R R					D Lab 9 R R R R R R R		12 R R R R R S	1 1 1 1 1	1 R R R R R R	3 	4 R R R R	5 R R R						R R R R R R	1 1 1 1 1	I					-			1 1 1 1 1	1 R R R R R R		b La 4 R R R R R R			D Lak			1 1 1 1 1	1 1 0.94 0.94
var_10/Lomeria R 12 (Palmos) R Banchu Red Fire IR var_03 R var_05/Patriot IR	1 R R R R R R R	3 R R R R R	Lab 4 R R R R R R R R R R S					D Lab 9 R R R R R R R R R		12 R R R R R S	1 1 1 1 1 0.64	1 R R R R R R	3 	4 R R R R	5 R R R						R R R R R R	1 1 1 1 0.49	I					-			1 1 1 1 1 1 1	1 R R R R R R		b La 4 R R R R R R S			D Lak			1 1 1 1 0.75 0.57	1 0.94 0.94 0.71
ar_10/Lomeria R 12 (Palmos) R Banchu Red Fire IR var_03 R var_05/Patriot IR var_11/Banchu Red Fire IR var_07 IR var_13/Romabella IR	1 R R R R R R R R R R	3 R R R R R	Lab 4 R R R R R R R R S R					D Lab 9 R R R R R R R R R R		12 R R R R S S S R	1 1 1 1 0.64 0.64	1 R R R R R R R R R R R R	3 F F F F F S	4 R R R R R S S S S	5 R R R						I2 R R R R R R R R	1 1 1 1 0.49 0.80	I					-			1 1 1 1 1 0.75	1 R R R R R R R R		b La R R R R R R R R R		b Lai 7 R R R R R S S	D Lak		12 R R R R R R R R	1 1 1 1 0.75 0.57	1 0.94 0.94 0.71 0.71 0.68
var_10/Lomeria R 12 (Palmos) R Banchu Red Fire IR var_03 R var_05/Patriot IR var_11/Banchu Red Fire IR var_07 IR	1 R R R R R R R R S	3 R R R R S R R	Lab A R R R R R R R S S S					D Lab 9 R R R R R R R R R S		12 R R R R S S R R	1 1 1 1 0.64 0.64	1 R R R R R R R R R R R S	3 F F F F F F S S S	4 R R R R R S S S S	S R R R R R R R R						R R R R R R R R R R	1 1 1 1 0.49 0.80 1	1 R R R R R R R R					-			1 1 1 1 1 0.75 1	1 R R R R R R R R		b La 4 R R R R R R R R R R R R R		b Lai 7 R R R R R S S	D Lak	9 R R R R R R R R	12 R R R R R R R R R	1 1 1 0.75 0.57 0.46 0.43	1 0.94 0.94 0.71 0.71 0.68
var_10/Lomeria R 12 (Palmos) R Banchu Red Fire IR var_03 R var_05/Patriot IR var_07 IR var_13/Romabella IR var_14/Ballerina IR var_g/Ballerina IR	1 R R R R R R R R R R S S	3 R R R R S R R	Lab 4 R R R R R R R R S S S					D Lab 9 R R R R R R R R R S S		12 R R R R S S R R	1 1 1 0.64 0.80 0.44	1 R R R R R R R R R R S S S	3 F F F F F F S S S	4 R R R R S S S S	S R R R R R R R R						L2 R R R R R R R R R R R	1 1 1 0.49 0.80 1 0.44	1 R R R R R R R R R S				Lak 7 R R R R R R S R S	-			1 1 1 1 1 0.75 1 0.46	1 R R R R R R R R S R		b La 4 R R R R R R R R R R R R R R		b Lai 7 R R R R R S S	D Lak	9 R R R R R R R R S	12 R R R R R R R R R	1 1 1 0.75 0.57 0.46 0.43 0.46	1 0.94 0.94 0.71 0.71 0.68 0.49
var_10/Lomeria R 12 (Palmos) R Banchu Red Fire IR var_03 R var_05/Patriot IR var_05/Patriot IR var_07 IR var_13/Romabella IR var_g/Ballerina IR var_20/Costa Rica S	1 R R R R R R R R R S S S	3 R R R R S R R	Lab A R R R R R R R R S S S S S					P Lab 9 R R R R R R R R S S S		12 R R R R S S S R R R S	1 1 1 0.64 0.80 0.44 0.80	1 R R R R R R R R R R S S S	3 F F F F F F S S S	4 R R R R S S S S	S R R R R R R R R						I2 R R R R R R R R R R R R S	1 1 1 0.49 0.80 1 0.44 0.44	1 R R R R R R R R R S				Lak 7 R R R R R R S R S	-			1 1 1 1 0.75 1 0.46 0.57	1 R R R R R R R R S R		b La 4 R R R R R R R R R R R S		b Lai 7 R R R R R S S	D Lak	9 R R R R R R R R S	12 R R R R R R R R R R	1 1 1 0.75 0.57 0.46 0.43 0.46	1 0.94 0.71 0.71 0.68 0.49 0.49
