Efficacy of different insecticides to control the green peach aphid (*Myzus persicae*), black bean aphid (*Aphis fabae*) and virus yellows in sugar beets in the Netherlands in 2022

Results of field trial 22-11-12.05 at Westmaas (NL)

Elma Raaijmakers (IRS)

23R05
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Samenvatting

Vergelingsziektevirus wordt overgebracht door bladluizen, waarvan de groene perzikluis (*Myzus persicae*) de meeste efficiënte vector is. De drie belangrijkste soorten vergelingsziektevirussen in suikerbieten zijn: Beet Yellows Virus (BYV), Beet Chlorotic Virus (BChV) en Beet Mild Yellowing Virus (BMYV). De virussen kunnen worden beheerst door de bladluizen te bestrijden. Doel van deze veldproef is de effectiviteit bepalen van verschillende soorten insecticiden voor de bestrijding van groene perzikluizen. Omdat de zwarte bonenluis van nature ook voorkwam in de proef, is het effect op deze bladluissoort ook meegenomen.

Er is een proefveld aangelegd in Westmaas waarbij groene perzikluizen op 17 mei 2022 in het 8-10 bladstadium werden uitgezet. Vervolgens zijn diverse insecticiden gespoten.

Op basis van dit proefveld kunnen de volgende conclusies worden getrokken:

- een volveldstoepassing met Teppeki, IRS 770, IRS 789, IRS 810 en/of IRS 785 was effectief in de beheersing van groene perzikluizen (*Myzus persicae*);
- een volveldstoepassing met Teppeki, IRS 770 + Teppeki, IRS 789, IRS 810 en/of IRS 785 was effectief in de beheersing van vergelingsziekte;
- IRS 803 was niet effectief in de beheersing van groene perzikluizen en/of vergelingsziekte;
- een volveldstoepassing met Teppeki, IRS 810 en/of IRS 785 was effectief in de beheersing van zwarte bonenluizen (*Aphis fabae*);
- IRS 803, IRS 770 en IRS 789 waren niet effectief in de beheersing van zwarte bonenluizen;
- een rijentoepassing met Teppeki of IRS 785 resulteerde in dezelfde effectiviteit als een volveldstoepassing met deze systemische insecticiden met betrekking tot de beheersing van groene perzikluizen, zwarte bonenluizen en/of vergelingsziekte;
- een rijentoepassing reduceerde de hoeveelheid actieve stof per hectare suikerbieten met 68%;
- volveldstoepassingen met Teppeki, IRS 770 + Teppeki, IRS 789 en/of IRS 785 en rijentoepassingen met Teppeki en/of IRS 785 leidden tot een significant hogere opbrengst dan bij de onbehandelde controle.

Summary

Virus yellows is an important disease in sugar beet. Virus yellows is caused by the viruses Beet Yellows Virus (BYV), Beet Chlorotic Virus (BChV) and Beet Mild Yellowing Virus (BMYV), which can cause up to 50%, 30% and 35% yield reduction, respectively. The green peach aphid (*Myzus persicae*) is the most important vector. The spread of the virus in a sugar beet field can be controlled by controlling aphids with insecticides. Also the black bean aphid (*Aphis fabae*) can cause problems in sugar beet. This aphid has a much higher damage threshold, since damage to sugar beets is mainly caused by feeding from the leaves and it hardly transmits viruses. Because this is a dominant species in sugar beet and it was present in the field trial, it was also taken into account in this report.

Different insecticides were compared with a treatment without insecticide.
Therefore a field trial was conducted in Westmaas. In this trial, green peach aphids were inoculated in sugar beet in the 8-10 leaf stage (BBCH 18-19) at the 17th of May, 2022. Plots were sprayed with insecticides according to the protocols.

The aim was to study the efficacy of different insecticides on the control of aphids and virus yellows in sugar beet. From this trial it can be concluded that:

- broadcast applications with Teppeki, IRS 770, IRS 789, IRS 810 and IRS 785 were effective in the control of green peach aphids (*Myzus persicae*);
- broadcast applications with Teppeki, IRS 770 + Teppeki, IRS 789, IRS 810 and IRS 785 were effective in the control of BMYV;
- IRS 803 was not effective in the control of green peach aphids and/or virus yellows;
- a broadcast application with Teppeki, IRS 810 and IRS 785 was effective in the control of black bean aphids (*Aphis fabae*);
- IRS 803, IRS 770 and IRS 789 were not effective in the control of black bean aphids;
- a band application with Teppeki or IRS 785 had the same efficacy as a broadcast application in the control of green peach aphids, black bean aphids and/or virus yellows;
- band applications reduced the amount of insecticide per hectare with 68%.
- broadcast applications with Teppeki, IRS 770 + Teppeki, IRS 789 or IRS 785 and band applications with Teppeki or IRS 785 resulted in a higher yield compared to the untreated control.

1. Introduction

Virus yellows is an important disease in sugar beet. Virus yellows is caused by the viruses Beet Yellows Virus (BYV), Beet Chlorotic Virus (BChV) and Beet Mild Yellowing Virus (BMYV), which can cause up to 50%, 30% and 35% yield reduction, respectively. The green peach aphid (*Myzus persicae*) is the most important vector. The spread of the virus in a sugar beet field can be controlled by controlling aphids with insecticides. Since virus yellows occurs in spots in the field, it is recommended to artificially inoculate field trials with *Myzus persicae* infected with one the viruses to achieve a homogeneous distribution of virus in field trials.
The black bean aphid (*Aphis fabae*) can also cause damage in sugar beet. This aphid has a much higher damage threshold compared to the green peach aphid, since damage to sugar beets is mainly caused by feeding from the leaves and it hardly transmits viruses. Because this is an important species in sugar beet, it is also taken into account in this research.
Since 2019, several field trials were conducted to test the efficacy of new insecticides and/or new spraying techniques against aphids and virus yellows. This is necessary for farmers to have enough active ingredients to control aphids and virus yellows in the future and to achieve the goals of the Farm-to-Fork strategy of the European Commission, in which it is mentioned that farmers have to reduce the amount of pesticides in 2030 compared to the reference years 2015-2017. It is important to have different active ingredients available for farmers to prevent the development of insecticide resistant aphids. It has already been reported that *Myzus persicae* can be resistant against different insecticides, like pyrethroïds and pirimicarb (Bass et al., 2014).

This field trial was conducted under Good Experimental Practises (GEP, Annex A).

2. Materials and methods

2.1 Trial site

The field trial was located in a sugar beet field in Westmaas, the Netherlands (Annex B).

2.2 List of products

Table 1 gives an overview of the treatments used in this study. Sugar beet seeds of the variety Leontina KWS were treated and delivered by KWS (Einbeck, Germany). All seeds, including the untreated control, were treated with the fungicide Tachigaren (14.7 g hymexazol per 100.000 seeds) and the insecticide Force (10 g tefluthrin per 100.000 seeds) to prevent influences of fungi and soil pests on plant establishment. Tefluthrin does not have any effect on green peach or black bean aphids (Wauters & Dewar, 1995). A homogeneous plant establishment in this trial is necessary, since the spread of virus yellows is influenced by plant spacing (Heathcote, 1974).

2.3 Drilling

Drilling was done with a precision sowing machine (Monosem Mecca 2017) adapted for sowing of field trials. Sowing distance within the rows was 18.0 cm and 50 cm between rows. The field trial was sown on the 16th of March, 2022. The trial was designed as randomised blocks in four replications (Annex C). Gross plot size: 3 meters wide (6 rows) and 16 meters long. Nett plot size: 3 meters wide (6 rows) and 12 meters long. General field data can be found in Annex D.

2.4 Inoculation with aphids

To obtain a homogenous distribution of green peach aphids and BMYV, the trial was inoculated with reared green peach aphids infected with BMYV in BBCH18-19 on the 17th of May, 2022 (treatments 1, 3-10).
In 2021, sugar beets containing Beet Mild Yellowing virus (BMYV) were collected from a sugar beet field in Klaaswaal (Netherlands; IRS diagnostic sample 21-260-1). These sugar beets were potted in a sand-potting soil mixture with a ratio of 1:1 and were placed in the climate chambers at IRS (Dinteloord). Climate room conditions were 23°C for 16 hours under LED lights and at 16°C for 8 hours in the dark each day. Green peach aphids (*Myzus persicae*), originally obtained from the Laboratory of Entomology of Wageningen University and Research (NL) in 2018, were transferred from virus free sugar beets to the leaves of the infected sugar beets. After 48 hours, the aphids were collected and transferred to six week old sugar beet plants (grown in 700 ml pots; variety Kleist, Strube GmbH, Söllingen, Germany) in the climate chambers and placed in an aphid rearing cage. Every three to four weeks, leaves with aphids were cut off and transferred to new, six weeks old plants to maintain the culture of BMYV containing green peach aphids in the climate chambers.
For field inoculation, leaves with aphids from the plants with BMYV in aphid rearing cages in the climate chambers were cut off and carefully transported to the field trials in small boxes. Three plants in row 2 and three plants in row 5 of each plot were marked with yellow sticks and inoculated with ten aphids per plant, by transferring the aphids using a small paint brush. Plant numbers 10, 20 and 30, counting from the beginning of row 2 and from the end of row 5, were inoculated. All plots were inoculated, except plots of treatment 2 (non-inoculated control).
One day before inoculation (16th of May, 2022), the commercial field (except for the field trial) was sprayed with Teppeki (0.14 kg/ha) to prevent spread of aphids over the field.

