RESISTENCIA A PERONÓSPORA EN VID

OBSERVATORIO VITIVINÍCOLA ARGENTINO

2016

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Resumen ejecutivo

El presente trabajo corresponde a "Resistencia de peronóspora en vid" y ha sido desarrollado en el marco de la creación de la Unidad Territorial de Vigilancia Tecnológica e Inteligencia Competitiva – Sector Vitivinícola que es coordinada por el Observatorio Vitivinícola Argentino (Corporación Vitivínicola Argentina y Bolsa de Comercio de Mendoza) y cuenta con la colaboración de distintos profesionales que representan a la Universidad Nacional de Cuyo (UNCuyo), Asociación de Cooperativas Vitivinícolas de Argentina (ACOVI) ,Bodegas de Argentina, Conicet Mendoza, Asociación Ad-hoc de Investigación y Desarrollo de la Corporación Vitivinícola Argentina, Instituto de Biología Agrícola de Mendoza (IBAM), Instituto Nacional de Vitivinicultura (INV), Trivento Bodegas y Viñedos y Catena Wine Institute.

Cabe destacar la activa participación y aportes de: Germán Puga, Darío Erquicia y Micaela Balbi (Observatorio Vitivinícola Argentino), María José Mescolatti (ACOVI), Laura Alturria (Bodegas de Argentina), Federico Berli y Diana Segura (IBAM), Pablo Pizzuolo (UNCuyo) y Rodrigo Alonso (Catena WIne Institute).

El objetivo central de este informe consiste en describir los principales avances y tendencias locales e internacionales asociados al control de Peronóspora a través de vides resistentes.

El presente estudio panorámico de vigilancia tecnológica e inteligencia competitiva forma parte de una serie de estudios que buscan obtener una visión general y una proyección futura de las tecnologías relacionadas a vides resistentes al patógeno Plasmopara vitícola.

Para ello se han utilizado técnicas de la disciplina de vigilancia e inteligencia tecnológica, orientadas a la búsqueda de publicaciones científicas, por un lado, y de patentes, por el otro, y analizar en forma estadística la evolución de la cantidad de publicaciones o patentes de los últimos años; los países con mayor cantidad de publicaciones o patentes; las organizaciones y autores/inventores con mayor cantidad de trabajos publicados o patentes.

Finalmente se presenta una serie de conclusiones que consideramos relevantes, incluyendo el análisis de tendencias y la aparición reciente de nuevas tecnologías que ilustran los temas con mayor interés actual o probable proyección futura.

Se espera que esta información obtenida íntegramente sobre la base del análisis objetivo y fundamentado de datos disponibles y comprobables, pueda contribuir a guiar planes de acción de los ámbitos públicos y privados.

1.Introducción

La peronóspora es una de las enfermedades de la vid más importantes a nivel mundial. El cultivo en Argentina no escapa a ella y los daños producidos por la misma tienen un impacto negativo enorme, causando grandes daños en numerosas campañas.

El control de la enfermedad, si bien puede ser complementado con tratos culturales específicos, es realizado con fungicidas. Esto significa que deben realizarse aplicaciones con productos químicos, lo cual provoca problemas para el personal que aplica dichos productos, además de aumentar los gastos de producción.

Imagen 1: Parral severamente afectado por peronóspora. Foto gentileza Huberto Lucero

http://jvenesemprendedores.blogspot.com.ar/2014_02_01_archive.html

El veloz y prometedor avance de la genética en las últimas décadas ha permitido la identificación y el desarrollo de diferentes especies resistentes a diversas enfermedades. La vid es una especie que ha sido muy estudiada. Y por la importancia de la peronóspora como enfermedad de la vid, resulta interesante investigar el estado de conocimientos sobre el tema.

Es así como surge un interrogante principal, motor de esta investigación: ¿Cuál es el estado de conocimiento y desarrollo sobre variedades de vid resistentes a peronóspora y qué se puede concluir al respecto?

La Vigilancia Tecnológica, como conjunto de técnicas que utilizan herramientas claves para la identificación de avances en la ciencia, permite enfrentarse a este interrogante. De esta manera puede redactarse un panorama de conocimientos y avances sobre el tema, y elaborar conclusiones.

2. Alcances y objetivos

El alcance del presente estudio es el del estado de conocimiento y desarrollo sobre vides resistentes a Pernóspora y forma parte de una serie de estudios de vigilancia e inteligencia tecnológica en los que los desafíos fueron la obtención de la información actualizada y relevante y el procesamiento efectivo de la enorme cantidad de información resultante.

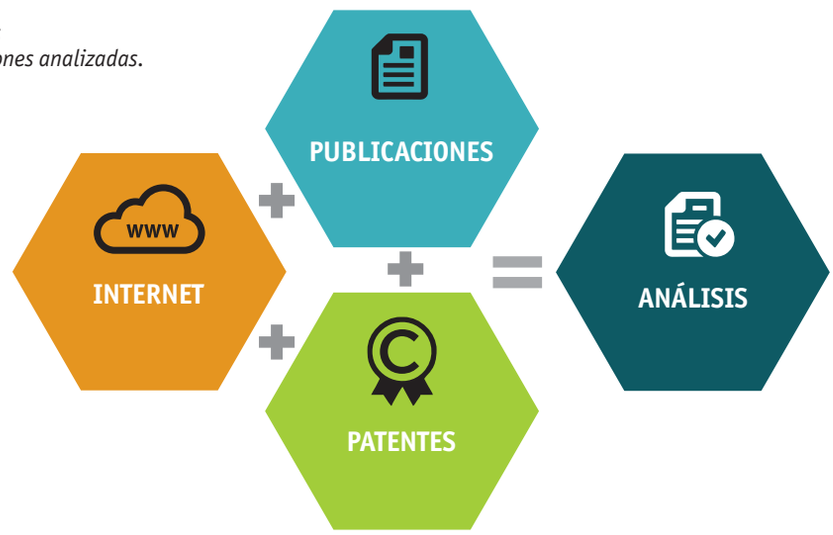
3. Metodología

Para el estudio de vigilancia tecnológica realizado se ha seguido una serie de pasos que pueden verse en el siguiente esquema:

GRÁFICO 1: Pasos seguidos en el estudio.

Se han utilizado tres tipos de fuentes de información: internet, habiéndose utilizando entre otras herramientas un software específico para vigilancia tecnológica denominado VigTeg; publicaciones, buscadas en la base de datos SCOPUS; y patentes, habiéndose usado la base de datos ESPACENET. La información recopilada fue posteriormente analizada.

GRÁFICO 2:
Informaciones analizadas.



En la búsqueda de publicaciones en SCOPUS, la ecuación utilizada fue: (TITLE-ABS-KEY((Plasmopara-viticola OR downy mildew) AND (vitis OR grapevine) AND resistan*)). En la de patentes en ESPACENET la ecuación fue: ((Plasmopara* OR downy*) and (vitis OR grape*) AND resistan*).

4.Peronóspora de la Vid

CARACTERÍSTICAS DE LA ENFERMEDAD*1

La peronóspora de la vid es una enfermedad que está entre las que causan los mayores perjuicios a la vitivinicultura argentina. Provoca graves daños cuando las condiciones climáticas son predisponentes, debido a que ataca a todos los órganos verdes de la planta.

Esta enfermedad se cree originaria de Norteamérica. Causó la tercera calamidad de la viticultura europea a partir de 1876, y contribuyó al éxodo de miles de europeos hacia América. Una curiosidad es que ayudó al descubrimiento del caldo bordelés como fungicida. En Argentina, diezmó la producción de vid en Entre Ríos, obligando a reemplazarla por cítricos.

Las pérdidas económicas pueden ser muy importantes. Si bien existe un avanzado conocimiento de su biología y podría recurrise a variadas herramientas para un manejo racional de la enfermedad, los daños siguen siendo muy serios, tal es así que, en algunas campañas ha sido la enfermedad que más problemática ha causado en los viñedos argentinos.

Entre los daños más importantes puede mencionarse pérdida de la producción (puede ser total), desvalorización de la cosecha, retraso de la fecha de vendimia y predisposición a pérdidas por podredumbre. El manejo no adecuado de la enfermedad puede tener diversas consecuencias, entre ellas: mediano plazo, puede ser responsable de una disminución del rendimiento cuantitativo en la campaña siguiente, y a largo plazo, de un debilitamiento progresivo del vigor del viñedo situación ésta última, que puede predisponer al cultivo al ataque de otras enfermedades como aquellas que interesan a la madera.

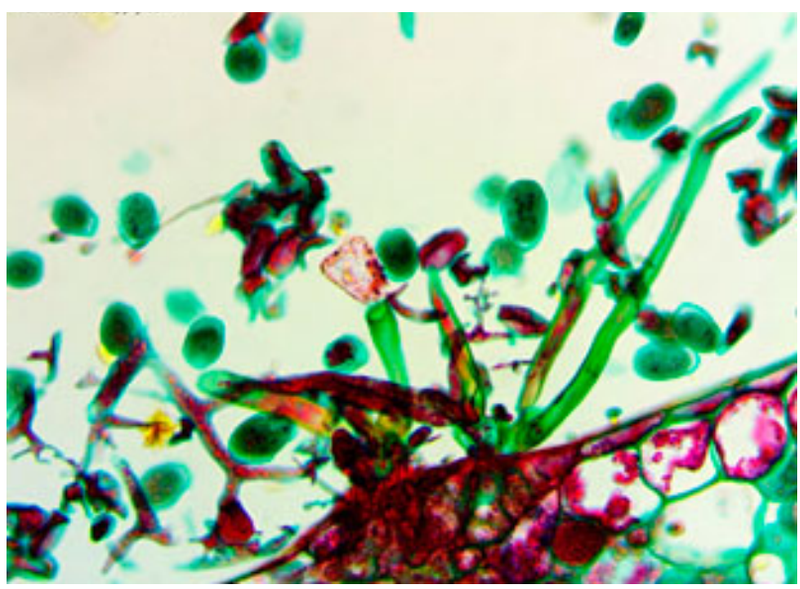


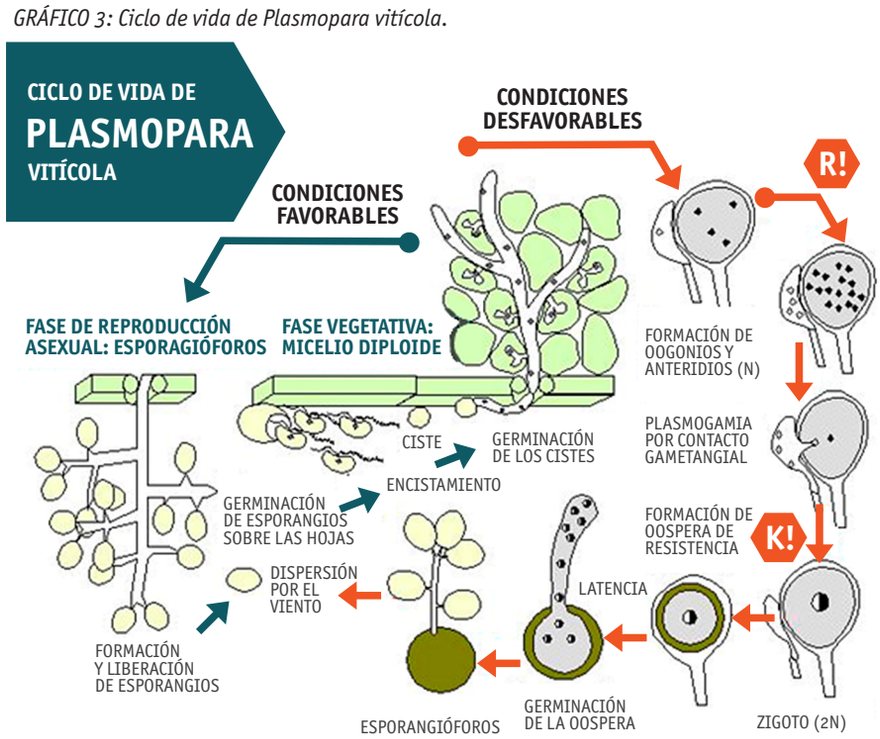
Imagen 2: Desarrollo de la peronóspora en hoja de vid.

http://www.grauhall.com/3863101_Plasmopara_viticola_on_grape_xs_400x.jpg

El agente causal es un microorganismo denominado *Plasmopara viticola*. Durante el invierno se conserva en el suelo, en las hojas secas de la vid, bajo la forma de oosporas (elementos de propagación y resistencia característicos de estos microorganismos). Estos elementos de propagación pueden permanecer vitales por varios años. En la primavera, el patógeno se dispersará gracias a los zoosporangios. Elementos éstos últimos de propagación que serán transportados por las gotas de lluvia y/o corrientes de aire hasta la canopia de las plantas, dónde, en presencia de agua libre, se resolverán en zoosporas. Estas nadarán hasta los estomas, lugar en el cual se enquistarán, germinarán y penetraran al interior del tejido del órgano susceptible.

Así, comienza el período de incubación de la infección primaria. Este período, comprendido entre la infección y la aparición de los síntomas puede variar a campo, según las condiciones ambientales, entre 7 y 18 días. En situaciones particulares puede prolongarse mucho más tiempo. Transcurrido este lapso y con condiciones de humedad relativa elevada, mayor al 90 %, e inducidos por la oscuridad, se formarán los nuevos zoosporangios que continuarán la dispersión del patógeno. En presencia de agua libre sobre los órganos susceptibles, se producirán las infecciones secundarias. Éstas, podrán repetirse varias veces durante el ciclo vegetativo de la vid dependiendo de las condiciones ambientales.

GRÁFICO 3: Ciclo de vida de Plasmopara vitícola.



Al iniciarse el verano comenzaran a formarse, en las hojas lesionadas, nuevas oosporas que constituirán la nueva fuente de inóculo para el próximo período vegetativo.

Las condiciones ambientales influyen decisivamente en el desarrollo de la enfermedad. Son condiciones para:

La infección primaria: humedad en el suelo mínima equivalente, a la alcanzada por una lluvia de 10 mm, brotes de más de 10 cm de largo, y temperatura mínima superiores a 10°C por al menos tres días. Esto es lo que se conoce en el medio como la regla de los tres 10. La condición de lluvias normalmente se cumple con el riego, en aquellas zonas dónde esta última práctica, es necesaria para el cultivo. Las otras dos se cumplen generalmente desde octubre en la mayoría de las regiones vitivinícolas. A estas condiciones se agrega la necesidad de contar con agua libre sobre los órganos susceptibles.

La infección secundaria: agua libre sobre órganos susceptibles por al menos 2 horas, temperatura óptima entre 15 y 25ºC.

La temperatura influye directamente sobre el ciclo de la enfermedad, ésta última, puede reducir o alargar el período incubación. Cuando la temperatura es óptima, entre 20-24ºC el ciclo podría cumplirse en aproximadamente una semana. Las temperaturas límites son 5ºC y 30ºC.

DAÑOS

La peronóspora puede afectar a los órganos verdes de la vid siempre y cuando los estomas, que estas estructuras poseen, se encuentren funcionales. Preferentemente los ataques se observan en: todos los órganos aéreos de la vid y durante todos los períodos de su desarrollo, localizándose preferentemente en:

Imagen 3: Cara adaxial de una hoja de vid con peronóspora.

http://inta.gob.ar/noticias/informe-sanitario-mildiu-o-peronospora-en-vid

HOJAS: se presenta bajo la forma de “manchas de aceite” inicialmente, luego evolucionan a cloróticas pudiendo alcanzar varios centímetros de diámetro, son visibles en ambas caras de la hoja. Si las condiciones ambientales son favorables aparecerán, en la cara inferior de las hojas, en coincidencia con las lesiones una eflorescencia blanquecina que constituyen los elementos de reproducción del patógeno. Cuando las hojas adultas son atacadas estas, manifiestan lesiones en forma de mosaico (manchas poliédricas en las cuales se alternan distintos tonos de verde). Los ataques intensos pueden producir desfoliación, la cual incidirá tanto en la cantidad y calidad de la cosecha, como en el buen agostamiento de los sarmientos y hasta en la brotación del próximo período vegetativo.

Imagen 4: Cara abaxial de una hoja de vid con peronóspora.

http://www.viarural.com.ar/viarural.com.ar/insumosagropecuarios/agricolas/agroquimicos/cheminova/especies/plasmopara-viticola-01.htm

RACIMO: Si la infección se produce entre floración y grano en arveja el racimo entero se deshidratará, oscurecerá y necrosará. Durante este proceso el racimo adquiere la forma de "S". Entre el estado de grano en arveja y envero sólo serán afectadas bayas aisladas o algunas de una misma raquilla. Estas bayas se pardean, arrugan y pueden finalmente caer. Si las condiciones ambientales son favorables se observará sobre los órganos afectados la eflorescencia blanquecina característica. Luego de envero las bayas no son afectadas.

Imagen 5: Racimo con peronóspora.

http://www.diccionariodelvino.com/index.php/mildiu-plasmopara-viticola-/

RECOMENDACIONES

Las variedades que muestran mayor susceptibilidad a peronóspora son Pedro Giménez, Criollas, Almería, Moscatel Rosado, Ugni Blanc y Cereza.

Las labores que favorecen una mayor ventilación del viñedo disminuyen la intensidad del ataque. El control de esta enfermedad debe ser siempre preventivo ya que una vez producida la infección, el manejo es sumamente dificultoso aun, con la ayuda de los diversos fungicidas de síntesis ofrecidos en el mercado y permitidos para el cultivo de la vid. Los momentos oportunos para el control están relacionados con la presencia de agua libre sobre los órganos susceptibles, humedad relativa elevada y estado de desarrollo del vegetal. Las hojas de los pámpanos podrán ser afectadas a partir de que el brote tenga más de 10 cm de largo. El período de mayor susceptibilidad de los racimos es el comprendido entre floración y grano en arveja, luego, disminuye hasta envero; posteriormente, las bayas no pueden ser afectadas. Siempre deberá respetarse el período de carencia del producto empleado. El éxito de la protección consiste en efectuar los tratamientos en forma oportuna y adecuada para impedir o detener la germinación de las oosporas.

TRATAMIENTOS

Tratamientos preventivos:

Con productos de contacto en base a cobre o de síntesis registrados para la enfermedad y el cultivo. Las aplicaciones deben efectuarse, antes o inmediatamente después de producida una lluvia. Esto limitará el establecimiento de nuevas infecciones. Los tratamientos fungicidas podrán repetirse cada 12-15 días dependiendo de que las condiciones favorables para el desarrollo de la enfermedad persistan y del fungicida utilizado.

Tabla 1: FUNGICIDAS DE CONTACTO PREVENTIVOS PARA PERONÓSPORA

PRODUCTO Y FORMULACIÓN	DOSIS C/100 L DE AGUA	PC	LMR (ppm)
Caldo bordelés	1-1,5%	14	10
Captan 80% WP	180 g	25	15
Folpet 80% WP	160 g	20	2
Hidróxido de Cobre 87,25% WP	160 g	14	10
Mancozeb 80% WP	200 g	21	5
Maneb 80% + Sufato de Zinc 3% WP	250 g	14	-
Oxicloruro de Cobre 84 - 85 % WP	300-400 g	14	10
Propineb 70% WP	200 g	7	5
Zineb 70% WP	250 g	10	5
Ziram 90% WP	250 g	7	5

inta.gob.ar/noticias/anticiparse-a-la-peronospora

TRATAMIENTOS CURATIVOS O POSTERIORES A LA INFECCIÓN:

Con productos sistémicos en base a fosetil aluminio, metalaxil u ofurace mezclados con otros productos de síntesis. Puede tener buena acción curativa el metalaxil aplicado hasta un plazo no mayor de 3 días desde la infección. Estos productos además, al ser absorbidos rápidamente, no necesitan ser aplicados nuevamente luego de una lluvia intensa. La persistencia de estos puede alcanzar los 12 a 15 días dependiendo de que hayan sido correctamente aplicados. Para evitar la aparición de cepas resistentes no debe abusarse del uso de los productos sistémicos, es recomendable intercambiarlos con productos de contacto.

TABLA 2: FUNGICIDAS SISTÉMICOS PARA PERONÓSPORA.

PRODUCTO Y FORMULACIÓN	DOSIS CADA 100 L DE AGUA	PC	LMR (ppm)
Benalaxil 8% + Mancozeb 65% WP	250 g	21	0,2; 5
Folpet 25% + Fosetil Al 50% WP	300 g	40	2; 20
Mancozeb 64 % WP + Metalaxil 4 %	250 g	7	5; 1

inta.gob.ar/noticias/anticiparse-a-la-peronospora

Cabe aclarar dos abreviaturas. PC significa periodo de carencia, y es el tiempo en días que deben transcurrir desde el último tratamiento fitosanitario hasta cosecha. LMR es el límite máximo de residuos.

Para lograr un apropiado manejo de los productos químicos se recomienda:
Utilizar siempre productos registrados para su uso en vid.
Respetar el momento de aplicación.
Utilizar la maquinaria adecuada y en perfectas condiciones de uso.

**1: Adaptado de http://www.inv.gob.ar/inv_contenidos/pdf/foro/2014/9-INV-EnfermedadesdelaCanopia.pdf y de http://inta.gob.ar/sites/default/files/script-tmp-peronospora.pdf. Acceso al 12/12/2016.*

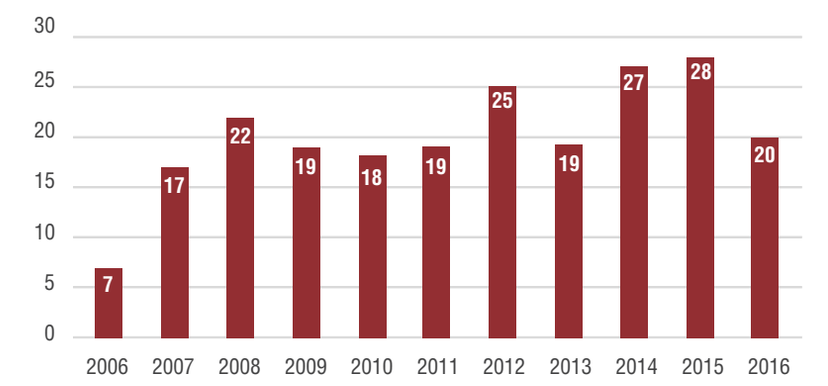
5.Análisis de publicaciones encontradas

Debido a la naturaleza de la temática, la importancia del análisis de publicaciones es enorme y al mismo tiempo esencial. Es por eso que se realizó un análisis detallado de las publicaciones.

