



# Mancozeb: An Essential Tool for Sustainable Protection Against Early & Late Potato Blight

Sjef van der Heijden Agronomic Development Officer, UPL Europe Ltd; Jean-Jacques Heller, Technical Manager, UPL Europe Ltd; Serge Duvauchelle, Engineer of Agronomy, Consultant, France.

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# Overview

Late blight (*Phytophthora*) is the most serious foliar disease of potato, however, early blight (*Alternaria*) is increasing each year.

Other populations of *Phytophthora infestans*, *Alternaria solani*, *A.alternata* are continually evolving. Some fungicides are specific to some diseases and have little or no efficacy against others.

The exclusive use of such fungicides may promote the development of resistance and poor efficacy.

# Greenhouse Study (2014): *Phytophthora infestans*

## Materials and Methods

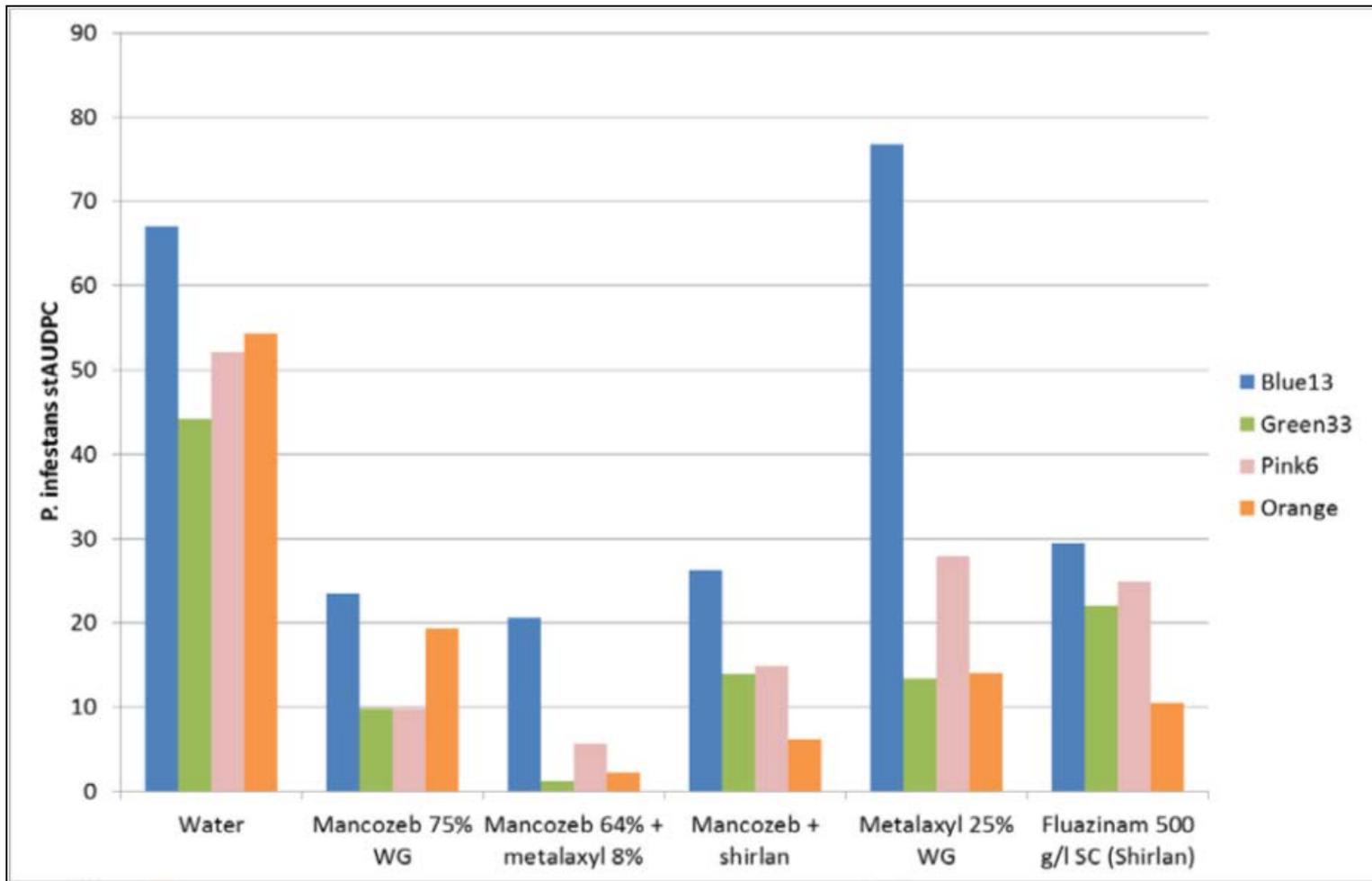
- **The Experiment:** Conducted in 2014 by Wageningen UR to test the efficacy of mancozeb (**PENNCOZEB**) on the control of different strains of *Phytophthora infestans*.
- **Design:** Cultivated potato plants (cv. Bintje) in pots, in a greenhouse with four replications (each replication = one potato plant). Analysis of variance on late blight assessments were made based on the percentage necrotic foliage.
- **Fungicides Used:** Mancozeb 1500g/ha, mancozeb 1600g/ha + metalaxyl-M 200 g/ha, mancozeb 1500g/ha + fluazinam 200g/ha, metalaxyl-M 200g/ha and fluazinam 200g/ha were sprayed on plants.