2.5 Application of treatments

Treatment 1 was the inoculated, untreated control. Treatments 2 to 10 were sprayed according to the schedule in table 1. Insecticides in treatments 2 to 8 were applied with a broadcast application, where the entire area of each plot was sprayed. Applications of these treatments were conducted by Wageningen Plant Research (WPR; location Westmaas), using a CHD field trial sprayer (system Van der Wey, with Lechler Nozzle 120-02 at 3.0 bar, at 2.3 km/h and 400 liter spraying solution per hectare) to apply the different treatments (Annex D). These nozzles had a 75% drift reduction at the pressure used (TCT, 2019). Applications of treatments 9 and 10 were conducted by IRS, using an row sprayer (6 rows width, with Nozzle 6503 E, at 3.6 km/h and 300 liters spraying solution per hectare). With the band sprayer the dosage was kept the same as with the broadcast sprayer, but only 16 centimeters out of 50 centimeters row width was sprayed (32%), resulting in a 68% reduction in active ingredient per hectare of sugar beets.

2.6 Assessment of efficacy

The effect of various treatments on the plants and aphids was measured by assessing plant establishment, the number of aphids and other insects per plant, phytotoxicity, vigour, canopy closure and percentage of plants with virus yellows.
Final plant stand density was determined at BBCH 14 (4th of May) by counting the number of plants in the middle four rows of each plot. Plant stand density was determined by calculating the percentage of plants related to the number of seeds sown.

Efficacy of the treatments on aphids was established by counting the number of green peach aphids and naturally occurring black bean aphids per plant on various moments in time (Table 2). On the same plants, the number of other aphids and the number of beneficials (e.g. eggs, larvae and adults of ladybird beetles, soldier beetles, spiders, parasitic wasps, hoverflies, lacewings) were counted as well (data only shown in Annexes). Based on the aphid data, percentage of plants with green peach aphids, black bean aphids and total aphids were calculated (data only shown in Annex I).

Table 2. Overview of dates and assessed plants during aphid observations. Plants were assessed for aphids, other pests and beneficials. Plants were counted starting at the beginning of row 2 and 4 and at the end of row 3 and 5.

date	*days after aphid inoculation*	*rows counted*	*plant number counted in each row*	*leaf stage*
23-5-2022	6	2*, 5*	5, 10**, 15, 20**, 25, 30**	BBCH31
27-5-2022	10	2*, 5*	5, 10**, 15, 20**, 25, 30**	BBCH33
1-6-2022	15	2*, 5*	5, 10**, 15, 20**, 25, 30**	BBCH35
14-6-2022	28	2*, 5*	10**, 20**, 30**	BBCH39

* row with inoculated plants.
** inoculated plant.

Plants were scored for symptoms of phytotoxicity when they showed stunting, deformation, discoloration, necrosis or chlorosis caused by insecticide application. The percentage of plants showing phytotoxicity symptoms was assessed on the 27th of May, 29th of June and 15th of July. In addition, whole plots were scored for vigour on a scale from 1 (dead crop) to 10 (highly vigorous crop) on 2nd of June.

The number of plants showing symptoms of yellowing were counted in the middle four rows (row 2-5) of each plot on 29th of June, the 15th of July, 29th of July, 26th of August and the 20th of September. The percentage of plants with yellowing virus was calculated based on the total number of emerged plants on the 4th of May.

2.7 Harvest

The field trial was harvested on 22nd of September 2022 with the six row sugar beet harvester of IRS (PASSI). From each plot the gross weight was measured and a subsample of 60-80 kg was taken to the tare house of Cosun Beet Company (Dinteloord, NL). The soil tare, sugar-, potassium-, sodium-, amino nitrogen-, and glucose content was determined. Based on quality assessments and net weight (=gross weight - soil tare), sugar percentage, sugar yield (t/ha) and financial yield (€/ha, based on 45 €/ton sugar beets with 17% sugar) were calculated. Costs of spraying and products were not taken into account.

2.8 Analysis of data

Since data on number of aphids per plant did not follow a normal distribution, these data were log transformed ($y = \log10(x+1)$) before statistical analysis.
Data was analysed by using a one-way ANOVA using Fisher Protected LSD. Analyses were performed using Genstat Software Package 21.0.

Table 1. Overview of treatments in the field trial in Westmaas, 2022 (trial code: 22-11-12.05). Trial was inoculated with green peach aphids (*Myzus persicae*) on the 17th of May.

number	*treatment*	*Treatment*				
		16 May	19 May	25 May	1 June	7 June
1	untreated control	-	-	-	-	-
2	not inoculated control + Teppeki[1]	-	Teppeki (0.14 kg/ha)	-	-	-
3	Teppeki	-	Teppeki (0.14 kg/ha)	-	-	-
4	IRS 770 + Teppeki	-	IRS 770 (0.25 l/ha) + Actirob (1 l/ha)	-	Teppeki (0.14 kg/ha)	-
5	IRS 803	-	IRS 803 (2.5 l/ha) + Dynex (1.5 l/ha)[3]	IRS 803 (2.5 l/ha) + Dynex (1.5 l/ha)	IRS 803 (2.5 l/ha) + Dynex (1.5 l/ha)	IRS 803 (2.5 l/ha) + Dynex (1.5 l/ha)
6	IRS 789	IRS 789 (0.75 l/ha) + Actirob (2 l/ha)	-	-	IRS 789 (0.75 l/ha) + Actirob (2 l/ha)	-
7	IRS 810	-	IRS 810 (0.2 l/ha)	-	-	-
8	IRS 785	-	IRS 785 (0.25 kg/ha)	-	-	-
9	IRS 785 (band application)[2]	-	IRS 785 (0.080 kg/ha)[2]	-	-	-
10	Teppeki (band application)[2]	-	Teppeki (0.045 kg/ha)[2]	-	-	-

[1] This treatment was sprayed with Teppeki (0.14 kg/ha) to prevent damage by naturally occurring green peach aphids.
[2] This treatment was sprayed with a row sprayer (16 cm of the row was sprayed instead of 50 cm). The concentration of the treatment was kept similar as in treatment 3 and 8, which means that only 32% of the dosage was used compared to a full field application.
[3] Due to heavy rain on the 19th of May just after application, this treatment was repeated on the 20th of May, because this was a contact insecticide. All other insecticides were systemic insecticides.

3. Results and discussion

3.1 Effect on phytotoxicity and vigour

No symptoms of phytotoxicity were observed in any of the treatments at any assessment date (Table 3; Annex F) and also, no significant effect on vigour at canopy closure was observed between treatments (Table 4; Annex F).

Table 3. Number of plants showing symptoms of phytotoxicity.

treatment		*phytotox*		
		27 May	29 June	15 July
1	untreated control	0	0	0
2	not inoculated control + Teppeki	0	0	0
3	Teppeki	0	0	0
4	IRS 770 + Teppeki	0	0	0
5	IRS 803	0	0	0
6	IRS 789	0	0	0
7	IRS 810	0	0	0
8	IRS 785	0	0	0
9	IRS 785 (band application)	0	0	0
10	Teppeki (band application)	0	0	0

Table 4. Plant vigour (1=dead; 10=highly vigorous crop) at 2nd of June (Westmaas, 2022).

treatment		*vigour*
1	untreated control	7.3
2	not inoculated control + Teppeki	7.8
3	Teppeki	7.5
4	IRS 770 + Teppeki	7.6
5	IRS 803	7.3
6	IRS 789	7.3
7	IRS 810	7.5
8	IRS 785	7.5
9	IRS 785 (band application)	7.0
10	Teppeki (band application)	7.5
P		0.269
LSD 5%		-
significance		not significant

3.2 Effect on aphids

On the 23rd of May, plants of all treatments had significantly less green peach aphids compared to the plants of the untreated control, except for plants of treatment IRS 770 and IRS 803 (Table 5; Annexes E and I). IRS 803 had significantly more green peach aphids than the untreated control.

On the 27th of May, 1st of June and 14th of June, plants in plots of all treatments, except IRS 803 (treatment 5), had significantly less green peach aphids compared to the untreated control. Treatments 2, 4, 6, 7, 8, 9 and 10 did not differ significantly from the control treatment with Teppeki (treatment 3).

The treatments with a band application (treatment 9 and 10), in which only 32% of the ground surface were sprayed, were not significantly different in the number of green aphids per plant from treatments 3 (Teppeki) and 8 (IRS 785). This means that the amount of the insecticides per hectare can be reduced by band spraying on small plants without any reduction of the efficacy of these systemic products to control green peach aphids.

Table 5. Average number of green peach aphids (*Myzus persicae*) per plant on the 23rd and 27th of May and 1st and 14th of June. Plants were inoculated with green peach aphids on the 17th of May (Westmaas, 2022). Different letters indicate significant differences within a column.

treatment		*mean number of green peach aphids per plant*							
		23 May		27 May		1 June		14 June	
1	untreated control	2.3	b	10.6	a	7.4	a	9.4	a
2	not inoculated control + Teppeki	0.6	d	0.6	cd	1.5	bcd	2.1	b
3	Teppeki	0.8	cd	1.1	bcd	1.4	bcde	1.0	bcd
4	IRS 770 + Teppeki	2.2	bc	3.1	b	3.5	bc	0.0	d
5	IRS 803	5.2	a	10.6	a	12.4	a	6.3	a
6	IRS 789	0.2	d	0.6	cd	1.3	bcde	2.1	bc
7	IRS 810	0.6	d	1.6	bc	2.3	b	2.4	b
8	IRS 785	0.4	d	0.7	cd	1.0	cde	1.8	bc
9	IRS 785 (band application)	0.1	d	0.1	d	0.5	de	1.0	bcd
10	Teppeki (band application)	0.3	d	0.1	d	0.4	e	0.5	cd
P		<0.001		<0.001		<0.001		<0.001	
significance		very significant		very significant		very significant		very significant	

[1] Data is log transformed for statistical analysis, therefore LSD-value is not available.

