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Results of potato late blight demonstrations in Garut and Pangalengan, Indonesia October 2014-January 2015

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vegIMPACT
Improved Vegetable Production and Marketing for small farmers to Increase the Food Security status and to promote Private Sector Development in Indonesia

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1. Introduction

Late blight caused by *Phytophthora infestans* is one of the most important diseases worldwide. Also in Indonesia control of late blight is very important in potato and tomato, especially in the rainy season. In order to learn more about the important factors that determine late blight control - such as fungicide product choice, application frequency of fungicides, spray volume and use of adjuvants - two demo plots were laid out in the potato growing regions of Garut and Pangalengan from December 2013 to February 2014 (Schepers et al., 2014a). In these demo plots only the influence of product choice was tested. The application interval was set at four days with a spray volume of 600 l/ha for all treatments. The adjuvant Agristick was added to all treatments. At both locations, the Farmers Practice strategy and vegIMPACT strategy resulted in a similar effect on the late blight epidemic in both potato varieties Atlantic and Granola. At both locations, costs of the vegIMPACT strategies were 10-15 % higher than the Farmers Practice strategy in both varieties. These higher costs were caused by the use of more expensive products.. Recommendations for follow-up demonstrations included:

- Position the fungicides with a good rainfastness and curative efficacy earlier in the growing season, since infection pressure can already be high directly from emergence onwards.
- Adapt the spray volume to the development of the crop and apply two strategies:
    - Normal practice: small plants - 250 l/ha; intermediate plants - 350 l/ha; full grown plants - 550 l/ha.
    - Normal practice -20%: small plants - 200 l/ha; intermediate plants - 280 l/ha; full grown plants - 440 l/ha.
- Include treatments with and without adjuvant.

In a pot trial the influence of spray volume and adjuvants on the deposition of mancozeb was studied (Schepers et al. 2014b). Without rain simulation there was a clear trend that spraying with 750 l/ha compared to 250 l/ha resulted in a lower mancozeb residue on the leaves, most probably caused by run-off. Without rain simulation there was a clear trend that mancozeb mixed with adjuvants resulted in lower mancozeb residue levels compared to mancozeb alone. The adjuvants probably also have surfactant properties resulting in an increased run-off. Based on these results, it was recommended to compare the influence of lower and higher spray volumes and adjuvants in a late blight demo.

Demo plots with potato varieties Atlantic and Granola were laid out in Garut and Pangalengan from October 2014 to January 2015. The objective of the demo plots described in this report are to investigate the influence of three factors on the efficacy of three factors in late blight control strategies:

1. Test the influence of fungicide product choice on the efficacy of late blight control in the most susceptible variety Atlantic;
2. Test the influence of spray volume on the efficacy to control late blight both in Atlantic and Granola;
3. Test the influence of the adjuvant Agristick at normal and reduced spray volumes both in Atlantic and Granola.

2. Materials and methods

2.1 Demo-plot lay-out and crop management

Demonstration plots in Pangalengan and Garut were planted in the rainy season on 8 and 9 October 2014, respectively with the potato varieties Granola and Atlantic. The plots consisted of 3 beds of 2 rows each with in total 40 plants with an area of 6 x 4 m. The demo-plot was laid-out in 3 replicates (Appendix 1). The beds were covered with silver-colored plastic mulch. The demo-plots were surrounded by border plots. The plants were not artificially inoculated with late blight. The potato plots were further managed according local management practices.

2.2 Spray applications

The Tables 2.1 – 2.4 show the characteristics of the fungicides used and the fungicide application strategies. The strategies consisted of both a Farmers Practice and three alternative 'vegIMPACT' strategies applied in the Atlantic as well as Granola variety. The Farmers Practice strategies were selected on the basis of the inventory described by De Putter et al. (2014). The vegIMPACT strategies in Granola and Atlantic were selected based on the susceptibility of the varieties for late blight, the characteristics of the products described in the fungicide table of EuroBlight (www.euroblight.net), the experiences of the demo plot results in December 2013-February 2014 and the results of a pot trial carried out in May 2014 in which the influence of spray volume and adjuvants was studied (Schepers et al. 2014a, 2014b).
Because of higher late blight incidence in Pangalengan compared to Garut observed in the previous demonstration, the spraying interval in Pangalengan was set at three days and the interval in Garut at four days. Based on the pot trial with high spray volume and adjuvants, the spray volume was adapted to the crop development stage and also spray strategies with a 25% reduction in spray volume were tested (Table 2.2). In Garut, 14 sprays were applied with an interval of four days: application dates were 30 October; 3, 7, 11, 15, 19, 23 and 27 November; 1, 5, 9, 13, 17 and 21 December 2014. In Pangalengan, 17 sprays were applied with an interval of three days: application dates were 29 October; 1, 4, 7, 10, 13, 16, 19, 22, 25 and 28 November; 1, 4, 7, 10, 13 and 16 December 2014. The adjuvant Agristick was added to some of the strategies. To ensure constant pressure while spraying a battery powered knapsack sprayer (16 liter) was used. The estimation of the costs of different strategies was based on prevailing market prices of the different fungicides in Garut and Pangalengan.

