Control of *Phytophthora infestans* with low copper amounts in potatoes in 2010

bio*K*ennis
voor biologische agroketens

Ir C. B. Bus

WAGENINGEN UR
For quality of life

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part of Wageningen UR
Business Unit AGV
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1 Introduction

Potato late blight, caused by *Phytophthora infestans,* causes substantial losses in organic potato production in the Netherlands. In the last years and especially in 2007, late blight was an enormous problem. The disease led to very low tuber yields. Also the tuber quality was poor. The risk of low and unpredictable yields is too high. That is why organic farmers planned to reduce the acreage with organic potatoes.
On the other hand the Dutch government stimulates organic cropping, including potatoes. Their ambition is an annual growth of 5% in acreage of organic agriculture. To support this, a research program was started in which research into measures to reduce the negative effects of late blight was an important topic.
Resistant varieties against late blight could be the solution. Breeders are rather successful in this. There are three interesting new varieties, Sarpo Mira, Bionica and Toluca with a high resistance against *Phytophthora infestans* but they also have some less respected characteristics, therefore it still is no breakthrough. Growers still have to use relatively susceptible varieties.
In common agriculture growers successfully use fungicides to protect their potato crop against late blight and also in some neighbouring countries some fungicides are allowed in organic potato growing.
At the moment – 2010 - in the Netherlands, copper products are, according to the Dutch pesticide law, not allowed at all to use to protect potatoes against late blight.
Between Dutch organic growers the late blight problems led to discussions in which a temporary registration of copper products is also suggested. Some growers do not want any pesticides at all, while others see that organic potatoes from abroad are sold in the super markets in years when Dutch organic potatoes are scarce. Those potatoes come from countries, where copper products are allowed. They speak about competition falsification.
In the research program to stimulate organic production the choice was made also to investigate the efficacy of copper and other products that are allowed in neighbouring countries in organic farming.
In the experiment of 2008 different copper containing products were tested. In 2009 this was repeated with the same products, but also other doses and combinations. In 2010 the most important objective of the experiment was to investigate the possibilities of a maximum of 300 gram copper per hectare, divided in different parts, in combination with a decision support system. 300 gram copper was based on the amount different crops need in a six year organic rotation. Except a standard copper product also a copper product used in organic farming in the Netherlands as a leaf fertilizer was used and some products financed by the industry.

Figure 1: **Detail 13 August; foliage affected by late blight**

2 Materials and methods

2.1 Trial set up

The potatoes were grown on a sandy clay soil at the Applied Plant Research - PPO-AGV - location at Lelystad. PPO-AGV is GEP certified (Appendix 1).
The experiment was treated conform local good agricultural practice. Trial figures are listed in table 1. The trial design is presented in Appendix 2.

Table 1. **Trial figures**

Soil	Light clay (14 % lutum)
Organic matter	1.8%
CaCO3	6.6%
Cultivar	Agria
Leaf blight resistance	5.5 – fairly susceptible
Tuber blight resistance	8 – fairly good resistance
Row distance	75 cm
Distance in the row	33 cm
Plot size nett	7 m x 1.5 m
Plot size gross	10 m x 4.5 m
Number of treatments	13
Number of replicates	4
Planting date and technique	7 May mechanically
Nitrogen fertilization; quantity and date	170 kg N per ha (17 May)
Weed control	27 May (0.25 l Centium and 1 l Butisan/ha)
Haulm desiccation	20 August with 4 l Reglone/ha
Harvest	13 September
1st assessment late blight tubers and bacterial diseased tubers	14 September
2nd assessment late blight tubers	20 October

2.2 Treatments

In the trial different copper containing products and combinations of products were tested. They are listed in table 2. A fungicide (Copper A) in a dosage of 600 gram Cu/ha, as cuprous oxide Cu_2O, was used as a standard; the other Cu-products were Copper B and Copper C. Also product A and product B were tested.

Table 2: **Treatments per spraying**

Factor code	Factor description
A	untreated
B	600 g Cu per ha as Copper A
C	300 g Cu per ha as Copper A
D	150 g Cu per ha as Copper A
E	75 g Cu per ha as Copper A
F	75 g Cu per ha as Copper B
G	150 g Cu per ha as Copper C
H	75 g Cu per ha as Copper C
I	0.09 l Product A per ha (Should have been 0.45 l per ha)
J	300 g Cu per ha as Copper A + 0,5 l Product B per ha
K	300 g Cu per ha as Copper A + 50 g Cu as Copper C + 0,5 l Product B per ha
L	150 g Cu per ha as Copper C + 1 l Product B per ha
M	75 g Cu per ha as Copper C + 1 l Product B per ha

In the treatments C, D, E, F, G and H in total 300 g Cu per ha was used
Treatments J, K, L and M are financed by an agrochemical industry

2.3 Spraying

To protect the crop from late blight the first spraying was carried out on 2 July when the crop had reached a height of 45-50 cm and the crop was almost closed. In table 3 all spraying dates in the different treatments are presented.
Fungicide applications were carried out using a trial site sprayer with Airmix 110.04 nozzles. Nozzles were hanging approximately 50 cm above the foliage. Sprayings were carried out based on 300 l/ha. With the trial site sprayer up to ten treatments can be sprayed in one run; see figure 2.
The frequency of sprayings was decided by the DSS Dacom Advice module to ensure that timing was as good as possible.
In the treatments B, I, J and K the sprayings were carried out on 2-12-19-26 July and 3-9-16 August (In total 7 times).
To prevent the development of weeds, before crop emergence, on 15 May, the soil was treated with 0,25 l Centium + 1 l Butisan + 0,5 l oil in 400 l of water per hectare.
On 20 August haulm killing was carried out with 4 l Reglone per hectare.