var_10/Lomeria R 12 (Palmos) R Banchu Red Fire IR var_03 R var_05/Patriot IR var_07 IR var_13/Romabella IR var_14/Ballerina IR var_02/Costa Rica S	1 R R R R R R R R R S S S S	3 R R R R S R R	Lab 4 R R R R R R R R S S S S S S					D Lab 9 R R R R R R R R S S S S		12 R R R R S S S R R R S	1 1 1 0.64 0.80 0.44 0.80	1 R R R R R R R R R R S S S	3 F F F F F F S S S	4 R R R R S S S S	S R R R R R R R R						L2 R R R R R R R R R R R R R R	1 1 1 0.49 0.80 1 0.44 0.47 0.53	1 R R R R R R R R R S				Lak 7 R R R R R R S R S	-			1 1 1 1 0.75 1 0.46 0.57	1 R R R R R R R R S R		b La 4 R R R R R R R R R R S S S		b Lai 7 R R R R R S S	D Lak	9 R R R R R R R R S	12 R R R R R R R R R R	1 1 1 0.75 0.57 0.46 0.43 0.46 0.71	1 0.94 0.71 0.71 0.68 0.49 0.49 0.50
var_10/Lomeria R 12 (Palmos) R Banchu Red Fire IR var_03 R var_05/Patriot IR var_05/Patriot IR var_07 IR var_13/Romabella IR var_g/Ballerina IR var_20/Costa Rica S	1 R R R R R R R R R S S S S	3 R R R R S R R	Lab 4 R R R R R R R R S S S S S S S S					D Lab 9 R R R R R R R S S S S S S		12 R R R R S S S R R R S	1 1 1 0.64 0.80 0.44 0.80	1 R R R R R R R R R R S S S	3 F F F F F F S S S	4 R R R R S S S S	S R R R R R R R R						L2 R R R R R R R R R R R R R R	1 1 1 0.49 0.80 1 0.44 0.47 0.53 0.80	1 R R R R R R R R R S				Lak 7 R R R R R R S R S	-			1 1 1 1 0.75 1 0.46 0.57	1 R R R R R R R R S R		b La 4 R R R R R R R R R S S S S		b Lai 7 R R R R R S S	D Lak	9 R R R R R R R R S	12 R R R R R R R R R R	1 1 1 0.75 0.57 0.46 0.43 0.46 0.71 1	1 0.94 0.71 0.71 0.68 0.49 0.49 0.50 0.89
var_10/Lomeria R 12 (Palmos) R Banchu Red Fire IR var_03 R var_05/Patriot IR var_07 IR var_13/Romabella IR var_14/Ballerina IR var_02/Costa Rica S	1 R R R R R R R R R S S S S S S	3 R R R R S R R	Lab 4 R R R R R R R R S S S S S S S S S S					D Lab 9 R R R R R R R R R R S S S S S S S		12 R R R R R S S S S S S S S S S S S S S	1 1 1 1 0.64 0.80 0.44 0.80 0.53 1 1 1 1 1	1 R R R R R S S S S S S S S S S S S	3 F F F F F F S S S	4 R R R R S S S S	S R R R R R R R R						L2 R R R R R R R R R R R R R S S S S S	1 1 1 0.49 0.80 1 0.44 0.47 0.53 0.80 0.80 1.00 1	1 R R R R R R R R R S S S S S S S S S				Lak 7 R R R R R R S R S	-		12 R R R R R R R R R R S S S S S	1 1 1 0.75 1 0.46 0.57 0.46 0.75 1 1 1	1 R R R R R R R R R R R R S S S S S		b La 4 R R R R R R R R R R S S S S S S		b Lai 7 R R R R R S S	D Lak	9 R R R R R R R R S	12 R R R R R R R R R R R S S S S	1 1 1 0.75 0.57 0.46 0.43 0.46 0.71 1 1 1 1	1 1 0.94 0.71 0.71 0.68 0.49 0.50 0.89 0.94 1 1
var_10/Lomeria R 12 (Palmos) R Banchu Red Fire IR var_03 R var_05/Patriot IR var_11/Banchu Red Fire IR var_07 IR var_13/Romabella IR var_g/Ballerina IR var_g/Ballerina IR var_g/Costa Rica S var_08/Gisela S	1 R R R R R R R R R S S S S S S	3 R R R S S S S S S S S S	Lab 4 R R R R R R R R S S S S S S S S S S S					D Lab 9 R R R R R R R R R S S S S S S S S		12 R R R R R S S S S S S S S S S S S S S	1 1 1 0.64 0.80 0.44 0.80	1 R R R R R S S S S S S S S S S S S	3 F F F F F F S S S	4 R R R R S S S S	S R R R R R R R R						L2 R R R R R R R R R R R R R S S S S S	1 1 1 0.49 0.80 1 0.44 0.47 0.53 0.80	1 R R R R R R R R R S S S S S S S S S				Lak 7 R R R R R R S R S	-		12 R R R R R R R R R R S S S S S	1 1 1 1 0.75 1 0.46 0.57	1 R R R R R R R R R R R R S S S S S		b La 4 R R R R R R R R R R R S S S S S		b Lai 7 R R R R R S S	D Lak	9 R R R R R R R R S	12 R R R R R R R R R R R S S S S	1 1 1 0.75 0.57 0.46 0.43 0.46 0.71 1 1 1 1	1 0.94 0.71 0.71 0.68 0.49 0.49 0.50 0.89 0.94

Figure 9: interpretation with Banchu Red Fire as intermediate resistant candidate control and Lomeria (var_10) (top table) and Palmos (var_12) (bottom table) used as candidate controls

