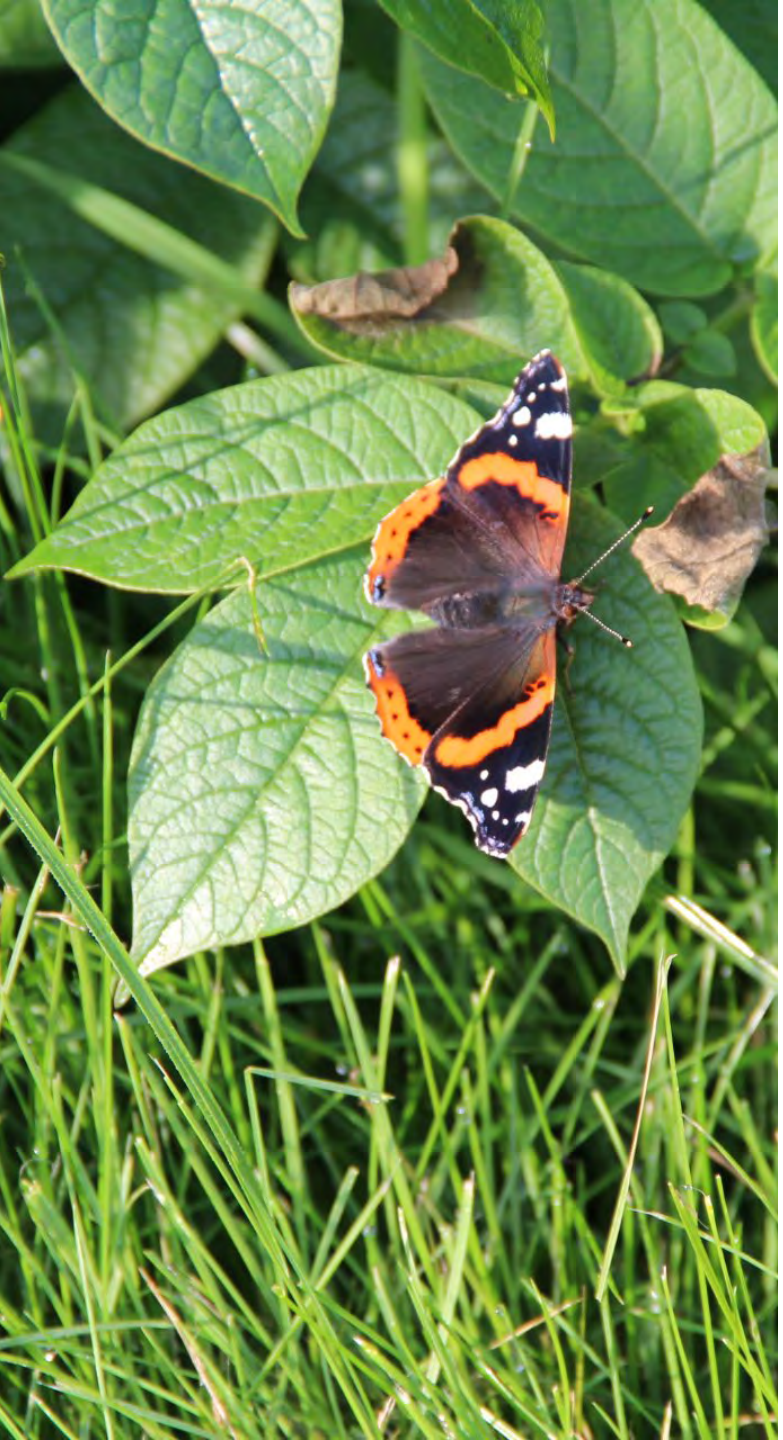


The *Phytophthora infestans* population in Denmark, with a special focus on EU43 - a new genotype spreading in Europe

Jens G. Hansen & Isaac K. Abuley, Aarhus University

Content

- EU43 resistance against mandipropamid – sounding the alarm
- The evolution and spread of the EU43 genotype in Europe, 2018-2023, comparison between DK and NL
- Phenotypic traits of EU43
- Discussion and conclusions

Kartoffel workshop 7 December 2023, Horizon Hotel,

STØTTET AF
Kartoffelafgiftsfonden

PLANTER | 30-08-2022 08:35:45 |

Risiko for resistens mod Revus

I flere forsøg ses der nu en vigende effekt af Revus mod skimmel i kartofler. Derfor anbefaler landskonsulent, at midlet indtil videre ikke anvendes, hvor der er udbredt skimmel.

Forsøgsmæssigt er der anvendt ren Revus i forsøgmarken i Arnborg. Den vigende effekt giver mistanke om resistensudvikling. Arkivfoto

SEGES sounding the alarm

News from SEGES, 30 August 2022

Reduced efficacy of Revus *(a.i. = mandipropamid).*
Observations from trials and commercial fields

Resistance to mandipropamid in EU_43_A1 reported

Press release by Aarhus University, 6 Jan 2023

5 isolates tested – all resistant to mandipropamid

https://agro.au.dk/en/current-news/news/show/artikel/kartoffelproduktionen-trues-af-stigende-resistens-hos-kartoffelskimmel-mod-kemiske-bekaempelsesmidler

Plant Pathology
An International Journal published by the British Society for Plant Pathology

ORIGINAL ARTICLE Open Access

The EU43 genotype of *Phytophthora infestans* displays resistance to mandipropamid

Isaac K. Abuley, James S. Lynott, Jens G. Hansen, David E. L. Cooke, Alison K. Lees

First published: 28 April 2023 | https://doi.org/10.1111/ppa.13737

Abstract

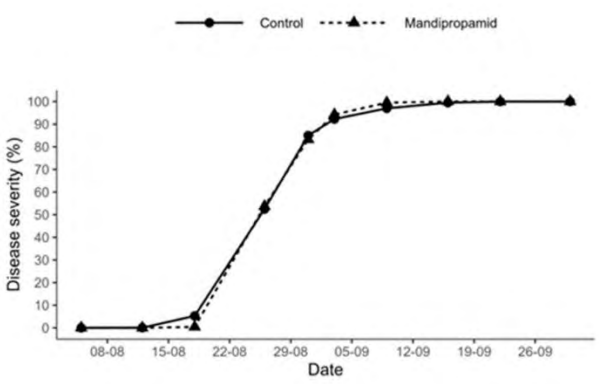
Mandipropamid is an active ingredient in the carboxylic acid amide group of fungicides and plays a key role in current potato late blight (*Phytophthora infestans*) management programmes. However, reports from Danish potato growers in 2022 suggested that mandipropamid had lost its efficacy. A study was therefore conducted to investigate the sensitivity of isolates collected from fields in which mandipropamid had been reported to be ineffective. Seventy-two isolates of *P. infestans* collected from potato fields in Denmark were genotyped using microsatellite markers, revealing a dominance of the clonal lineage EU43 and fewer isolates of EU41 and 'other' genetically distinct genotypes. Isolates belonging to the EU43 and EU41 lineages were selected, in addition to representative isolates of clones EU36 and EU37 from Scotland, and tested for sensitivity to mandipropamid at five concentrations ranging from 0.1 to 10 µg/mL on potato leaf discs (cultivar Maris Piper). The EU43 genotype infected leaf discs at all tested concentrations, and therefore no dose–response curve could be calculated. A dose response was observed for isolates of genotypes EU36, EU37 and EU41 with EC_{50} values ranging from 0.35 to 0.75 µg/mL. Field experiments confirmed resistance of tested isolates of genotype EU43 to mandipropamid, with no significant difference in the area under the disease curve between the untreated and mandipropamid treatments. Analysis of the Danish population of *P. infestans* showed that EU43 was widely distributed across the country. To our best knowledge, this is the first report of resistance to mandipropamid in *P. infestans*.

25 Isolates tested – all resistant to mandipropamid

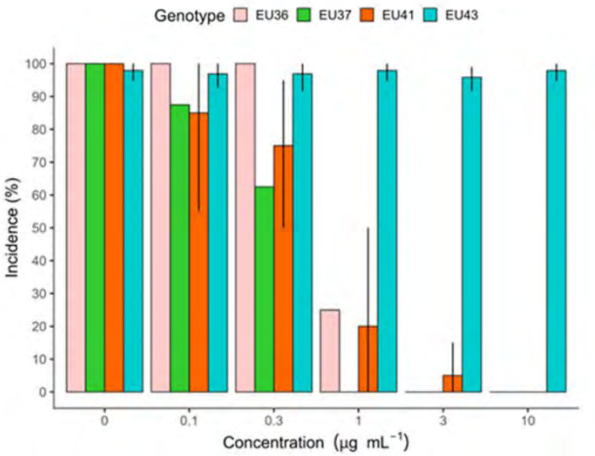
***Phytophthora infestans* was isolated from late blight lesions**

