COBRI N Use Efficiency trials 2024 trial report

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This report was produced by the members of COBRI (COordination Beet Research International), which represents the sugar beet research institutes in Denmark/Sweden (NBR, Holeby), Germany (IfZ, Göttingen), Belgium (IRBAB, Tienen) and the Netherlands (IRS, Dinteloord).

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Summary

The purpose of this COBRI project was to test new biostimulants in sugar beets and evaluate their effect on sugar yield. Therefore, five trials were conducted in Belgium (2), Denmark, Germany and The Netherlands.

Results from the COBRI trials showed that the effect of BlueN and Vixeran varied considerably across individual trials, and the overall effect was generally uncertain across the three N levels. No significant differences were observed when analyzing interactions between the three levels of N fertilizer and the biostimulants in the trials in Belgium, Germany and the Netherlands.

The Danish trial showed a rather considerable yield decline in the untreated plots at high N levels compared to moderate N levels. The decline in sugar yield at the high N level relative to the moderate N level is likely due to a reduction in sugar concentration, a well-known phenomenon when there is an excess of available nitrogen, especially late in the growing season for sugar beets.

The growth conditions in 2024 were optimal for high nitrogen mineralization in the soil, which may help to explain the yield reductions observed in the untreated plots in the Danish NBR trials. However, with only one year of trial data and significant variation across locations, it is too early to conclude whether there is a real and consistent effect of biostimulants on nitrogen utilization in sugar beets.

Objective

The main objective of this COBRI trial project was to investigate whether the application of nitrogen-fixing bacteria in commercial products can add value in sugar beet cultivation. Recently, Corteva and Syngenta have entered the market with such products (BlueN/UtrishaN and Vixeran). Their claim is that these biostimulants can provide 30 to 50 kg of nitrogen to crops, saving nitrogen fertilization. For testing, the trial design comprised three N fertilizer levels (low, moderate, high) with and without the application of each product.

Trial plan

Issue	Description
Location	No use of organic fertilizer since last autumn, to avoid unpredictable high mineralization.
Actual trial locations	Avernas and Lauw, Belgium Sofiehøj, Denmark Sieboldshausen, Germany Westmaas, the Netherlands
Soil Mineral N (SMN)	SMN analysis in February or March to calculate N doses.
Trial design	Randomized complete block design. Factor A: Fertilizer. Factor B: Biostimulant
Objects	Based on the SMN, there are two possible strategies. Basically, N rates are divided in low, moderate and high. Exact doses depends on the location. **Case A: SMN 0-60 cm > 60 kg N/ha** 1. SMN 2. SMN + BlueN 3. SMN + Vixeran 4. N120 (120-SMN=Ndose, kg N/ha) 5. N120 (120-SMN=Ndose, kg N/ha) + BlueN 6. N120 (120-SMN=Ndose, kg N/ha) + Vixeran 7. N160 (160-SMN=Ndose, kg N/ha) 8. N160 (160-SMN=Ndose, kg N/ha) + BlueN 9. N160 (160-SMN=Ndose, kg N/ha) + Vixeran **Case B: SMN 0-60 cm < 60 kg N/ha** 1. SMN + Ndose 30 kg N/ha 2. SMN + Ndose 30 kg N/ha + BlueN 3. SMN + Ndose 30 kg N/ha + Vixeran 4. N120 (120-SMN=Ndose, kg N/ha) 5. N120 (120-SMN=Ndose, kg N/ha) + BlueN 6. N120 (120-SMN=Ndose, kg N/ha) + Vixeran 7. N160 (160-SMN=Ndose, kg N/ha) 8. N160 (160-SMN=Ndose, kg N/ha) + BlueN 9. N160 (160-SMN=Ndose, kg N/ha) + Vixeran
Application details:	Both products should be applied at BBCH 16-18. BlueN: 333 gram per hectare. Vixeran: 50 gram per hectare. Water volume: 200-300 liter per hectare. Not during cold weather (at least 15°C during the day). Apply in the morning or evening (low radiation and higher humidity).
Crop growth	Crop development should be rated frequently. (e.g. aboveground biomass, leave color, foliar diseases)
Harvest and analysis	Trials are harvested and processed to determine yield and internal quality (sugar content, K/Na, Amino-N).

Trial results in Belgium (IRBAB), Germany (IfZ) and the Netherlands (IRS)

It was decided to exclude the Danish trial from the overall dataset, as Vixeran was not included in the Danish trial, which introduced interference in the data analysis. The results in the COBRI collaboration therefore comprise four trials: two from Belgium, one from the Netherlands, and one from Germany. The trial results were analyzed using a three-factor ANOVA (factors A, B, C), where Factor A is location, Factor B is the N fertilizer level, and Factor C is the use of biostimulants. These factors were introduced as fixed factors in the ANOVA. The full factorial analysis is presented in *Appendix 6*. The whisker bars in the figures indicate standard error.

There were observed significant differences between the trial locations (factor A): trials at Avernas in Belgium and Westmaas in the Netherlands resulted in significantly higher sugar yield (18.1-17.7 t/ha) compared to the trails at Lauw in Belgium and Sieboldshausen in Germany (15.3 t/ha; *Appendix 6*).

As expected, factor B, the N fertilizer level, had a significant response on sugar yield, with notable differences observed between the low, moderate, and high N levels (*Figure 1*).
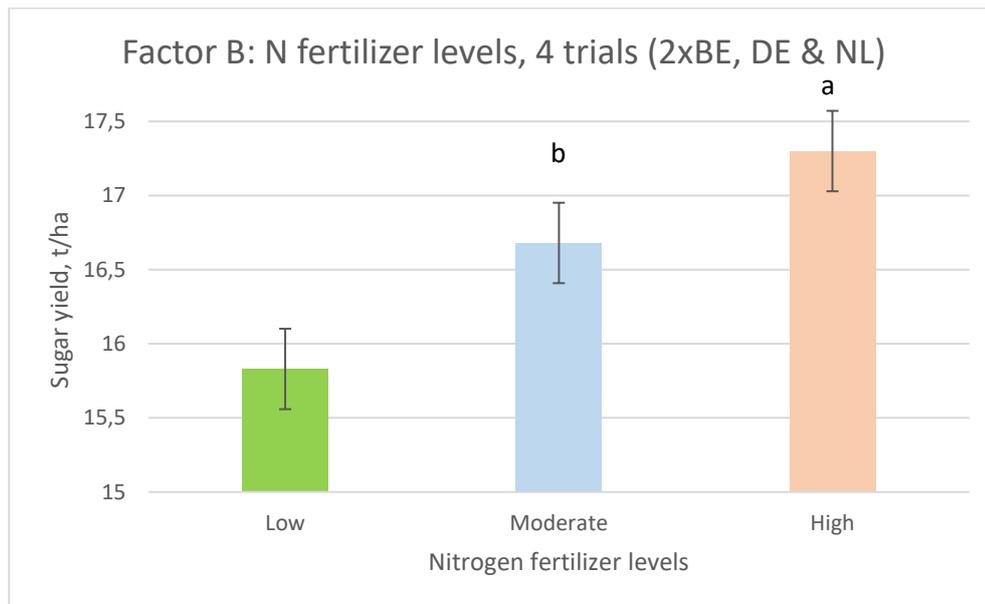
Figure 1. Overall ANOVA results of Factor B – N fertilizer level: low, moderate and high. Significant differences between the fertilizer levels low, moderate and high.

Factor C, biostimulants, showed no significant difference between the untreated plots and those treated with BlueN or Vixeran (*Figure 2*).
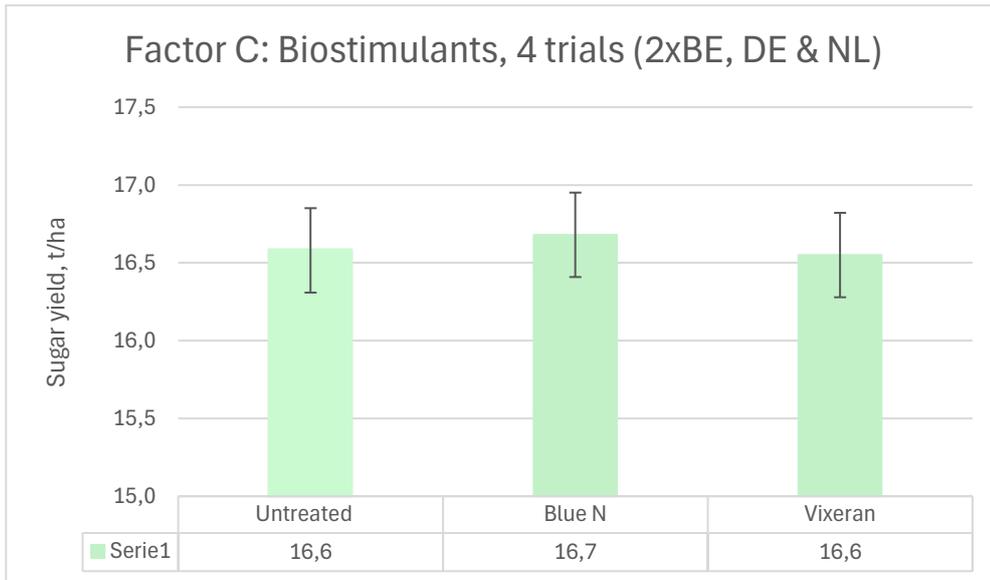
Figure 2. Overall ANOVA results of Factor C - Biostimulants: Untreated control, BlueN and Vixeran. No significant differences, compilation of 4 trials.

