Project title:	AHDB Brassica Trials Scotland - Brussels Sprouts herbicide screen
Project number:	FV 462
Project leader:	Angela Huckle, ADAS Horticulture
Report:	Annual report, March 2022
Previous report:	None
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Location of project:	East of Scotland Growers, Balmullo
Industry Representative:	James Rome, East of Scotland Growers
Date project commenced:	1 April 2020

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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Angela Huckle

Associate Director

RSK ADAS

Signature .. .. Date ....22/3/22........

Report authorised by:

Dr Jill England

Technical Director

RSK ADAS

Signature .... Date ....

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SCIENCE SECTION

Introduction

The limited range of herbicides currently available for use in brassica crops leaves gaps in the weed control spectrum, and growers experience problems with a wide range of weeds. In addition to having a short list of approved actives, only a small subset of these offer the longevity of control required to protect longer season brassicas, such as Brussels sprouts.

In hand harvested brassica crops, weeds are a physical impediment to those working in the crop, and species such as nettles can deter crop workers. In machine harvested crops, excessive weeds can slow down machinery which incurs penalties on harvest efficiency; where excessive, weeds mean heads are missed, harvested yields can be reduced by up to 30%. The increased humidity in the crop canopy can also increase the risk of disease and weed seeds can contaminate the fresh product.

While mechanical hoeing can be successfully used as an alternative weed control method, it is limited by crop growth stage and ground conditions—if soil conditions are not suitable, this approach cannot always be used. Therefore, further options for weed control are required.

The objective of this trial was to compare a number of experimental herbicide products which are close to authorisation on brassicas, at both pre- and post-planting application timings for efficacy and crop safety in planted crops of Brussels sprouts.

Materials and methods

The trial was carried out in a Brussels sprouts crop of the commercially grown cultivar, Petrus, planted on 4th June. The plots were situated at the East Scotland growers trial ground located at Balmullo, Fife. A randomised block design was used for the trial layout, with four replicates of eight treatments (Table 1), including one untreated control. There were thirty-two plots in total with the total trial area measuring 11 m x 47 m. Plots were 1.8 m wide comprising of three rows of sprouts, of which the central row was used for all assessments. A discard bed was planted on either side of the trial.

Table 1. Treatment products, rates and timings for the Brussels sprouts herbicide screen at Balmullo, Scotland, 2020

	Timing 1 – pre-planting 2 June 2020		Timing 2 – post-planting 4-5 true leaves 30 June 2020	
Trt. No.	**Product**	**Rate (L/ha or kg/ha)**	**Product**	**Rate (L/ha or kg/ha)**
1	UTC	-		
2*	-	-	Butisan S (metazochlor) + Gamit 36 CS (clomazone)	1.5 0.25
3	AHDB 9987	2.0	-	-
4	AHDB 9875	3.0	-	-
5	-	-	AHDB 9987	2.0
6	-	-	AHDB 9875	3.0
7	-	-	AHDB 9840	0.5
8	-	-	AHDB 9840	0.75

Treatments were applied as per Table 1 with the first pre planting application made on 2 June, and the post-planting spray applied on 30 June when the crop was at four to five true leaves. Treatments were applied using a precision knapsack sprayer with a 1.5m boom and 02F110 nozzles at medium quality at 200 L/ha water volume. Details of conditions at application are given in Table 2.

Table 2. Application details

	Application 1	**Application 2**
Application date	02/06/20	30/06/20
Time of day	8:50	9:00
Crop growth stage (BBCH)	0 (preplant)	14-15
Crop height (cm)	N/A	12
Crop coverage (%)	N/A	30
Application Method	Spray	Spray
Application Placement	Soil	Soil/Foliar
Application equipment	Azo small plot sprayer	Azo small plot sprayer
Nozzle type	DG Teejet	DG Teejet
Nozzle size	02F110	02F110
Application water volume/ha	200	200
Temperature of air - shade (°C)	21.1	17.4
Relative humidity (%)	50	77
Wind speed range (kph)	0	10
Dew presence (Y/N)	N	N
Temperature of soil - 2-5 cm (°C)	18.4	15.7
Wetness of soil - 2-5 cm	Very Dry	Moist
Cloud cover (%)	30	70

The plots were assessed on three occasions at approximately two, four and eight weeks after the Timing 2 post-planting treatment application on 17 and 30 July, and 26 August 2020. The assessments included weed counts - from 4 quadrats per plot to give weeds per m^2, an estimation of percentage reduction of the three main weed species, and crop phytotoxicity (i.e treatment safety).

