



Zorvec[™]
active

**THIS CHANGES
EVERYTHING**

**A HIGHLY EFFECTIVE
FUNGICIDE WITH A
NEW BIOCHEMICAL
MODE OF ACTION.**

Contents

Overview 2

Mode of Action 3

Key Features 8

Food Chain Advantages 12

Summary 15



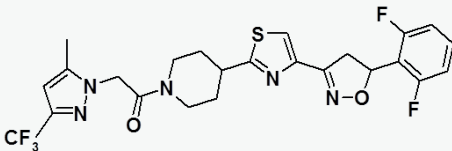
Zorvec™ active fungicide is the first member of a novel class of fungicides to control diseases caused by oomycete pathogens.

Zorvec binds to a unique target site, conferring a completely new biochemical mode of action and has no cross-resistance with existing fungicides. It produces multiple effects on the pathogen's life cycle (preventative, curative, eradicator and antispore) for better efficacy and length of control. Zorvec protects treated leaves as they grow and expand, including leaves that are less than 20% of their final size at the time of application. Studies in potato and certain vegetable crops have also demonstrated that Zorvec protects new leaves as they emerge and grow.*

Zorvec features a favourable environmental profile, being effective on target organisms at low use rates and having very low toxicity to non-target organisms. Mammalian oral, neurological, developmental and dermal toxicity is low, as is avian and bee toxicity. When assessed on these and other criteria, Zorvec represents highly effective oomycete disease control technology.

* Source: Stine-Haskell Research Center - Delaware, USA (2014)

General information

Trade name	Zorvec™ disease control
Chemical class	Piperidinyl thiazole isoxazoline 2012 Agrow Award for most innovative chemistry 2014 Agrow Award for best formulation innovation 2016 Best New Crop Protection Product
Common chemical name	oxathiapiprolin
Company development code	DPX-QGU42
Molecular formula	$C_{24}H_{22}F_5N_5O_2S$
Chemical structure	
CAS number	1003318-67-9
Disease spectrum	Controls diseases caused by oomycete pathogens

Mode of Action / Activity

Disease control spectrum		
Crop	Disease caused by	Common name
Grapes	<i>Plasmopara viticola</i>	Downy mildew
Potato	<i>Phytophthora infestans</i>	Late blight
Onion	<i>Peronospora destructor</i>	Downy mildew

Favourable toxicological profile		
Acute Toxicity Studies	Acute Oral Rat Acute Dermal Rat Acute Inhalation Rat	LD ₅₀ > 5000 mg/kg LD ₅₀ > 5000 mg/kg LC ₅₀ > 5.1 mg/kg
	Not an irritant to the eyes or skin of rabbits Dermal sensitisation – Non-sensitising in guinea pigs	
Genetic Toxicity Studies	Not mutagenic in a battery of tests	
Developmental Toxicity Studies	No developmental toxicity observed in rats or rabbits	
Reproductive Toxicity Studies in Rats	No effects on reproduction Slight delays in maturation at high doses Decreases in body weight at extremely high doses	
Neurotoxicity Studies	Acute Rat (oral gavage): no neurotoxicity observed Repeated Dose Rat (diet): no neurotoxicity observed	
Immunotoxicity Study	No immunotoxicity observed in mice	
Repeated Dose Toxicity Studies	No adverse effects in rats, mice and dogs	
Carcinogenicity Studies	Not carcinogenic in rats or mice	
Physical Properties	Water solubility (distilled) Log Kow Kfoc Vapor pressure (20°C) Hydrolysis Aqueous photolysis Degradation in soil	0.175 mg/Lw 3.67 8368 g/kg 1.14 X 10 ⁻⁶ PA Stable DT ₅₀ ~ 15 days DT ₅₀ ~ 90 days
Aquatic Toxicity	Exposure limited by solubility	LD ₅₀ > highest dose
Avian Toxicity	Acute Oral Acute Dietary Reproduction	LD ₅₀ > 2250 mg/kg bw LD ₅₀ > 1280 mg/kg bw NOAEC > 1200 mg/kg bw
Bee Toxicity	Oral Contact	LD ₅₀ 48hr ~ 40 µg/bee LD ₅₀ 48hr ~ 100 µg/bee
Non-target arthropods		48hr ER ₅₀ & LR ₅₀ > highest rate tested
Earthworms		LC ₅₀ , 28d; EC ₅₀ , 28d growth/ biomass; 56d repro > 1000 mg ai/kg soil