The interaction between N level and biostimulant treatment across the four trials for the sugar yield data is presented in *Figure 3* below.
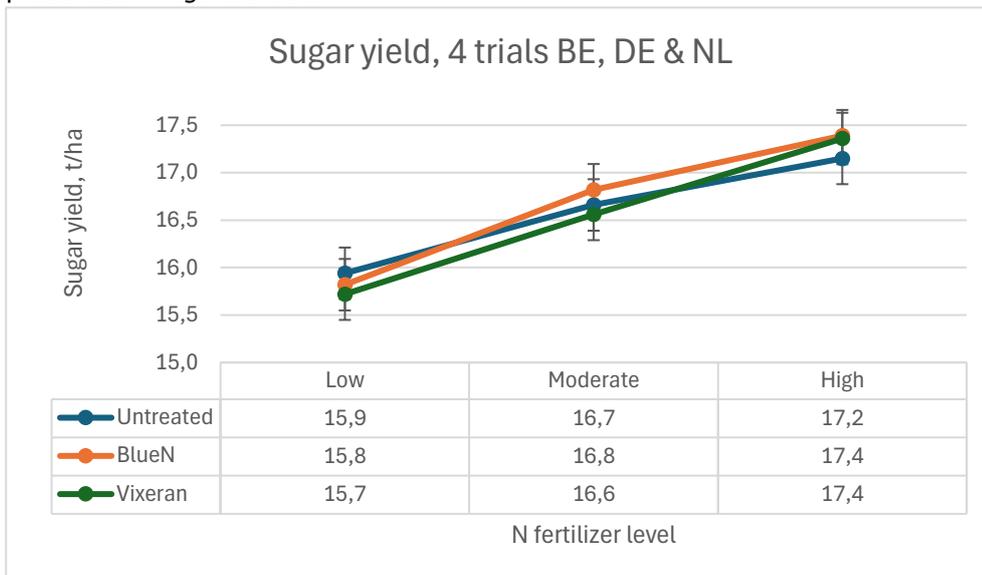
Figure 3. Interactions between N fertilizer level and biostimulants, compilation of 4 trials.

The interactions between N fertilizer level and biostimulant were not significant (*Table 1* & *Appendix 6*). There were no significant interactions in other yield parameters: sugar content, root yield, K content, Na content and AminoN content (*Table 1* & *Appendix 6*). The interactions from the individual trials are presented in *Figure 4* below.

Sugar yield, BE Avernas

	Low	Moderate	High
Untreated	17,6	18,2	18,0
BlueN	17,8	18,5	18,7
Vixeran	17,8	18,0	18,7

Sugar yield, BE Lauw

	Low	Moderate	High
Untreated	15,2	15,3	15,6
BlueN	15,5	15,2	15,4
Vixeran	15,4	14,7	15,4

Sugar yield, DE Sieboldshausen

	Low	Moderate	High
Untreated	14,9	15,2	15,7
BlueN	14,7	15,8	16,0
Vixeran	14,5	14,8	16,3

Sugar yield, NL Westmaas

	Low	Moderate	High
Untreated	16,1	18,1	19,3
BlueN	15,3	17,8	19,5
Vixeran	15,2	18,8	19,2

Figure 4. Interactions between fertilizer level and biostimulants, single trial results from Belgium, Germany and the Netherlands. At none of the trial sites the Interaction between Factor B (N fertilizer level) and Factor C (biostimulants) was significant.

Table 1. Results of the trials in Belgium, Germany and the Netherlands.

		Belgium		Germany	Netherlands
		Avernas	Lauw	Sieboldshausen	Westmaas
N application (SMN + dose) kg N/ha					
Low		40+30	86+30	80	18 + 40
Moderate		40+60	86+60	80+40	18 + 100
High		40+90	86+90	80+80	18 + 160
Sugar yield (t/ha)					
Low	Untreated	17,56	15,22	14,87	16,12
	BlueN	17,77	15,54	14,72	15,27
	Vixeran	17,84	15,35	14,47	15,23
Moderate	Untreated	18,16	15,25	15,15	18,09
	BlueN	18,49	15,20	15,79	17,80
	Vixeran	17,97	14,71	14,78	18,77
High	Untreated	17,98	15,63	15,66	19,30
	BlueN	18,68	15,39	16,04	19,46
	Vixeran	18,65	15,37	16,26	19,17
Prob(F)		0,859	0,334	0,809	0,5101
lsd 5%		0,484	0,347	0,788	0,666
Root yield (t/ha)					
Low	Untreated	101,6	96,5	91,4	93,9
	BlueN	101,9	98,7	90,3	89,5
	Vixeran	102,9	97,3	88,1	88,1
Moderate	Untreated	105,4	96,6	92,9	105,0
	BlueN	106,5	96,0	96,2	103,1
	Vixeran	104,7	93,8	89,7	108,3
High	Untreated	104,8	99,4	95,2	112,4
	BlueN	108,5	98,1	97,7	112,3
	Vixeran	108,1	97,9	99,5	112,0
Prob(F)		0,715	0,713	0,744	0,5039
lsd 5%		2,24	2,03	4,91	3,54
Sugar content (%)					
Low	Untreated	17,27	15,77	16,28	17,18
	BlueN	17,43	15,74	16,29	17,04
	Vixeran	17,33	15,78	16,42	17,28
Moderate	Untreated	17,22	15,79	16,31	17,22
	BlueN	17,36	15,84	16,41	17,25
	Vixeran	17,17	15,67	16,49	17,32
High	Untreated	17,16	15,73	16,45	17,18
	BlueN	17,21	15,69	16,41	17,32
	Vixeran	17,25	15,70	16,36	17,11
Prob(F)		0,565	0,523	0,339	0,4124
lsd 5%		0,141	0,078	0,09	0,153

Trial results from NBR trial in Denmark

The Danish trial did not include Vixeran, and it was therefore decided to exclude this trial from the compiled results. However, BlueN was tested in three different combinations in the Danish trial: applied as early (BBCH 16-18), late (BBCH 32-35), and in combination with Kinsidro Grow+. Moreover, a test product Stimplex (based on seaweed extract of *Ascophyllum nodosum*).

Sugar yield, NBR trial in Denmark 2024

	Low	Moderate	High
Untreated	14,9	16,3	15,9
BlueN early	15,2	16,0	16,2
BlueN late	15,0	15,6	16,5
Kinsidro Grow+ + BlueN	14,8	16,1	16,5
Stimplex	14,4	16,0	16,5
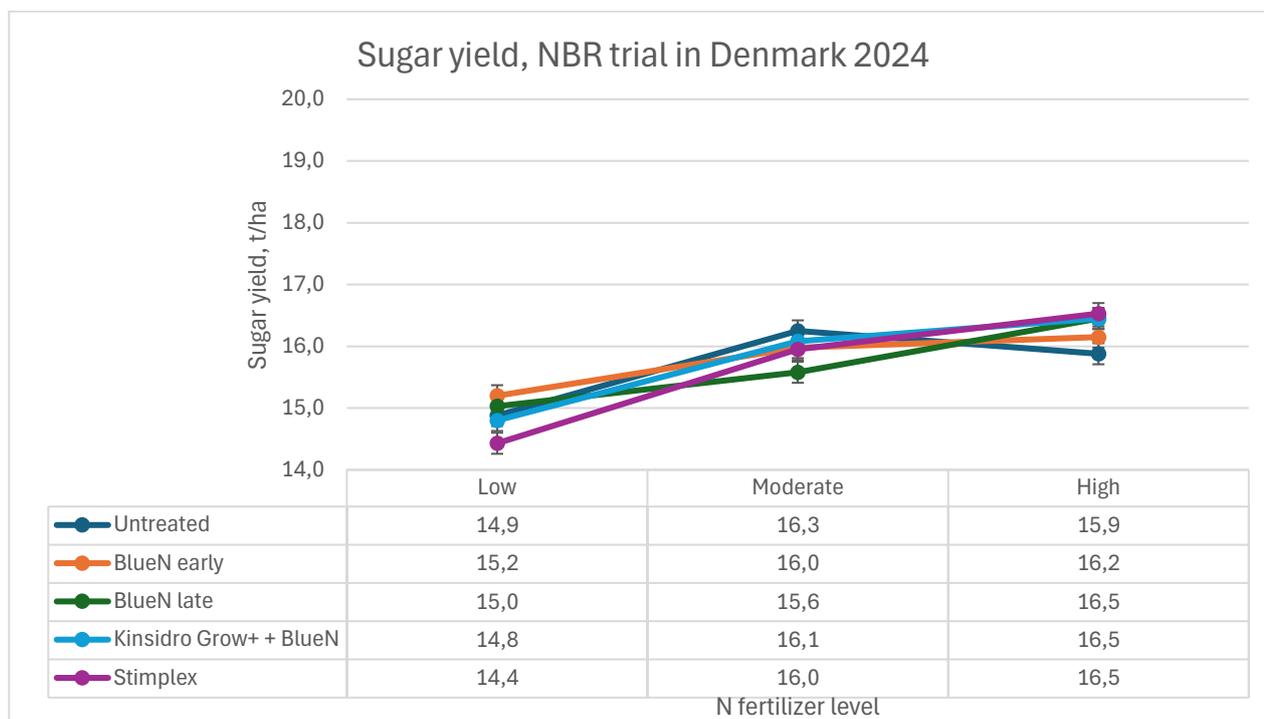
N fertilizer level