Crop phytotoxicity was assessed using the 0-10 scale in Table 3 below where 0 signifies no effect on the crop, and 10 indicates crop death.

Table 3. Crop tolerance scores from 0-10, where 0 = no damage, to 10 = complete crop loss with an associated percentage score for each tolerance score conveying the phytotoxic damage. * ≤2 = acceptable damage, i.e. damage unlikely to reduce yield and acceptable to the farmer.

Crop tolerance score	**Equivalent to crop damage (% phytotoxicity)**
0	(no damage) 0%
1	10%
*2	20%
3	30%
4	40%
5	50%
6	60%
7	70%
8	80%
9	90%
10	(complete crop kill) 100%

The results of these assessments were analysed using Analysis of Variance with Duncan's multiple range test to determine where significant differences between treatments lay. Where significant differences between treatments were identified, the Abbott's formula was applied to compare the percentage reduction of the treatments compared to the control. Data was analysed by ADAS Statistician Chris Dyer.

Results

Phytotoxicity

All treatments with the exception of AHDB 9840 were safe for use as pre or post-planting herbicide treatments (Table 4). AHDB 9840 applied post-planting, presented higher levels of phytotoxicity over the crop than would be considered commercially acceptable, which was exhibited as deformation of the growing point and newest emerged leaves at two weeks after application, and at seven weeks after application the crop was observed to bolt, or flower early (Figure 1).

Table 4. Mean crop phytotoxicity scored at two weeks after the pre planting treatment application in sprouts. Scored on a 0-10 scale, with 0 being 'no effect', and 10 being 'dead'. Scores <2 deemed commercially acceptable level of damage. WAA = weeks after application

Treatment number	Product	Application timing	Mean crop damage scores (0-10)		
			2 WAA	4 WAA	8 WAA
1	**Untreated control**	-	0.00	0.00	0.00
2	**Butisan S 1.5 L/ha + Gamit 36 CS 0.25 L/ha**	Post	0.75	0.00	0.00
3	**AHDB 9987**	Pre	0.00	0.00	0.00
4	**AHDB 9875**	Pre	0.00	0.00	0.00
5	**AHDB 9987**	Post	0.00	0.00	0.00
6	**AHDB 9875**	Post	0.00	0.00	0.00
7	**AHDB 9840 ½ rate**	Post	4.75	4.75	4.75
8	**AHDB 9840 ¾ rate**	Post	4.25	4.25	6.25

Figure 1. Deformation caused by AHDB 9840 of the growing point at 2 weeks after application (left), and early flowering at seven weeks after application (right).

Weed control

<u>Weed counts</u>

In the trial area, the most common weed species were fat hen (*Chenopodium album),* knot grass *(Polygonum aviculare)* and mayweed *(Matricaria).*

Weed counts were higher in the untreated control compared to most of the treatments (Fig. 1). The industry standard (Butisan S 1.5 L/ha + Gamit 36 CS 0.25 L/ha) performed well at the three assessment dates. Overall, there were very few weeds in the trial area with an average of 33.5 per m^2 at week two, 38.5 per m^2 at week four and 36 per m^2 at week eight for the untreated plots. Despite this some treatment differences were observed within both the pre and post treatments. The pre planting treatments AHDB 9987 and AHDB 9875 significantly reduced fat hen and knot grass on all assessment dates and mayweed on all apart from the four weeks post application.

The post planting treatments were more variable. AHDB 9987 significantly reducing only fat hen at four and eight weeks post application. While AHDB 9875 significantly reduced both fat hen and knotgrass at all assessments but only reduced mayweed at the final assessment. AHDB 9840 significantly reduced fat hen throughout the assessments, but the control of knot grass and mayweed varied between assessments. Mayweed was present in very low levels therefore it is difficult to draw solid conclusions on the control of this species from this trial.

