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Mancozeb: essential tool for sustainable protection of potato against late blight

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SUMMARY
Late blight (*Phytophthora infestans)* is still the most damaging fungal disease of potato, 2014 demonstrated this aspect again in many European countries, even if damages by early blight (*Alternaria solani/alternata*) are increasing. New active ingredients have recently been registered but most of them have a single-site mode of action and are prone to select resistant strains. Mancozeb has been registered for more than 60 years and thanks to its multi-site mode of action, it has consistently maintained its efficacy against both diseases. Looking at the evolution of *P. infestans* strains over the last 15 years, it has become critical to demonstrate how effective mancozeb is against the "new strains" of late blight: 13_A2, 6_A1, 33_A2. Studies conducted under laboratory and greenhouse conditions at the renowned University of Wageningen at the request of UPL Europe show high levels of efficacy on all strains confirming the practical results widely observed in commercial fields. Mancozeb continues to remain an essential tool in managing fungicide resistance on populations of *P. infestans* identified in the past and today.

KEYWORDS
Phytophthora infestans, fungicides, efficacy, new population

INTRODUCTION

In Europeans Countries, **late blight is the most important disease on potato, it is very frequent** and often very severe as we can see in the example of North of France in 2014 (Fig. 1 risks of sporulation given by the DSS Mileos): since last of April to the end of September, except for ten days in June, everyday was at the maximum level. The first symptoms appeared on potato dumps piles during planting and numerous fields were infected, even if the disease was controlled with a number of treatments.

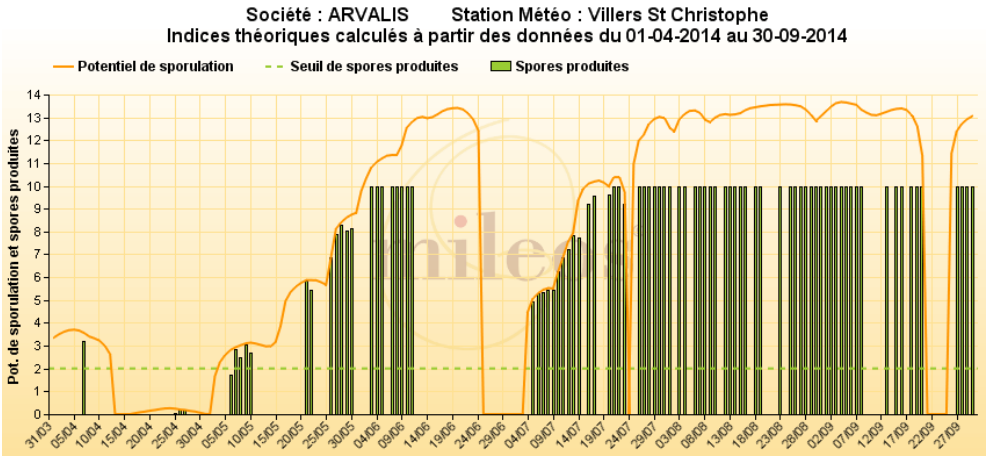


Figure 1. *Risks of sporulation given by the DSS Mileos*

If weather conditions are the essential elements of the development of the epidemic, it is imperative to take into account the **evolution of *Phytophthora infestans*.** For several years new strains have evolved. It should be noted the development of 13_A2 (Blue 13), detected in NL and DE in 2004, in UK and FR in 2005, in Ireland in 2007, and also present in many other EU countries since 2012. This strain is more aggressive at low temperatures (8°C) than the older ones; it is also resistant to Phenylamides.

6_A1 (Pink 6), was detected in NL in 2002, in UK and FR in 2004 and it seems very aggressive on the leaf at temperatures around 10°C. It was dominant in UK in 2011 and 2012, but has regressed during the last few years.

33_A2 (Green 33) was detected in NL in 2011, and is also present in BE and PL. Fluazinam is less effective on this strain. 33_A2 strains express a weak fitness, therefore regress when straight fluazinam is not used in a systematic way. Green 33 represented more than 20% of the strains in 2010 and 2011 in NL but only 6% in 2012.

Figure 2 shows the situation of the different strains in Europe in 2013 (Euroblight).