	1						Isola	ate l										iso	ate	M									isol	ate	N								iso	late	w				1
		Lab	Lab	Lab	Lab					o La	b Lab		Lab	Lab	Lab	Lab					ab L	ab L	abl		Lab	Lab	Lab					ab La	abl		Lab	Lab	b Lal) Lab		
		1	3	4	5	6	7	9	9		1 12		1	3	4	5	6	-	7 9			11 :			1	3	4	6	7			9 1			1	3	4	5			9		12		
r_10/Lomeria	R	R	R	R	R	R	R	R	R	R	R	1	R	R	R	R	R	F	R F	۲ ا	R	R	R	1	R	R	R	R	R	F	R I	r F	2	1	R	R	R	R	F	R	R	R	R	1	1
var_03	R	R	R	R	R	R	R	R	R	R	R	1	R	R	R	R	R	F	R F	२	R	R	R	1	R	R	R	R	R	F	R I	R F	۲	1	R	R	R	R	F	R	R	R	R	1	1
var_04	R	R	R	R	R	R	R	R	R	R	R	1	R	R	R	R	R	F	R F	۲ ا	R	R	R	1	R	R	R	R	R	F	۲ (5 F	R 0	0.75	R	R	R	R	F	R	R	R	R	1	0.94
var_12 (Palmos)	R	R	R	R	R	R	S	R	R	R	R	0.80	R	R	R	R	R	F	R F	۲ ۱	R	R	R	1	R	R	R	R	R	F	R F	R F	۲	1	R	R	R	R	F	R	R	R	R	1	0.94
var_05/Patriot	IR	R	R	R	R	R	R	R	R	R	R	1	R	R	R	R	S/	RF	r F	۲ ا	R	R	R	0.80	R	R	R	R	R	F	R F	R F	۲	1	R	R	R	R	F	R	R	R	R	1	0.94
var_07	IR	R	R	R	R	R	S	R	R	R	R	0.80	R	R	R	R	R	5	5 F	۲ I	R	R	R	0.80	R	S	R	R	R	F	R I	R F	R 0	0.75	R	S	S	R	5	S	R	R	R	0.46	0.71
var_11/Banchu Red Fire	IR	S	R	R	R	S	S	R	S	R	R	0.47	R	R	R	R	S/	RF	2 5	5 !	S	R	R	0.49	R	S	R	R	R	F	۲ (5 F	R 0	0.57	S	R	R	R	F	R	S	S	S	0.43	0.51
Banchu Red Fire	IR	R	R	R	R	R	S	R	S	R	R	0.64	R	R	R	R	S/	R S	5 5	5 !	S	S	R	0.36	R	S	S	R	R	5	5 5	5 F	R 0	0.43	S	R	S	R	F	R	R	S	S	0.43	0.48
var_13/Romabella	IR	S	S	R	S	S	S	S	R	R	R	0.47	S	R	R	R	R	5	5 5	5 :	S	R	R	0.47	S	S	R	R	S	5	5 5	5 F	R 0	0.46	S	R	R	R	F	R	S	S	R	0.46	0.49
var_14/Ballerina	IR	S	R	S	S	S	S	S	S	R	S	0.64	S	R	S	R	S	5	5 5	5 :	S	R	R	0.47	S	R	S	R	S	F	R .	5 F	R 0	0.43	R	R	S	R	F	R	S	S	R	0.46	0.50
var_g/Ballerina	IR	R	R	S	S	S	S	S	S	R	R	0.47	S	R	S	R	S	5	5 5	5 :	S	R	S	0.53	R	S	R	S	R	5	5 5	5 F	R 0	0.43	S		S	R	F	R	S	S	S	0.52	0.52
var_02/Costa Rica	S	S	S	S	S	S	S	S	S	S	R	0.80	S	S	S	S	S	5	5 5	5 :	S	S	R	0.80	S	S	S	S	S	5	5 5	5 S	5 1	1.00	S	S	S	S	5	S	S	S	S	1	0.89
Costa Rica	S	S	S	S	S	S	S	S	S	S	S	1	S	S	S	S	S	5	5 5	5 !	S	S	S	1	S	S	S	S	S	5	5 5	5 F	R 0	0.75	S	S	S	S	5	S	S	S	S	1	0.94
var_d/Gisela	S	S	S	S	S	S	S	S	S	S	S	1	S	S	S	S	S	5	5 5	5 :	S	S	S	1	S	S	S		S	5	5 5	5 S	5	1	S	S	S	S	5	S	S	S	S	1	1
var_08/Gisela	S	S	S	S	S	S	S	S	S	S	S	1	S	S	S	S	S/	R S	5 5	5 :	S	S		0.80	S	S	S	S	S	5	5 5	5 S	-	1	S	S	S	S	5	S	S	S	S	1	0.94
												0.792												0.751					_				0	.755										0.770	0.773
																									_																				
								late											late						1					late										late					
		Lal	o Lak	o Lal	b La	b La					ab Lal			b Lal	b La	b La	ab La						.ab		Lak	o Lak	o La				ab La	ab La				o Lal	b La					Lab	Lab		
	obse	Lal 1	b Lak 3	o Lal 4	b La 5	b La 6			ıb La		ab Lal .1 12		La 1		b La 4	b La	ab La 5 (ab L		Lab I 11	.ab		Lak 1	Lak	b La 4				ab La	abLa Э1			Lab 1	b Lal 3	b La 4			ab L		Lab	Lab 12		
var_03	R	Lal 1 R	b Lak 3 R	o Lal 4 R	b La 5 R	b La 6		b La	ıb La						b La 4 R	b La 5	abLa 5 (ab L			.ab	1		D Lak 3 R	o Lal 4 R			ıb La	ab La			1		D Lal 3 R	b La 4 R			ab L	ab I	Lab		1	1
var_03 var_10/Lomeria	R R	Lal 1 R R	b Lab 3 R R	o Lal 4 R R	b La 5 R R	b La 6 R R		b La	ıb La			1 1			b La 4 R R	b La 5	ab La 5 (7 7			ab L			.ab	1		D Lak 3 R R	o Lal 4 R R			ıb La	ab La			1		D Lal 3 R R	b La 4 R R			ab L	ab I	Lab		1	1
var_03 var_10/Lomeria ar_12 (Palmos)	R R R	Lal 1 R R R	b Lak 3 R R R	o Lal 4 R R R	b La 5 R R R	b La 6 R R R		b La	ıb La			1			b La 4 R R R	b La 5 F	abLa 5 (R R R			ab L			.ab	1 1 1		2 Lak 3 R R R	o La 4 R R R			ıb La	ab La			1 1 1		D Lal 3 R R R	b La 4 R R R			ab L	ab I	Lab		1 1	1