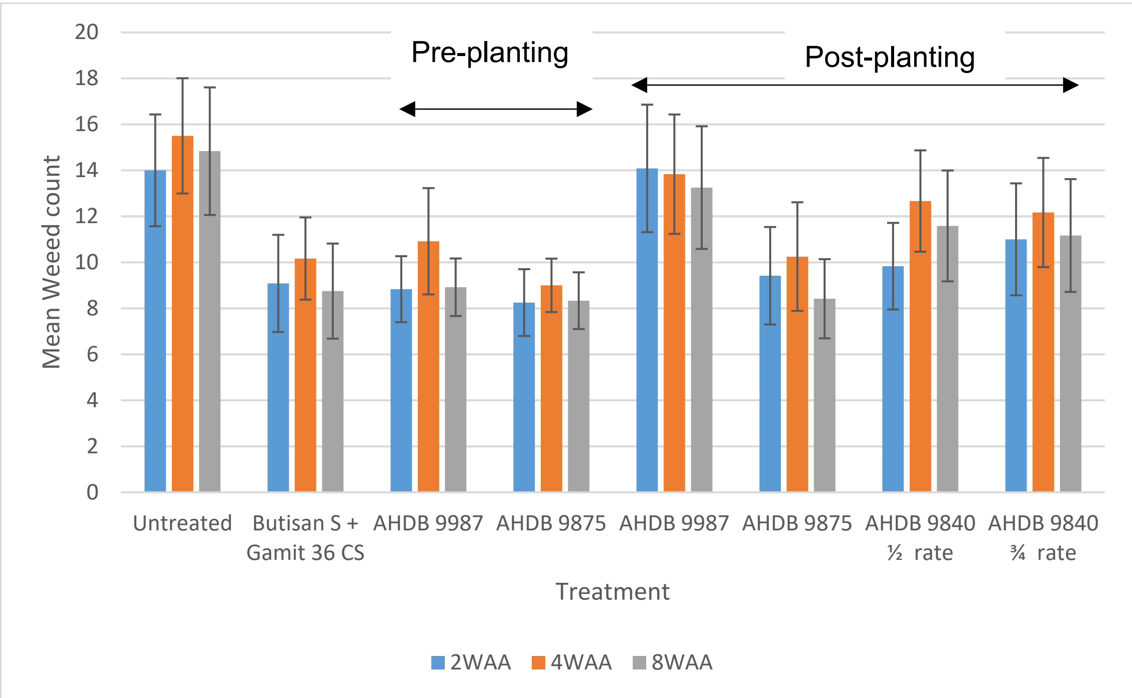


Figure 1. Mean weed counts per m^2 at the three assessment dates.

Table 5. Mean weed counts at two, four and eight weeks after the post planting treatment application Timing 2. WAA = weeks after application

Trt no	Treatment	Mean weed counts (m^2)								
		2 WAA 17 July			4 WAA 30 July			8 WAA 26 August		
		Fat hen	Knot grass	Mayweed	Fat hen	Knot grass	Mayweed	Fat hen	Knot grass	Mayweed
1	**Untreated control**	6.25	23.75	3.50	7.25	24.00	7.25	7.50	25.25	3.25
2	**Butisan S 1.5 L/ha + Gamit 36 CS 0.25 L/ha**	3.75	5.25	0.50	4.00	5.50	2.75	3.25	5.25	0.00
3	**AHDB 9987 pre**	2.75	9.25	0.25	3.00	8.75	6.75	3.25	8.75	0.50
4	**AHDB 9875 pre**	2.75	8.50	0.75	2.75	8.50	3.00	2.25	9.00	1.00
5	**AHDB 9987 post**	5.00	20.25	2.00	4.50	19.00	3.00	4.25	19.00	1.50
6	**AHDB 9875 post**	0.25	13.75	1.50	0.75	11.50	5.75	0.75	11.25	0.50
7	**AHDB 9840 ½ rate post**	1.75	13.50	0.75	2.75	17.00	4.75	2.75	18.00	0.50
8	**AHDB 9840 ¾ rate post**	2.00	17.50	0.00	2.75	17.25	3.00	2.50	17.50	0.00
	p-value	**<0.05**	**<.001**	**<0.05**	**<0.05**	**<.001**	**<0.05**	**<0.05**	**<.001**	**<0.05**
	d.f.	**21**	**21**	**21**	**21**	**21**	**21**	**21**	**21**	**21**
	L.S.D.	**2.504**	**6.168**	**2.126**	**2.394**	**6.548**	**5.452**	**2.514**	**6.710**	**1.777**
not significantly different from the untreated control					(blue)					
significantly different from the untreated control					(yellow)					

The percent reduction in weed cover compared to the untreated control was calculated from these figures (using Abbott's formula), and results for each treatment are listed in Table 3.