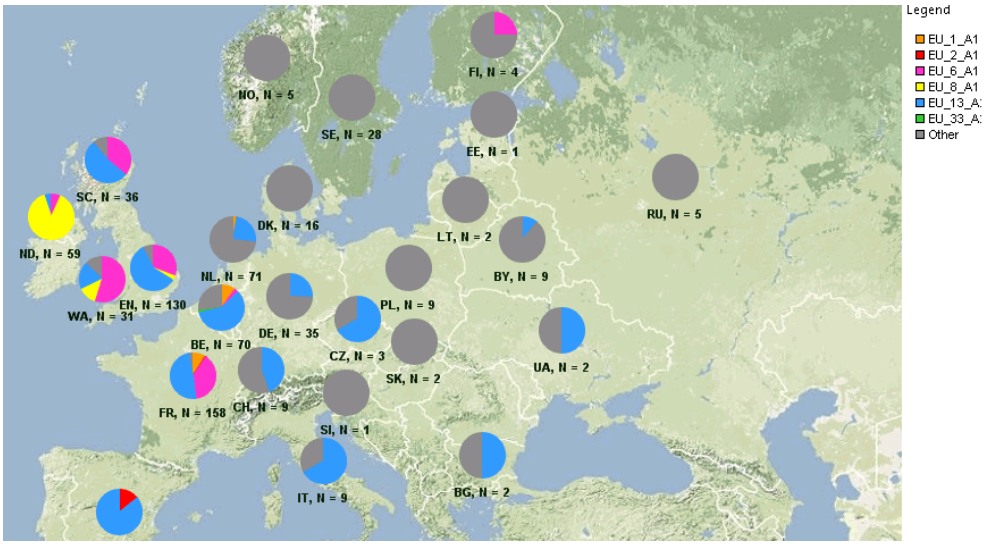


Figure 2. *P. infestans strains in Europe*

To fight against late blight growers have at their disposal **many fungicides,** the active ingredients are multiple but most of them have a single site mode of action against the fungus thus a high risk of resistance developing (Fig. 3). Only some ingredients have a multisite mode of action, e.g. mancozeb which has been registered for 60 years, with no known resistance and good efficacy against early and late blight.

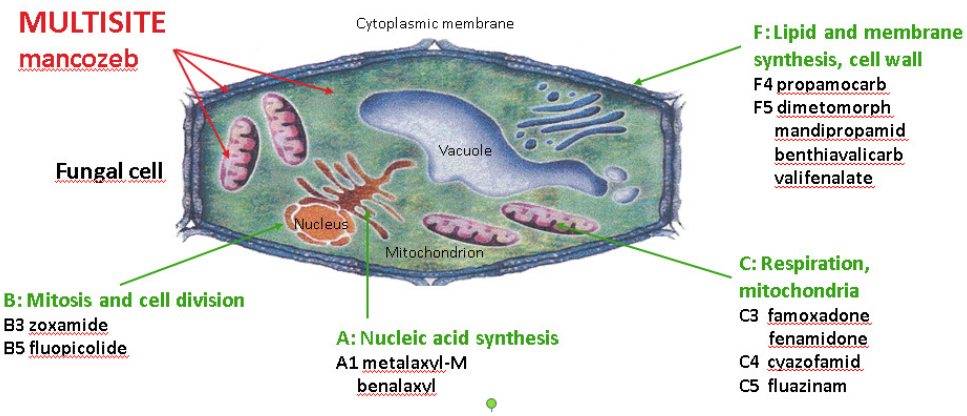


Figure 3. *Modes of action fungicides*

RESEARCH

Efficacy of fungicides to control different strains of potato late blight (Phytophthora infestans)
The trial was conducted by Applied Plant Research, part of Wageningen UR.

The efficacy of mancozeb (Penncozeb), to control potato late blight – *Phytophthora infestans* – was tested in the laboratory.

MATERIAL AND METHODS

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 isolate VK 98014 (old population).
Leaves (cv. Bintje) were punched to obtain leaf discs. Five potato leaf discs were laid on water agar. The fungicides were sprayed using a spray boom with three spray nozzles, placed 50 cm apart, 40 cm over the top of the leaf discs. Spray volume was 250 l/ha.
Spraying of the product (mancozeb 1500 g/ha) was carried out in a spraying cabin, 2 days before inoculation with potato late blight (preventive efficacy).
The isolates are cultivated on agar plates and potato slices. The inoculum density was set at approximately 10,000 sporangia per ml. Inoculation was carried out by spraying potato leaf discs over head with approximately 0.1 ml of inoculum. After inoculation the petri dishes containing leaf discs were incubated in a climate chamber.
Late blight disease severity was established 1 week after inoculation. Percentage necrotic foliage per leaf disc was determined.