* OF: open field, GH: greenhouse

Zorvec™ active

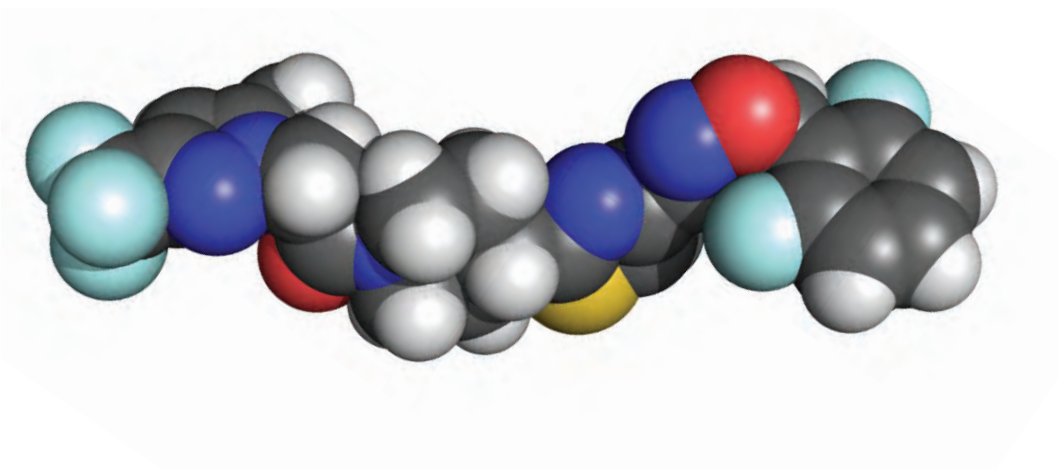
Studies show that the novel target site, new mode of action and diverse movement properties deliver effective disease control with no cross-resistance and a favourable environmental profile.

New chemistry, multiple advantages

- | Novel target site, completely new biochemical mode of action
- | Binds in the oxysterol-binding protein (OSBP) domain
- | No cross-resistance with existing fungicides
- | FRAC 49 (F9)

Improved effectiveness, favourable environmental profile

- | Oomycete-specific binding site
- | Highly effective against late blights and downy mildews at low rates for reduced environmental load
- | Very low toxicity to non-target organisms



Multiple effects

Zorvec™ active fungicide produces multiple effects on the pathogen's life cycle, providing unmatched consistency and control for healthier crops.

Preventive*: inhibits zoospore release and germination. In potatoes, it also inhibits sporangia germination.

Curative*: stops mycelial growth in the host plant before visible symptoms occur, providing up to two days' protection.

Post-Infection*: stops mycelial growth; inhibits further lesion growth.

Antisporulant*: inhibits spore production.

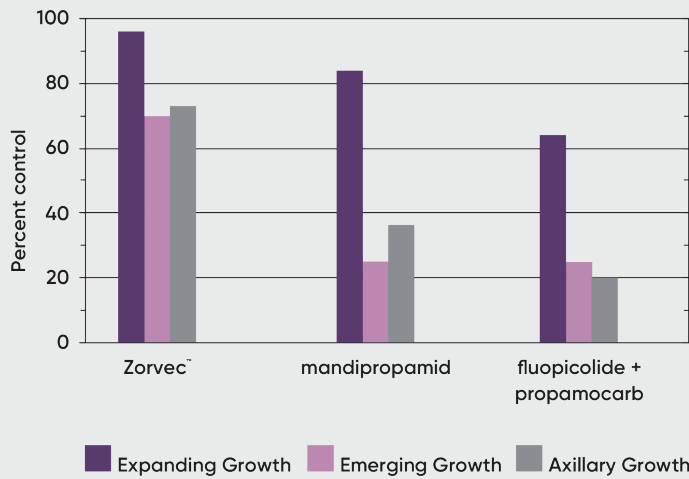
* Zorvec will only be recommended in a preventive manner.