On the 23rd of May, plants of all treatments had significantly less black bean aphids compared to the untreated control, except for treatment 2, 4, 5 and 6 (Table 6; Annexes E and I). Treatments 2, 7, 8, 9 and 10 were not significantly different in number of black bean aphids per plant from the treatment with Teppeki (treatment 3).

On the 27th of May and 1st of June, all treatments had significantly less black bean aphids per plant compared to the untreated control, except for treatment 4, 5 and 6. Treatments 2, 6, 7, 8, 9 and 10 were not significantly different from the treatment with Teppeki (treatment 3).

On the 14th of June, treatment 4 had significantly less aphids compared to the untreated control. This is an effect of the treatment with Teppeki on the 1st of June in this treatment. Although treatment 9 (band application with IRS 785) did not differ significantly from the

untreated control anymore, it was also not significantly different from treatment 8 (broadcast application with IRS 785).

The treatments with a band application (treatment 9 and 10), in which only 32% of the ground surface was sprayed, were not significantly different from treatments 3 (Teppeki) and 8 (IRS 785) in the number of black bean aphids per plant. This means that the total amount of insecticides per hectare can be reduced by band spraying on small plants without any reduction of the efficacy of these systemic products to control black bean aphids.

Table 6. Average number of natural occurring black bean aphids (*Aphis fabae*) per plant 4 days (23 May), 8 days (27 May), 13 days (1 June) and 26 days (14 June; 13 days after T2) after T1 (Westmaas, 2022). Different letters indicate significant differences within a column.

treatment		*mean number of black bean aphids per plant*							
		23 May		27 May		1 June		14 June	
1	untreated control	29.7	ab	115.0	a	169.2	a	414.8	a
2	not inoculated control + Teppeki	12.0	abc	4.6	cde	5.0	cd	1.8	d
3	Teppeki	3.7	c	4.1	de	4.6	d	8.4	bcd
4	IRS 770 + Teppeki	25.0	ab	68.3	ab	30.0	ab	32.9	bcd
5	IRS 803	34.9	a	34.8	abc	77.2	a	87.2	abc
6	IRS 789	18.7	abc	83.0	abcd	42.7	abc	186.1	ab
7	IRS 810	3.2	c	50.1	bcde	8.0	bcd	27.9	bcd
8	IRS 785	1.8	c	4.8	cde	8.8	bcd	16.3	bcd
9	IRS 785 (band application)	1.8	c	1.6	e	7.5	bcd	45.3	abc
10	Teppeki (band application)	11.4	bc	27.4	cde	3.6	cd	4.1	cd
P		0.015		0.015		0.004		0.031	
significance		significant		significant		significant		significant	

[1] Data is log transformed for statistical analysis, therefore LSD-value is not available.

3.3 Effect on virus yellows

At the 29th of June, six weeks after inoculation with green peach aphids, the first assessments was done on the percentage of plants with virus yellows per plot (Table 7; Annex G). Treatments 2, 4, 6, 8, 9 and 10 had significantly a lower percentage of plants with virus yellows compared the untreated control. Treatment 3 (control treatment with Teppeki) was at that time not significantly different from the untreated control yet.

At the 15th of July, 29th of July and 26th of August all treatments, except for treatment 5 (IRS 803) had significantly a lower percentage of plants with virus yellows compared to the untreated control.

At the 26th of August the not inoculated control had significantly the lowest percentage of plants with virus yellows.

Data of the assessment at the 19th of September are not shown, because magnesium deficiency was also visible at that time, making assessment on virus yellows questionable.

Table 7. Average percentage of plants showing yellowing symptoms in the middle four rows per plot. Different letters indicate significant differences within a column.

treatment		*percentage of plants with virus yellows*							
		29 June		15 July		29 July		26 August	
1	untreated control	5.9	ab	43.1	a	49.2	a	68.4	a
2	not inoculated control + Teppeki	0.1	e	2.7	d	4.8	e	11.9	e
3	Teppeki	3.9	bcd	19.5	bc	27.4	bc	46.2	b
4	IRS 770 + Teppeki	2.3	de	13.8	c	16.4	cde	28.9	cd
5	IRS 803	6.8	a	43.1	a	50.4	a	65.3	a
6	IRS 789	2.4	cde	9.6	cd	13.5	de	26.4	d
7	IRS 810	4.7	abc	26.5	b	34.1	b	50.3	b
8	IRS 785	2.8	cd	17.3	bc	22.3	bcd	39.9	bc
9	IRS 785 (band application)	2.1	de	11.3	cd	14.2	cde	28.8	cd
10	Teppeki (band application)	2.9	cd	10.8	cd	15.5	cde	33.0	cd
P		<0.001		<0.001		<0.001		<0.001	
LSD 5%		2.4		11.0		13.5		13.1	
significance		very significant		very significant		very significant		very significant	

3.4 Effect on yield

There was no significant effect of treatment on root yield (table 8; Annex H).
All treatments resulted in a significantly higher percentage of sugar, sugar yield and financial yield compared to the untreated control, except for treatments 5 and 7.
Treatments 3, 4, 6, 8, 9 and 10 had significantly the same financial yield as the not inoculated control, which had the highest financial yield.

Table 8. Average yield per treatment expressed in root weight (t/ha), sugar content (%), sugar yield (t/ha) and financial yield (€/ha). Different letters indicate significant differences within a column. The field trial was harvested on 22nd of September 2022

treatment		*root yield (t/ha)*	*sugar percentage*		*sugar yield (t/ha)*		*financial yield (€/ha)*	
1	untreated control	118.1	16.2	d	19.1	d	4871	d
2	not inoculated control + Teppeki	129.9	17.1	a	22.2	a	5847	a
3	Teppeki	127.3	16.6	bc	21.1	abc	5493	abc
4	IRS 770 + Teppeki	128.5	16.7	ab	21.4	ab	5588	ab
5	IRS 803	121.0	16.3	cd	19.7	cd	5046	cd
6	IRS 789	127.1	16.7	ab	21.2	abc	5549	ab
7	IRS 810	123.4	16.5	bcd	20.3	bcd	5229	bcd
8	IRS 785	129.6	16.8	ab	21.7	ab	5686	ab
9	IRS 785 (band application)	129.8	16.6	bc	21.6	ab	5627	ab
10	Teppeki (band application)	128.4	16.6	bc	21.3	ab	5511	ab
P		0.086	0.004		0.009		0.005	
LSD 5%		-	0.38		1.55		463.4	
significance		not significant	significant		significant		significant	

4. Conclusions

The aim was to study the efficacy of different insecticides on the control of aphids and virus yellows in sugar beet. From this trial, with a high incidence of aphids and virus yellows in the untreated control, it can be concluded that:

- broadcast applications with Teppeki, IRS 770, IRS 789, IRS 810 and IRS 785 were effective in the control of green peach aphids (*Myzus persicae*);
- broadcast applications with Teppeki, IRS 770 + Teppeki, IRS 789, IRS 810 and IRS 785 were effective in the control of BMYV;
- IRS 803 was not effective in the control of green peach aphids and/or virus yellows;
- a broadcast application with Teppeki, IRS 810 and IRS 785 was effective in the control of black bean aphids (*Aphis fabae*);
- IRS 803, IRS 770 and IRS 789 were not effective in the control of black bean aphids;
- a band application with Teppeki or IRS 785 had the same efficacy as a broadcast application in the control of green peach aphids, black bean aphids and/or virus yellows;
- band applications reduced the amount of insecticide per hectare with 68%.
- broadcast applications with Teppeki, IRS 770 + Teppeki, IRS 789 or IRS 785 and band applications with Teppeki or IRS 785 resulted in a higher yield compared to the untreated control.

5. Literature

Bass, C., Puinean, A.M., Zimmer, C.T., Denholm, I., Field, L.M., Foster, S.P., Gutbrod, O., Nauen, R., Slater, R., Williamson, M.S. (2014). The evolution of insecticide resistance in the peach potato aphid, *Myzus persicae*. Insect Biochemistry and Molecular Biology 51: 41-51. doi: 10.1016/j.ibmb.2014.05.003.

Heathcote, G. D. (1974). Effect of plant spacing, nitrogen fertilizer and irrigation on appearance of symptoms and spread of virus yellows in sugar-beet crops. The Journal of Agricultural Science. 82 (1): 53-60. https://doi.org/10.1017/s002185960005022x.

Technische Commissie Techniekbeoordeling (2019). Lijst met indeling van spuitdoppen in DriftReducerende Dop-klassen (DRD-klassen). Versie 1 juli 2019. https://www.sklkeuring.nl/media/files/DRD%20Lijst%201%20juli%202019.pdf.

Wauters, A. & Dewar, A.M. (1995). The effect of insecticide seed treatments on pest of sugar beet in Europe: Results of the IIRB co-operative trials with pesticides added to pelleted seed in 1991, 1992 and 1993. *Parasitica* 51 (4): 143-173.

Annex A GEP CERTIFICATE IRS

Netherlands Food and Consumer
Product Safety Authority
Ministry of Agriculture,
Nature and Food Quality

Certificate

of Official Recognition of Efficacy Testing Organisations in the Netherlands
This certifies that, in conformity with the request of December 13, 2019

Stichting IRS

Residing: Kreekweg 1, Dinteloord the Netherlands

has officially been recognised as an organisation for efficacy testing in the Netherlands.

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 commences on: December 19, 2020
and expires on: December 19, 2026

The above organisation is competent to carry out efficacy trials/tests in the categories mentioned in the annex of this certificate.