Al realizar una búsqueda con la ecuación (TITLE-ABS-KEY((Plasmopara-viticola OR downy mildew) AND (vitis OR grapevine) AND resistan*)) en la base de datos SCOPUS, 221 resultados fueron obtenidos en diciembre de 2016.

La evolución de la cantidad de documentos por año muestra una tendencia al aumento. Esto puede verse con claridad después del año 2000. El promedio de publicaciones desde el año 2006 hasta 2016 (diciembre) es de 20.

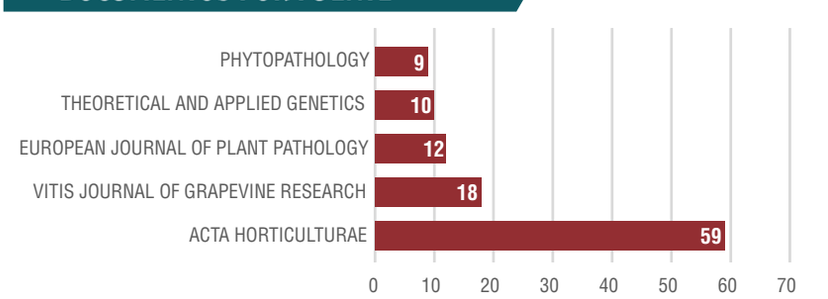
DOCUMENTOS POR AÑO



Fuente: Elaboración propia en base a SCOPUS

Los artículos resultantes de la búsqueda pueden verse distribuidas en 88 fuentes. Cinco revistas (Acta Horticulturae, Vitis Journal Of Grapevine Research, European Journal Of Plant Pathology, Theoretical And Applied Genetics, y Phytopathology) concentran casi la mitad de los resultados.

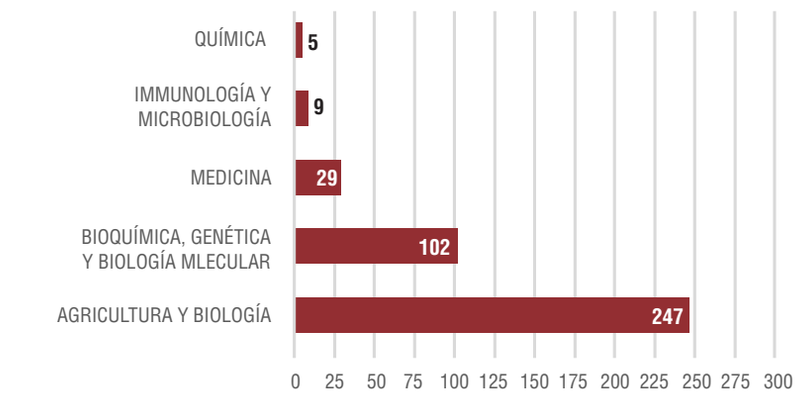
DOCUMENTOS POR FUENTE



Fuente: Elaboración propia en base a SCOPUS

Los documentos encontrados están automáticamente categorizados en 12 temáticas principales. La mayoría están incluidos en agricultura y biología, o bioquímica, genética y biología molecular.

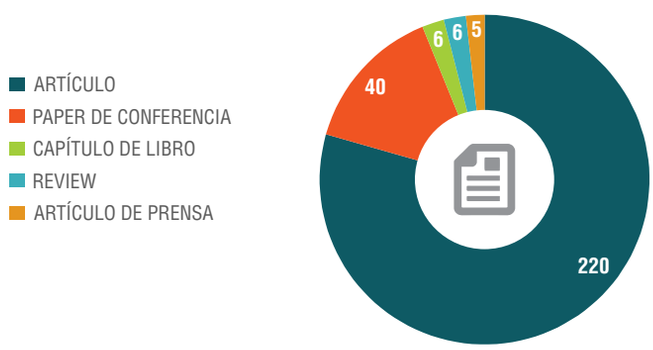
DOCUMENTOS POR TEMA



Fuente: Elaboración propia en base a SCOPUS

Casi el 80% de los documentos son artículos, aunque también muchos son papers de conferencias. Pocos resultados están vinculados con capítulos de libros, reviews o artículos de prensa.

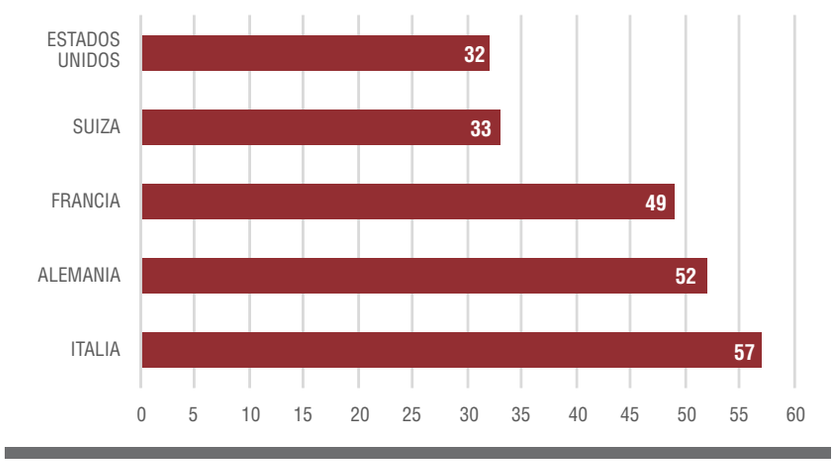
DOCUMENTOS SEGÚN TIPO



Fuente: Elaboración propia en base a SCOPUS

En cuanto al país de origen de las investigaciones y publicaciones, puede inducirse que existe una importante colaboración entre investigadores de diferentes nacionalidades. Los países con más documentos son Italia, Alemania, Francia, Suiza y Estados Unidos. También se destacan otros como China, España y Hungría. Ningún resultado existe para Argentina.

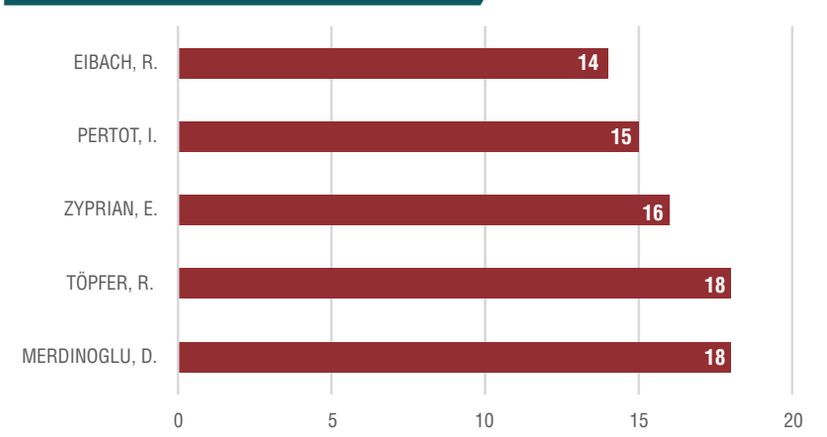
DOCUMENTOS POR PAÍS



Fuente: Elaboración propia en base a SCOPUS

Los autores del total de publicaciones encontradas son 158, con un mínimo de dos publicaciones cada uno. Diez autores tienen más de 10 documentos, y 45 más de 5. Los principales son Merdinoglu, Topfer, Zyprian, Pertot y Eibach.

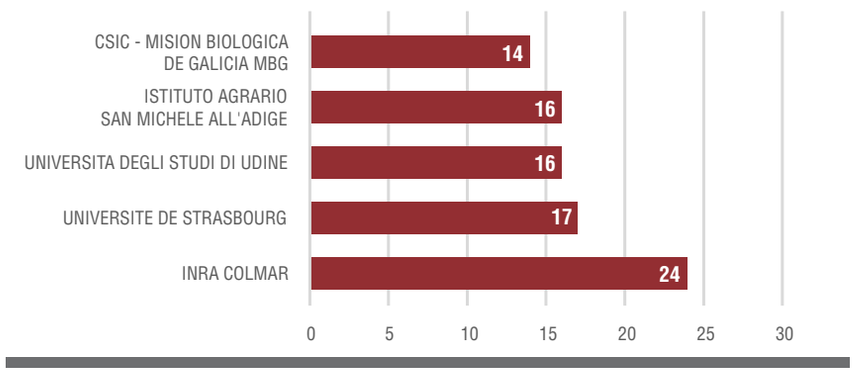
DOCUMENTOS POR AUTOR



Fuente: Elaboración propia en base a SCOPUS

Las afiliaciones resultantes son 160. Las cinco que tienen más documentos son INRA Colmar, Universite de Strasbourg, Universita degli Studi di Udine, Istituto Agrario San Michele all'Adige, y CSIC - Mision Biologica de Galicia MBG. Le siguen Forschungsanstalt Agroscope Changins-Wadenswil, Eidgenossische Technische Hochschule Zurich, Universita degli Studi di Verona, e INRA Bordeaux-Aquitaine. El INRA en su conjunto cuenta con 34 documentos publicados.

DOCUMENTOS POR AFILIACIÓN



Fuente: Elaboración propia en base a SCOPUS

En el anexo I se presentan los resúmenes (en inglés) de las 37 publicaciones que fueron seleccionadas como las más relevantes para su análisis.

Primero, se seleccionaron las publicaciones de SCOPUS que respondieran a la siguiente ecuación:

TITLE ((plasmopara-
viticola OR downy mildew) AND (vitis OR grapevine) AND resistan*) AND (LIMIT-
TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-
TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-
TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-
TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010) OR LIMIT-
TO (PUBYEAR , 2009) OR LIMIT-TO (PUBYEAR , 2008) OR LIMIT-
TO (PUBYEAR , 2007) OR LIMIT-TO (PUBYEAR , 2006))
Scopus
EXPORT DATE:02 Dec 2016

Segundo, se eliminó los documentos que fuesen conference paper, book chapter o review. Dejando solo article o article in press.

Tercero, se desestimó a todo aquel artículo cuya revista figurara en Scimago Journal and Country Rank en el Q3 o Q4 según la temática del mismo. Los nombres de revistas que para la temática vinculada están en el Q1 se encuentran en verde, y los que están en el Q2 en amarillo.

Y cuarto, se sacó aquellos que estuviesen citados menos de 5 veces, o 4 (si fueran del 2012), 3 (si fueran del 2013), 2 (si fueran del 2014), 1 (si fueran del 2015), o 0 (si fueran del 2016).

Finalmente, los artículos se encuentran clasificados en tres temas: relación patógeno-planta, resistencia (campo) y biología molecular. La clasificación de cada uno de ellos puede verse escrita en rojo.

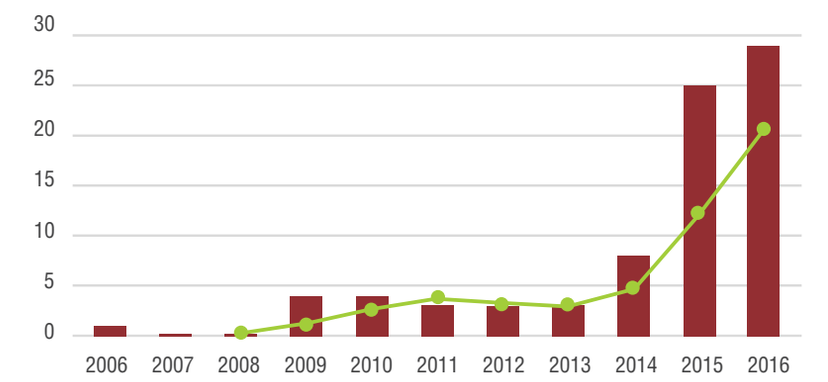
6.Análisis de patentes encontradas

Al realizar la búsqueda con la ecuación (ta all Plasmopara* OR downy* and (vitis OR grape*) AND resistan* and pd="20100101 20161231") en el periodo comprendido entre los años 2006 y 2016 se obtuvieron 208 patentes relacionadas con el tema en la base de ESPACENET.

Realizando la misma búsqueda en PatentInspiration se obtuvieron 80 pantentes.

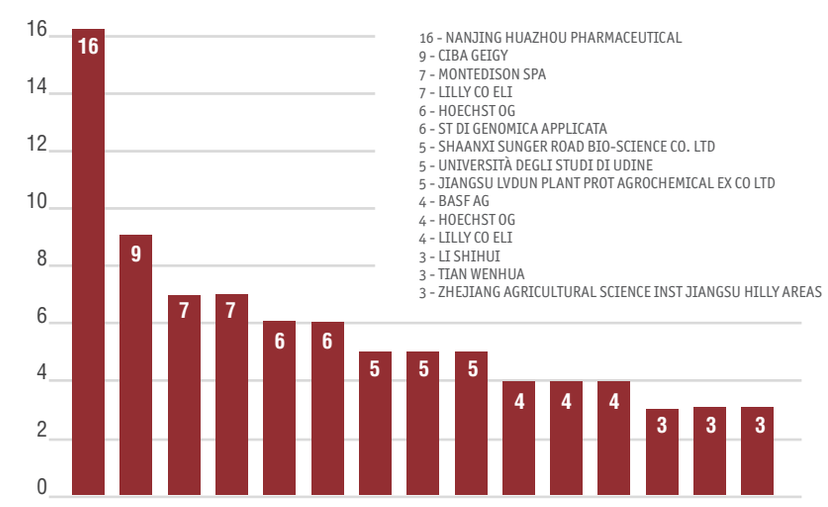
Las patentes más importantes se pueden ver en Anexo II del presente trabajo,

EVOLUCIÓN DE PATENTES POR AÑO



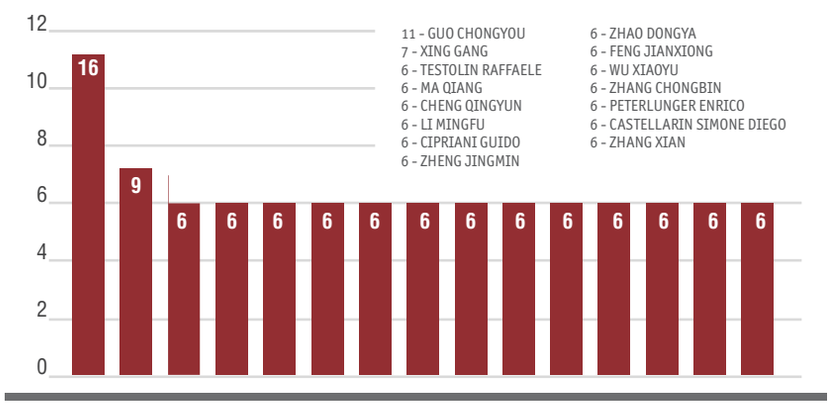
Fuente Patentinspiration

CANTIDAD DE PATENTES POR SOLICITANTE



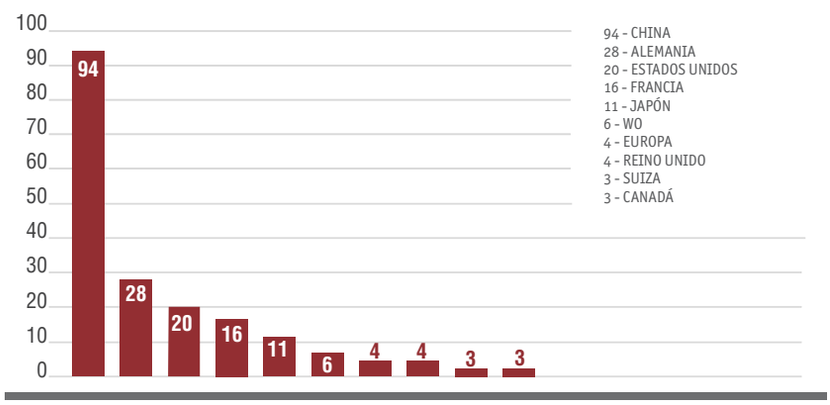
Fuente: Plataforma VigTeg en base a datos de ESPACENET

CANTIDAD DE PATENTES POR INVENTOR



Fuente: Plataforma VigTeg en base a datos de ESPACENET

CANTIDAD DE PATENTES PRESENTADAS POR PAÍS



Fuente: Plataforma VigTeg en base a datos de ESPACENET

NUBE DE PALABRAS SEGÚN INVENTOR

11	GUO CHONGYOU	7	XING GANG

6	ZHANG CHONGBIN	CHEN YEQING	CASTELLARIN
	MA QIANG	PETERLUNGER ENRICO	SIMONE DIEGO
	CIPRIANI GUIDO	ZHANG XIAN	TESTOLIN RAFFAELE
	WU XIAOYU	WAN WEIXIAO	ZHENG JINGMIN
	CHENG QINGYUN	ZHAO DONGYA	MORGANTE MICHELE
	FENG JIANXIONG	LI MINGFU	

5	GAO RUIHUA	4	YANG QIN	3	ZHU CHENGGANG
	SUN HUIJIE		JI MUXIANG		MUSETTI RITA
	SHI ZHENLONG		WANG LILI		TIAN WENHUA
	BAI JIE		XIA XIAOYUN		LI SHIHUI
	PENG YONGQIANG		WU XIANG		YAO KEBING
	GASPERO GABRIELE DI		ZHANG BAOJUN		TIAN TIAN
					ZANG WEIGONG
					BORSELLI STEFANO
					D AMBROSIO MICHELE
					NIU SHANGUANG
					CHI ZONGLEI

2	MUSETTI RITA	LINGLING JI	GEWEHR MARKUS	WANG QINGHAI
	LIU XINGHONG	YU SHUYI	BORSELLI STEFANO	GUAN TIANSHU
	LI BAOYAN	ZHANG WEI	LIU CHANGYUAN	LIU LI
	WU HUALONG	WANG PEISONG	LIANG CHUNHAO	YU XIAOLI
	WILHELM RONALD	BURGERS JAN WILLEM	XU LITING	WANG ZHENWEI
	ZHANG SHUJING	MIAO KANG	CHENG XIANGDI	WANG HUI
	CHEN HONGZHOU	WANG WENQIAO	WANG YINGZI	
	WU HAOTIAN	FEI ZIHUA	LI BAIHONG	

1	SUN LIQUAN	YAN YIBO	QIUFANG ZHANG	CHEN SHA
	HUI JING	SHEN XUEFENG	TAMM LUCIUS	LI LE
	MULHOLLAND DULCIE	DUAN CHUNHUA	DUAN XIANMING	ZHOU MINGGUO
	ANTCLIFF ALLAN J	YANG BOTAO	YE HONG	FENG SHIMING
	HONGNIAN WANG	ANTCLIFF JUDITH R	REN CHENGCAI	CHEN WENYUE
	LIU QISHUN	ZHANG DENGKE	DAMBROSIO MICHELE	WEI ZHANG
	DING ZHENYANG	GUO DAN	MA RUIBIN	MA ZHIQIANG
	FAN KUN	LI YINGWU	TANG MANCANG	QIN WENTAO
	YANG CHEN	YAN CHONGZE	YANG JINGHUI	LIU WEI
	DUAN YABING	WANG JI	ZHUANG YIQING	QU JIANLU
	SHI ZHENG	MI ZHE	SONG TINGTING	ZUMAN ZHANG
	SU XIANYAN	LI XIUXIANG	WU SHUKE	LUO JIANHUI
	CHONGBIN ZHANG	FU LI	PING ZHAO	GUIHUA ZHUANG
	YING DUAN	WU JUNJIE	ZHOU ZENGQIANG	ZANG CHAOQUN
	HUI WANG	HOU HUI	XIAOMING LIU	CHEN CHANGJUN
	BO LI	LIU YULING	SI XIAOFAN	WILLIAMS GILLIAN M
	HOU YIPING	MA HUASHENG	LILI WANG	WU HOUCHANG
	ZENG SHENGHUA	WANG LONGHUA	HAN XIUYING	RITA MUSETTI
	TANG RUI	STEFANO BORSELLI	ANTCLIFF PETER J	LIU XIAOJUN
	LI ZHENGNAN	MA YUMING	ZHANG XIADFENG	ZHAO LAICHENG
	YUAN CHEN	PAN YUEMIN	ZOU CHUNLEI	WANG LUJUN
	SHEN HONGMIAO	KONG FANFANG	TAN RENYAN	DAI BAO
	LI GUOPING	HUANG YUXI	DE ZHAO	HUANG SONGQI
	WANG LI	WANG GENHAO	KORNIEIEVETS VOLODYMYR MYKHAIL	LI XIANLING
	MENG BO	ZHU DAN	WANG SHIHENG	HUANG XIAOQING
	WANG JIANXIN	ZHU FUQING	KANG MIU	LI MEIQIONG
	XIUCHENG YI	XU XINAI	RUI SUN	XIAOYU WU
	FENGWU YANG	YIN HENG	LIANG XIAOWEN	WANG DONGLIANG
	KRAFT-KLAUNZER PETRA	LIGONG LIU	ZHANG BAODUN	ZHAOYU NING
	SHUBAI LI	GUOAN LI	YANG HUA	DU YUGUANG
	SURKOVA VALENTYNA MYKOLAIIVNA	TUO DAISONG	LI PEILONG	LI HUIPING
	AMBROSIO MICHELE D	CHEN PENG	LIU HUI	ANTCLIFF SUSAN R
	RUAN SONGLIN	CHAO GAO	DENG WANPING	ZOU CHEN
	WEI BANGZHI	XIAOLEI SHI	CLINGELEFFER PETER R	ANTCLIFF VERONICA R
	MO LIFAN	JIANXIONG FENG	HAIJUN ZHAO	JAMES T BRISTO
	CHEN ZHI	SCHAERER HANSJACOB	GUO MIN	LAICHENG ZHAO
	WU ZHANG	WANG WENXIA	FAN ZILIANG	ZHAO DA
	WANG ZHONGYUE	WANG ZHONGTANG	ZHU WEIDONG	ZHANG QIONG
	GE DAPENG	JINGMIN ZHENG	ZHANG QIAOMU	ZHAO BINGXIAN
	WANG JIAN	HONGYU MEI	ZHAN FUKANG	LI QUANYONG
	ZHAO XIAOMING	CHEN YUAN	FENG ZHANG	KONG XUEHUA
	ZHANG XUEDAN	ZHENG YUEJIE	WU YANFANG	XIN YA
	GUO JINTANG	DI GASPERO GABRIELE	ZHANG HAO	LIU BAOYOU
	XIANG WU	LIU SHUANLIN	SHEN GUOZHENG	XIAO WENFEI
	YE LONGJIANG	BI QIUYAN	RAN LONGXIAN	BEI SU
	MENZLER-HOKKANEN INGEBORG	WENQIAO WANG	BAI YUANJUN	LU DEPENG
	MARIANNE	HOKKANEN HEIKKI MATTI TAPIO	CHEN ZHIQIN	AIHUA HE
	HAO YUMEI	LI XIAOYU	ZENG QINGSHENG	KLAUNZER NORMAN
	HU JIANFENG	LI PENG	HUA RIMAO	
	LUO CHANGYAN	ZHANG QING	MOSES LANGAT	