Table 2.1. Fungicide and adjuvant doses and costs used in the strategies at the highest spray volume (550 l/ha) in the demonstration plots.

Product name	**Active ingredients**	**Dose rate**	**Per 3 plots/replicates (72 m^2)**		**Per hectare (10,000 m^2) with 550 liter**	
			Dose (g or ml)	**Cost (IDR)**	**Dose (g or ml)**	**Cost (IDR)**
Antracol 70 WP	propineb (70%)	100%	14.84	1,542	2,061	214,500
Daconil 75 WP	chlorothalonil (75%)	100%	5.94	867	825	120,450
Dithane M45 80 WP	mancozeb (80%)	50%	4.75	394	660	54,780
Curci 10 WP	cymoxanil (10%)	50%	7.92	634	1,100	88,000
Akrobat 50 WP	dimethomorph (50%)	50%	1.98	1,534	275	213,125
Revus 250 SC	mandipropamid (250 g/l)	75%	5.94	3,552	825	493,350
Infinito 687.5 SC	propamocarb (625 g/l) + fluopicolide (62.5 g/l)	50%	4.95	2,574	688	357,760
Agristick 400 L	Adjuvant	100%	1.98	133	275	18,425

Table 2.2. Spray volumes (l/ha) depending on the crop development stage tested in the demo plots in Garut and Pangalengan. See text for the dates of the spray numbers.

Spray number	**Normal (100%)**	**Normal – 20% (80%)**
Sprays 1-3 (Garut) Sprays 1-4 (Pangalengan)	250	200
Sprays 4-10 (Garut) Sprays 5-14 (Pangalengan)	350	280
Sprays 11-14 (Garut) Sprays 15-17 (Pangalengan)	550	440

Table 2.3. The fungicide application strategies used in the demonstration plots in Pangalengan and Garut in the variety Atlantic.

	A Farmers practice	**B vegIMPACT 1**	**C vegIMPACT 2**	**D vegIMPACT 3**
spray volume	**Normal**	**Normal**	**Normal-20%**	**Normal-20%**
Adjuvant	**Agristick**	**Agristick**	**Agristick**	**none**
Spray number:				
Sprays 1-4	100% Daconil +50% Dithane + 50% Curci	75% Revus + 50% Curci	75% Revus + 50% Curci	75% Revus + 50% Curci
Sprays 5-8	100% Daconil +50% Dithane + 50% Curci	50% Infinito + 100% Antracol	50% Infinito + 100% Antracol	50% Infinito + 100% Antracol
Sprays 9-14 (Garut) Sprays 9-17 (Pangalengan)	100% Daconil +50% Dithane + 50% Curci	75% Revus + 50% Curci	75% Revus + 50% Curci	75% Revus + 50% Curci

Table 2.4. The fungicide application strategies used in the demonstration plots in Pangalengan and Garut in the variety Granola.

	A Framers practice	**B vegIMPACT 1**	**C vegIMPACT 2**	**D vegIMPACT 3**
spray volume	**Normal**	**Normal-20%**	**Normal**	**Normal-20%**
Adjuvant	**Agristick**	**Agristick**	**none**	**none**
Spray number:				
Sprays 1-14 (Garut) Sprays 1-17 (Pangalengan)	100% Daconil + 50% Dithane + 50% Akrobat	100% Daconil + 50% Dithane + 50% Akrobat	100% Daconil + 50% Dithane + 50% Akrobat	100% Daconil + 50% Dithane + 50% Akrobat

2.3 Disease observations

Late blight observations were carried out every 3-4 days in the net plots which consisted of 32 plants (see Appendix 1). The percentage of infected foliage was estimated per individual plant per plot. The average percentage infected foliage was calculated per plot. For the assessments, two visual keys were used namely:

- Efficacy evaluation of fungicides: *Phytophthora infestans* on potato. EPPO Guideline PP 1/2 (4)
- An illustrated assessment key for foliage blight of potatoes (Cruickshank et al., 1982).