Table 3. Percentage reduction in weed cover of all weed species compared to the untreated control at two, four and eight weeks after treatment application.

Treatment	Weed cover reduction (%)		
	+ 2 Weeks	+ 4 Weeks	+ 8 Weeks
Butisan S 1.5 L/ha + Gamit 36 CS 0.25 L/ha	67.60	61.32	58.58
AHDB 9987 pre	69.91	42.75	50.91
AHDB 9875 pre	66.26	61.75	50.11
AHDB 9987 post	25.86	39.12	34.14
AHDB 9875 post	65.08	39.12	61.05
AHDB 9840 ½ rate post	64.57	41.90	51.17
AHDB 9840 ¾ rate post	64.77	49.60	57.46

At the eight week assessment, AHDB 9875 applied post-planting reduced weed cover by the greatest percentage. By the conclusion of the trial, all treatments showed significant control of at least one weed species when compared to the untreated control.

Discussion

All treatments except AHDB 9840, were crop safe. Brussels sprouts treated with AHDB 9840 presented commercially unacceptable levels of phytotoxicity exhibited as distortion and bolting (premature flowering). The industry standard (Butisan S 1.5 L/ha + Gamit 36 CS 0.25 L/ha) caused a small amount of damage exhibited as yellow fringing to the leaves, but this fell within acceptable limits, and was transient. This is a common effect observed where clomazone is used commercially.

All pre-planting treatments significantly reduced weed populations compared with the untreated at all assessments. However, not all post-planting sprays significantly reduced percentage weed cover. The activity of AHDB 9987 is residual and therefore not effective once weeds have emerged. The weeds had emerged at the time of application and therefore it would not be expected to perform as well as when it is applied pre-emergence. AHDB 9875 performed the best out of the coded products significantly reducing percentage weed cover, and giving equivalent weed control to the current standard Butisan S + Gamit.

Conclusions

The treatments AHDB 9987 (applied pre planting) and AHDB 9875 (applied either pre or post planting) were the most effective at reducing weeds compared to the untreated control.

AHDB 9840 caused commercially unacceptable crop damage at both rates trialled.

Knowledge and Technology Transfer

East of Scotland Grower Group day – spoke to small groups of growers in organised slots who came to view the trials – 23 and 24 September 2020

Video of overview of trials at Scottish Strategic Centre for Brassicas – https://www.youtube.com/watch?v=7kj8vNOogg8

Presentation to the Brassica Grower Association – 14 October 2020

Acknowledgements

AHDB for funding the work, and also the crop protection companies for their financial contributions as well as providing samples for the trials. Thanks should also be given to East of Scotland Growers (ESG) for hosting the trial and Kettle Produce for their input. Particular thanks should be given to James Rome and Duncan MacLachlan of ESG for their technical input and in-kind support with trial management and assessments.

Appendix

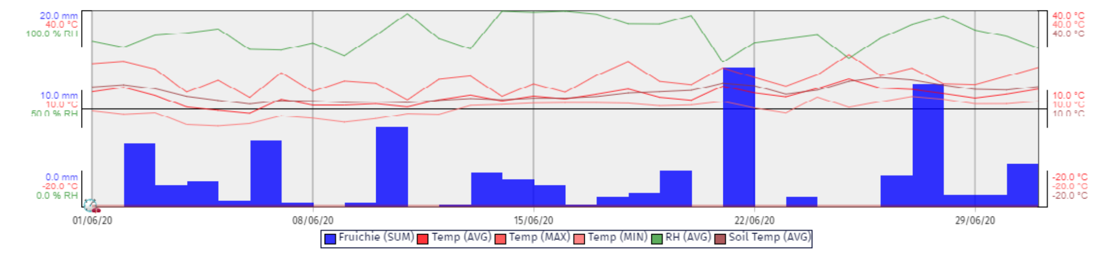
Weather data – provided by East of Scotland Growers

