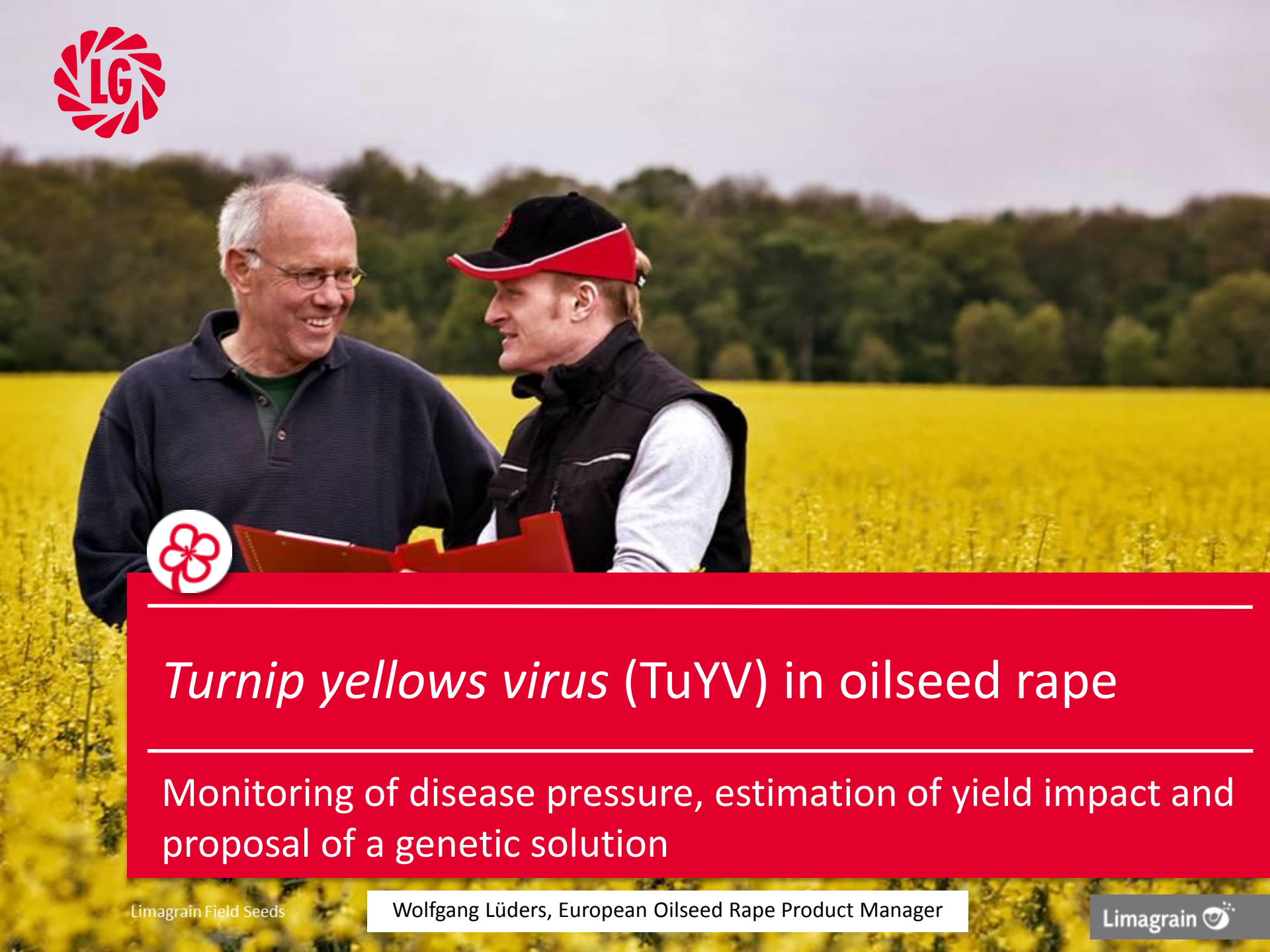


Turnip yellows virus (TuYV) in oilseed rape

Monitoring of disease pressure, estimation of yield impact and proposal of a genetic solution

Limagrain Field Seeds

Wolfgang Lüders, European Oilseed Rape Product Manager

Limagrain

Limagrain: An international cooperative group - owned by French Farmers

4th largest seed company worldwide

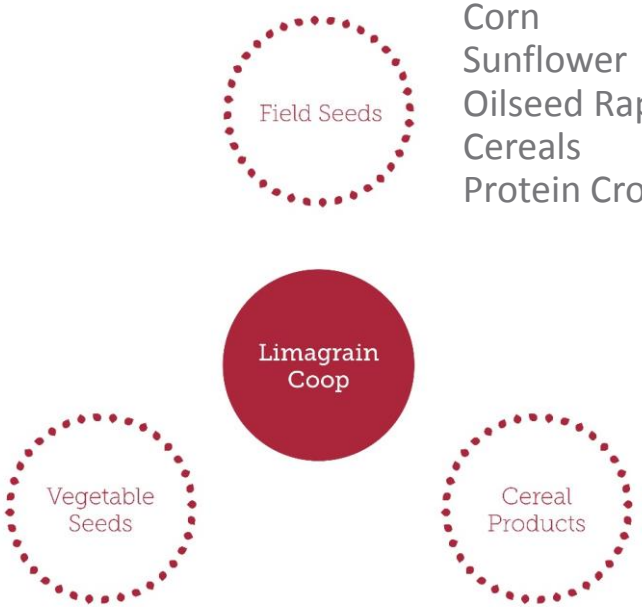
Nearly 2,000 members

Nearly €2 Billion sales

More than 8,600 employees

Subsidiaries in 41 countries

13.5 % of professional sales on research



(Status 2015)