Protects new plant growth

Studies on potatoes and various vegetable crops have shown that Zorvec™ active fungicide protects plants in distinct ways:

- | It protects new plant growth for better crop establishment.
- | It protects treated leaves as they grow and expand with no spread of disease.

Protection of expanding and emerging potato growth ten (10) days after a preventative treatment



Expanding growth refers to leaves that were 30–50% of their final size at application

Emerging growth refers to leaves that were only 5–25% of their final size at application

Axillary growth refers to new leaves emerging from stem axils NOT present at application

Excellent control on expanding and emerging new growth following Zorvec. Superior protection of new growth compared with mandipropamid and fluopicolide + propamocarb.



During treatment
(expanding and emerging growth above tagged leaf)



10 days after treatment
(fully expanded leaves above tagged leaf)

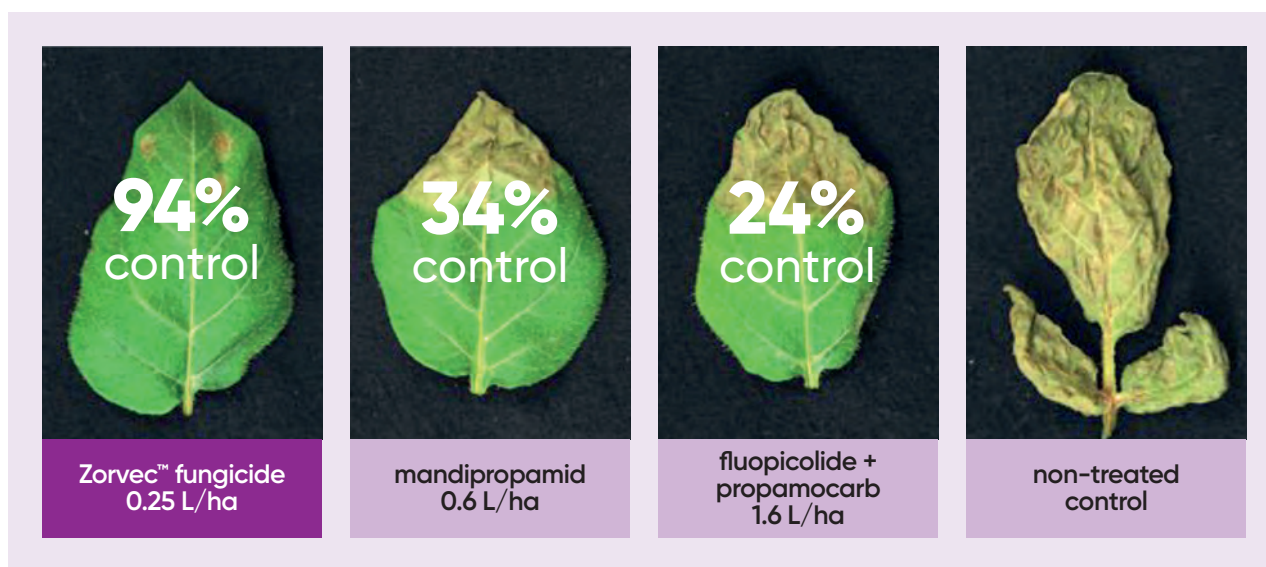
Systemic movement

Systemic movement of Zorvec™ active enables uniform protection even for portions of leaves receiving partial spray coverage.



Local movement test

- Half of each target leaf protected from spray
- Entire leaf inoculated with late blight after 48 h
- Target leaf rated 5 days after inoculation (DAI)



Source: Stine-Haskell Research Center - Delaware, USA (2017)

Notes

- ❖ Zorvec was only applied to the basal 1/3 of the leaf
- ❖ Translaminar – movement is from the upper leaf surface to the lower
- ❖ Acropetal (indicated by arrows) – movement in xylem tissue out to the leaf tip
- ❖ Systemic movement in xylem tissue gives complete protection outward to the leaf tip
- ❖ No movement in the phloem, thus the presence of disease below the treated area
- ❖ In actual applications, the entire surface of the leaf is treated, resulting in the protection of all new growth.