June

2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Y

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	June
SUM (mm)	6.4	2.2	2.6	0.6	6.8	0.4	0.0	0.4	8.2	0.0	0.2	3.4	2.8	2.2	0.2	1.0	1.4	3.6	0.0	14.2	0.0	1.0	0.0	0.0	3.2	12.6	1.2	1.2	4.4	80.2
AVG (°C)	14.1	10.6	9.6	8.7	13.0	11.1	11.1	11.6	10.6	12.8	14.2	12.5	13.9	13.1	14.5	16.1	13.6	12.7	17.0	14.9	13.7	16.3	19.2	16.4	15.9	14.7	13.4	14.5	16.1	13.8
MIN (°C)	8.9	5.3	4.9	5.6	7.9	7.1	6.0	7.0	8.6	8.4	11.1	11.4	11.8	11.9	11.9	11.7	11.0	11.2	12.3	10.3	8.9	13.6	10.5	12.2	13.8	13.0	11.5	11.5	12.3	4.9
MAX (°C)	22.2	15.2	18.8	13.5	21.1	15.4	18.6	17.9	12.8	19.1	20.1	13.9	17.7	15.1	20.3	24.4	18.5	17.5	22.5	19.7	17.0	20.4	26.7	20.2	22.5	17.8	17.5	20.0	22.7	26.7
AVG (% RH)	87.7	89.0	90.9	80.5	80.2	83.8	77.3	87.7	98.8	86.0	80.8	100.0	99.4	100.0	98.5	93.5	93.4	97.8	74.0	83.9	85.9	87.9	76.0	86.2	93.2	97.6	90.4	87.2	81.2	88.3
MIN (% RH)	58.5	74.2	67.2	62.2	62.8	74.1	60.7	69.6	94.8	69.0	65.8	100.0	96.4	100.0	89.0	72.5	75.0	82.9	46.3	65.2	73.2	74.0	53.0	72.5	68.5	87.0	78.3	66.0	53.7	46.3
MAX (% RH)	100.0	100.0	99.6	99.5	99.0	94.8	88.8	98.8	100.0	100.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8	98.9	97.7	100.0	99.8	100.0	100.0	96.6	97.0	99.2	100.0
AVG (°C)	16.2	13.9	12.7	11.5	12.6	12.4	12.0	12.2	11.9	12.7	13.2	12.8	13.3	13.3	13.8	14.9	15.2	15.7	17.9	17.1	14.5	15.7	18.5	19.6	18.9	17.3	16.0	15.8	16.9	14.9