Figure 5. Interactions between fertilizer level and biostimulants, trial results from NBR trial in Denmark.

At the low N level, the sugar yield was measured at 14.9 t/ha, while the moderate N level resulted in a 9% increase in sugar yield (16.3 t/ha). The high N level led to a smaller increase of 7% (15.9 t/ha) compared to the low N level (*Figure 5*). The decline in sugar yield at the high N level relative to the moderate N level is likely due to a reduction in sugar concentration (see *Appendix 7* for further details), a well-known phenomenon when there is an excess of available nitrogen, especially late in the growing season for sugar beets.

Discussion and concluding remarks

Biostimulants are marketed with claims that they can replace up to 30–50 kg N/ha in various crops by fixing nitrogen from the air and converting it into plant-available nitrogen. Therefore, the greatest effect would normally be expected at moderate or low N levels—this was not observed in either of the trials in this COBRI project. There was not observed any significant yield increase by BlueN and Vixeran at moderate or low N fertilizer levels. No significant difference was observed when analyzing interactions between the three levels of N fertilizer and the biostimulants in the trials in Belgium, Germany and the Netherlands.

Appendix 1. Daily weather data Rødby, Denmark

Weather data Denmark 2024
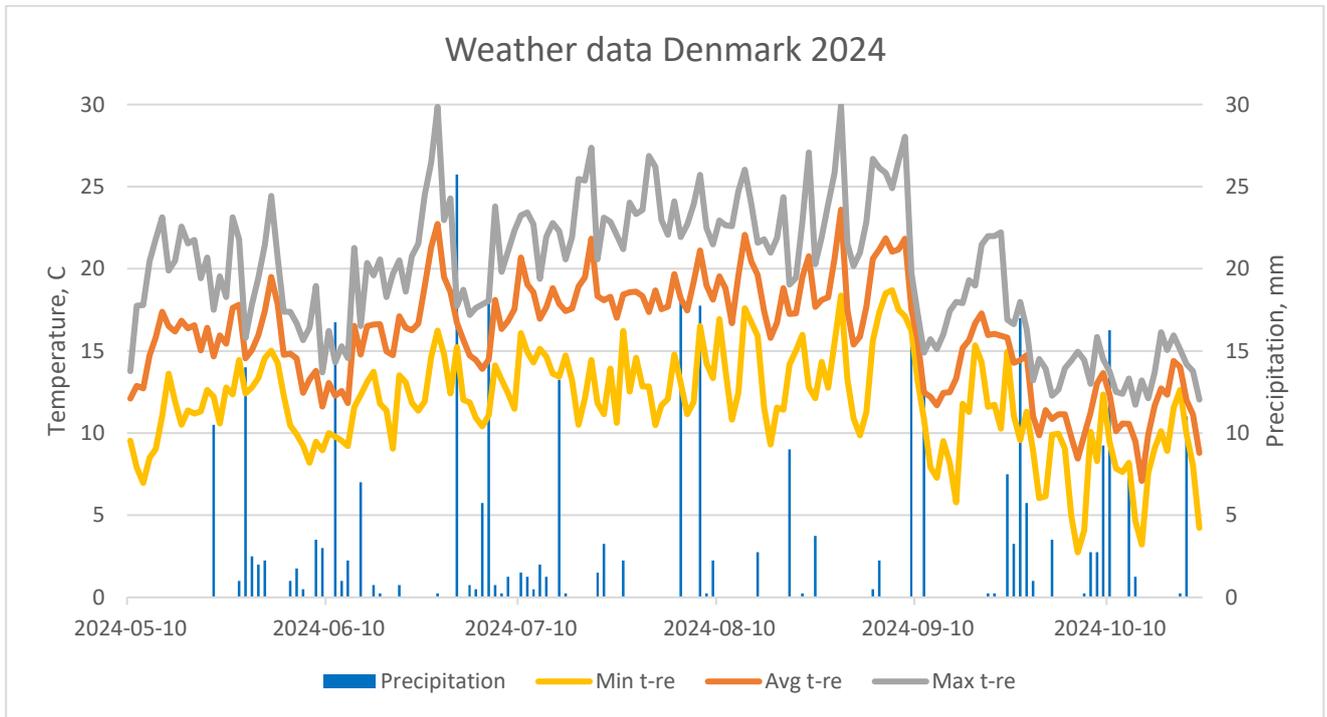
Appendix 2. Daily weather data Westmaas, the Netherlands

Weather data Netherlands 2024
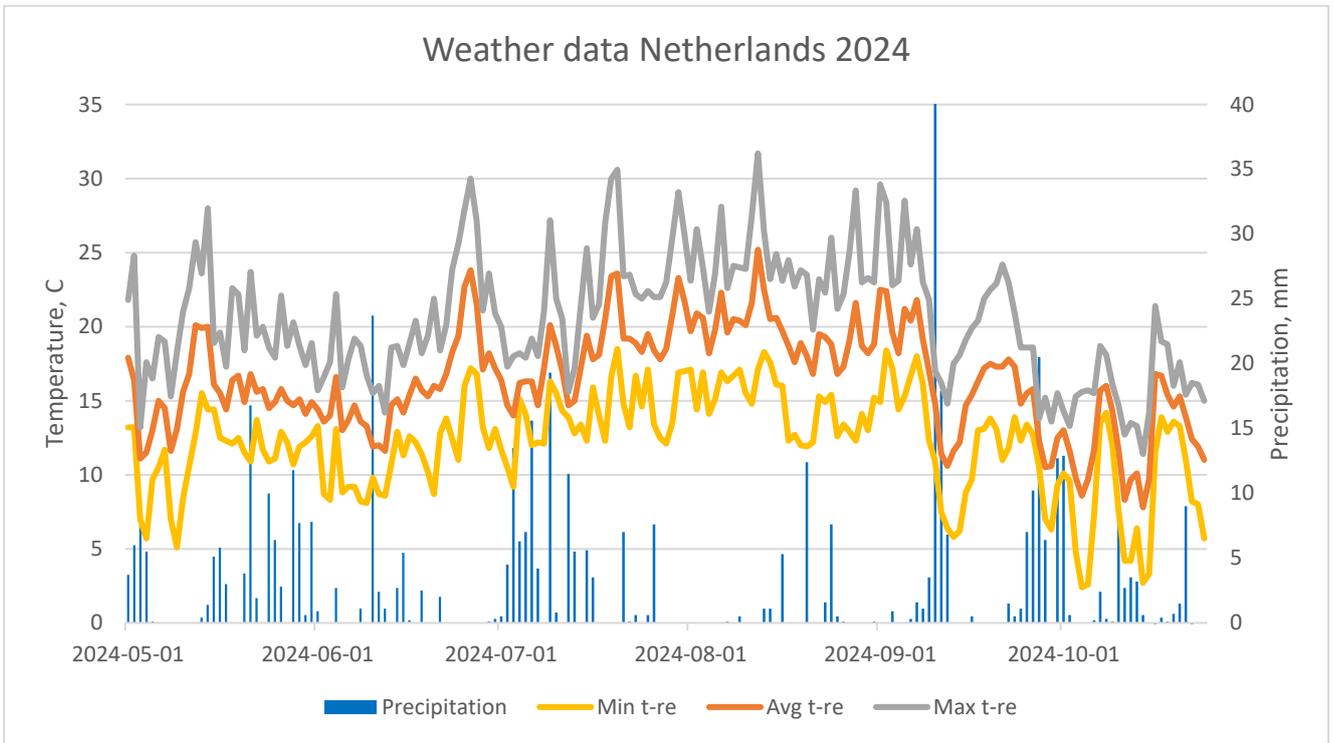
Appendix 3. Daily weather data Sieboldshausen, Germany