The AUDPC (Area Under the Disease Progress Curve) was calculated and used as an indicator of the efficacy of the strategies during the complete growing season. The AUDPC is a measure of the total amount of disease over a period of time, determined from graphs of disease *vs*. time, which can be used to compare epidemics quantitatively.

2.4 Yield

The variety Atlantic was manually harvested in Pangalengan on 22 December 2014 and Granola on 7 January 2015. In Garut both varieties were harvested on 14 January 2015. The tubers were classified in Class A (1 kg contains 5 tubers), Class B (1 kg contains 10 tubers) and Class C (1 kg contains 20 tubers) and counted and weighed per class. Also the rotten tubers were weighed.

3. Results

3.1 Pangalengan

Many potato plants were seriously infected by bacterial wilt (*Ralstonia solanacearum*) (Table 3.1). The infected plants were irregularly distributed over the plots (Photo 1). This made it very difficult to carry out reliable assessments on foliar late blight and yield. Therefore, it was decided not to present and analyze the data from the Pangalengan demo plots.

Table 3.1. Percentage of plants with bacterial wilt at the end of the growing season in Garut and Pangalengan.

	A Farmers Practice	B vegIMPACT 1	C vegIMPACT 2	D vegIMPACT 3
Garut				
Atlantic	0	0	0	0
Granola	0	0	0	0
Pangalengan				
Atlantic	32	33	26	37
Garut	23	27	26	27

Photo 1. Severe infection by bacterial wilt in demo plots in Pangalengan (December 2014).

3.2 Garut

In both potato varieties some late blight infection was already present at the first fungicide application, 21 days after planting (End of October 2014). The level of infestation remained low for a number of weeks and started to increase around 48 days after planting (End of November 2014). In December 2014 the level of infection increased very rapidly and reached 100% infection at the end of the growing season.

3.2.1 Granola

In Granola, the four fungicide strategies all applied 100% Daconil +50% Dithane + 50% Akrobat. The strategies differed in spray volume and adjuvant use. There is an indication that the development of late blight in strategies with the 100% spray volume (A and C) was somewhat slower compared to the strategies with the 80% spray volume (Table 3.2). This is also reflected in the lower AUDPC values of these strategies A and C but the differences with the strategies with the 80% spray volume (B and D) are not significant (Figure 3.1).

The aggregated costs over the entire growing season of vegIMPACT strategies 1, 2 and 3 are lower compared to the Farmers Practice strategy (Table 3.2).

The total marketable yield of the vegIMPACT 1 strategy was higher (17.7 ton/ha) compared to the other three strategies but differences were not significant (Table 3.3).

Table 3.2. Infected foliage (%) and AUDPC in the potato variety Granola in the different late blight control strategies in Garut.

	A	B	C	D
Spray volume	Farmers Practice	vegIMPACT 1	vegIMPACT 2	vegIMPACT 3
Adjuvant	Normal	Normal-20%	Normal	Normal-20%
Days after planting:	Yes	Yes	No	No
21	0.2	0.1	0.0	0.2
25	0.3	0.1	0.1	0.2
28	0.1	0.1	0.1	0.2
32	0.0	0.0	0.4	0.0
35	0.2	0.2	0.5	0.2
40	0.0	0.0	0.0	0.0
44	0.0	0.0	0.0	0.0
48	0.3	0.3	0.1	0.1
53	0.8	2.6	1.3	3.3
57	3.9	10.9	3.9	13.0
61	14.7	19.8	12.4	23.6
65	23.7	58.0	34.3	52.5
69	68.7	80.3	59.6	78.3
73	70.3	82.0	60.5	79.2
77	95.8	97.9	95.9	97.3
81	96.6	98.4	96.9	97.5
AUDPC[1]	1307	1606	1270	1587
Cost (IDR)[2]	28755	23004	27453	21960

[1] At P=0.05 no significant differences. F-prob=0.445 and LSD=586.

[2] Cost (in IDR) per 3 plots of the fungicide application strategies sprayed in the variety Granola in Garut. With an interval of 4 days, 14 applications were carried out. The spray volume was adapted to the plant size (Table 2.2).