RESULTS

Table 1. *Results of laboratory test*

Type of strain	Untreated % necrotic surface 7 days after inoculation	Mancozeb 1500g/ha % necrotic surface 7 days after inoculation (efficacy)
Blue 13	99,8	17,3 (82,7)
Green 33	96,8	2,5 (97,4)
Pink 6	95,5	5,0 (94,8)
VK 98074	91,2	2,5 (97,3)

DISCUSSION AND CONCLUSION

The efficacy of mancozeb is excellent on the strains Pink 6, Green 33, and the strain of the old population and very good on Blue 13.

The efficacy of mancozeb (Penncozeb) to control potato late blight – *Phytophthora infestans* – was tested in the greenhouse.

MATERIAL AND METHODS

The experiment was carried out with four replications. Each replication consisted of one potato plant. Analysis of variance on the late blight assessments was made based on the percentage necrotic foliage.

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).

The cultivated potato plants (cv. Bintje) were grown in pots. The pots with a content of 5 litres were filled with soil and the potato tubers were placed at a depth of 10 cm. From emergence until the experiment, the plants were placed in the greenhouse in Lelystad.

The potato plants were sprayed with the different fungicides in a spraying cabin developed by Applied Plant Research (PPO). The fungicides were sprayed using a spray boom with three spray nozzles, placed 50 cm apart, which is moving approximately 40 cm over the top of the potato plants. Spray volume was 250 l/ha.

The fungicides used were: mancozeb 1500 g/ha, mancozeb 1600 g/ha + metalaxyl-M 200 g/ha, mancozeb 1500 g/ha + fluazinam 200 g/ha, metalaxyl-M 200 g/ha and fluazinam 200 g/ha. The untreated control was sprayed with tap water.

The isolates were cultivated on agar plates and potato slices. An inoculum suspension was made by rinsing a one week old culture of *P. infestans* with tap water. The inoculum density was set at approximately 10,000 sporangia per ml. Inoculation of the potato plants was carried out by spraying the leaves over head with inoculum five days after spraying the fungicides. After inoculation the potato plants were incubated in a climate chamber for one week.

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.

Analysis of variance on the late blight assessments was made based on the percentage necrotic foliage and sporulation