Utrecht, October 27, 2020

For the Minister of Agriculture, Nature and Food Quality,

Ton van Arnhem

Director NPPO (National Plant Protection Organization)

CERTIFICATE NUMBER: NL_GEP_04209626

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Annex

ORGANISATION is officially recognised as being competent to carry out efficacy trials/tests in the following categories:

- Outdoor crops of sugar beet and cichory

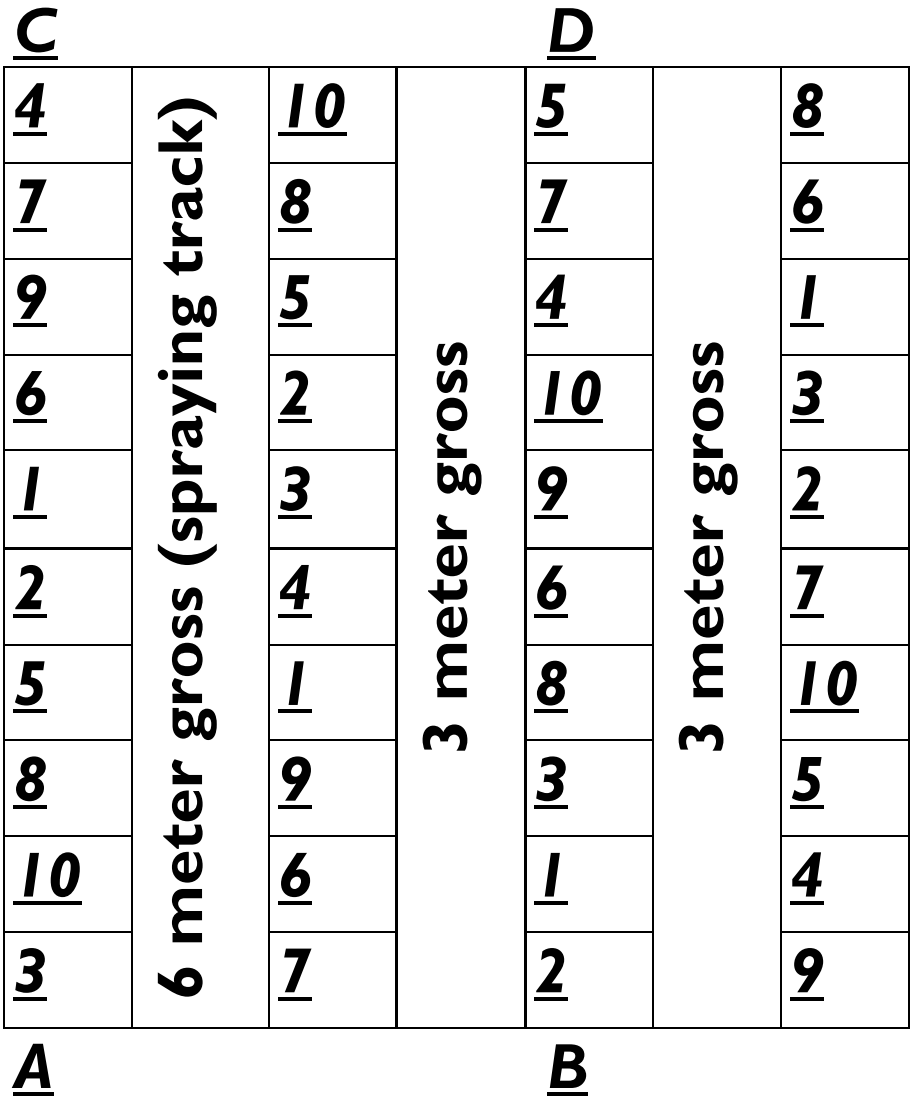
This annex has been approved by Ton van Arnhem
Director NPPO (National Plant Protection Organisation)

Annex B Location field trial

IRS trial field 22-11-12.05
GPS location:
51.789751, 4.453716

Annex C Trail scheme

Trial field:	Westmaas		
Number of replications:	4		
Net size (m):	12×3	Gross size (m):	16×3



Annex D General field data and spraying conditions

soil type:	marine soil (clay loam) Organic matter = 2.6% pH-$CaCl_2$ = 7.3 K-value = 18 clay (<2 µm) = 18% silt (2-50 µm) = 36 % sand (>50 µm) = 36% parts <16 µm = 29% PAL = 44 mg P_2O_5/100g of soil
preceding crop:	2021 winter wheat
drilling date:	16th of March 2022
variety:	Leontina KWS (KWS Einbeck, Germany)
distance in row:	18.0 cm
distance between rows:	50 cm

equipment:	CHD field trial sprayer (system van der Wey); Wageningen Plant Research (WPR; location Westmaas)
speed:	2.3 km/h
nozzle type:	Lechler 120-02
pressure:	3.0 bar
spray volume:	400 l/ha

Table D.1. Overview of weather conditions during insecticide spraying with the CHD field trial sprayer at the field trial in Westmaas (2022).

conditions	*date of spraying*					
	16 May	19 May	20 May	25 May	1 June	7 June
treatments sprayed	6	2, 3, 4, 5, 7, 8	5	5	4, 5, 6	5
BBCH	18-19	19	19	32	35	37
time of spraying (h)	8.00 h	12.00 h	9.30 h	9.15 h	9.00 h	11.30 h
wind speed (km/h)	8	3	8	12	10	8
temperature (°C)	18.0	23.3	15.8	13.5	12.0	17.0
relative humidity (%)	70	74	86	87	90	83
wind direction	S	SW	E	S	W	W

equipment:	row sprayer (IRS, Dinteloord)
speed:	3.6 km/h
nozzle type:	6503 E
spray volume:	300 l/ha

Table D.2. Overview of weather conditions during insecticide spraying with the band application sprayer at the field trial in Westmaas (2022).

conditions	*19 May*
treatments sprayed	9, 10
BBCH	19
time of spraying (h)	19.00 h
wind speed (km/h)	10.8
temperature (°C)	21
relative humidity (%)	76
wind direction	Southwest

Annex E Raw data number of aphids, beneficials and other pests

Table E.1. Mean number of aphids, beneficials and other pests per plant and percentage of plants with aphids per plot at the field trial in Westmaas (23th of May, 2022).

		mean number per plant						*percentage of plants with*		
treatment	*replicate*	green peach aphids	black bean aphids	other aphids	total aphids	total bene-ficials	total other pests	aphids	green peach aphids	black bean aphids
1	A	0.6	19.6	0.5	20.7	0.5	0.3	75	33	58
1	B	2.4	50.6	0.3	53.3	1.9	0.0	92	42	75
1	C	1.9	47.4	1.1	50.4	1.3	0.5	83	33	50
1	D	4.2	1.1	0.1	5.4	0.4	0.1	64	36	36
2	A	1.8	8.7	0.1	10.5	0.3	0.3	83	42	75
2	B	0.1	3.9	0.2	4.2	1.1	0.1	58	8	50
2	C	0.2	35.5	0.3	36.0	0.6	0.1	75	17	58
2	D	0.3	0.1	0.1	0.5	0.2	0.1	33	17	8
3	A	1.4	6.2	1.8	9.4	0.3	0.1	100	58	50
3	B	0.1	4.9	0.1	5.1	2.0	0.3	33	8	25
3	C	1.2	3.0	0.2	4.3	0.9	0.2	67	42	42
3	D	0.5	0.6	0.0	1.1	0.4	0.2	43	29	21
4	A	1.1	5.5	0.2	6.8	3.2	0.2	58	33	42
4	B	5.8	21.0	1.6	28.4	0.6	0.2	92	50	33
4	C	0.8	24.3	0.0	25.0	0.8	0.1	58	42	42
4	D	1.3	49.3	0.1	50.6	0.8	0.1	58	25	33
5	A	3.3	4.8	0.3	8.3	0.3	0.2	75	58	42
5	B	8.5	76.8	0.5	85.8	2.4	0.1	83	58	50
5	C	2.3	30.9	1.6	34.8	0.3	0.0	100	42	75
5	D	6.8	27.3	1.3	35.4	1.1	0.3	92	75	75
6	A	0.3	44.6	0.2	45.0	0.3	0.1	58	8	42
6	B	0.1	2.1	0.0	2.2	1.1	0.1	58	8	58
6	C	0.3	26.6	0.2	27.1	0.6	0.1	70	10	50
6	D	0.0	1.4	0.0	1.4	0.3	0.0	42	0	42
7	A	0.7	6.0	0.2	6.8	0.0	0.1	75	25	58
7	B	1.2	0.3	0.2	1.6	1.1	0.3	58	25	25
7	C	0.3	5.2	0.2	5.6	0.4	0.4	67	25	58
7	D	0.2	1.3	0.1	1.6	0.5	0.2	50	17	25
8	A	0.3	3.3	0.2	3.8	0.2	0.1	50	17	42
8	B	0.1	1.4	0.1	1.6	1.4	0.0	50	8	33
8	C	0.8	0.8	0.1	1.8	0.8	0.0	58	25	25
8	D	0.4	1.7	0.0	2.1	0.2	0.0	50	33	25
9	A	0.0	2.2	0.1	2.3	0.3	0.0	42	0	33
9	B	0.3	1.9	0.0	2.2	0.7	0.0	83	25	75
9	C	0.1	2.1	0.0	2.2	0.4	0.2	42	8	42
9	D	0.1	0.9	0.0	1.0	0.3	0.1	30	10	20
10	A	0.5	38.0	0.2	38.7	4.4	0.1	67	25	67
10	B	0.3	3.2	0.0	3.5	0.6	0.1	42	25	33
10	C	0.3	4.5	0.5	5.3	0.6	0.3	75	17	50
10	D	0.0	0.1	0.3	0.3	0.3	0.0	25	0	8

Table E.2. Mean number of aphids, beneficials and other pests per plant and percentage of plants with aphids per plot at the field trial in Westmaas (27th of May, 2022).