var_03 var_10/Lomeria ar_12 (Palmos) var_04	R R R R	Lal 1 R R R R	b Lab 3 R R R R R	o Lal 4 R R R R	b La 5 R R R R	b La 6 R R R		b La	ıb La			1 1 1 1			b La 4 R R R R	b La F F	ab La 5 (R R R R			ab L			.ab	1		2 Lab 3 R R R R	D Lai 4 R R R R			ıb La	ab La ab La A		.2 R R R R	1 1 1		D Lal 3 R R R R	b Lai 4 R R R R			ab L	ab I	Lab		1 1 1	1 1 0.94
var_03 var_10/Lomeria ar_12 (Palmos) var_04 var_05/Patriot	R R R IR	Lal 1 R R R R	o Lak 3 R R R R R	D Lal 4 R R R R R	b La 5 R R R R R	b La 6 R R R R		b La	ıb La			1 1 1 1 1 1	1 R R R R R		b La 4 R R R R R	b La F F F	ab La 5 (7 7 7 7 7 7 7 7			ab L			.ab	1 1 1. 0.80 1		Lab 3 R R R R R R	D Lal 4 R R R R R			ıb La	ab La ab La A	9 1 R F R F R F	.2 R R R R R	1 1 1 0.75		D Lal 3 R R R R R	b Lal 4 R R R R			ab L	ab I	Lab		1 1 1 1	1 1 0.94 0.94
var_03 var_10/Lomeria ar_12 (Palmos) var_04 var_04 var_05/Patriot var_07	R R R IR IR	1 R R R R R R R	3 R R R R R	D Lal 4 R R R R R R	b La 5 R R R R R	b La 6 R R R R		b La	ab La 9 9 8 R 8 R 8 R 8 R 8 R 8 R) 1		1 1 1 1 1 0.80	1 R R R R R R		b La 4 R R R R R	b La F F F	ab La 5 (7 7 7 7 7 7 7			ab L			.ab	1 1 0.80 1 0.80		D Lak 3 R R R R R S	D Lal 4 R R R R R R			ıb La	ab La 9 9 7 1 7 1 7 1 7 1 7 1 7 1 7 1	9 1 R F R F R F S F R F R F	.2 R R R R R R C R	1 1 0.75 0.75		D Lal 3 R R R R S	b Lal 4 R R R R S			ab L	ab I	Lab 9 R R R R R R		1 1 1 0.46	1 1 0.94 0.94 0.71
var_03 var_10/Lomeria var_12 (Palmos) var_04 var_04 var_05/Patriot var_07 var_11/Banchu Red Fire	R R R IR IR IR IR	1 R R R R R R S	3 R R R R R R R	D Lal 4 R R R R R R R	b La 5 R R R R R R	b La 6 R R R R R R		b La	ab La 9 9 8 R 8 R 8 R 8 R 8 R 8 R 8 R 8 R) 1		1 1 1 1 0.80 0.53	1 R R R R R R R R		b La 4 R R R R R R	b La F F F F	ab La 5 (6 7 F 7 F 7 F 7 F 7 F			ab L			.ab	1 1 0.80 1 0.80 0.64		D Lab 3 R R R R R S S	D Lal 4 R R R R R R R			ıb La	ab La 9 9 7 1 7 1 7 1 7 1 7 1 7 1 7 1 7 1	9 1 R F R F R F S F R F S F	.2 R R R R R C R C R	1 1 0.75 0.75 0.57		D Lal R R R R R R R R	b Lal 4 R R R R R R R			ab L	ab I	Lab 9 R R R R R R S		1 1 1 0.46 0.46	1 0.94 0.94 0.71 0.59
var_03 var_10/Lomeria ar_12 (Palmos) var_04 var_04 var_05/Patriot var_07 var_11/Banchu Red Fire Banchu Red Fire	R R R IR IR IR IR	1 R R R R R R R S R	3 R R R R R R R R	D Lal R R R R R R R R	b La 5 R R R R R R R R R R R	b La 6 R R R R R R		b La 9 R R R R R R R R R R R R	ab La 9 9 8 R 8 R 8 R 8 R 8 R 8 R 8 S 8 S) 1 R F R F R F R F R F S F S F	.1 12 R R R R R R R R R R R R R R	1 1 1 1 0.80 0.53 0.64	1 R R R R R R R R R	3 R R R R R R R	b La 4 R R R R R R R	b La F F F F F F F F F	ab La 5 (7 7 7 7 7 7 7 7 7 7			ab L			.ab	1 1 0.80 1 0.80 0.64 0.36	1 R R R R R R R R	R R R R R R S S S	D La 4 R R R R R R R R			ıb La	ab La 9 9 9 7 1 7 1 7 1 7 1 7 1 7 1 7 1 7 1	9 1 R F R F S F R F S F S F S F S F	.2 R R R R R C R C R C R	1 1 0.75 0.75 0.57 0.46	1 R R R R R R S S	D Lai 3 R R R R R S R R R	b La 4 R R R R S R S			ab L 7 3 3 3 3 3 5 3 3 3	ab I 9 R R R R R R R R R	Lab 9 R R R R R R S S		1 1 1 0.46 0.46 0.46	1 0.94 0.94 0.71 0.59 0.51