Fuente: Plataforma VigTeg en base a datos de ESPACENET

NUBE DE PALABRAS POR SOLICITANTES

16	NANJING HUAZHOU PHARMACEUTICAL
6	ST DI GENOMICA APPLICATA
3	JIANGSU LVDUN PLANT PROT AGROCHEMICAL EX CO LTD UNIVERSITÀ DEGLI STUDI DI UDINE SHAANXI SUNGER ROAD BIO-SCIENCE CO LTD
2	LI SHIHUI ZHENJIANG AGRICULTURAL SCIENCE INST JIANGSU HILLY AREAS TIAN WENHUA ISAGRO SPA JINAN CAVIN BIOTECHNOLOGY CO UNIV DEGLI STUDI UDINE HANGZHOU UDRAGON CHEMICAL CO LTD SHANDONG YANTAI AGRICULTURAL SCI & TECH INST PLANT PROT INST PPI HEBEI ACADEMY AGRICULTURAL & FORESTRY SCIENCES QINGDAO STAR CROPSCIENCE CO SHAANXI WEIERQI CROP PROT CO LIAONING ACADEMY OF AGRICULTURAL SCIENCES SHAANXI TANGPUSEN BIOTECH CO
1	SHAANXI SUNGER BIOTECHNOLOGY C KLAUNZER NORMAN BEIJING ACAD AGRIC & FORESTRY QUANZHOU LYUBANG TRADE CO LTD FORSCH BIOLOG LANDBAU FIBL YUNNAN TIANZHI NETWORK SCIENCE & TECHNOLOGY CO LTD ANHUI HEZHONG AGRICULTURAL TECHNOLOGY CO LTD SHANXI BIAOZHENG CORP SCIENCE ZHEJIANG SEGA SCIENCE AND TECHNOLOGY CO LTD JINAN CAVIN BIOLOG SCIENCE & TECHNOLOGY CO LTD ANTCLIFF ALLAN J DALIAN CHEMICAL PHYSICS INST INST PLANT PROTECTION IPP CAAS D AMBROSIO MICHELE TRENTINO SVILUPPO SPA UNIV DEGLI STUDI DI UDINE QUANZHOU LYUBANG TRADING CO LTD ANHUI BOFA CULTURE AND ECOLOGY PARK CO LTD WEIFANG WANSHENG BIOLOG PESTICIDE CO LTD ANHUI HEZHONG AGRICULTURAL SCIENCE AND TECHNOLOGY CO LTD NIU SHANGUANG ANTCLIFF PETER J TANG RUI ZHEJIANG HETIAN CHEMICAL CO LTD QINGDAO STAR CROPSCIENCE CO LT PAPANNA BEIJING TECHNOLOGY CO LTD SHAANXI SUNGER ROAD BIO SCI CO HEBEI SHUANGJI CHEMICAL CO LTD LIANYUNGANG HETIAN CHEMICAL CO LTD SHANDONG RUIPONT CHEMICAL CO LTD UNI DEGLISTUDI DI UDINE ZHENGZHOU FRUIT RES INST CHINESE ACAD OF AGRICULTURAL SCIENCES HUNAN JINXIN AGRICULTURAL SCIENCE AND TECHNOLOGY CO LTD KRAFT-KLAUNZER PETRA WILLIAMS GILLIAN M COMMW SCIENT IND RES ORG JIANGSU LITTORAL AGRICULTURE SCIENCE RES INST JIANGSU LUYE AGROCHEMICALS CO LTD AGROKHIMINVEST PRIVATE ENTPR SHANGDONG TENOV PESTICIDES CO LTD ANTCLIFF SUSAN R UNIV NANJING AGRICULTURAL HAILIR PESTCIDES AND CHEMICALS GROUP CO LTD ANTCLIFF VERONICA R QINGDAO HANSEN BIOLOG SCIENCE BORSELLI STEFANO SHANDONG INST POMOLOGY LIUZHOU SHENGXINLONG FLOWER CULTIVATION SPECIALTY COOPERATIVES HANGZHOU ACAD AGRICULTURAL SCI UNIV ANHUI AGRICULTURAL CLINGELEFFER PETER R UNIV SURREY SHAANXI HENTIAN CHEM TECH CO LTD JIANGSU ROTAM CHEMISTRY CO LTD ZHU WEIDONG ZHANG QIAOMU ANTCLIFF JUDITH R MUSETTI RITA GUZHEN HUAFENG AGRICULTURE CO LTD GAUNGXI TIANYUAN BIOCHEMISTRY CHEN ZHIQIN UNIV HEBEI AGRICULTURE UNI DEGLISTUDI DI UDINE

Fuente: Plataforma VigTeg en base a datos de ESPACENET

NUBE DE PALABRAS DE TÉRMINOS USADOS CON MAYOR FRECUENCIA

127	MILDEW	104	DOWNY
89	GRAPE	58	BACTERICIDE
76	RESISTANCE	49	CONTROL
73	CONTAINING	47	PLASMOPARA
69	BACTERICIDAL	46	PESTICIDE
67	APPLICATION	44	CONTROLLING
64	DISEASES	44	METHOD
		43	VITICOLA

38	PREVENTING	27	DRUG	25	DISCLOSES	21	LOW
37	PREVENTION	26	POWDERY	24	LEAF	21	REDUCED
35	STERILIZATION	26	FUNGICIDE	24	CROPS	20	WHICH
35	BLIGHT	26	AGENT	24	COMPRISES	20	CAUSED
33	DISEASE	25	STRAIN	24	INGREDIENTS	20	WATER
32	CUCUMBER	25	SYNERGISTIC	24	BIOLOGICAL	20	ANTHRACNOSE
		25	EFFECTIVE	24	BACILLUS	20	SPOT
		25	COST	23	COMPOUND		

19	ALTERNARIA	17	ZOXAMIDE	15	EFFECTS
18	STERILIZING	16	CYAZOFAMID	15	FOLLOWING
18	ACCORDING	16	FRUIT	15	VEGETABLES
18	COMPOSITE	16	PYRACLOSTROBIN	15	SPECTRUM
17	WHEREIN	16	LATE		
17	GRAPEVINE	15	BACTERIAL		
17	FUNGI	15	PATHOGENIC		

Fuente: Plataforma VigTeg en base a datos de ESPACENET

PERFILES DE LAS EMPRESAS SOLICITANTES DE PATENTES

NANJING PHARMACEUTICAL CO. LTD.

Fundada en el Año 1935 es uno de los principales fabricantes de la industria farmacéutica de China. La empresa se dedica principalmente al I+D de nuevos fármacos y productos químicos.

INTITUTE OF APPLIED GENOMICS

Es un centro privado, sin fines de lucro para la investigación en genética, genómica y bioinformatica, con sede en Undine, Italia.

Dedicados a la mejora de los cultivos para el avance de la agricultura, la silvicultura y la industria alimentaria, desarrollo de biotecnologías verdes y sensibilizar al público sobre la seguridad y la inocuidad de los alimentos.

JIANGSU LVDUN PLANT PROTECTION PESTICIDE EXPERIMENTATION CO., LTD.

Compañia estatal China dedicada a la fabricación de pesticidas y productos químicos.

La universidad de Udine fue fundada en el año 1978 como parte de la reconstrucción de la región del Friule luego del terremoto de 1976, su objetivo es proporcionar a la comunidad fruiliana un centro independiente para la formación avanzada en estudios culturales y científicos. Cuenta actualmente con programas de grado sobre Agricultura, Economía, ingeniería, medicina entre otros.

7.Análisis de proyectos

Se analizaron que proyectos se encuentran en ejecución en distintos países, para ello se consultaron diferentes fuentes de información:

CORDIS.

AWRI. The Australian Wine Research Institute.

INRA.

CSIRO.

USDA (United States Departement of Agriculture).

IMIDRA (Instituto Madrileño de Investigación y Desarrollo Rural, Agrario y Alimentario).

Entre los principales proyectos encontrados podemos destacar los siguientes:

VIGILANCE IN THE VINES: CAN GRAPEVINE DOWNY MILDEW ADAPT TO RESISTANT GRAPE VARIETIES?

(INRA) Francia.

http://presse.inra.fr/en/Press-releases/grapevine-downy-mildew-and-resistant-grape-varieties

Este proyecto intenta ver la durabilidad de la resistencia de las nuevas variedades debido a que existe la posibilidad de que surjan patógenos con la capacidad de adaptarse a las nuevas condiciones.

INNOVINE (Combining innovation in vineyard management and genetic diversity for a sustainable European viticulture)

http://cordis.europa.eu/result/rcn/175827_en.html

http://www.innovine.eu/project/wp3.html

El proyecto combina enfoques de corto, mediano y largo plazo para concebir sistemas vitivinícolas innovadores, diseñar y probar nuevas prácticas agronómicas y sistemas de apoyo a la toma de decisiones y aprovechar la diversidad genética de la vid a través de la selección. En conjunto, estos avances garantizarán un progreso hacia una viticultura sostenible.

PROECOWINE (Development of a process to generate a novel plant protection product enriched with micronutrients to replace copper in organic viticulture)

http://cordis.europa.eu/result/rcn/164201_en.html

http://www.proecowine.eu/

El objetivo del proyecto es desarrollar un nuevo producto de protección biológica para el tratamiento de enfermedades fúngicas comunes de la vid y reemplazar así los fungicidas de cobre en la viticultura orgánica y convencional. Para lograr esto, se cultivaron dos cepas de microalgas que inhiben fiablemente las propiedades fúngicas y así obtener un producto fitosanitario.

FORESTSPECS (Wood Bark and Peat Based Bioactive Compounds, Speciality Chemicals, and Remediation Materials: from Innovations to Applications)

http://cordis.europa.eu/result/rcn/149969_en.html

El proyecto consistió en el análisis cualitativo y cuantitativo de extractos de la corteza de una serie de especies arbóreas de importancia industrial y además se analizaron y estudiaron las sustancias húmicas de la turba para fines médicos, cosméticos y fitosanitarios para aplicaciones industriales. También se investigó el uso de la biomasa total o restante en la producción de sustratos de crecimiento, fertilizantes orgánicos y materiales de biorremediación

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ECTOPATH (Pioneering post-genomic approaches for studying algal host-pathogen interactions: characterisation of the Ectocarpus-Eurychasma model)

http://cordis.europa.eu/result/rcn/49119_en.html

El proyecto aspira a largo plazo a dilucidar los mecanismos de la enfermedad causada por Eurychasma en algas marrones para comprender mejor cómo los oomycetes logran infectar a sus huéspedes, como parte de la búsqueda constante de tratamientos nuevos o mejorados contra la Enfermedades que causan. También apoya el estudio de la biología Eurychasma en el campo, y de su impacto en el funcionamiento de los ecosistemas costeros marinos.

SUPERVISED CONTROL TRIALS AGAINST GRAPE DOWNY MILDEW (PLASMOPARA VITICOLA) USING ELECTRONIC APPARATUS AND TRADITIONAL METEOROLOGICAL INSTRUMENTS

http://cordis.europa.eu/publication/rcn/1989128020537_en.html

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PROLARIX (Botanical plant Protection agent from Larix by-products)

http://cordis.europa.eu/result/rcn/186831_en.html

El objetivo general del proyecto es facilitar la introducción en el mercado de un producto innovador para la protección de las plantas a patógenos a partir de subproductos de la industria forestal europea. También se van a desarrollar y explotar las oportunidades de negocio para las PYME relacionadas con la protección de plantas en Europa y proporcionar una oportunidad para la industria forestal de transformar el bajo valor de los subproductos en extractos bioactivos de alto valor añadido. Improving Fruit Quality, Disease Resistance, and Tolerance to Abiotic Stress in Grape

https://www.ars.usda.gov/research/project/?accnNo=425016

Tiene como objetivo mejorar la calidad de los frutos, la resistencia a las enfermedades y la tolerancia al estrés abiótico en la uva.

Evaluation of resistance to downy mildew in grape varieties grown in a Spanish collection

https://www.researchgate.net/publication/283051611_Evaluation_of_resistance_to_downy_mildew_in_grape_varieties_grown_in_a_Spanish_collection

Se evaluó la resistencia al moho (Plasmopara viticola) de la mayoría de las principales y las menores variedades de vid cultivadas en España.

VitisGen

http://vitisgen.org/index.html

Es un gran proyecto multidisciplinario y colaborativo enfocado en disminuir el tiempo, esfuerzos y costos involucrados en el desarrollo de la próxima generación de uvas. Incorpora tecnología de vanguardia genómica y la investigación socioeconómica en el proceso de selección y evaluación de uva tradicional, que acelerará la capacidad de identificar genes importantes relacionados con los rasgos valorados por los consumidores, la resistencia a las enfermedades, tolerancia a baja temperatura y la mejora de la calidad de la fruta. La identificación de estos genes ayudará a los programas de mejoramiento de uva de todo el mundo a desarrollar más rápidamente nuevas variedades de uva que atraerán a una amplia gama de consumidores, al mismo tiempo que atenderán las necesidades de los productores. Adicionalmente, Los recursos científicos desarrollados durante el proyecto permitirán a los científicos y obtentores abordar otras cuestiones y necesidades que tienen importancia regional, como la salinidad o la tolerancia a la sequía.

ENDURE is the European Network for the Durable Exploitation of Crop Protection Strategies.

www.endure-network.eu

PERFILES DE LAS EMPRESAS EJECUTORAS DE PROYECTOS

Primer instituto de investigación agronómica de Europa y segundo del mundo, lleva a cabo trabajos de investigación orientada con miras a una alimentación sana y de calidad, una agricultura competitiva y sostenible y un medio ambiente preservado y valorizado.

InnoVine es un proyecto de colaboración europeo financiado a través del programa basada en el conocimiento Bio-Economía (KBBE), puesto en marcha en enero de 2013. Durante 4 años, implicará 27 socios diferentes de 7 países europeos (Bulgaria, Francia, Alemania, Hungría, Italia, Portugal y España). Combina innovación en el manejo del viñedo y genética para una Viticultura Europea sostenible.

Es una asociación transeuropea de 6 PYME de 5 estados miembros de la UE que planean desarrollar un nuevo fungicida biológico para tratar las enfermedades fúngicas comunes de la vid.

CENTRE FOR DRUG RESEARCH FACULTY OF PHARMACY

ForestSpeCs es un programa de la CE financiado por el 7PM coordinado por la Universidad de Helsinki. Otros socios incluyen Centro de Investigaciones Técnicas de Finlandia, Academia Médica Estatal de San Petersburgo (Rusia), Universidad de Surrey (Reino Unido), Instituto de Investigación del Norte de Silvicultura (Rusia), FGU Instituto de Investigación Forestal del Lejano Oriente (Rusia), Instituto de Investigación para la Agricultura Orgánica (Suiza), Trifolio-M (Alemania) y Oy Granula Ab Ltd (Finlandia).

La Universidad de Columbia Británica es un centro mundial para la investigación y la enseñanza, consistentemente clasificada entre las 40 mejores universidades del mundo.

El Instituto de Investigación de Agricultura Orgánica fue fundada en 1973 como una fundación privada y es uno de los centros orgánicos más importantes del mundo de investigación agrícola y de transferencia de tecnología dedicadas a la agricultura sostenible.

Trifolio-M GmbH se ha comprometido en el control biológico de plagas desde 1985. Actualmente 25 empleados están trabajando para la compañía con su ubicación en el centro de Alemania, Lahnau. En este sentido, la investigación y el desarrollo de biopesticidas innovadoras y estrategias de protección de plantas es uno de nuetros principales focos.

GAB Consulting es un proveedor de servicios líder en el registro de productos fitosanitarios, biocidas, productos químicos, aditivos para raciones y medicamentos veterinarios en la UE y en otras regiones de todo el mundo. Desde el inicio de actividades de la empresa en 1998, el registro de extractos de plantas y microorganismos como ingredientes activos en productos fitosanitarios y registro de dichos productos es una parte central de la obra.

La Universidad de Surrey es un miembro del Grupo de investigación intensiva universidades del Reino Unido de 1994 y tiene experiencia tanto en liderar y participar en la investigación financiado por la CE.

Departamento de agricultura de los Estados Unidos

Servicio de Investigación Agrícola

El Servicio de Investigación Agrícola (ARS) es la principal agencia de investigación científica del Departamento de Agricultura de los Estados Unidos . Su trabajo consiste en encontrar soluciones a los problemas agrícolas que afectan a los estadounidenses todos los días de toda la cadena productiva.

El Instituto Nacional de Alimentación y Agricultura (NIFA) proporciona liderazgo y financiamiento para programas que promueven las ciencias relacionadas con la agricultura. Invierten y apoyan iniciativas que garanticen la viabilidad a largo plazo de la agricultura. NIFA aplica un enfoque integrado para asegurar que los descubrimientos innovadores en las ciencias y tecnologías relacionadas con la agricultura lleguen a las personas que pueden ponerlas en práctica.

ENDURE reúne a algunos de los principales institutos europeos de investigación agrícola, enseñanza y extensión con especial interés en el Manejo Integrado de Plagas (MIP) dentro del contexto general de la agricultura ecológica y sostenible.

8.Búsqueda y análisis de información a partir de otras fuentes de información

Como complemento al análisis de publicaciones científicas, patentes y proyectos relacionados con el tema, también es importante contar con información sobre normativas legales y técnicas, mercados, eventos y noticias. Capturar y utilizar eficientemente esta información disponible requiere el conocer fuentes de información oficiales a fin de respaldar conceptos con información valida, confiable y útil.

Con el apoyo de la plataforma de vigilancia Tecnológica desarrollada en el Observatorio Vitivinicola Argentino (VigTeg), se analizan más de 300 fuentes de información, tanto de fuentes científicas, de patentes, mercados, legación, proyectos, entre otras.

A continuación se detallas algunas de las novedades más relevantes que han sido capturadas en los últimos años de acuerdo a la temática actual del presente estudio.

31/05/17

Downy Mildew en los viñedos de California

https://www.winesandvines.com/template.cfm?section=news&content=185051

25/04/17

Examen de la eficacia de los productos biológicos contra la peronóspera.

http://www.growingproduce.com/fruits/grapes/examining-the-effectiveness-of-biologicals-against-downy-mildew-in-grapes/

06/03/17

Estudio de bastones de vid como una fuente fungicida natural contra la peronóspera.

http://oeno-one.eu/article/view/1178

16/11/16

Investigación a la resistencia de fungicidas en Vid.

http://research.wineaustralia.com/research-finds-some-red-warning-flags-in-the-vineyard/

10/10/16

Tras la producción de vinos superorgánicos.

http://www.decanter.com/wine-news/opinion/jefford-on-monday/jefford-monday-2-2-334078/

07/10/16

El renovado interés en el desarrollo de vides resistentes a enfermedades.

http://research.wineaustralia.com/renewed-interest-in-breeding-disease-resistant-vines/

10/11/15

Primera detección de peronóspera en un viñedo mediante un método basado en fluorescencia.

http://pubs.rsc.org/en/Content/ArticleLanding/2015/PP/c5pp00121h#!divAbstract

18/09/15

Se necesitan otras opciones al uso del fungicida "Captan"

http://winetitles.com.au/dwn/details.asp?ID=18169

21/05/15

Desarrollo para generar un novedoso producto fitosanitario enriquecido con micronutrientes para sustituir el uso de cobre en la vitivinicultura orgánica.

http://cordis.europa.eu/result/rcn/164201_en.html

http://www.proecowine.eu/

23/04/14

Congreso sobre los avances contra plagas de la vid.

http://www.tecnovino.com/un-congreso-que-se-centro-en-los-avances-contra-el-mildiu-y-oidio-de-la-vid/

9.Conclusiones

La peronóspora de la vid causada por el Oomycete *Plasmopara viticola,* es una de las enfermedades más graves que afectan a la vid a nivel mundial[1]. Sólo puede ser controlada mediante intensivos tratamientos con fungicidas de síntesis. El uso inadecuado y repetitivo de este tipo de productos puede, por una parte, afectar negativamente al medio ambiente y a los seres humanos y por otra, seleccionar cepas resistentes del patógeno. De hecho, existen cepas de *P. vitícola* resistentes al fungicida Quinona outside inhibiting (Qol)[2].

