

Multilocal field trials to test alternative products to reduce copper applications to control potato late blight in organic systems

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Summary

The main objective of those trials was to determine alternatives to massive copper utilization to control potato late blight (*Phytophthora infestans* (Mont.) de Bary) in organic systems.

To reach such a target, we first performed a screening of candidate products and additives under controlled conditions in the laboratory. Thereafter, the most promising products were tested in the field in 2006. Those trials were set up in three different sites, two sites in Belgium and one site in France. Herseaux (B) and Loos-en-Gohelle (F) are situated near by sea level in an important potato culture basin with silty soil. Libramont is located at 500 m of altitude, far from any potato culture basin, with a sandy - loamy and stony soil.

The cultivar Ditta was used in Belgium while the cultivar Juliette was planted in France. Their resistance to foliage late blight is, respectively, medium and medium-high. In total 8 modalities were compared. The products were applied in accordance to the advice of the local late blight warning system. The control was sprayed, at each advice, with 3kg/ha of copper sulphate (Bordeaux mixture). We tested two additives to Bordeaux mixture, used at the 3kg/ha rate as well, the first one is a short chain amino-acid extract, used to enhance rainfastness, while the other one is an hydrogen peroxide stabilised with an organic molecule. This second product was used for its disinfectant effect added to the protection effect of copper sulphate. We also tested the efficiency of a formulation presenting a low copper concentration (Glutex CU 90 with 10% copper) and of an association between a potassium phosphite and a copper tallate (Solucivre with 5% copper). Those two components were also evaluated separately. Finally, we tested a product containing rhamnolipid biosurfactant (Zonix) supposed to physically destroy the zoospore's membrane.

The 2006 climatic conditions were very particular. June and July were very dry while August was very wet with optimum late blight development conditions. The disease development was very slow during July and radically increased during August.

The two additives tested didn't improve the efficiency of Bordeaux mixture. The association of potassium phosphite and copper tallate gave good results. Separately, both products gave good results excepted the copper tallate in the site of Libramont. The formulation with low copper concentration as the rhamnolipid biosurfactant allowed an as good crop protection as the Bordeaux mixture modality.

Given the particular climatic conditions of 2006, those products have to be tested an additional year to confirm their efficiency.

Keywords: late blight, organic, pesticide, fungicide, elicitor, phosphite, copper, rhamnolipids

Introduction

Recently, the European Union, in the regulation 2091/92, imposed to reduce the amount of copper application to control fungal diseases in organic production. It imposes to reduce the amount of copper metal to 6 kg per year and per hectare since January 2006. The point is that, today, there are no known effective alternative to copper to control potato late blight in organic systems. So, the VETAB project, co-financed by the European Union in the INTERREG III Wallonie-France-Flandre program, aimed to explore the new control opportunities. To do so, promising products have been tested in field trials in three locations distributed in France and Belgium.

Material and Method

The products tested were the most promising identified in laboratory tests performed in 2006 (Dupuis *et al.*, 2007).

- Bordeaux mixture (3 kg/ha), widely used by the growers to control fungal diseases in organic farming (Tomlin, 2000), was used as positive reference. Its fungicidal activity on the spore is based on the accumulation of free copper ions in the cell till a toxic concentration and the formation of complexes, with sulfhydryl, carboxylic and hydroxyl groups, resulting in a non-specific denaturation of enzymes of the respiration chain (Schwinn *et al.*, 1991). It was tested at the dose of 3 kg/ha to correspond to the new EU prerogatives.
- Glutex CU 90 (4 l/ha) is a copper based product including an amount of 10% of copper.
- PK2 (2 l/ha) is a potassium phosphite. The efficacy of phosphite-based compounds on oomycete has been reported in the literature. Cohen and Coffey (1986) report the studies of Thizy *et al.* (1978) showing that various salts of phosphorous acid display activity against various oomycetes. The studies of Erwin and Ribeiro (1996) reported by Miller *et al.* (2006) confirmed that phosphites could be used to control 19 species of *Phytophthora*. Our previous studies in the laboratory (Dupuis *et al.*, 2007), proved that PK2 was as efficient as Bordeaux mixture to control late blight on inoculated potato detached leaves.
- Solucivire (2 l/ha) is a copper tallate including an amount of 5% of copper, this product also presented an efficiency as good as Bordeaux mixture (Dupuis *et al.*, 2007).
- Ecoclearprox (3 l/ha) is an hydrogen peroxyde stabilised with organic molecule. Ecoclearprox wasn't efficient, alone, in the laboratory trials (Dupuis *et al.*, 2007). Nevertheless, we decided to test its association to Bordeaux mixture in the field to evaluate the efficiency of a combination of protection and disinfectant products.
- Zonix (0,5 l/ha) is a product containing rhamnolipids considered as biosurfactant that could explode the zoospores membranes. The Zonix didn't allow to reach a good level of protection in the laboratory trials (Dupuis *et al.*, 2007). Nevertheless, in others unpublished laboratory trials, Zonix tended to be efficient. So, we decided to test it in the field in 2006 to support or not those observations.
- Finally, the effect of Splinter (0,65 l/ha), a mixture of short amino-acids chain aiming to enhance product rainfastness, was tested in association with Bordeaux mixture.