# Greenhouse Study (2014): *Phytophthora infestans*

- **Inoculum:** Four different strains of *P. infestans* were used: Blue 13, Pink 6, Green 33 (coming from a field with a less susceptibility to fluazinam) and an Orange genotype (old population). Inoculation (10,000 sporangia/ml) of the plants was carried out by spraying the leaves over-head five days after spraying the fungicides.
- **Assessment(s):** Late blight disease severity was assessed five times after inoculation. Percentage necrotic foliage was estimated. From the individual disease ratings, a Standard Area Under Disease Progress Curve (stAUDPC) was calculated.

# Results: Laboratory Study (2014)

The Efficacy of mancozeb (PENNZOZEB), to Control Different Strains of *Phytophthora infestans*



# Conclusion: Laboratory Study (2014)

The laboratory study carried out by Wageningen UR in 2014 to test the efficacy of mancozeb (PENNCOZEB) on the control of different strains of *Phytophthora infestans*, concludes that;

- **Mancozeb:** Is efficacious on all type of strains, 13\_A2 (Blue 13), 6\_A1(pink 6), 33\_A2 (green 33) “old strain”
- **Metalaxyl:** Is not efficient against blue 13
- **Fluazinam:** Has a lower efficacy on green 33

# Laboratory Study (2015): Spore Germination of *Alternaria solani*

## Materials and Methods

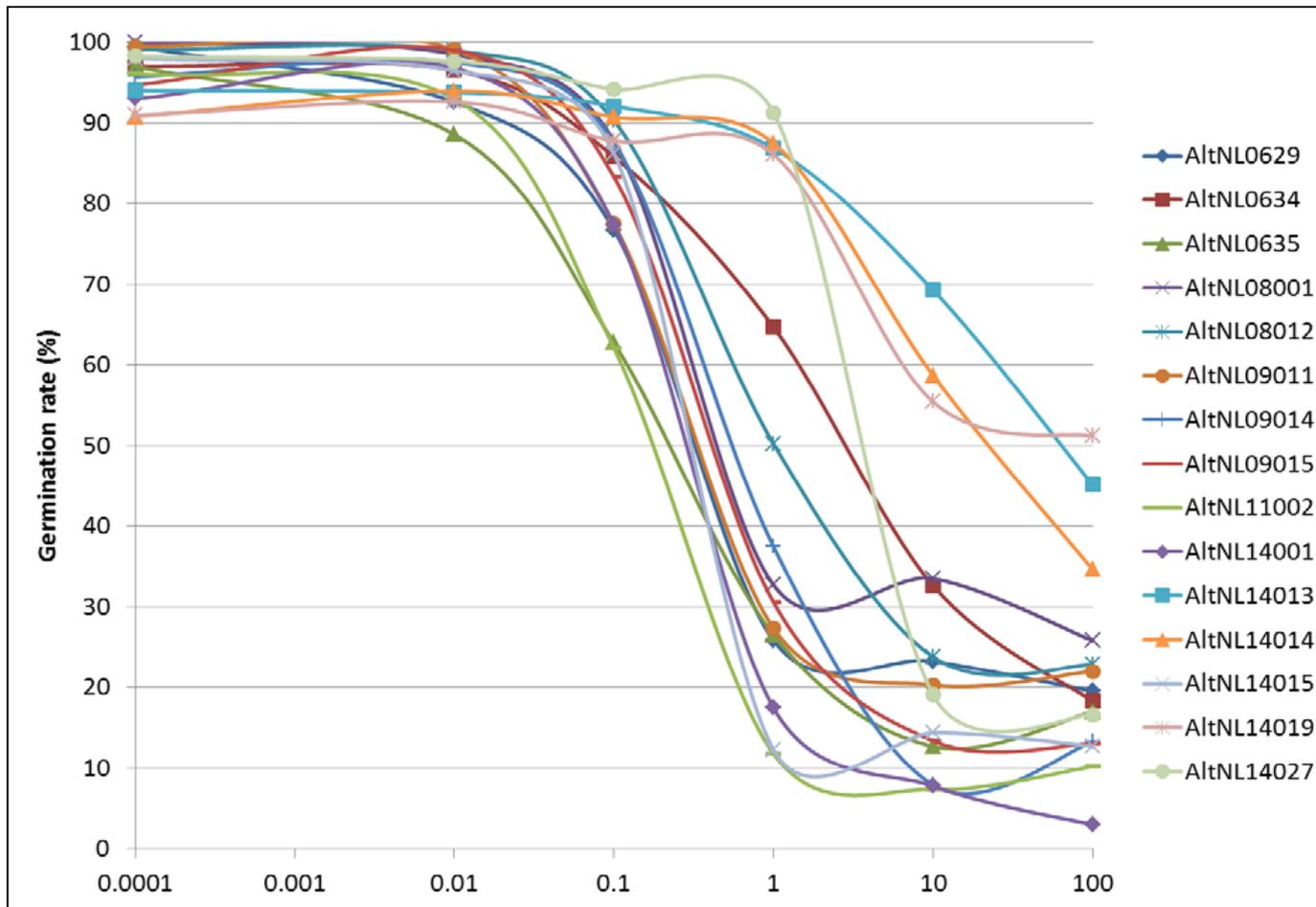
- **The Experiment:** Conducted in 2015 by Wageningen UR to measure the efficacy of fungicides on spore germination against different strains of *Alternaria solani*.
- **Design:** Two replicates were carried out on a selection of 15 isolates of *Alternaria solani*, collected from various fields between 2006 and 2014.
- **Fungicides Used:** Azoxystrobin 250g/L, boscalid 26.7% + pyraclostrobin 6.7% at 0.01, 0.1, 1, 10, and 100ppm. Mancozeb WG 75% at 0,1, 1, 10, 100, 1000ppm. The fungicides were added during the cooling of water agar and poured into Petri dishes.