var_03 var_10/Lomeria var_04 var_05/Patriot var_07 var_11/Banchu Red Fire Banchu Red Fire var_13/Romabella	R R R IR IR IR IR IR IR	1 R R R R R R S S	3 R R R R R R R S	4 R R R R R R R R R R	b La 5 R R R R R R R R S	b La 6 R R R R R R R S		b La	ib La 9 9 8 R 8 R 8 R 8 R 8 R 8 S 8 S 8 S 8 S 8 R	1 R F R F R F R F R F S F S F S F S F S F	1 12 R R R R R R R R R R R R R R R R R	1 1 1 1 0.80 0.53 0.64 0.44	1 R R R R R R R R R R S	3 R R R R R R R R	b La 4 R R R R R R R R	b La 5 F F F F F F F F	ab La 5 (7 7 7 7 7 7			ab L		11 R R R R R R R	.ab	1 1 0.80 1 0.64 0.36 0.47	1 R R R R R R R R S	D Lak R R R R S S S S S	2 La 4 R R R R R R R R R R R			ıb La	ab La 9 9 9 7 1 7 1 7 1 7 1 7 1 7 1 7 1 7 1	9 1 R F R F S F R F S F S F S F S F S F	.2 R R R R R C R C R C R C R C C R C	1 1 0.75 0.75 0.57 0.46 0.46		D Lal 3 R R R R R R R R R R R	b Lai 4 R R R R S R S R			ab L 7 3 3 3 3 3 5 3 3 3	ab I	Lab 9 R R R R R R S		1 1 0.46 0.46 0.46 0.46	1 0.94 0.94 0.71 0.59 0.51 0.49
var_03 var_10/Lomeria ar_12 (Palmos) var_04 var_05/Patriot var_07 var_11/Banchu Red Fire Banchu Red Fire var_13/Romabella var_14/Ballerina	R R R IR IR IR IR IR IR IR	1 R R R R R R R S S S	3 R R R R R R R S R	D Lai 4 R R R R R R R R R S	b La 5 R R R R R R R R S S	b La 6 R R R R R R R R S S		b La 9 R R R R R R R R R R R R	ab La 9 9 8 R 8 R 8 R 8 R 8 R 8 R 8 S 8 S	1 R F R F R F R F R F S F S F S F S F S F	.1 12 R R R R R R R R R R R R R R	1 1 1 0.80 0.53 0.64 0.44 0.53	1 R R R R R R R R R R S S	3 R R R R R R R R R R R	b La 4 R R R R R R R R S	b La 5 F F F F F F F F	ab La 5 (7 1 7			ab L		11 R R R R R R R R R R R	ab 12 R R R R R R R R R R R	1 1 0.80 1 0.80 0.64 0.36 0.47 0.47	1 R R R R R R R R	D Lak 3 R R R R S S S S S R	A R R R R R R R R R R R R R			ıb La	ab La ab La S S	 → 1 R F R F S F 	.2 R R R R R C R C R C R C R C R C R C C R C C R C C R C C C R C	1 1 0.75 0.75 0.57 0.46 0.46 0.46	1 R R R R R R S S	D Lai 3 R R R R R R R R R R R	b La 4 R R R R R S R S R S			ab L 7 3 3 3 3 3 5 3 3	ab I 9 R R R R R R R R R	Lab 9 R R R R R R S S		1 1 0.46 0.46 0.46 0.46 0.46	1 0.94 0.94 0.71 0.59 0.51 0.49 0.49
var_03 var_10/Lomeria ar_12 (Palmos) var_04 var_07 var_07 var_11/Banchu Red Fire Banchu Red Fire var_13/Romabella var_14/Ballerina var_g/Ballerina	R R R IR IR IR IR IR IR IR IR IR	1 R R R R R R S S S S	3 R R R R R R R S R	4 R R R R R R R R R R	b La 5 R R R R R R R S S S S	b La 6 R R R R R R R R S S S		b La 9 R R R R R R R R R R R R	ib La 9 9 8 R 8 R 8 R 8 R 8 R 8 S 8 S 8 S 8 S 8 R	1 R F R F R F R F R F S F S F S F S F S F	1 12 R R R R R R R R R R R R R R R R R	1 1 1 1 0.80 0.53 0.64 0.53 0.64 0.53	1 R R R R R R R R R S S S S S	3 R R R R R R R R R R R	b La 4 R R R R R R R S S	b La 5 F F F F F F F F F F F F	ab La 5 (7 1 7			ab L		11 R R R R R R R R R R R	.ab	1 1 0.80 1 0.64 0.64 0.47 0.47 0.53	1 R R R R R R R R R S S R	D Lak R R R R S S S S S S R S	A A R R R R R R R R R R R S			ıb La	ab La ab La S S	9 1 R F R F S F R F S F S F S F S F S F	.2 R R R R R R C R C R C R C R C R C R C	1 1 0.75 0.75 0.57 0.46 0.46 0.46 0.46	1 R R R R R R S S	D Lai 3 R R R R R R R R R R R R	b La 4 R R R R S S R S S S			ab L 7 3 3 3 3 3 5 3 3	ab I 9 R R R R R R R R R	Lab 9 R R R R R R S S		1 1 0.46 0.46 0.46 0.46 0.46 0.46	1 0.94 0.71 0.59 0.51 0.49 0.54