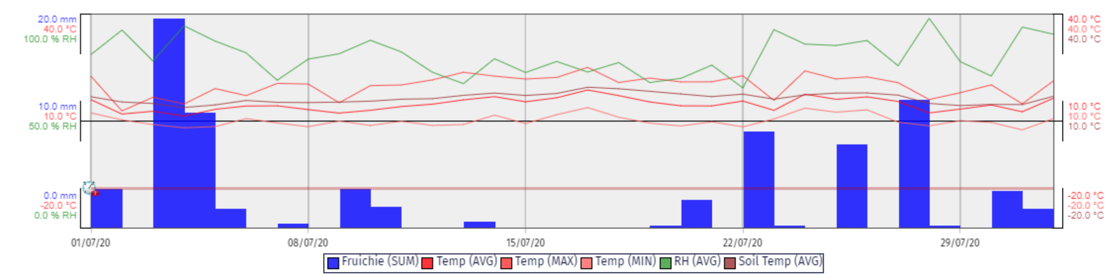


July

2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Y

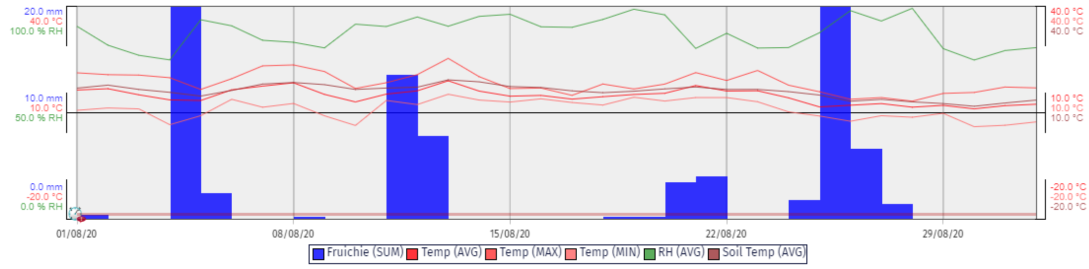
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	July
SUM (mm)	0.0	19.6	10.8	1.8	0.0	0.4	0.0	3.6	2.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.2	2.6	0.0	9.0	0.2	0.0	7.8	0.0	12.0	0.2	0.0	3.4	1.	79.6
AVG (°C)	12.8	11.4	13.3	14.3	14.3	13.2	12.3	13.1	14.1	14.8	16.0	16.9	15.4	16.6	18.8	17.2	15.4	14.3	14.3	15.7	13.0	17.6	16.1	16.8	15.5	12.3	13.4	14.6	12.6	16.	14.7
MIN (°C)	9.0	8.1	8.5	10.7	9.5	8.4	10.0	8.8	10.0	8.8	9.0	11.7	9.3	11.8	13.8	11.1	9.4	8.6	9.8	8.4	10.6	13.7	12.5	13.2	9.7	8.7	10.1	9.6	7.5	10.	7.5
MAX (°C)	16.7	14.8	19.2	17.2	20.6	20.4	15.2	20.0	20.2	21.6	23.8	22.7	21.9	22.3	25.1	20.9	22.1	21.0	21.1	22.8	15.8	24.2	21.9	22.5	20.8	16.1	18.0	20.2	14.9	21.	25.1
AVG (% RH)	78.2	94.7	87.6	82.1	69.2	79.1	81.6	88.0	82.5	72.9	67.6	79.3	72.8	78.0	73.1	77.5	68.1	70.1	76.3	65.6	92.9	86.2	85.5	87.8	76.0	98.3	77.9	71.2	94.1	90.	80.6
MIN (% RH)	63.5	69.8	69.2	65.2	47.8	50.5	62.4	53.5	56.2	50.1	44.2	53.9	50.7	55.3	56.0	57.1	44.6	48.0	51.1	42.9	75.9	57.4	63.2	67.7	47.9	93.2	61.3	49.6	79.3	75.	42.9
MAX (% RH)	96.3	100.0	100.0	100.0	89.9	93.6	96.1	100.0	100.0	95.8	88.5	96.4	95.9	97.0	87.7	93.8	97.6	90.1	94.5	92.7	100.0	100.0	99.7	100.0	99.1	100.0	98.5	90.4	100.0	100	100.0
AVG (°C)	15.0	13.8	14.6	15.8	15.3	15.2	15.4	15.6	16.2	16.3	17.3	17.9	17.2	17.8	19.5	19.1	18.4	17.7	16.9	17.6	16.2	17.4	17.9	17.9	17.3	15.0	14.4	14.7	14.7	17.	16.5



August

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Y

	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	August
SUM (mm)	0.0	26.4	2.4	0.0	0.0	0.2	0.0	0.0	13.6	7.8	0.0	0.0	0.0	0.0	0.0	0.2	0.2	3.4	4.0	0.0	0.0	1.8	31.6	6.6	1.4	0.0	0.0	0.0	0.0	100.0
AVG (°C)	13.7	13.5	16.5	17.6	18.5	15.2	13.1	15.3	16.2	19.1	16.1	14.7	14.9	13.9	14.6	15.2	15.5	17.7	16.2	16.2	14.2	11.7	12.1	12.6	11.6	12.1	11.1	12.0	12.4	14.7
MIN (°C)	6.6	9.2	13.8	11.6	12.6	9.2	6.4	13.5	12.3	15.3	13.6	13.0	14.0	12.9	12.2	14.4	13.3	14.3	14.3	13.1	10.3	9.1	7.6	9.2	8.7	9.8	6.1	6.5	7.4	6.1
MAX (°C)	19.9	16.6	19.7	23.3	23.5	21.7	16.9	18.5	20.8	25.4	20.2	16.9	17.0	14.9	18.1	16.7	18.1	21.4	19.2	22.0	17.8	16.0	13.8	14.3	13.3	15.5	15.8	17.3	17.1	25.4
AVG (% RH)	75.0	93.9	91.0	84.2	83.3	80.6	91.8	90.7	95.2	90.8	95.5	96.5	90.6	90.3	94.1	98.9	96.2	80.4	87.5	80.5	80.8	87.8	98.2	93.3	99.3	80.3	74.9	79.4	80.7	87.8
MIN (% RH)	51.4	79.6	78.6	63.4	65.9	54.2	79.7	78.1	82.5	73.9	85.2	90.4	81.1	84.7	81.4	92.6	86.1	61.8	76.8	58.8	60.3	71.1	92.0	81.4	94.5	56.0	56.9	53.7	57.0	50.5
MAX (% RH)	98.8	100.0	99.4	99.4	98.1	99.5	100.0	98.9	100.0	100.0	100.0	100.0	98.3	95.9	100.0	100.0	100.0	100.0	98.3	94.6	98.5	100.0	100.0	100.0	100.0	100.0	94.1	94.9	98.8	100.0
AVG (°C)	15.8	14.7	16.3	18.1	18.6	18.0	16.6	17.0	17.3	19.3	18.8	17.4	17.2	16.2	15.7	16.1	16.8	17.3	16.6	16.6	16.0	15.0	13.3	13.8	13.1	12.6	11.8	12.8	13.6	16.0