Isolates were tested for their sensitivity to mandipropamid

Field experiment with EU43



Disease development in the untreated control and mandipropamid treated plots



EU43 infected leaf discs at all concentrations of mandipropamid

Sign up Log in

Podcast Episode

Den største inkaskat 2/2: Truslen

Plante-podcast fra SEGES Innovation

15 Jun · 24 min 19 sec

Episode Description

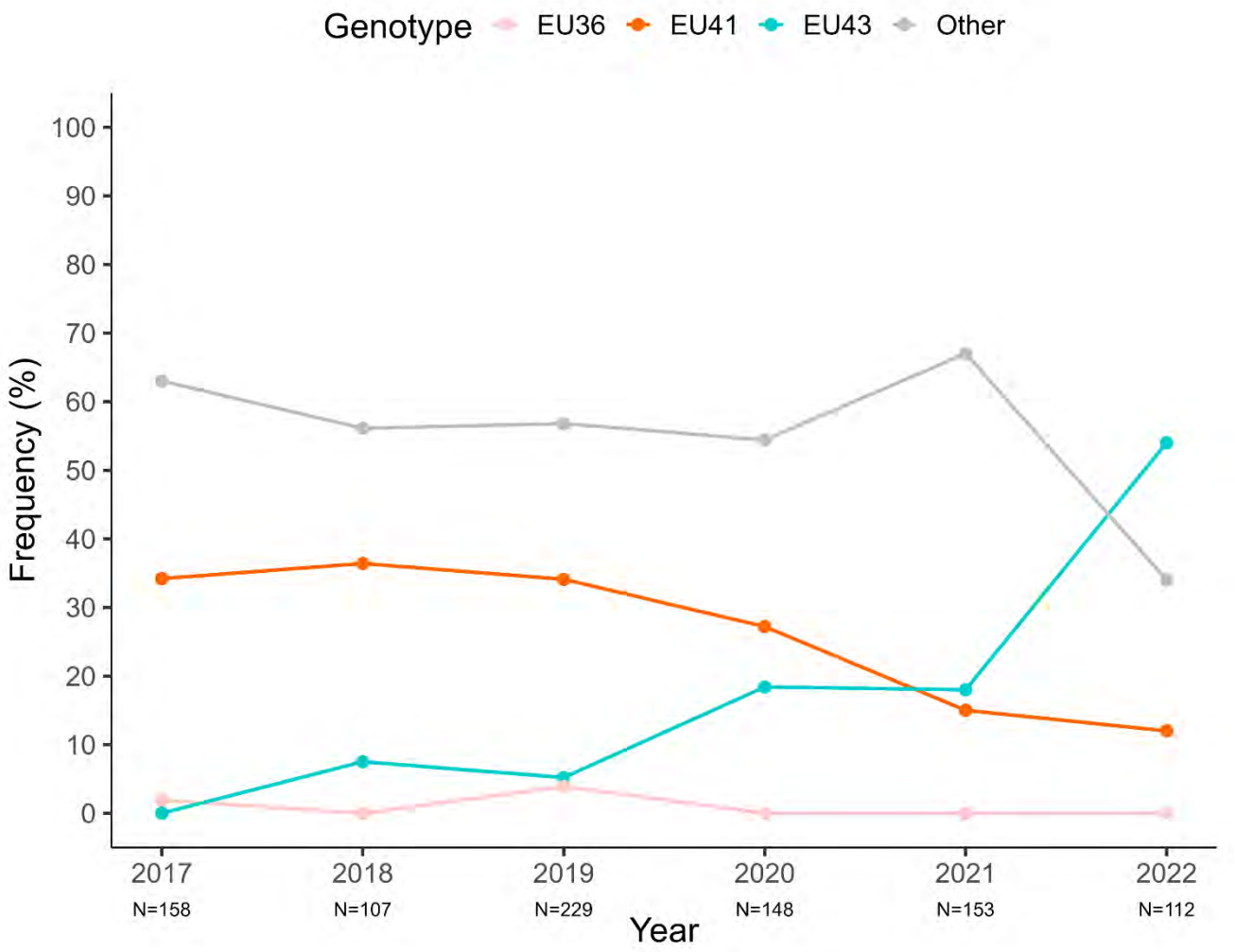
Vi har fulgt kartoflens rejse til Europa – fra lastrummet i et skib til at være en særdeles populær fødevare den dag i dag.

Men kartoflerne trues stadig af skimmelsvamp, som udviser stadig større aggressivitet og resistens imod vores svampemidler.

I dette afsnit af vores miniserie i to dele om hører vi om, hvordan vi kæmper for hele tiden kæmper for at være et skridt foran skimmelsvampen.

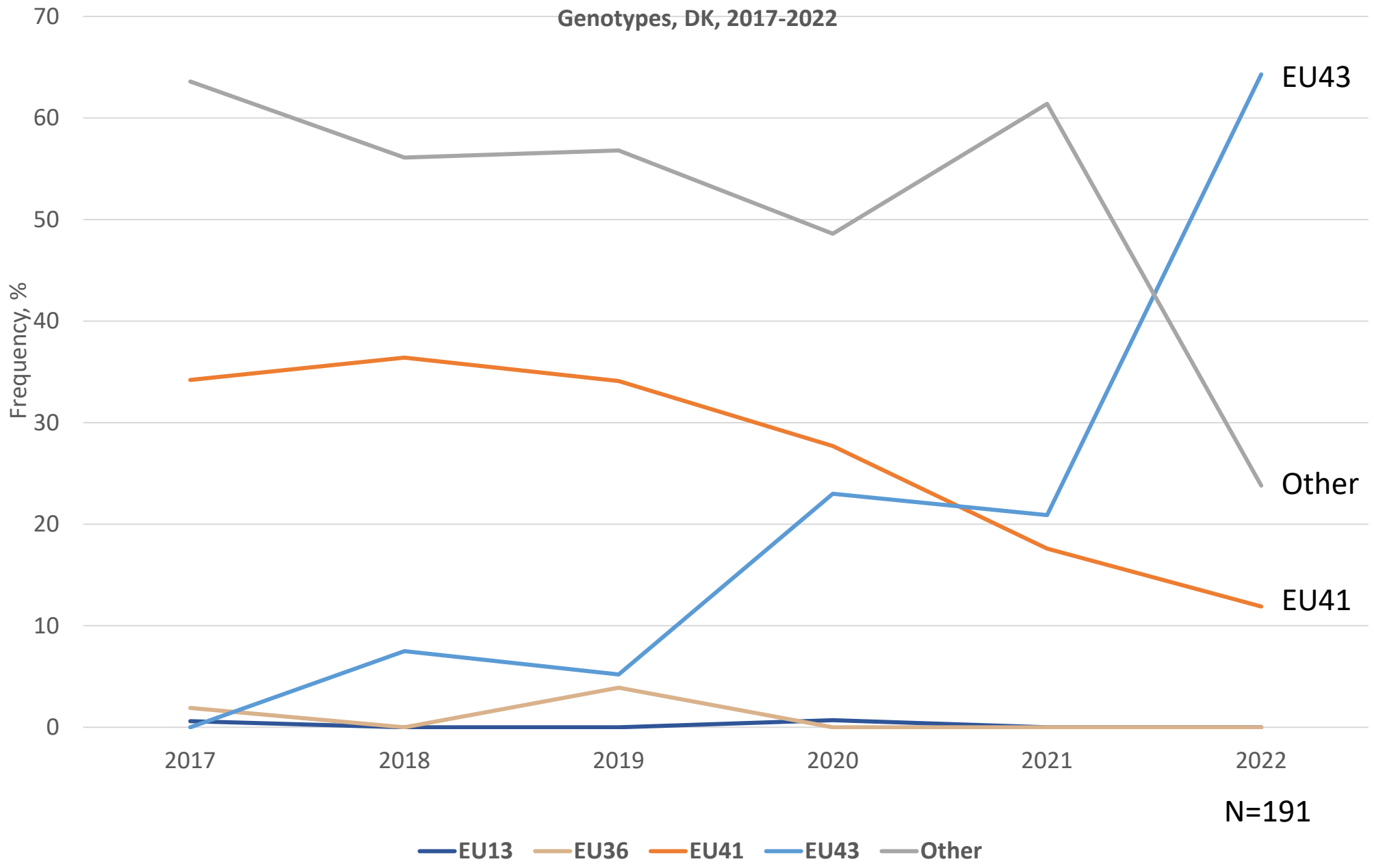
Podcast in June, 2023 – sounding the alarm for farmers