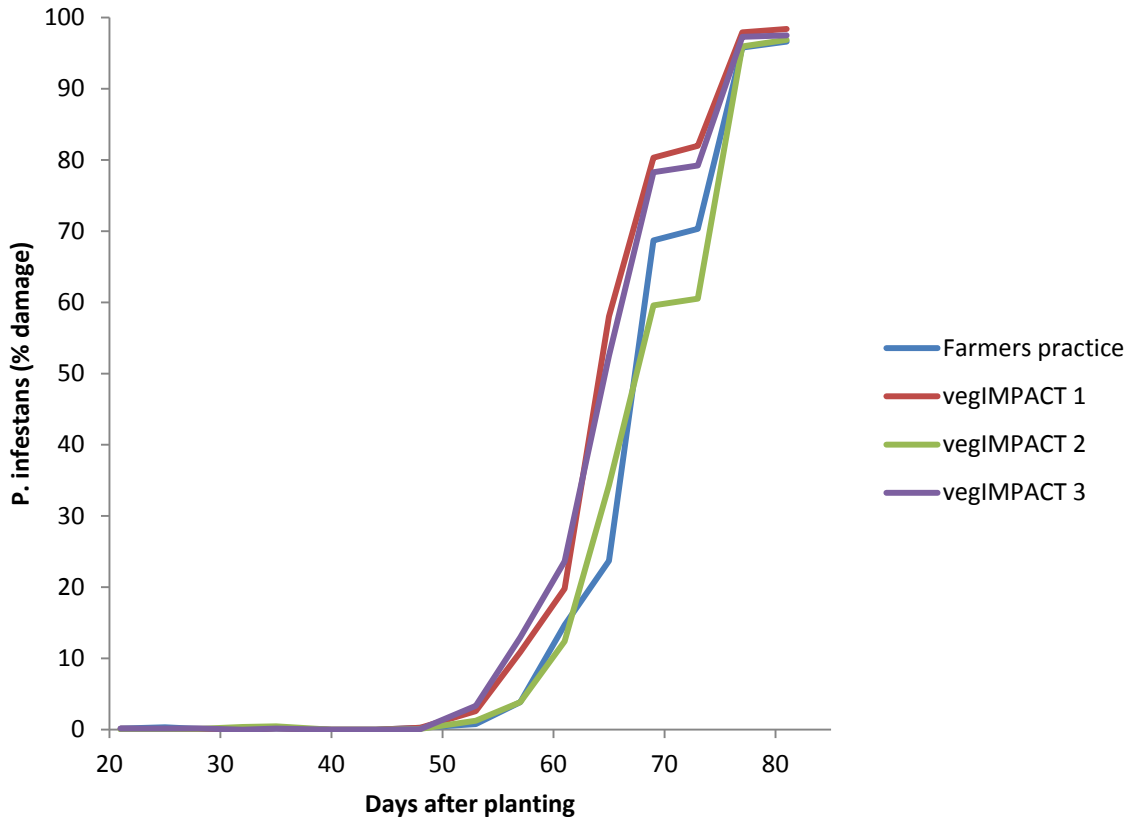

Figure 3.1. *The development of foliar blight (as percentage infected foliage) in the potato variety Granola under different late blight control strategies during the growing season October-December 2014 in Garut.*

Table 3.3. *Potato yield (ton/ha) in the different late blight control strategies in the variety Granola in Garut.*

	A Farmers Practice	B vegIMPACT 1	C vegIMPACT 2	D vegIMPACT 3	p =	$LSD_{0.05}$
Class A	3.7	2.2	5.1	3.1	0.24	3.1
Class B	6.0	11.6	6.6	6.6	0.38	7.9
Class C	3.8	3.9	3.7	3.2	0.87	2.0
Total Marketable Yield [1]	13.5	17.7	15.4	12.9	0.45	7.1
Rotten tubers	0.2	0.3	0.2	0.1	0.80	0.3

[1] At P=0.05 no significant differences. F-prob = 0.452 and LSD = 7.1

3.2.2 Atlantic

In Atlantic the Farmers Practice strategy applied 100% Daconil + 50% Dithane + 50% Curci during the whole season. In the vegIMPACT strategies 1, 2 and 3, other products were used including Revus, Infinito and Antracol (Table 2.3). The strategies also differed in spray volume and inclusion of adjuvant

(Table 2.3). There was an indication that the development of late blight in the vegIMPACT 1 strategy (B) was somewhat slower compared to the other 3 strategies (Table 3.4; Figure 3.2). This was also reflected in the lower AUDPC value of the vegIMPACT 1 strategy compared to the other 3 strategies (Table 3.4). Both strategies A and B were sprayed with 100% volume and adjuvant, but differed in the fungicides used. Strategies B, C and D used the same fungicides but differed in spray volume and adjuvant use. Strategy B was sprayed with the 100% volume and the adjuvant was added. Strategies C and D were sprayed at 80% volume.