treatment	*replicate*	*mean number per plant*						*percentage of plants with*		
		green peach aphids	black bean aphids	other aphids	total aphids	total bene-ficials	total other pests	aphids	green peach aphids	black bean aphids
1	A	2.4	163.5	0.6	166.5	0.7	0.1	92	67	75
1	B	5.3	123.8	1.6	130.8	0.8	0.0	100	75	92
1	C	28.9	169.5	0.7	199.1	1.3	0.3	100	100	50
1	D	5.8	3.0	0.8	9.6	0.7	0.2	92	75	33
2	A	1.1	4.5	0.0	5.6	0.8	0.7	92	67	58
2	B	0.6	4.7	0.1	5.3	0.8	0.3	67	25	50
2	C	0.3	8.2	0.5	8.9	0.7	0.0	67	25	42
2	D	0.5	1.0	0.1	1.6	0.4	0.0	50	33	17
3	A	1.8	10.8	0.3	12.8	0.7	0.1	92	83	42
3	B	0.7	2.2	0.6	3.4	0.3	0.4	75	50	25
3	C	1.0	3.1	0.1	4.2	1.1	0.2	83	50	58
3	D	1.0	0.3	0.1	1.4	0.8	0.2	58	50	8
4	A	1.8	15.3	0.4	17.6	3.8	0.4	100	50	92
4	B	8.2	13.9	1.2	23.3	0.6	0.2	100	92	58
4	C	1.8	46.5	0.3	48.6	3.5	0.3	75	42	58
4	D	0.8	197.3	0.0	198.1	1.3	0.0	58	42	58
5	A	9.0	14.3	0.3	23.6	1.4	0.0	100	100	58
5	B	12.2	19.1	1.3	32.6	2.0	0.3	92	83	33
5	C	4.2	64.8	0.5	69.4	0.9	0.0	75	58	75
5	D	17.0	40.9	1.2	59.1	0.8	0.3	92	75	50
6	A	0.8	189.3	0.1	190.2	2.6	0.1	83	50	67
6	B	1.0	1.8	0.1	2.8	1.1	0.1	50	25	33
6	C	0.1	140.1	0.0	140.2	0.7	0.0	58	8	50
6	D	0.5	1.0	0.0	1.5	0.4	0.0	42	25	25
7	A	1.8	193.4	0.2	195.3	3.1	0.0	92	50	58
7	B	2.7	0.2	0.4	3.3	0.8	0.0	83	67	17
7	C	0.9	4.4	0.0	5.3	1.0	0.3	58	33	58
7	D	0.9	2.3	0.0	3.3	0.8	0.1	42	25	25
8	A	0.6	4.2	0.7	5.4	0.7	0.6	67	33	50
8	B	0.7	1.2	0.0	1.8	0.7	0.1	58	33	50
8	C	0.5	4.5	0.1	5.1	1.0	0.0	75	33	50
8	D	1.1	9.2	0.2	10.4	0.8	0.0	58	33	33
9	A	0.1	4.0	0.0	4.1	0.4	0.1	75	8	67
9	B	0.0	1.8	0.3	2.0	0.6	0.1	42	0	33
9	C	0.1	0.8	0.0	0.8	0.7	0.6	33	8	33
9	D	0.2	0.0	0.0	0.2	0.3	0.1	8	8	0
10	A	0.3	107.1	0.1	107.4	3.7	0.3	67	17	42
10	B	0.0	1.3	0.0	1.3	0.8	0.4	33	0	33
10	C	0.2	0.8	0.2	1.1	0.8	0.1	42	17	25
10	D	0.0	0.5	0.2	0.7	0.8	0.0	17	0	8

Table E.3. Mean number of aphids, beneficials and other pests per plant and percentage of plants with aphids per plot at the field trial in Westmaas (1st of June, 2022).

		mean number per plant						*percentage of plants with*		
treatment	*replicate*	green peach aphids	black bean aphids	other aphids	total aphids	total bene-ficials	total other pests	aphids	green peach aphids	black bean aphids
1	A	5.8	78.8	1.7	86.3	0.9	0.4	100	75	92
1	B	8.6	538.8	2.3	549.6	4.2	0.1	100	92	100
1	C	9.8	53.7	4.1	67.5	4.5	0.3	100	100	83
1	D	5.3	5.4	0.2	10.9	0.3	0.1	92	75	58
2	A	1.8	7.3	0.6	9.6	3.8	0.4	92	42	58
2	B	2.2	5.7	0.0	7.8	2.2	0.5	83	58	58
2	C	0.6	6.8	0.1	7.5	0.7	0.1	92	42	67
2	D	1.4	0.3	0.0	1.7	0.3	0.0	50	50	25
3	A	2.3	5.8	0.5	8.7	1.2	0.4	50	25	42
3	B	0.8	4.8	0.2	5.8	0.2	0.2	83	50	50
3	C	1.1	7.8	0.0	8.8	0.8	0.1	83	25	67
3	D	1.2	0.1	0.0	1.3	0.5	0.0	50	50	8
4	A	1.6	17.4	0.1	19.1	6.6	0.3	100	67	75
4	B	10.7	41.1	3.8	55.6	3.8	0.1	100	100	83
4	C	0.4	34.7	0.1	35.2	1.7	0.1	92	25	92
4	D	1.3	26.8	0.0	28.0	2.5	0.1	92	50	83
5	A	11.8	12.0	1.4	25.3	1.1	0.2	100	100	67
5	B	16.2	23.8	0.7	40.7	3.3	0.0	100	100	67
5	C	4.7	31.8	0.9	37.3	0.2	0.0	83	58	75
5	D	17.0	241.3	2.7	260.9	0.3	0.1	100	83	83
6	A	2.8	105.0	0.0	107.8	4.3	0.0	92	75	83
6	B	1.4	7.0	0.3	8.8	0.4	0.1	100	67	83
6	C	0.6	56.8	0.0	57.4	0.3	0.0	83	33	75
6	D	0.3	1.9	0.0	2.2	0.2	0.1	50	17	50
7	A	2.0	4.6	0.3	6.8	0.6	0.0	75	33	67
7	B	3.4	7.0	1.1	11.5	0.8	0.4	100	75	100
7	C	1.8	6.3	0.0	8.1	3.5	0.3	75	33	67
7	D	2.2	14.3	0.2	16.6	1.6	0.1	92	42	67
8	A	0.3	10.8	0.7	11.7	1.3	0.1	100	25	83
8	B	2.6	11.0	0.1	13.7	0.6	0.2	83	50	75
8	C	0.1	3.8	0.2	4.0	0.2	0.0	67	8	58
8	D	1.0	9.7	0.3	10.9	0.7	0.0	75	33	58
9	A	0.8	13.8	0.5	15.0	0.3	0.0	100	50	92
9	B	0.1	4.5	0.7	5.3	0.7	0.1	75	8	58
9	C	0.1	4.8	0.0	4.9	0.1	0.0	67	8	58
9	D	1.1	6.8	0.2	8.1	0.3	0.2	100	33	92
10	A	0.4	4.7	0.2	5.3	1.9	0.3	92	33	67
10	B	0.3	3.7	0.0	4.0	0.3	0.5	50	17	33
10	C	0.1	3.6	0.1	3.8	0.4	0.2	75	8	75
10	D	0.6	2.7	0.0	3.3	0.4	0.0	75	25	67

Table E.4. Mean number of aphids, beneficials and other pests per plant and percentage of plants with aphids per plot at the field trial in Westmaas (14th of June, 2022).

treatment	*replicate*	*mean number per plant*						*percentage of plants with*		
		green peach aphids	black bean aphids	other aphids	total aphids	total bene-ficials	total other pests	aphids	green peach aphids	black bean aphids
1	A	15.5	482.5	0.2	498.2	9.7	0.7	100	100	83
1	B	14.2	1100.2	0.0	1114.3	21.5	0.5	100	100	83
1	C	5.2	59.3	0.3	64.8	3.5	0.5	83	67	83
1	D	2.7	17.0	0.2	19.8	10.7	2.0	100	67	67
2	A	2.8	2.3	0.0	5.2	3.8	0.5	83	67	50
2	B	1.8	0.8	0.3	3.0	3.8	1.0	83	67	67
2	C	2.7	2.3	0.2	5.2	7.2	1.0	100	67	67
2	D	1.2	1.7	0.0	2.8	1.5	0.7	67	50	17
3	A	0.3	9.7	0.0	10.0	0.4	0.8	78	22	56
3	B	1.5	5.8	0.0	7.3	1.3	0.3	83	83	33
3	C	0.7	5.5	0.0	6.2	6.2	1.3	100	50	67
3	D	1.5	12.7	0.0	14.2	1.8	0.3	67	50	50
4	A	0.2	2.0	0.0	2.2	7.0	0.2	50	17	33
4	B	0.0	3.7	0.0	3.7	5.0	1.0	83	0	83
4	C	0.0	105.5	0.2	105.7	6.3	0.3	83	0	83
4	D	0.0	20.5	0.0	20.5	7.2	0.2	67	0	67
5	A	4.7	3.5	0.3	8.5	4.0	0.7	100	100	33
5	B	15.3	135.7	0.2	151.2	8.2	0.3	100	100	67
5	C	1.7	13.8	0.0	15.5	1.7	0.8	67	50	67
5	D	3.7	195.8	2.5	202.0	3.0	0.7	100	67	83
6	A	5.8	295.8	0.0	301.7	10.3	0.2	100	83	67
6	B	1.0	7.7	0.7	9.3	2.3	0.0	83	50	50
6	C	1.2	438.2	0.0	439.3	6.2	0.0	100	67	100
6	D	0.3	2.8	0.2	3.3	4.8	0.5	50	17	33
7	A	3.5	86.2	0.0	89.7	1.7	1.0	83	67	67
7	B	5.3	12.3	1.8	19.5	8.0	0.0	100	100	100
7	C	0.3	6.7	1.8	8.8	3.7	0.2	100	17	100
7	D	0.5	6.5	0.0	7.0	2.2	0.5	67	17	50
8	A	2.0	32.2	0.0	34.2	1.7	0.3	100	83	100
8	B	2.7	4.0	0.2	6.8	2.0	0.0	100	67	67
8	C	0.7	13.7	0.0	14.3	8.3	0.8	83	33	83
8	D	1.7	15.5	0.0	17.2	1.7	0.0	100	67	67
9	A	2.2	34.7	0.0	36.8	1.3	0.5	100	50	83
9	B	0.5	118.2	0.0	118.7	1.0	0.8	83	50	50
9	C	0.0	27.2	0.0	27.2	17.0	0.3	67	0	67
9	D	1.2	1.3	0.3	2.8	2.5	0.0	83	33	33
10	A	0.3	2.3	0.0	2.7	1.3	0.7	50	33	33
10	B	0.8	2.2	0.5	3.5	0.3	0.3	83	33	83
10	C	0.2	7.0	0.0	7.2	2.7	0.2	83	17	83
10	D	0.5	5.0	0.0	5.5	0.3	0.8	100	33	83