The spatial and temporal distribution of EU43 in Denmark

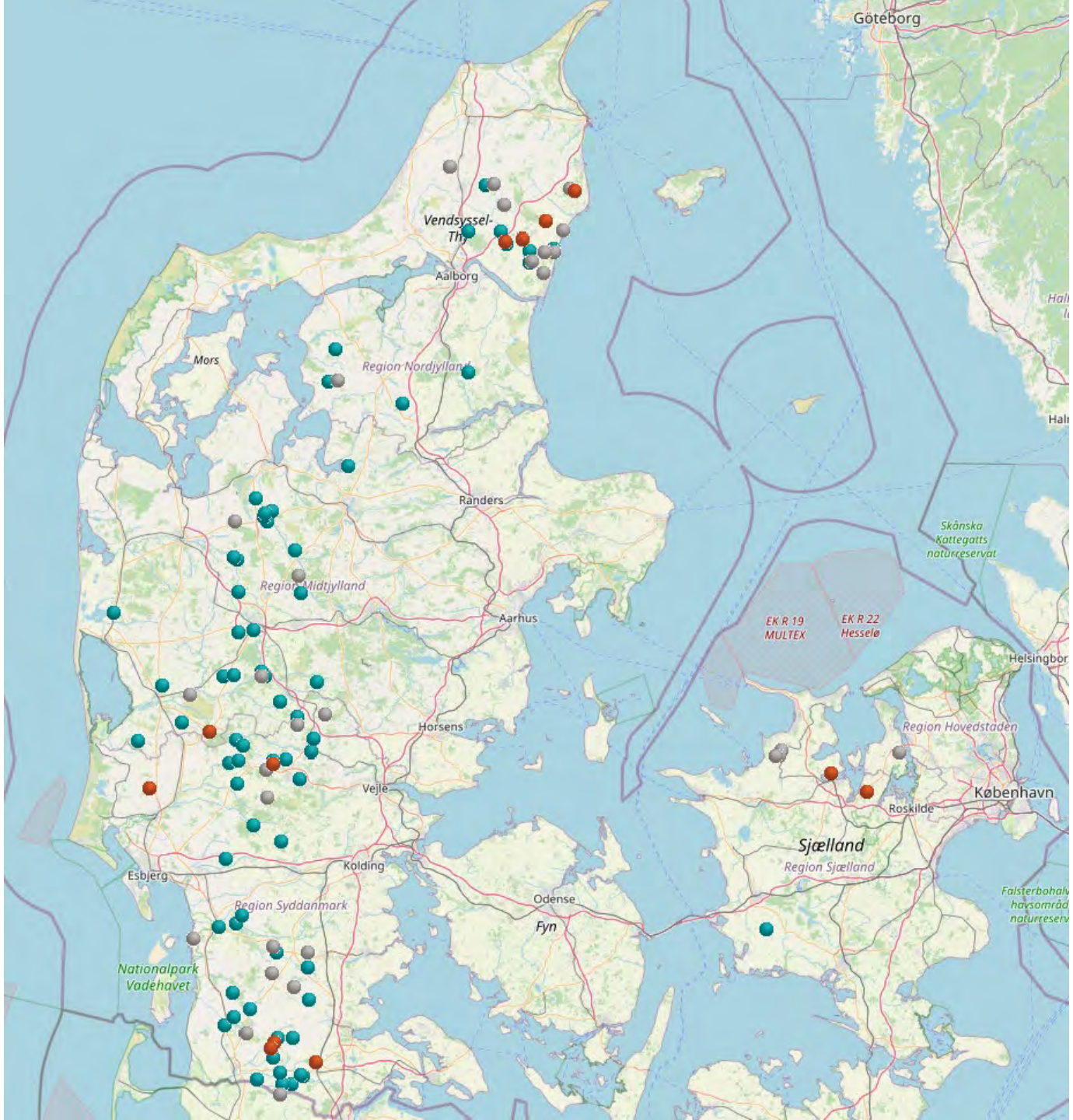


N=112

15/12/2022

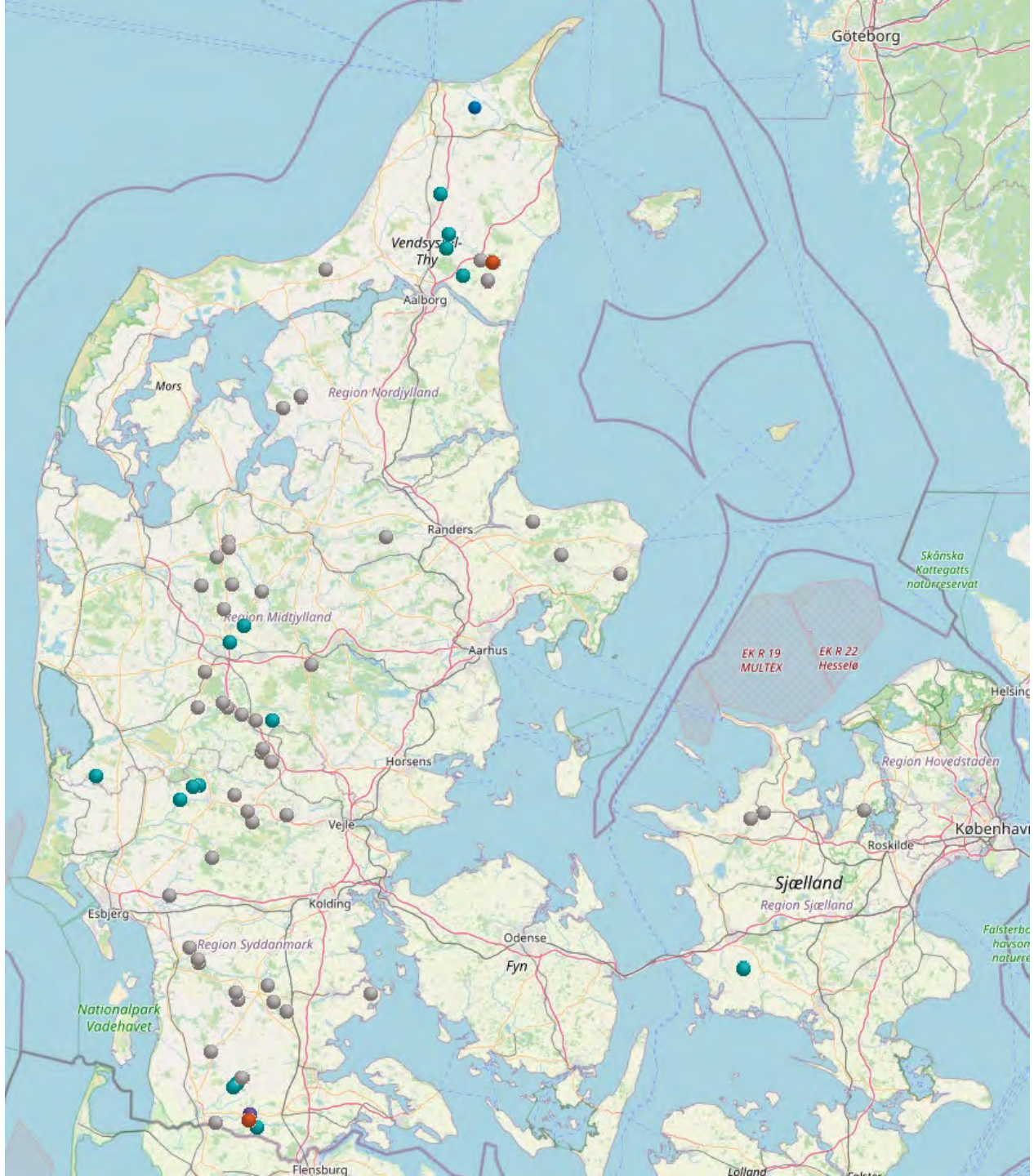

Genotypes, DK, 2017-2022
Frequency, %
70
60
50
40
30
20
10
0
2017
2018
2019
2020
2021
2022
EU43
Other
EU41
N=191
EU13
EU36
EU41
EU43
Other

2022
N=191
EU43=64%



Genotypes
All
EU_41_A2
EU_43_A1
Other

2023
N=113
EU43=24%



Genotypes

- [x] All
- [x] EU_13_A2
- [x] EU_41_A2
- [x] EU_43_A1
- [x] EU_46_A1
- [x] Other

Genotype

Genotype map | Genotype frequency map | Genotype frequency chart | Frequency rank | World map | World appearance

Year
2023

Continent
Europe

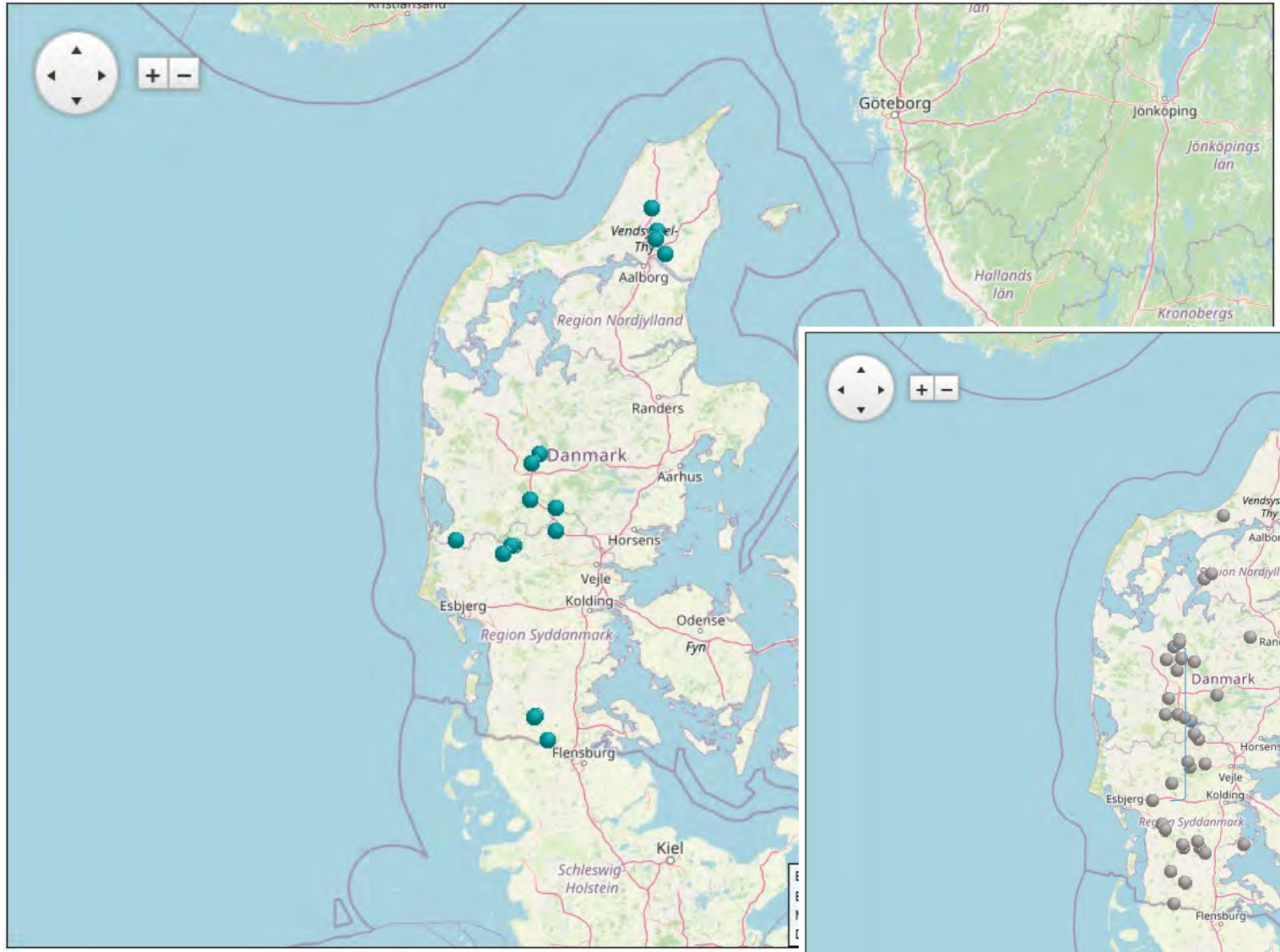
Country
Denmark

Host
- [x] All
- [x] Potato

Genotypes
- [ ] All
- [ ] EU_13_A2
- [ ] EU_41_A2
- [x] EU_43_A1
- [ ] EU_46_A1
- [ ] Other

Show

Help



Genotype

Genotype map | Genotype frequency map | Genotype frequency chart | Frequency rank | World map | World appearance