# Laboratory Study (2015): Spore Germination of *Alternaria solani*

- **Innoculum:** A suspension with 10.000 sporangia/ml was sprayed on to the agar plates containing the fungicides. The plates were incubated for 6 hours at room temperature (20°C) under daylight conditions. After warm incubation, the plates were transferred to a cool chamber at 4°C in the dark until germination assessment.
- **Assessment(s):** The germination rate of *A. solani* was established by counting the number of germinated and not germinated spores under a light microscope. Fungicide sensitivity was measured as the concentration at which spore germination was inhibited by 50% relative to the untreated control (EC<sub>50</sub> value) and was determined for each isolate.

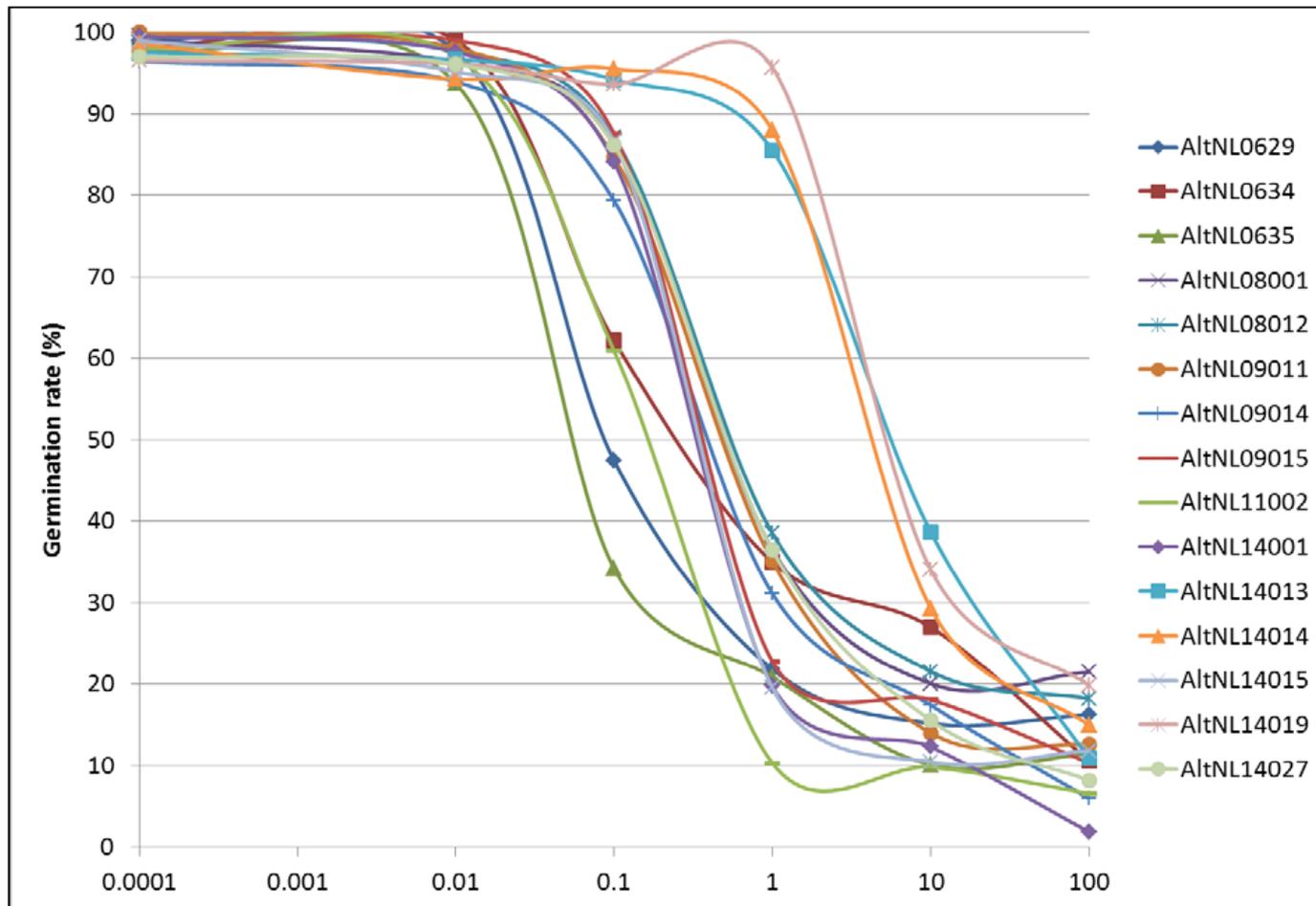
# Results: Laboratory Study (2015)