RESULTS

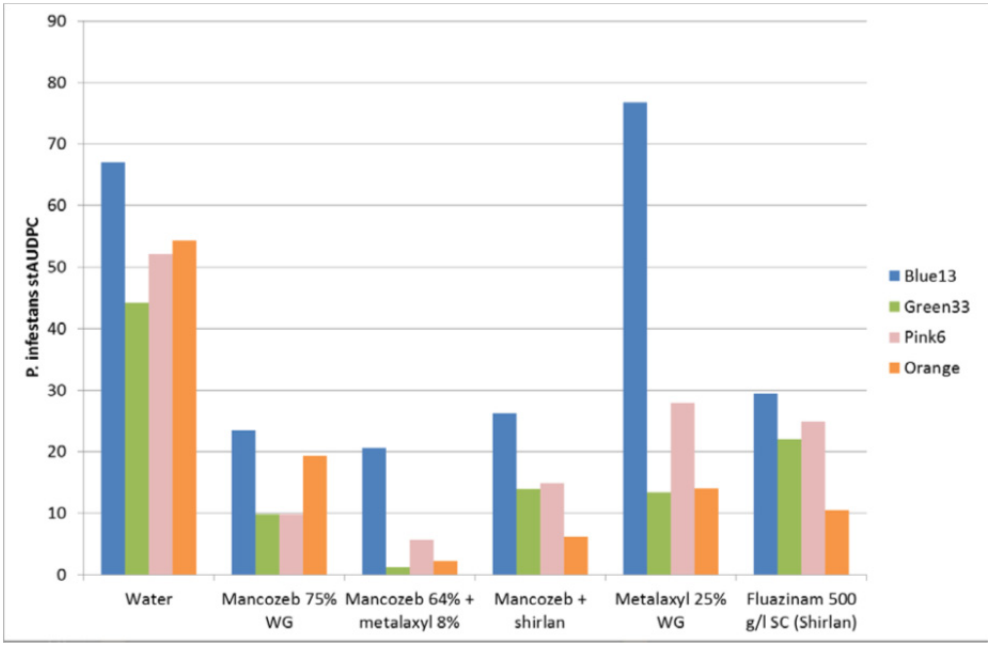
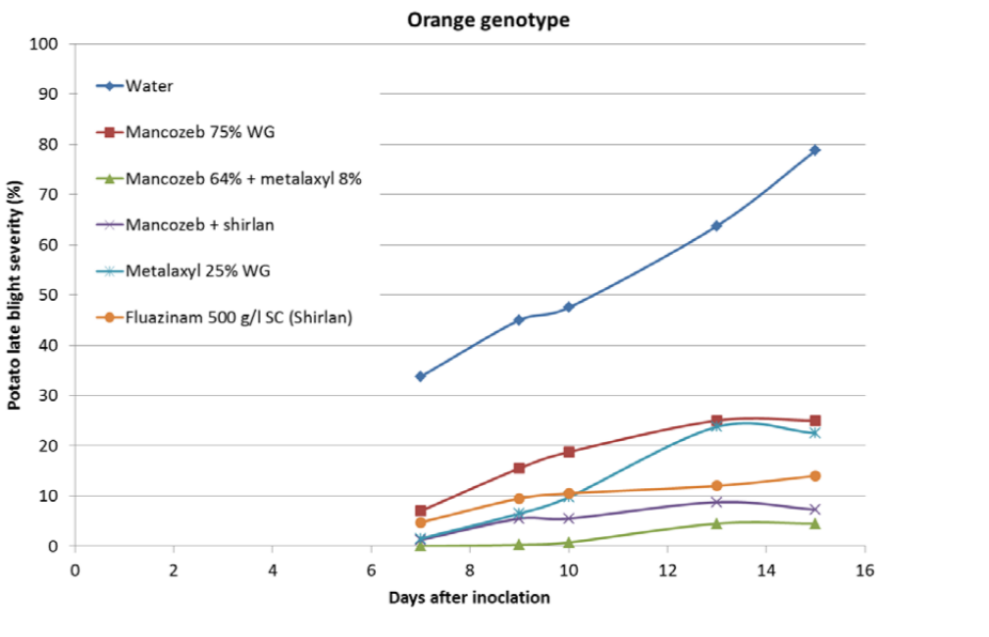
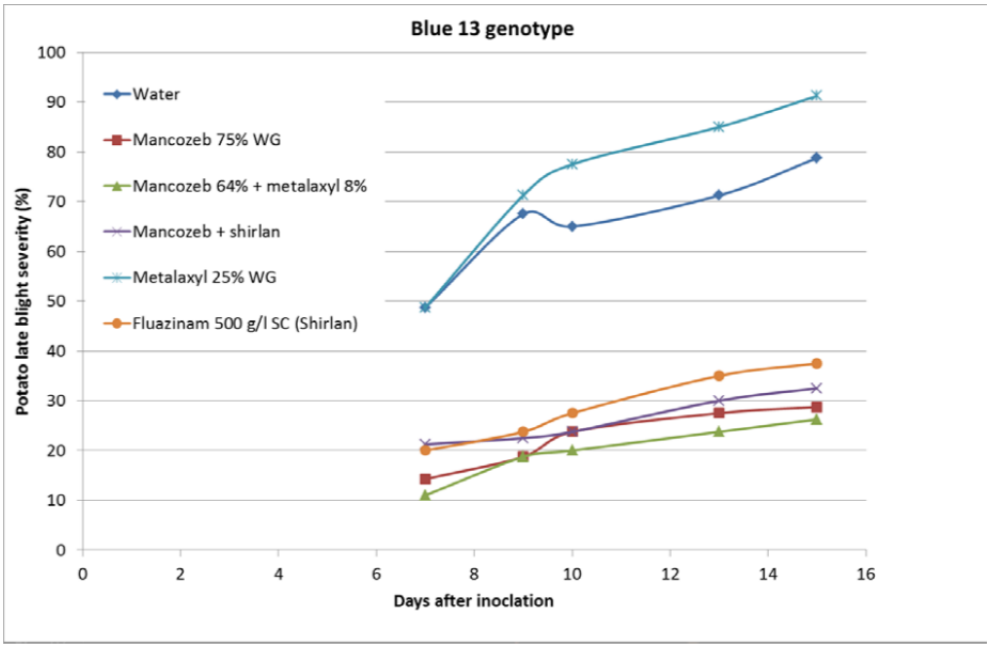
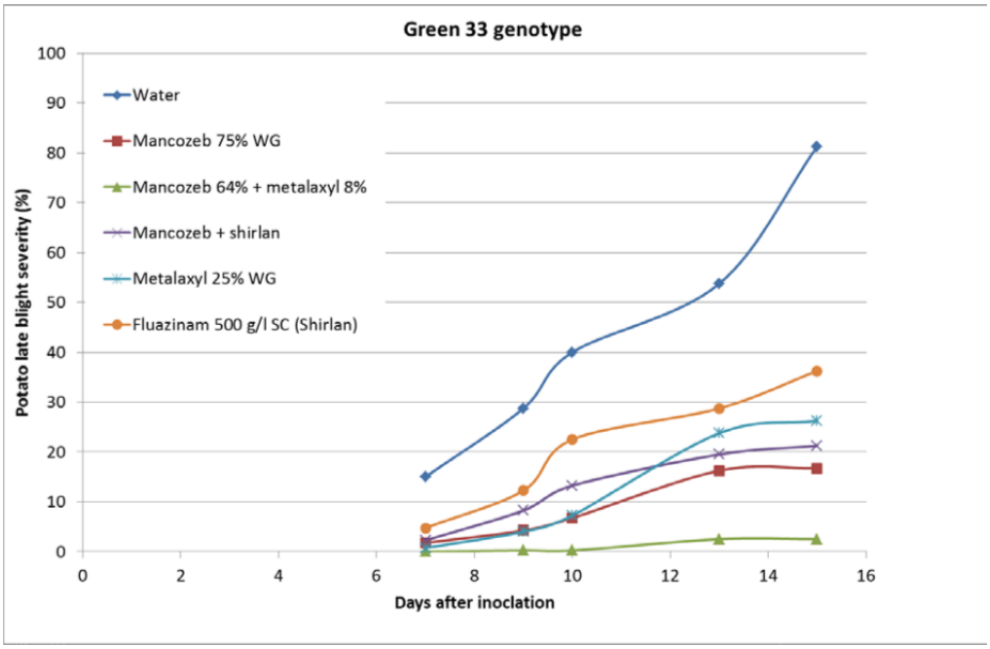