Potatoes

Key attributes and features of Zorvec vs competing products at commercial rates						
Multiple Effects on the Pathogen's Life Cycle						
Fungicide	Rainfastness	Preventative	Curative	Anti-Sporulant	Stem blight	Mobility
Zorvec	+++	+++	++	+++	+++	S + T
fluopicolide + propamocarb	++(+)	+++	++	++(+)	++	S + T
mandipropamid	+++	+++	+	+(+)	+(+)	C + T
cyazofamid	+++	+++	-	-	+	C
cymoxanil + mancozeb	++	++	++	+	+(+)	T + C
benthiavalicarb + mancozeb	+++	+++	+(+)	+	+(+)	T + C

Source: DuPont European Research and Development Center, France, and Stine-Haskell Research Center - USA (2012-2014) and Euroblight fungicide comparison (2012)

C: Contact activity S: Systemic activity T: Translaminar activity

Rating	Designation
+++	Excellent
++	Good
+	Moderate
-	Poor

Key Features

Zorvec™ active

Controlled wash-off studies have demonstrated that Zorvec is protected from wash-off just 20 minutes after application to a dry leaf.



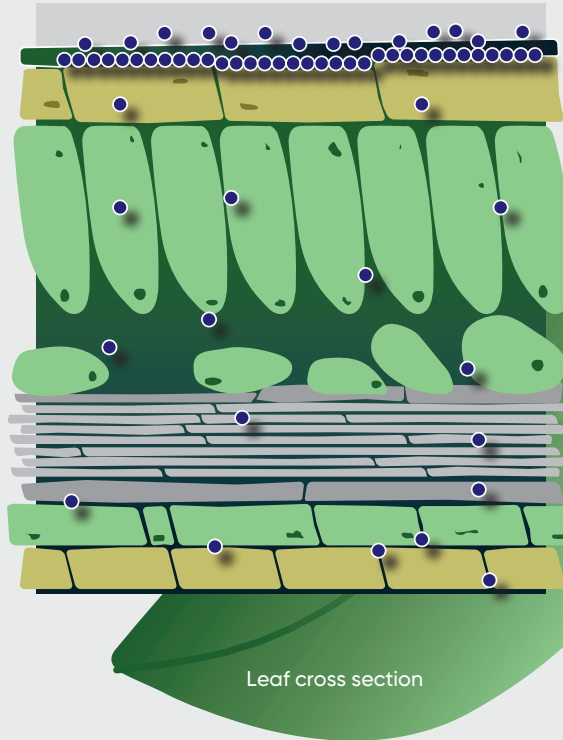
Key Features

Quick movement within the plant

Rainfastness is related to how quickly an active moves into the plant. Zorvec™ active moves quickly into the waxy epicuticular layer of plant tissue, making it extremely resistant to wash-off.



Rainfastness is related to how quickly an active moves into plant tissue



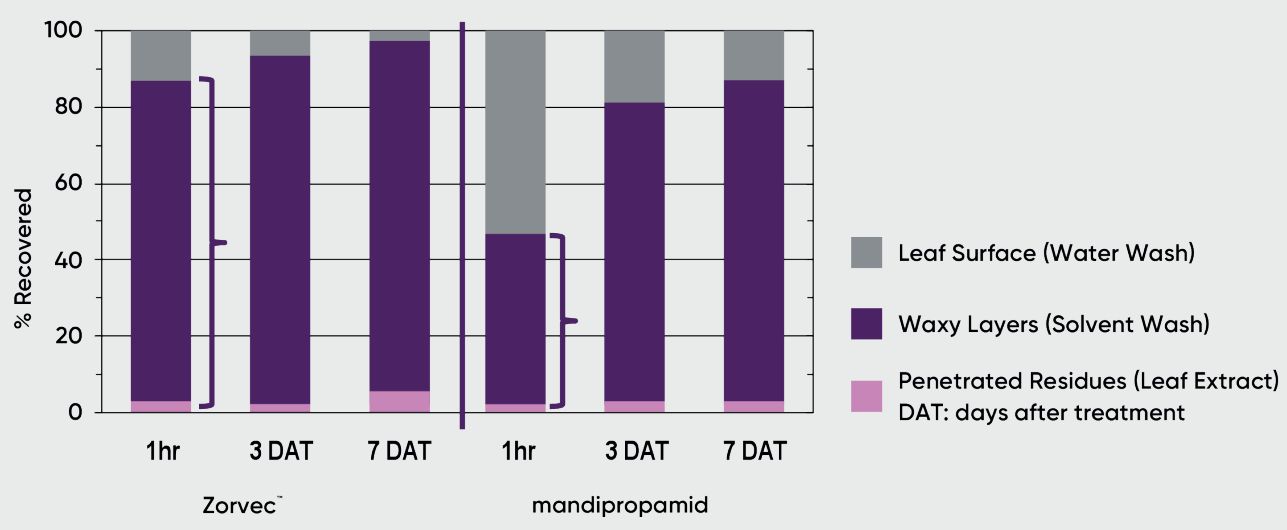
Location of Zorvec 1 hour after application