Very common view after winter…

TuYV infection rate: 100%

Foto: Schliephake, Rabenstein, Habekuß (2016)

What caused the leaf discolorations???

Rosenthal, Germany, 21 Sept 2016; Fotos: Limagrain Europe

Taxonomy

Family
Luteoviridae

Genus

Enamovirus

Pea enation mosaic virus 1

Luteovirus

Barley yellow dwarf virus-kerII
Barley yellow dwarf virus-kerIII
Barley yellow dwarf virus-MAV
Barley yellow dwarf virus-PAS
Barley yellow dwarf virus-PAV
Bean leafroll virus
Rose spring dwarf-associated virus
Soybean dwarf virus

Polerovirus

Turnip yellows virus
Beet chlorosis virus
Beet mild yellowing virus
Beet western yellows virus
Carrot red leaf virus
Cereal yellow dwarf virus-RPS
Cereal yellow dwarf virus-RPV
Chickpea chlorotic stunt virus
Cotton leafroll dwarf virus
Maize yellow dwarf virus-RMV
Melon aphid-borne yellows virus
Cucurbit aphid-borne yellows virus
Pepper vein yellows virus
Potato leafroll virus
Suakwa aphid-borne yellows virus
Sugarcane yellow leaf virus
Tobacco vein distorting virus

Unassigned

Barley yellow dwarf virus-GPV
Barley yellow dwarf virus-SGV
Chickpea stunt disease associated virus
Groundnut rosette assistor virus
Indonesian soybean dwarf virus
Sweet potato leaf speckling virus
Tobacco necrotic dwarf virus

Source: Schliephake, Rabenstein, Habekuß (2016)

Effects of TuYV

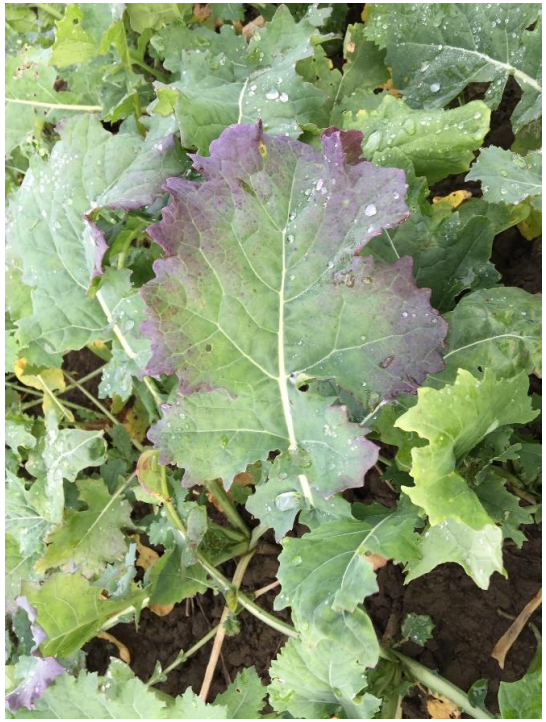
- Leaf discoloration
- Stunted plants
- Leaf area reduction
- Reduced primary branching
- Fewer seeds per pods
- Reduced oil content
- Increased content of glucosinolates

- **Reduced yield**

Leaf discolorations in autumn 2016

Northern Germany, 30.09.2016;
Foto: T. Herzog, LG

Poland, 29.09.2016;
Foto: L. Chwalisz, LG



Germany, 01.11.2016;
Foto: W. Lüders, LG

Autumn symptoms of TuYV

infected plants

Pictures from Limagrain Europe

uninfected plants = green leaves

Autumn symptoms

Spring symptoms of TuYV

Photos kindly supplied by Bill Clarke.