Help

Year
2023

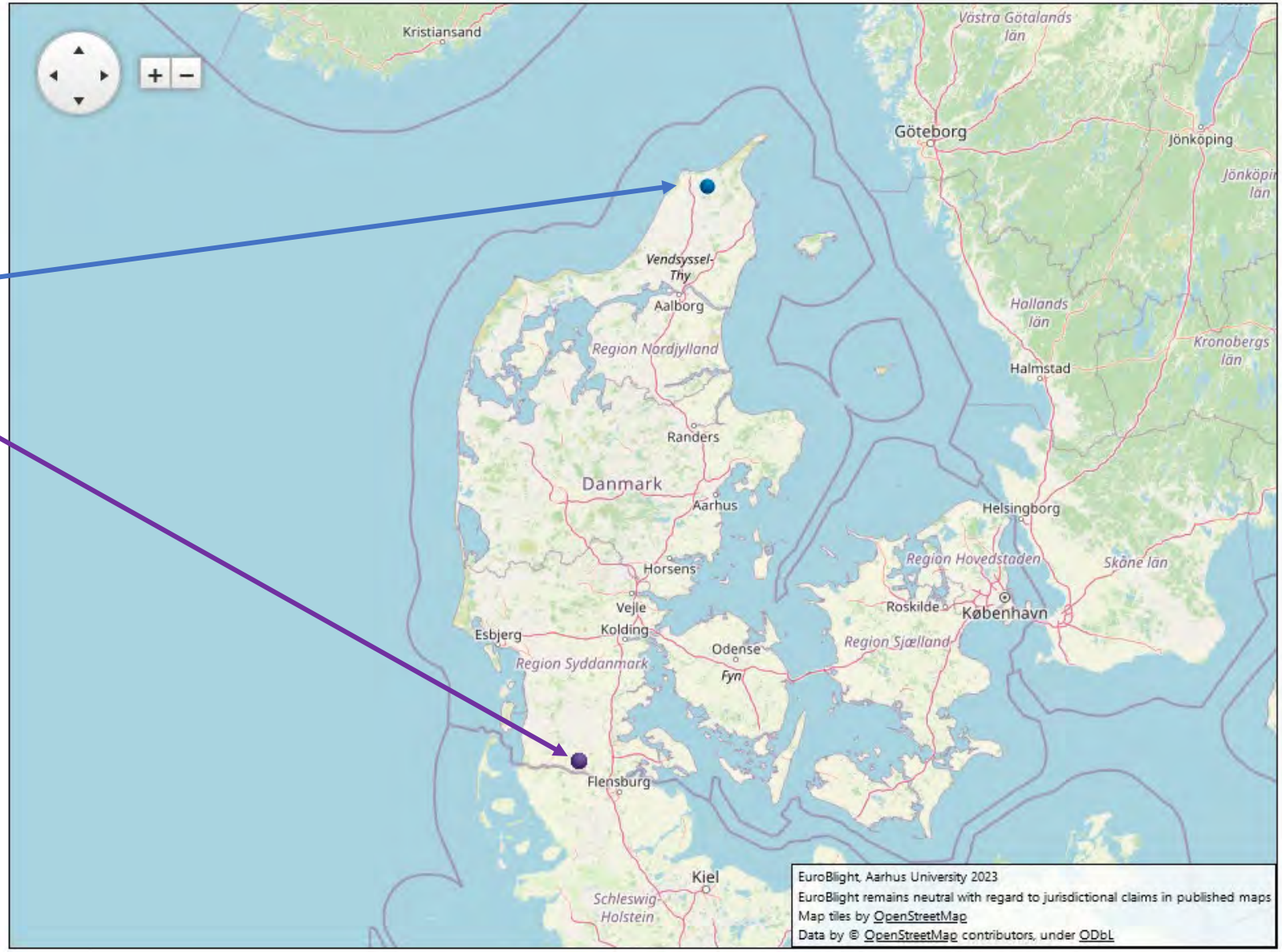
Continent
Europe

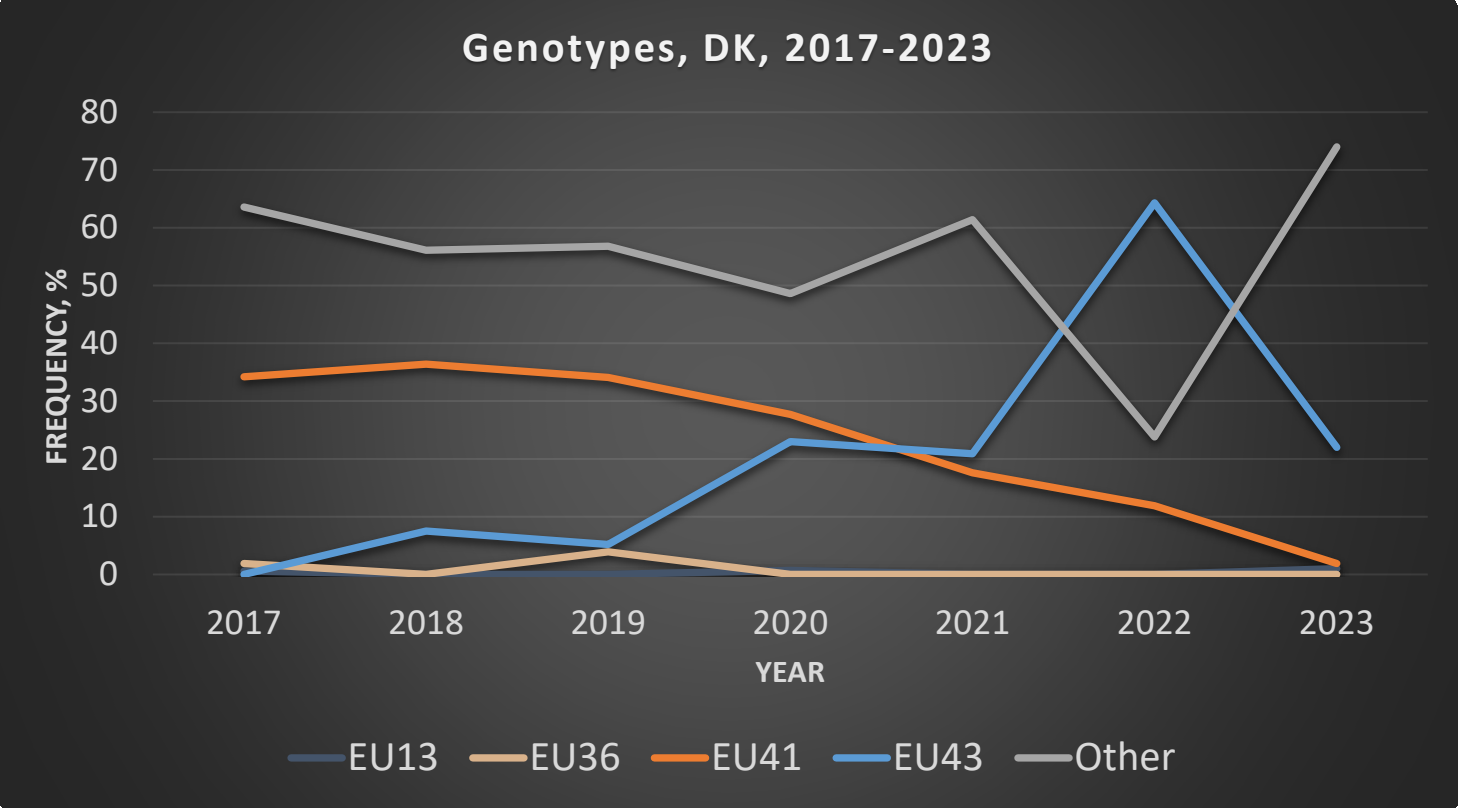
Country
Denmark

Host
- [x] All
- [x] Potato

Genotypes
- [ ] All
- [x] EU_13_A2
- [ ] EU_41_A2
- [ ] EU_43_A1
- [x] EU_46_A1
- [ ] Other

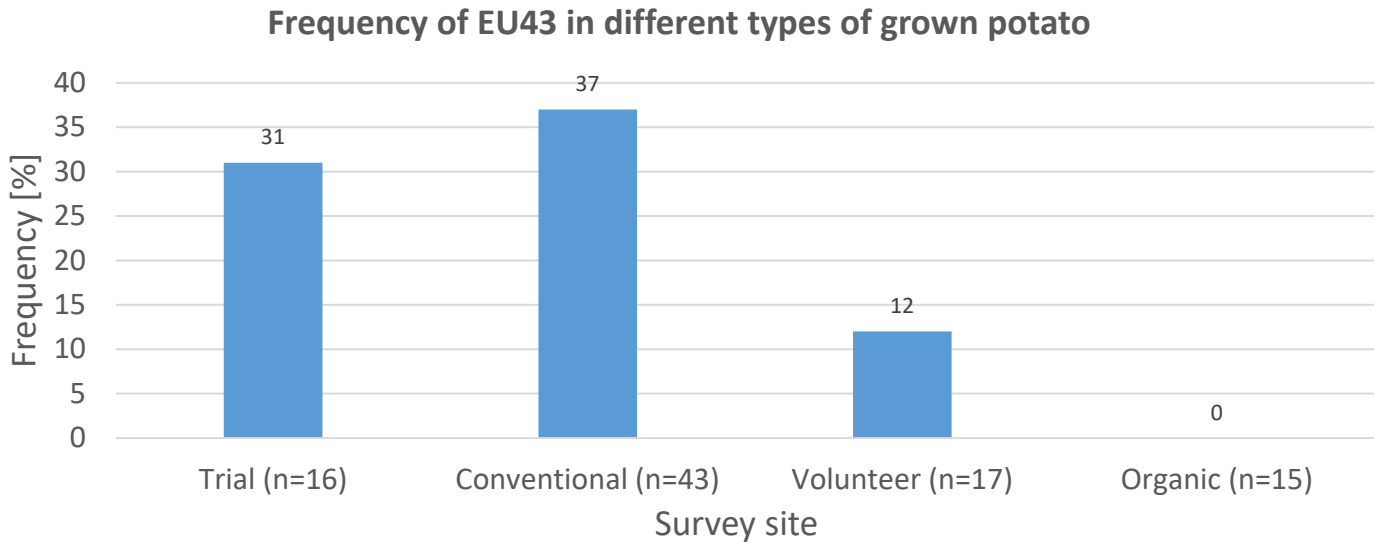
Show

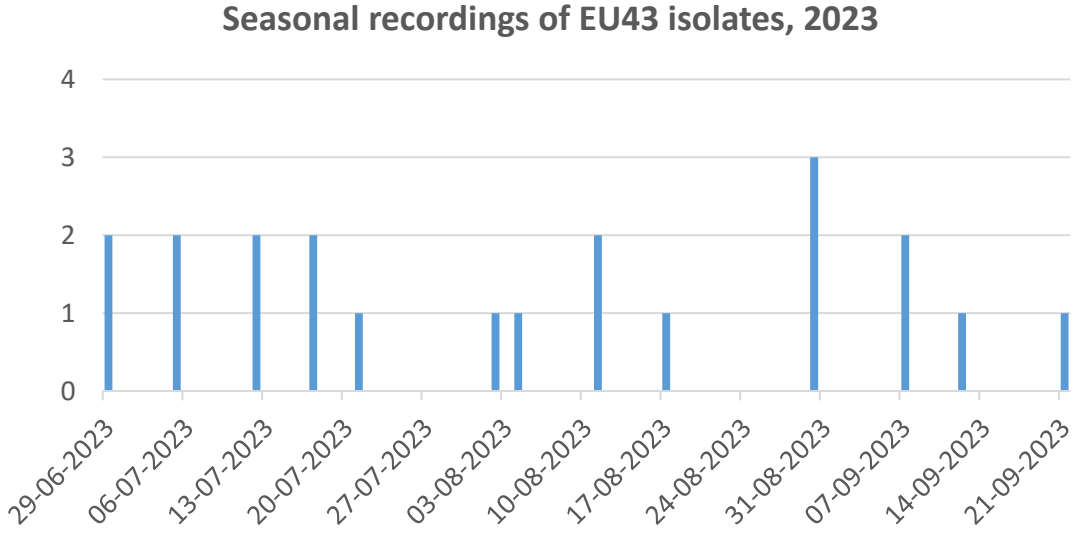




Status 2023

EU43: from 64% in 2022 to 24% in 2023.
EU41: from 12 to 1% and
Others: from 24% to 73%





Genotype

Genotype map | Genotype frequency map | Genotype frequency chart | Frequency rank | World map | World appearance