Weather data Germany
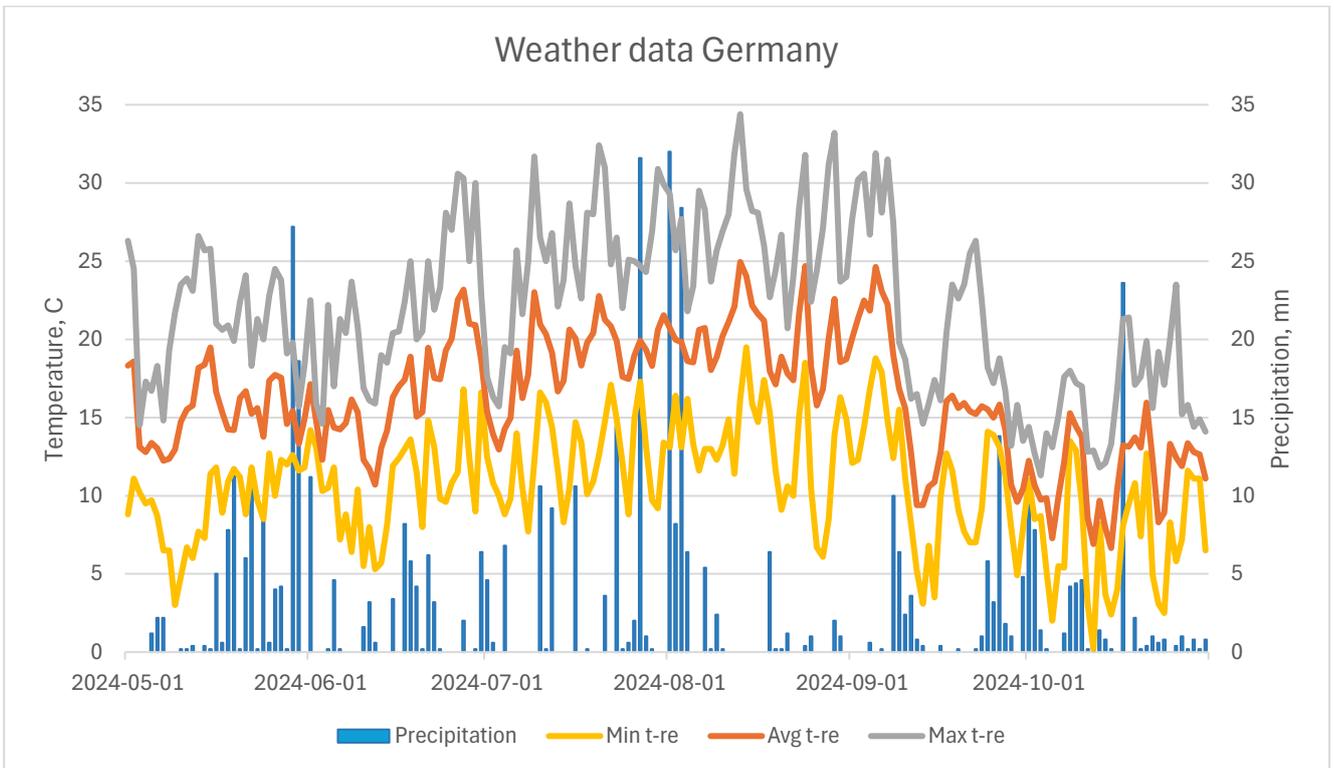
Appendix 4. Daily weather data Avernas, Belgium

Weather data Belgium (Avernas)
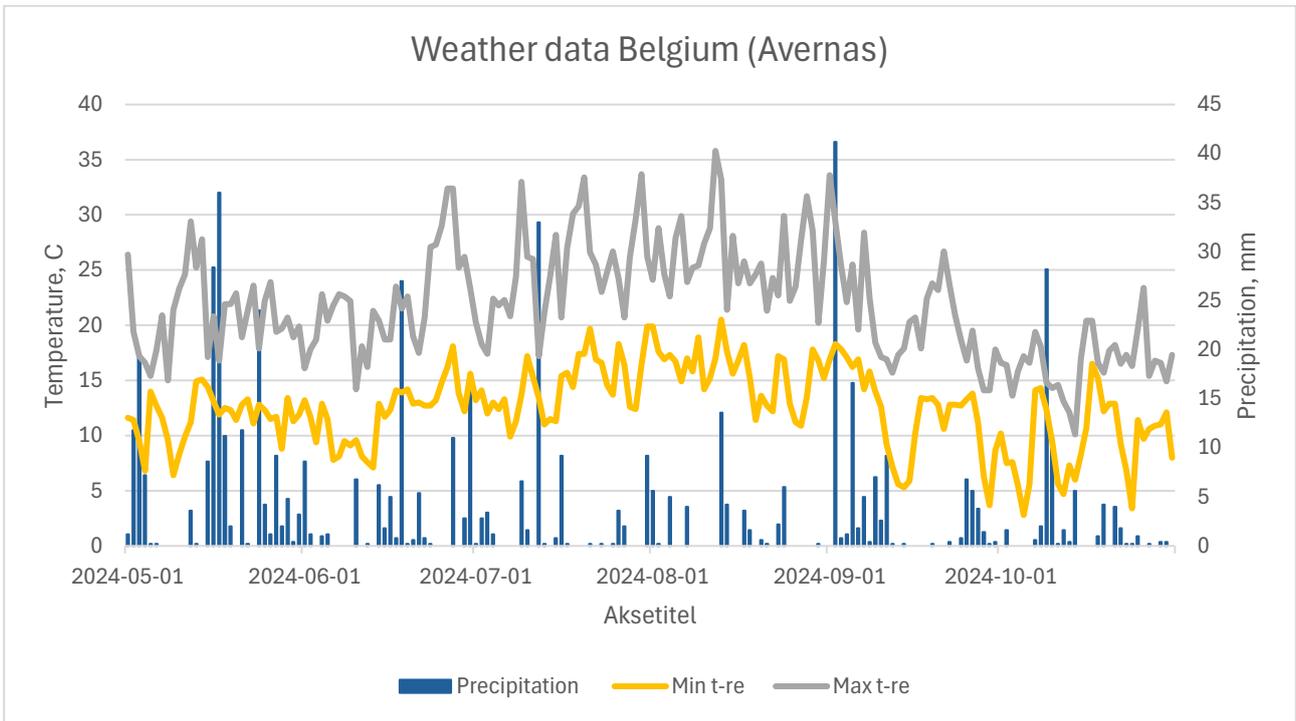
Appendix 5. Daily weather data Lauw, Belgium