Figure 4. *Percentage necrotic foliage per treatment expressed as stAUDPC after inoculation with 4 different P. infestans isolates*




Blue 13 genotype
Potato late blight severity (%)
Days after inoculation
Water
Mancozeb 75% WG
Mancozeb 64% + metalaxyl 8%
Mancozeb + shirlan
Metalaxyl 25% WG
Fluazinam 500 g/l SC (Shirlan)


Green 33 genotype
Potato late blight severity (%)
Days after inoculation
Water
Mancozeb 75% WG
Mancozeb 64% + metalaxyl 8%
Mancozeb + shirlan
Metalaxyl 25% WG
Fluazinam 500 g/l SC (Shirlan)

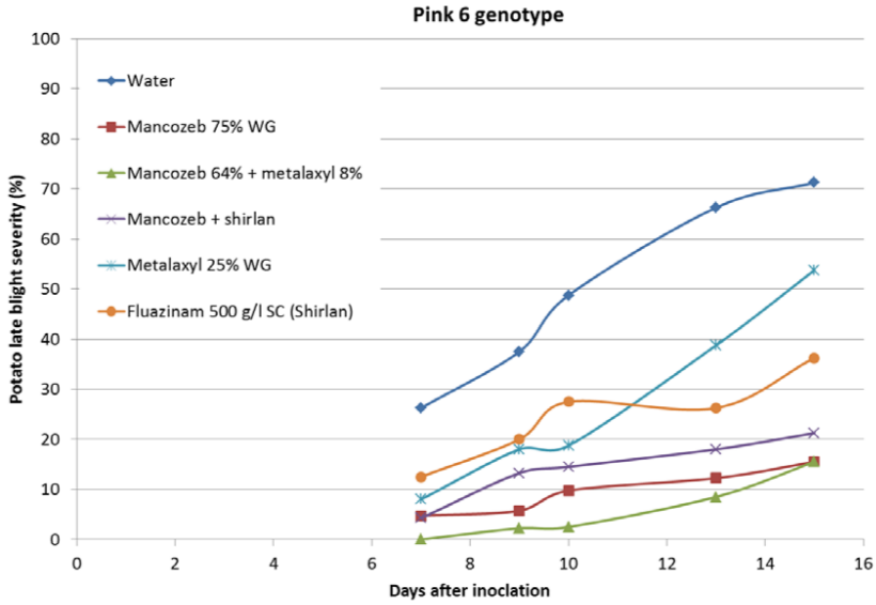


Figure 5. *Percentage necrotic foliage per treatment after inoculation with P. infestans isolates, representing clonal lineages*