Continent: Europe

Country: Denmark

Host: All, Potato

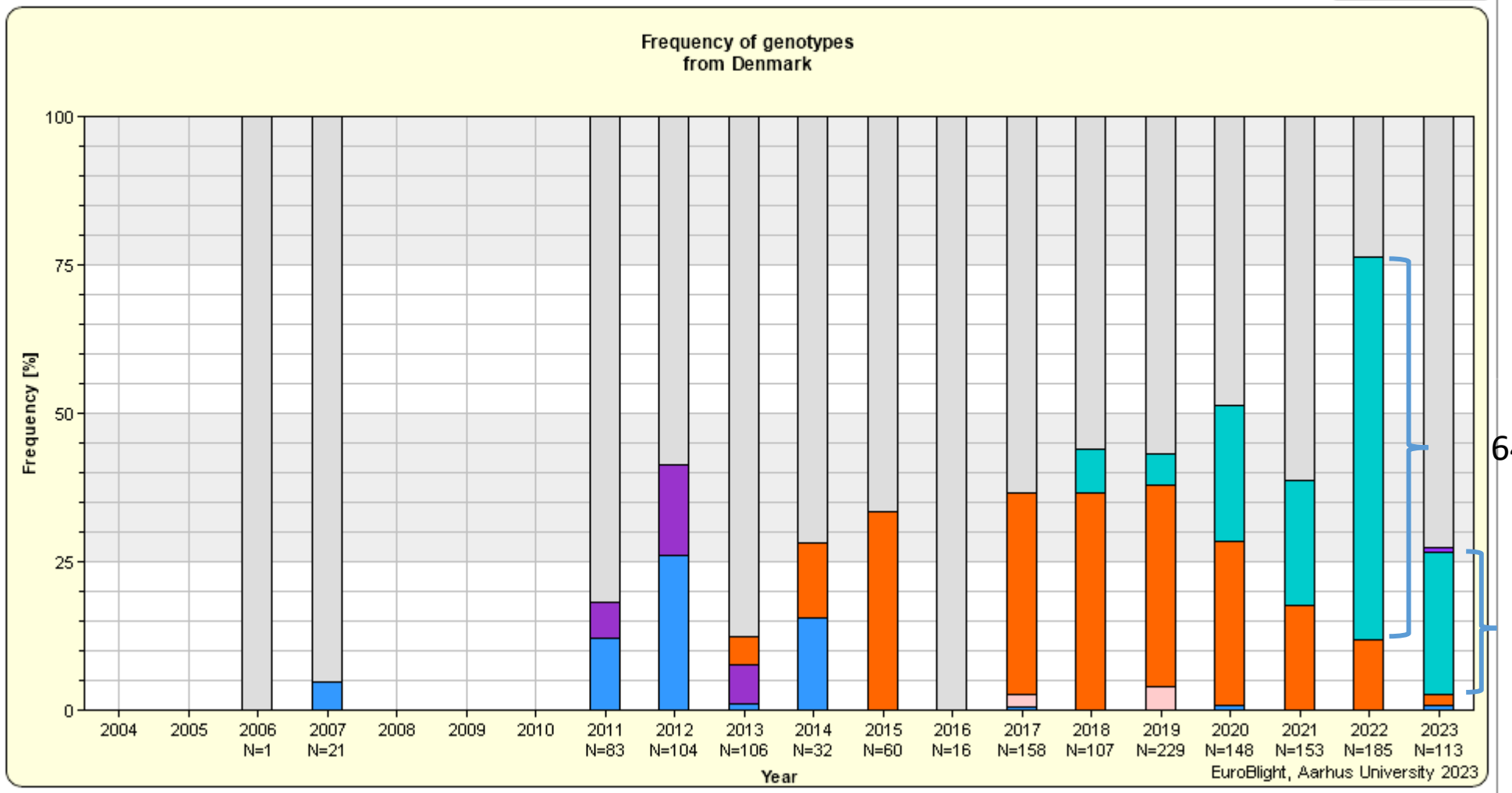
Show

Genotype legend

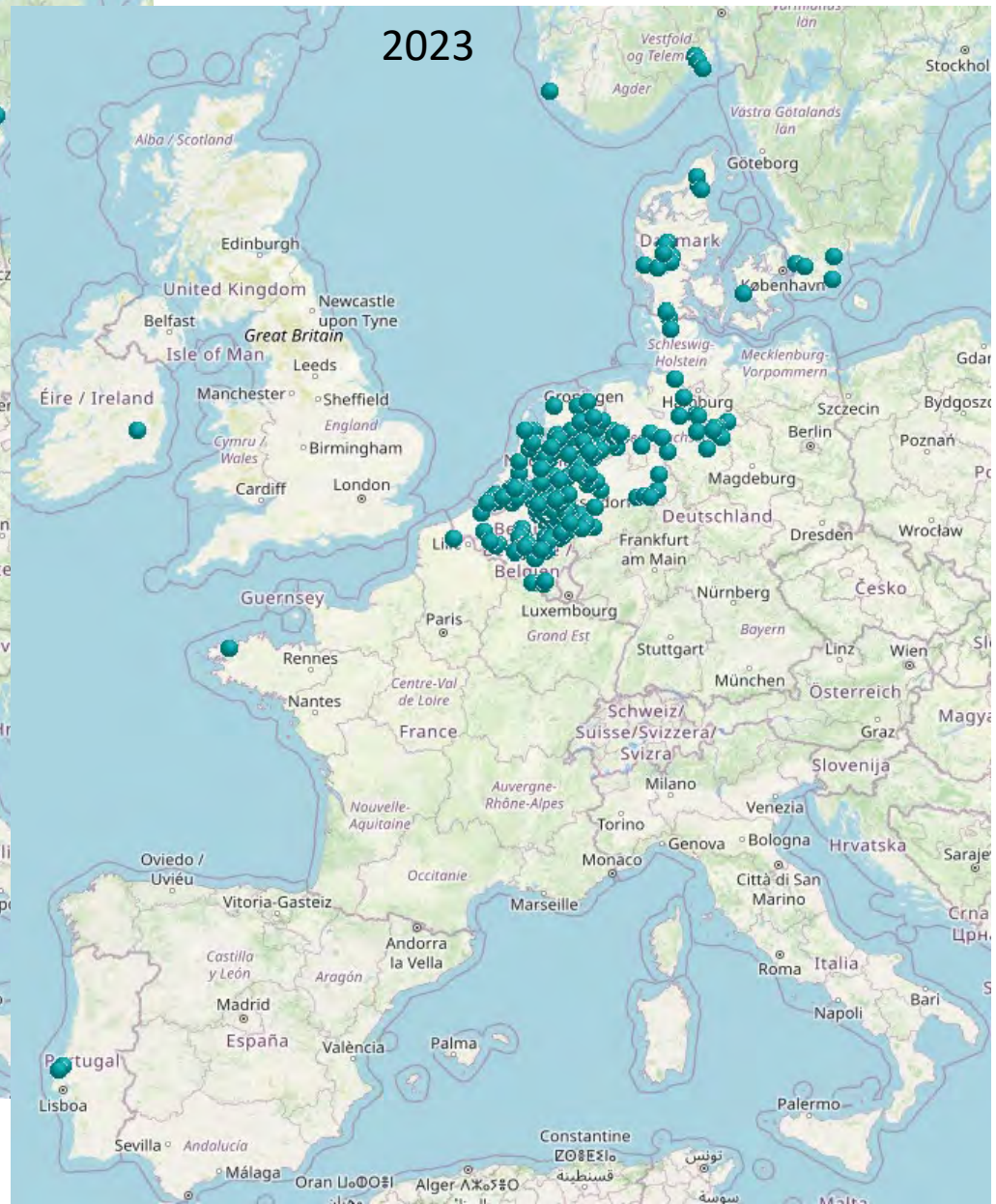
EU_13_A2, EU_36_A2, EU_40_A2, EU_41_A2, EU_43_A1, EU_46_A1, Other

Genotype frequency distribution

Help



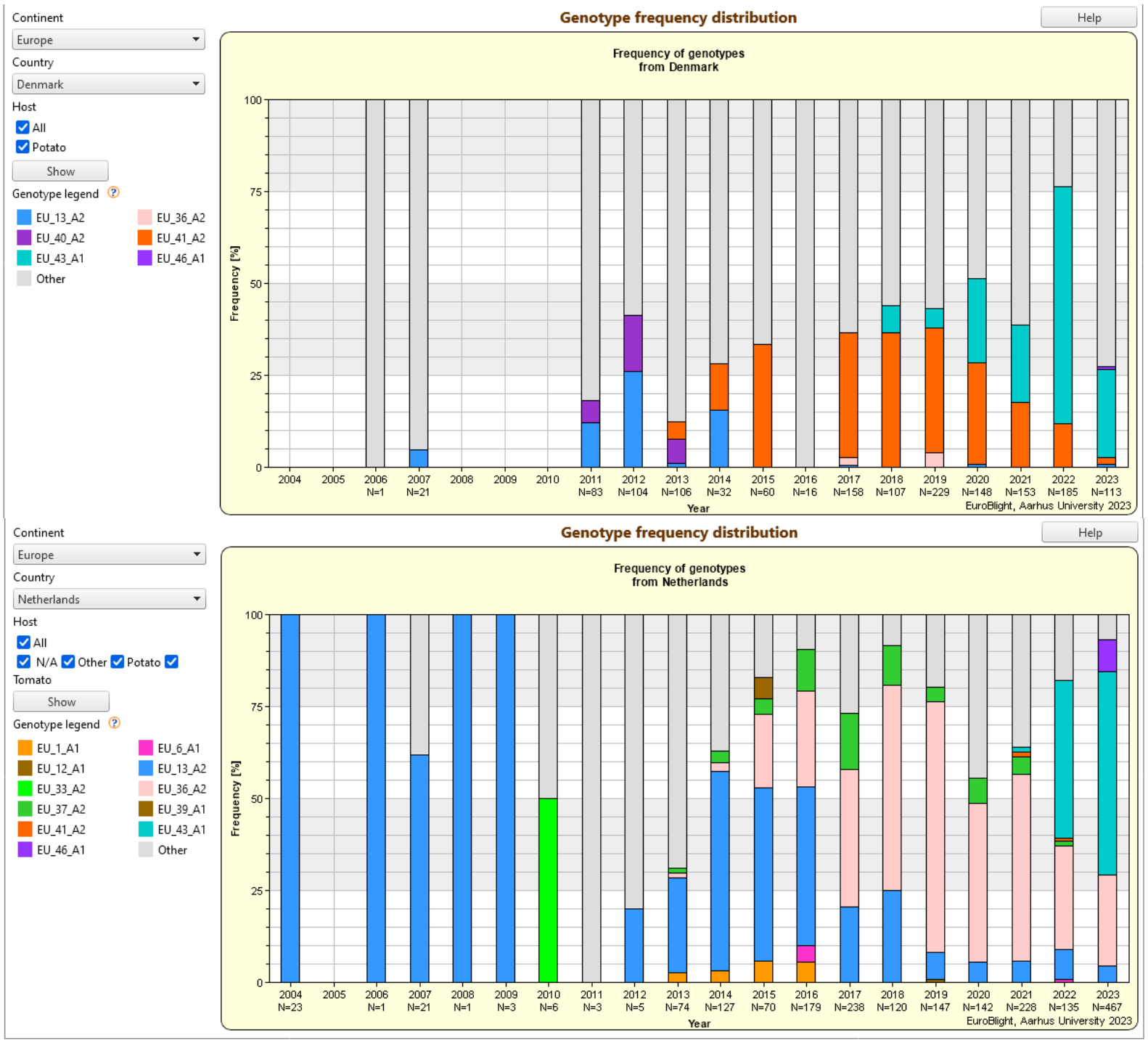
EU43 distribution in Europe



EU43 frequency shift from 2022 to 2023

- DK: from 64 to 24%
- NL: from 43 to 55%
- DE: from 7 to 52%

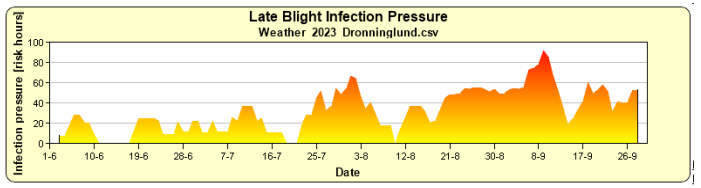
EU43 first time found in France and Ireland