2.4 DSS and weather conditions

Sprays were timed according to the Decision Support System (DSS) Dacom Advice module. See for more information about DSS Dacom Advice module the world wide web for DSS and Dacom; www.dacom.nl. Timing of applications was based on previous spray, variety, crop growth, weather conditions, weather forecast, blight in the crop itself and blight pressure in the neighbourhood. The 7 sprayings in the treatments B, I, J and K were carried as soon as late blight pressure according to Dacom Advice module was >200.
In an experiment at a distance of 10 – 200 m, to increase the infection chances, artificial inoculation was carried out on 7 July. Subsequently artificial irrigation was carried out to prolong the leaf wetness period and from 26 July onwards a fast spread of late blight was observed in the untreated plots of that artificially irrigated experiment.
In treatment C one spraying was programmed. It was carried out as soon as late blight pressure was very high and also pressure from the plots itself was high in combination with a starting late blight infection. The spraying was carried out 28 July.
In the treatments D, G and L two sprayings were programmed. Also these treatments started after a beginning of late blight infection. These two sprayings were carried out 26 July and 3 August.
In treatments E, F, H and M four sprayings were programmed. These treatments started as soon as late blight pressure was high in combination with visible late blight in the neighbouring potato crop. The four

sprayings were carried out 12 and 26 July and 3 and 9 August.

Table 3: **Treatments and spraying dates**

Factor code	Factor description	2 July	12 July	19 July	26 July	28 July	3 Aug.	9 Aug.	16 Aug.
A	untreated								
B	600 g Cu per ha as Copper A	**x**	**x**	**x**	**x**		**x**	**x**	**x**
C	300 g Cu per ha as Copper A					**x**			
D	150 g Cu per ha as Copper A				**x**		**x**		
E	75 g Cu per ha as Copper A		**x**		**x**		**x**	**x**	
F	75 g Cu per ha as Copper B		**x**		**x**		**x**	**x**	
G	150 g Cu per ha as Copper C				**x**		**x**		
H	75 g Cu per ha as Copper C		**x**		**x**		**x**	**x**	
I	0.09 l Product A per ha	**x**	**x**	**x**	**x**		**x**	**x**	**x**
J	300 g Cu/ha as Copper A + 0,5 l Product B/ha	**x**	**x**	**x**	**x**		**x**	**x**	**x**
K	300 g Cu/ha as Copper A + 50 g Cu/ha as Copper C + 0,5 l Product B/ha	**x**	**x**	**x**	**x**		**x**	**x**	**x**
L	150 g Cu/ha as Copper C + 1 l Product B/ha				**x**		**x**		
M	75 g Cu/ha as Copper C + 1 l Product B/ha		**x**		**x**		**x**	**x**	

Weather conditions during the growing season are presented in Appendix 2. April, June and the first 3 weeks of July were very dry, May was chilly, June and especially July were very warm. On 27 July a wet period started. The precipitation in August was even 231 mm. In September rainfall was not exceptional but the soil hardly dried. Because of the dry weather in July, on 9 July the crop was irrigated with 15 mm per hectare.

2.5 Disease observations

To determine the effects of the different products and product combinations late blight observations were carried out weekly, and if necessary twice a week. Every time the percentage of destroyed foliage (leaves and stems) by *Phytophthora infestans* was estimated visually. 15 September, the day after harvest, affected tubers were picked out. By cutting, they were divided in tubers affected by late blight or bacterial diseases. Number and weight were recorded. The other tubers were stored for another 5 weeks at 15-20°C and washed. Late blight affected tubers again were picked out and counted and weighed and also the other tubers were counted and weighed.
Artificial inoculation with *Phytophthora infestans* spores was not carried out.

2.6 Statistical analyses

Analysis of variance was conducted on all data. The probability according to the F-test from these analyses is presented.
Separation of the means is provided using least significant differences (LSD) based on the t-distribution, with probability 0.05.
All analyses were performed using Genstat 13 (VSN International, 2010).

Figure 2: **One of the beams of the Sosef-trial-spraying machine (in another experiment).**
Every time the spraying machine goes to the experimental field 10 different products can be sprayed.

3 Results

3.1 Crop development

14 June: 12% soil coverage and an irregular plant height of 1-15 cm.
28 June: 55% soil coverage and an average plant height of 45 cm.
5 July: 95% soil coverage and a plant height of 55 cm. The crop starts to bloom.
26 July: 100% soil coverage and a plant height of 60 cm. The crop is in full bloom.

3.2 Disease development in the foliage

On 26 July the first infections were observed, especially on the lower leaves and in the treatments that were not yet sprayed.
The assessments of late blight in the foliage on 6 dates, are presented in Appendix 3 and the averages per treatment, including the results of the statistical analysis, in table 4 and figure 3.
From 26 July onwards the infection pressure was high.

Table 4. **Foliage infestation per date (0% = completely free from late blight; 100% = completely destroyed by late blight)**

Treatment	26/7	30/7	3/8	9/8	12/8	18/8
A	1,15	1,88	14,0	36,0	67,9	90,7
B	0,001	0,002	0,3	1,4	7,1	42,6
C	0,83	4,00	11,5	16,8	42,6	91,3
D	2,25	4,51	8,8	17,3	53,9	90,6
E	0,38	1,03	5,5	17,0	58,9	91,8
F	0,75	2,75	7,3	25,0	70,1	92,6
G	3,88	5,75	10,5	16,5	40,1	89,3
H	0,03	0,88	5,0	17,8	47,6	85,1
I	1,75	2,75	10,8	26,3	66,4	92,8
J	0,0003	0,001	0,18	1,5	13,9	56,3
K	0,005	0,005	0,05	0,9	4,9	35,1
L	3,52	3,75	7,0	5,0	20,1	77,6
M	0,005	0,13	2,9	8,8	25,9	67,6
Lsd	2,2	3,2	5,3	11,1	21,4	13,2
Fprob	0,004	0,004	<0.001	<0.001	<0.001	<0.001