var_03 var_10/Lomeria ar_12 (Palmos) var_04 var_05/Patriot var_07 var_11/Banchu Red Fire Banchu Red Fire var_13/Romabella var_14/Ballerina var_g/Ballerina var_02/Costa Rica	R R R IR IR IR IR IR IR IR S	1 R R R R R R R S S S	3 R R R R R R R S R	4 R R R R R R R R R R	b La 5 R R R R R R S S S S S	b La 6 R R R R R R R S S S S		b La 9 R R R R R R R R R R R R	ib La 9 9 8 R 8 R 8 R 8 R 8 R 8 S 8 S 8 S 8 S 8 R	1 R F R F R F R F R F S F S F S F S F S F	1 12 R R R R R R R R R R R R R R R R R	1 1 1 1 0.80 0.53 0.64 0.44 0.53 0.47 0.80	1 R R R R R R R R R S S S S S	3 R R R R R R R R R R R	b La 4 R R R R R R R R S S S	b La 5 F F F F F F F F F F F F S S	ab La 5 (7 1 7 1 7			ab L		11 R R R R R R R R R R R	ab 12 R R R R R R R R R R R R R R	1 1 0.80 1 0.80 0.64 0.36 0.47 0.47 0.53 0.80	1 R R R R R R R R S	D Lak R R R R R S S S S S S S S S S S	2 Lai 4 R R R R R R R R R R R R R			ıb La	ab La ab La S S	 → 1 R F R F S F 	.2 R R R R R R C R C R C R C R C R C R C	1 1 0.75 0.75 0.57 0.46 0.46 0.46 0.46 0.46	1 R R R R R R S S	D Lai 3 R R R R R R R R R R S	b La 4 R R R R S S S S S S			ab L 7 3 3 3 3 3 5 3 3	ab I 9 R R R R R R R R R	Lab 9 R R R R R R S S		1 1 1 0.46 0.46 0.46 0.46 0.46 0.46 0.52 1	1 0.94 0.71 0.59 0.51 0.49 0.49 0.54 0.84
var_03 var_10/Lomeria ar_12 (Palmos) var_04 var_05/Patriot var_07 var_11/Banchu Red Fire Banchu Red Fire var_13/Romabella var_14/Ballerina var_g/Ballerina var_g/Ballerina var_02/Costa Rica var_d/Gisela	R R R IR IR IR IR IR IR S S	1 R R R R R R S S S S	3 R R R R R R R S R	4 R R R R R R R R R R	b La 5 R R R R R R R S S S S S S S	b La 6 R R R R R R S S S S S S S		b La 9 R R R R R R R R R R R R	ib La 9 9 8 R 8 R 8 R 8 R 8 R 8 S 8 S 8 S 8 S 8 R	1 R F R F R F R F R F S F S F S F S F S F	1 12 R R R R R R R R R R R R R R R R R	1 1 1 1 0.80 0.53 0.64 0.53 0.47 0.80 1	1 R R R R R R R R R S S S S S	3 R R R R R R R R R R R	b La 4 R R R R R R R R S S S S	b La 5 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	ab La 5 (7 1 7			ab L		11 R R R R R R R R R R R	ab 12 R R R R R R R R R R R	1 1 0.80 1 0.64 0.64 0.47 0.47 0.53	1 R R R R R R R R R S S R	D Lak 3 R R R R R R S S S S S S S S S S	D Lai 4 R R R R R R R R R R R S S			ıb La	ab La ab La S S	 → 1 R F R F S F 	2 R R R R R R C R C R C R C R C R C C S S	1 1 0.75 0.75 0.57 0.46 0.46 0.46 0.46 0.75 1	1 R R R R R R S S	D Lal 3 R R R R R R R R R R S S	b Lai 4 R R R R R S S S S S S S			ab L 7 3 3 3 3 3 5 3 3 3	ab I 9 R R R R R R R R R	Lab 9 R R R R R R S S		1 1 1 0.46 0.46 0.46 0.46 0.46 0.52 1 1	1 0.94 0.94 0.71 0.59 0.51 0.49 0.54 0.84 0.94
var_03 var_10/Lomeria ar_12 (Palmos) var_04 var_05/Patriot var_07 var_11/Banchu Red Fire Banchu Red Fire var_13/Romabella var_14/Ballerina var_g/Ballerina var_02/Costa Rica var_d/Gisela Costa Rica	R R R IR IR IR IR IR IR IR S S S S	1 R R R R R R R R S S S S S S S S S S S	3 R R R R R R R R R R S S S S	4 R R R R R R R R R R	b La 5 R R R R R R R S S S S S S S S S	b La 6 R R R R R R S S S S S S S S S S S		b La 9 R R R R R R R R R R R R	ib La 9 9 8 R 8 R 8 R 8 R 8 R 8 S 8 S 8 S 8 S 8 R	1 R F R F R F R F R F S F S F S F S F S F	.1 12 R R R R R R R R R R R R R R R R R R R R R R S R S S S S	1 1 1 1 0.80 0.53 0.64 0.53 0.47 0.80 1 1	1 R R R R R R R R R S S S S S	3 R R R R R R R R R R R	b La 4 R R R R R R R R S S S S S S	b La 5 F F F F F F F F F F F F F S S S S	ab La 5 (7 1 7			ab L		11 R R R R R R R R R R R	ab 12 R R R R R R R R R R R R R R	1 1 0.80 1 0.80 0.64 0.36 0.47 0.47 0.53 0.80	1 R R R R R R R R R S S R	D Lak 3 R R R R R S S S S S S S S S S	D Lal 4 R R R R R R R R R R R S S S			ıb La	ab La ab La S S	9 1 8 F 8 F 8 F 8 F 8 F 8 F 9 S 9	2 R R R R R C C R C C R C C C R C C C C	1 1 0.75 0.75 0.57 0.46 0.46 0.46 0.46 0.46	1 R R R R R R S S	D Lal 3 R R R R R R R R R R R S S S	b Lai 4 R R R R R S S R S S S S S S S			ab L 7 3 3 3 3 3 5 3 3 3	ab I 9 R R R R R R R R R	Lab 9 R R R R R R S S		$1 \\ 1 \\ 1 \\ 0.46 \\ 0.46 \\ 0.46 \\ 0.46 \\ 0.52 \\ 1 \\ 1 \\ 1 \\ 1$	1 0.94 0.94 0.71 0.59 0.51 0.49 0.54 0.84 0.94 0.94