DISCUSSION AND CONCLUSION

The infection level of untreated plants was 70-85% at the end of the experiment indicating that the artificial inoculation was successful for all four *P. infestans* isolates. All the fungicide treatments were able to reduce the percentage necrotic foliage compared to the untreated control, regardless of which *P. infestans* isolates were used except for metalaxyl-M when potato plants were inoculated with Blue 13

The absence of control of Blue 13 by metalaxyl-M confirms that this strain is metalaxyl-M resistant

The efficacy of mancozeb (B) to control Blue 13 isolate was significantly better than fluazinam (F) and metalaxyl-M (E)

Green 33 isolate was less effectively controlled by fluazinam (F) than mancozeb (B) and mancozeb + metalaxyl-M (C)

Pink 6 isolate was significantly better controlled by mancozeb (B), mancozeb + metalaxyl-M (C) and mancozeb + fluazinam (D) than fluazinam (F) or metalaxyl-M

The orange isolate was significantly better controlled with mancozeb + metalaxyl-M (C) than mancozeb (B) or metalaxyl-M

CONCLUSIONS FOR THE TWO EXPERIMENTS

Mancozeb is effective against all genotypes.

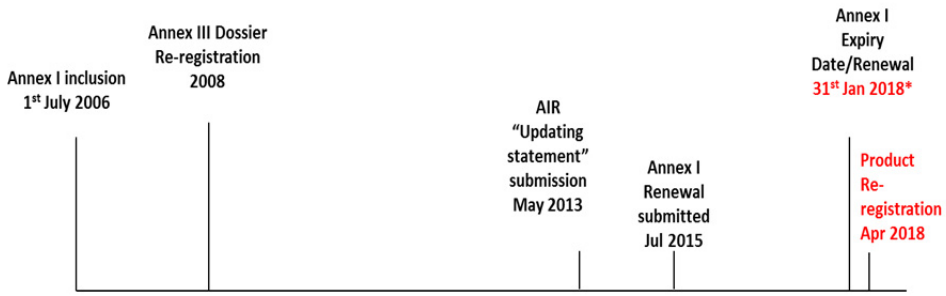
Mancozeb strengthens significantly the efficacy of fluazinam and metalaxyl-M, even on strains sensitive to these fungicides.

The stability of performance is ensured whatever the type of strains that is present in the field.
Mancozeb is an essential component of resistance management and therefore an important tool for developing efficient integrated management programs.

Next Step
UPL has commissioned Wageningen University to study the efficacy of mancozeb against *Alternaria*, especially against strains resistant to strobilurins.

REGULATORY STATUS

Mancozeb AIR 3 Timeline



Regulatory Hurdles
R63/H361d (possible harm to the unborn child) classification based on European Chemicals Agency (ECHA) evaluation on public literature in 2006 showing ED effects at unrealistic high concentrations.
Interim Criteria: Reproductive Category 2 + "toxic" effects on endocrine organs may be considered to have ED properties – as a result of its current classification.

ETU, a metabolite of mancozeb has been shown to affect the T3/T4 hormones in rats when dosed at very unrealistic high concentrations in public literature resulting in a R63/H361d classification.

DISCUSSION AND CONCLUSION

- Effects seen in the rat are not relevant to humans due to well known differences in physiology.
- When dosed at realistic exposure concentrations - New data shows that there is NO ADVERSE EFFECT.
- Proposed application to ECHA for removal of H361d classification.

REFERENCES

A. Evenhuis, G.B.M. van den Bosch & H.T.A.M Schepers, 2013, Testing the efficacy of fungicides to control different strains of potato late blight, Applied Plant Research, part of Wageningen UR, PPO no. 3250281500

A. Evenhuis & H.T.A.M. Schepers, 2014, Testing the efficacy of fungicides to control different strains of *Phytophthora infestans*, Applied Plant Research, part of Wageningen UR, PPO no. 3250294400

Anonymous, 2015, website Arvalis Mileos www. Mileos.fr

Anonymous, 2015, website Euroblight www.euroblight.net