VIII Fungicide strategies against powdery mildew resistance in sugar beet

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Summary
Two field trials were carried out to test different fungicide control strategies on powdery mildew (*Erysiphe betae*) and to minimise the spread of strobilurin resistance. The treatments included registered products as well as not registered products including Propulse SE 250 and Balaya. As examples of alternative products, Serenade ASO (*Bacillus subtilis* QST 713) and Kumulus S (sulphur) were also included. All fungicide treatments controlled powdery mildew and rust effectively. Kumulus S reduced powdery mildew significantly and was comparable to the other fungicide solutions. Serenade ASO showed only a low effect on powdery mildew. Powdery mildew samples from Denmark and Sweden were tested for strobilurin resistance in 2020. Two samples from Denmark and two samples from Sweden were tested positive for strobilurin resistance in a trial under controlled conditions. All four samples harboured the point mutation G143A, which has previously been associated with strobilurin resistance. The results from this project show that strobilurin resistance in powdery mildew in sugar beet is a real risk. Furthermore, the results show that powdery mildew can still be effectively controlled and that spray strategies which may lower the risk of spreading strobilurin resistance are an option. The project was financed by ”Sukkerroeafgiftsfonden”.

Field trials
Investigations on the improvement on the control of powdery mildew in sugar beet were continued in a collaboration between Aarhus University and Nordic Beet Research (NBR). In the project ‘Fungicide resistance in powdery mildew in sugar beet (*Erysiphe betae*)’, the effect of different control strategies against fungal leaf diseases in sugar beet was tested (Table 1). Two randomised field trials were set up in Lolland and Zealand (Flakkebjerg). The trials were sown at the beginning of April. The cultivar Lombok was used in both trials; this cultivar is known to be susceptible to powdery mildew and moderately susceptible to rust (*Uromyces betae*). The trials were treated two to three times before disease onset in the week commencing 20 July (week 30) (T0 - A), at disease onset in the week commencing 27 July (week 31) (T1 - B) and in the week commencing 17 August (week 34) (T2 - C). Leaf diseases were scored at 10-day intervals on a scale of 0 to 100 (100 = 100% attacks).

Powdery mildew and rust were the predominant diseases. *Cercospora beticola* and *Ramularia beticola* appeared late and at a low level. Mildew attacks occurred earlier and developed more strongly in Zealand with attacks of 90% and 80% in the untreated check, respectively.

Table 1. Fungicide spray programmes tested against fungal leaf diseases in sugar beet.

Trt	T0 - A (week 30)	T1 – B (week 31)	T2 – C (week 34)
1		Untreated	
2		0.5 l/ha Opera	0.5 l /ha Opera
3		0.5 l/ha Revysol + 0.18 l/ha Comet Pro	0.5 l/ha Revysol + 0.18 l/ha Comet Pro
4		0.62 l/ha Comet Pro	0.62 l/ha Comet Pro
5		0.5 l/ha Amistar Gold	0.5 l/ha Amistar Gold
6		0.5 l/ha Propulse SE 250	0.5 l/ha Amistar Gold
7		0.5 l/ha Revysol + 0.18 l/ha Comet Pro	0.25 l/ha Amistar Gold
8		1 l/ha Revysol + 0.375 l/ha Comet Pro	0.5 l/ha Amistar Gold
9	4 l/ha Serenade ASO	4 l/ha Serenade ASO	4 l/ha Serenade ASO
10	4 l/ha Serenade ASO	0.62 l/ha Comet Pro	4 l/ha Serenade ASO
11	5 kg/ha Kumulus S	5 kg/ha Kumulus S	5 kg/ha Kumulus S
12	5 kg/ha Kumulus S	0.62 l/ha Comet Pro	5 kg/ha Kumulus S

Two treatments (trt) at T1 and T2 reduced attacks of mildew significantly compared to the untreated control (Figures 1 and 2). No differences were found among spray programmes (trt 2 to 8). Two treatments with 0.5 l/ha Revysol and 0.18 l/ha Comet Pro (trt 3) performed equally well as the standard recommendation of two times 0.5 l/ha Opera or two times 0.62 l/ha Comet Pro. The effect of spray programmes with different fungicides used at T1 and T2 (trt 6 to 8) was in line with the standard treatment. However, the effect of two applications of 0.5 l/ha Amistar Gold (trt 5) or spray programmes finishing off with 0.5 l/ha Amistar Gold (trt 6 to 8) was slightly inferior compared to the other fungicide solutions at later assessment dates. Still, those spray programmes can be regarded as an alternative to two times 0.5 l/ha Opera, which will not be available after 2021. Those alternative fungicide programmes might also help to reduce the spread of strobilurin resistance in powdery mildew as they are built up around mixing and alteration of different active ingredients. Three applications of 5 kg/ha Kumulus S (trt 11) showed a high effect against powdery mildew at the same level as treatments 2 to 8. The same strategy with 0.62 l/ha Comet Pro at T1 instead of Kumulus S showed a very high control of both moderate and high levels of attack. The application of three times 4 l/ha Serenade ASO (trt 9) had a low effect and only at the early assessment dates. The effect of Serenade ASO improved when alternated with 0.62 Comet Pro l/ha at T1 (trt 10). Results, however, varied between the two field trials (Figure 1).