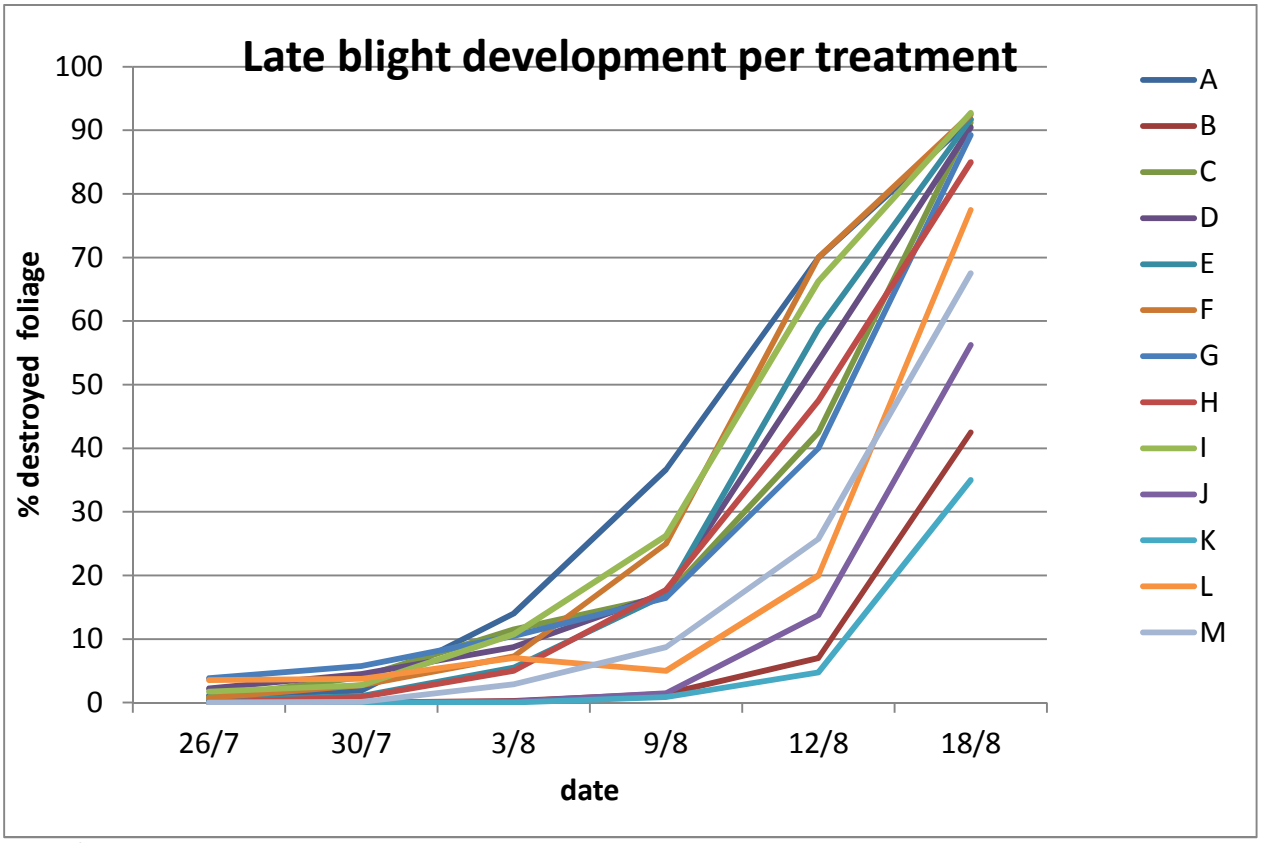


Figure 3: **Development of foliage late blight during the growing season**

- Treatment I, in which Product A was used seven times, but by misunderstanding in a five times too low amount, did not differ in late blight infection from the untreated control B.
- The treatments D, E, F in which in total only 300 g/ha Cu was used, in the beginning of August performed better than the untreated control, but as late blight pressure increased, failed to protect the crop.
- In August the late blight pressure was so high, that none of the spraying regimes could protect the crop completely.
- The highest copper concentration, treatment B, sprayed 7 times, and the combination of Copper A and Copper C and Product B, treatment K, gave the best foliage protection.
- Also treatment J, performed rather well. The difference with treatment K was only 50 g/ha Cu extra, sprayed as Copper C. Only at the last assessment treatment K was significantly less affected.
- When comparing treatments G and H (Copper A) and D and E (Copper C) there were no clear differences in crop protection.
- When comparing treatments G and H (without Product B) and L and M (with Product B) L and M performed better.
- When comparing treatments E and F, both sprayed 4 times with the same amount of Cu. There was no significant difference in foliage blight. There was just a tendency that Copper A (cuprous oxide, Cu2O) gave a better protection compared to Copper B.
- Spraying 2 or 4 times with in total 300 g/ha Cu did not lead to significant differences in protecting the crop from late blight in this year in which the late blight pressure after a long dry period suddenly was so high.
- Treatment C, Copper A spraying once with 300 g/ha Cu on 28 July, showed significantly more late blight on 3 August but not on 9 and 12 August when compared with treatments D and E also sprayed with in total 300 g/ha Cu.

- When we accept 35% dead foliage as a limit for haulm killing, than with 300 g/ha Cu haulm killing could be postponed with only about 2 days. When we accept 15% dead foliage than it was about 6 days in this experiment with this high pressure in the beginning of August.

Figure 4: **13 August. Overview experiment. Almost in front, on the right side plot 24, treatment B with only about 10% destroyed foliage. On the other side of the path plot 37, treatment G, with about 70% destroyed leaves.**

3.3 Tuber yield and disease development in the tubers

In table 5 tuber number and tuber weight are presented.