Field trials were set up in 3 different locations, two in Belgium and one in France.

- In Loos-en-Gohelle, situated in the North department of France, near by sea level, in an important potato culture basin with silty soil.
- In Herseaux, located in the Hainaut province of Belgium, 50 km, at the North-East of Loos-en-Gohelle, in the same potato culture basin.
- In Libramont, situated in the Luxembourg province of Belgium, 200 km at the East of Loos-en-Gohelle. Libramont is located at 500 m of altitude, far from any potato culture basin, with a sandy - loamy and stony soil.

Table 1: List of the products tested, in 2006, in different locations

Product	Loos-en-Gohelle	Herseaux	Libramont
Bordeaux mixture	X	X	X
Untreated	X		
Glutex CU 90	X	X	X
PK2	X	X	X
Solucuvivre	X		X
PK2+Solucuvivre	X	X	X
Zonix			X
Ecoclearprox + Bordeaux mixture		X	X
Splinter + Bordeaux mixture		X	X

The experimental scheme was a 4 fully randomized blocks device. The elementary unit included 60 plants. Blocks were separated with infecting rows planted with the late blight sensitive cultivar Bintje. The role of those rows was to homogenize the late blight infection distribution in the trial by placing each plot at the same distance of a strong source of potential infection. The cultivar Ditta was used in Belgian trials while the cultivar Juliette was planted in France. Their resistance to foliage late blight is, respectively, medium and medium-high according to the www.europotato.org website. These trials were managed under natural inoculation excepted in Libramont where artificial inoculation has been performed. Nevertheless, this inoculation has been performed in July and couldn't succeed due to the dry and hot weather. The crop was managed in accordance with organic farming rules. This means that the copper based products were applied according to a maximum amount of 6 kg native copper per hectare and per year. The products were applied in accordance to the advice of the local late blight warning system.

The 2006 climatic conditions were the same for the 3 regions. The month of May and August were very wet and the month of June and July were very dry. The wet conditions of May and August were particularly favourable to late blight development.

The observations were performed during the whole growing season and the notations began at first symptoms apparition. Eight observations were performed in Belgium (from 21 of June till 22 of August for Herseaux and from 11 of August till 5 of September for Libramont) while 5 observations were performed in Loos-en-Gohelle (from the 6 of July till the 3 of August). Each trial site used his proper notation scale. In Loos-en-Gohelle the French scale, ranged from 0 to 10, was used. In Herseaux, the Wageningen scale, ranged from 10 to 0, was used, while in Libramont, the Euroblight scale, ranged from 0 to 100, was used. All those scales are correlated to a percentage of foliage destruction by the disease.

Then, we calculated the relative stAUDPC (standard Area Under Disease Progression Curve divided by trial duration since first symptoms apparition). A two ways ANOVA, including the block (random factor, 4 levels) and the product (fix factor, 6 levels for Loos-en-Gohelle and Herseaux, and 8 levels for Libramont) factors was performed on the data of each location. Thereafter a multiple mean comparison objects was made using the Student-Newman-Keuls method (Dagnelie, 1975) to segregate the different objects.

Results

The two ways ANOVA allowed to identify significant differences among the products tested in Loos-en-Gohelle ($F(5,15) = 91.65$; $p < 0.001$). Using a multiple mean comparison, all the products were compared to the positive and negative controls: Bordeaux mixture and untreated object (Figure 1).