A partir de las publicaciones seleccionadas se identifican diversas estrategias de manejo de la enfermedad que están siendo estudiadas en la actualidad en otros países, entre ellas, resultan particularmente prometedoras el empleo de variedades resistentes[3], sustancias inductoras de los mecanismos de resistencia[4] y el empleo de biocontroladores como *Trichoderma spp*.

Las diversas variedades de *Vitis vinífera* mayormente cultivadas en nuestro país y en el mundo son altamente susceptibles a la enfermedad. Se reportan como especies mayormente resistentes a la enfermedad *Vitis cinerea, Vitis labrusca, Vitis x champinii*[5], *Vitis riparia, Muscadinea rotundifolia*[6], *Vitis piasezkii* Liuba-8 -originaria de China[7] y algunos cultivares de reciente introducción como Bianca[8], Regent[9], Mgaloblishvili N – originaria del Cáucaso[10]-, 'Wilcox 321 1[11]. A pesar de que el uso de variedades resistentes, como estrategia de manejo de la enfermedad, resultaría un método amigable con el medio ambiente, su empleo se encuentra actualmente restringido como portainjerto ya que sólo está permitido en nuestro país el uso de *V. vinifera* para la elaboración de vino. Estudios regionales mencionan variedades de *V. vinífera* "muy sensibles" como lo son Pedro Giménez, Criolla Grande, Criolla Chica, Almería, Moscatel Rosado y Ugni Blanc´, variedades "tolerantes" como Alphonse Lavallée, Barbera de Asti, Cabernet, Malbeck y Pinot y "muy tolerantes" como lo son algunos híbridos de *Vitis europea* por vides de origen americano.

El análisis de los transcriptomas (conjunto de genes que se están expresando en un momento dado en una célula) en plantas resistentes y susceptibles mostraron que ambas especies cambian su transcriptoma entre 24 y 48 horas después de la infección con *Plasmopara vitícola*. Pero en *V. riparia* cambia en mayor cantidad, aumentando la transcripción de genes en cascada que desencadenan la respuesta hipersensible (máxima expresión de resistencia de las plantas al ataque por patógenos donde las células que rodean el sitio donde penetró el patógeno mueren con la intención de detener su avance e infección) y la biosíntesis de jasmonatos, mientras que en *V. vinífera* la respuesta es en menor cantidad[12].

Estudios recientes han permitido observar que, en general, los cultivares de vid resistentes a Peronóspora no sólo poseen características morfológicas diferenciales en los órganos susceptibles sino también presentan una mayor acumulación, respecto a

1 - Banani et al., 2014; Perazzolli et al., 2011;
2 - Chen, 2007
3 - Peressotti et al., 2010; Liu et al., 2014
4 - Harm et al., 2011
5 - Cadle-Davidson et al., 2008
6 - Chen et al., 2007
7 - Liu et al., 2014
8 - Peressotti et al., 2010
9 - Peressotti et al., 2009
10 - Toffolatti et al., 2016
11 - Prajongjai et al., 2008
12 - Polesani, 2010

aquellos susceptibles, de sustancias químicas que se correlacionan con el grado de resistencia como lo son glucósido 3-O-quercitina, derivados del trans-feruloyl[13], ácido 3-hidroxibutanoico; isómero del ácido 2,3,4-trihidroxigutanoico, ácido hexadeconico, ácido 3-hidroxihexanoico y mio-inositol[14].

Además, de diferencias a nivel de hospedante, en cuanto respecta a variedades o especies resistentes o susceptibles, han sido reportadas variaciones a nivel del patógeno. En general los aislados más agresivos de *Plasmopara viticola* presentan una gran capacidad de esporulación, menor período de latencia, entre otras[15]. Algunos trabajos han demostrado que nuevas poblaciones del patógeno emergen en los agroecosistemas en los cuales se han empleado plantas con resistencia parcial al mismo. Esta plasticidad adaptativa del patógeno implica la necesidad de utilizar métodos de manejo que incluyan diversas herramientas de control de modo de asegurar la sustentabilidad del sistema en el tiempo[16]. Algunas publicaciones sugerirían que, en realidad, la resistencia no estaría ligada a la virulencia del patógeno.[17]

Según se ha reportado en los últimos años en diversos artículos, la resistencia de la vid a la Peronóspora se explica fundamentalmente por expresión de genes mayores[18]. Asimismo se ha citado que la respuesta de las plantas mediados por distintos genes, puede diferir entre cultivares y los diversos inductores involucrados[19]. La activación de los genes mayores se expresa a través de la síntesis de más de 800 proteínas, algunas de las cuales se encuentran involucradas en procesos oxidativos y en el metabolismo energético[20]. En los casos en los cuales la resistencia ha sido asociada a la presencia de un único gen, se observó que el patógeno era capaz de superar rápidamente la barrera defensiva asociada a la expresión de ese gen[21].

Estudios realizados con plantas hospedantes y no hospedantes del patógeno[22] han permitido identificar el instante en el cual se desencadenaría la activación del mecanismo defensivo del vegetal. Se vinculó al momento de formación del haustorio del patógeno como disparador de la respuesta defensiva[23]. En la reacción de defensa estaría involucrada la pared celular y se vería impedida la formación de futuros haustorios[24].

Entre los mecanismos de defensa activos empleados por la vid se señalan en diversos estudios, la producción de fitoalexinas, especialmente aquellas estilbénicas[25], las cuales han sido ligadas a especies o cultivares menos susceptibles al patógeno. Existen diversas sustancias que podrían ser empleadas como inductores de las respuestas de defensas de vegetal. Estas permitirían alertar a las plantas antes de producirse el contacto con el patógeno. La mejora de la eficacia del sistema defensivo a través del empleo de este tipo de sustancias podría emplearse como otra herramienta de manejo de la enfermedad complementaria al control químico clásico[26]. La eficacia de los activadores suele estar ligada a diversos factores abióticos que participan a nivel de campo[27]. Existen diversos ejemplos de estas sustancias tales como los quitosanos aplicados junto al caldo bordelés que resultan fuertes inductores de la acumulación de fitoalexinas. Algunos β-1,3-glucanos y particularmente el sulfato de laminarina, el S-metil ester del ácido carbotioico 7-benzothiadiazol (BTH), se reportaron como activadores de las defensas. El

13 - Kashif et al., 2009
14 - Batovska et al., 2009
15 - Delmas et al., 2016; Delmotte et al., 2014
16 - Delmotte et al., 2014
17 - Peressotti et al., 2010
18 - Peressotti et al., 2010
19 - Delmotte et al., 2014
20 - Nascimento-Gavioli et al., 2016
21 - Peressotti et al., 2010
22 - Peressotti et al., 2010
23 - Chen et al., 2007
24 - Chen et al., 2007
25 - Paolocci et al., 2014; Van Leeuwen et al., 2013
26 - Roatti et al., 2013
27 - Roatti et al., 2013

ácido 3-dl- β-aminobutirico (BABA) se mencionó como el involucrado en la acumulación de proteínas relacionadas con la patogenicidad (PR).

Resulta interesante el hecho de que algunas cepas del hongo *Trichoderma harzianum* están involucradas en la modulación de los genes relacionados al mecanismo de reconocimiento de microorganismos[28] y a la mejora de la expresión de los procesos defensivos luego de la llegada del patógeno a su hospedante[29]. Las vías metabólicas involucradas en la traducción de la señal inducida por T. harzianum son las del ácido jasmónico y la del etileno[30]. Esto contrasta con la de otros activadores, como el BTH, en la cual interviene la vía del ácido salicílico[31].

Otras líneas de investigación plantean métodos alternativos de control a través del empleo de extractos de plantas[32]. Los extractos de raíces de *Rheum palmatum* y corteza de *Frangula alnus* fueron capaces de proteger a las hojas de vid del ataque de *P. viticola*[33]. Éstos resultaron no solamente tóxicos para el patógeno, sino que también indujeron la acumulación de fitoalexinas, al aumento de la actividad peroxidásica y a la manifestación de la reacción de hipersensibilidad[34]. La toxicidad manifestada por los extractos pudo asociarse a la presencia de compuestos fenólicos como la emodina.

En cuanto a la ejecución de proyectos figura sobre todo Europa como centro. Las investigaciones tienen como fin común la combinación de la innovación en la gestión del viñedo y la diversidad genética cuidando la sostenibilidad de la viticultura en el tiempo.

Hay varios proyectos que parten del análisis de los recursos genéticos de la vid para seleccionar genotipos que muestren alta resistencia contra factores bióticos (hongos, insectos) y abióticos (sequía, altas temperaturas). Estos estudios demuestran que es necesario una gestión integrada del viñedo que permita la durabilidad de las variedades resistentes. El objetivo de muchos proyectos llevados a cabo es lograr determinar o desarrollar nuevas variedades viníferas resistentes a las enfermedades causadas por la humedad en exceso, sin que estos clones afecten a la calidad del producto.

También se encuentran estudios sobre el desarrollo de un nuevo producto para combatir enfermedades fúngicas de la vid y así reemplazar fungicidas a base de cobre, el cual está siendo limitado por diversas normas, por afectar la salubridad del suelo y afectar potencialmente a quienes consumen productos que lo han utilizado en su producción. Para lograr esto, se ha trabajado sobre cepas de microalgas cultivadas y procesadas obteniendo así un producto fitosanitario con micronutrientes.

La búsqueda de compuestos bioactivos, como los que se han encontrado en cortezas de pinos, en turba y en extractos de plantas como *Larix sp.*, para ser utilizados tanto como fungicidas o elicitores.

Se puede concluir a partir de la información analizada que se ha avanzado bastante en cómo reacciona la planta a partir del contacto con el patógeno, en como inducir mecanismos de resistencia en vides, sobre el empleo de biocontroladores y también en el desarrollo de sistemas de gestión de viñedos entre otros pero se tiene que hacer mayor énfasis en lograr elaborar un producto comercial que disminuya las pérdidas producidas por este patógeno pero que sea amigable con el ambiente. Hoy en día el mejoramiento genético se realiza en su mayoría a través de una selección sobre variedades tradicionales

28 - Perazzoll et al., 2012
29 - Perazzoll et al., 2012; Banani et al., 2014
30 - Perazzolli et al., 2011
31 - Perazzolli et al., 2011
32 - Godard et al., 2009
33 - Godard et al., 2009
34 - Godard et al., 2009

o a través de una selección clonal y sanitaria. Es notable y muy positivo la conciencia que se ha adquirido en Europa sobre la importancia de desarrollar productos amigables con el ambiente y con el ser humano que se están tratando de implementar pero todavía falta que esa conciencia llegue a América Latina donde las publicaciones y proyectos acerca de vides resisitentes a *Plasmopara vitícola* son escasos.

10. Bibliografía y fuentes de información utilizadas

Las fuentes de información utilizadas son:

- § SCOPUS
- § ESPACENET
- § Plataforma de Vigilancia Tecnológica "VigTeg"
- § CORDIS
- § CSIRO (Commonwealth Scientific and Industrial Research Organisation – Australia).
- § INRA (Instituto Nacional de la investigación Agronómica de Francia).
- § Catena Institute.
- § The Australian Wine Research institute.
- § USDA (United States Departement of Agriculture).
- § IMIDRA (Instituto Madrileño de Investigación y Desarrollo Rural, Agrario y Alimentario).

La bibliografía se encuentra citada en los anexos I y II, exceptuando otras fuentes que se detallan a continuación:

Enfermedades de la canopia, INV. http://www.inv.gob.ar/inv_contenidos/pdf/foro/2014/9-INV-EnfermedadesdelaCanopia.pdf. Acceso al 12/12/2016.

Peronóspora, INTA. http://inta.gob.ar/sites/default/files/script-tmp-peronospora.pdf. Acceso al 12/12/2016.

Anticiparse a la peronóspora, INTA. http://inta.gob.ar/noticias/anticiparse-a-la-peronospora. Acceso al 8/12/2016.

La peronóspora de la vid. Serie de enfermedades de los cultivos de Mendoza, Lucero H. y Lucero C. 2000. 26pp.

11.Anexo I: Publicaciones encontradas

RELACIÓN PATÓGENO-PLANTA

Delmas, C.E.L.a b , Fabre, F.a b , Jolivet, J.a b , Mazet, I.D.a b , Richart Cervera, S.a b , Delière, L.a b , Delmotte, F.a b

Adaptation of a plant pathogen to partial host resistance: Selection for greater aggressiveness in grapevine downy mildew

(2016) Evolutionary Applications, 9 (5), pp. 709-725. Cited 1 time.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84959419496&partnerID=40&md5=6cd84ff1f43a71c88310fbf76aebce8b

DOI: 10.1111/eva.12368

AFFILIATIONS: UMR 1065 Santé et Agroécologie du Vignoble, INRA, Villenave d'Ornon, France;

Bordeaux Science Agro, UMR 1065 SAVE, ISVV, Université de Bordeaux, Villenave d'Ornon, France

ABSTRACT: An understanding of the evolution of pathogen quantitative traits in response to host selective pressures is essential for the development of durable management strategies for resistant crops. However, we still lack experimental data on the effects of partial host resistance on multiple phenotypic traits (aggressiveness) and evolutionary strategies in pathogens. We performed a cross-inoculation experiment with four grapevine hosts and 103 isolates of grapevine downy mildew (Plasmopara viticola) sampled from susceptible and partially resistant grapevine varieties. We analysed the neutral and adaptive genetic differentiation of five quantitative traits relating to pathogen transmission. Isolates from resistant hosts were more aggressive than isolates from susceptible hosts, as they had a shorter latency period and higher levels of spore production. This pattern of adaptation contrasted with the lack of neutral genetic differentiation, providing evidence for directional selection. No specificity for a particular host variety was detected. Adapted isolates had traits that were advantageous on all resistant varieties. There was no fitness cost associated with this genetic adaptation, but several trade-offs between pathogen traits were observed. These results should improve the accuracy of prediction of fitness trajectories for this biotrophic pathogen, an essential element for the modelling of durable deployment strategies for resistant varieties. © 2016 John Wiley & Sons Ltd.

AUTHOR KEYWORDS: Erosion; Evolvability; Fitness cost; Host specificity; Obligate plant pathogen; Quantitative resistance; Virulence; Vitis vinifera

DOCUMENT TYPE: Article

SOURCE: Scopus

INDUCCIÓN DE RESISTENCIA (CAMPO)

Paris, F.a b c , Krzyzaniak, Y.c , Gauvrit, C.c , Jamois, F.d , Domergue, F.e f , Joubès, J.e f , Ferrières, V.a b , Adrian, M.g , Legentil, L.a b , Daire, X.c , Trouvelot, S.g

An ethoxylated surfactant enhances the penetration of the sulfated laminarin through leaf cuticle and stomata, leading to increased induced resistance against grapevine downy mildew

(2016) Physiologia Plantarum, 156 (3), pp. 338-350.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84948155098&partnerID=40&md5=01a446fccb2218a93a97fb312ac8170b

DOI: 10.1111/ppl.12394

AFFILIATIONS: Ecole Nationale Supérieure de Chimie de Rennes, CNRS, UMR 6226, Rennes, France;

Université européenne de Bretagne, Rennes, France;

INRA, UMR 1347 Agroécologie, ERL CNRS 6300, Dijon, France;

Laboratoires Goëmar, S.A.S.-Parc technopolitain Atalante, Saint-Malo, France;

Université de Bordeaux, Laboratoire de Biogenèse Membranaire, UMR 5200, Bordeaux, France;

CNRS, UMR 5200, Laboratoire de Biogenèse Membranaire, Bordeaux, France;

Université de Bourgogne, UMR 1347 Agroécologie, ERL CNRS 6300, Dijon, France

ABSTRACT: Some β-1,3-glucans and particularly sulfated laminarin (PS3) are known as resistance inducers (RIs) in grapevine against the downy mildew. However, their efficacy in vineyard is still often too low, which might be caused by a limited penetration through the leaf cuticle following spray application. We used 14C-sucrose uptake experiments with grapevine leaves in order to select a surfactant as saccharide penetration enhancer. Our results showed that although sucrose foliar uptake was low, it was strongly enhanced by Dehscofix CO125 (DE), a highly ethoxylated surfactant. Fluorescent saccharides were then produced and laser scanning microscopy was used to analyze their foliar diffusion pattern in Arabidopsis thaliana and grapevine. Interestingly, sucrose and PS3 were seemingly able to penetrate the leaf cuticle only when formulated with DE. Diffusion could preferentially occur via stomata, anticlinal cell walls and trichomes. In grapevine, PS3 penetration rate was much higher on the stomateous abaxial surface of the leaf than on the adaxial surface. Finally, using DE allowed a higher level of downy mildew control by PS3, which corroborated diffusion observations. Our results have practical consequences for the improvement of treatments with saccharidic inducers on grape. That is, formulation of such RIs plays a critical role for their cuticular diffusion and consequently their efficacy. Also, spray application should preferentially target the abaxial surface of the leaves in order to maximize their penetration. © 2016 Scandinavian Plant Physiology Society.

DOCUMENT TYPE: Article

SOURCE: Scopus

RELACIÓN PATÓGENO-PLANTA

Toffolatti, S.L.a , Maddalena, G.a , Salomoni, D.a , Maghradze, D.b , Bianco, P.A.a , Failla, O.a

Evidence of resistance to the downy mildew agent Plasmopara viticola in the Georgian Vitis vinifera germplasm

(2016) Vitis - Journal of Grapevine Research, 55 (3), pp. 121-128.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84981249474&partnerID=40&md5=3cb14209652712c0d3e3486a203bca2e

DOI: 10.5073/vitis.2016.55.121-128

AFFILIATIONS: Dipartimento di Scienze Agrarie e Ambientali, Università degli Studi di Milano, Via Giovanni Celoria 2, I-Milano, Italy;

Scientific - Research Center of Agriculture, Tbilisi, Georgia

ABSTRACT: Grapevine downy mildew, caused by Plasmopara viticola, is one of the most important diseases at the international level. The mainly cultivated Vitis vinifera varieties are generally fully susceptible to P. viticola, but little information is available on the less common germplasm. The V. vinifera germplasm of Georgia (Caucasus) is characterized by a high genetic diversity and it is different from the main European cultivars. Aim of the study is finding possible sources of resistance in the Georgian autochthonous varieties available in a field collection in northern Italy. The resistance levels to P. viticola were estimated both by experimental inoculations and by disease assessment in field conditions in a multi-year activity. Of the 93 tested accessions, 'Mgaloblishvili N' showed a constant resistant behaviour, by reducing the disease severity and the pathogen sporulation. High levels of leaf hair density did not always associate with reduced disease gravity in experimental inoculations, confirming that this kind of preformed barrier is not completely efficient in preventing pathogen infections. © The author(s).

AUTHOR KEYWORDS: Disease incidence; Disease resistance; Grapevine

DOCUMENT TYPE: Article

SOURCE: Scopus

BIOLOGÍA MOLECULAR

Nascimento-Gavioli, M.C.A.a , Agapito-Tenfen, S.Z.b , Nodari, R.O.a , Welter, L.J.c , Sanchez Mora, F.D.a , Saifert, L.a , da Silva, A.L.a , Guerra, M.P.a

Proteome of Plasmopara viticola-infected Vitis vinifera provides insights into grapevine Rpv1/Rpv3 pyramided resistance to downy mildew

(2016) Journal of Proteomics, . Article in Press.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84973545815&partnerID=40&md5=f8b099ebed22d95e27842d239284fb09

DOI: 10.1016/j.jprot.2016.05.024

AFFILIATIONS: CropScience Department, Federal University of Santa Catarina, Rod. Admar Gonzaga 1346, Florianópolis 88034-000, Brazil;

Genøk, Center for Biosafety, The Science Park, P.O. Box 6418, Tromsø 9294, Norway;

Agronomy Department, Federal University of Santa Catarina, Rod. Ulysses Gaboardi, Km 3, Curitibanos 89520-000, Brazil

ABSTRACT: Grapevine is one of the major fruit crops worldwide and requires phytochemical use due to susceptibility to numerous pests, including downy mildew. The pyramiding of previous identified QTL resistance regions allows selection of genotypes with combined resistance loci in order to build up sustainable resistance. This study investigates resistance response of pyramided plants containing Rpv1 and Rpv3 loci to Plasmopara viticola infection process. Phenotypic characterization showed complete resistance and lack of necrotic hypersensitive response spots. Principal Component Analysis revealed infected 96. hpi (hours post-inoculation) samples with the most distant proteomes of the entire dataset, followed by the proteome of infected 48. hpi samples. Quantitative and qualitative protein differences observed using 2-DE gels coupled to nanoHPLC-ESI-MS/MS analysis showed a lack of transient breakdown in defense responses (biphasic modulation) accompanying the onset of disease. Forty-one proteins were identified, which were mainly included into functional categories of redox and energy metabolism. l-ascorbate degradation pathway was the major altered pathway and suggests up-regulation of anti-oxidant metabolism in response to apoplastic oxidative burst after infection. Overall, these data provide new insights into molecular basis of this incompatible interaction and suggests several targets that could potentially be exploited to develop new protection strategies against this pathogen. Biological significance: This study provide new insights into the molecular basis of incompatible interaction between Plasmopara viticola and pyramided Rpv1/. Rpv3 grapevine and suggests several targets that could potentially be exploited to develop new protection strategies against this pathogen. This is the first proteomic characterization of resistant grapevine available in the literature and it presents contrasting proteomic profiles of that of susceptible plants. The resistance against downy mildew in grapevine has been a long sought and the availability of resistance loci is of major importance. This is the first molecular characterization of resistance provided by Rpv1 and Rpv3 genes. © 2016 Elsevier B.V.