Table 5: **Number and weight of tubers infected with *P. infestans* and Erwinia-bacteria, nett and total**

Treatment	Number of tubers/10 m^2					Weight of tubers: kg/are			
	nett	P.infestans	Erwinia	total		nett	P.infestans	Erwinia	total
A	456.7	8.1	1.0	465.7		350.2	4.8	0.4	355.4
B	431.7	15.0	2.6	449.3		368.0	10.2	1.8	380.1
C	485.0	8.1	1.2	494.3		384.2	5.1	0.5	389.8
D	482.4	9.0	0.7	492.1		386.5	3.6	0.3	390.4
E	473.3	9.8	1.2	484.3		357.8	5.0	1.4	364.2
F	467.9	3.8	2.1	473.8		352.5	1.8	1.5	355.8
G	466.9	8.8	1.2	476.9		369.4	4.1	0.8	374.4
H	472.9	8.6	1.4	482.9		357.7	3.6	0.8	362.0
I	441.7	6.4	2.6	450.7		346.8	2.6	2.2	351.6
J	440.5	14.8	2.1	457.4		383.0	12.8	1.3	397.2
K	446.0	14.0	2.6	462.6		381.6	10.3	1.6	393.6
L	436.2	7.9	5.0	449.0		356.8	4.9	4.7	366.4
M	481.0	13.8	2.9	497.6		382.0	4.8	2.8	389.6
Lsd	59.7	7.7	2.7	57.2		31.7	5.3	3.0	29.5
Fprob	0.62	0.11	0.15	0.67		0.10	0.003	0.26	0.016

- There were no significant differences in tuber numbers between the treatments.
- There were significant differences between treatments in amount (weight) of late blight affected tubers and in total amount.

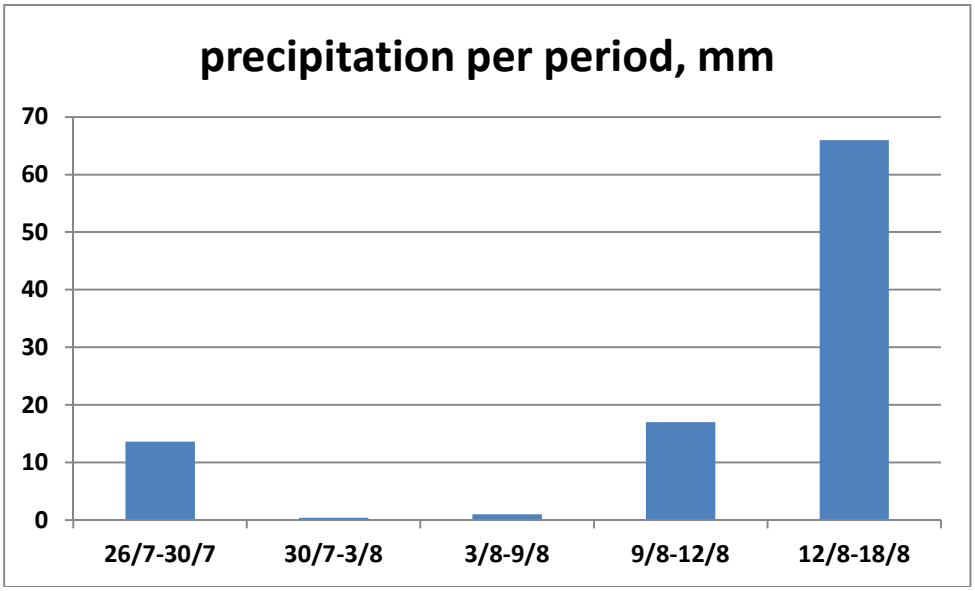


Figure 5: **Precipitation per period of foliage late blight observations**

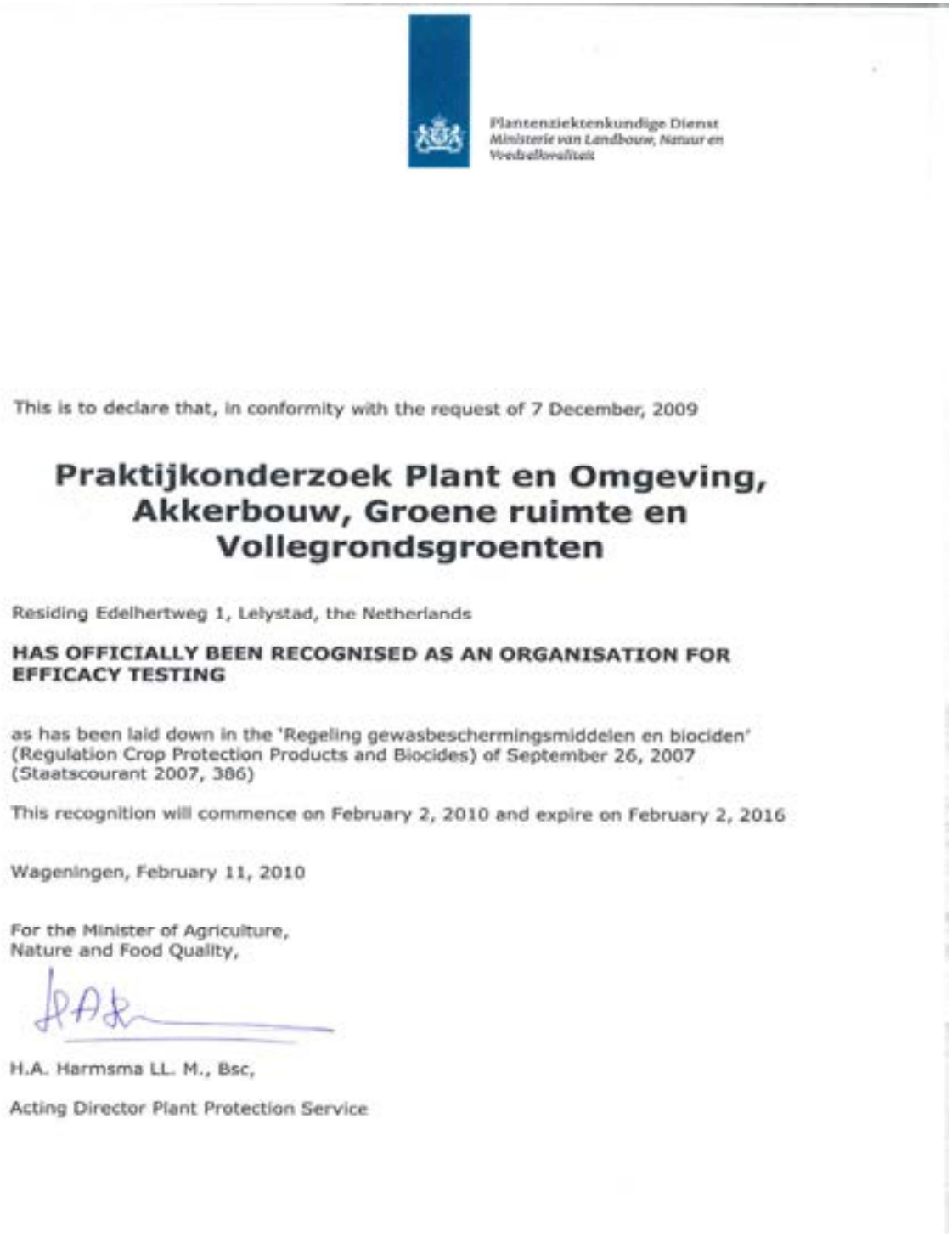
- Treatments B, J and K, the treatments in which the foliage was better protected against late blight, had significantly more affected tubers compared to the untreated control treatment and the other treatments. Probably the amount of vital spores at the moment of heavy rainfall was higher in these treatments compared to the other treatments. The number and amount of late blight affected tubers was lowest in the treatments with the lowest total yield (F and I) also indicating that the foliage in those treatments had died earlier. In figure 5 the precipitation per period is presented. In the treatments B, J and K the foliage blight especially increased between 12 and 18 August. Therefore an immense quantity of spores was produced in that period. In the other treatments this increase in foliage late blight happened between 3 and 12 August, a period in which the total amount of rainfall was more limited. Figure 4, a photo made on 13 August, also shows that on that moment the soil was not very wet.
- In general, tuber yields in this experiment were rather high for organic potatoes. This was caused by the relatively dry weather till the last week of July.
- The numbers of affected tubers clearly shows that with the amounts and products that were sprayed here, the tubers could not be protected from late blight infection, although the tubers of the variety Agria, used in this trial, have a fairly good resistance to tuber blight.