- 12-15% on the leaf surface
- Up to 80% associated with the waxy cuticle
- 3-5% associated with the inter-cellular layers

Leaf cross section

Source: Stine-Haskell Research Center, USA (2013)

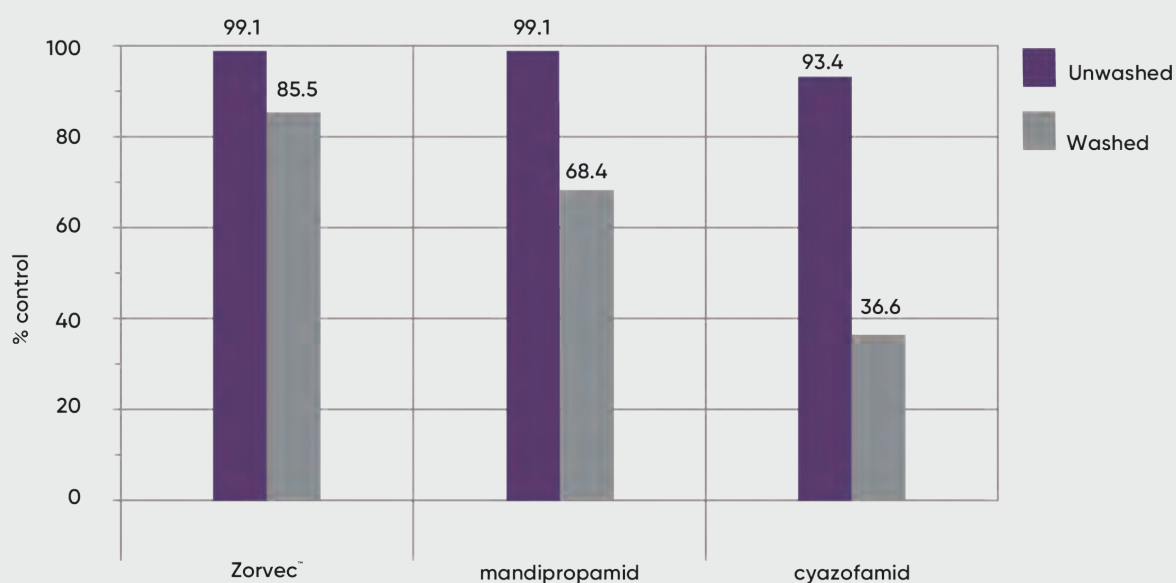
Leaf partitioning following a preventative application



Rainfastness at low application rates

Zorvec is effective against target diseases at low application rates, exhibiting significant rainfastness compared to competing products. In fact, research shows that the control of competing fungicides drops off rapidly in the face of rain, even when applied at much higher rates.

Efficacy on potato late blight following a simulated rain event*



Source: Whole plant studies, DuPont European Research and Development Center, France (2015)

* 100 mm over 4 hours starting 20 minutes after application to a dry leaf
Tested with laboratory dose rate corresponding to the same dilution of field rate

Key Features

Consistently robust disease control at low use rates

When plants treated with Zorvec™ active at various rates are compared with untreated plants and with the performance of competing products, Zorvec exhibits a consistently higher level of disease control.