Figure 1. The Dose Response of azoxystrobin on Germination



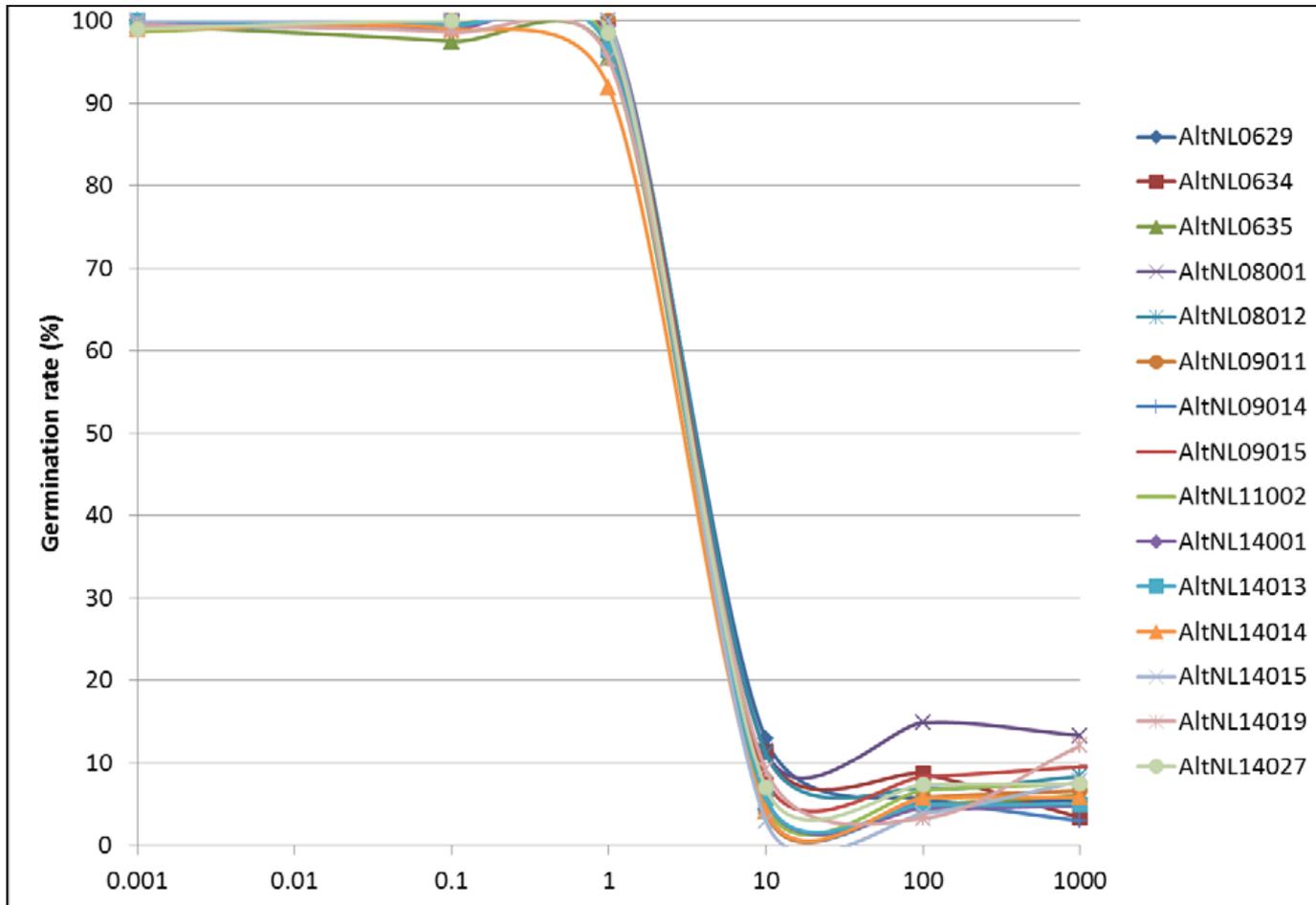
# Results: Laboratory Study (2015)

Figure 2. The Dose Response of boscalid + pyraclostrobin on Germination



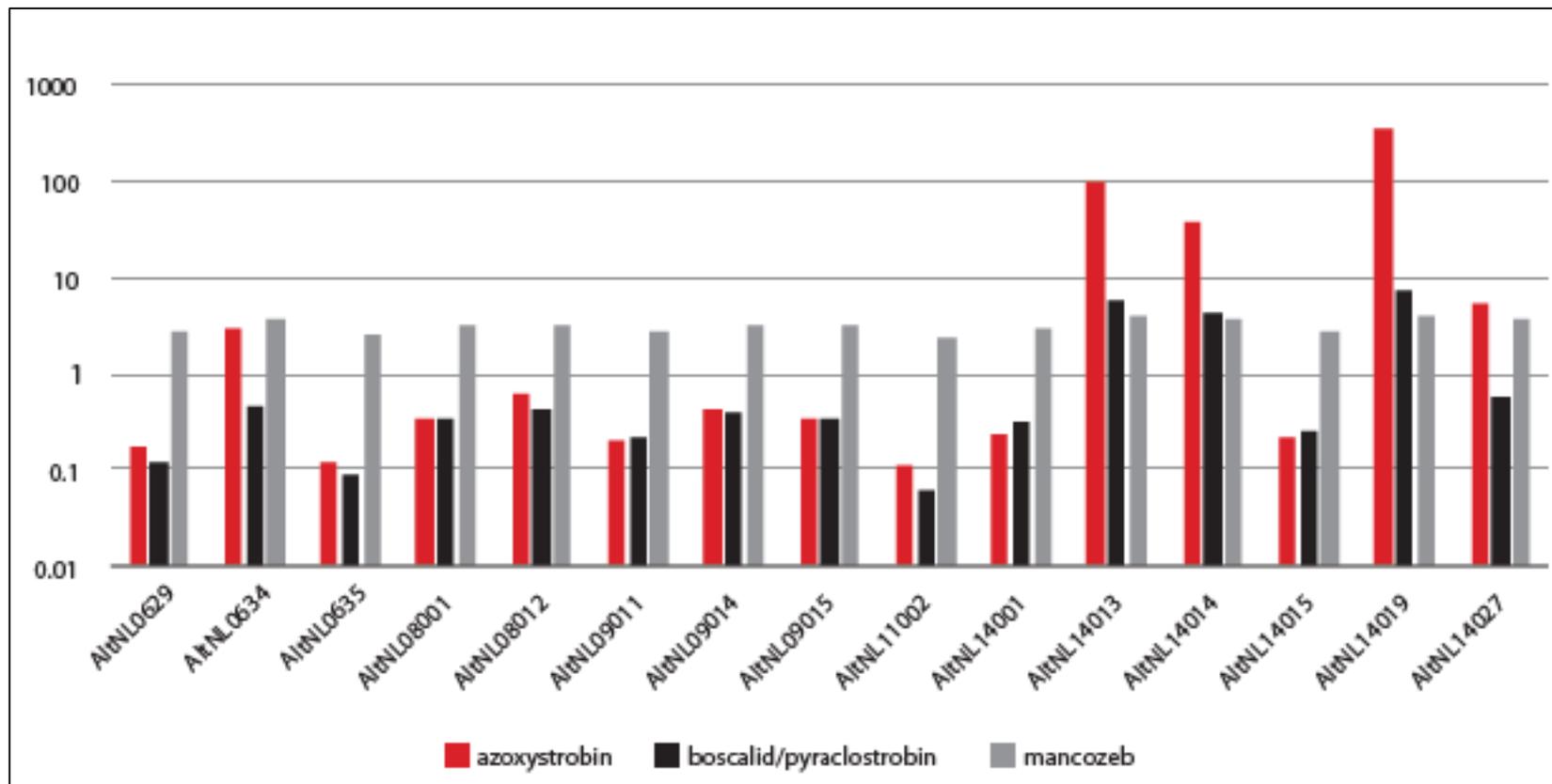
# Results: Laboratory Study (2015)

