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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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Results of potato late blight demonstrations in Garut and Pangalengan, Indonesia November 2015-February 2016

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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.

Demo plots with the potato varieties Atlantic and Granola were again laid out in Garut and Pangalengan from October 2014 to January 2015 (Schepers et al., 2015). The objective of the demonstrations was to investigate the influence of product choice, spray volume and adjuvant in late blight control strategies. The product choice in Atlantic did not influence the efficacy of late blight control. The 20% reduction in spray volume tended to result in a decreased efficacy of control but these small differences did not negatively influence yield. In most strategies the adjuvant did not influence the efficacy of control.

In a pot trial the influence of spray volume and adjuvants on the deposition of mancozeb was studied (Schepers et al., 2014b). There was a clear trend that spraying with 750 L/ha compared to 250 L/ha resulted in a lower mancozeb deposit on the leaves, most probably caused by run-off. Besides there was a clear trend that mancozeb mixed with adjuvants resulted in lower mancozeb deposits compared to mancozeb alone. The adjuvants probably also have surfactant properties resulting in an increased run-off.

In a second pot trial the influence of adjuvants and spray volume on rainfastness and biological efficacy of mancozeb in potato and onion was investigated (De Putter et al., 2016; Schepers et al., 2016). Simulated rain caused a clear decrease in mancozeb deposits on both potato and onion leaves, leading to a lower biological efficacy in potato. Under dry conditions the use of adjuvants in sprays applied to potato did not result in higher mancozeb deposits or less *P. infestans* incidence. Except at 750 L/ha with the addition of the adjuvant Bond® a higher retention was observed. With rain simulation a significant amount of mancozeb was washed-off from the leaves. The adjuvant Bond® produced much higher mancozeb deposits, and increased rainfastness, in both potato and onion. In potato this resulted in better control of *P. infestans*. The adjuvant Indostick® did result in higher mancozeb residues in potato and onion compared to mancozeb without an adjuvant, though this effect was not statistically significant.

Demo plots with potato varieties Atlantic and Granola were laid out in Pangalengan from November 2015 to February 2016. The objective of the demo plots described in this report is to investigate the influence of two factors on the efficacy of late blight control:

1. Test the influence of spray volume on the efficacy to control late blight both in Atlantic and

Granola;

2. 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 were planted in the rainy season on 25 November 2015 with the potato varieties Granola and Atlantic. The plots consisted of 3 beds of 2 rows each with in total 90 plants with an area of 4.5 x 4 m. Of these plants a total of 32 inner plants were used for observations. The demo-plots were 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, October 2014-January 2015 and the results of the pot trials in which the influence of spray volume and adjuvants was studied (Schepers et al., 2014a, 2014b, 2015; De Putter et al., 2016).

Because the late blight pressure in Pangalengan was always high in the previous wet seasons, the spraying interval was set at three days. Based on the pot trials with high spray volume and adjuvants, the spray volume was adapted to the crop development stage and next to that spray strategies with a 20% reduction of this spray volume were tested (Table 2.2). In Granola, 26 sprays were applied with an interval of three days: application dates were 9, 12, 15, 18, 21, 24, 27 and 30 December 2015: 2, 5, 8, 11, 14, 17, 20, 23, 26 and 29 January 2016; 1, 4, 7, 10, 13, 16, 19 and 22 February 2016. In Atlantic, 17 sprays were applied with the spray on 26 January as the last spray. The number of sprays in Atlantic was lower compared to Granola because of a shorter growing season caused by a heavier late blight infestation. The adjuvant Agristick was added to some of the strategies. A battery powered knapsack sprayer (16 liter) was used to ensure constant pressure while spraying. The estimation of the costs of different strategies was based on prevailing market prices of the different fungicides and quantities applied (Table 2.1).

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 [1)]	Per 3 plots/replicates (54 m^2)	
			Dose (g or ml/l)	Cost (IDR/ml or g)
Daconil 75 WP	chlorothalonil (75%)	100%	5.94	867
Dithane M45 80 WP	mancozeb (80%)	50%	4.75	394
Curci 10 WP	cymoxanil (10%)	50%	7.92	634
Akrobat 50 WP	dimethomorph (50%)	50%	1.98	1,534
Agristick 400 L	Adjuvant	100%	1.98	133

[1)] Rate as percentage of recommended label dose.