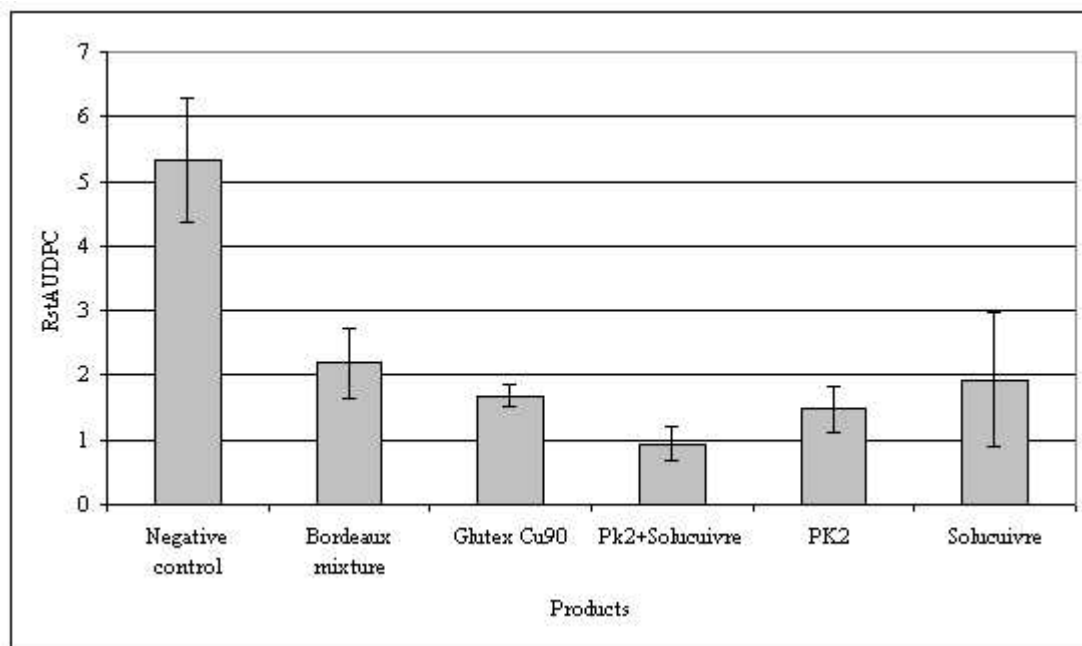


Figure 1: Products performances against late blight infection development quantified through the RstAUDPC index, in Loos-en-Gohelle's field trial.

Glutex Cu 90 ($p = 0.787$), PK2 ($p = 0.482$), Solucivire ($p = 0.987$) and PK2 + Solucivire ($p = 0.056$) offered a protection level similar as or higher than Bordeaux mixture. We notice that the association of PK2 and Solucivire present the lower infection values. Nevertheless, the efficiency of the association of both products couldn't be distinguished from the PK2 ($p = 0.749$) or the Solucivire used alone ($p = 0.179$).

Loos-en-Gohelle was the only location where an untreated plot was installed. We observed that all the modalities tested significantly limit late blight disease development ($p < 0.001$).

The two ways ANOVA of Herseaux couldn't allowed to identify significant differences among the products tested ($F(5,15) = 1.37$; $p = 0.291$) (figure 2).

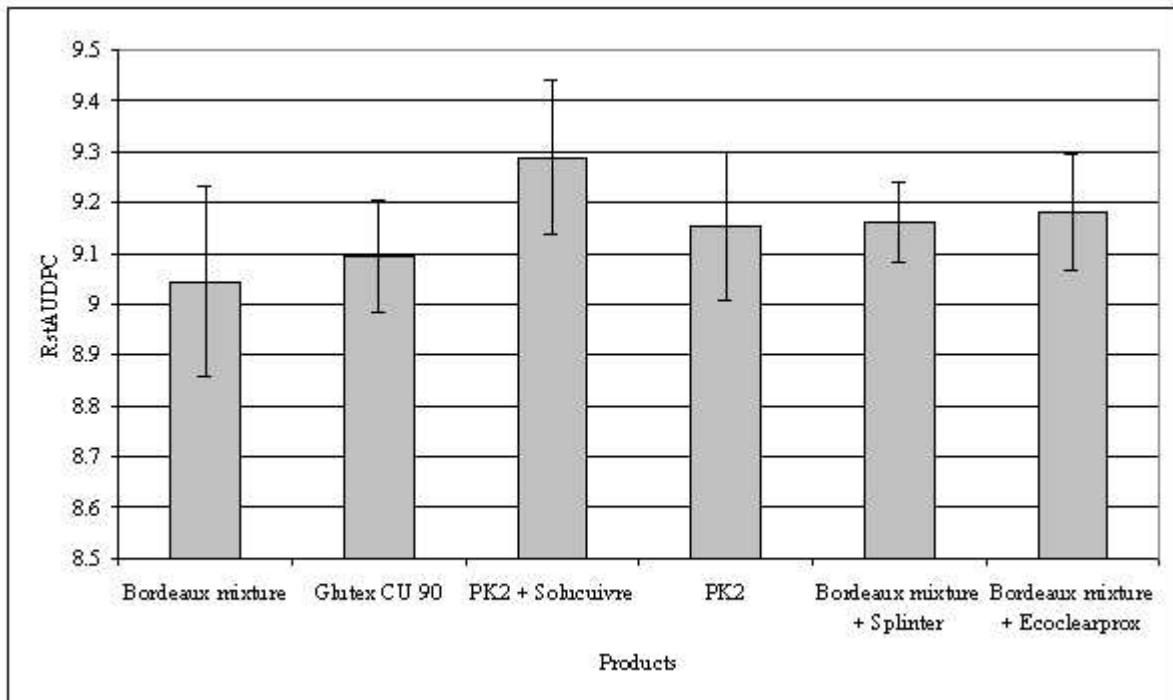


Figure 2: Products performances against late blight infection development quantified through the RstAUDPC index : Herseaux's field trial.