var_03 var_10/Lomeria ar_12 (Palmos) var_04 var_05/Patriot var_07 var_11/Banchu Red Fire Banchu Red Fire var_13/Romabella var_14/Ballerina var_g/Ballerina var_g/Ballerina var_02/Costa Rica var_d/Gisela	R R R IR IR IR IR IR IR S S	1 R R R R R R S S S S	3 R R R R R R R R R R S S S S	4 R R R R R R R R R R	b La 5 R R R R R R S S S S S S S S S S S	b La 6 R R R R R R R R S S S S S S S S S S S		b La 9 R R R R R R R R R R R R	ib La 9 9 8 R 8 R 8 R 8 R 8 R 8 S 8 S 8 S 8 S 8 R	1 R F R F R F R F R F S F S F S F S F S F	1 12 R R R R R R R R R R R R R R R R R	1 1 1 1 0.80 0.53 0.64 0.53 0.47 0.80 1	1 R R R R R R S S S S S S S S S S S S S S	3 R R R R R R R R R R R	b La 4 R R R R R R R R S S S S S S S S S	b La 5 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	ab La 5 (7 1 7			ab L		11 R R R R R R R R R R S S S	ab 12 R R R R R R R R R R S S S S S	1 1 0.80 1 0.80 0.64 0.36 0.47 0.47 0.53 0.80	1 R R R R R R R R R R R S S S S S S	C Lak 3 R R R R S S S S S S S S S S S S S	D La 4 R R R R R R R R R R R S S S S			ıb La	ab La ab La S S	9 1 8 F 8 F 8 F 8 F 8 F 8 F 9 S 9	2 R R R R R C R C C R C C R C C R C C C S S C S S	1 1 0.75 0.75 0.57 0.46 0.46 0.46 0.46 0.75 1	1 R R R R R R S S	D Lal 3 R R R R R R R R R R S S S S S	b Lai 4 R R R S S S S S S S S S S S S			ab L 7 3 3 3 3 3 5 3 3 3	ab I 9 R R R R R R R R R	Lab 9 R R R R R R S S	12 R R R R R R R R R R R S S S S S S	$1 \\ 1 \\ 1 \\ 0.46 \\ 0.46 \\ 0.46 \\ 0.46 \\ 0.46 \\ 0.52 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}$	1 0.94 0.94 0.71 0.59 0.51 0.49 0.54 0.84 0.94

Figure 10: interpretation with Patriot as intermediate resistant candidate control and Lomeria (var_10) (top table) and Palmos (var_12) (bottom table) used as candidate controls

-					solat	el								iso	late I	Л								isolat	te N							isola	te W				
	lat	LabLa	ab			b Lab I	labl	abla	Ы		Lab	Lab		150	Lab		Labl	abl	abl			LabLa	ab	Lal		Lab	Lab		Lab				ab	I.	abLab	1	Accu
	1			5 Lab				11 12		Lab 1			Lab 5	Labé		Lab 9					Lab 1			067						ah 3 I	Lab 4 I						racy
var 10/Lomeria	R R		R R	R	S	_		RR	_	R	R	R	R	R	R	R	R		_	1.00	R	R	R F	R	R	R	_	1.00	R	R	R	R	R II	R/R	RR	0.88	0.94
var 04 F			R R	R	R		IR	RR	0.70	IR	R	IR	IR/R	R	R	IR/R	IR			0.50	IR/R	RI	R IR	/R R	IR/F	RIR		0.38	IR	R	R	IR/R	RI	R/R	IR R		0.53
ar 12 (Palmos)			RR	R	IF			RR	0.40	R	IR	IR	IR/R	IR	R	IR/R				0.40	IR/R		R IR	/R R	IR/F			0.38		IR	IR			R/R		0.25	
var 03 F		-	R R	R	R	R	R	R IF		IR	IR	IR	IR/R	IR	R	IR/R		R		0.40	IR	RI	R IR	/R R	R	IR		0.50	IR	R	IR	IR/R	R		RR		0.58
var 07 II		IR I	R IR/	R IR	} IF		IR	R IF		IR	IR	IR	IR/R	IR	IR	IR/R	IR	R		0.44	IR/R	IR I	R IR					0.38	IR	IR	S/IR	IR/R	IR II	R/R	IR IR		0.42
var_05/Patriot	R IR	IR I	RR	IR	R	IR	IR	IR IF	0.50	IR	IR	IR	IR/R	S/IR	R	IR	IR	IR	IR	0.44	IR	IR I	R IR	R IR				0.42	IR	IR	IR	IR/R		R/R I	IR IR	0.43	0.45
var_11/BRF	R IR	IR I	R R	IR	۱F	IR	IR	R IF	0.50	IR	IR	IR	IR/R	S/IR	IR	IR	IR	IR	IR	0.44	IR	IR I	R IR	R IR	R	IR		0.45	IR	IR	IR	IR	R	S	IR IR	0.46	0.47
Banchu Red Fire	R IR	IR I	R R	IR	R IF	RIR	IR	S IF	0.47	IR	IR	IR	IR/R	S/IR	IR	IR	IR	IR	IR	0.44	IR	IR I	R IR	R IR	IR	IR	R	0.46	S	IR	IR	IR/R	IR II	R/R	IR IR	0.38	0.44