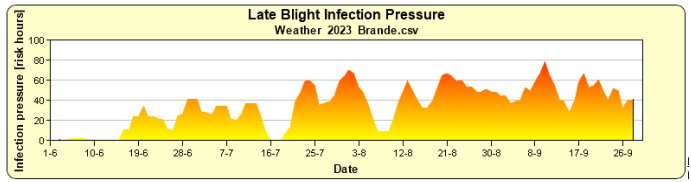
Infection pressure

Denmark

Other



EU46



EU43

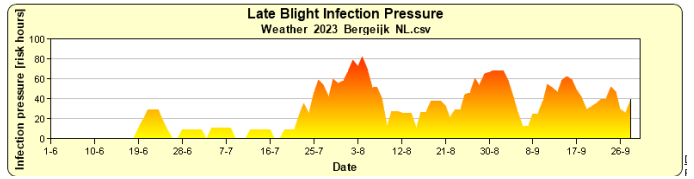
EU41 & EU13

1. Similar weather-based blight risk
2. But different late blight management strategy
3. Different organisation and communication

The Netherlands

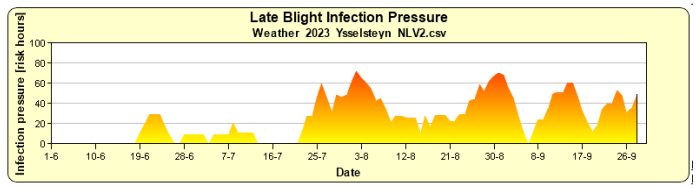
EU46

EU43



EU36

EU13



Tabel 1. General strategies for Starch potatoes

Nr.	1	2	3	4	5	6	7	8	9	10	11	12	13	Antal behand.	Mængde, l/ha	Pris, kr./kg-l	Omkostninger, kr./ha
Uge	25	26	27	28	29	30	31	32	33	34	35	36	37				
Dato	12-jun	19-jun	26-jun	03-jul	13-jul	13-jul	24-jul	31-jul	07-aug	14-aug	21-aug	28-aug	04-sep	Number Treat-ments	Amount l/ha	Cost / Kg - l	Total Cost / ha
Ranman Top/ Azuleo																	
Revus							0,6			0,6				2	1,2	325	390
Shirlan/Zignal/ Banjo	0,4	0,4	0,4	0,4	0,4			0,4	0,4		0,4	0,4	0,4	10	4	528	2.112
Zorvec				0,15	0,15									2	0,3	1.457	437
Proxanil		2					2			2				3	6	239	1.434
Cymbal/Option	0,25		0,25					0,25	0,25		0,25	0,25		6	1,5	280	420
Amistar							0,5							1	0,5	235	118
														24			**4.911** **~ 660 €**
	Indledende blok			Zorvec blok			Proxanilblok				Afsluttende blok						

Key issues

Revus:
Starch: 2 times, late season
Ware: 0 times

Shirlan:
Starch: 10 times
Ware: 7 times

Danger! It puts pressure on other active ingredients, especially fluazinam

Gradual loss in sensitivity found earlier for EU33 and EU37 (not on/off)

Avoid! Revus and then Zorvec

GENOTYPE

Genotype map | Genotype frequency map | Genotype frequency chart | Frequency rank | World map | World appearance

Continent

Europe

Year

All
2023 2022
2021 2020
2019 2018
2017 2016
2015 2014
2013 2012
2011 2010
2009 2008
2007 2006
2005 2004