The costs of vegIMPACT strategies 1, 2 and 3 are clearly higher compared to the Farmers Practice strategy (Table 3.4).

The potatoes were harvested on 14 January 2015 and sorted in class A, B and C and rotten tubers. The total marketable yield of the vegIMPACT 3 strategy was significantly lower compared to vegIMPACT 2 strategy (Table 3.5). The marketable yield of the Farmers Practice strategy was comparable to the vegIMPACT 1 and 2 strategies.

Table 3.4. Infected foliage (%) and AUDPC in the potato variety Atlantic in the different late blight control strategies in Garut.

	A	B	C	D
Spray volume	Farmers Practice	vegIMPACT 1	vegIMPACT 2	vegIMPACT 3
Adjuvant	Normal	Normal	Normal – 20%	Normal – 20%
Days after planting	Yes	Yes	Yes	No
21	0.1	0	0.1	0.1
25	0	0	0.1	0.1
28	0.1	0	0.1	0
32	0	0	0	0
35	0.2	0.1	0	0
40	0.1	0.2	0.2	0.1
44	0.1	0.3	0.3	0.1
48	0.2	4.1	2.4	5.2
53	2.8	2.0	2.4	5.3
57	13.3	7.6	10.5	10.9
61	30.2	18.0	28.0	35.4
65	52.8	29.6	44.1	48.6
69	84.0	67.6	87.5	87.1
73	86.0	68.2	89.1	88.9
77	99.7	96.7	99.0	100.0
81	99.8	97.3	100.0	100.0
AUDPC[1]	1,679	1,375	1,656	1,731
Cost (IDR)[2]	19,908	42,225	33,780	32,739

[1] At P=0.05 no significant differences. F-prob=0.180 and LSD=360

[2] Cost (in IDR) per 3 plots of the fungicide application strategies sprayed in the variety Atlantic in Garut. With an interval of four days, 14 applications were carried out. The spray volume was adapted to the plant size (Table 2.2).