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

Spray number	**Normal (100%)**	**Normal – 20% (80%)**
Sprays 1-8	250	200
Sprays 9-19	350	280
Sprays 20-26	550	440

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

	A Farmers' 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 1-17	100% Daconil +50% Dithane + 50% Curci	100% Daconil +50% Dithane + 50% Curci	100% Daconil +50% Dithane + 50% Curci	100% Daconil +50% Dithane + 50% Curci

Table 2.4. The fungicide application strategies used in the demonstration plots in Pangalengan 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 1-26	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 (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 quantitative summary of disease intensity over time, calculated from graphs showing the disease *vs*. time, which can be used to compare epidemics quantitatively.

2.4 Yield

The variety Atlantic was manually harvested in Pangalengan on 3 February 2016 (70 days after planting) and Granola on 29 February 2016 (96 days after planting). The tubers were graded over three weight classes: Class A (tubers > 100 g), Class B (50 g < tubers < 100 g) and Class C (tubers < 50 g) and counted and weighed per class. Also the rotten tubers were weighed.

3. Results

3.1 Pangalengan

In both potato varieties late blight infection was already present 27 days after planting (End of December 2015). The level of infestation was high in the untreated Atlantic plots (3-26%) At the same date also a low level of infestation was visible in some treated Atlantic plots. In the untreated Atlantic plots the epidemic developed very rapidly, at 35 days after planting already a 80% level of infection was reached.

Compared to the level observed in Atlantic the late blight infestation in Granola was low (< 1%) 27 days after planting. In the untreated Granola plots, late blight developed much slower than in Atlantic, the level of 80% infection was reached at 56 days after planting which was 20 days later than in Atlantic.

3.1.1 Granola

In Granola, at all four fungicide strategies 100% Daconil + 50% Dithane + 50% Akrobat was applied with each spray application. The strategies differed only in spray volume and adjuvant use (Table 2.4).

In the Untreated plots, the late blight epidemic started approximately 14 days earlier compared to the treated plots. This resulted in a significantly higher AUDPC value for Untreated compared to all other treatments. In all fungicide treatments development of late blight was similar. Strategy D with an 80% spray volume without adjuvant had a slightly higher AUDPC compared to strategy C with a 100% spray volume without adjuvant (Table 3.1 and Figure 3.1).

The aggregated costs over the entire growing season of the Farmers Practice strategy was IDR 43,553 per 3 plots (Table 3.1). With 26 sprays this results in an average cost per spray of 1,675 IDR/3 plots. Applying 80% spray volume compared to 100% spray volume reduces the costs with 20%.

The total marketable yield of all strategies was significantly higher compared to the untreated (Table 3.2). The yield of strategy D (80% spray volume- no adjuvant) was significantly lower compared to strategy B (100% spray volume + adjuvant).

Table 3.1. Infected foliage (%) and AUDPC in the potato variety Granola in the different late blight control strategies in Pangalengan.

	0	A	B	C	D
	Untreated	Farmers' Practice	vegIMPACT 1	vegIMPACT 2	vegIMPACT 3
Spray volume		Normal	Normal – 20%	Normal	Normal – 20%
Adjuvant		Agristick	Agristick	None	None
Days after planting:					
13	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0
27	0.3	0.0	0.0	<0.1	0.0
34	0.3	<0.1	<0.1	<0.1	<0.1
41	2.3	<0.1	<0.1	<0.1	<0.1
48	18.6	<0.1	<0.1	<0.1	<0.1
55	89.5	19.3	26.6	24.4	25.8
62	94.7	86.9	84.8	83.5	86.6
69	100	94.8	94.3	95.0	96.2
76	100	96.9	98.4	94.2	98.6
83	100	99.9	99.4	99.5	99.9
90	100	100	100	100	100
AUDPC[1]	3889	3135	3175	3126	3200
Cost (IDR)[2]	-	43,553	34,843	41,589	33,271

[1] At P=0.05 significant AUDPC differences. F-prob<0.001 and LSD=65.