Weather data Belgium (Lauw)
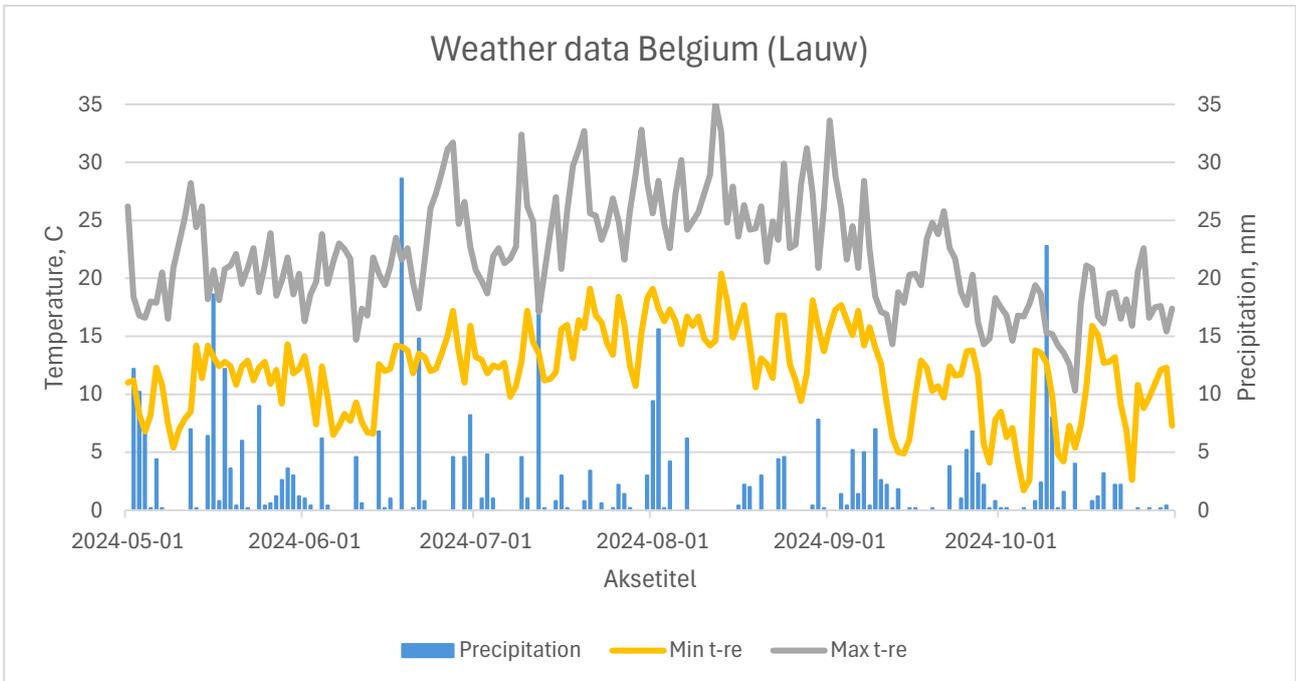
Appendix 6. Trial results from BE, DE &NL – factorial analysis

2025-3-6 (COBRI NUE three factor trial) ARM 2024.4 Factorial AOV Table Page 1 of 1
NBR Nordic Beet Research

Assessment:	Sugar yield		Root yield		Sugar content	K content	Na content	AminoN content
Units:	t/ha		t/ha		%	mmol/100g	mmol/100g	mmol/100g
TABLE OF R MEANS								
Replicate 1	16,742		100,309		16,678	10,973	1,57	2,514
Replicate 2	16,693		99,838		16,694	10,841	1,639	2,452
Replicate 3	16,475		98,883		16,635	11,135	1,578	2,334
Replicate 4	16,503		99,238		16,599	11,411	1,6	2,389
TABLE OF A (Location) MEANS								
1 BE_A	18,122 a		104,936 a		17,267 a	3,448 c	0,901 c	1,328 c
2 BE_L	15,295 b		97,146 b		15,744 c	3,186 c	1,449 b	1,536 b
3 DE	15,305 b		93,44 c		16,383 b	3,803 b	0,793 d	0,614 d
4 NL	17,69 a		102,747 a		17,212 a	33,923 a	3,244 a	6,212 a
LSD P=.05	0,4386		2,4625		0,1086	0,347	0,1032	0,1576
Standard Deviation	0,9385		5,269		0,2325	0,7424	0,2209	0,3371
CV	5,6529		5,2919		1,3961	6,6946	13,8334	13,9182
TABLE OF B (N level) MEANS								
1 Low	15,829 c		95,021 c		16,652 a	11,254 a	1,51 b	2,148 c
2 Moderate	16,68 b		99,858 b		16,671 a	11,06 a	1,616 a	2,373 b
3 High	17,3 a		103,822 a		16,631 a	10,956 a	1,664 a	2,746 a
LSD P=.05		0,3799		2,1326	0,0941	0,3005	0,0894	0,1365
Standard Deviation		0,9385		5,269	0,2325	0,7424	0,2209	0,3371
CV		5,6529		5,2919	1,3961	6,6946	13,8334	13,9182

TABLE OF C (Biostimulant) MEANS

Assessment:	Sugar yield	Root yield	Sugar content	K content	Na content	AminoN content
Units:	t/ha	t/ha	%	mmol/100g	mmol/100g	mmol/100g
1 Untreated	16,584 a	99,594 a	16,63 a	11,108 a	1,621 a	2,47 a
2 BlueN	16,68 a	99,912 a	16,667 a	11,09 a	1,576 a	2,354 a
3 Vixeran	16,545 a	99,196 a	16,657 a	11,072 a	1,593 a	2,442 a
LSD P=.05	0,3799	2,1326	0,0941	0,3005	0,0894	0,1365
Standard Deviation	0,9385	5,269	0,2325	0,7424	0,2209	0,3371
CV	5,6529	5,2919	1,3961	6,6946	13,8334	13,9182

TABLE OF A (Location) B (N level) MEANS

Assessment:	Sugar yield		Root yield		Sugar content		K content		Na content		AminoN content	
Units:	t/ha		t/ha		%		mmol/100g		mmol/100g		mmol/100g	
1 BE_A 1 Low	17,72	b	102,147	cd	17,345	a	3,502	a	0,855	a	1,189	f
2 BE_L 1 Low	15,371	cde	97,504	e	15,764	a	3,286	a	1,358	a	1,379	ef
3 DE 1 Low	14,683	e	89,931	g	16,333	a	3,948	a	0,789	a	0,575	g
4 NL 1 Low	15,542	cd	90,503	g	17,168	a	34,28	a	3,038	a	5,449	c
1 BE_A 2 Moderate	18,207	b	105,547	bc	17,248	a	3,443	a	0,905	a	1,362	ef
2 BE_L 2 Moderate	15,053	de	95,468	ef	15,764	a	3,079	a	1,492	a	1,507	de
3 DE 2 Moderate	15,243	cde	92,925	fg	16,406	a	3,799	a	0,796	a	0,598	g
4 NL 2 Moderate	18,217	b	105,493	bc	17,265	a	33,919	a	3,271	a	6,027	b
1 BE_A 3 High	18,438	b	107,114	b	17,208	a	3,4	a	0,943	a	1,433	ef
2 BE_L 3 High	15,463	cd	98,465	de	15,704	a	3,192	a	1,498	a	1,722	d
3 DE 3 High	15,989	c	97,465	e	16,411	a	3,663	a	0,793	a	0,67	g
4 NL 3 High	19,312	a	112,245	a	17,203	a	33,569	a	3,423	a	7,159	a
LSD P=.05	0,7597		4,2651		0,1882		0,601		0,1788		0,2729	
Standard Deviation	0,9385		5,269		0,2325		0,7424		0,2209		0,3371	

Assessment:	Sugar yield	Root yield	Sugar cont.	K content	Na content	AminoN c.
CV	5,6529	5,2919	1,3961	6,6946	13,8334	13,9182
Units:	t/ha	t/ha	%	mmol/100g	mmol/100g	mmol/100g
TABLE OF A (Location) C (Biostimulant) MEANS						
1 BE_A 1 Untreated	17,9 a	103,959 a	17,217 a	3,441 a	0,917 a	1,366 a
2 BE_L 1 Untreated	15,368 a	97,509 a	15,761 a	3,2 a	1,438 a	1,54 a
3 DE 1 Untreated	15,228 a	93,153 a	16,353 a	3,839 a	0,81 a	0,616 a
4 NL 1 Untreated	17,839 a	103,754 a	17,192 a	33,953 a	3,322 a	6,36 a
1 BE_A 2 BlueN	18,315 a	105,641 a	17,335 a	3,435 a	0,843 a	1,268 a
2 BE_L 2 BlueN	15,378 a	97,596 a	15,756 a	3,175 a	1,422 a	1,512 a
3 DE 2 BlueN	15,518 a	94,749 a	16,373 a	3,789 a	0,788 a	0,618 a
4 NL 2 BlueN	17,508 a	101,662 a	17,204 a	33,96 a	3,253 a	6,019 a
1 BE_A 3 Vixeran	18,15 a	105,208 a	17,249 a	3,469 a	0,943 a	1,349 a
2 BE_L 3 Vixeran	15,14 a	96,332 a	15,716 a	3,182 a	1,488 a	1,556 a
3 DE 3 Vixeran	15,169 a	92,419 a	16,423 a	3,782 a	0,78 a	0,608 a
4 NL 3 Vixeran	17,723 a	102,826 a	17,24 a	33,856 a	3,158 a	6,256 a
LSD P=.05	0,7597	4,2651	0,1882	0,601	0,1788	0,2729
Standard Deviation	0,9385	5,269	0,2325	0,7424	0,2209	0,3371

	Sugar yield	Root yield	Sugar content	K content	Na content	AminoN content
CV	5,6529	5,2919	1,3961	6,6946	13,8334	13,9182

Assessment:	Sugar yield	Root yield	Sugar content	K content	Na content	AminoN content
Units:	t/ha	t/ha	%	mmol/100g	mmol/100g	mmol/100g