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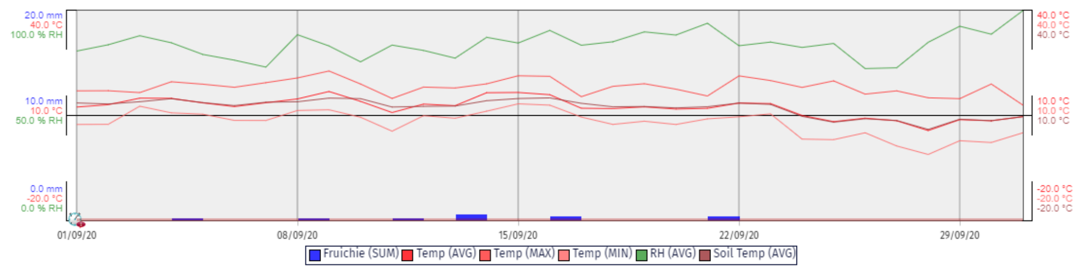
September – note the rain gauge may have been stuck in this month

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	September
SUM (mm)	.0	0.0	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.6	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
AVG (°C)	.1	15.0	14.9	13.6	12.6	13.7	14.7	16.9	14.1	10.8	13.3	12.8	16.5	16.6	15.9	12.1	12.0	12.5	11.8	12.1	13.6	13.4	10.0	8.2	9.2	8.5	5.7	8.8	8.5	9.7	12.3
MIN (°C)	.5	12.7	10.8	10.4	8.6	8.6	11.4	11.6	9.5	5.5	9.9	9.2	11.2	13.3	13.0	9.6	7.4	8.4	7.4	9.0	9.6	10.5	3.2	3.1	5.1	1.3	-1.2	2.8	2.3	5.0	-1.2
MAX (°C)	.1	16.5	19.7	19.0	18.1	19.4	20.7	22.7	19.0	14.9	18.1	17.9	19.1	21.4	21.2	15.4	18.3	19.1	17.5	15.6	21.3	20.0	18.0	19.9	16.1	17.0	15.1	14.8	19.0	13.0	22.7
AVG (% RH)	.7	88.1	84.7	79.1	76.4	73.1	88.5	83.2	75.6	83.6	81.0	77.3	87.3	84.6	90.6	83.5	85.2	89.9	88.4	94.0	83.3	85.0	82.5	84.4	72.4	72.8	84.9	92.6	88.8	100.0	84.1
MIN (% RH)	.3	78.9	65.6	58.2	51.7	41.9	75.6	61.5	57.0	68.7	62.0	54.9	77.1	64.0	67.6	72.7	66.5	61.7	51.3	80.3	54.1	58.2	59.0	55.6	48.0	45.0	46.7	78.5	47.6	100.0	41.9
MAX (% RH)	.6	97.9	98.7	95.9	91.4	97.5	97.2	97.5	96.4	99.5	91.1	97.2	98.6	97.9	100.0	95.3	98.5	100.0	100.0	100.0	100.0	97.4	100.0	100.0	97.7	97.8	100.0	100.0	100.0	100.0	100.0
AVG (°C)	.3	13.9	14.8	13.7	12.8	13.8	13.9	15.0	14.8	12.4	12.6	12.7	14.2	14.9	15.0	13.5	12.5	12.6	12.2	12.5	13.6	13.2	9.8	8.1	9.1	8.6	6.0	8.9	8.5	9.7	12.2



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