[2] Cost (in IDR) per 3 plots of the fungicide application strategies sprayed in the variety Granola. With an interval of 3 days, 26 applications were carried out. The spray volume was adapted to the plant size (Table 2.2).

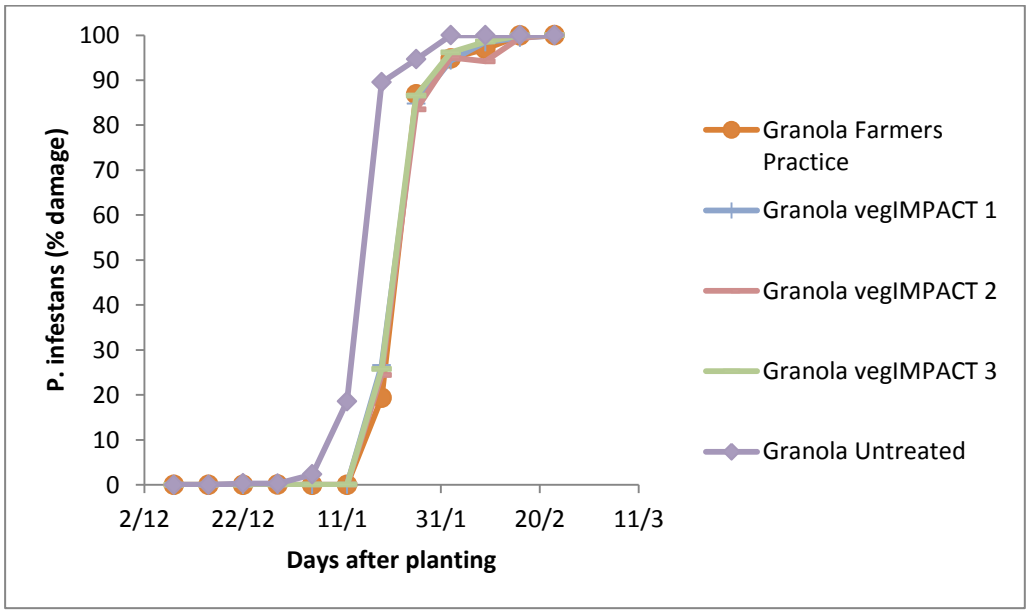

Figure 3.1. The development of foliar late blight (as percentage infected foliage) in the potato variety Granola under different late blight control strategies during the growing season December 2015 – February 2016 in Pangalengan.

Table 3.2. Potato yield (ton/ha) in the different late blight control strategies in the variety Granola in Pangalengan.

	0 Untreated	A Farmers' Practice	B vegIMPACT 1	C vegIMPACT 2	D vegIMPACT 3	p =	$LSD_{0.05}$
Class A	0.2	4.8	6.7	4.0	3.4	0.008	2.9
Class B	1.3	6.6	6.9	6.2	4.8	<0.001	1.9
Class C	3.2	5.2	5.2	6.1	4.8	0.2	2.3
Total Marketable Yield	4.7	16.6	18.8	16.4	13.0	<0.001	4.2

3.1.2 Atlantic

In Atlantic the four fungicide strategies all applied 100% Daconil + 50% Dithane + 50% Curci. The strategies differed in spray volume and adjuvant use (Table 2.3).

In the Untreated plots, the late blight epidemic started approximately 14 days earlier compared to the treated plots. This resulted in a significantly higher AUDPC value for Untreated compared to all treatments. In all treatments the development of late blight infestation was similar. There was no significant effect of spray volume or adjuvant on late blight development (Table 3.3 and Figure 3.2).

The aggregated costs over the entire growing season of the Farmers Practice strategy was IDR 17,214 per 3 plots (Table 3.3). With 17 sprays this results in an average cost per spray of IDR 1,012 per 3 plots. The costs of all strategies used in Atlantic are clearly lower compared to Granola. This difference was caused by the lower number of sprays (17 compared to 26) and the lower price of Curci compared to Akrobat (Table 2.1).

The total marketable yield of all strategies was significantly higher compared to the untreated (Table 3.5). The marketable yield of strategy B (80% spray volume + adjuvant) was significantly lower compared to strategy C (100% spray volume- no adjuvant).

Table 3.3. Infected foliage (%) and AUDPC in the potato variety Atlantic in the different late blight control strategies in Pangalengan.