Figure 3. The Dose Response of mancozeb on Germination



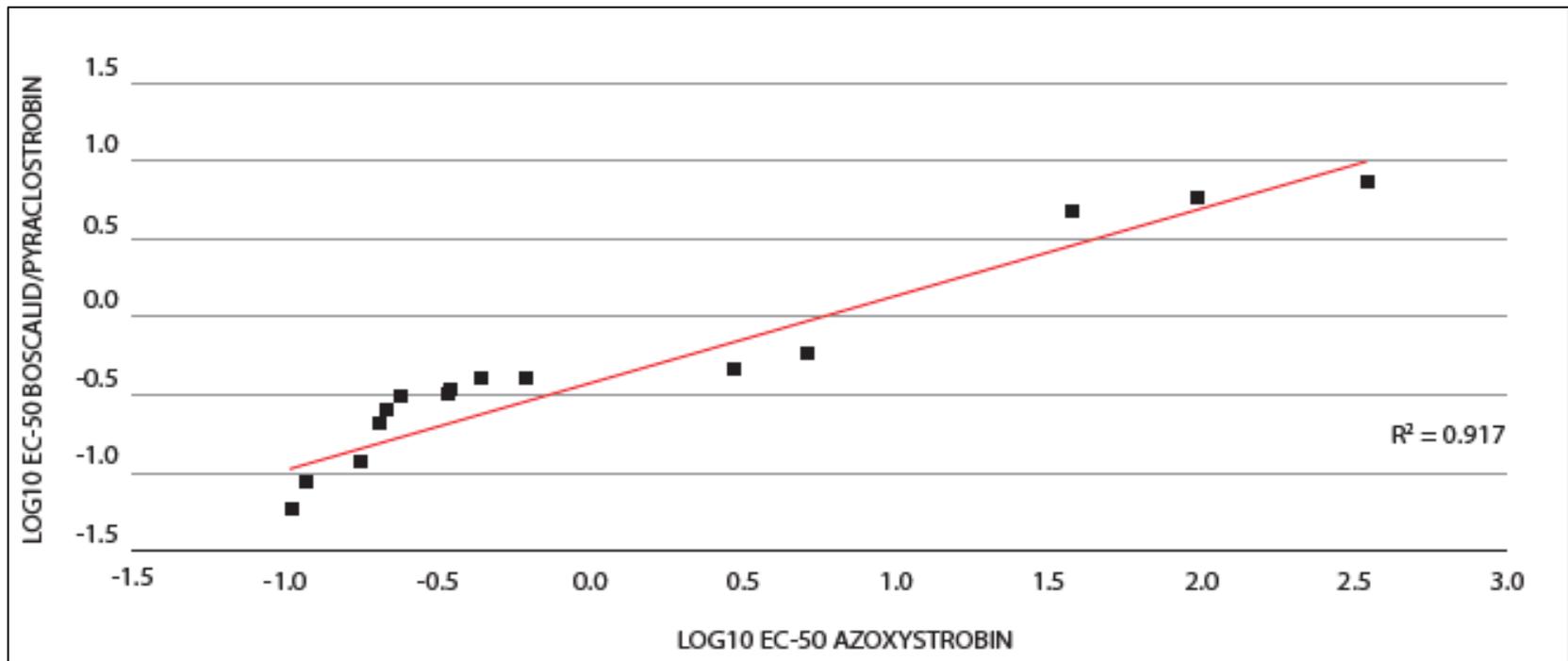
# Results: Laboratory Study (2015)

Figure 4. EC<sub>50</sub> Values (ppm) of the Fungicides Used. Displaying the 15 Isolates of *A. solani*, in Order of Sampling Year