Annex F Raw data plant numbers, phytotoxicity and vigour

Table F.1. Number of plants per hectare, percentage of emerged plants and vigour (1=dead; 10=highly vigorous crop). Number of plants showing signs of phytotoxicity, caused by insecticide treatment at different dates (Westmaas, 2022).

treatment	*replicate*	*number of plants per hectare*	*percentage of emerged plants*	*vigour*	*number of plants with phytotox*		
		4 May	4 May	2 June	27 May	29 June	15 July
1	A	86667	78.0	7.0	0	0	0
1	B	77917	70.1	7.5	0	0	0
1	C	88750	79.9	7.0	0	0	0
1	D	92083	82.9	7.5	0	0	0
2	A	96667	87.0	7.5	0	0	0
2	B	86250	77.6	8.0	0	0	0
2	C	86250	77.6	7.5	0	0	0
2	D	82083	73.9	8.0	0	0	0
3	A	84167	75.8	7.0	0	0	0
3	B	86667	78.0	8.0	0	0	0
3	C	89167	80.3	7.5	0	0	0
3	D	89167	80.3	7.5	0	0	0
4	A	92500	83.3	7.5	0	0	0
4	B	81667	73.5	7.0	0	0	0
4	C	90833	81.8	8.0	0	0	0
4	D	92083	82.9	8.0	0	0	0
5	A	94583	85.1	7.0	0	0	0
5	B	77917	70.1	7.0	0	0	0
5	C	92083	82.9	7.5	0	0	0
5	D	87500	78.8	7.5	0	0	0
6	A	82500	74.3	6.5	0	0	0
6	B	92500	83.3	7.5	0	0	0
6	C	87500	78.8	7.5	0	0	0
6	D	93750	84.4	7.5	0	0	0
7	A	80417	72.4	6.5	0	0	0
7	B	82500	74.3	7.0	0	0	0
7	C	90833	81.8	8.0	0	0	0
7	D	92500	83.3	8.5	0	0	0
8	A	88750	79.9	7.0	0	0	0
8	B	87083	78.4	8.0	0	0	0
8	C	83750	75.4	7.0	0	0	0
8	D	89167	80.3	8.0	0	0	0
9	A	82083	73.9	6.0	0	0	0
9	B	82917	74.6	7.0	0	0	0
9	C	92500	83.3	7.5	0	0	0
9	D	82083	73.9	7.5	0	0	0
10	A	90417	81.4	7.0	0	0	0
10	B	88750	79.9	7.5	0	0	0
10	C	88750	79.9	7.5	0	0	0
10	D	84167	75.8	8.0	0	0	0

Annex G Raw data virus yellows

Table G.1. Percentage of plants with virus yellows, assessed in the middle four rows per plot.

treatment	*replicate*	*percentage of plants with virus*				
		29 June	15 July	29 July	26 August	19 September
1	A	5.8	47.1	53.8	68.3	72.6
1	B	7.0	53.5	55.1	86.6	72.2
1	C	5.2	32.4	34.7	62.9	51.2
1	D	5.9	39.4	52.9	55.7	57.9
2	A	0.0	0.9	1.3	3.9	2.6
2	B	0.0	2.9	4.3	12.6	8.7
2	C	0.0	2.4	5.8	13.0	7.7
2	D	0.5	4.6	7.6	18.3	11.7
3	A	3.0	12.9	19.8	35.1	33.7
3	B	3.4	21.2	25.0	56.3	47.6
3	C	2.3	19.6	26.2	41.1	34.6
3	D	7.0	24.3	38.8	52.3	63.6
4	A	2.7	12.2	16.2	24.8	21.2
4	B	3.6	22.4	30.1	43.9	42.3
4	C	1.4	12.8	10.1	26.6	28.9
4	D	1.4	7.7	9.0	20.4	19.5
5	A	4.0	26.4	35.2	63.0	59.9
5	B	10.2	63.1	72.7	73.3	87.7
5	C	5.0	38.9	45.2	61.1	56.6
5	D	8.1	43.8	48.6	63.8	75.7
6	A	4.0	20.2	28.3	42.9	42.9
6	B	0.9	6.8	10.8	21.6	19.4
6	C	1.0	5.2	5.7	18.6	13.8
6	D	3.6	6.2	9.3	22.7	14.7
7	A	2.1	21.2	30.1	42.0	45.1
7	B	9.6	49.5	62.1	78.8	84.8
7	C	4.1	21.1	22.0	43.6	45.4
7	D	3.2	14.0	22.1	36.9	36.9
8	A	2.3	13.1	19.7	40.8	43.2
8	B	2.9	17.7	24.9	41.1	36.8
8	C	3.5	18.4	20.4	32.8	32.8
8	D	2.3	20.1	24.3	44.9	44.9
9	A	1.5	8.1	10.2	23.9	21.3
9	B	2.0	13.6	13.6	32.7	34.2
9	C	2.3	6.3	7.7	25.2	25.7
9	D	2.5	17.3	25.4	33.5	38.1
10	A	3.2	10.1	14.3	32.7	31.3
10	B	2.3	12.2	17.4	31.0	28.6
10	C	0.9	8.0	9.4	25.4	23.9
10	D	5.0	12.9	20.8	43.1	37.6

Annex H Data on yield

Table H.1. Average yield per plot expressed in root weight (t/ha), sugar content (%), sugar yield (t/ha), soil tare (%), potassium (mmol/kg), sodium (mmol/kg), amino nitrogen (mmol/kg) and financial yield (€/ha). The field trial was harvested on 22nd of September 2022.

treatment	*replicate*	*root yield (t/ha)*	*sugar percen-tage*	*sugar yield (t/ha)*	*soil tare (%)*	*potassium (mmol/kg)*	*sodium (mmol/kg)*	*amino nitrogen (mmol/kg)*	*financial yield (€/ha)*
1	A	114.0	15.9	18.1	5.9	28.7	4.2	8.3	4558
1	B	118.2	15.8	18.7	7.0	32.9	4.2	7.3	4646
1	C	128.1	16.6	21.3	3.2	31.7	3.4	7.5	5586
1	D	111.9	16.4	18.4	8.0	32.5	3.5	6.5	4696
2	A	136.1	17.0	23.2	5.1	33.0	3.1	7.5	6121
2	B	131.7	17.0	22.4	6.3	35.7	3.6	6.7	5852
2	C	126.2	17.2	21.7	6.1	32.5	3.6	7.2	5746
2	D	125.7	17.1	21.5	6.2	32.5	3.0	6.5	5669
3	A	128.4	16.8	21.5	5.0	33.3	3.5	8.4	5610
3	B	135.9	16.5	22.4	1.6	32.5	3.3	6.2	5865
3	C	124.3	16.8	20.8	4.4	31.8	3.7	8.6	5448
3	D	120.6	16.3	19.7	5.4	34.4	3.5	7.8	5047
4	A	125.4	17.0	21.4	5.2	32.8	3.4	7.2	5646
4	B	124.5	16.5	20.6	5.5	35.8	3.3	6.2	5313
4	C	131.1	16.7	21.9	4.8	31.0	3.2	7.5	5711
4	D	132.9	16.5	22.0	5.7	33.6	3.7	6.8	5682
5	A	130.1	16.6	21.5	4.0	32.3	3.9	8.2	5603
5	B	113.3	16.4	18.6	4.9	33.3	3.4	7.0	4791
5	C	119.9	16.4	19.7	3.4	30.0	3.6	8.0	5108
5	D	120.7	15.8	19.0	7.0	35.3	4.7	10.5	4683
6	A	120.8	16.3	19.7	3.2	33.2	3.8	8.0	5067
6	B	131.3	16.7	21.9	5.1	33.5	3.7	7.3	5694
6	C	133.7	16.8	22.5	4.5	32.4	3.2	6.7	5926
6	D	122.5	17.0	20.8	4.4	34.2	3.1	6.5	5509
7	A	121.3	16.3	19.7	4.5	33.1	3.9	7.8	5064
7	B	116.1	16.4	19.1	5.9	31.1	3.3	6.9	4912
7	C	126.7	16.3	20.6	6.4	33.8	3.4	7.7	5241
7	D	129.8	16.9	21.9	7.9	32.7	3.4	6.1	5697
8	A	132.7	16.9	22.4	2.6	34.0	3.5	7.0	5908
8	B	134.5	16.8	22.6	3.5	32.9	3.3	6.9	5962
8	C	125.9	16.6	20.9	6.4	32.9	3.6	7.5	5389
8	D	125.1	16.8	21.0	6.1	32.0	2.9	7.1	5486
9	A	127.9	16.6	21.3	4.9	32.6	3.5	7.1	5536
9	B	125.4	16.6	20.8	5.0	31.5	3.1	7.8	5405
9	C	131.9	16.7	22.1	5.3	31.6	3.0	6.7	5776
9	D	133.9	16.6	22.2	3.7	32.6	3.6	6.9	5791
10	A	129.2	16.5	21.4	5.8	32.5	3.3	7.1	5522
10	B	121.8	16.8	20.5	5.5	31.9	3.1	6.0	5380
10	C	129.8	16.4	21.3	5.7	31.3	3.9	8.2	5482
10	D	132.8	16.5	21.9	5.2	34.0	3.5	7.2	5660