Like in Loos-en-Gohelle, the two ways ANOVA performed on Libramont data allowed to identify significant differences among the products tested ($F(7,21) = 4.29$; $p = 0.004$). Using a multiple mean comparison, all the products were compared to the Bordeaux mixture (Figure 3).

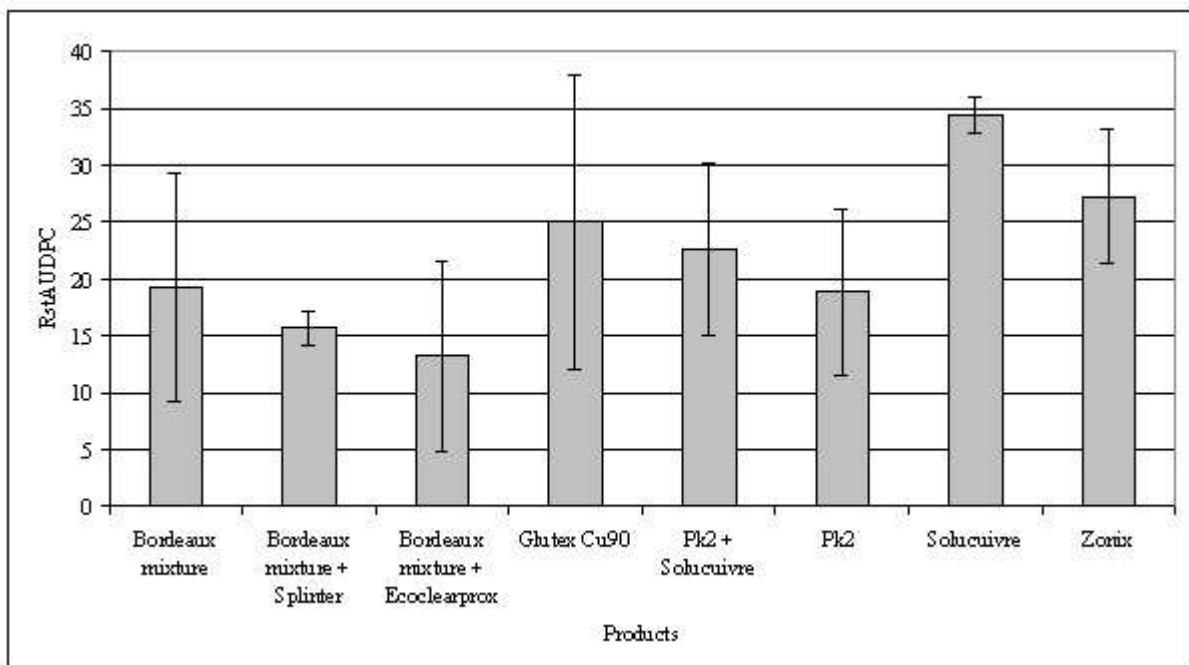


Figure 3: Products performances against late blight infection development quantified through the RstAUDPC index : Libramont's field trial.

Nevertheless, we didn't observe any significant difference between the different products tested and Bordeaux mixture ($p > 0.5$), excepted for Solucuire treatment ($p = 0.058$). Bordeaux mixture + Splinter ($p = 0.011$) and Bordeaux mixture + Ecoclearprox ($p = 0.003$) were significantly more efficient than Solucuire.

Discussion and Conclusion

The late blight pressure was very high in 2006. The symptoms developed rapidly during August. In those conditions, it was necessary to repeat the treatments to renew foliage protection. It is possible that the products efficiency has been affected by the consecutives rain events. However, Loos-en-Gohelle results hasn't been affected by this phenomena as the observations ended at the beginning of August.

Glutex CU 90 presented, in the three trials, an efficiency similar to Bordeaux Mixture with a reduction of 30% of the amount of sprayed copper. Solucuire was tested in two locations, this product allowed to reduce the copper amount by more than 80%. However, in one trial location, this product seemed to be less effective than Bordeaux mixture.

The two additives tested, Ecoclearprox and Splinter, didn't enhance significantly Bordeaux mixture efficiency. These results confirmed the laboratory results (Dupuis *et al.*, 2007).

PK2 and Zonix were the 2 copperless products presenting a level of protection close to the protection level of Bordeaux mixture. PK2 has been tested in three locations and confirmed its efficiency. It seems that the addition of Solucuire to PK2 doesn't reinforce PK2 protection level. Zonix has only been tested in one location and couldn't be compared to an untreated control, the efficiency of this product has to be confirmed.

Acknowledgements

The authors want to thanks the European Union (INTERREG Wallonie – Flandre – France program – n°4123) and the Ministry from Walloon Area (DGA) for funding.

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