4 Conclusions

- Spraying 1, 2 or 4 times with in total 300 g/ha Cu slowed down infection with *Phytophthora infestans*.
- When we accept 15% dead foliage as a limit for haulm killing, the desiccation timing with in total 300 g/ha Cu was postponed about 6 days in this experiment with this high pressure in the beginning of August (on average 4.8 tonnes per hectare).
- When we accept 35% dead foliage as a limit for haulm killing, than with in total 300 g/ha Cu haulm killing in this year 2010 could be postponed with only about 2 days (on average 1.6 tonnes per hectare).
- In August the late blight pressure was so high that none of the spraying regimes could completely protect the crop.
- The highest copper dose, 600 g /ha Cu, sprayed 7 times, and the combination of copper A and Copper C and Product B, gave the best foliage protection.
- Adding product B increased the efficacy of the treatments.
- When comparing the treatments with equal amounts of Copper A and Copper C, there were no clear differences in crop protection.
- When comparing Copper A (cuprous oxide, Cu2O) and Copper B, both sprayed 4 times with 75 g/ha Cu, there was no significant difference in foliage late blight.
- Product A was used seven times, but in a too low amount. There was no significant difference in late blight infection with the untreated control treatment.
- Also late blight in the tubers was recorded. There were significant differences in the amount of late blight affected tubers and in the total amount.
- The treatments in which the foliage was best protected against late blight also had most affected tubers. Most likely the amount of vital spores at the moments of heavy rainfall was higher in these treatments compared to the other treatments.
- In general the tuber yields in this experiment were rather high for organic potatoes. This was caused by the relatively dry weather till the last week of July.
- The numbers of affected tubers clearly shows that with the amounts and products that were sprayed here, the tubers could not be protected against late blight infection.

The late blight situation differs from year to year. When 300 g Cu can postpone the desiccation timing with 6 days (threshold 15%) under the conditions of 2010, it is very likely that 300 g Cu can postpone the desiccation timing even longer when the epidemic is less severe compared to 2010. When the epidemic occurs earlier in the season the use of 300 g Cu could not only postpone the desiccation timing but could also make an important difference in quality of tubers harvested (size, under water weight).

Appendix 1. PD-recognition



Plantenziektenkundige Dienst
Ministerie van Landbouw, Natuur en Voedselkwaliteit

This is to declare that, in conformity with the request of 7 December, 2009

Praktijkonderzoek Plant en Omgeving, Akkerbouw, Groene ruimte en Vollegrondsgroenten

Residing Edelhertweg 1, Lelystad, the Netherlands

HAS OFFICIALLY BEEN RECOGNISED AS AN ORGANISATION FOR EFFICACY TESTING

as has been laid down in the 'Regeling gewasbeschermingsmiddelen en biociden' (Regulation Crop Protection Products and Biocides) of September 26, 2007 (Staatscourant 2007, 386)

This recognition will commence on February 2, 2010 and expire on February 2, 2016