TABLE OF B (N level) C (Biostimulant) MEANS

	Sugar yield	Root yield	Sugar content	K content	Na content	AminoN content
1 Low 1 Untreated	15,942 a	95,846 a	16,628 a	11,285 a	1,519 a	2,201 a
2 Moderate 1 Untreated	16,663 a	99,991 a	16,634 a	11,099 a	1,643 a	2,429 a
3 High 1 Untreated	17,147 a	102,945 a	16,629 a	10,94 a	1,703 a	2,781 a
1 Low 2 BlueN	15,824 a	95,134 a	16,625 a	11,065 a	1,516 a	2,096 a
2 Moderate 2 BlueN	16,821 a	100,454 a	16,716 a	11,081 a	1,579 a	2,295 a
3 High 2 BlueN	17,394 a	104,148 a	16,661 a	11,124 a	1,633 a	2,672 a
1 Low 3 Vixeran	15,721 a	94,084 a	16,704 a	11,412 a	1,496 a	2,147 a
2 Moderate 3 Vixeran	16,555 a	99,13 a	16,663 a	11,001 a	1,625 a	2,395 a
3 High 3 Vixeran	17,361 a	104,374 a	16,604 a	10,804 a	1,656 a	2,785 a
LSD P=.05	0,6579	3,6937	0,163	0,5205	0,1548	0,2364
Standard Deviation	0,9385	5,269	0,2325	0,7424	0,2209	0,3371
CV	5,6529	5,2919	1,3961	6,6946	13,8334	13,9182

TABLE OF A (Location) B (N level) C (Biostimulant) MEANS

Assessment:	Sugar yield	Root yield	Sugar content	K content	Na content	AminoN content
Units:	t/ha	t/ha	%	mmol/100g	mmol/100g	mmol/100g
1 BE_A 1 Low 1 Untreated	17,555 a	101,638 a	17,273 a	3,508 a	0,85 a	1,223 a
2 BE_L 1 Low 1 Untreated	15,223 a	96,51 a	15,773 a	3,313 a	1,325 a	1,405 a
3 DE 1 Low 1 Untreated	14,865 a	91,378 a	16,285 a	4,02 a	0,82 a	0,613 a
4 NL 1 Low 1 Untreated	16,125 a	93,858 a	17,18 a	34,3 a	3,08 a	5,565 a
1 BE_A 2 Moderate 1 Untreated	18,158 a	105,45 a	17,218 a	3,413 a	0,925 a	1,37 a
2 BE_L 2 Moderate 1 Untreated	15,253 a	96,6 a	15,785 a	3,078 a	1,458 a	1,498 a
3 DE 2 Moderate 1 Untreated	15,155 a	92,895 a	16,315 a	3,858 a	0,823 a	0,593 a
4 NL 2 Moderate 1 Untreated	18,088 a	105,018 a	17,22 a	34,05 a	3,368 a	6,258 a
1 BE_A 3 High	17,988 a	104,79 a	17,16 a	3,403 a	0,975 a	1,505 a

	V1	V2	V3	V4	V5	V6
1 Untreated						
2 BE_L 3 High 1 Untreated	15,63 a	99,418 a	15,725 a	3,21 a	1,53 a	1,718 a
3 DE 3 High 1 Untreated	15,665 a	95,185 a	16,458 a	3,64 a	0,788 a	0,643 a
4 NL 3 High 1 Untreated	19,305 a	112,388 a	17,175 a	33,508 a	3,518 a	7,258 a
1 BE_A 1 Low 2 BlueN	17,768 a	101,92 a	17,43 a	3,5 a	0,83 a	1,135 a
2 BE_L 1 Low 2 BlueN	15,54 a	98,73 a	15,74 a	3,21 a	1,365 a	1,335 a
3 DE 1 Low 2 BlueN	14,72 a	90,348 a	16,293 a	3,86 a	0,788 a	0,553 a
4 NL 1 Low 2 BlueN	15,27 a	89,54 a	17,038 a	33,69 a	3,08 a	5,363 a
1 BE_A 2 Moderate 2 BlueN	18,495 a	106,535 a	17,363 a	3,435 a	0,85 a	1,3 a
2 BE_L 2 Moderate 2 BlueN	15,2 a	95,965 a	15,835 a	3,07 a	1,478 a	1,475 a
3 DE 2 Moderate 2 BlueN	15,793 a	96,18 a	16,415 a	3,808 a	0,79 a	0,605 a

4 NL 2 Moderate 2 BlueN	17,795 a	103,135 a	17,25 a	34,01 a	3,2 a	5,8 a
1 BE_A 3 High 2 BlueN	18,683 a	108,468 a	17,213 a	3,37 a	0,848 a	1,37 a
2 BE_L 3 High 2 BlueN	15,393 a	98,093 a	15,693 a	3,245 a	1,423 a	1,725 a
3 DE 3 High 2 BlueN	16,04 a	97,72 a	16,413 a	3,7 a	0,785 a	0,698 a
4 NL 3 High 2 BlueN	19,46 a	112,31 a	17,325 a	34,18 a	3,478 a	6,895 a
1 BE_A 1 Low 3 Vixeran	17,838 a	102,883 a	17,333 a	3,498 a	0,885 a	1,21 a
2 BE_L 1 Low 3 Vixeran	15,35 a	97,273 a	15,78 a	3,335 a	1,385 a	1,398 a
3 DE 1 Low 3 Vixeran	14,465 a	88,068 a	16,42 a	3,965 a	0,76 a	0,56 a
4 NL 1 Low 3 Vixeran	15,23 a	88,113 a	17,285 a	34,85 a	2,955 a	5,42 a
1 BE_A 2 Moderate 3 Vixeran	17,968 a	104,655 a	17,165 a	3,483 a	0,94 a	1,415 a

Treatment		Col1	Col2	Col3	Col4	Col5	Col6
2	BE_L	14,705 a	93,838 a	15,673 a	3,09 a	1,54 a	1,548 a
2	Moderate						
3	Vixeran						
3	DE	14,78 a	89,7 a	16,488 a	3,733 a	0,775 a	0,595 a
2	Moderate						
3	Vixeran						
4	NL	18,768 a	108,328 a	17,325 a	33,698 a	3,245 a	6,023 a
2	Moderate						
3	Vixeran						
1	BE_A	18,645 a	108,085 a	17,25 a	3,428 a	1,005 a	1,423 a
3	High						
3	Vixeran						
2	BE_L	15,365 a	97,885 a	15,695 a	3,12 a	1,54 a	1,723 a
3	High						
3	Vixeran						
3	DE	16,263 a	99,49 a	16,363 a	3,648 a	0,805 a	0,67 a
3	High						
3	Vixeran						
4	NL	19,17 a	112,038 a	17,11 a	33,02 a	3,275 a	7,325 a
3	High						
3	Vixeran						
LSD P=.05		1,3159	7,3874	0,3259	1,0409	0,3097	0,4727
Standard Deviation		0,9385	5,269	0,2325	0,7424	0,2209	0,3371
CV		5,6529	5,2919	1,3961	6,6946	13,8334	13,9182

Means followed by same letter or symbol do not significantly differ (P=.05, LSD).

Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.

COMPLETE FACTORIAL AOV For Sugar yield 1 2025-3-6 (Data Column 1)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)	LSD (.05)
Total	143	457,554616				
R	3	1,942147	0,65	0,597	0,621	
A	3	247,782919	82,6	58,509	1E-04	0,634
RA	9	12,704862	1,41			
B	2	52,386985	26,2	183,615	1E-04	0,189
RB	6	0,855926	0,14			
AB	6	52,522154	8,75	8,997	1E-04	0,846
RAB	18	17,513157	0,97			
C	2	0,458085	0,23	0,476	0,643	0,347
RC	6	2,890043	0,48			
AC	6	2,533754	0,42	0,728	0,633	0,653
RAC	18	10,437474	0,58			
BC	4	1,079565	0,27	0,357	0,834	0,67
RBC	12	9,07374	0,76			
ABC	12	6,357979	0,53	0,489	0,908	1,493
RABC	36	39,015826	1,08			

FACTORIAL/POOLED ERROR AOV For Sugar yield 1 2025-3-6 (Data Column 1)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)	LSD (.05)
Total	143	457,554616				
R	3	1,942147	0,65	0,735	0,534	
A	3	247,782919	82,6	93,765	1E-04	0,439
B	2	52,386985	26,2	29,736	1E-04	0,38
AB	6	52,522154	8,75	9,938	1E-04	0,76
C	2	0,458085	0,23	0,26	0,772	0,38
AC	6	2,533754	0,42	0,479	0,822	0,76
BC	4	1,079565	0,27	0,306	0,873	0,658
ABC	12	6,357979	0,53	0,601	0,837	1,316
ERROR	105	92,491028	0,88			