AUTHOR KEYWORDS: Defense response; Hypersensitive response; Incompatible interaction; Oomycete; Plant-pathogen interaction; Proteomic

DOCUMENT TYPE: Article in Press

SOURCE: Scopus

RELACIÓN PATÓGENO-PLANTA

Delmotte, F.a b , Mestre, P.c d , Schneider, C.c d , Kassemeyer, H.-H.e , Kozma, P.f , Richart-Cervera, S.a b , Rouxel, M.a b , Delière, L.a b

Rapid and multiregional adaptation to host partial resistance in a plant pathogenic oomycete: Evidence from European populations of Plasmopara viticola, the causal agent of grapevine downy mildew

(2014) Infection, Genetics and Evolution, 27, pp. 500-508. Cited 13 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84951906194&partnerID=40&md5=98547ca69d533b601f63f9f600c0c2bf

DOI: 10.1016/j.meegid.2013.10.017

AFFILIATIONS: INRA, Institut des Sciences de la Vigne et du Vin, UMR1065 Santé et Agroécologie du Vignoble, Villenave d'Ornon, France;

Université de Bordeaux, ISVV, UMR1065 SAVE, Villenave d'Ornon, France;

INRA, UMR 1131 Santé de la Vigne et Qualité du Vin, Colmar, France;

Université de Strasbourg, UMR 1131 Santé de la Vigne et Qualité du Vin, Colmar, France;

Staatliches Weinbauinstitut, Merzhauser Strasse 119, Freiburg, Germany;

University of Pécs, Research Institute for Viticulture and Oenology, Pázmány Péter u.4, Pécs, Hungary

ABSTRACT: Crop pathogens evolve rapidly to adapt to their hosts. The use of crops with quantitative disease resistance is expected to alter selection of pathogen life-history traits. This may result in differential adaptation of the pathogen to host cultivars and, sometimes, to the erosion of quantitative resistance. Here, we assessed the level of host adaptation in an oomycete plant pathogenic species. We analysed the phenotypic and genetic variability of 17 Plasmopara viticola isolates collected on Vitis vinifera and 35 isolates from partially resistant varieties (Regent and genotypes carrying the Rpv1 gene). Cross-inoculation experiments assessed two components of aggressiveness and a life-history trait of the pathogen: disease severity, sporangial production and sporangia size. The results contribute evidence to the emergence of P. viticola aggressive isolates presenting a high level of sporulation on the partially resistant Regent. By contrast, no adaptation to the Rpv1 gene was found in this study. The erosion of Regent resistance may have occurred in less than 5. years and at least three times independently in three distant wine-producing areas. Populations from resistant varieties showed a significant increase in sporangia production capacity, indicating an absence of fitness costs for this adaptation. The increase in the number of sporangia was correlated with a reduction in sporangia size, a result which illustrates how partial plant disease resistance can impact selection of the pathogen's life-history traits. This case study on grapevine downy mildew shows how new plant pathogen populations emerge in agro-ecosystems by adapting to partial host resistance. This adaptive pattern highlights the need for wise management of plant partial disease resistance to ensure its sustainability over time. © 2013 Elsevier B.V.

AUTHOR KEYWORDS: Aggressiveness; Erosion of quantitative host resistance; Fungal plant pathogen; Life-history traits; Regent grape cultivar; Vitis vinifera

DOCUMENT TYPE: Article

SOURCE: Scopus

INDUCCIÓN DE RESISTENCIA (CAMPO)

Banani, H.a b d , Roatti, B.a c , Ezzahi, B.a b , Giovannini, O.a , Gessler, G.c , Pertot, I.a , Perazzolli, M.a

Characterization of resistance mechanisms activated by Trichoderma harzianum T39 and benzothiadiazole to downy mildew in different grapevine cultivars

(2014) Plant Pathology, 63 (2), pp. 334-343. Cited 5 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84900356524&partnerID=40&md5=c0d23276c628ced227d0608e0eda6db3

DOI: 10.1111/ppa.12089

AFFILIATIONS: Department of Sustainable Agro-ecosystems and Bioresources, Research and Innovation Centre, Fondazione Edmund Mach (FEM), Via E. Mach 1, 38010 San Michele all'Adige, Italy;

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ABSTRACT: Downy mildew, caused by Plasmopara viticola, is one of the most destructive diseases of grapevine and is controlled with intense application of chemical fungicides. Treatment with Trichoderma harzianum T39 (T39) or benzothiadiazole-7-carbothioic acid S-methyl ester (BTH) has been previously

shown to activate grapevine resistance to downy mildew and reduce disease symptoms in the Pinot noir cultivar. However, enhancement of plant resistance can be affected by several factors, including plant genotype. In order to further extend the use of resistance inducers against downy mildew, the physiological and molecular properties of T39- and BTH-activated resistance in different cultivars of table and wine grapes were characterized under greenhouse conditions. T39 treatment reduced downy mildew symptoms, but the degree of efficacy differed significantly among grapevine cultivars. However, efficacy of BTH-activated resistance was consistently high in the different cultivars. Expression profiles of defence-related genes differed among cultivars in response to resistance inducers and to pathogen inoculation. T39 treatment enhanced the expression of defence-related genes in the responsive cultivars, before and after P. viticola inoculation. A positive correlation between the efficacy of T39 and the expression level of defence-related genes was found in Primitivo and Pinot noir plants, while different genes or more complex processes were probably activated in Sugraone and Negroamaro. The data reported here suggest that the use of a responsive cultivar is particularly important to maximize the efficacy of resistance inducers and new natural inducers should be explored for the less responsive cultivars. © 2013 British Society for Plant Pathology.

AUTHOR KEYWORDS: Biocontrol; Cultivar; Defence-related genes; Genotype; Induced systemic resistance; Vitis vinifera

DOCUMENT TYPE: Article

SOURCE: Scopus

RESISTENCIA (CAMPO)

Prajongjai, T., Poolsawat, O., Pombungkerd, P., Wongkaew, S., Tantasawat, P.A.

Evaluation of grapevines for resistance to Downy Mildew (Plasmopara viticola) under laboratory and field conditions

(2014) South African Journal of Enology and Viticulture, 35 (1), pp. 43-50. Cited 2 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84924850920&partnerID=40&md5=d669df831884a829d92c11cb53ac3081

AFFILIATIONS: Suranaree University of Technology, 111 University Avenue, Muang District, Nakhon Ratchasima, Thailand

ABSTRACT: Downy mildew of grapevine (Vitis vinifera L.), caused by the oomycete Plasmopara viticola, can seriously devastate grapevine production in tropical countries, such as Thailand. Four susceptible grapevine cultivars, four potentially resistant lines and 18 F 1 hybrids, propagated by air layering and chip budding, were evaluated for resistance to downy mildew at laboratory (using a detached leaf assay) and field (natural infection in 2011 and 2013) levels. Significant differences in the disease scores among grapevine genotypes, ranging from 0.54 (resistant) to 4.83 (susceptible) and 3.30 (resistant) to 7.70 (susceptible), were observed under the laboratory and field conditions respectively. No significant difference in disease severity was observed between the two propagation methods or between the two different years of field evaluations. Resistance evaluations under both conditions consistently classified 'NY88.0517.01' and 'NY65.0550.04' as resistant lines what would be useful as parents for future breeding programmes. Moreover, one F 1 hybrid, '5UT0403.091, was reported to have considerable resistance to downy mildew under both laboratory and field conditions for the first time. The field resistance level of this hybrid was almost comparable to its highly resistant parent 'Wilcox 321 1, suggesting its potential for the future development of resistant cultivars in Thailand. Although the ranking of genotypes varied between screening methods, the resistance levels of the 26 grapevine genotypes evaluated under laboratory and field conditions were comparable based on the Spearman's rank correlation coefficients of 0.73 ($p \leq 0.01$). These results suggest that the laboratory screening assay is efficient for the rapid, reliable and economical identification of resistant hybrids in grapevine breeding programmes.

AUTHOR KEYWORDS: Correlation; Disease resistance; Disease screening method; Grape; Hybrid; Propagation method; Vitis spp

DOCUMENT TYPE: Article

SOURCE: Scopus

RELACIÓN PATÓGENO-PLANTA

Paolocci, M.a , Muganu, M.a , Alonso-Villaverde, V.b , Gindro, K.c

Leaf morphological characteristics and stilbene production differently affect downy mildew resistance of Vitis vinifera varieties grown in Italy

(2014) Vitis - Journal of Grapevine Research, 53 (3), pp. 155-161. Cited 2 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-05857962&partnerID=40&md5=0bc2196ab17d3ba984b1c1bffd63a752

AFFILIATIONS: Department of Agriculture, Forests, Nature and Energy (DAFNE), University of Tuscia, via S. Camillo de Lellis sne, 01100 Viterbo, Italy;

Misión Biológica de Galicia (CSIC), Pontevedra, Spain;

Swiss Federal Research Station Agroscope Changins-Wädenswil ACW, Nyon, Switzerland

ABSTRACT: The degree of resistance to downy mildew of grape varieties belonging to the oenological tradition of Central Italy was evaluated by the analysis of plant responses to pathogen infections carried out in natural and controlled environments. Leaf morphological traits, such as hair and stornata! density, were determined for each variety, and the percentage of infected stornata and pathogen colonization of host mesophyll at 24, 48, and 72 hours post inoculation were assessed by epifluorescence microscopy. Furthermore, stilbene production at the site of Plasmopara viticola infection was analyzed at 72 hours post inoculation. Results indicate differences in resistance to downy mildew among selected varieties. Different significant values were detected among grapevines in the percentage of infected stornata and average number of successfully penetrated zoospores per stornata and per leaf surface unit. Differences also emerged in the rate of pathogen growth and stilbene production, signifying that defence mechanisms involved or induced during pathogen infection could be differentially effective among grapevine cultivars in limiting disease progression.

AUTHOR KEYWORDS: Grapevine; Plasmopara viticola; Stilbenes; Stornata; Sustainable viticulture

DOCUMENT TYPE: Article

SOURCE: Scopus

RELACIÓN PATÓGENO-PLANTA

Liu, R.a b c , Wang, L.a b c , Zhu, J.a b c , Chen, T.a b c , Wang, Y.a b c , Xu, Y.a b c

Histological responses to downy mildew in resistant and susceptible grapevines

(2014) Protoplasma, 252 (1), pp. 259-270. Cited 4 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84939878465&partnerID=40&md5=88639bb3e285f877cdac28c5acf11ad5

DOI: 10.1007/s00709-014-0677-1

AFFILIATIONS: State Key Laboratory of Crop Stress Biology in Arid Areas, Northwest A&F University, Shaanxi, Yangling, China;

College of Horticulture, Northwest A&F University, Shaanxi, Yangling, China;

Key Laboratory of Horticultural Plant Biology and Germplasm Innovation in Northwest China, Ministry of Agriculture, Shaanxi, Yangling, China

ABSTRACT: Downy mildew in grapevines, caused by Plasmopara viticola, is a very serious disease throughout the grape-producing nations, especially in more humid climates. Downy mildew mainly affects the cultivated varieties of Vitis vinifera. A promising way to minimize or eliminate P. viticola infections is by the adoption of resistant cultivars. Chinese wild grapevines are reported to possess resistance to many fungal diseases. In this study, three Chinese wild grapevines (Vitis pseudoreticulata Baihe-35-1, Vitis davidii var. cyanocarpa Langao-5, and Vitis piasezkii Liuba-8) and a European cultivated variety (V. vinifera cv. Pinot noir) were inoculated with P. viticola, and a histological survey was undertaken.

Macroscopic observations revealed no sporulation in V. piasezkii Liuba-8, little sporulation in V. pseudoreticulata Baihe-35-1 and V. davidii var. cyanocarpa Langao-5, but serious sporulation in V. vinifera cv. Pinot noir. Aniline blue staining indicated callose deposition in V. pseudoreticulata Baihe-35-1, V. davidii var. cyanocarpa Langao-5, and V. piasezkii Liuba-8. Cells with distinctive fluorescence were also observed in V. pseudoreticulata Baihe-35-1. After staining with 3,3-diaminobenzidine, production of H<inf>2</inf>0<inf>2</inf> was observed early on, after infection in V. davidii var. cyanocarpa Langao-5 and V. piasezkii Liuba-8. No H<inf>2</inf>0<inf>2</inf> accumulation was observed in V. vinifera cv. Pinot noir. It is concluded that V. piasezkii Liuba-8 should be classified as "highly resistant" to downy mildew, V. pseudoreticulata Baihe-35-1 and V. davidii var. cyanocarpa Langao-5 as "resistant," and V. vinifera Pinot noir as "susceptible." The possible roles of stomatal callose deposition in the defense r6eactions of the mildew-resistant grapevines are discussed. © 2014, Springer-Verlag Wien.

AUTHOR KEYWORDS: Downy mildew; Histological responses; Plasmopara viticola; Resistant grapevines; Susceptible grapevines

DOCUMENT TYPE: Article

SOURCE: Scopus

RESISTENCIA (CAMPO)

Roatti, B.a b , Perazzolli, M.a , Gessler, C.b , Pertot, I.a

Abiotic stresses affect trichoderma harzianum T39-Induced resistance to downy mildew in grapevine

(2013) Phytopathology, 103 (12), pp. 1227-1234. Cited 4 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84890905111&partnerID=40&md5=acb4cf1889f68842df3ef8d9431b41c8

DOI: 10.1094/PHYTO-02-13-0040-R

AFFILIATIONS: Department of Sustainable Agro-Ecosystems and Bioresources, Research and Innovation Centre, Fondazione Edmund Mach (FEM), Via E. Mach 1, 38010 S. Michele All'adige, Italy;

Institute of Integrative Biology, ETH Zürich, 8092 Zürich, Switzerland

ABSTRACT: Enhancement of plant defense through the application of resistance inducers seems a promising alternative to chemical fungicides for controlling crop diseases but the efficacy can be affected by abiotic factors in the field. Plants respond to abiotic stresses with hormonal signals that may interfere with the mechanisms of induced systemic resistance (ISR) to pathogens. In this study, we exposed grapevines to heat, drought, or both to investigate the effects of abiotic stresses on grapevine resistance induced by Trichoderma harzianum T39 (T39) to downy mildew. Whereas the efficacy of T39-induced resistance was not affected by exposure to heat or drought, it was significantly reduced by combined abiotic stresses. Decrease of leaf water potential and upregulation of heat-stress markers confirmed that plants reacted to abiotic stresses. Basal expression of defense-related genes and their upregulation during T39-induced resistance were attenuated by abiotic stresses, in agreement with the reduced efficacy of T39. The evidence reported here suggests that exposure of crops to abiotic stress should be carefully considered to optimize the use of resistance inducers, especially in view of future global climate changes. Expression analysis of ISR marker genes could be helpful to identify when plants are responding to abiotic stresses, in order to optimize treatments with resistance inducers in field. © 2013 The American Phytopathological Society.

DOCUMENT TYPE: Article

SOURCE: Scopus

BIOLOGÍA MOLECULAR

Monteiro, F., Sebastiana, M., Pais, M.S., Figueiredo, A.

Reference Gene Selection and Validation for the Early Responses to Downy Mildew Infection in Susceptible and Resistant Vitis vinifera Cultivars

(2013) PLoS ONE, 8 (9), art. no. e72998, . Cited 22 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84883339876&partnerID=40&md5=2a8844fff0de6a01cb2f00bb79f17da1

DOI: 10.1371/journal.pone.0072998

AFFILIATIONS: Plant Systems Biology Lab, Center of Biodiversity, Functional and Integrative Genomics (BioFIG), Science Faculty of Lisbon University, Lisboa, Portugal

ABSTRACT: The pivotal role of cultivated grapevine (Vitis vinifera L.) in many countries economy is compromised by its high susceptibility to Plasmopara viticola, the causal agent of downy mildew disease. Recent research has identified a set of genes related to resistance which may be used to track downy mildew infection. Quantification of the expression of these resistance genes requires normalizing qPCR data using reference genes with stable expression in the system studied. In this study, a set of eleven genes (VATP16, 60 S, UQCC, SMD3, EF1α, UBQ, SAND, GAPDH, ACT, PsaB, PTB2) was evaluated to identify reference genes during the first hours of interaction (6, 12, 18 and 24 hpi) between two V. vinifera genotypes and P. viticola. Two analyses were used for the selection of reference genes: direct comparison of susceptible, Trincadeira, and resistant, Regent, V. vinifera cultivars at 0 h, 6, 12, 18 and 24 hours post inoculation with P. viticola (genotype effect); and comparison of each genotype with mock inoculated samples during inoculation time-course (biotic stress effect). Three statistical methods were used, GeNorm, NormFinder, and BestKeeper, allowing to identify UBQ, EF1α and GAPDH as the most stable genes for the genotype effect. For the biotic stress effect, EF1α, SAND and SMD3 were the most constant for the susceptible cultivar Trincadeira and EF1α, GAPDH, UBQ for the resistant cultivar Regent. In addition, the expression of three defense-related transcripts, encoding for subtilisin-like protein, CYP and PR10, was analysed, for both datasets, during inoculation time-course. Taken together, our results provide guidelines for reference gene(s) selection towards a more accurate and widespread use of qPCR to study the first hours of interaction between different grapevine cultivars and P. viticola. © 2013 Monteiro et al.

DOCUMENT TYPE: Article

SOURCE: Scopus

RESISTENCIA (CAMPO)

Calonnec, A.a b , Wiedemann-Merdinoglu, S.c d , Delière, L.a b , Cartolaro, P.a b , Schneider, C.c d , Delmotte, F.a b

The reliability of leaf bioassays for predicting disease resistance on fruit: A case study on grapevine resistance to downy and powdery mildew

(2013) Plant Pathology, 62 (3), pp. 533-544. Cited 5 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84876803799&partnerID=40&md5=e3dca29ce1b31d48a0c23dc3aca31b15

DOI: 10.1111/j.1365-3059.2012.02667.x

AFFILIATIONS: INRA, UMR1065 SAVE, F-33883 Villenave d'Ornon, France;

Université de Bordeaux, ISVV, UMR1065 SAVE, F-33883 Villenave d'Ornon, France;

INRA, UMR1131 SVQV, F6802 Colmar, France;

Université de Strasbourg, UMR1131 SVQV, F-6802 Colmar, France

ABSTRACT: This study was designed to assess the reliability of grapevine leaf bioassays for predicting disease resistance on fruit in the field. The efficacy of various grapevine quantitative trait loci (QTLs) for conferring resistance to downy and powdery mildew was evaluated in bioassays and in a 2-year field experiment for downy mildew. The resistance genes studied were inherited from Muscadinia rotundifolia (Rpv1 and Run1) and from American Vitis species through cv. Regent (QTLRgP and QTLRgD). In bioassays, genotypes carrying Run1 blocked powdery mildew development at early stages. Genotypes combining Run1 with QTLRgP displayed no greater level of resistance. For downy mildew, genotypes carrying Rpv1 and/or QTLRgD were more resistant than the susceptible cv. Merlot, and showed a high level of leaf

resistance in the field (<10% severity). Disease levels on bunches were much higher than those on leaves, with a high variability between Rpv1 genotypes (1-48%). A Bayesian decision theory framework predicted that an OIV-452 threshold of 5 in leaf bioassays allowed accurate selection of grapevine genotypes (P=0·83) with satisfactory disease severity on bunches. Therefore, this study validates that the use of early bioassays on leaves, as currently performed by grapevine breeders, ensures a satisfactory level of resistance to downy mildew of bunches in the field. © 2012 BSPP.

AUTHOR KEYWORDS: Erysiphe necator; Marker-assisted selection; Perennial plant; Plasmopara viticola; Receiver operating characteristic

DOCUMENT TYPE: Article

SOURCE: Scopus

BIOLOGÍA MOLECULAR

Venuti, S.a , Copetti, D.b f , Foria, S.a , Falginella, L.a , Hoffmann, S.c , Bellin, D.a e , Cindri , P.d , Kozma, P.c , Scalabrin, S.b , Morgante, M.a b , Testolin, R.a b , Di Gaspero, G.a b

Historical Introgression of the Downy Mildew Resistance Gene Rpv12 from the Asian Species Vitis amurensis into Grapevine Varieties

(2013) PLoS ONE, 8 (4), art. no. e61228, . Cited 15 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84876080648&partnerID=40&md5=6c7bed30e838c49a29a47d03f8617008

DOI: 10.1371/journal.pone.0061228

AFFILIATIONS: Dipartimento di Scienze Agrarie e Ambientali, University of Udine, Udine, Italy;

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Research Institute of Viticulture and Enology, University of Pécs, Pécs, Hungary;

Faculty of Agriculture, University of Novi Sad, Novi Sad, Serbia;

Dipartimento di Biotecnologie, University of Verona, Verona, Italy;

Arizona Genomics Institute, University of Arizona, Tucson, AZ, United States

ABSTRACT: The Amur grape (Vitis amurensis Rupr.) thrives naturally in cool climates of Northeast Asia. Resistance against the introduced pathogen Plasmopara viticola is common among wild ecotypes that were propagated from Manchuria into Chinese vineyards or collected by Soviet botanists in Siberia, and used for the introgression of resistance into wine grapes (Vitis vinifera L.). A QTL analysis revealed a dominant gene Rpv12 that explained 79% of the phenotypic variance for downy mildew resistance and was inherited independently of other resistance genes. A Mendelian component of resistance-a hypersensitive response in leaves challenged with P. viticola-was mapped in an interval of 0.2 cM containing an array of coiled-coil NB-LRR genes on chromosome 14. We sequenced 10-kb genic regions in the Rpv12+ haplotype and identified polymorphisms in 12 varieties of V. vinifera using next-generation sequencing. The combination of two SNPs in single-copy genes flanking the NB-LRR cluster distinguished the resistant haplotype from all others found in 200 accessions of V. vinifera, V. amurensis, and V. amurensis x V. vinifera crosses. The Rpv12+ haplotype is shared by 15 varieties, the most ancestral of which are the century-old 'Zarja severa' and 'Michurinets'. Before this knowledge, the chromosome segment around Rpv12+ became introgressed, shortened, and pyramided with another downy mildew resistance gene from North American grapevines (Rpv3) only by phenotypic selection. Rpv12+ has an additive effect with Rpv3+ to protect vines against natural infections, and confers foliar resistance to strains that are virulent on Rpv3+ plants. © 2013 Venuti et al.