Wageningen, February 11, 2010

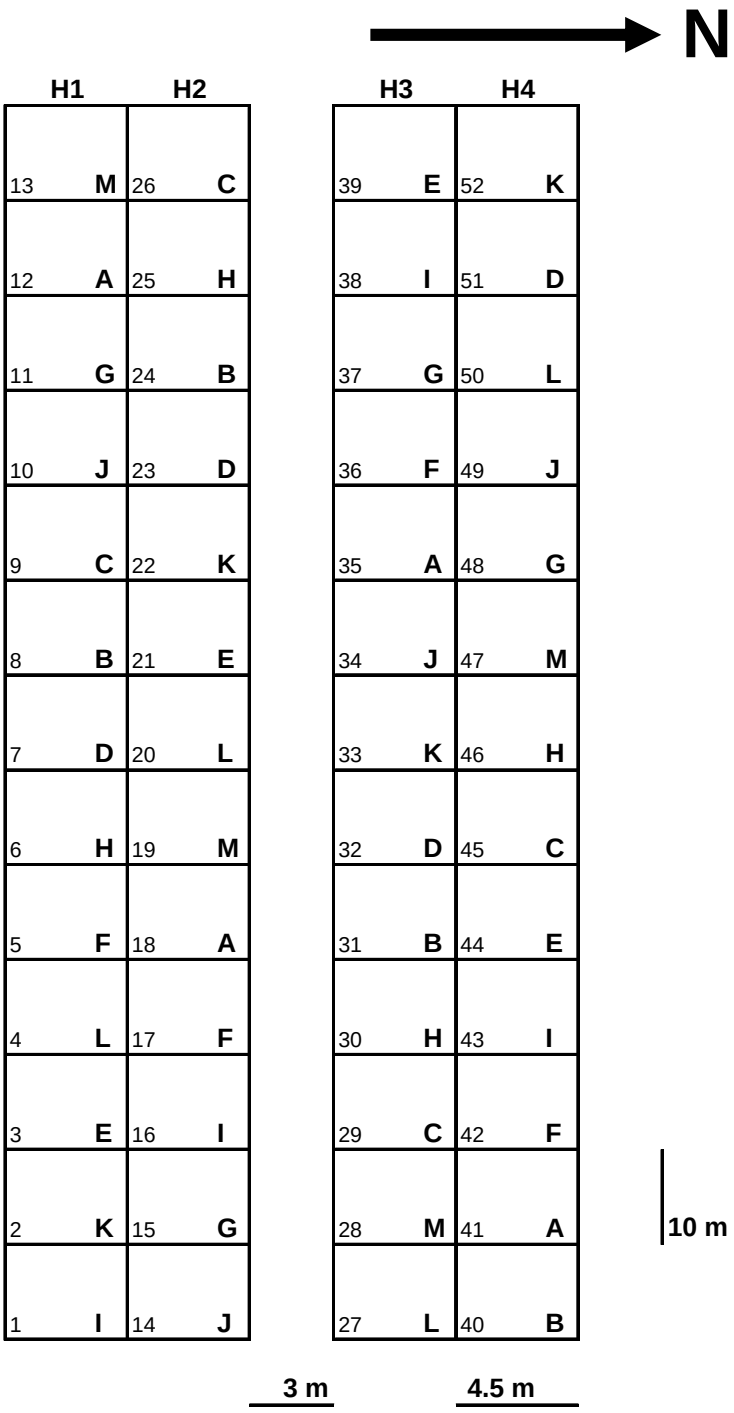
For the Minister of Agriculture,
Nature and Food Quality,

H.A. Harmsma LL. M., Bsc,

Acting Director Plant Protection Service

Appendix 2. Trial design

Late blight control in organic farming, project 3250112110
site C4
number of treatments: 13
number of replications: 4
Variety: Agria



Appendix 3. Weather conditions

Weather data Lelystad May - half June 2010

date	T-gem (°C)	T-max (°C)	T-min (°C)	rainfall (mm)	RH-min (%)
01-05-10	10	12	8	3.6	69
02-05-10	8	9	5	17	78
03-05-10	6	7	5	6.8	81
04-05-10	7	10	5	0	61
05-05-10	9	12	5	0	50
06-05-10	8	13	4	0	53
07-05-10	7	8	5	1.2	76
08-05-10	8	11	7	3.8	72
09-05-10	8	10	6	0.8	66
10-05-10	7	9	3	0	53
11-05-10	7	10	5	8.6	46
12-05-10	6	7	4	25.8	81
13-05-10	7	10	6	0.2	70
14-05-10	9	11	5	0	35
15-05-10	9	13	3	0	57
16-05-10	11	13	8	0	50
17-05-10	11	14	9	0.8	67
18-05-10	10	12	7	0	62
19-05-10	12	14	9	0	55
20-05-10	13	18	7	0	42
21-05-10	13	16	9	0	70
22-05-10	13	15	9	0	76
23-05-10	15	21	9	0	60
24-05-10	16	20	13	0	61
25-05-10	12	14	9	0	53
26-05-10	10	14	6	0	46
27-05-10	11	14	8	0.2	52
28-05-10	11	15	7	0	48
29-05-10	13	20	6	2.6	33
30-05-10	12	14	10	5.4	69
31-05-10	13	17	10	1.2	64
01-06-10	13	18	7	0	66
02-06-10	14	18	9	0	62
03-06-10	15	20	9	0	49
04-06-10	15	20	8	0	53
05-06-10	17	23	8	0	42
06-06-10	18	25	12	2.4	48
07-06-10	14	16	12	0.2	76
08-06-10	15	23	11	7.6	47
09-06-10	17	19	15	3.2	80
10-06-10	18	21	15	2.8	77
11-06-10	17	20	13	0.4	79
12-06-10	14	16	10	0	62
13-06-10	14	17	10	0	46
14-06-10	16	19	12	0	48
15-06-10	13	16	9	0	51

Weather data Lelystad half June - July 2010

date	T-gem (°C)	T-max (°C)	T-min (°C)	rainfall (mm)	RH-min (%)
16-06-10	14	20	8	0	50
17-06-10	15	22	9	0	39
18-06-10	13	15	11	0.6	63
19-06-10	11	13	9	17.6	64
20-06-10	11	12	10	1.6	64
21-06-10	13	15	11	0	61
22-06-10	13	18	6	0	56
23-06-10	17	24	10	0	40
24-06-10	19	25	12	0	43
25-06-10	18	22	14	0	52
26-06-10	18	23	12	0	43
27-06-10	20	27	12	0	31
28-06-10	21	27	13	0	41
29-06-10	19	25	14	0.4	42
30-06-10	18	23	13	10	68
01-07-10	20	25	14	0	56
02-07-10	25	32	18	0	35
03-07-10	22	25	19	6.4	64
04-07-10	20	25	16	0	44
05-07-10	18	22	16	0	56
06-07-10	17	20	13	0	49
07-07-10	18	25	9	0	32
08-07-10	21	25	16	0	44
09-07-10	24	33	15	0	27
10-07-10	24	30	18	0.2	40
11-07-10	23	29	19	22.4	52
12-07-10	21	25	17	10.2	65
13-07-10	20	25	14	3.4	51
14-07-10	22	29	18	10	43
15-07-10	18	21	16	0	57
16-07-10	18	23	14	4.2	52
17-07-10	16	20	14	3.2	59
18-07-10	17	23	11	0	42
19-07-10	20	26	13	0	37
20-07-10	23	30	15	0	36
21-07-10	22	25	17	0	51
22-07-10	19	22	15	0	54
23-07-10	18	22	13	0	43
24-07-10	17	19	14	0	47
25-07-10	16	21	11	0.2	52
26-07-10	17	20	16	1.4	69
27-07-10	18	22	16	0.2	52
28-07-10	18	21	17	0	59
29-07-10	16	18	15	13.4	69
30-07-10	17	21	14	0	48
31-07-10	17	21	14	0	71