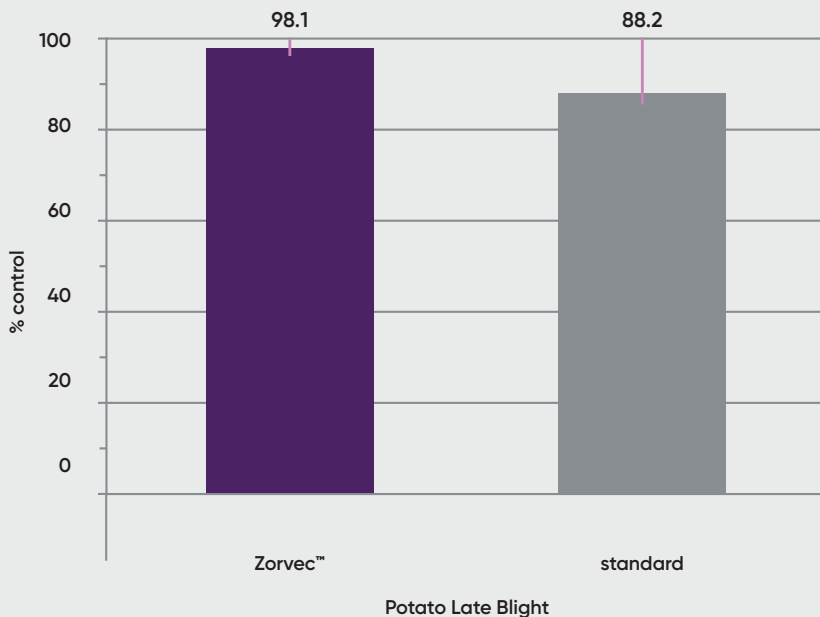
Intrinsic activity against *Phytophthora infestans*

In vitro test type	Zorvec EC ₅₀ , ppm	Cyazofamid EC ₅₀ , ppm	Mandipropamid EC ₅₀ , ppm	
Zoospore germination	<input checked="" type="checkbox"/> < 0.00001	<input type="checkbox"/> < 0.00002	<input checked="" type="checkbox"/> < 0.00001	<input checked="" type="checkbox"/> Highly active
Sporangia direct germination	<input checked="" type="checkbox"/> < 0.00001	<input type="checkbox"/> < 0.0002	<input checked="" type="checkbox"/> < 0.1	<input type="checkbox"/> Active
Mycelial growth	<input checked="" type="checkbox"/> < 0.0002	<input type="checkbox"/> < 0.004	<input checked="" type="checkbox"/> < 0.1	<input checked="" type="checkbox"/> Inactive
Zoospore release	<input checked="" type="checkbox"/> < 0.01	<input type="checkbox"/> < 0.03	<input checked="" type="checkbox"/> < 1.0	

Source: Stine-Haskell Research Center, USA (2011-2012)

EC50 = concentration needed to inhibit 50% of the population X Inactive at concentrations used in these studies
Based on laboratory studies with *Phytophthora infestans*. Effect on zoospore release varies between species.

Zorvec Field Efficacy Median % control across trials

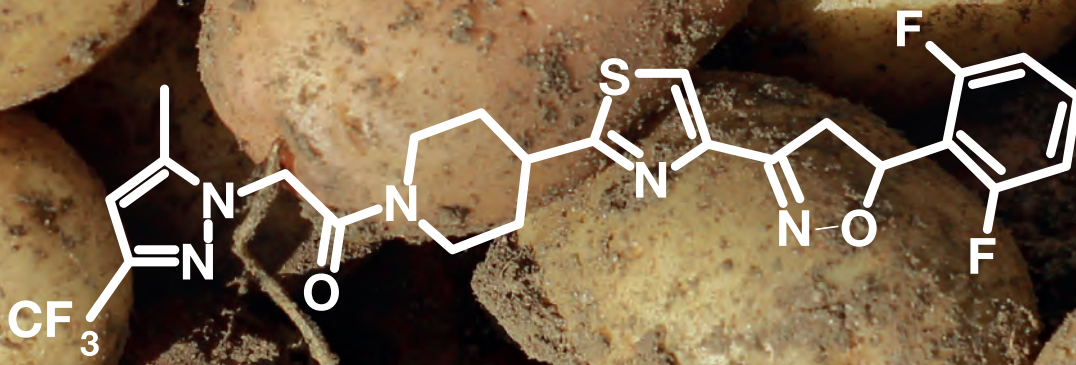


Source: DuPont sponsored trials** in various countries across Europe (2009-2012)

* Commercial standards varied between regions. ** 18 trials for potato late blight

Zorvec[™] active

A new, highly effective fungicide with a favourable environmental profile.