The infection level of rust in the control plots was moderate to high: between 40% at Flakkebjerg and 70% at the site in Lolland (Figure 3). Spray programmes 2-8 showed moderate effect against rust.

Generally, fungicide treatments had a low effect in the field trial in Lolland. The treatments with Kumulus S and Serenade ASO were inferior to all fungicide solutions in controlling rust (Figure 3).

All spray programmes including fungicides resulted in higher root yield and higher sugar content (data not shown). Also treatments with Kumulus S and treatment 10 (Serenade ASO - Comet Pro - Serenade ASO) increased the root weight and sugar content. No significant differences were seen for yield parameters after a fungicide treatment. Only trt 9 with three applications of Serenade ASO resulted in significantly lower yields.

Table 2 shows a summary of the data from the four trials across the two seasons. It also summarises control of rust, which was present at a significant level along with minor attacks of Ramularia leaf spot and Cercospora leaf spot.

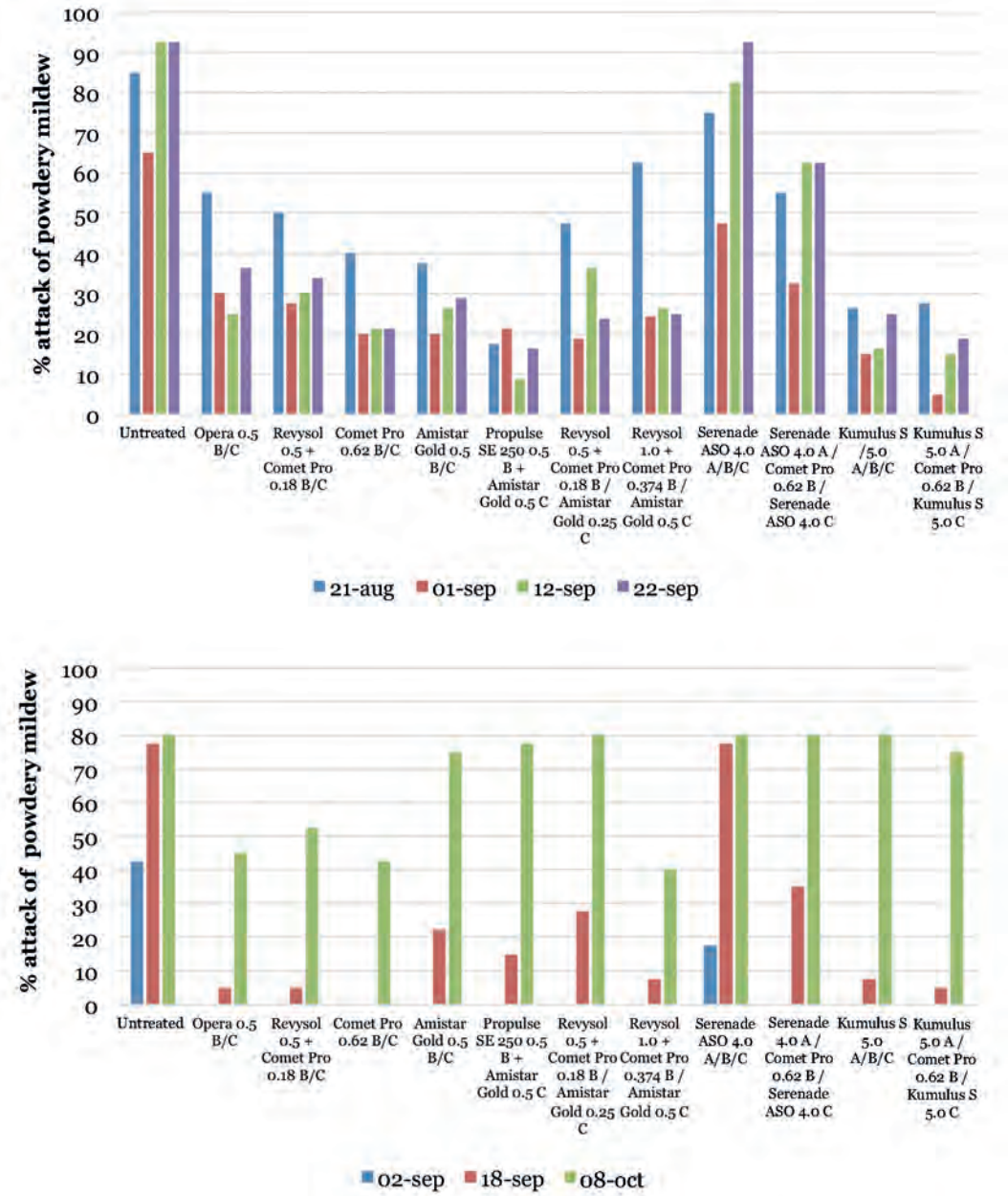

Figure 1. Per cent powdery mildew following different spray programmes assessed at four timings. Flakkebjerg at the top, Lolland below. A, B and C = spray timings T1, T2 and T3.

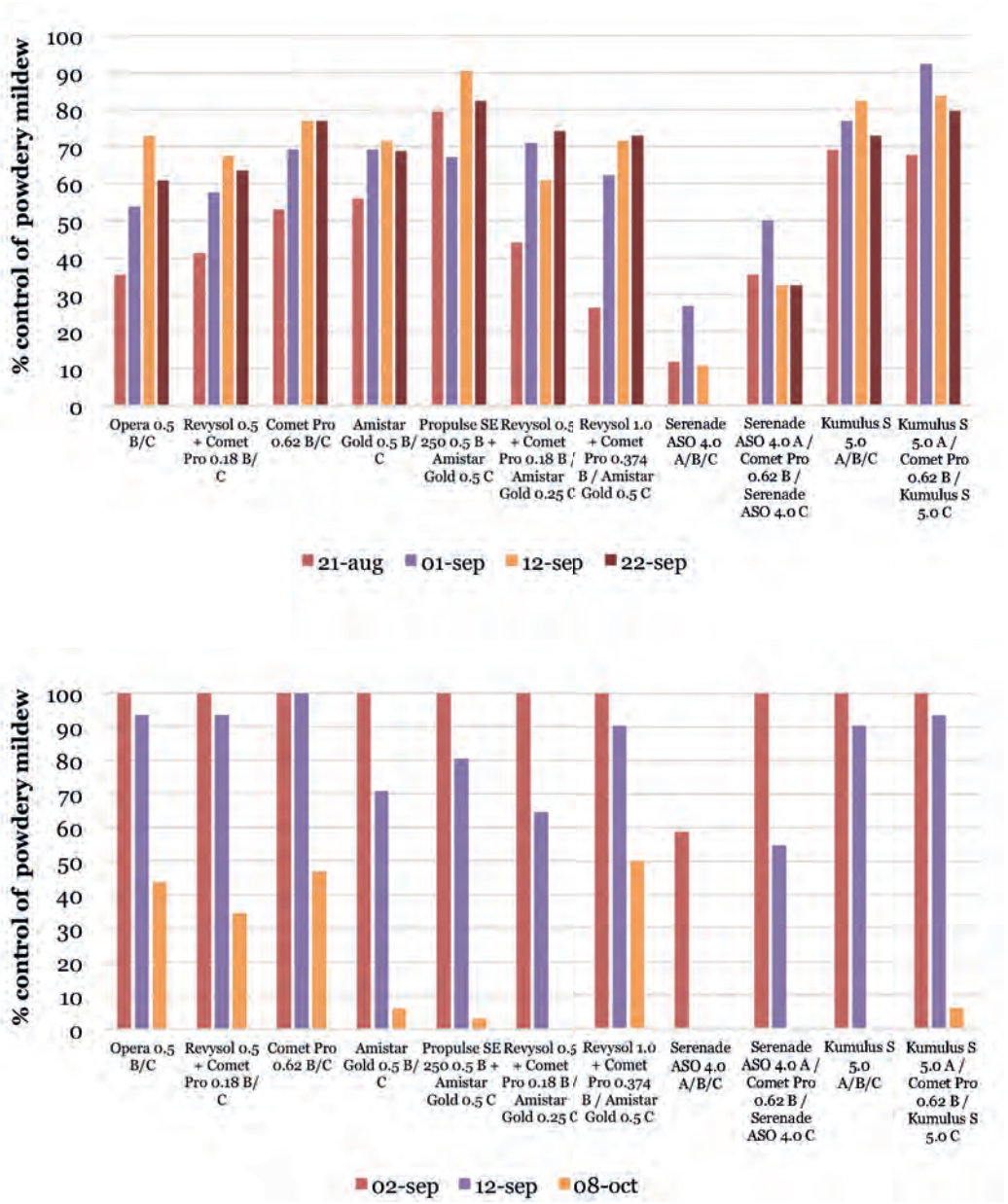

Figure 2. Per cent control of powdery mildew following different spray programmes assessed at four timings. Flakkebjerg at the top, Lolland below. A, B and C = spray timings T1, T2 and T3.