var_13/Romabella	R S	S I	R IR	S	IF	IR	IR	IR IF	0.41	S/IR	IR	IR	IR/R	IR	IR	IR	IR	IR	IR	0.44	IR	S I	R IR	R S	IR	IR	R	0.36	S	IR	IR	IR/R	IR	S	IR IR	0.38	0.41
var_g/ Ballerina II	R IR	IR I	R IR	S/I	R IF	R IR	IR	IR IF	0.47	S/IR	IR	S	IR/R	S/IR	IR	IR	IR	IR	IR	0.38	IR	IR I	R II	R IR	IR	IR	IR	0.50	IR		IR	IR/R	IR II	R/R	IR IR	0.42	0.44
var_14/Ballerina	RS	IR	S S	S/I	R S	S	IR	IR S	0.23	S	IR	S	IR/R	S	S	IR	S	R	IR	0.25	S	IR	S IR,	/R S	IR/F	R IR	R	0.22	IR	IR	IR	IR/R	IR	S	S IR	0.38	0.28
var_02/Costa Rica		S	S S	S	S	S	S	S IF	0.90	S/IR	S	S	S	S	S	IR	S	S	IR	0.70	S	S	S II	R S	S	S	IR	0.75	S S	S/IR	S/IR	S	S	S	S IR	0.71	0.77
Costa Rica S		S	S S	S	S	S	S	S IF	0.90	S	S	S	IR	S	S	IR	S	S	S	0.80	S	S :	S S	5 S	S	S	IR	0.88	S	IR	S	S	S	S	S S	0.88	0.86
var_08/Gisela		S	S S	S	S	S	S	S S	1.00	S	S	S	S	S	S	S	S	-		1.00	S	S	S S	S S	S	S		1.00	S	IR	S/IR	S	S	-	S S	0.75	
var_d/Gisela	5 S	S :	S S	S	S	S	S	S S	1100	S	S	S	S	S	S	S	S	S		1.00	S	S :	S F	R S	S	S		0.88	S	S	S	S	S	S	S S	1.00	
									0.644											.576								0.570								0.562	0.592
				Isola										isolat									isola								iso	late W	/				
	La La			La					ab		La				La			LabL		.	La			La		La Lat		La									Accu
	b1b	3b 4 La	ab 5 La	_		9 Lab	9 La	b 11 :			1b3	Lab	4 Lab	5 Lat	06b7	Labs	b9		_	_	ab 1b 3	3 Lab	4 Lab	6671	Lab 9	5912 D	_		Lab 3	Lab 4	Lab 5	Lab /	Lab 9	Labs	Eab 1	_	racy
var_10/Lomeria R	RR	R	К	R IR	K	ĸ	11	K/ K	R 0.8		K	K	K ID/		кк	IK	к			.90	K K			К	IR/R	кк	0.7	-	К	к	R/R	К	IK/K	К	К		8 0.83
var_03 R	RR	R	R	кк	K	R R IR/I		R/R R/R				IR	IR/			IR IR	R IR				IR R R/R R	IR/F	R IR/ R IR/		R R/R	IR R	0.6		R	R		R	R/R	IR/R	ĸ		8 0.72
var_04 R var 12 (Palmos) R	RR	R D	R D		IR/I			R/R	R 0.7		R	R	IR/						RC		R/R R		R IR/				0.3		R D	R D	IR/R IR/R	R/R	IR/R				0.58
	IR IF				IR				R 0.4		IR	IR				IR			_		IR IR		IR/	_				0 IR	IR	IR		IR	IR/R	1			0.58
				IR IR		_	_		R 0.4					R II							R/R IF				IR/R	IR IR		3 IR		S/IR		IR	IR/R				0.35
var g/ Ballerina IR				/IR IR					IR 0.4			S/II					IR						IR			IR IR			3/ IN	IR	IR/R	IR/R		IR	IR		0.33
var 11/BRF IR			R I		IR/I				R 0.4			IR		R II	R IR	IR	IR				IR IR						0.4		R	IR	IR	R	S	IR	IR		0.43
Banchu Red Fire IR			R	IR R	IR			· ·	R 0.4			R	IR/	R S/		IR	IR			.43	IR IR		IR/	RIR		IR R	0.4	-	R	IR	IR/R	IR	IR/R		IR		0.43
var 13/Romabella IR	S S		IR	S R	IR	IR	IF	-	R 0.3		RIR	IR		R II	R IR	IR	IR	IR		.44	IR S	IR	IR/	RS			0.4	-	IR	IR	IR/R	IR/R	S	IR	IR/F		0.37
var 14/Ballerina IR	SIF		S S	/IR S	Ş	IR	IF		S 0.1	1		S/II	R IR/	R S/	IR S	IR	S	R		.25	S IF	IR	IR/	RS	IR/R	IR R	0.3		R	IR	IR/R	IR	S	S	IR/F		0.25
var 02/Costa Rica S	S S		S	S S	S	S			R 0.9	· · ·	RS	S/1	RS	S/	IR S	IR	S			.50	S S	IR	IR	S	S	S IR	0.6		S	S/IR	S	S	S	S	IR		0.69
Costa Rica S	S S	S	S	s s	S	S		S	R 0.9		RS	S/II	R IR	S/	IR S	IR	S	S	S C	.50	S S	S	S	S	S	S IR	0.8		IR	S/IR	S	S	S	S	S		0.75
var_d/Gisela S	S S	S	S	s s	S	S		S	S 1.0	5 S/I	R S	S/II	R S	S/	IR S	S	S	S	s d	.70	S S	S	R	S	S	S S	0.8	8 S	S/IR	S/IR	S	S	S	S	S	0.75	0.83
var_08/Gisela S	S S	S	S	s s	S	S		S	S 1.0	S/I	R S	S/II	R S	S/	IR S	S	S	S	SC	.70	S S	S	S	S	S	S S	1.0	0 S	S/IR	S/IR	S	S	S	S	S	0.75	0.86
									0.63	1									0	.53							0.5	5								0.52	60.569
			_						0.00	-										6							9									0.33	

Annex 3: interpretation of the varieties done by Pathostat based on the second scenario of decision rule with three levels of interpretation

Figure 11: interpretation with Lomeria (var_10) (top table) and Palmos (var_12) (bottom table) used as resistant candidate controls