Table H.2. Average yield per treatment expressed in soil tare (%), potassium (mmol/kg), sodium (mmol/kg) and amino nitrogen (mmol/kg). The field trial was harvested on 22nd of September 2022. Analysed data of root weight (t/ha), sugar content (%), sugar yield (t/ha) and financial yield (€/ha) are shown in paragraph 3.4.

treatment		*soil tare (%)*	*potassium (mmol/kg)*	*sodium (mmol/kg)*	*amino nitrogen (mmol/kg)*
1	untreated control	6.0	31.4	3.8	7.4
2	not inoculated control + Teppeki	5.9	33.4	3.3	7.0
3	Teppeki	4.1	33.0	3.5	7.7
4	IRS 770 + Teppeki	5.3	33.3	3.4	6.9
5	IRS 803	4.8	32.7	3.9	8.4
6	IRS 789	4.3	33.3	3.4	7.1
7	IRS 810	6.2	32.7	3.5	7.1
8	IRS 785	4.6	33.0	3.3	7.1
9	IRS 785 (band application)	4.7	32.1	3.3	7.1
10	Teppeki (band application)	5.6	32.4	3.4	7.1
P		0.197	0.556	0.254	0.205
LSD 5%		-	-	-	-
significance		not significant	not significant	not significant	not significant

Annex I Analysed data percentage of aphids

Table I.1. Percentage of assessed plants with green peach aphids (*Myzus persicae*) on the 23rd and 27th of May and 1st and 14th of June. Plants were inoculated with green peach aphids on the 17th of May (Westmaas, 2022). Different letters indicate significant differences within a column.

treatment		*percentage of plants with green peach aphids*							
		23 May		27 May		1 June		14 June	
1	untreated control	36.2	b	79.2	a	85.4	a	83.3	a
2	not inoculated control + Teppeki	20.8	bc	37.5	bc	47.9	bc	62.5	abc
3	Teppeki	34.2	b	58.3	ab	37.5	bcd	51.4	cd
4	IRS 770 + Teppeki	37.5	b	56.3	b	60.4	b	4.2	e
5	IRS 803	58.3	a	79.2	a	85.4	a	79.2	ab
6	IRS 789	6.7	c	27.1	cd	47.9	bc	54.2	bcd
7	IRS 810	22.9	bc	43.8	bc	45.8	bc	50.0	cd
8	IRS 785	20.8	bc	33.3	c	29.2	cd	62.5	abc
9	IRS 785 (band application)	10.8	c	6.3	d	25.0	cd	33.3	d
10	Teppeki (band application)	16.7	c	8.3	d	20.8	d	29.2	de
P		<0.001		<0.001		<0.001		<0.001	
LSD 5%		17.5		21.36		23.94		27.1	
significance		very significant		very significant		very significant		very significant	

Table I.2. Percentage of assessed plants with natural occurring black bean aphids (*Aphis fabae*) on the 23rd and 27th of May and 1st and 14th of June (Westmaas, 2022). Different letters indicate significant differences within a column.

treatment		*percentage of plants with black bean aphids*						
		23 May		27 May		1 June		14 June
1	untreated control	54.9		62.5	ab	83.3	a	79.2
2	not inoculated control + Teppeki	47.9		41.7	cd	52.1	bc	50.0
3	Teppeki	34.5		33.3	d	41.7	c	51.4
4	IRS 770 + Teppeki	37.5		66.7	a	83.3	a	66.7
5	IRS 803	60.4		54.2	abc	72.9	ab	62.5
6	IRS 789	47.9		43.8	bcd	72.9	ab	62.5
7	IRS 810	41.7		39.6	cd	75.0	ab	79.2
8	IRS 785	31.3		45.8	bcd	68.8	ab	79.2
9	IRS 785 (band application)	42.5		33.3	d	75.0	ab	58.3
10	Teppeki (band application)	39.6		27.1	d	60.4	abc	70.8
P		0.280		0.005		0.021		0.290
LSD 5%		-		19.99		23.58		-
significance		not significant		significant		significant		not significant

Annex J Weather data

Table J.1. Weather data from the nearest KNMI weather station (344: Rotterdam), 17 km from trial.

date	*wind speed (m/s)*	*mean air tempera-ture (ºC)*	*min. air tempera-ture (ºC)*	*max. air tempera-ture (ºC)*	*precipi-tation (mm)*	*mean humidity (%)*	*max. humidity (%)*	*min. humidity (%)*
20220316	4.6	9.7	4	12.9	<0.05	76	89	67
20220317	4.3	7.8	3.3	11.3	0.6	78	95	52
20220318	3	8.5	1.2	14.9	0	78	97	54
20220319	6.4	8.7	4.4	13.8	0	60	90	31
20220320	4.2	4.6	2	8.7	0.6	74	84	58
20220321	2.1	8.6	-0.5	16.5	0	67	97	37
20220322	1.6	11.7	4.1	19.5	0	68	97	41
20220323	1.5	10.1	2	18.5	0	68	98	26
20220324	1.6	10	1	18.9	0	71	99	30
20220325	2.5	9.2	2.1	15.4	0	69	98	40
20220326	2.7	10.5	2.1	17.4	0	74	98	47
20220327	3.7	10.3	6.1	16	0	71	98	34
20220328	2	8.8	3.1	15.9	0	83	98	57
20220329	3.8	8.4	6.1	12.5	0	84	98	66
20220330	3.9	6.7	1.7	11.8	1.4	77	93	59
20220331	5.8	2.6	0.1	6.1	7.1	88	97	74
20220401	7.7	2.6	-0.1	5.2	2.5	73	98	51
20220402	4.7	3.5	-0.4	7.6	<0.05	63	86	44
20220403	3.1	3.7	-2.9	9.3	<0.05	77	97	57
20220404	8.7	7.9	4.7	11.1	9.7	88	95	73
20220405	6.3	10.4	9.1	11.9	3.6	86	98	79
20220406	9.6	9.9	8.8	11.1	2.2	84	90	74
20220407	10.8	8.8	5.2	11.8	11.1	76	94	59
20220408	4.5	6.5	4.3	8.6	0.3	74	85	64
20220409	5.4	6	1.1	9.9	0.4	72	83	57
20220410	2.3	6.9	0.6	12.3	0	66	92	39
20220411	4.2	10	1.5	14.7	0	58	88	39
20220412	3.7	14.3	7.9	21.3	0	61	84	44
20220413	2.6	13.1	9.8	16.6	0	79	92	62
20220414	2.2	11.9	4.5	17.9	0	82	99	59
20220415	3	10.2	5.1	15.4	0	80	99	62
20220416	4.3	11.2	4.9	15.8	0	61	90	37
20220417	3.7	12.3	5.4	18.2	0	45	62	30
20220418	2.8	13.2	6.8	20	0	47	88	26
20220419	3.4	12.9	4.6	18.8	0	59	94	35
20220420	4.4	12	5.1	17.4	0	60	83	43
20220421	4.9	12.6	4.9	17.9	0	62	88	36
20220422	5.9	12.8	8.5	17.7	0	65	87	44
20220423	6.5	13.5	9	18.8	0	63	82	47
20220424	5.5	12	7.7	17.3	0	63	83	40
20220425	3.6	9	6.5	10.4	1.4	81	91	70
20220426	4.1	9	1.9	13.5	<0.05	72	99	50
20220427	2	7.6	1.8	12.7	0	75	99	54
20220428	3.2	9.1	1.4	14.7	0	72	98	50
20220429	4.5	8.9	6.1	13.2	0	74	86	61
20220430	2.8	8.1	1.8	12.6	0.4	78	98	62
20220501	1.3	8.9	0.7	15.5	0	74	99	46
20220502	2.4	11	3.6	17.3	0	70	98	40