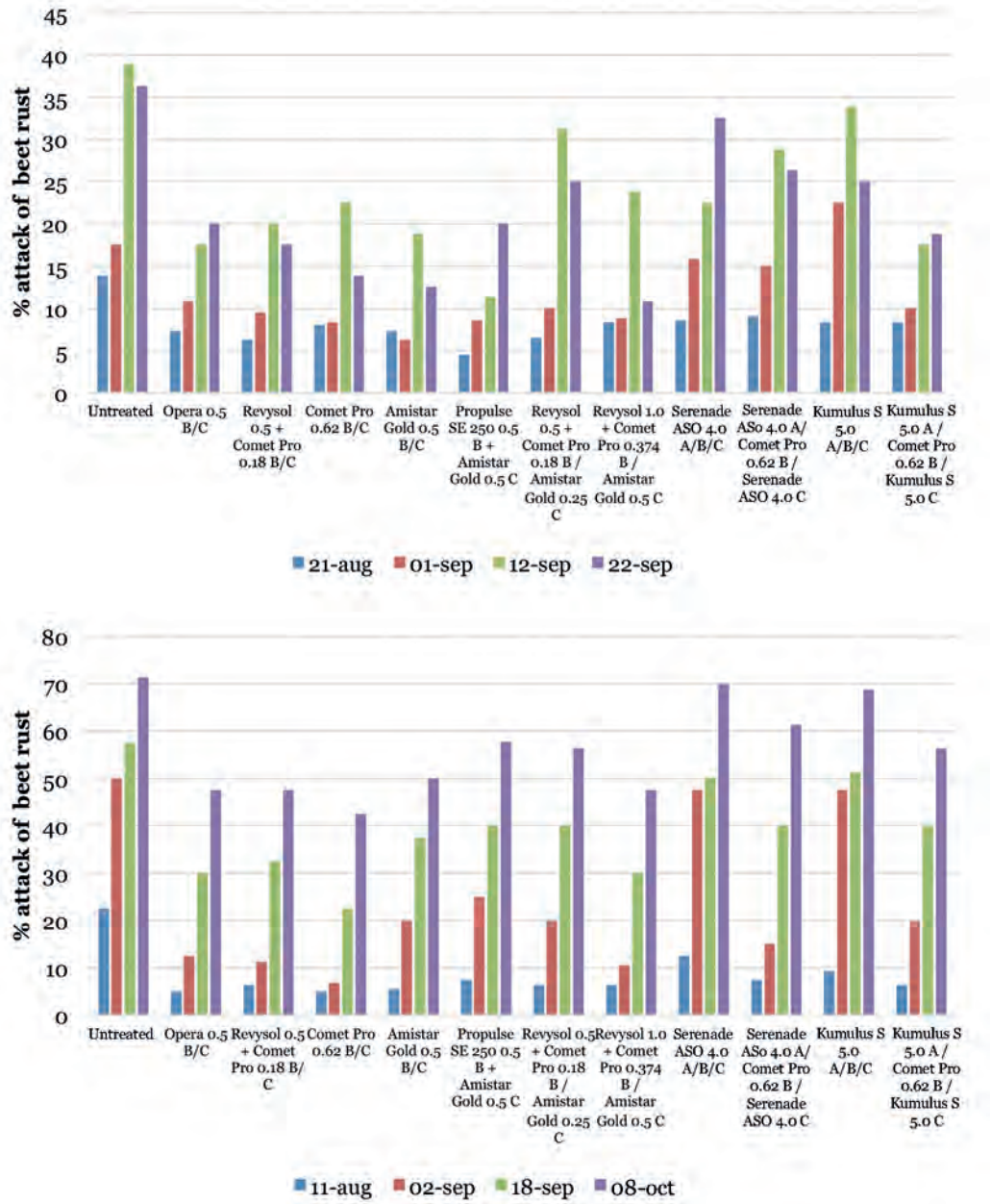

Figure 3. Per cent rust following different spray programmes assessed at four timings. Flakkebjerg at the top, Lolland below. A, B and C = spray timings T1, T2 and T3.