	0	A	B	C	D
	Untreated	Farmers' Practice	vegIMPACT 1	vegIMPACT 2	vegIMPACT 3
Spray volume		Normal	Normal-20%	Normal	Normal-20%
Adjuvant		Agristick	Agristick	None	None
Days after planting:					
13	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0
27	8.6	0.0	<0.1	0.0	<0.1
34	77.9	0.2	0.7	<0.1	4.2
41	79.0	1.6	3.6	2.1	2.4
48	91.7	11.6	17.2	16.4	14.7
55	100	94.7	91.1	96.5	98.1
62	100	99.9	99.6	99.9	85.9
AUDPC[1]	2851	1107	1136	1156	1186
Cost (IDR)[2]	-	17,214	13,771	16,171	12,937

[1] At P=0.05 significant AUDPC differences. F-prob<0.001 and LSD=217.

[2] Cost (in IDR) per 3 plots of the fungicide application strategies sprayed in the variety Atlantic. With an interval of 3 days, 17 applications were carried out. The spray volume was adapted to the plant size (Table 2.2).

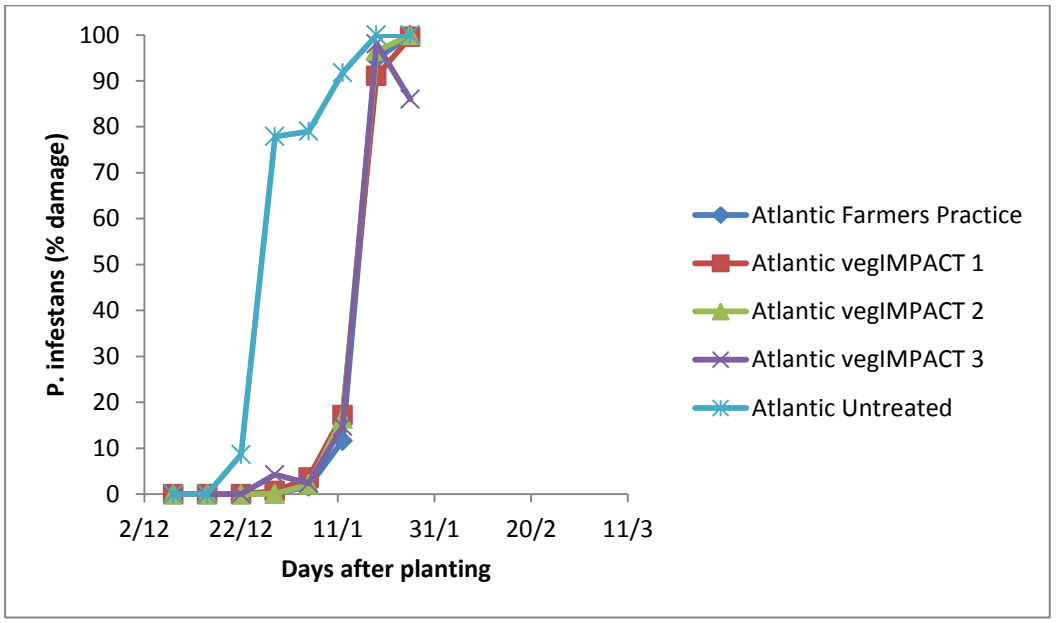

Figure 3.2. The development of foliar late blight (as percentage infected foliage) in the potato variety Atlantic under different late blight control strategies during the growing season December 2015 – February 2016 in Pangalengan.

Table 3.4. Potato yield (ton/ha) in the different late blight control strategies in the variety Atlantic in Pangalengan.

	0	A	B	C	D	p=	$LSD_{0.05}$
	Untreated	Farmers Practice	vegIMPACT 1	vegIMPACT 2	vegIMPACT 3		
Class A	0	2.4	2.0	2.1	1.9	0.006	1.1
Class B	0	4.4	4.1	5.6	4.6	<0.001	1.8
Class C	2.0	5.3	4.7	6.1	6.2	0.004	1.8
Total Marketable Yield	2.0	12.1	10.8	13.8	12.7	<0.001	1.9

3.2 Weather data

The rainfall at the demo plots in Pangalengan is presented in Table 3.5. The very wet conditions in December 2015 coincided with the rapid development of late blight in this period.