Food Chain Advantages

❖ Favourable residue profile

- Manageable with EU and many global MRLs established
- All mixture partner active substances are widely used and known

❖ New fungicide with a unique mode of action

❖ Control of diseases that are resistant to other fungicides and a valuable rotation partner with other chemistries

❖ Most effective when used as a protectant

❖ Compatible with IPM principles

- Minimal impact on beneficial insects, including bees and natural enemies, **when application follows label directions for use**

❖ Persistence offers opportunity for longer intervals between fungicide applications

MRL and PHI for Zorvec; grapes, onions, potatoes and tomatoes

Country	Grapes		Onions	Potatoes		Tomatoes	
	MRL/IT	PHI*	MRL/IT	MRL	PHI	MRL	PHI
USA	0,7	14	0,04	0,04	7	0,5	3
EU	0,7	14	0,01	0,01	7	0,2	3
Japan	0,7	14	0,04	0,05	7	0,5	3
Korea	1	14	0,05	0,05	7	0,7	3
Codex	0,9	14	0,04	0,01	7	0,4	3

❖ **PHI (Pre Harvest Interval)** is the estimated time(days) between final application and earliest harvest to be below MRL and meet EU label directions

❖ **IT:** Import tolerance

❖ **MRL:** Maximum residue level from global.mrl.com (31 October 2018)

Additional information Regarding MRLs is available online at:

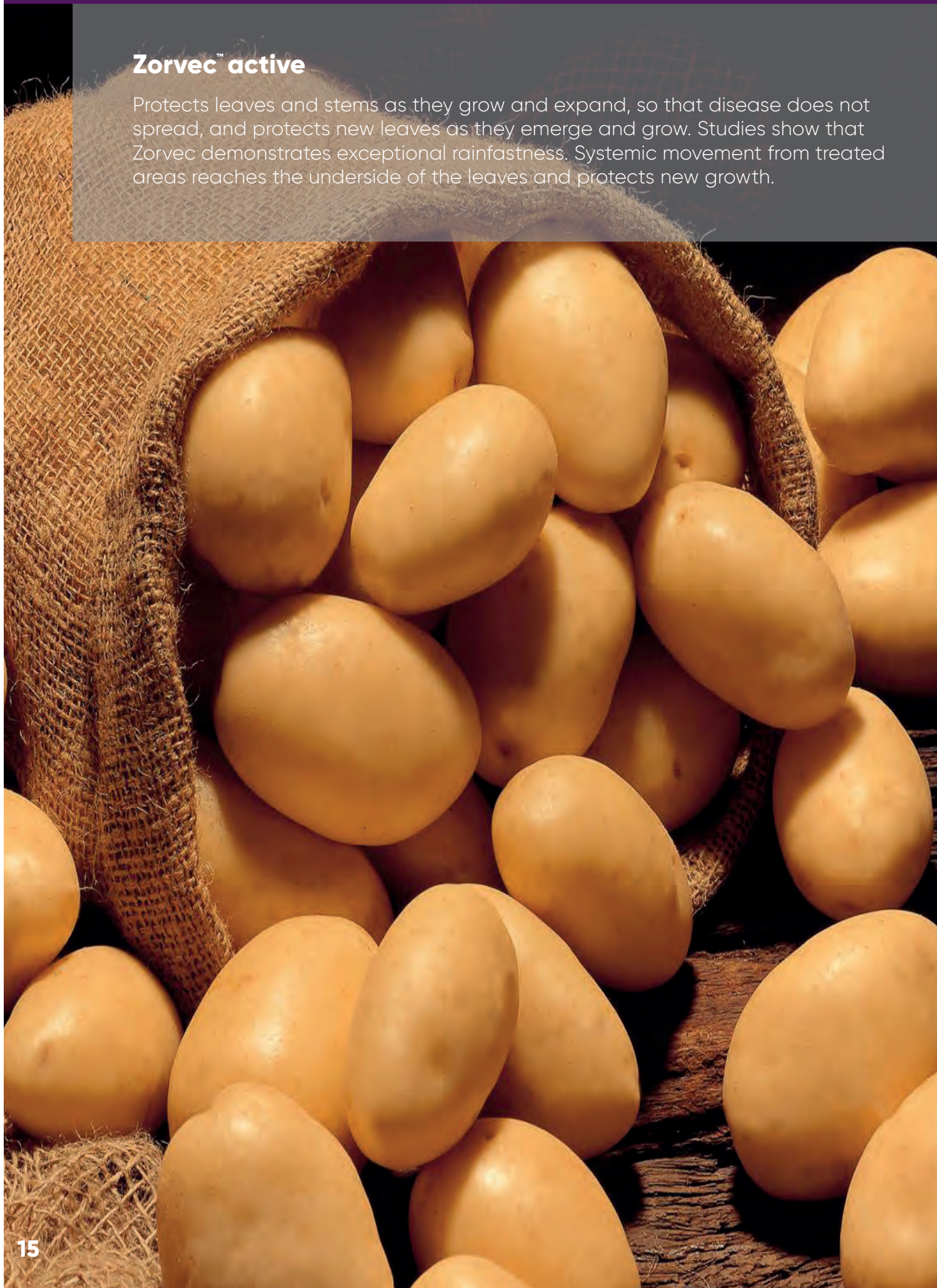
USA	www.epa.gov/pesticide-tolerances
Canada	pr-rp.hv-sc.gc.ca/mrl-lrm/index-eng.php
Codex	http://www.fao.org/fao-who-codexalimentarius/codes-texts/dbs/pestres/en/
EU	ec.europa.eu/food/plant/pesticides/max_residue_levels_en
Global	globalmrl.com