DOCUMENT TYPE: Article

SOURCE: Scopus

BIOLOGÍA MOLECULAR

Wang, P.a b , Liu, C.b , Wang, D.a , Liang, C.a b , Zhao, K.b , Fan, J.a

Isolation of resistance gene analogs from grapevine resistant to downy mildew

(2013) Scientia Horticulturae, 150, pp. 326-333. Cited 6 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84871659329&partnerID=40&md5=81c21aa4047aa174f5ea01742212fbc4

DOI: 10.1016/j.scienta.2012.11.035

AFFILIATIONS: Department of Plant Protection, Shenyang Agricultural University, Shenyang 110161, China;

Institute of Plant Protection, Liaoning Academy of Agricultural Sciences, Shenyang 110161, China

ABSTRACT: Downy mildew caused by Plasmopara viticola is a devastating disease that results in considerable economic losses as well as environmental damage through the repeated application of fungicides in cultivated grapevine (Vitis spp.). In this study, degenerate primers that were designed based on the conserved motifs in the NBS domain of resistance proteins were used to isolate NBS-type sequences. A total of 10 RGA fragments were identified, and their predicted amino acid sequences compared to each other and to the amino acid sequences of known R-genes revealed significant sequence similarity. Phylogenetic analysis demonstrated that 10 RGAs dispersed along the phylogram on the two major branches of either TIR or non-TIR type of the NBS-LRR proteins. Quantitative real-time polymerase chain reaction (qRT-PCR) analysis showed that transcripts of RGA1, RGA2, RGA5 and RGA23 were specifically induced after infection with P. viticola. These results suggest that RGA1, RGA2, RGA5 and RGA23 may play roles in defense mechanisms that confer resistance to downy mildew in grapevine. © 2012 Elsevier B.V.

AUTHOR KEYWORDS: Downy mildew; NBS-LRR; QRT-PCR; Resistance gene analogs; Vitis spp.

DOCUMENT TYPE: Article

SOURCE: Scopus

RESISTENCIA (CAMPO)

Van Leeuwen, C.a b , Roby, J.-P.a b , Alonso-Villaverde, V.c , Gindro, K.d

Impact of clonal variability in Vitis vinifera cabernet franc on grape composition, wine quality, leaf blade stilbene content, and downy mildew resistance

(2013) Journal of Agricultural and Food Chemistry, 61 (1), pp. 19-24. Cited 14 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84872118612&partnerID=40&md5=516681723efa2603c7fce3e82f8650e5

DOI: 10.1021/jf304687c

AFFILIATIONS: Univ. Bordeaux, ISVV, Ecophysiology and Functional Genomics of Grapevines, UMR 1287, F-33140 Villenave d'Ornon, France;

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Misión Biológica de Galicia (CSIC), P.O. Box 28, 36080 Pontevedra, Spain;

Station de Recherche Agroscope Changins-Wädenswil ACW, Route de Duiller 50, CP 1012, 1260 Nyon 1, Switzerland

ABSTRACT: In this study, 10 clones of Vitis vinifera Cabernet franc (not yet commercial) have been phenotyped on precocity, grape composition, and assessment of wine quality made by microvinification in 2008-2010. Additionally, two original criteria have been considered: concentration of 3-isobutyl-2-methoxypyrazine (IBMP) in grapes and wines (the green bell pepper flavor) and resistance of grapevines to downy mildew (Plasmopara viticola) by stilbene quantification upon infection. Precocity of veraison varied up to four days at veraison. Berry size and yield were highly variable among clones. However, these variables were not correlated. Tanins and anthocyanins varied among clones in grapes and wines.

Variations in grape and wine IBMP were not significant. Some clones showed lower susceptibility for downy mildew on leaves. Lower susceptibility was linked to a higher production of stilbenic phytoalexins involved in downy mildew resistance mechanisms. © 2012 American Chemical Society.

DOCUMENT TYPE: Article

SOURCE: Scopus

RESISTENCIA (CAMPO)

Pinto, K.M.S.a , do Nascimento, L.C.a , de Souza Gomes, E.C.b , da Silva, H.F.c , dos Reis Miranda, J.a

Efficiency of resistance elicitors in the management of grapevine downy mildew Plasmopara viticola: Epidemiological, biochemical and economic aspects

(2012) European Journal of Plant Pathology, 134 (4), pp. 745-754. Cited 6 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84868444430&partnerID=40&md5=28c54478fd42d25d9e1e597a9c93b858

DOI: 10.1007/s10658-012-0050-1

AFFILIATIONS: Programa de Pós-Graduação em Agronomia, Universidade Federal da Paraíba, CCA/UFPB, Campus II, Rodovia PB 079, Km 12, CEP 58397-000 Areia, PB, Brazil;

Instituto Federal do Sertão Pernambucano, Petrolina, PE, Brazil;

Laboratório de Fitopatologia CCA/UFPB, Campus II, Rodovia PB 079, Km 12, CEP 58397-000 Areia, PB, Brazil

ABSTRACT: This paper aimed to evaluate the efficiency of resistance elicitors in the management of grapevine downy mildew (Plasmopara viticola), identify the action of the elicitors on host metabolism, and determine their economic viability. The experiments were performed in a commercial vineyard variety 'Isabel' (Vitis labrusca) at Vale do Sirijí [Natuba, Paraiba State in Brazil, in the period of September 2009 to January 2010 (first season) and February to June 2010 (second season)]. The statistical design of randomized blocks consisted of eight treatments (untreated control, fungicide (pyraclostrobin+metiram), potassium phosphite, Agro-Mos®, Fungicide+potassium phosphite, Fungicide+Agro-Mos®, potassium phosphite+AgroMós® and Fungicide+potassium phosphite+Agro-Mos®) with four replications, with the experimental unit consisting of 45 leaves. Applications were made every 7 days, starting 20 days after pruning (DAP) with a total of 12 sprays. The evaluations were carried out biweekly, analyzing the following variables: incubation period, disease incidence and severity, area under the disease progress curve, and efficiency of control. The enzymatic determination was performed using pulp extracts from three fruits harvested at 45, 60, 90 and 120 DAP for each treatment. The resistance elicitors were able to reduce the disease incidence under different climatic conditions, indicating their viability as an alternative for the management of Plasmopara viticola. © 2012 KNPV.

AUTHOR KEYWORDS: Mildew; Resistance induction; Vitis labrusca L.

DOCUMENT TYPE: Article

SOURCE: Scopus

BIOLOGÍA MOLECULAR Y RESISTENCIA (CAMPO)

Perazzolli, M.a , Moretto, M.a , Fontana, P.a , Ferrarini, A.b , Velasco, R.a , Moser, C.a , Delledonne, M.b , Pertot, I.a

Downy mildew resistance induced by Trichoderma harzianum T39 in susceptible grapevines partially mimics transcriptional changes of resistant genotypes

(2012) BMC Genomics, 13 (1), art. no. 660, . Cited 38 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84869861785&partnerID=40&md5=71d8c1e6b32032cea4ebecb533546908

DOI: 10.1186/1471-2164-13-660

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Dipartimento di Biotecnologie, Università degli Studi di Verona, Strada Le Grazie 15, 37134, Verona, Italy

ABSTRACT: Background: Downy mildew, caused by Plasmopara viticola, is one of the most severe diseases of grapevine and is commonly controlled by fungicide treatments. The beneficial microorganism Trichoderma harzianum T39 (T39) can induce resistance to downy mildew, although the molecular events associated with this process have not yet been elucidated in grapevine. A next generation RNA sequencing (RNA-Seq) approach was used to study global transcriptional changes associated with resistance induced by T39 in Vitis vinifera Pinot Noir leaves. The long-term aim was to develop strategies to optimize the use of this agent for downy mildew control.Results: More than 14.8 million paired-end reads were obtained for each biological replicate of T39-treated and control leaf samples collected before and 24 h after P. viticola inoculation. RNA-Seq analysis resulted in the identification of 7,024 differentially expressed genes, highlighting the complex transcriptional reprogramming of grapevine leaves during resistance induction and in response to pathogen inoculation. Our data show that T39 has a dual effect: it directly modulates genes related to the microbial recognition machinery, and it enhances the expression of defence-related processes after pathogen inoculation. Whereas several genes were commonly affected by P. viticola in control and T39-treated plants, opposing modulation of genes related to responses to stress and protein metabolism was found. T39-induced resistance partially inhibited some disease-related processes and specifically activated defence responses after P. viticola inoculation, causing a significant reduction of downy mildew symptoms.Conclusions: The global transcriptional analysis revealed that defence processes known to be implicated in the reaction of resistant genotypes to downy mildew were partially activated by T39-induced resistance in susceptible grapevines. Genes identified in this work are an important source of markers for selecting novel resistance inducers and for the analysis of environmental conditions that might affect induced resistance mechanisms. © 2012 Perazzolli et al.; licensee BioMed Central Ltd.

AUTHOR KEYWORDS: Gene expression; Induced resistance; Next generation sequencing; Plant-pathogen interactions; RNA-Seq; Transcriptomics; Vitis vinifera

DOCUMENT TYPE: Article

SOURCE: Scopus

BIOLOGÍA MOLECULAR

Palmieri, M.C.a , Perazzolli, M.a , Matafora, V.b , Moretto, M.a , Bachi, A.b , Pertot, I.a

Proteomic analysis of grapevine resistance induced by Trichoderma harzianum T39 reveals specific defence pathways activated against downy mildew

(2012) Journal of Experimental Botany, 63 (17), pp. 6237-6251. Cited 33 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84868029990&partnerID=40&md5=340a055b07e8bd494b73b8a1ad2402cd

DOI: 10.1093/jxb/ers279

AFFILIATIONS: IASMA Research and Innovation Centre, Fondazione Edmund Mach, via E. Mach 1, 38010 San Michele all'Adige, Trento, Italy;

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ABSTRACT: Downy mildew is caused by the oomycete Plasmopara viticola and is one of the most serious diseases of grapevine. The beneficial microorganism Trichoderma harzianum T39 (T39) has previously been shown to induce plant-mediated resistance and to reduce the severity of downy mildew in susceptible grapevines. In order to better understand the cellular processes associated with T39-induced resistance, the proteomic and histochemical changes activated by T39 in grapevine were investigated before and 1 day after P. viticola inoculation. A comprehensive proteomic analysis of T39-induced resistance in grapevine was performed using an eight-plex iTRAQ protocol, resulting in the identification

and quantification of a total of 800 proteins. Most of the proteins directly affected by T39 were found to be involved in signal transduction, indicating activation of a complete microbial recognition machinery. Moreover, T39-induced resistance was associated with rapid accumulation of reactive oxygen species and callose at infection sites, as well as changes in abundance of proteins involved in response to stress and redox balance, indicating an active defence response to downy mildew. On the other hand, proteins affected by P. viticola in control plants mainly decreased in abundance, possibly reflecting the establishment of a compatible interaction. Finally, the high-throughput iTRAQ protocol allowed de novo peptide sequencing, which will be used to improve annotation of the Vitis vinifera cv. Pinot Noir proteome. © 2012 The Author.

AUTHOR KEYWORDS: biocontrol agent; induced resistance; Plasmopara viticola; quantitative proteomics; reactive oxygen species; tripartite interaction; Vitis vinifera

DOCUMENT TYPE: Article

SOURCE: Scopus

BIOLOGÍA MOLECULAR

Schwander, F., Eibach, R., Fechter, I., Hausmann, L., Zyprian, E., Töpfer, R.

Rpv10: A new locus from the Asian Vitis gene pool for pyramiding downy mildew resistance loci in grapevine

(2012) Theoretical and Applied Genetics, 124 (1), pp. 163-176. Cited 32 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84856066287&partnerID=40&md5=d8eae44f0476c7bac07ef0b05e4de310

DOI: 10.1007/s00122-011-1695-4

AFFILIATIONS: JKI Institute for Grapevine Breeding Geilweilerhof, 76833 Siebeldingen, Germany

ABSTRACT: A population derived from a cross between grapevine breeding strain Gf. Ga-52-42 and cultivar 'Solaris' consisting of 265 F1-individuals was genetically mapped using SSR markers and screened for downy mildew resistance. Quantitative trait locus (QTL) analysis revealed two strong QTLs on linkage groups (LGs) 18 and 09. The locus on LG 18 was found to be identical with the previously described locus Rpv3 and is transmitted by Gf. Ga-52-42. 'Solaris' transmitted the resistance-related locus on LG 09 explaining up to 50% of the phenotypic variation in the population. This downy mildew resistance locus is named Rpv10 for resistance to Plasmopara viticola. Rpv10 was initially introgressed from Vitis amurensis, a wild species of the Asian Vitis gene pool. The one-LOD supported confidence interval of the QTL spans a section of 2.1 centi Morgan (cM) corresponding to 314 kb in the reference genome PN40024 (12x). Eight resistance gene analogues (RGAs) of the NBS-LRR type and additional resistance-linked genes are located in this region of PN40024. The F1 sub-population which contains the Rpv3 as well as the Rpv10 locus showed a significantly higher degree of resistance, indicating additive effects by pyramiding of resistance loci. Possibilities for using the resistance locus Rpv10 in a grapevine breeding programme are discussed. Furthermore, the marker data revealed 'Severnyi' × 'Muscat Ottonel' as the true parentage for the male parent of 'Solaris'. © 2011 Springer-Verlag.

DOCUMENT TYPE: Article

SOURCE: Scopus

BIOLOGÍA MOLECULAR

Di Gaspero, G.a b , Copetti, D.a b , Coleman, C.c d , Castellarin, S.D.a , Eibach, R.e , Kozma, P.f , Lacombe, T.g , Gambetta, G.h , Zvyagin, A.i , Cindri , P.j , Kovács, L.c , Morgante, M.a b , Testolin, R.a b

Selective sweep at the Rpv3 locus during grapevine breeding for downy mildew resistance

(2012) Theoretical and Applied Genetics, 124 (2), pp. 277-286. Cited 20 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-84860337941&partnerID=40&md5=9a9a9912acc4f0bea207f9f1223c2a32

DOI: 10.1007/s00122-011-1703-8

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Department of Viticulture and Enology, University of California, Davis, CA 95616, United States;

Kuban State Agrarian University, Krasnodar, Russian Federation;

Faculty of Agriculture, University of Novi Sad, 21000 Novi Sad, Serbia

ABSTRACT: The Rpv3 locus is a major determinant of downy mildew resistance in grapevine (Vitis spp.). A selective sweep at this locus was revealed by the DNA genotyping of 580 grapevines, which include a highly diverse set of 265 European varieties that predated the spread of North American mildews, 82 accessions of wild species, and 233 registered breeding lines with North American ancestry produced in the past 150 years. Artificial hybridisation and subsequent phenotypic selection favoured a few Rpv3 haplotypes that were introgressed from wild vines and retained in released varieties. Seven conserved haplotypes in Wve descent groups of resistant varieties were traced back to their founders: (1) 'Munson', a cross between two of Hermann Jaeger's selections of V. rupestris and V. lincecumii made in the early 1880s in Missouri, (2) V. rupestris 'Ganzin', Wrst utilised for breeding in 1879 by Victor Ganzin in France, (3) 'Noah', selected in 1869 from intermingled accessions of V. riparia and V. labrusca by Otto Wasserzieher in Illinois, (4) 'Bayard', a V. rupestris × V. labrusca oVspring generated in 1882 by George Couderc in France, and (5) a wild form closely related to V. rupestris accessions in the Midwestern United States and introgressed into 'Seibel 4614' in the 1880s by Albert Seibel in France. Persistence of these Rpv3 haplotypes across many of the varieties generated by human intervention indicates that a handful of vines with prominent resistance have laid the foundation for modern grape breeding. A rampant hot spot of NB-LRR genes at the Rpv3 locus has provided a distinctive advantage for the adaptation of native North American grapevines to withstand downy mildew. The coexistence of multiple resistance alleles or paralogues in the same chromosomal region but in diVerent haplotypes counteracts eVorts to pyramidise them in a diploid individual via conventional breeding. © Springer-Verlag 2011.

DOCUMENT TYPE: Article

SOURCE: Scopus

BIOLOGÍA MOLECULAR

Casagrande, K.a , Falginella, L.a , Castellarin, S.D.a , Testolin, R.a b , Di Gaspero, G.a b

Defence responses in Rpv3-dependent resistance to grapevine downy mildew

(2011) Planta, 234 (6), pp. 1097-1109. Cited 25 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-81955163011&partnerID=40&md5=8af9b7bd83579ee66549cfb41c27abd1

DOI: 10.1007/s00425-011-1461-5

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Parco Scientifico e Tecnologico Luigi Danieli, Istituto di Genomica Applicata, 33100 Udine, Italy

ABSTRACT: The Rpv3 locus determines the ability to operate an isolate-specific hypersensitive response (HR) against Plasmopara viticola in grapevines that carry a resistant Rpv3+ haplotype. Artificial infection was performed on leaf discs of Rpv3+ and Rpv3- grapevines with two distinct isolates of the pathogen (avrRpv3+ and avrRpv3-). The plant response, including the establishment of HR and changes in expression of 33 genes, was compared to the development of the pathogen. HR was induced exclusively in the Rpv3+ host upon inoculation with the avrRpv3+ isolate of the pathogen, which is assumed to use avrRpv3+ effectors that are recognised by/through the plant Rpv3+ gene product. The limitation imposed on pathogen growth was the result of inducible responses elicited by the Rpv3+-avrRpv3+ interaction. This host reaction relied on transcriptional induction of the HR-associated gene HSR1 and salicylic acid-induced pathogenesis-related (PR) genes PR-1 and PR-2 during the initial 24-48 h post-inoculation. These events had no parallel in the Rpv3- host or upon infection with the avrRpv3- isolate. The emerging model for Rpv3-mediated defence, which is dependent upon race-specific recognition, associated with up-regulation of PR-1 and PR-2 genes, and enforced by localised HR-type necrosis, is compatible with the cascade of events initiated by the products of NB-LRR and LRR-kinase receptor-like genes, such as those residing in the Rpv3 locus. © 2011 Springer-Verlag.

AUTHOR KEYWORDS: Pathogenesis-related proteins; Plasmopara viticola; Signal transduction; Vitis vinifera

DOCUMENT TYPE: Article

SOURCE: Scopus

RESISTENCIA (CAMPO)

Perazzolli, M.a , Roatti, B.a b , Bozza, E.a , Pertot, I.a

Trichoderma harzianum T39 induces resistance against downy mildew by priming for defense without costs for grapevine

(2011) Biological Control, 58 (1), pp. 74-82. Cited 36 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-79956102076&partnerID=40&md5=22d647b626580c2ffc5c8a489554a0a9

DOI: 10.1016/j.biocontrol.2011.04.006

AFFILIATIONS: IASMA Research and Innovation Centre, Fondazione Edmund Mach, Via E. Mach 1, S. Michele all'Adige 38010, Trento, Italy;

Institute of Integrative Biology, ETH Zürich, Zürich 8092, Switzerland

ABSTRACT: Downy mildew caused by Plasmopara viticola is one of the most destructive grapevine diseases worldwide. The biocontrol agent Trichoderma harzianum T39 (T39) has previously been shown to be an inducer of grapevine resistance, and we aimed at characterizing the molecular mechanisms activated by T39 and the energy costs of the induced resistance in terms of plant growth. Here, we showed that T39 reduced downy mildew severity on susceptible grapevines under controlled greenhouse conditions by a direct modulation of defense-related genes and the activation of priming for enhanced expression of these genes after pathogen inoculation. The stronger local than systemic modulation of defense-related genes corresponded to an higher local than systemic disease control in T39-treated plants. The activation of a priming state was confirmed by the absence of any negative effect of T39 on grapevine growth, shoot and root weight, leaf dimension and chlorophyll content, in contrast to benzothiadiazole (BTH) applications. Priming of defense gene expression was greater in T. harzianum T39- than in BTH-treated plants. The modulation of marker genes suggested the involvement of jasmonic acid and ethylene signals in the defense processes induced by T39, in contrast to the salicylic acid pathway activated by BTH. These results offer a greater understanding of the mechanisms underlying the grapevine induced resistance and indicate that T. harzianum T39 can be used to control downy mildew without apparent costs for grapevine growth. © 2011 Elsevier Inc.