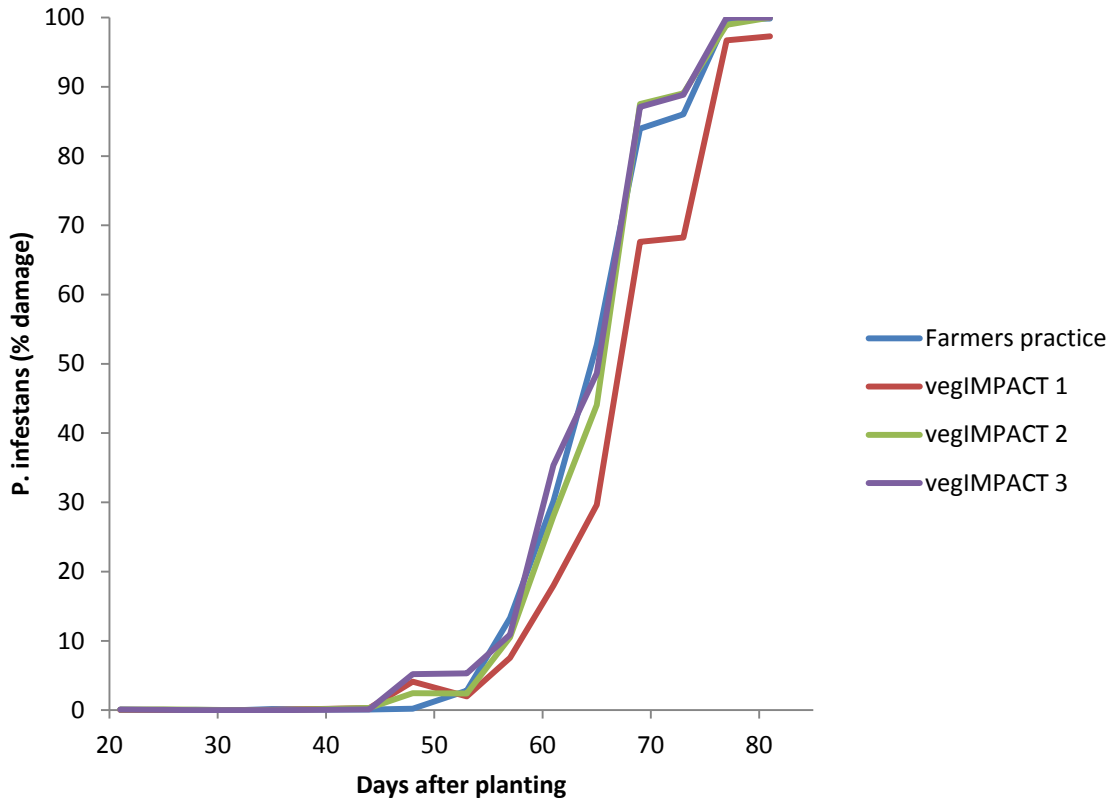

Figure 3.2. The development of foliar blight (as percentage infected foliage) in the potato variety Atlantic under different late blight control strategies during the growing season October-December 2014 in Garut.

Table 3.5. Potato yield (ton/ha) in the different late blight control strategies in the variety Atlantic in Garut.

	A Farmers Practice	B vegIMPACT 1	C vegIMPACT 2	D vegIMPACT 3	p=	$LSD_{0.05}$
Class A	4.1	2.6	4.4	2.8	0.22	2.2
Class B	6.2	7.1	7.3	5.1	0.23	2.4
Class C	1.9	1.7	1.7	1.5	0.73	1.0
Total Marketable Yield [1]	12.2	11.4	13.4	9.4	0.11	3.3
Rotten tubers	0.2	0.3	0.1	0.2	0.52	0.2

[1] At P=0.05 significant differences. F-prob = 0.107 and LSD = 3.3

3.3 Weather data

The rainfall at the demo plots in Garut and Pangalengan is presented in Table 3.6. The wet conditions in November and December 2014 coincided with the rapid development of late blight in this period.

Table 3.6. Amount of rain (mm) and number of days with rain in August 2014 to January 2015 at the demo plots in Garut and Pangalengan.

Month	Total (mm)		Rain-days	
	Pangalengan	Garut	Pangalengan	Garut
August 2014	87.5	58	10	3
September 2014	2.5	4	1	2
October 2014	17	107	6	7
November 2014	358.5	486	22	25
December 2014	537.5	725	29	25
January 2015	484	293	18	18

4. Discussion and conclusions

Demo plots with the potato varieties Atlantic and Granola were laid out in Garut and Pangalengan from October 2014 to January 2015. The objective of the demonstrations was to investigate the influence of three factors in late blight control strategies:

1. Test the influence of fungicide product choice on the efficacy of late blight control in the most susceptible potato variety Atlantic;
2. Test the influence of spray volume on the efficacy to control late blight both in Atlantic and Granola;
3. Test the influence of the adjuvant Agristick at normal and reduced spray volumes both in Atlantic and Granola.

The weather information that was available (total amount of rain and rainy days) showed that during the growing season in both regions the weather conditions were very conducive for late blight.

At both locations, in some plots potato late blight was already observed very early in the growing season, indicating that the natural inoculum pressure at that time was very high.

In the demo plots in Pangalengan many potato plants were seriously infected by bacterial wilt (*Ralstonia solanacearum*). These infections probably started from either infected seed or infected soil. The infected plants were irregularly distributed over the plots. This made it very difficult to carry out reliable assessments on foliar late blight and yield. Therefore, it was decided not to present and analyze the data from the Pangalengan demo plots.

Therefore, only the data from the Garut demo plots could be used to investigate the three objectives mentioned above.