# Results: Laboratory Study (2015)

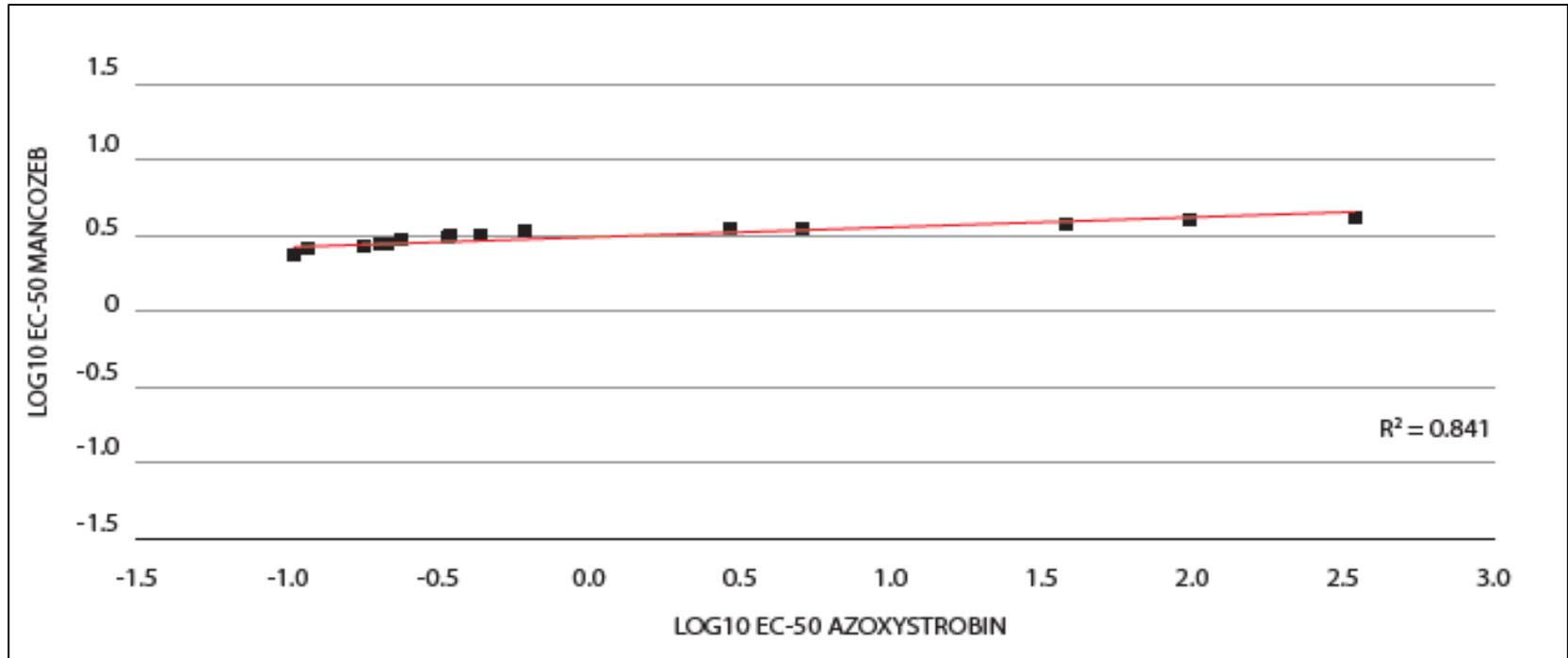
Figure 5. Correlation Between EC50 Values (ppm) and Spore Germination of azoxystrobin and boscalid + pyraclostrobin



Isolates less **sensitive to boscalid + pyraclostrobin** appeared less sensitive to **azoxystrobin**, suggesting the possibility of cross resistance.

# Results: Laboratory Study (2015)

Figure 6. Correlation Between EC50 Values for Spore Germination of mancozeb and azoxystrobin



The slope of the curve is much less steep in comparison to Figure 5, therefore, on tested strains, there was no cross resistance between **mancozeb** and **azoxystrobin**.

# Conclusion: Laboratory Study (2015)

The laboratory study carried out by Wageningen UR in 2015 to measure the efficacy of fungicides on spore germination against different strains of *Alternaria solani*, concludes that;

- **Comparing doses used in the field:** EC<sub>50</sub> values for mancozeb in most cases were higher than for azoxystrobin or boscalid + pyraclostrobin.
- **Azoxystrobin and boscalid + pyraclostrobin:** For both, the range of EC<sub>50</sub> values differed significantly between the isolates tested.
- **Mancozeb:** EC<sub>50</sub> values were very stable. This indicates that there was no shift in sensitivity to mancozeb within the population tested. Some *A. solani* isolates became less sensitive to azoxystrobin and to a lesser extent to boscalid + pyraclostrobin.
- **Results data:** Shows that the loss of sensitivity is observed on strains sampled in the last years (mainly strains AltNL14013, AltNL14014 and AltNL14019) suggesting an evolution of the population.

# Field Study (2016): Different Genotypes of *Alternaria solani*

## Materials and Methods

- **The Experiment:** Conducted in 2016 by Wageningen UR to measure the efficacy of different fungicides to control various genotypes of *Alternaria solani* (1 wild + 1 having F129L\* mutation), and the possible shift of populations during the season.
- **Design:** Four replicates were carried out in a randomized block.
- **Fungicides Application(s):** These were carried out using a trial site sprayer with Airmix 110.04 nozzles. Sprayings were carried out based on 300L/ha. Potato plants (Cultivar Agria) were sprayed for the first time when they reached a height of 20-30cm.