AUTHOR KEYWORDS: Benzothiadiazole; Energy cost; Gene expression; Induced systemic resistance (ISR); Plant-pathogen interaction; Trichoderma harzianum T39; Vitis vinifera

DOCUMENT TYPE: Article

SOURCE: Scopus

RESISTENCIA (CAMPO)

Harm, A.a , Kassemeyer, H.-H.b , Seibicke, T.b , Regner, F.a

Evaluation of chemical and natural resistance inducers against downy mildew (Plasmopara viticola) in grapevine

(2011) American Journal of Enology and Viticulture, 62 (2), pp. 184-192. Cited 15 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-79958050631&partnerID=40&md5=88b1d1f52e3489acab32557fbd8ea664

DOI: 10.5344/ajev.2011.09054

AFFILIATIONS: Höhere Bundeslehranstalt und Bundesamt für Wein- und Obstbau, Klosterneuburg, Wienerstrasse 74, A-3400 Klosterneuburg, Austria;

Staatliches Weinbauinstitut, Abteilung Biologie, Merzhauser Strasse 119, D-79100 Freiburg im Breisgau, Germany

ABSTRACT: Chemical and natural resistance-inducing substances may be used to decrease the susceptibility of plants to various pathogens, thus reducing the application of pesticides in agriculture. This study evaluated the potential of biocontrol products and of plant extracts. The invoked mode of induced resistance was verified to control downy mildew on grapevine plants using leaf discs and potted vines. Induced resistance was determined by the increase of pathogenesis-related (PR) proteins, including peroxidase, polyphenol oxidase, β-1,3-glucanase, phenylalanine ammonia-lyase, stilbene synthase, β-1,3-glucanase, PR-1 protein, and caffeoyl-coenzyme A 3-O-methyltransferase. Candidate resistance inducers, including Solidago canadensis (CanG) extract, mycelium extract of Penicillium crysogenum (PEN), linoleic acid (LIN), and biocontrol agent Aureobasidium pullulans (Aureo), and chemical elicitors 3-dl-β-aminobutyric acid (BABA) and benzothiadiazole (BTH) were tested against Plasmopara viticola in potted vines grown outdoors. BABA, BTH, and CanG provided a protection of more than 80%, whereas PEN, LIN, and Aureo provided minimal protection. BABA and Aureo were not able to inhibit zoospores, whereas a concentration-dependent inhibition of zoospore mobility was observed for all other tested substances. BTH, CanG, PEN, and LIN induced the production of a broad spectrum of resistance-related metabolites, whereas Aureo did not cause any response. BABA provoked formation of necrotic spots and PR proteins immediately after inoculation. These results indicate the potential to partly induce natural resistance metabolites to enhance tolerance of grapevine plants to P. viticola, thus offering a synergistic effect when used with fungicides and aiding in reducing their ecological burden, even if they are not effective enough to replace them fully.

AUTHOR KEYWORDS: Elicitors; Induced resistance; Plasmopara viticola; Vitis

DOCUMENT TYPE: Article

SOURCE: Scopus

BIOLOGÍA MOLECULAR

Blasi, P.a b , Blanc, S.a b , Wiedemann-Merdinoglu, S.a b , Prado, E.a b , Rühl, E.H.c , Mestre, P.a b , Merdinoglu, D.a b

Construction of a reference linkage map of Vitis amurensis and genetic mapping of Rpv8, a locus conferring resistance to grapevine downy mildew

(2011) Theoretical and Applied Genetics, 123 (1), pp. 43-53. Cited 41 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-79958099685&partnerID=40&md5=347aa1654579b4a21fcfefd3c8f8d7a2

DOI: 10.1007/s00122-011-1565-0

AFFILIATIONS: UMR 1131 Santé de la Vigne et Qualité du Vin, Institut National de la Recherche Agronomique, 28 rue de Herrlisheim, BP 20507, 68021 Colmar Cedex, France;

UMR 1131 Santé de la Vigne et Qualité du Vin, Université de Strasbourg, 28 rue de Herrlisheim, BP 20507, 68021 Colmar, France;

Hochschule RheinMain, Geisenheim Research Center, von-Lade-Str. 1, 65366 Geisenheim, Germany

ABSTRACT: Downy mildew, caused by the oomycete Plasmopara viticola, is one of the major threats to grapevine. All traditional cultivars of grapevine (Vitis vinifera) are susceptible to downy mildew, the control of which requires regular application of fungicides. In contrast, many sources of resistance to P. viticola have been described in the Vitis wild species, among which is V. amurensis Rupr. (Vitaceae), a species originating from East Asia. A genetic linkage map of V. amurensis, based on 122 simple sequence repeat and 6 resistance gene analogue markers, was established using S1 progeny. This map covers 975 cM on 19 linkage groups, which represent 82% of the physical coverage of the V. vinifera reference genetic map. To measure the general level of resistance, the sporulation of P. viticola and the necrosis produced in response to infection, five quantitative and semi-quantitative parameters were scored 6 days post-inoculation on the S1 progeny. A quantitative trait locus (QTL) analysis allowed us to identify on linkage group 14 a major QTL controlling the resistance to downy mildew found in V. amurensis, which explained up to 86.3% of the total phenotypic variance. This QTL was named 'Resistance to Plasmopara viticola 8' (Rpv8). © 2011 Springer-Verlag.

DOCUMENT TYPE: Article

SOURCE: Scopus

BIOLOGÍA MOLECULAR

Seehalak, W.a , Moonsom, S.a c , Metheenukul, P.b , Tantasawat, P.a

Isolation of resistance gene analogs from grapevine resistant and susceptible to downy mildew and anthracnose

(2011) Scientia Horticulturae, 128 (3), pp. 357-363. Cited 8 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-79952449103&partnerID=40&md5=b2bbe257b3f5ef6d4e475d2987636e93

DOI: 10.1016/j.scienta.2011.01.003

AFFILIATIONS: School of Crop Production Technology, Suranaree University of Technology, 111 University Ave., Muang District, Nakhon Ratchasima 30000, Thailand;

Faculty of Veterinary Technology, Kasetsart University, Chatuchak, Bangkok 10900, Thailand;

Department of Protozoology, Faculty of Tropical Medicine, Mahidol University, Bangkok 10400, Thailand

ABSTRACT: Downy mildew and anthracnose are major diseases of the grapevine (Vitis spp.) cultivars grown in Thailand. Due to the deleterious effects of fungicides frequently used for disease management in grapevine, disease resistance genes have been sought after with the ultimate goal of developing new cultivars with improved disease resistance levels. In this study, nucleotide-binding site (NBS)-leucine rich repeat (LRR) class of resistance gene analogs (RGAs) were cloned by PCR amplification using degenerate primers specific to P-loop and GLPL, conserved regions of NBS. Ninety-one clones containing putative RGA sequences were obtained from a downy mildew and anthracnose resistant hybrid 'NY88.0507.01' and a susceptible cultivar 'Black Queen'. These cloned sequences were subdivided into 14 groups based on their nucleotide sequence similarity of 90% or greater. BLASTx of fourteen selected clones showed the highest amino acid sequence similarity with known NBS-LRR proteins or putative resistance (R) protein candidates. Multiple alignments of these representative RGAs with 5 known R proteins revealed conserved P-loop, kinase-2, RNBS and GLPL motifs which are typical components of the NBS-LRR proteins. Four RGAs had at least 40% identity with known R proteins. Phylogenetic analysis demonstrated that the representative RGAs from both resistant and susceptible grapevines dispersed along the phylogram on the two major branches of either TIR (Drosophila Toll and mammalian Interleukin-1 Receptor) or non-TIR type of the NBS-LRR proteins. © 2011 Elsevier B.V.

AUTHOR KEYWORDS: Anthracnose; Downy mildew; NBS-LRR; Resistance gene analogs; Vitis spp.

DOCUMENT TYPE: Article

SOURCE: Scopus

RESISTENCIA (CAMPO)

Deglène-Benbrahim, L.a , Wiedemann-Merdinoglu, S.b , Merdinoglu, D.b , Walter, B.a

Evaluation of downy mildew resistance in grapevine by leaf disc bioassay with in vitro- and greenhouse-grown plants

(2010) American Journal of Enology and Viticulture, 61 (4), pp. 521-528. Cited 5 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-78649919659&partnerID=40&md5=399c81dec4e39e8fb6d2e147d5b4dadb

DOI: 10.5344/ajev.2010.10009

AFFILIATIONS: Université de Haute Alsace, Laboratoire Vigne Biotechnologies et Environ-nement, EA 3991, 33 Rue de Herrlisheim, BP 50568, 68008 Colmar, France;

Institut National de la Recherche Agronomique, UMR1131 Santé de la Vigne et Qualité du Vin, 28 Rue de Herrlisheim, 68021 Colmar, France

ABSTRACT: Genetic improvement of grapevine for resistance against downy mildew (Plasmopara viticola) by biotechnological techniques requires reliable procedures to screen large populations of plants. In comparison with greenhouse-grown plants, in vitro plantlets are not often used in screening procedures, although they present some advantages such as compact size, the availability of a high number of replicates per genotype, and the potential to screen improved genotypes directly from in vitro plants. Leaf disc inoculation bioassay was used to evaluate grapevine resistance to downy mildew on Vitis vinifera Chardonnay, hybrid Seyval, and Vitis riparia Gloire de Montpellier (susceptible, moderately susceptible, and highly resistant, respectively) with both in vitro plantlets and greenhouse-grown plants. Disease symptoms and resistance reaction were evaluated for sporula-tion and necrosis in two independent experiments. For all parameters, leaves from in vitro plantlets appeared more resistant than leaves from greenhouse-grown plants, in particular for the intermediate and the susceptible genotypes. Necroses were not observed on leaf discs of the susceptible genotype, whereas necrotic spots appeared on leaf discs of both intermediate and resistant genotypes regardless of how the plants were grown. Based on sporulation and necrosis symptoms, ranking of genotypes differed according to growing conditions. Although the method based on in vitro grown plants is less reliable than that based on greenhouse plants, it can be used as a preliminary assay to eliminate the most susceptible plantlets obtained by biotechnology.

AUTHOR KEYWORDS: Disease resistance; Downy mildew; Greenhouse plants; In vitro-grown plants; Leaf discs; Oomycete; Screening assay; Vitis

DOCUMENT TYPE: Article

SOURCE: Scopus

RESISTENCIA (CAMPO)

Peressotti, E., Wiedemann-Merdinoglu, S., Delmotte, F., Bellin, D., Di Gaspero, G., Testolin, R., Merdinoglu, D., Mestre, P.

Breakdown of resistance to grapevine downy mildew upon limited deployment of a resistant variety.

(2010) BMC plant biology, 10, p. 147. Cited 36 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-77954845613&partnerID=40&md5=34db7bea6372895e23d2028fbec26fdc

DOI: 10.1186/1471-2229-10-147

AFFILIATIONS: INRA, UMR Santé de la Vigne et Qualité du Vin, Colmar, France.

ABSTRACT: BACKGROUND: Natural disease resistance is a cost-effective and environmentally friendly way of controlling plant disease. Breeding programmes need to make sure that the resistance deployed is effective and durable. Grapevine downy mildew, caused by the Oomycete Plasmopara viticola, affects viticulture and it is controlled with pesticides. Downy mildew resistant grapevine varieties are a promising strategy to control the disease, but their use is currently restricted to very limited acreages. The arising of

resistance-breaking isolates under such restricted deployment of resistant varieties would provide valuable information to design breeding strategies for the deployment of resistance genes over large acreages whilst reducing the risks of the resistance being defeated. The observation of heavy downy mildew symptoms on a plant of the resistant variety Bianca, whose resistance is conferred by a major gene, provided us with a putative example of emergence of a resistance-breaking isolate in the interaction between grapevine and P. viticola. RESULTS: In this paper we describe the emergence of a P. viticola isolate (isolate SL) that specifically overcomes Rpv3, the major resistance gene carried by Bianca at chromosome 18. We show that isolate SL has the same behaviour as two P. viticola isolates avirulent on Bianca (isolates SC and SU) when inoculated on susceptible plants or on resistant plants carrying resistances derived from other sources, suggesting there is no fitness cost associated to the virulence. Molecular analysis shows that all three isolates are genetically closely related. CONCLUSIONS: Our results are the first description of a resistance-breaking isolate in the grapevine/P. viticola interaction, and show that, despite the reduced genetic variability of P. viticola in Europe compared to its basin of origin and the restricted use of natural resistance in European viticulture, resistance-breaking isolates overcoming monogenic resistances may arise even in cases where deployment of the resistant varieties is limited to small acreages. Our findings represent a warning call for the use of resistant varieties and an incentive to design breeding programmes aiming to optimize durability of the resistances.

DOCUMENT TYPE: Article

SOURCE: Scopus

RESISTENCIA (CAMPO)

Peressotti, E.a d , Wiedemann-Merdinoglu, S.a b , Delmotte, F.c , Bellin, D.d f , Di Gaspero, G.d e , Testolin, R.d e , Merdinoglu, D.a b , Mestre, P.a b

Breakdown of resistance to grapevine downy mildew upon limited deployment of a resistant variety

(2010) BMC Plant Biology, 10, art. no. 147, . Cited 6 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-79959902907&partnerID=40&md5=0e74320e532b5d049a37dfbb4943dc9d

DOI: 10.1186/1471-2229-10-147

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Université de Strasbourg, UMR1131 Santé de la Vigne et Qualité du Vin, F-68000 Colmar, France;

INRA, UMR1065 Santé Végétale, Institut des Sciences de la Vigne et du Vin - Bordeaux Aquitaine, BP 81, F-33883 Villenave d'Ornon, France;

Dipartimento di Scienze Agrarie e Ambientali, University of Udine, via delle Scienze 208, 33100 Udine, Italy;

Istituto di Genomica Applicata, Parco Scientifico e Tecnologico Luigi Danieli, via Jacopo Linussio 51, 33100 Udine, Italy;

Dipartimento di Biotecnologie, University of Verona, Strada le Grazie 15, 37134 Verona, Italy

ABSTRACT: Background: Natural disease resistance is a cost-effective and environmentally friendly way of controlling plant disease. Breeding programmes need to make sure that the resistance deployed is effective and durable. Grapevine downy mildew, caused by the Oomycete Plasmopara viticola, affects viticulture and it is controlled with pesticides. Downy mildew resistant grapevine varieties are a promising strategy to control the disease, but their use is currently restricted to very limited acreages. The arising of resistance-breaking isolates under such restricted deployment of resistant varieties would provide valuable information to design breeding strategies for the deployment of resistance genes over large acreages whilst reducing the risks of the resistance being defeated. The observation of heavy downy mildew symptoms on a plant of the resistant variety Bianca, whose resistance is conferred by a major gene, provided us with a putative example of emergence of a resistance-breaking isolate in the interaction between grapevine and P. viticola.Results: In this paper we describe the emergence of a P. viticola isolate (isolate SL) that specifically overcomes Rpv3, the major resistance gene carried by Bianca at chromosome

18. We show that isolate SL has the same behaviour as two P. viticola isolates avirulent on Bianca (isolates SC and SU) when inoculated on susceptible plants or on resistant plants carrying resistances derived from other sources, suggesting there is no fitness cost associated to the virulence. Molecular analysis shows that all three isolates are genetically closely related.Conclusions: Our results are the first description of a resistance-breaking isolate in the grapevine/P. viticola interaction, and show that, despite the reduced genetic variability of P. viticola in Europe compared to its basin of origin and the restricted use of natural resistance in European viticulture, resistance-breaking isolates overcoming monogenic resistances may arise even in cases where deployment of the resistant varieties is limited to small acreages. Our findings represent a warning call for the use of resistant varieties and an incentive to design breeding programmes aiming to optimize durability of the resistances.

DOCUMENT TYPE: Article

SOURCE: Scopus

BIOLOGÍA MOLECULAR

Polesani, M.a , Bortesi, L.a , Ferrarini, A.a , Zamboni, A.a , Fasoli, M.a , Zadra, C.b , Lovato, A.a , Pezzotti, M.a , Delledonne, M.a , Polverari, A.a

General and species-specific transcriptional responses to downy mildew infection in a susceptible (Vitis vinifera) and a resistant (V. Riparia) grapevine species

(2010) BMC Genomics, 11 (1), art. no. 117, . Cited 64 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-77949439770&partnerID=40&md5=92036e627da9e92b7e3126c98a17ddc8

DOI: 10.1186/1471-2164-11-117

AFFILIATIONS: Department of Biotechnology, University of Verona, Strada le Grazie 15, 37134 Verona, Italy;

Department of Agricultural and Environmental Science, University of Perugia, B.go XX Giugno 72, 06121 Perugia, Italy

ABSTRACT: Background: Downy mildew is a destructive grapevine disease caused by Plasmopara viticola (Berk. and Curt.) Berl. and de Toni, which can only be controlled by intensive fungicide treatments. Natural sources of resistance from wild grapevine (Vitis) species are used in conventional breeding approaches, but the signals and effectors involved in resistance in this important crop species are not well understood.Results: Early transcriptional changes associated with P. viticola infection in susceptible V. vinifera and resistant V. riparia plants were analyzed using the Combimatrix microarray platform. Transcript levels were measured 12 and 24 h post-inoculation, reflecting the time points immediately preceding the onset of resistance in V. riparia, as determined by microscopic analysis. Our data indicate that resistance in V. riparia is induced after infection, and is not based on differences in basal gene expression between the two species. The strong and rapid transcriptional reprogramming involves the induction of pathogenesis-related proteins and enzymes required for the synthesis of phenylpropanoid-derived compounds, many of which are also induced, albeit to a lesser extent, in V. vinifera. More interestingly, resistance in V. riparia also involves the specific modulation of numerous transcripts encoding components of signal transduction cascades, hypersensitive reaction markers and genes involved in jasmonate biosynthesis. The limited transcriptional modulation in V. vinifera represents a weak attempted defense response rather than the activation of compatibility-specific pathways.Conclusions: Several candidate resistance genes were identified that could be exploited in future biotechnological approaches to increase disease resistance in susceptible grapevine species. Measurements of jasmonic acid and methyl jasmonate in infected leaves suggest that this hormone may also be involved in V. riparia resistance to P. viticola.

DOCUMENT TYPE: Article

SOURCE: Scopus

RESISTENCIA (CAMPO) QUIMICA ORGÁNICA!!!

Kashif, A.a , Federica, M.a , Eva, Z.b , Martina, R.b , Young, H.C.a , Robert, V.a

NMR metabolic fingerprinting based identification of grapevine metabolites associated with downy mildew resistance

(2009) Journal of Agricultural and Food Chemistry, 57 (20), pp. 9599-9606. Cited 40 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-70350321013&partnerID=40&md5=06afc986fe995deadfec67b9f68c5068

DOI: 10.1021/jf902069f

AFFILIATIONS: Division of Pharmacognosy, Section Metabolomics, Institute of Biology, Leiden University, 2333 CC, Leiden, Netherlands;

Julius Kuehn Institute, Federal Research Centre for Cultivated Plants, Institute for Grapevine Breeding Geilweilerhof, D-76833 Siebeldingen, Germany

ABSTRACT: Grapevine (Vitis vinifera ssp. vinifera L.) and grapes have been extensively studied due to their numerous nutritional benefits and health affecting activities. In this study, metabolite fingerprinting of crude leaf extracts, based on 1H nuclear magnetic resonance (NMR) spectroscopy and multivariate data analyses, has been used for the metabolic characterization of six different grapevine cultivars including downy and powdery mildew resistant 'Regent' and susceptible 'Lemberger' among others. Several two-dimensional (2D)-NMR techniques were also employed leading to the identification of a number of different types of compounds. Principal component analysis (PCA), hierarchical cluster analysis (HCA), and partial least-squares-discriminant analysis (PLS-DA) of the processed 1H NMR data revealed clear differences among the cultivars. Metabolites responsible for the discrimination in different grapevine cultivars belong to major classes, that is, organic acids, amino acids, carbohydrates, phenylpropanoids and flavonoids. A differentiation of the cultivars based on their resistance to downy mildew infection was also achieved, and metabolites associated with this trait, namely, quercetin-3-O-glucoside and a trans-feruloyl derivative, were identified. On the basis of these results, the distribution of different plant metabolites among the different grapevine cultivars is presented. ©2009 American Chemical Society.

AUTHOR KEYWORDS: Cultivars; Downy mildew; Leaf metabolites; Multivariate data analyses; NMR; Resistance; Vitis vinifera

DOCUMENT TYPE: Article

SOURCE: Scopus

RESISTENCIA (CAMPO)

Godard, S.a , Slacanin, I.b , Viret, O.a , Gindro, K.a

Induction of defence mechanisms in grapevine leaves by emodin- and anthraquinone-rich plant extracts and their conferred resistance to downy mildew

(2009) Plant Physiology and Biochemistry, 47 (9), pp. 827-837. Cited 27 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-67649819383&partnerID=40&md5=8eb6fbba9cee3e381f60988e68f5d85a

DOI: 10.1016/j.plaphy.2009.04.003

AFFILIATIONS: Swiss Federal Research Station Agroscope Changins-Wädenswil, Route de Duillier, CH-1260 Nyon, Switzerland;

ILIS, Chemin de la Passerelle 17, CH-2503 Bienne, Switzerland

ABSTRACT: The ability of two plant extracts, Rheum palmatum root extract (RPRE) and Frangula alnus bark extract (FABE), to protect Vitis vinifera leaves from Plasmopara viticola infection was evaluated. These natural products are toxic to the pathogen and induce defence reactions in a susceptible cultivar of V. vinifera (V. vinifera cv. Chasselas), including stilbenic phytoalexin accumulation, enhanced peroxidase (EC 1.11.1.7) activity, and a hypersensitive reaction. Inhibition of the first stage of biotrophic hyphal

development of P. Viticola by the two plant extracts was observed. HPLC-DAD-MS analysis showed that these two natural extracts contain many phenolic compounds belonging to the anthraquinone family, such as rhein, frangulin A, emodin, aloe-emodin, chrysophanol, and physcion. Emodin alone is able to impair P. viticola development and to stimulate viniferins and the accumulation of pterostilbene.