Table 3.5. Amount of rain (mm) and number of days with rain in November 2015 to February 2016 at the demo plots in Pangalengan.

Month	Total (mm)	Rain days
August 2015	0	0
September 2015	0	0
October 2015	0	0
November 2015	282	20
December 2015	544	24
January 2016	315	24
February 2016	372	26

4. Discussion and conclusions

Demo plots with the potato varieties Atlantic and Granola were laid out in Pangalengan from November 2015 to February 2016. The objective of the demonstration was to investigate the influence of two factors on the efficacy of late blight control:

1. Test the influence of spray volume on the efficacy to control late blight both in Atlantic and Granola;
2. 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 Pangalengan the weather conditions were very conducive for late blight.

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.

The following observations made in the demo plots are important in relation to the objectives mentioned above:

1. In **Granola**, the four fungicide strategies all applied 100% Daconil +50% Dithane + 50% Akrobat during the whole growing season. The strategies differed in spray volume (100% or 80%) and adjuvant use (yes/no). All four control strategies significantly reduced late blight compared to the untreated control. Strategy D with an 80% spray volume without adjuvant had slightly more blight compared to strategy C with a 100% spray volume without adjuvant. The total marketable yield of all strategies was significantly higher compared to the untreated. Strategy D (80% spray volume- no adjuvant) yielded significantly lower compared to strategy B (100% spray volume + adjuvant).
2. In **Atlantic** the four fungicide strategies all applied 100% Daconil + 50% Dithane + 50% Curci during the whole growing season. The strategies differed in spray volume (100% or 80%) and adjuvant use (yes or no). All four control strategies significantly reduced late blight compared to the untreated control. There was no significant influence on late blight development of spray volume or adjuvant. The total marketable yield of all strategies was significantly higher compared to the untreated. Strategy B (80% spray volume + adjuvant) yielded significantly lower compared to strategy C (100% spray volume- no adjuvant). Since all strategies used the same fungicides, the costs of the strategies were only influenced by use of Agristick (yes/no) and spray volume: 20% lower costs when spray volume was 80%.
3. Influence of **spray volume** on late blight control: in Atlantic there was no influence of spray volume on late blight control. In Granola, strategy D with an 80% spray volume without adjuvant had slightly more late blight compared to strategy C with a 100% spray volume without adjuvant. In Atlantic, Strategy B (80% spray volume + adjuvant) had a significant lower total marketable yield compared to strategy C (100% spray volume- no adjuvant). In Granola, strategy D (80% spray volume- no adjuvant) showed a significant lower marketable yield compared to strategy B (100% spray volume + adjuvant).
4. Influence of the **adjuvant** Agristick on late blight control: in both Atlantic and Granola there was no influence of adjuvant use on late blight control. In Atlantic, strategy B (80% spray volume + adjuvant) resulted in a significant lower yield compared to strategy C (100% spray volume- no adjuvant). In Granola, strategy D (80% spray volume- no adjuvant) had a significant lower yield compared to strategy B (100% spray volume + adjuvant). However, it is unclear whether these yield differences are caused by the differences in spray volume or adjuvant use.

Conclusions

- In this season at this location, the late blight control in the variety Atlantic was more difficult compared to Granola.
- A 20% reduction in spray volume in both Atlantic and Granola resulted in similar late blight control compared to the 100% spray volume when the adjuvant Agristick was used. An 80% spray volume without adjuvant resulted in Granola in a lower efficacy on late blight and consequently also a lower yield.

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Appendix 1: lay out demo plots

Demoplot Control strategy of late blight in Potatoes
(Pangalengan-2015/2016)

Treatment : 4 control strategy and 1 control treatment in each variety
Variety : Granola and Atlantic
Replication : 3 (three)
Area per plot : 4.0 m x 4.5 m= 18 m^2

A = Granola – Strategy A
B = Granola – Strategy B
C = Granola – Strategy C
D = Granola – Strategy D
I = Granola - control

E = Atlantic – Strategy A
F = Atlantic – Startegy B
G = Atlantic – Strategy C
H = Atlantic – Strategy D
J = Atlantic - control