1. The Farmers Practice strategy in Atlantic applied 100% Daconil + 50% Dithane + 50% Curci during the whole season. In the vegIMPACT 1 strategy, other products were used including Revus, Infinito and Antracol. Both strategies were sprayed with 100% volume and adjuvant. There was an indication that the development of late blight in the vegIMPACT 1 strategy was somewhat slower compared to the Farmers practice strategy. This was also reflected in the lower AUDPC value of the vegIMPACT 1 strategy. The yield of both strategies was similar. The costs of the vegIMPACT strategy 1 was more than 100% higher compared to the costs of the Farmers Practice strategy.
2. In Granola, the development of late blight in strategies with the 100% spray volume (A and C) tended to be somewhat slower compared to the strategies with the 80% spray volume. This was also reflected in the lower AUDPC values of these strategies A and C but the differences with the strategies with the 80% spray volume (B and D) were not significant. The spray volume did not significantly influence the yield.
3. In Atlantic, strategies B, C and D used the same fungicides but differed in spray volume. There was an indication that the development of late blight in the strategy with the 100% spray volume (B) was somewhat slower compared to the strategies with the 80% spray volume (C and D). This was also reflected in the lower AUDPC value of strategy B compared to strategy C and D. The spray volume did not significantly influence the yield.
4. In Granola, the adjuvant Agristick did not significantly influence the efficacy to control late blight and yield at both 80% and 100% spray volume. In Atlantic, the influence of the adjuvant Agristick

could only be investigated at the 80% spray volume. The adjuvant did not influence the efficacy to control late blight. Apparently the surfactant characteristics of Agristick did not increase the run-off of droplets and the sticker characteristics did not improve the rainfastness in such an extent that this influenced the efficacy of the fungicides. However, the strategy with 80% spray volume without adjuvant resulted in a significantly lower yield compared to the strategy with 80% spray volume with adjuvant.

Conclusions

- The fungicide product choice in Atlantic does not significantly influence the efficacy of late blight control.
- A 20% reduction in spray volume in both Atlantic and Granola tended to result in a decreased efficacy of late blight control. However, this small difference did not negatively influence potato yield.
- In most comparisons the adjuvant did not significantly influence the efficacy to control late blight or yield. However, in the strategies with 80% spray volume in Atlantic, the strategy without the adjuvant resulted in a significantly lower yield.

Recommendations for future demonstration trials:

- Repeat the demonstration in Pangalengan on a location that is free from a soil infection of bacterial wilt and with the use of healthy seed.
- Include an untreated control in both varieties to determine the level of control of all strategies compared to the untreated control..
- The reduction of spray volume can be achieved by only spraying the upper side of the leaves.
- Use the same fungicide product choice in both Granola and Atlantic in all strategies. Thus the influence of spray volume and adjuvant use can be tested.