Host

All
N/A Other
Potato Tomato

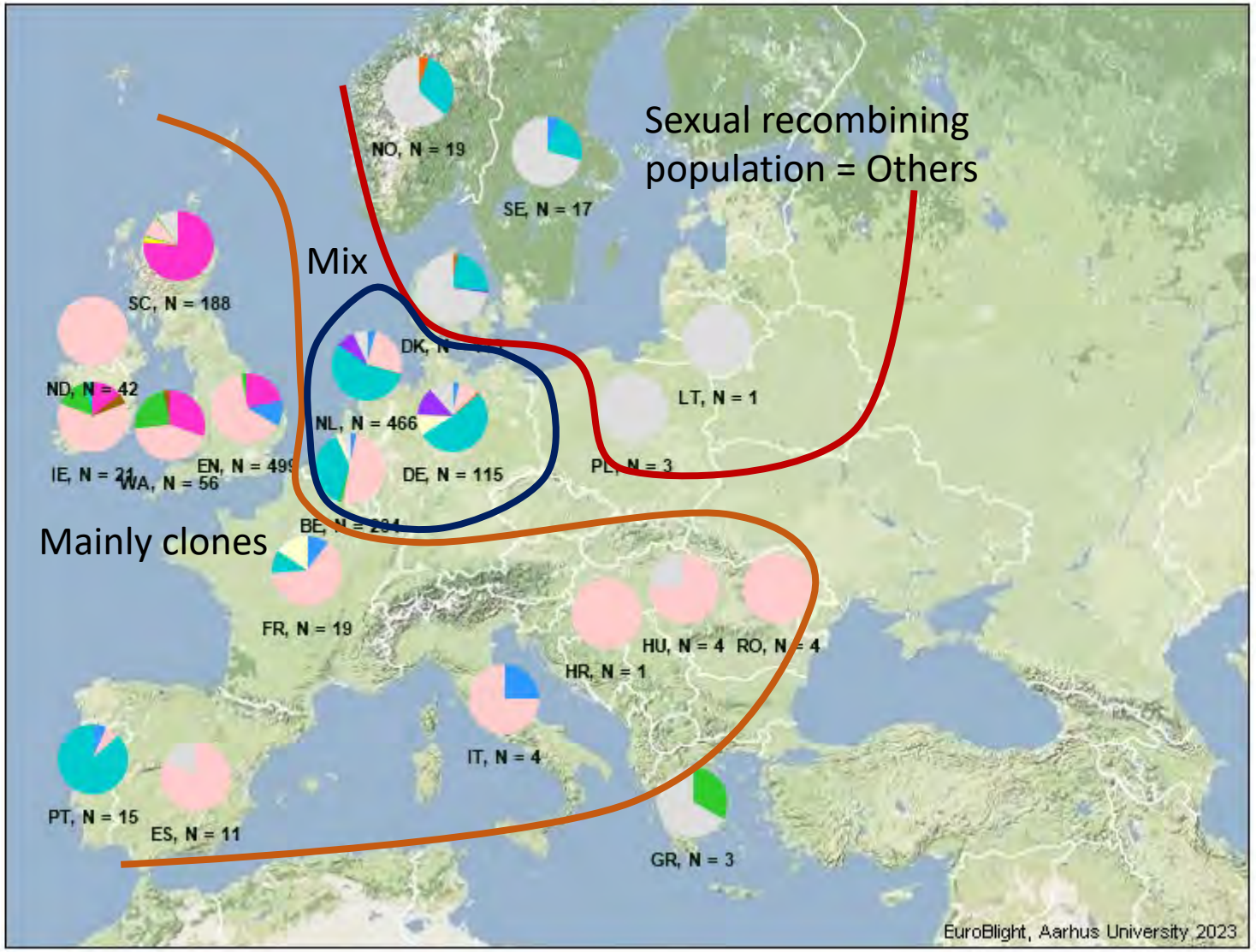
Show

Genotype legend

EU_6_A1
EU_8_A1
EU_12_A1
EU_13_A2
EU_36_A2
EU_37_A2
EU_39_A1
EU_41_A2
EU_43_A1
EU_45_A1
EU_46_A1
Other

Genotype frequency distribution

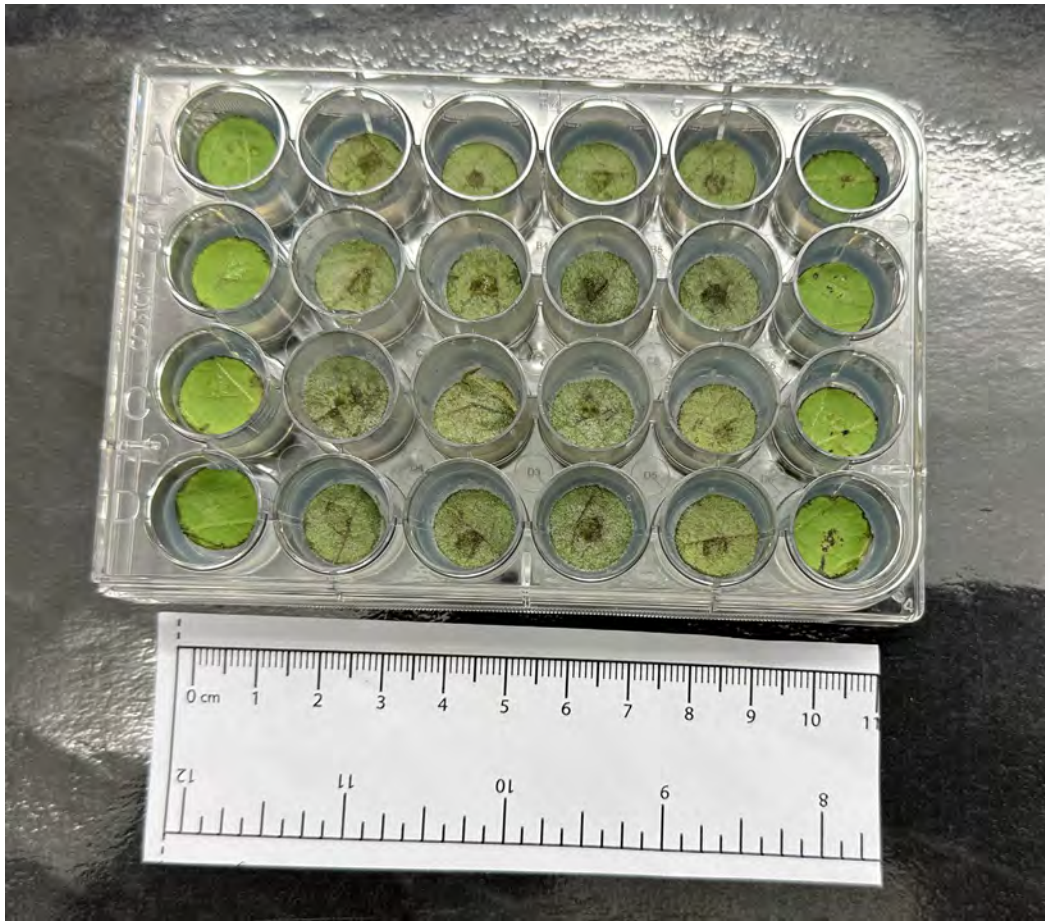
Help

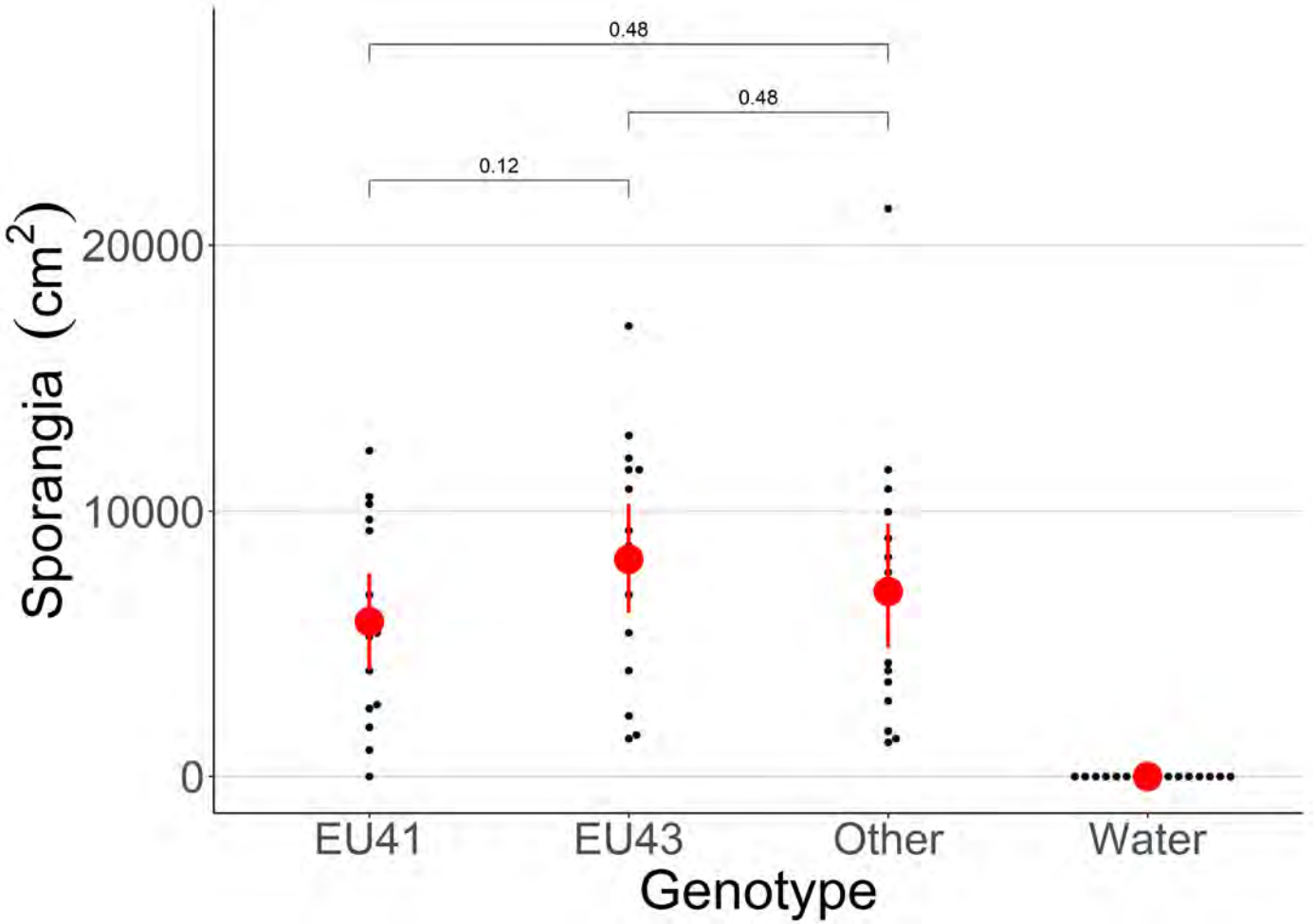


Sampling of late blight infected leaves

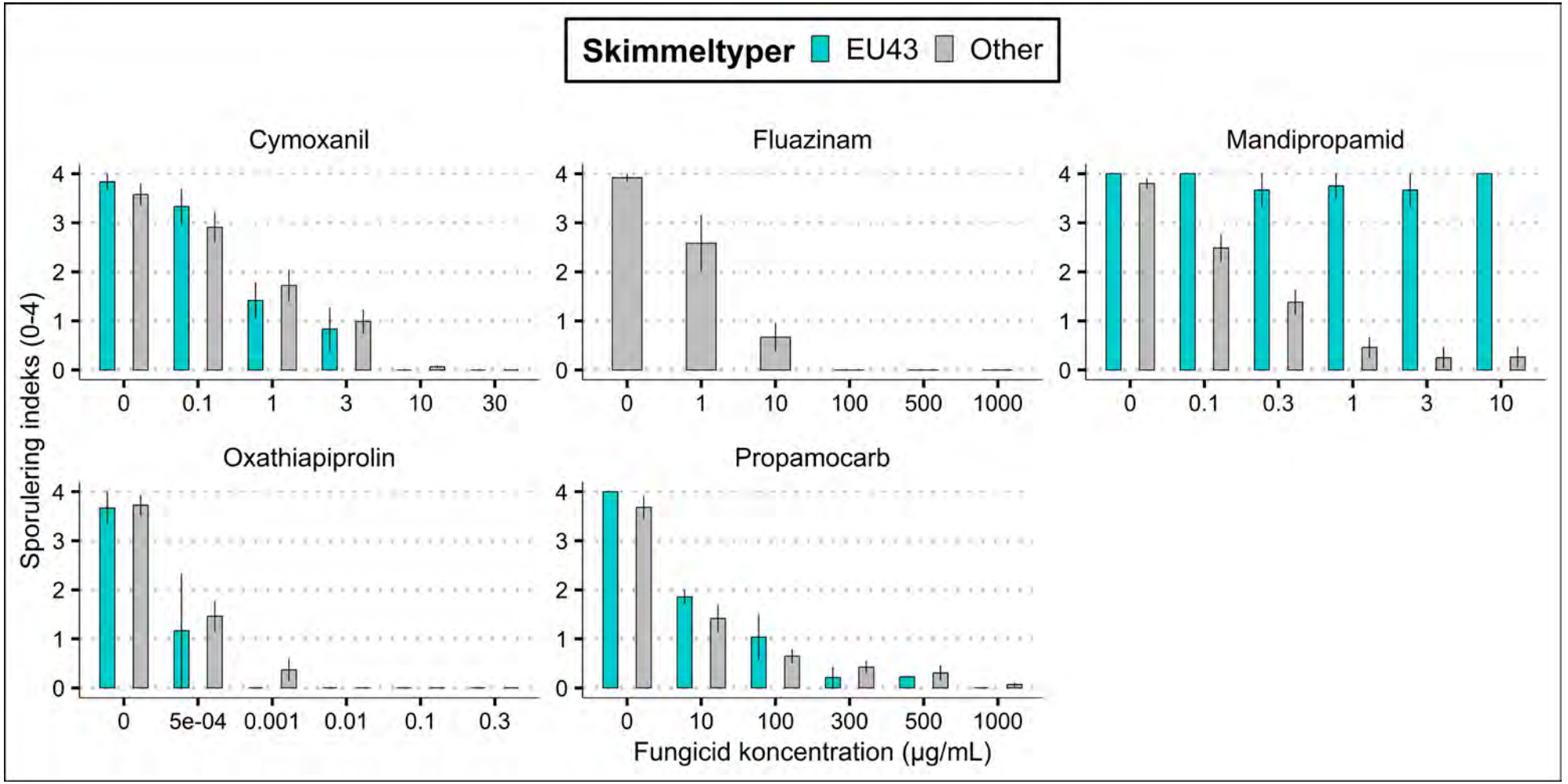
- >100 samples from different types of potato e.g. farmers fields and field trials
- 120 isolates have been isolated and purified in the lab
- 20 isolates tested for:
  - Sporulation capacity
  - Sensitivity against fungicides
    - Cymoxanil (Cymbal)
    - Oxathiapiprolin (fx Zorvec Enicade)
    - Mandipropamid (fx Revus)
    - Propamocarb (fx Sporax)
    - Fluazinam (fx Shirlan)