COMPLETE FACTORIAL AOV For Root yield 1 2025-3-6 (Data Column 2)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)	LSD (.05)
Total	143	9797,958889				
R	3	43,229872	14,4	0,384	0,765	
A	3	2964,178906	988	26,391	1E-04	3,263
RA	9	336,958022	37,4			
B	2	1865,092985	933	184,736	1E-04	1,122
RB	6	30,287899	5,05			
AB	6	1663,206232	277	9,698	1E-04	4,586
RAB	18	514,506574	28,6			
C	2	12,348685	6,17	0,422	0,674	1,91
RC	6	87,726099	14,6			
AC	6	78,362982	13,1	0,838	0,557	3,386
RAC	18	280,578857	15,6			
BC	4	46,115094	11,5	0,442	0,776	3,932
RBC	12	312,674306	26,1			
ABC	12	210,393206	17,5	0,467	0,921	8,789
RABC	36	1352,299172	37,6			

FACTORIAL/POOLED ERROR AOV For Root yield 1 2025-3-6 (Data Column 2)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)	LSD (.05)
Total	143	9797,958889				
R	3	43,229872	14,4	0,519	0,67	
A	3	2964,178906	988	35,59	1E-04	2,462
B	2	1865,092985	933	33,591	1E-04	2,133
AB	6	1663,206232	277	9,985	1E-04	4,265
C	2	12,348685	6,17	0,222	0,801	2,133
AC	6	78,362982	13,1	0,47	0,829	4,265
BC	4	46,115094	11,5	0,415	0,797	3,694
ABC	12	210,393206	17,5	0,632	0,811	7,387
ERROR	105	2915,030928	27,8			

COMPLETE FACTORIAL AOV For Sugar content 1 2025-3-6 (Data Column 3)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)	LSD (.05)
Total	143	63,883064				
R	3	0,200053	0,07	2,807	0,053	
A	3	57,174697	19,1	70,792	1E-04	0,277
RA	9	2,422914	0,27			
B	2	0,037251	0,02	0,984	0,427	0,069
RB	6	0,11356	0,02			
AB	6	0,215749	0,04	1,079	0,411	0,157
RAB	18	0,59964	0,03			
C	2	0,034489	0,02	1,324	0,334	0,057
RC	6	0,078122	0,01			
AC	6	0,116728	0,02	0,312	0,922	0,214
RAC	18	1,121394	0,06			
BC	4	0,110561	0,03	0,685	0,616	0,155
RBC	12	0,483928	0,04			
ABC	12	0,318739	0,03	1,118	0,376	0,221
RABC	36	0,855239	0,02			

FACTORIAL/POOLED ERROR AOV For Sugar content 1 2025-3-6 (Data Column 3)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)	LSD (.05)
Total	143	63,883064				
R	3	0,200053	0,07	1,234	0,301	
A	3	57,174697	19,1	352,632	1E-04	0,109
B	2	0,037251	0,02	0,345	0,709	0,094
AB	6	0,215749	0,04	0,665	0,678	0,188
C	2	0,034489	0,02	0,319	0,728	0,094
AC	6	0,116728	0,02	0,36	0,903	0,188
BC	4	0,110561	0,03	0,511	0,727	0,163
ABC	12	0,318739	0,03	0,491	0,916	0,326
ERROR	105	5,674797	0,05			

COMPLETE FACTORIAL AOV For K content 1 2025-3-6 (Data Column 4)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)	LSD (.05)
Total	143	25105,1548				
R	3	6,514956	2,17	10,395	1E-04	
A	3	25031,03629	8344	2873,671	1E-04	0,909
RA	9	26,131422	2,9			
B	2	2,196987	1,1	3,077	0,12	0,298
RB	6	2,141974	0,36			
AB	6	1,644874	0,27	0,628	0,706	0,567
RAB	18	7,853432	0,44			
C	2	0,031179	0,02	0,028	0,972	0,371
RC	6	3,315132	0,55			
AC	6	0,085315	0,01	0,03	1	0,587
RAC	18	8,424507	0,47			
BC	4	1,867758	0,47	2,251	0,124	0,351
RBC	12	2,488714	0,21			
ABC	12	3,901147	0,33	1,556	0,15	0,655
RABC	36	7,521114	0,21			

FACTORIAL/POOLED ERROR AOV For K content 1 2025-3-6 (Data Column 4)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)	LSD (.05)
Total	143	25105,1548				
R	3	6,514956	2,17	3,94	0,01	
A	3	25031,03629	8344	15137,223	1E-04	0,347
B	2	2,196987	1,1	1,993	0,141	0,3
AB	6	1,644874	0,27	0,497	0,809	0,601
C	2	0,031179	0,02	0,028	0,972	0,3
AC	6	0,085315	0,01	0,026	1	0,601
BC	4	1,867758	0,47	0,847	0,499	0,52
ABC	12	3,901147	0,33	0,59	0,846	1,041
ERROR	105	57,876294	0,55			

COMPLETE FACTORIAL AOV For Na content 1 2025-3-6 (Data Column 5)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)	LSD (.05)
Total	143	145,9174				
R	3	0,103022	0,03	2,688	0,061	
A	3	139,2077	46,4	121,249	1E-04	0,33
RA	9	3,444344	0,38			
B	2	0,593788	0,3	21,945	0,002	0,058
RB	6	0,081174	0,01			
AB	6	0,503596	0,08	2,612	0,053	0,154
RAB	18	0,578376	0,03			
C	2	0,050754	0,03	5,408	0,045	0,034
RC	6	0,028157	0			
AC	6	0,211046	0,04	1,816	0,152	0,119
RAC	18	0,348643	0,02			
BC	4	0,028458	0,01	0,469	0,757	0,095
RBC	12	0,181897	0,02			
ABC	12	0,096608	0,01	0,63	0,802	0,162
RABC	36	0,459836	0,01			

FACTORIAL/POOLED ERROR AOV For Na content 1 2025-3-6 (Data Column 5)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)	LSD (.05)
Total	143	145,9174				
R	3	0,103022	0,03	0,704	0,552	
A	3	139,2077	46,4	951,164	1E-04	0,103
B	2	0,593788	0,3	6,086	0,003	0,089
AB	6	0,503596	0,08	1,72	0,123	0,179
C	2	0,050754	0,03	0,52	0,596	0,089
AC	6	0,211046	0,04	0,721	0,634	0,179
BC	4	0,028458	0,01	0,146	0,965	0,155
ABC	12	0,096608	0,01	0,165	0,999	0,31
ERROR	105	5,122428	0,05			

COMPLETE FACTORIAL AOV For AminoN content 1 2025-3-6 (Data Column 6)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)	LSD (.05)
Total	143	739,008597				
R	3	0,656964	0,22	2,473	0,077	
A	3	706,048125	235	986,398	1E-04	0,26
RA	9	2,147353	0,24			
B	2	8,748668	4,37	25,17	0,001	0,208
RB	6	1,042765	0,17			
AB	6	10,566221	1,76	9,904	1E-04	0,362
RAB	18	3,200701	0,18			
C	2	0,351776	0,18	2,514	0,161	0,132
RC	6	0,41984	0,07			
AC	6	0,458279	0,08	1,445	0,252	0,197
RAC	18	0,951393	0,05			
BC	4	0,023828	0,01	0,073	0,989	0,221
RBC	12	0,985956	0,08			
ABC	12	0,2195	0,02	0,207	0,997	0,427
RABC	36	3,187228	0,09			

FACTORIAL/POOLED ERROR AOV For AminoN content 1 2025-3-6 (Data Column 6)

Source	DF	Sum of Squares	Mean Square	F	Prob(F)	LSD (.05)
Total	143	739,008597				
R	3	0,656964	0,22	1,927	0,13	
A	3	706,048125	235	2070,482	1E-04	0,158
B	2	8,748668	4,37	38,483	1E-04	0,136
AB	6	10,566221	1,76	15,493	1E-04	0,273
C	2	0,351776	0,18	1,547	0,218	0,136
AC	6	0,458279	0,08	0,672	0,673	0,273
BC	4	0,023828	0,01	0,052	0,995	0,236
ABC	12	0,2195	0,02	0,161	0,999	0,473
ERROR	105	11,935236	0,11			