date	*wind speed (m/s)*	*mean air tempera-ture (ºC)*	*min. air tempera-ture (ºC)*	*max. air tempera-ture (ºC)*	*precipi-tation (mm)*	*mean humidity (%)*	*max. humidity (%)*	*min. humidity (%)*
20220503	2.5	9.8	3.9	15	0	81	99	70
20220504	1.8	10.5	3.1	15.5	<0.05	71	96	51
20220505	2	12.6	7.5	18.1	0	82	98	63
20220506	2.3	14.4	8.7	20.4	0	73	99	49
20220507	3.5	14.8	10.8	19.6	0	76	92	62
20220508	3.9	12.3	7.6	16.9	0	66	87	39
20220509	2	15	5.6	22.9	0	59	94	33
20220510	5.6	17.1	12.3	22.1	<0.05	60	76	40
20220511	6.4	15.4	9.8	20.1	3.4	66	93	51
20220512	4.8	14	8	19	0	64	91	45
20220513	6.4	14.4	11.7	18.4	0	66	87	51
20220514	2.5	15.2	9.4	20.5	0	71	94	51
20220515	4	18.8	9.3	25.7	0	53	93	26
20220516	4.9	18	13.9	24.7	1	69	87	52
20220517	2.4	19.2	13.3	26.5	<0.05	70	93	44
20220518	2.6	18.6	12.9	21.9	0	70	97	53
20220519	2.9	17.2	10.7	23.7	10.4	85	98	63
20220520	3.8	13.7	9.7	19.1	13.8	85	99	61
20220521	4.2	14.1	9.3	17.8	0	76	97	59
20220522	2.3	16.8	7.2	22.3	0	63	99	41
20220523	2.8	15.6	13	21	12.8	82	95	63
20220524	5.5	13.4	9.3	17.1	4.4	77	91	57
20220525	7.1	14.4	9.8	18.2	0.1	76	93	53
20220526	6.9	15.9	13.5	18.7	0	75	85	58
20220527	4.8	13.9	10.5	16.1	0.6	69	91	50
20220528	4.5	12	7.5	15.8	0.3	70	88	50
20220529	3.3	10.8	6.9	14.5	2.5	76	89	58
20220530	1.2	11	6.4	14.5	<0.05	72	96	55
20220531	1.9	12.8	6.3	18.4	3.3	71	97	42
20220601	3.5	12.4	7.3	15.9	1	78	98	65
20220602	2.3	14.2	6.2	19.7	0	66	99	42
20220603	5	17.5	10.2	23.9	0	60	87	36
20220604	6.4	16.3	12.2	21.5	<0.05	70	79	56
20220605	3.8	15.3	12.7	19.3	22.2	90	97	73
20220606	5.8	13.8	12.6	16.8	4.5	87	92	77
20220607	3.8	15.9	13.1	19.1	<0.05	76	89	66
20220608	4.5	15.8	12.5	18.4	7	86	95	74
20220609	4.1	16.4	13.4	20.2	2	72	92	50
20220610	4.5	17.8	14.2	21.7	<0.05	76	88	63
20220611	4.8	17.5	14	21.4	0	66	85	43
20220612	3.8	16.3	12.1	19.5	0	72	94	54
20220613	3.5	14.5	9	17.4	0	70	94	52
20220614	1.8	15.7	7.8	21.2	0	65	96	47
20220615	2.8	18.3	9.9	24	0	62	97	42
20220616	1.8	18.9	11.6	25.2	0	59	89	37
20220617	4.3	23.2	13.7	29.3	<0.05	53	94	33
20220618	3.8	20.7	14.9	26.8	0	69	87	55
20220619	4.4	14.5	12.6	17.1	2.7	74	89	60
20220620	3	14.9	9.8	19.1	0	72	97	55
20220621	2	16	8.3	21.8	0	72	98	46
20220622	3	18.7	8.4	25.3	0	62	100	25

date	*wind speed (m/s)*	*mean air tempera-ture (ºC)*	*min. air tempera-ture (ºC)*	*max. air tempera-ture (ºC)*	*precipi-tation (mm)*	*mean humidity (%)*	*max. humidity (%)*	*min. humidity (%)*
20220623	2.8	22.6	14.1	30.4	0	67	90	40
20220624	2.9	20.2	17.9	23.1	12.9	77	96	61
20220625	3.1	18.1	15.9	22.9	2.8	80	95	56
20220626	3.3	18.3	14.3	22.9	0	70	93	48
20220627	2.5	16.9	12.7	21.1	11.1	78	95	58
20220628	3.5	18.8	12.7	23.8	0	61	85	41
20220629	3	21.2	16	27.1	0	60	88	40
20220630	3.1	16.6	13.2	21.6	13.2	83	97	63
20220701	4.8	16.3	13.2	20.5	0.7	74	91	55
20220702	3.8	18.6	12.8	24.2	<0.05	60	85	41
20220703	3.4	16.9	12.2	20.1	0.1	76	96	63
20220704	3.1	17.6	11.7	22	0	71	97	49
20220705	2.8	16.2	11	20.1	0	70	98	51
20220706	3.2	16.9	8.7	21.8	<0.05	69	96	43
20220707	5.2	16	11.3	19	0.6	76	91	63
20220708	2.6	17.5	9.8	23	0	76	99	52
20220709	3.5	17.2	11.8	21	0	75	98	60
20220710	2.7	16.8	10.4	21.9	<0.05	76	97	52
20220711	2.2	19.3	14.9	25	0	78	96	52
20220712	2.1	22.5	13.1	27.7	0.1	62	97	33
20220713	3.5	20.9	15.1	25.9	0	70	84	56
20220714	2.5	17.2	11.4	23.1	0	70	97	41
20220715	2.5	17.3	10	21.9	0	67	97	49
20220716	3.3	17.4	11.4	20.8	0	67	96	50
20220717	1.8	19.3	10.4	25.5	0	60	97	36
20220718	1.5	24.4	13.6	32.2	0	51	91	21
20220719	3.3	29.2	17.1	37.1	0	40	78	20
20220720	4.8	22.8	19.1	27.8	0.2	68	84	44
20220721	3.9	17.7	15.7	19.4	5.9	88	96	81
20220722	2.1	17.3	13.6	20.7	0.5	74	90	56
20220723	1.5	19.1	11.4	24.8	0	69	98	48
20220724	4	23.4	16.1	30.1	0	61	82	40
20220725	5.7	20.6	18.2	23.8	<0.05	72	85	51
20220726	3.6	16.9	11.1	20.7	0.6	74	95	52
20220727	2.8	15.9	9.7	20.7	0.3	71	97	49
20220728	4.7	17.5	12	23.1	0	59	78	41
20220729	2.7	18.8	13.1	25.2	0	68	97	40
20220730	2	19.4	11.4	25.6	<0.05	68	98	51
20220731	4.6	19.6	18.4	22.2	1.4	87	93	79
20220801	2.6	19.7	16.7	23.7	0.4	69	95	42
20220802	5.4	21.5	15.8	26.9	0	65	80	51
20220803	3.9	22.8	18	28.8	0	72	92	49
20220804	2.5	21.3	17.9	26.7	0	71	93	50
20220805	2.9	17	10.4	21.7	<0.05	70	95	48
20220806	1.8	16	9.3	21.8	0	69	97	39
20220807	1.7	16.7	9.5	22.8	0	71	98	43
20220808	2.4	17.7	10.4	23.5	0	73	98	51
20220809	3.8	19.8	11.7	26	0	68	98	45
20220810	3.6	22.2	13.6	29.4	0	61	87	35
20220811	3.4	23.8	14.9	31.4	0	57	94	26

date	*wind speed (m/s)*	*mean air tempera-ture (ºC)*	*min. air tempera-ture (ºC)*	*max. air tempera-ture (ºC)*	*precipi-tation (mm)*	*mean humidity (%)*	*max. humidity (%)*	*min. humidity (%)*
20220812	3	24.3	16.2	31.8	0	55	84	26
20220813	2.5	23.9	14.6	31.9	0	50	86	22
20220814	2.4	24.4	16	32.2	0	56	87	28
20220815	2.6	21.4	17.9	26	11	77	96	63
20220816	2.5	21.3	16.7	26.5	0	77	96	58
20220817	2.8	19.1	16.6	20.7	11.7	91	95	82
20220818	1.8	20.1	15	25.7	0	81	99	56
20220819	2.7	20	15.1	24.7	0.2	86	97	69
20220820	2.8	18.8	13.6	23.6	0	73	99	49
20220821	3.1	18.9	15	23.1	0	75	90	51
20220822	2.4	20.7	15.3	26.2	<0.05	66	93	42
20220823	2.1	21.7	15.6	27.8	0	74	93	51
20220824	2.4	23.5	17.4	28.7	0	76	97	52
20220825	3.2	23.4	18.2	31.8	0	72	98	33
20220826	3.5	18.4	12.2	22.3	<0.05	79	97	63
20220827	2.5	16.6	10.6	21.6	<0.05	76	100	53
20220828	2.8	16.6	9.5	22.4	0	74	97	51
20220829	1.8	16.9	10.8	21.9	0	74	97	49
20220830	4.8	19	14.5	24.4	0	67	93	40
20220831	5.5	18.8	14.1	23.8	0	59	78	39
20220901	3.6	18.5	12.2	25.2	0	59	88	32
20220902	4	19.8	12.5	26.8	0	51	75	33
20220903	3.3	20.8	15.7	27.2	0	52	85	33
20220904	2.1	20.6	14.6	27.1	0	68	94	31
20220905	3.2	21.9	14.9	30.2	23.8	64	92	34
20220906	3	20.6	16.5	24.7	19.9	77	98	55
20220907	3.5	19.3	15.6	23.9	6.2	78	96	55
20220908	4.2	18	15.1	22	1	80	94	57
20220909	5	16.1	14.6	19.1	14.8	89	95	77
20220910	3.1	17.4	13	21.6	4.1	86	99	67
20220911	1	17.1	10.9	23.1	0	82	99	60
20220912	2.5	19.1	13.3	23.9	0	75	92	55
20220913	2.2	18.5	15.2	22.2	<0.05	79	95	58
20220914	1.9	15.8	11.9	19.7	<0.05	80	94	64
20220915	3	15.2	11.1	18.8	0.9	74	91	52
20220916	3.9	13	10.8	16.4	13	78	95	63
20220917	4.5	13	10.3	16.6	8.6	75	89	51
20220918	3.9	12.6	10.3	15.3	16.9	80	92	71
20220919	2.8	12.5	8	17.9	0.8	79	97	54
20220920	1.8	12.9	8.2	17.7	1.5	78	97	50
20220921	0.9	12.3	6.9	18.2	0	78	98	45
20220922	2	12.6	5.6	18.9	0	74	99	47