\* F129L mutation genotypes reported in Germany (Leiminger et al., 2014) and in the Netherlands (Evenhuis et al, 2013)

# Field Study (2016): Different Genotypes of *Alternaria solani*

- **Fungicides Used:**

Code	Fungicide	Active Ingredient	Dose Rate (L or kg/ha)
N		difenoconazole 250g/L	0.5
S		boscalid 26.7% + pyraclostrobin 6.7%	0.2
P	PENNCOZEB 80 WP	Mancozeb 80%	2.0

- **Spray Strategies and Dates of Application:**

Treatment	Product	12 Jul	19 Jul	26 Jul	2 Aug	9 Aug	16 Aug	23 Aug
A	UTC	—	—	—	—	—	—	—
B	S	S	—	S	—	S	—	S
C	P	P	P	P	P	P	P	P
D	P+S	P+S	P	P+S	P	P+S	P	P+S
E	N	N	—	N	—	N	—	N
H	S or N	S	—	S	—	N	—	N

# Field Study (2016): Different Genotypes of *Alternaria solani*

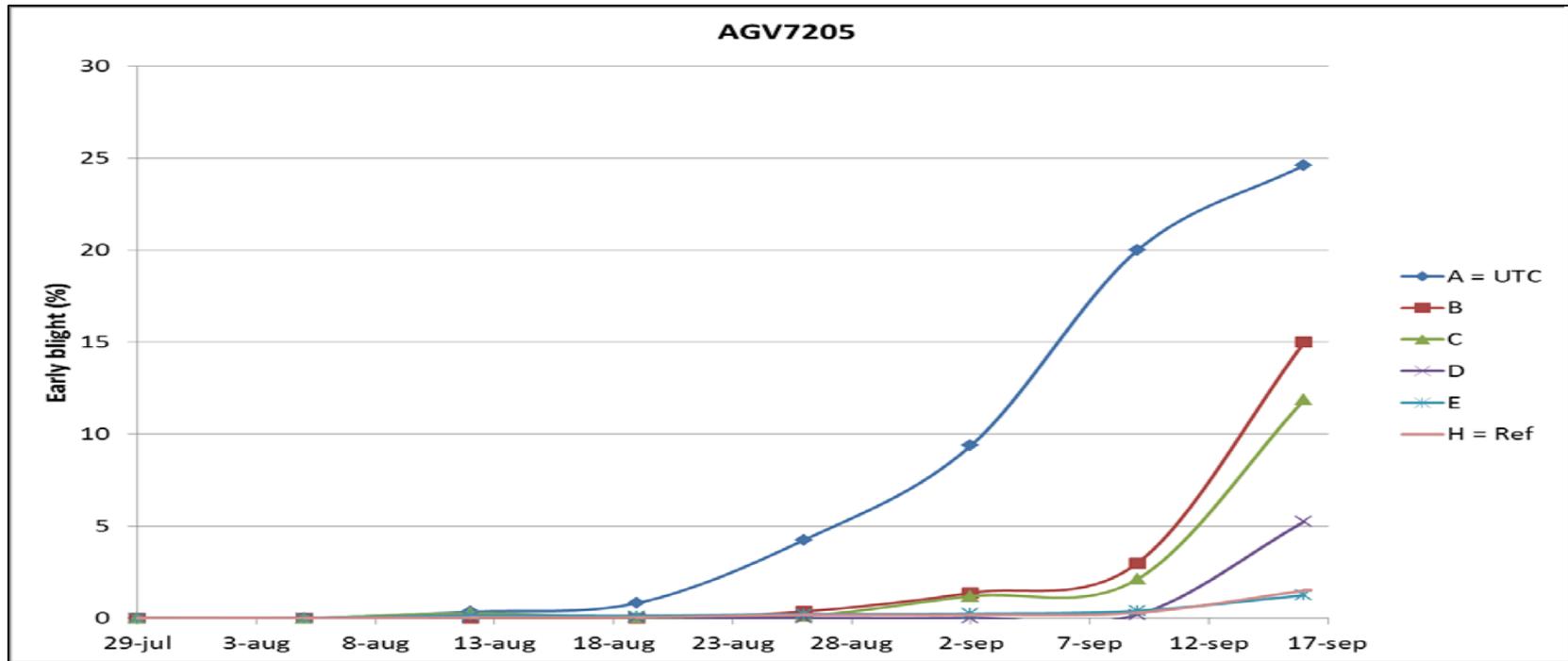
- **Innocolum:** A selection of two *A. solani* isolates were made: AltNL03003, wildtype\* and AltNL15002\*\* **possessing the F129L mutation**. Both isolates were grown on wheat kernels separately. **A mixture of 95% wildtype and 5% F129L type was inoculated** in the field on 15<sup>th</sup> July 2016.
- **Assessment(s):** Leaves with *Alternaria* lesions were collected (8 per plot) the 17<sup>th</sup> September 2016 and genotyped, then assessed for the presence of the F129L mutation. At the laboratory, monospore cultures were made on agar. The genotype involved was assessed by carrying out two PCR described by Pasche et al., 2004 and Lieminger et al., 2015.