+ 09-07-2010 15 mm per hectare irrigated

Weather data Lelystad Augustus - half September 2010

date	T-gem (°C)	T-max (°C)	T-min (°C)	rainfall (mm)	RH-min (%)
01-08-10	19	22	16	0	53
02-08-10	16	19	13	0.4	70
03-08-10	17	21	12	0	55
04-08-10	16	18	14	0.4	72
05-08-10	16	19	13	0.4	62
06-08-10	16	22	9	0	42
07-08-10	16	20	14	0.2	67
08-08-10	17	20	15	0	71
09-08-10	18	22	15	0	46
10-08-10	17	21	13	3.2	64
11-08-10	18	21	14	2.4	49
12-08-10	14	19	9	11.4	60
13-08-10	15	20	10	8.2	53
14-08-10	17	23	11	0	51
15-08-10	17	20	15	6.2	65
16-08-10	19	21	17	21.2	62
17-08-10	16	18	15	21.8	85
18-08-10	17	19	16	8.6	54
19-08-10	17	21	14	0	46
20-08-10	20	26	14	0	42
21-08-10	20	24	17	0	66
22-08-10	20	22	17	0	72
23-08-10	18	20	17	4.8	67
24-08-10	16	19	13	16.8	51
25-08-10	16	19	14	2.6	56
26-08-10	14	16	13	39.8	94
27-08-10	14	16	13	27.4	67
28-08-10	14	16	12	8.4	68
29-08-10	13	16	10	21	69
30-08-10	14	17	10	28.4	64
31-08-10	14	17	12	0	65
01-09-10	12	17	8	0.2	60
02-09-10	13	16	8	0	76
03-09-10	13	18	8	0	63
04-09-10	14	18	9	0	59
05-09-10	13	18	7	0	51
06-09-10	14	20	9	0	40
07-09-10	12	13	10	8.2	63
08-09-10	14	19	12	4	76
09-09-10	15	19	12	0.6	67
10-09-10	15	19	12	5.6	75
11-09-10	18	23	14	0	52
12-09-10	16	18	13	0.6	72
13-09-10	15	19	11	0	52
14-09-10	16	17	13	29.6	87
15-09-10	14	16	11	10	49

Appendix 4. Late blight assessments

Percentage of foliage destroyed by late blight per plot

Plot	Treatment	Replication	26/7	30/7	3/8	9/8	12/8	18/8
12	a	1	0,02	0,5	8	40	60	85
18	a	2	0,5	1	8	30	75	95
35	a	3	0,1	4	20	40	75	95
41	a	4	4	2	20	15*	35*	92*
8	b	1	0,003	0,002	0,1	0,5	6	20
24	b	2	0	0,003	0,5	2	5	50
31	b	3	0	0	0,5	1	10	60
40	b	4	0	0,001	0,1	2	7	40
9	c	1	0,2	3	6	15	30	90
26	c	2	0,001	0,01	7	10	45	92
29	c	3	3	8	18	30	65	98
45	c	4	0,1	5	15	12	30	85
7	d	1	5	10	12	15	45	85
23	d	2	4	8	10	30	80	97
32	d	3	0,01	0,01	8	20	65	95
51	d	4	0,01	0,01	5	4	25	85
3	e	1	1	1	6	15	60	90
21	e	2	0,001	0,1	5	15	65	95
39	e	3	0,002	1	3	18	60	92
44	e	4	0,5	2	8	20	50	90
5	f	1	1	1	5	20	65	88
17	f	2	1	1	6	20	70	95
36	f	3	0	5	8	35	75	95
42	f	4	1	4	10	25	70	92
11	g	1	0,5	3	4	3	15	85
15	g	2	5	6	10	15	60	92
37	g	3	5	10	20	40	65	95
48	g	4	5	4	8	8	20	85
6	h	1	0,01	0,01	2	10	50	80
25	h	2	0,01	0,5	5	8	35	90
30	h	3	0,1	3	8	35	70	95
46	h	4	0,01	0,01	5	18	35	75
1	i	1	4	2	8	25	60	92
16	i	2	2	5	12	35	80	95
38	i	3	0,003	1	5	20	60	92
43	i	4	1	3	18	25	65	92
10	j	1	0	0	0,1	1	8	30
14	j	2	0,001	0,003	0,5	2	25	70
34	j	3	0	0	0,1	1	12	65
49	j	4	0	0,002	0	2	10	60
2	k	1	0	0	0,1	1	5	45
22	k	2	0,001	0	0	2	6	45
33	k	3	0,01	0,01	0,1	0,5	7	35
52	k	4	0,001	0,001	0	0,1	1	15
4	l	1	7	5	8	5	10	60
20	l	2	0,1	3	7	4	15	75
27	l	3	3	3	5	6	25	90
50	l	4	4	4	8	5	30	85
13	m	1	0	0	0,5	3	8	50
19	m	2	0,01	0,5	4	4	25	65
28	m	3	0,01	0,01	5	20	45	85
47	m	4	0,001	0,001	2	8	25	70

plot 41 was sprayed by mistake on 29/7 with 600 g Cu/ha

Appendix 5. Tuber yield

Number and weight of tubers affected with late blight or bacterial diseases, nett and total