For Potatoes: no residues of Zorvec are expected (< limit of detection) in potato and processed potato when the product is applied following directions on EU labels

Summary

Zorvec™ active

Protects leaves and stems as they grow and expand, so that disease does not spread, and protects new leaves as they emerge and grow. Studies show that Zorvec demonstrates exceptional rainfastness. Systemic movement from treated areas reaches the underside of the leaves and protects new growth.



Zorvec™ active delivers unparalleled disease control. By expressing multiple effects on the pathogen, it provides favourable and more diverse plant protection. The product is rainfast, providing excellent disease control at low rates, has no cross-resistance to other products and offers a favourable environmental profile.

For these reasons, Zorvec is a crop protection technology with the potential to provide many benefits to growers, including lower operational costs and overall improved farm management efficiency.

Potato Late Blight (*Phytophthora infestans*)



Source: Corteva Agriscience trial, Netherlands (2016)

Zorvec Enicade®



Commercial standard.
The area above was treated with Standard (propamocarb + fluopicolide) at a 7 day spray interval.

Zorvec based formulation.
The area above was treated with Zorvec Enicade + partner product at a 10 day spray interval.

Source: Jinan, Shandong, China (2014)

Continuous Innovation

RELIABLE RESISTANCE MANAGEMENT WITH ZORVEC™ FUNGICIDE

The risk of resistance development with the use of fungicides is generally known. The unparalleled efficacy and length of control means that **Zorvec™** will become the cornerstone of growers' control programmes and therefore needs to be used responsibly.

Corteva Agriscience™ has integrated clear strategies of stewardship in launching **Zorvec** branded products to minimise the risk of resistance development.

REDUCED RISK STATUS

Oxathiapiprolin was granted reduced risk status by US/EPA for all of the food uses which are now registered.

CONSISTENCY AND CONTROL

Zorvec provides an unmatched combination of consistency and control that can be used every season to help growers achieve better crops, even under challenging environmental conditions.

ZORVEC: MOST INNOVATIVE CHEMISTRY AND FORMULATION

Zorvec was recently recognised with 3 global Agrow Awards for both Most Innovative Chemistry, Best Formulation Innovation and finally Best New Crop Protection Product.



Corteva Agriscience™ continues to discover and develop products that will meet the needs of growers, consumers and the environment around the world.

USE PLANT PROTECTION PRODUCTS SAFELY AND WITH RESPONSIBLE CARE.
PLEASE ALWAYS FOLLOW THE LABEL WHEN APPLYING PLANT PROTECTION PRODUCTS.
The information contained in this technical brochure is based on the latest to-date technical information available. Corteva Agriscience™ reserves the right to update this information anytime.