AUTHOR KEYWORDS: Anthraquinone; Emodin; Frangula alnus; Plasmopara viticola; Resveratrol; Rheum palmatum; Stilbenes

DOCUMENT TYPE: Article

SOURCE: Scopus

BIOLOGÍA MOLECULAR

Marguerit, E.a c , Boury, C.b c , Manicki, A.b c , Donnart, M.b c , Butterlin, G.d , Némorin, A.b c , Wiedemann-Merdinoglu, S.d , Merdinoglu, D.d , Ollat, N.b c , Decroocq, S.b c

Genetic dissection of sex determinism, inflorescence morphology and downy mildew resistance in grapevine

(2009) Theoretical and Applied Genetics, 118 (7), pp. 1261-1278. Cited 65 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-67349181299&partnerID=40&md5=f0199c0abb36fdb27ef91a3ca14a3f4c

DOI: 10.1007/s00122-009-0979-4

AFFILIATIONS: Université de Bordeaux, UMR 1287, Ecophysiologie et Génomique Fonctionelle de la Vigne (EGFV), 33175 Gradignan, France;

INRA, UMR 1287, Ecophysiologie et Génomique Fonctionelle de la Vigne (EGFV), 210 Chemin de Leysotte, 33882 Villenave d'Ornon Cedex, France;

Institut des Sciences de la Vigne et du Vin (ISVV), UMR 1287, Ecophysiologie et Génomique Fonctionelle de la Vigne, 33882 Villenave d'Ornon, France;

INRA, UMR 1131, Santé de la Vigne et Qualité du Vin, 68021 Colmar, France

ABSTRACT: A genetic linkage map of grapevine was constructed using a pseudo-testcross strategy based upon 138 individuals derived from a cross of Vitis vinifera Cabernet Sauvignon × Vitis riparia Gloire de Montpellier. A total of 212 DNA markers including 199 single sequence repeats (SSRs), 11 single strand conformation polymorphisms (SSCPs) and two morphological markers were mapped onto 19 linkage groups (LG) which covered 1,249 cM with an average of 6.7 cM between markers. The position of SSR loci in the maps presented here is consistent with the genome sequence. Quantitative traits loci (QTLs) for several traits of inflorescence and flower morphology, and downy mildew resistance were investigated. Two novel QTLs for downy mildew resistance were mapped on linkage groups 9 and 12, they explain 26.0-34.4 and 28.9-31.5% of total variance, respectively. QTLs for inflorescence morphology with a large effect (14-70% of total variance explained) were detected close to the Sex locus on LG 2. The gene of the enzyme 1-aminocyclopropane-1-carboxylic acid synthase, involved in melon male organ development and located in the confidence interval of all QTLs detected on the LG 2, could be considered as a putative candidate gene for the control of sexual traits in grapevine. Co-localisations were found between four QTLs, detected on linkage groups 1, 14, 17 and 18, and the position of the floral organ development genes GIBBERELLIN INSENSITIVE1, FRUITFULL, LEAFY and AGAMOUS. Our results demonstrate that the sex determinism locus also determines both flower and inflorescence morphological traits.

DOCUMENT TYPE: Article

SOURCE: Scopus

RESISTENCIA (CAMPO)

Batovska, D.I.a , Todorova, I.T.a , Parushev, S.P.a , Nedelcheva, D.V.a , Bankova, V.S.a , Popov, S.S.a , Ivanova, I.I.b , Batovski, S.A.a

Biomarkers for the prediction of the resistance and susceptibility of grapevine leaves to downy mildew

(2009) Journal of Plant Physiology, 166 (7), pp. 781-785. Cited 9 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-63649128432&partnerID=40&md5=a31b64710adac4664a60e1d46875ab44

DOI: 10.1016/j.jplph.2008.08.008

AFFILIATIONS: Institute of Organic Chemistry with Centre of Phytochemistry, Bulgarian Academy of Sciences, Acad. G. Bonchev Str., Bl. 9, Sofia 1113, Bulgaria;

Institute of Agriculture and Seed Science, National Centre of Agricultural Science, Prof. I. Ivanov Str. 1, Rousse, 7007, Bulgaria

ABSTRACT: We examined metabolic profiles of acetone and butanol extracts obtained from the leaves of 18 seedlings of the Bulgarian wine-making cultivar Storgozia. The acetone extracts contained the components from the leaf surface, while the butanol extracts were enriched with polar components from inside the leaf tissue. The leaves displayed different degrees of resistance and susceptibility to the etiological agent downy mildew, Plasmopara viticola. Based on the statistically significant correlations ($P<0.05$) between the GC-MS data of the identified metabolites and the estimated leaf resistances, 10 individual components were proposed as possible biomarkers for the downy mildew resistance and susceptibility in grapevine. All were found in the butanol extracts, and can be considered to form two groups: compounds with high correlations ($r=\pm0.50$ to ±1.00) - 3-hydroxybutanoic acid, 2,3,4-trihydroxybutanoic acid, 2,3,4-trihydroxybutanoic acid (isomer), hexadecanoic acid, 3-hydroxyhexanoic acid and myo-inositol, and compounds with moderate correlations ($r=\pm0.30$ to ±0.49) hydroxybutanedioic acid, alanine, glutamine, arabinoic acid and aldohexoses. Among them, the more polar compounds were related to sensitivity, and only hexadecanoic and the monohydroxycarboxylic acids were related to resistance in grapevine.

AUTHOR KEYWORDS: Fungal resistance biomarkers; GC-MS; Metabolite profiling; Plasmopara viticola; Vitis vinifera leaves

DOCUMENT TYPE: Article

SOURCE: Scopus

RESISTENCIA (CAMPO)

Cadle-Davidson, L.

Variation within and between Vitis spp. for foliar resistance to the downy mildew pathogen Plasmopara viticola

(2008) Plant Disease, 92 (11), pp. 1577-1584. Cited 30 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-55849135581&partnerID=40&md5=f695b59c0333667c2b2ce47b36d43272

DOI: 10.1094/PDIS-92-11-1577

AFFILIATIONS: United States Department of Agriculture-Agricultural Research Service, Grape Genetics Research Unit, Geneva, NY 14456, United States

ABSTRACT: To complement existing control strategies, grape growers in humid climates desire cultivars with resistance to downy mildew caused by Plasmopara viticola. Numerous disease resistance screens of diverse Vitis germplasm have been conducted previously to identify downy mildew resistance; however, ratings of named cultivars were inconsistent and identities of resistant individuals in wild species were not typically provided. Inconsistencies among previous studies could be due to race-specific resistance. In the current study, controlled inoculations of two single isolates onto two leaf ages of 883 Vitis

accessions were used and these results compared with natural infection in a fivefold replicated vineyard of 80 Vitis accessions in 2006 and 2007. Of the accessions rated in both assays, 16.2% were resistant to a single isolate but susceptible in the vineyard. Otherwise, there was good correlation of ratings between the field assay and the rating of older leaves (r = 0.62 to 0.71). Five accessions from Vitis cinerea, V. labrusca, and Vitis x champinii averaged zero severity in both vineyard years, yet some individuals of V. cinerea and V. labrusca were moderately or highly susceptible in the field. Similarly, although significant differences in mean severity separated V. vinifera, Vitis hybrid, V. riparia, and V. labrusca for single-isolate inoculations (from susceptible to resistant), notable intraspecies variation was identified for all well-represented species. Resistant individuals were identified in most species with the prominent exceptions of V. vinifera and V. acerifolia. Single-isolate, detached-leaf resistance ratings in 2006 corresponded well (94.6%) to 2007 ratings using a separate isolate collected from the same vineyard. Categorizing the ratings for this and previous studies, ratings infrequently corresponded among previous studies (31.9%) as well as between previous studies and

the current single-isolate (34.9%) or vineyard (46.4%) ratings. These results highlight important factors for downy mildew resistance screens: leaf age, pathogen genotype, and host species and accession. The results further underscore the importance to breeders of uniform testing in multiple environments.

DOCUMENT TYPE: Article

SOURCE: Scopus

RELACIÓN PATÓGENO-PLANTA

Díez-Navajas, A.M.a b , Wiedemann-Merdinoglu, S.a , Greif, C.a , Merdinoglu, D.a

Nonhost versus host resistance to the grapevine downy mildew, Plasmopara viticola, studied at the tissue level

(2008) Phytopathology, 98 (7), pp. 776-780. Cited 38 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-47649095686&partnerID=40&md5=d1ae09665bd943511855884827d5c27d

DOI: 10.1094/PHYTO-98-7-0776

AFFILIATIONS: Unité Mixte de Recherche 1131, INRA-ULP Santé de la Vigne et Qualité du Vin, 28 rue de Herrlisheim, F-68021 Colmar Cedex, France;

NEIKER-Tecnalia, Granja Modelo Arkaute, E-01080 Vitoria-Gazteiz, Spain

ABSTRACT: Following inoculation of host and nonhost plants with Plasmopara viticola, the grapevine downy mildew, a histological survey was undertaken to identify the stage where its development is contained in nonhosts and in resistant host plants. Three herbaceous nonhost species, Beta vulgaris, Lactuca sativa, and Capsicum annuum, and three grapevine species displaying different level of resistance (Vitis vinifera [susceptible], Vitis riparia [partially resistant] and Muscadinia rotundifolia [totally resistant]) where inoculated by P. viticola using a controlled leaf disk inoculation bioassay. During the early steps of infection, defined as encystment of zoospores on stomata, penetration of the germ tube, and production of the vesicle with the primary hypha, there was no evidence of a clear-cut preference to grapevine tissues that could attest to host specificity. The main difference between host grapevine species and nonhosts was observed during the haustorium formation stage. In nonhost tissues, the infection was stopped by cell wall-associated defense responses before any mature haustorium could appear. Defense responses in resistant grapevines were triggered when haustoria were fully visible and corresponded to hypersensitive responses. These observations illustrate that, for P. viticola, haustorium formation is not only a key stage for the establishment of biotrophy but also for the host specificity and the recognition by grapevine resistance factors. © 2008 The American Phytopathological Society.

AUTHOR KEYWORDS: Biotrophism; Cytology; Oomycete

DOCUMENT TYPE: Article

SOURCE: Scopus

BIOLOGÍA MOLECULAR

Chen, W.-J.a , Delmotte, F.a , Richard-Cervera, S.a , Douence, L.a , Greif, C.b , Corio-Costet, M.-F.a c

At least two origins of fungicide resistance in grapevine downy mildew populations

(2007) Applied and Environmental Microbiology, 73 (16), pp. 5162-5172. Cited 63 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-34548227331&partnerID=40&md5=7283d8b9846f7baddb2b025f3bf22923

DOI: 10.1128/AEM.00507-07

AFFILIATIONS: Institut National de la Recherche Agronomique, UMR Sante Vegetale (INRA-ENITAB), Institut des Sciences de la Vigne et du Vin, BP 81, 33883 Villenave d'Ornon Cedex, France;

Institut National de la Recherche Agronomique, UMR Santé de la Vigne et Qualité du Vin (INRA-ULP), BP 20507, 68021 Colmar Cedex, France;

Institut National de la Recherche Agronomique, INRA-Bordeaux, UMR Santé Végétale, Domaine de la Grande Ferrade, Villenave d'Ornon Cedex, France

ABSTRACT: Quinone outside inhibiting (QoI) fungicides represent one of the most widely used groups of fungicides used to control agriculturally important fungal pathogens. They inhibit the cytochrome bc1 complex of mitochondrial respiration. Soon after their introduction onto the market in 1996, QoI fungicide-resistant isolates were detected in field plant pathogen populations of a large range of species. However, there is still little understanding of the processes driving the development of QoI fungicide resistance in plant pathogens. In particular, it is unknown whether fungicide resistance occurs independently in isolated populations or if it appears once and then spreads globally by migration. Here, we provide the first case study of the evolutionary processes that lead to the emergence of QoI fungicide resistance in the plant pathogen Plasmopara viticola. Sequence analysis of the complete cytochrome b gene showed that all resistant isolates carried a mutation resulting in the replacement of glycine by alanine at codon 143 (G143A). Phylogenetic analysis of a large mitochondrial DNA fragment including the cytochrome b gene (2,281 bp) across a wide range of European P. viticola isolates allowed the detection of four major haplotypes belonging to two distinct clades, each of which contains a different QoI fungicide resistance allele. This is the first demonstration that a selected substitution conferring resistance to a fungicide has occurred several times in a plant-pathogen system. Finally, a high population structure was found when the frequency of QoI fungicide resistance haplotypes was assessed in 17 French vineyards, indicating that pathogen populations might be under strong directional selection for local adaptation to fungicide pressure.

DOCUMENT TYPE: Article

SOURCE: Scopus

RESISTENCIA CAMPO

Aziz, A.a d , Trotel-Aziz, P.a d , Dhuicq, L.b , Jeandet, P.c , Couderchet, M.a d , Vernet, G.a

Chitosan oligomers and copper sulfate induce grapevine defense reactions and resistance to gray mold and downy mildew

(2006) Phytopathology, 96 (11), pp. 1188-1194. Cited 86 times.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-33750293009&partnerID=40&md5=d823fbec5d97668720ab7e4bf2b2da4a

DOI: 10.1094/PHYTO-96-1188

AFFILIATIONS: Eco-Toxicologie, URVVC-EA 2069, Université de Reims, B.P. 1039, F-51687 Reims Cedex 2, France;

Agrolor, CA Le Cahn, 17, rue Laurent Bonnevay, 54100 Nancy, France;

ŒNologie and Chimie Appliquée, URVVC-EA 2069, Université de Reims, B.P. 1039, F-51687 Reims Cedex 2, France;

Plantes-Pesticides and Développement Durable, URVVC-EA 2069, Université de Reims, B.P. 1039, F-51687 Reims Cedex 2, France

ABSTRACT: Chitosan (CHN), a deacetylated derivative of chitin, was shown to be efficient in promoting plant defense reactions. CHN oligomers of different molecular weight (MW) and degree of acetylation (DA) triggered an accumulation of phytoalexins, trans- and cis-resveratrol and their derivatives ε-viniferin and piceid, in grapevine leaves. Highest phytoalexin production was achieved within 48 h of incubation with CHN at 200 µg/ml with an MW of 1,500 and a DA of 20% (CHN 1.5/20), while oligomers with greater MW were less efficient, indicating that a specific MW threshold could be required for phytoalexin response. Treatment of grape-vine leaves by highly active CHN 1.5/20 also led to marked induction of chitinase and β-1,3-glucanase activities. CHN 1.5/20 applied together with copper sulfate ($CuSO_4$) strongly induced phytoalexin accumulation. $CuSO_4$ alone, especially at low concentrations also elicited a substantial production of phytoalexins in grapevine leaves. Evidence is also provided that CHN 1.5/20 significantly reduced the infection of grapevine leaves by Botrytis cinerea and Plasmopara viticola, and in combination with $CuSO_4$ conferred protection against both pathogens.

AUTHOR KEYWORDS: Elicitor; Vitis vinifera

DOCUMENT TYPE: Article

SOURCE: Scopus

12.Anexo II: Patentes encontradas

ANEXO II: PATENTES ENCONTRADAS

1 METHOD FOR CONTROLLING PLASMOPARA VITICOLA

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
CHENG XIANGDI	ANHUI HEZHONG AGRICULTURAL TECHNOLOGY CO LTD		A01G17/02 A01G7/06 A01N65/42 (+1)	Cn105123419 (A)	26/06/2015 09/12/2015

2 STERILIZING COMPOSITION CONTAINING PYRACLOSTROBIN AND ZOXAMIDE

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
WU HUALONG XU LITING (+1)	HANGZHOU UDRAGON CHEMICAL CO LTD		A01N37/20 A01N47/24 A01P3/00	Cn104663689 (A)	16/02/2015 03/06/2015

3 STERILIZATION COMPOSITION CONTAINING DIACETONE AMINE COPPER OXALATE

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
ZHENG JINGMIN MA QIANG (+5)	SHAANXI SUNGER ROAD BIO SCI CO		A01N37/46 A01N43/50 A01N43/76 (+6)	Cn104430491 (A)	12/11/2014 25/03/2015

4 COMPOUND COMPOSITION CONTAINING 2-(P-FLUOROPHENYL)-5-METHANESULFONYL-1,3,4-OXADIAZOLE AND COPPER(SUCCINATE+GLUTARATE+ADIPATE) AND PREPARATION

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
WEI BANGZHI LIU YULING (+3)	GAUNGXI TIANYUAN BIOCHEMISTRY		A01N37/04 A01N43/824 A01P1/00 (+2)	Cn104521988 (A) 2015-04-22 CN104521988 (B)	18/12/2014 24/08/2016

5 BACTERICIDE COMPOSITION CONTAINING ARTEMISIA CAPILLARIS THUNB EXTRACTIVE AND PROPAMOCARB HYDROCHLORIDE AS WELL AS APPLICATION OF BACTERICIDE COMPOSITION

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
TANG MANCANG MA YUMING (+2)	SHAANXI HENTIAN CHEM TECH CO LTD		A01N47/12 A01N65/12 A01P3/00	Cn104397040 (A)	17/11/2014 11/03/2015

6 METHOD RAPIDLY IDENTIFYING CUCUMBER BREEDING MATERIAL WITH HEAT RESISTANCE AND MOISTURE RESISTANCE WITHOUT DAMAGING SEEDLING STAGE

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
FENG ZHANG LIGONG LIU	BEIJING ACAD AGRIC & FORESTRY		A01G1/00 A01G7/06	Cn102523854 (A) 2012-07-04 CN102523854 (B)	10/12/2010 31/07/2013

7 DERIVATIVES OF AMINO ACID AMIDES, METHOD OF THEIR SYNTHESIS AND FUNGICIDE FOR AGRICULTURE AND GARDENING

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
MASARU SIBATA KAZUKHIKO SUGIJAMA (+4)	KUMIAJ KEMIKAL INDASTRI KO LTD (+1)	A01N47/12 C07C2101/08 C07C2101/14 (+20)	A01N37/46 A01N47/12 A01N47/24 (+25)	Ru94046335 (A) 1996-10-27 RU2128186 (C1)	28/04/1993 27/03/1999

8 BACTERICIDE COMPOSITION FOR AGRICULTURE AND HORTICULTURE

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
SAKAI MITSUYOSHI KOJIMA YOSHIYUKI (+1)	KUMIAI CHEMICAL INDUSTRY CO		A01N37/32 A01N37/34 A01N37/44 (+20)	JPH09183703 (A) 1997-07-15 JP3775841 (B2)	28/12/1995 17/05/2006

ANEXO II: PATENTES ENCONTRADAS

9 SYSTEMIC FUNGICIDES CONTG. COPPER CHELATES - WITH ZINEB OR MANEB AND AN IRON FERRATE COMPLEX

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
SZAVA JENO	PETI NITROGENMUEVEK? [HU]	A01N47/12	A01N47/12 (IPC1-7): A01N9/02	Fr2295699 (A1) 1976-07-23 FR2295699 (B1)	24/12/1974 05/03/1982

10 METHOD FOR ENHANCING THE DISEASE RESISTANCE IN PLANTS BY ALTERING TREHALOSE-6-PHOSPHATE LEVELS

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
SCHLUEPMANN HENRIETTE?[NL]	STICHTING TECH WETENSCHAPP?[NL] SMEEKENS JOSEPHUS CHRISTIANUS?[NL]	C12N15/8279 C12N15/8282 C12N9/90	C12N15/82 C12N9/90 (IPC1-7): A01H5/00 (+1)	Ep1375669 (A1)	13/06/2002 02/01/2004

11 NEW AMMONIO:ALKANOIC ACID TRI:PHENYL-TIN ESTER(S)S - USED AS BROAD-SPECTRUM PLANT FUNGICIDES, PREPD. FROM HALO:ALKANOIC ESTER AND TRI:ALKYLAMINE

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
BANASIAK LOTHAR DR RER NAT?[DE] SEIDEL PETRA DR?[DE] (+1)	BANASIAK LOTHAR DR RER NAT?[DE] SEIDEL PETRA DR?[DE] (+1)	A01N55/04 C07F7/2244	A01N55/04 C07F7/22 (IPC1-7): A01N55/04 (+1)	De4214592 (A1)	02/05/1992 04/11/1993

12 PYRIDYL-PYRIMIDINE DERIVS. FUNGICIDES USEFUL AS PLANT PROTECTANTS AND AS PRESERVATIVES IN PAINTS OR OILS

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
HOFFMANN MICHAEL DR?[DE] BRAUN PETER DR?[DE] (+2)	HOECHST AG?[DE]	A01N43/54 C07D401/04	A01N43/54 C07D401/04 (IPC1-7): A01N43/54 (+2)	De4031798 (A1)	08/10/1990 09/04/1992

13 PLANT TREATMENT COMPSN. FOR CONTROLLING SPECIFIC FUNGI CONTG. AMINO OR CARBOXYLIC ACID, NUCLEOSIDE AND VITAMINS

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
WELTZIEN HEINRICH PROF DR?[DE] TEINER KLAUS?[DE]	BTC BIOTECH INT?[DE]	A01N2300/00 (+19)	A01N61/00 A01N65/00 C05F9/04 (+3)	De3943501 (A1)	28/03/1989 18/10/1990

14 PHOSPHORIC ACID DERIVS. OF 1,2,4-TRIAZOLE AND IMIDAZOLE FUNGICIDES FOR PROTECTING PLANTS, ESP. EFFECTIVE AGAINST MILDEW

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
KOCUR JEAN DR?[DE] MILDENBERGER HILMAR DR?[DE] (+1)	HOECHST AG?[DE]	A01N57/24 A01N57/36 C07F9/65061 (+1)	A01N57/24 A01N57/36 C07D233/60 (+5)	De3046329 (A1)	09/12/1980 15/07/1982

15 DI:ARYL 1-ACYLOXY-2,2,2-TRI:CHLOROETHYL-PHOSPHONATE ESTER(S) USEFUL AS AGRICULTURAL FUNGICIDES

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
BLIZNJUK NIKOLAJ KIRILLOVITSCH?[SU] PROTASOVA LJUDMILA DMITRIEVNA?[SU] (+20)	VNII FITOPATOLOGII	A01N57/22 C07F9/4006 C07F9/4084	A01N57/22 C07F9/40 (IPC1-7): A01N9/36 (+1)	De2839828 (A1) 1980-04-24 DE2839828 (C2)	13/09/1978 15/09/1983

16 SYSTEMIC FUNGICIDES CONTG. COPPER CHELATES - WITH ZINEB OR MANEB AND AN IRON FERRATE COMPLEX

INVENTOR	APPLICANT	CPC	IPC	PUBLICATION INFO	PRIORITY DATE
SZAVA JENOE DIPL ING DR	PETI NITROGENMUEVEK	A01N41/04 A01N41/08	A01N41/04 A01N41/08 (IPC1-7): A01N9/02	De2551282 (A1) 1977-05-26 DE2551282 (B2) 1977-09-22 DE2551282 (C3)	14/11/1975 18/05/1978