			number of tubers/10 m2				weight of tubers: kg/are			
Plot	Treatment	Replication	nett	P.inf.	Erwinia	total	nett	P.inf.	Erwinia	total
12	A	1	482,9	11,4	1,0	495,2	344,9	6,2	0,8	352,0
18	A	2	476,2	10,5	1,0	487,6	346,3	5,2	0,2	351,6
35	A	3	460,0	1,9	1,0	462,9	348,6	2,0	0,3	351,0
41	A	4	407,6	8,6	1,0	417,1	361,0	5,9	0,3	367,1
8	B	1	403,8	7,6	1,0	412,4	378,2	9,1	1,1	388,5
24	B	2	445,7	13,3	2,9	461,9	385,3	5,1	1,1	391,5
31	B	3	463,8	15,2	1,9	481,0	355,5	9,2	1,2	365,8
40	B	4	413,3	23,8	4,8	441,9	353,1	17,6	3,9	374,6
9	C	1	426,7	8,6	1,0	436,2	375,5	8,8	0,4	384,7
26	C	2	480,0	6,7	0,0	486,7	371,3	1,5	0,0	372,7
29	C	3	563,8	7,6	1,9	573,3	405,8	2,3	0,9	409,0
45	C	4	469,5	9,5	1,9	481,0	384,2	7,8	0,9	392,8
7	D	1	447,6	13,3	0,0	461,0	352,7	7,6	0,0	360,3
23	D	2	461,9	4,8	1,0	467,6	359,7	3,4	0,4	363,4
32	D	3	512,4	12,4	0,0	524,8	420,8	0,4	0,0	421,3
51	D	4	507,6	5,7	1,9	515,2	412,9	3,2	0,7	416,8
3	E	1	451,4	13,3	0,0	464,8	325,3	8,1	0,0	333,4
21	E	2	435,2	13,3	1,9	450,5	354,2	4,4	3,1	361,7
39	E	3	511,4	0,0	1,0	512,4	389,0	0,0	0,6	389,6
44	E	4	495,2	12,4	1,9	509,5	362,8	7,4	1,8	372,0
5	F	1	424,8	1,9	2,9	429,5	326,1	1,9	2,6	330,6
17	F	2	509,5	3,8	0,0	513,3	361,5	0,6	0,0	362,1
36	F	3	461,0	4,8	2,9	468,6	355,8	1,3	2,4	359,5
42	F	4	476,2	4,8	2,9	483,8	366,7	3,4	1,0	371,1
11	G	1	485,7	16,2	1,0	502,9	365,8	8,1	0,3	374,3
15	G	2	382,9	5,7	2,9	391,4	344,6	3,4	1,1	349,0
37	G	3	527,6	6,7	0,0	534,3	388,2	2,1	0,0	390,3
48	G	4	471,4	6,7	1,0	479,0	379,1	2,8	1,9	383,8
6	H	1	493,3	4,8	0,0	498,1	353,1	1,0	0,0	354,1
25	H	2	446,7	7,6	1,9	456,2	357,4	3,6	0,6	361,6
30	H	3	469,5	7,6	1,9	479,0	340,0	1,3	0,9	342,1
46	H	4	481,9	14,3	1,9	498,1	380,2	8,3	1,7	390,2
1	I	1	372,4	10,5	1,9	384,8	307,1	3,0	2,2	312,4
16	I	2	442,9	5,7	2,9	451,4	367,0	1,9	2,6	371,5
38	I	3	475,2	5,7	2,9	483,8	359,3	3,2	2,3	364,8
43	I	4	476,2	3,8	2,9	482,9	353,5	2,4	1,8	357,8
10	J	1	418,1	9,5	1,0	428,6	373,9	12,8	0,8	387,4
14	J	2	391,4	22,9	3,8	418,1	365,3	21,8	3,3	390,4
34	J	3	488,6	17,1	1,0	506,7	408,0	9,9	0,6	418,5
49	J	4	463,8	9,5	2,9	476,2	384,9	6,9	0,5	392,2
2	K	1	422,9	24,8	1,0	448,6	349,4	22,0	0,3	371,7
22	K	2	436,2	8,6	1,9	446,7	378,6	3,5	0,9	383,0
33	K	3	510,5	12,4	3,8	526,7	429,4	7,4	1,8	438,7
52	K	4	414,3	10,5	3,8	428,6	369,1	8,5	3,3	380,9
4	L	1	428,6	15,2	1,9	445,7	337,0	11,2	0,7	349,0
20	L	2	476,2	1,9	2,9	481,0	374,6	1,1	2,1	377,9
27	L	3	359,0	7,6	13,3	380,0	328,6	4,1	14,5	347,2
50	L	4	481,0	6,7	1,9	489,5	387,1	2,9	1,5	391,5
13	M	1	534,3	11,4	1,9	547,6	415,0	8,0	1,0	424,1
19	M	2	449,5	8,6	1,9	460,0	367,3	4,7	1,4	373,4
28	M	3	442,9	24,8	5,7	473,3	352,0	1,3	6,2	359,5
47	M	4	497,1	10,5	1,9	509,5	393,7	5,0	2,7	401,3

Het doel van Bioconnect is het verder ontwikkelen en versterken van de biologische landbouwsector door het initiëren en uitvoeren van onderzoeksprojecten. In Bioconnect werken ondernemers (van boer tot winkelvloer) samen met onderwijs- en onderzoeksinstellingen en adviesorganisaties. Dit leidt tot een vraaggestuurde aanpak die uniek is in Europa.

Bioconnect
Het innovatienetwerk van biologische agroketens

Het Ministerie van Economische Zaken, Landbouw en Innovatie is financier van de onderzoeksprojecten

Ministerie van Economische Zaken, Landbouw en Innovatie

Wageningen UR (University & Research centre) en het Louis Bolk Instituut zijn de uitvoerders van het onderzoek. Op dit moment zijn dit voor de biologische landbouwsector ongeveer 140 onderzoeksprojecten.

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