Appendix 7. NBR Danish Trial results

Expl. Unit		NBR trial 363-2024	Nmin=57kg/ha	Applied N: kg/ha	Plant no 100% 1000/ha	Root t/ha	Sugar %	Sugar t/ha	Sugar relative	Cleaness %	K pr 100 g sugar mmol	Na pr 100 g sugar mmol	Amino-N pr 100 g sugar mg
			Dose rate:		94	77,4	19,2	14,9	100	93,1	679,0	38,6	23,7
1	R	Untreated		20	94	77,4 c	19,2 a	14,867	100 .de	93,1	679,0	38,6 .f	23,7 .h
2		Blue N early	333 g/ha	20	93	79,2 c	19,2 a	15,207	102 .d	93,0	714,3	46,1 .ef	25,0 .gh
3		Blue N late	333 g/ha	20	90	79,1 c	19,0 ab	15,002	101 .de	93,8	706,8	44,9 .ef	25,1 .gh
4		Kinsidro Grow+ Blue N	150+333 g/ha	20	95	77,6 c	19,1 a	14,819	100 .de	93,3	688,7	39,0 .f	24,2 .gh
5		Stimplex	2 l/ha	20	93	76,2 c	18,9 abc	14,433	97 .e	92,9	715,5	43,4 .ef	24,4 .gh
6		Untreated		63	94	85,7 ab	19,0 ab	16,261	109 ab.	92,9	689,0	52,1 b.	28,1 .
7		Blue N early	333 g/ha	63	92	84,1 b	19,0 a	15,983	108 ab.	93,6	666,6	46,9 .e	27,5 .g
8		Blue N late	333 g/ha	63	94	83,4 b	18,7 bcd	15,582	105 .bd	93,3	667,5	50,5 .e	27,9 .
9		Kinsidro Grow+ Blue N	150+333 g/ha	63	94	84,9 ab	18,9 abc	16,073	108 ab.	93,4	663,7	50,1 .e	28,7 .
10		Stimplex	2 l/ha	63	92	85,6 ab	18,6 cd	15,947	107 ab.	93,7	671,0	55,5 ab.	32,2 b.
11		Untreated		103	89	85,5 ab	18,6 d	15,866	107 ab.	93,4	668,0	59,5 ab.	35,6 ab.
12		Blue N early	333 g/ha	103	92	87,3 ab	18,5 d	16,169	109 ab.	93,2	670,4	62,1 a.	33,5 ab.
13		Blue N late	333 g/ha	103	90	88,7 a	18,5 d	16,424	110 a.	93,6	693,4	63,1 a.	35,6 ab.
14		Kinsidro Grow+ Blue N	150+333 g/ha	103	95	88,8 a	18,5 d	16,45	111 a.	92,8	678,7	60,8 a.	35,5 ab.
15		Stimplex	2 l/ha	103	96	88,7 a	18,6 cd	16,537	111 a.	93,8	671,7	60,5 a.	36,4 a.
LSD					ns	4,0	0,3	0,8		ns	ns	7,8	3,6
CV					4,3	3,4	1,2	3,5		0,6	3,7	10,9	8,5
P_value					0,430	<0,0001	<0,0001	<0,0001		0,189	0,055	<0,0001	<0,0001

Appendix 8. Site description

General Trial Information					
Trial location (short name):	DK, Sofiehøj	BE, Avernas	BE, Lauw	DE, Sieboldshausen, Wendegraben	NL, Westmaas
Trial ID at test organisation	363-831-2024	B24FN_AV	B24FN_LA	24PB05	
Initiation Day (Application date):	2024-06-04	2024-03-29	2024-03-21	03./07.06.2024	2024-06-05
Completion Date (Harvest date):	2024-10-16	2024-11-04	2024-09-22	2024-10-14	2024-10-24
Trial Location (City, postcode, Country)	Byhavevej, DK-4970 Rødby	Hannut, 4280, Belgium	Lauw, 3700, Belgium	Sieboldshausen	Groeneweg 3, 3273LP Westmaas
Latitude of LowerLeft Corner	54.687784	50.682327	50.733643	51.468600	51.789711
Longitude of LowerLeft Corner	11.447413	5.075726	5.421472	9.911856	4.457063
Contacts					
Organization name	NBR Nordic Beet Research	IRBAB	IRBAB	Institute of Sugar Beet Research (IfZ)	Stichting IRS
Country	Denmark	Belgium	Belgium	Germany	Netherlands
Study director (responsible for the trial) name	Andrius Hansen Kemezys	André Wauters	André Wauters	Heinz-Josef Koch/Anna Jacobs	André van Valen
Study director email:	ahk@nbrf.nu	a.wauters@irbab.be	a.wauters@irbab.be	koch@ifz-goettingen.de jacobs@ifz-goettingen.de	valen@irs.nl
Crop Description					
Variety	Cascara KWS	Tessilia KWS	Tessilia KWS	KWS Blandina	Leontina KWS
Planting Date	2024-05-10	2024-04-14	2024-04-11	2024-04-28	2024-04-30
Planting Depth	2 cm	2,5 cm	2,5 cm	2 cm	2 cm
Planting Rate	110 000 s/ha	110 000 s/ha	110 000 s/ha	96.000 plants/ha (after manual singling)	110000
Rows per Plot	6	6	6	6	12
Row Spacing	50 cm	45 cm	45 cm	45	50 cm
Spacing within Row	18 cm	19 cm	19 cm	21,3	18 cm

Site and Design					
Study Design	Randomized Complete Block	Randomized Complete Block	Randomized Complete Block	Randomized Complete Block	Randomized Block Design
Treated Plot Width	3	2.7 m	2.7 m	2,7 m	6 m
Treated Plot Length	8	5,25 m	5,25 m	8	10 m
Treated Plot Area:	24	14.18 m²	14.18 m²	21,6	60
Replications: **Soil Description**	4	4	4	4	4
% OM	1,4	1,15	1,35	1,7	2,8
% Sand	69			5	30
% Silt:	14			71	35
% Clay:	17			14	25
Texture:	Sandy loam	Loam	Loam	Silty loam (loess)	Clay loam
Soil Mineral N:	57	40	86	80 (0-90cm)	18
Weather Conditions					
Overall Moisture Conditions:	Normal	Rainy	Rainy	Moist-wet	Normal
Weather Station Name:	Byhavevej, DK-4970 Rødby	Hannut, 4280, Belgium	Waremme, BE	IfZ own station	Rotterdam
Distance from the field	100 m	1 km	7 km	50 m	17 km
Fill in the form for weather data	Yes			Yes	Yes

Application Description					
Date	2024-06-14	2024-06-02	2024-06-02	2024-06-03 (BlueN) / 2024-06-07 (Vixeran)	2024-06-05
Start Time	11:00	10:30	15:35	09:30	10:30
Stop Time	11:45	11:00	16:15	10:30	12:00
Method	Spray	Spray	Spray	Spray	Spray
Air Temperature	17,1	17,1	21,2	14,7 / 16,4	18
% Relative Humidity Start, Stop	68	94	77	77 / 63	58
Wind Velocity	4,4 m/s	5,1 m/s	5.5 m/s	1,9 / m/s	3 m/s
Wet Leaves (Y/N)	Yes, slightly moist	Yes, slightly moist	Yes, slightly moist	No	Dry
Soil Temperature	16,4			12,4 /18,3	unknown
Soil Moisture	Moist	Wet	Wet	Moist	Dry
% Cloud Cover	65%	95%	95%	50 / 50 %	unknown
Time to First Precipitation	1 day	2 days	2 days	1 (2) days / 3 days	3 days
Amount of First Precipitation	7 mm	6 mm	1 mm	0,2 (4,6) / 1,6 mm	1,1
Precipitation 1 Week Before Appl.	26,5 mm	> 20 mm	> 20 mm	57,2 mm / 16,2 mm	19,7
Precipitation 6 Hours After Appl.	0 mm	0 mm	0 mm	0 mm/ 0 mm	0 mm
Precipitation 24 Hours After Appl.	7 mm	3 mm	0 mm	0,2 mm / 0 mm	0 mm
Precipitation 1 Week After Appl.	8 mm	7 mm	7 mm	6,6 mm / 5,4 mm	28,3
Problems with Application?	No	No	No	No / No	No
Crop Stage At Application					
Stage majority BBCH (%):	16 (100%)	16	16	16-18	16
Application Equipment					
Equipment Name	Plot sprayer	Schachtner Plot Sprayer	Schachtner Plot Sprayer	Plot sprayer	Handheld plot sprayer
Operation Pressure	2,5 bar	3,9 bar	3,9 bar	1,7 bar	3,6
Nozzle Model	F-110-03	AVI 110-015	AVI 110-015	AirMix-110-02	Lechler ID-120-03
Nozzle Spacing	50 cm	45 cm	45 cm	45 cm	50 cm
Ground Speed	5,3 km/h	3,6 km/h	3,6 km/h	3,6 km/h	unknown
Application Amount	248 l/ha	250 l/ha	250 l/ha	200 l/ha	250 l/ha
Propellant	Compressed air	Compressed air	Compressed air	Compressed air	Compressed air