Table 2. Average attack of the four leaf diseases and yield responses from the four trials carried out in 2019 and 2020. The treatments were applied at A, B and C = spray timings T1, T2 and T3.

Treatments	Timing	Powdery mildew	Rust	*Ramularia*	*Cercospora*	Yield, t/ha	Sugar, t/ha
Untreated	BC	49.2	30.8	1.9	2.4	96.7	16.3
2 x 0.5 Opera	BC	7.5	11.3	0.4	0.6	104.6	18.1
2 x (0.5 Revysol + 0.18 Comet Pro)	BC	7.6	12.2	0.2	2.1	104.9	18.3
2 x 0.62 Comet Pro	BC	5.4	8.2	0.4	2.8	107.3	18.7
2 x 0.5 Amistar Gold	BC	5.3	12.9	0.3	0.6	106.0	18.2
0.5 Propulse SE 250 / 0.5 Amistar Gold	BC	5.9	14.8	0.7	0.8	106.7	18.4
0.5 Revysol + 0.18 Comet Pro / 0.25 Amistar Gold	BC	6.5	14.0	0.4	0.8	107.5	18.6
1.0 Revysol + 0.375 Comet Pro / 0.5 Amistar Gold	BC	6.1	10.4	0.1	0.4	106.2	18.3
3 x 4.0 Serenade ASO	ABC	35.8	28.1	0.4	1.3	96.4	16.3
4.0 Serenade ASO / 0.62 Comet Pro / 4.0 Serenade ASO	ABC	12.3	12.9	0.4	1.3	103.5	17.6
3 x 5.0 Kumulus S	ABC	4.3	31.5	0.4	3.9	103.6	17.5
5.0 Kumulus S / 0.62 Comet Pro / 5.0 Kumulus S	ABC	1.4	14.1	0.1	4.0	108.6	18.7
No. of trials		4	4	3	2	4	4
LSD_{95}		6.4	3.8	NS	NS	4.0	0.7

Resistance monitoring

In 2020, ten powdery mildew (*Erysiphe betae*) samples were tested for strobilurin resistance. Diseased leaves from five Danish and five Swedish sites were collected from commercial fields (Table 3). The leaves were used to infect disease-free plants (cv. Lombok - powdery mildew-susceptible) at growth stage 19. Powdery mildew was transferred by rubbing diseased leaves against uninfected leaves. Twelve plants per site were used; three plants were treated with either 0.5 l/ha Comet Pro (pyraclostrobin), 0.5 l/ha Opera (epoxiconazole + pyraclostrobin) or 0.5 Amistar Gold.

Table 3. Sites, from where powdery mildew samples were collected.

Swedish samples	Danish samples
1. Vadensjö	6. Byhave
2. Skegrie	7. Skelby
3. Österbo	8. Dannemare
4. Petersborg	9. Brandstrup
5. Lönnstrup	10. Døllefjelle

Table 4. Powdery mildew attacks 14 days after artificial inoculation. + = starting infection, ++ = moderately infected, +++ = highly infected.

	1	2	3	4	5	6	7	8	9	10
Untreated	+++	++	+	+++	++	+++	++	-	++	++
0.5 l/ha Comet Pro	+++	+	-	-	-	-	+	-	-	++
0.5 l/ha Opera	-	-	-	-	-	-	-	-	-	-
0.5 l/ha Amistar Gold	-	-	-	-	-	-	-	-	-	-

The plants were assessed for powdery mildew one, two and three weeks after inoculation (Table 4). A treatment with 0.5 l/ha Opera controlled all powdery mildew samples; however, powdery mildew developed symptoms on two Danish and two Swedish samples treated with 0.5 l/ha Comet Pro. Those samples were tested for the presence of *cytb* point mutation G143A, which is associated with powdery mildew strobilurin resistance (Bolton and Neher, 2014). All four samples tested positive for G143A, indicating that the strobilurin-resistant isolates occur in the Danish and Swedish *Erysiphe betae* population. The presence of resistance has not been seen at field level; however, choosing an alternative fungicide programme in order to minimise the spread of strobilurin resistance should be considered. This is especially the case when powdery mildew is the primary disease.

The project was financed by “Sukkerroeafgiftsfonden”.

References

Bolton, M. D. and O. T. Neher (2014). First Report of Q(O)I-insensitive Powdery Mildew (*Erysiphe polygoni*) on Sugar Beet in the United States. Plant Disease 98: 1004-1004. https://doi.org/10.1094/PDIS-12-13-1217-PDN