5. References

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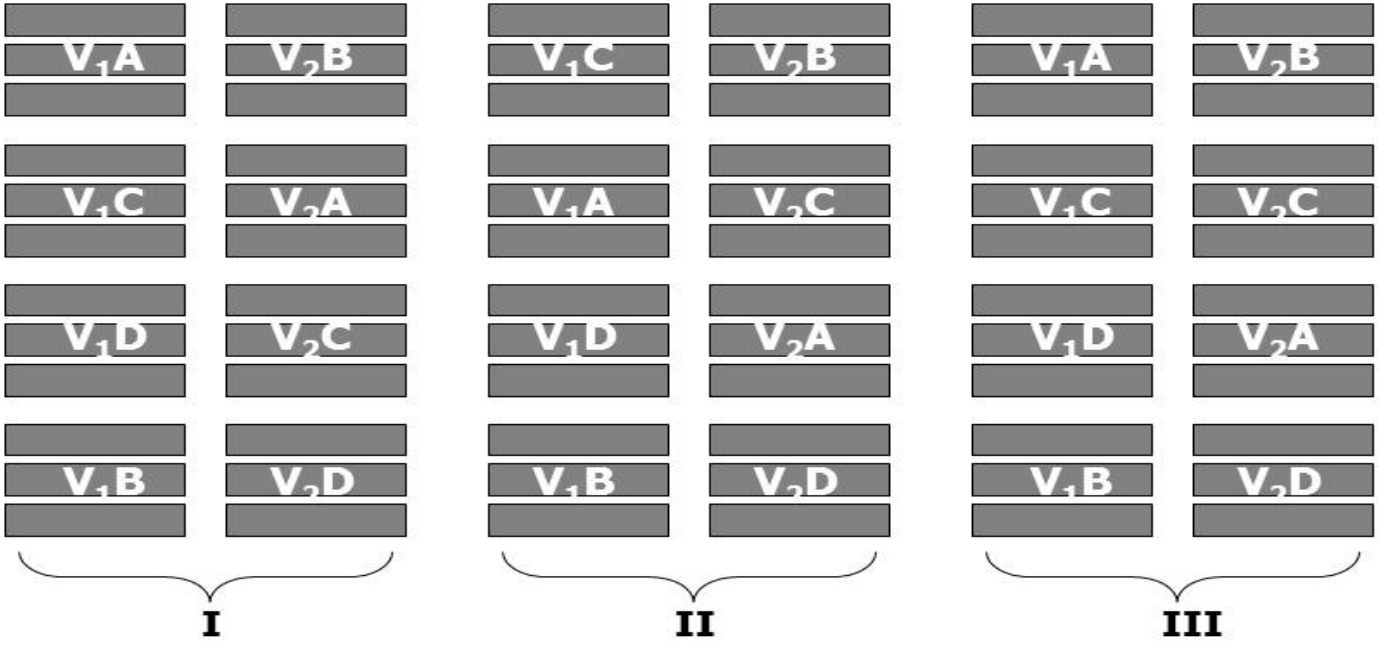
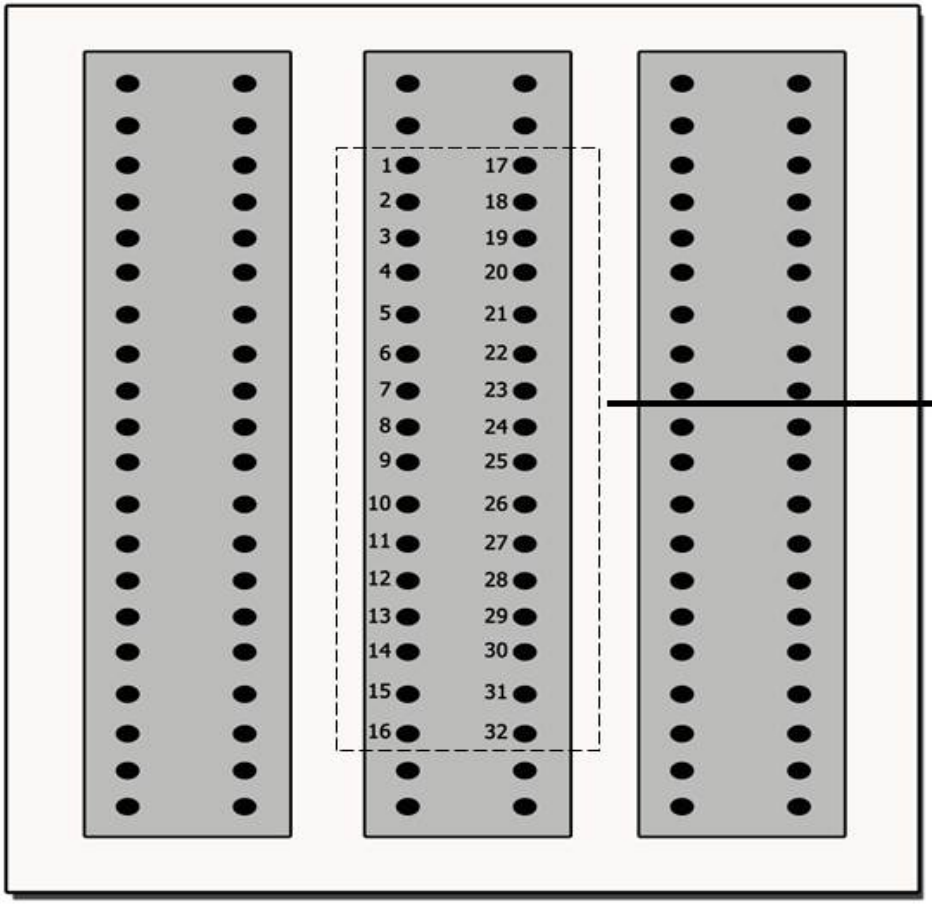
- Huub Schepers, Bert Evenhuis & Corina Topper (2014b) Influence of adjuvants on the deposition of mancozeb. vegIMPACT Report nr. 5.

6. Appendix 1: lay out demo plots



Variety:
V_1 = Granola
V_2 = Atlantic

Control strategy treatment:
A = Farmer practice
B = VegImpact-1
C = VegImpact-2
D = VegImpact-3



Potato plants used for observation of late blight incidence in each plot (No.1 to 32)

Note:

- Plot size: 4 m x 6 m, consisting of 3 beds and each bed was 1 m x 6 m)
- Each bed was planted by 2 rows and 20 plants per row so that the total number of plants was 120 plants per plot
- Plant spacing was 30 cm x 70 cm