\* Belonging to genotype I

\*\* Belonging to genotype II

# Results: Field Study (2016)

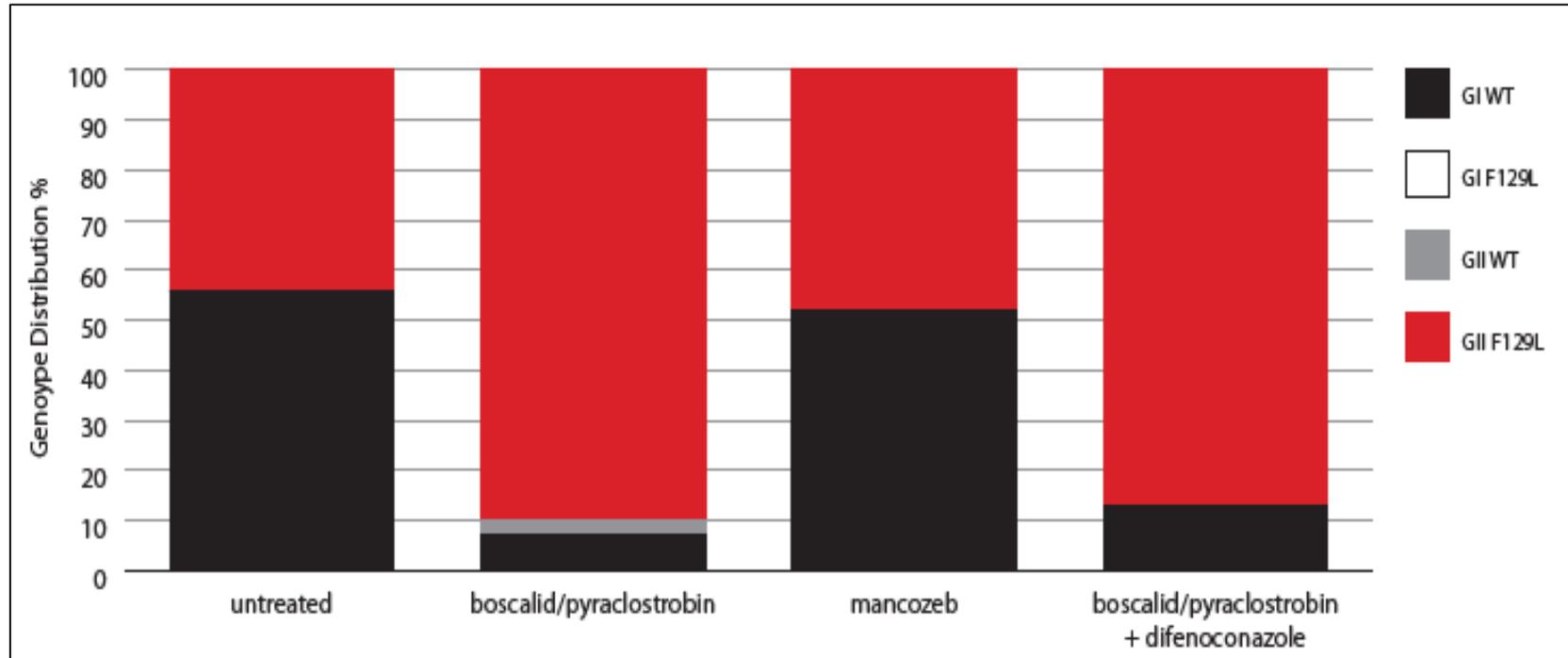
Figure 1. Early Blight Disease Severity (%)



**Trial Evolution:** 15<sup>th</sup> July = Disease inoculation. 29<sup>th</sup> July = First symptoms in all plots. 5<sup>th</sup> August = Beginning of the epidemic. 23<sup>rd</sup> August = last spray. 17<sup>th</sup> September = last notation. All spray strategies were very efficient until 9<sup>th</sup> September

# Results: Field Study (2016)

Figure 2. *Alternaria solani* Genotype Distribution (%) (17<sup>th</sup> September)



No significant shift of the *Alternaria solani* genotype was found when mancozeb was used compared to the untreated control. When boscalid + pyraclostrobin or the same followed by difenoconazole was sprayed, significantly more GII F129L types were found compared to the untreated control

# Conclusion: Field Study (2016)

The field study carried out by Wageningen UR in 2016 to measure the efficacy of different fungicides to control various genotypes of *Alternaria solani*, concludes that;

- **Spray Programs:** They all effectively controlled Early Blight, although the efficacy varied between strategies.
- **Boscalid + pyraclostrobin:** When this product or the same followed by difenoconazole was sprayed, significantly more GII F129L *A. solani* types were found than in the untreated control and when mancozeb was sprayed. This suggests that selection towards GII F129L occurred under influence of spray strategies with boscalid + pyraclostrobin.
- **F129L mutation:** It is known that this causes a reduced sensitivity to QoI fungicides (group of pyraclostrobin).

**\*\*For details of UPL Europe Ltd's Efficacy Field Trial in Netherlands, 2015 – Please See Poster\*\***

# Summary

- Mancozeb has been found to be effective against all genotypes of *Alternaria solani*, the same have been already shown previously on *Phytophthora infestans*.
- No shift in the *A.solani* genotypes was found compared to the untreated control after using mancozeb at the opposite of boscalid + pyraclostrobin or azoxystrobin. Therefore, today, mancozeb appears to be an essential tool in managing fungicide resistance of populations of *A. solani*.
- Mancozeb does not cause change in the composition of the populations of the two pathogens maintaining the natural equilibrium between the main potato diseases.
- Mancozeb has been registered for more than 60 years, and thanks to its multisite mode of action, it has consistently maintained its efficacy against both diseases. According to the good “balanced” efficacy on the foliar diseases of potatoes, mancozeb seems to remain an essential for a sustainable protection of the crop, also useful to preserve the efficacy of fungicides with unisite mode of action.