Sporangia production of EU43, EU41, and other genotypes





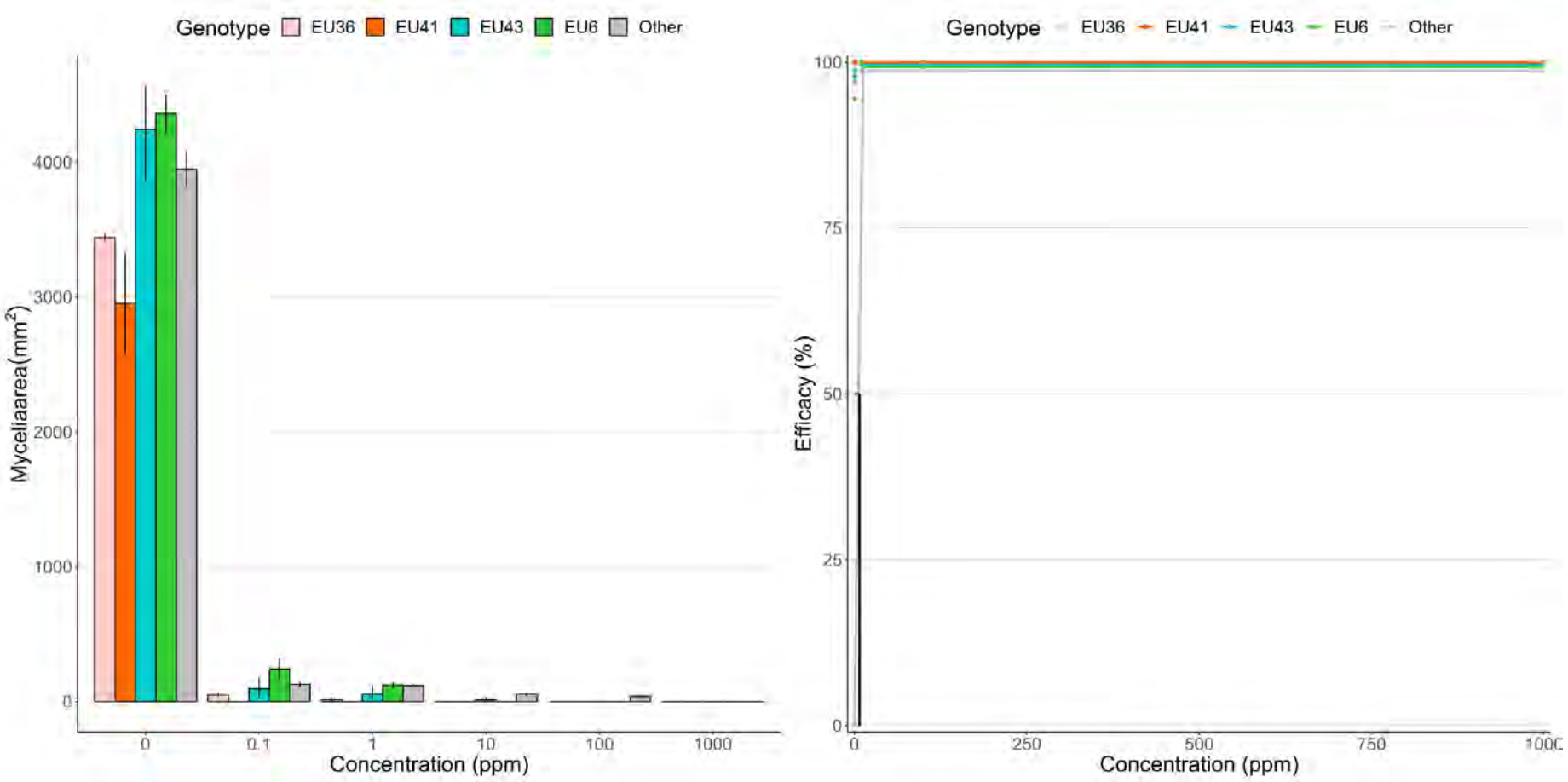
Except EU43 and mandipropamid, there all tested isolates were sensitive to the fungicides



Number of isolates:
EU43 = 3
Other = 17

2022 Danish isolates were also very sensitive to fluazinam

EC50 <0.2 ppm for all tested genotypes



Danish isolates are very sensitive, with EC50 values way below field rates (ppm)!

Produkt	Aktivstof	Markniveau (ppm)	EC50 fra testede isolater (ppm)	Skimmeltyper
Cymbal WG	Cymoxanil	375	0,59 (0,00013)	EU43
			0,91 (0,0007)	Other
Sporax	Propamocarb	3369	9,1 (0.00041)	EU43
			6,1 (0.00047)	Other
Shirlan Ultra	Fluazinam	667	1,8 0 (0.00021)	Other
Revus	Mandipropamid	500	0,165 (0.000071)	Other
			NA	EU43
Zorvec	Oxathiapiprolin	50	0,000256 (0.00000009)	EU43
			0,000287 (0.00000009)	Other

Conclusions

What we find

1. The proportion of EU43 decreased from appr 64 % in 2022 to 24% in 2023.
2. EU43 found all through the season – evenly distributed
3. All EU43 tested in 2023 were resistant to mandipropamid but sensitive to oxathiapiprolin, cymoxanil and propamocarb
4. Results on sensitivity to fluazinam is inconclusive due to few isolates tested, but the tested isolates so far were all sensitive

What we do

1. AU will test more isolates and investigate other phenotypic traits that can co-explain the spread of EU43 and other clones
2. Several projects dig into the problem e.g. “Proactive **F**ungicide **R**esistance **A**voidance **S**trategies in potato – Potato FRAS” (2023-2026). Also a key issue at the forthcoming EuroBlight workshop 13-16 May 2024 in the Netherlands.

Fungicide Resistance Avoidance Strategies – IPM ⟹ ICM - Recommendations

1. Include DIVERSIFICATION (use different and more resistant cultivars, mix in field (strips) and landscape)
2. SANITATION (no dumps, more years between potatoes, control of volunteers, use healthy seed)
3. ECOSOL: test if biologicals can be used (in low risk periods) in combination with traditional fungicides
4. COLLABORATE and share data with Nordic and European colleagues – link up with EuroBlight, include the Europe perspective and make data and tools FAIR to obtain faster and more robust conclusions

Thank you for your attention

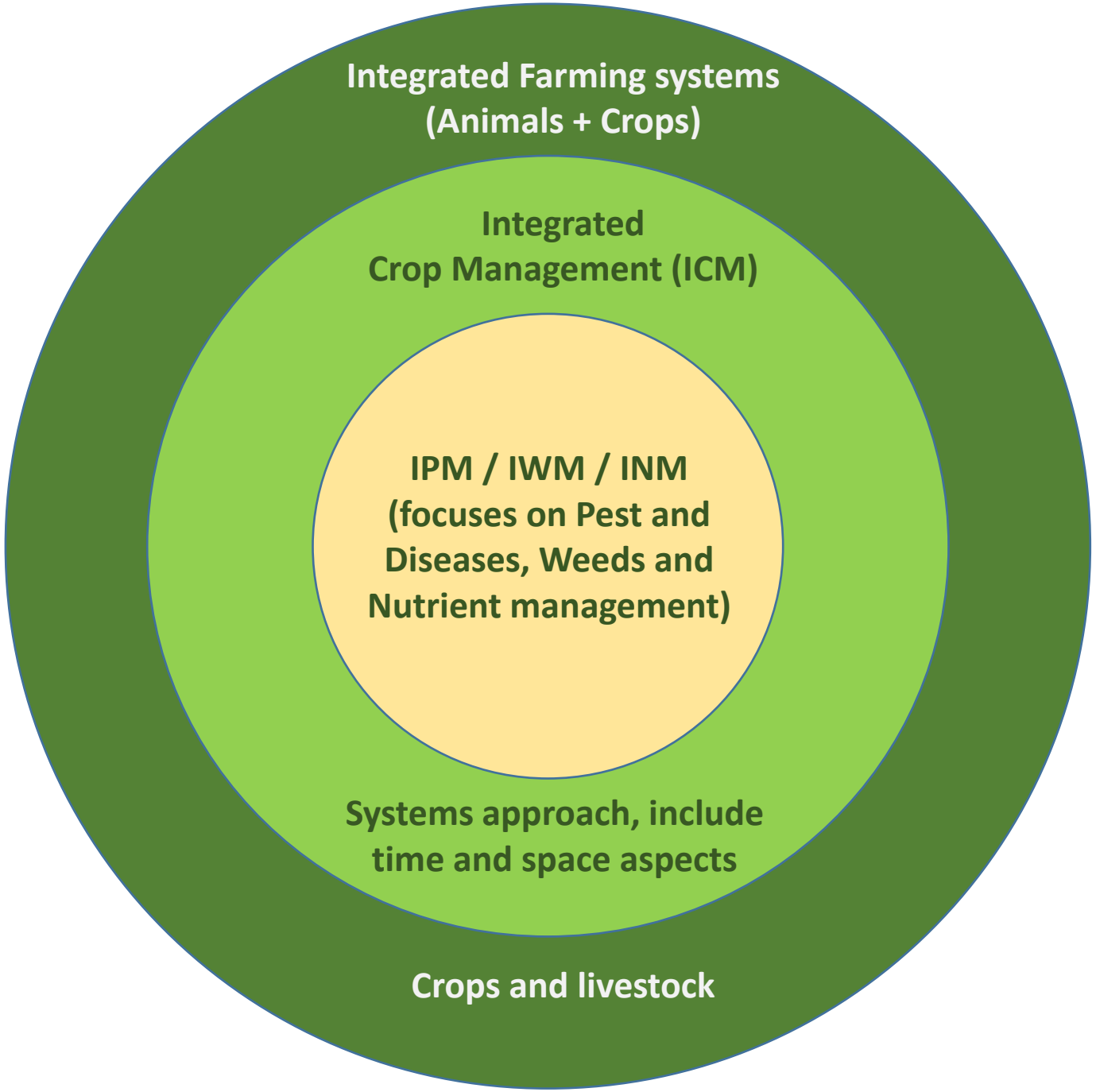
AARHUS UNIVERSITY

EuroBlight
A potato late blight network for Europe

Thanks to all who helped in sampling of isolates

And many partners

Title of ongoing “Potato diseases” projects	Level	Period
Development of proactive fungicide resistance avoidance strategies in potato (Acronym: **Potato-FRAS**) - MST	DK	2023-2026
Sustainability and resilience in organic potatoes (**SROPP**) – ICROFS/GUDP	DK / PhD	2023-2026
IPM bekæmpelse af kartoffelskimmel IV	DK	2023
Ecosol - Eco-friendly solutions for the integrated management of late and early blight of potatoes	EU	2021-24
EuroBlight – A potato late blight network for Europe	EU	2007 -
Potato Early Dying complex – importance and implications	DK / PhD	2021-24
N’TOP - Northern tubers of potato	NKJ	2021-23
Late Blight epidemiology and control in Iceland	IS	2022-2023



EuroBlight
A potato late blight network for Europe

Integrated Crop Management and late blight

- Use a diverse set of more resistant varieties
- Keep plants healthy and strong (water, nutrients, healthy soils)
- More focus on prevention strategies and reduction of primary inoculum sources: e.g. crop rotation, healthy seed, eradicate dumps and volunteer plants & diversify e.g. by strip cultivation and more diverse use of varieties
- Use fungicide resistance avoidance strategies
- Include pathogen information and host resistance information in control strategies and weather based DSSs
- Monitor the stability of host resistance in time and space
- Monitor the pathogen population in time and space
- Use resistance inducers, biological control agents and low impact fungicides to protect R-genes and horizontal resistance in new and more resistant varieties
- Information and training / regulation and control