Occurence of the Green Peach Potato Aphid

Source: Invasive Species Compendium

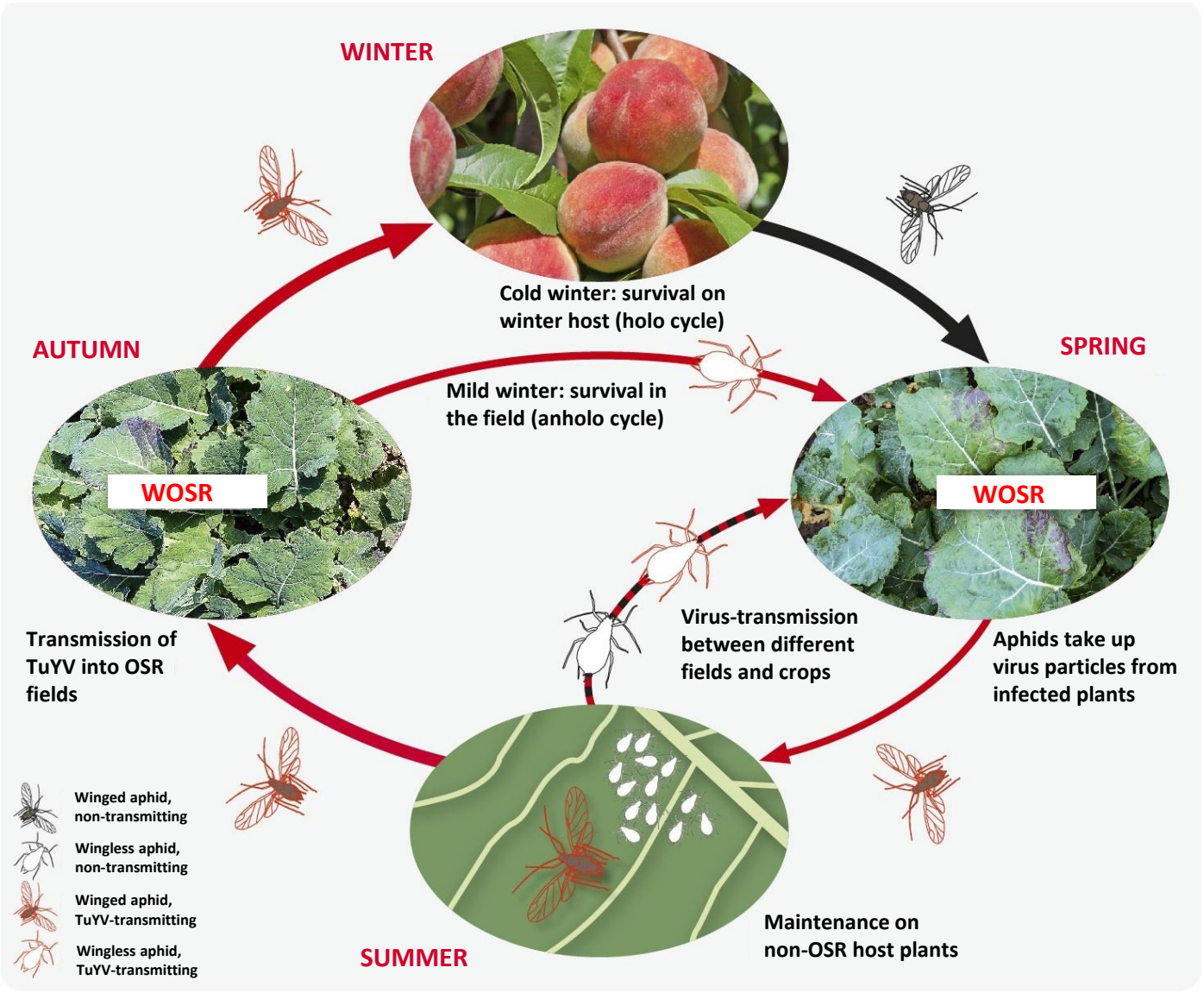
Myzus persicae

- Probably of Asian origin, now world wide
- Polyphagous: host plants in over 40 families including very important crops
- Could resist at -15°C during winter
- Vector of several virus on sugar beet, potatoes, vegetable crops, fruit productions, inter-crop (brassicas)
- Vector and transmitter of OSR TuYV (*Turnip yellows virus*)

Life cycle of TuYV infection in winter oilseed rape

Winged aphid

Wingless aphids



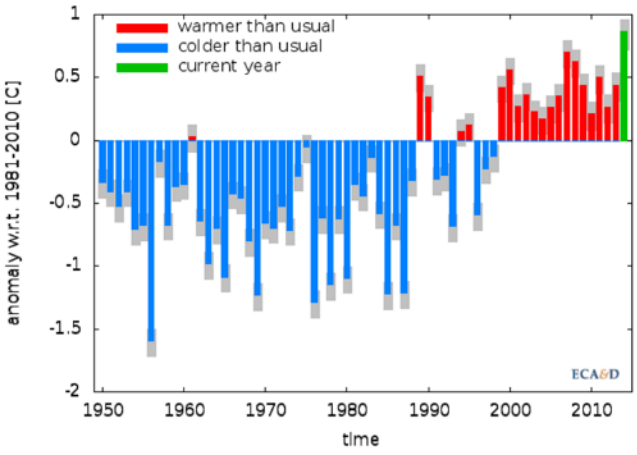
Source: Habekuß, Schliephake and Rabenstein, 2016, modified

Occurence of TuYV is increasing – Why?

1. **Global warming**
   - → Longer periods for aphid activity
   - → Bigger aphid populations

2. **Greening**
   - → More host plants for virus and vectors

3. **Ban on Neonic seed treatments**
   - → Reduced protection of yound seedlings



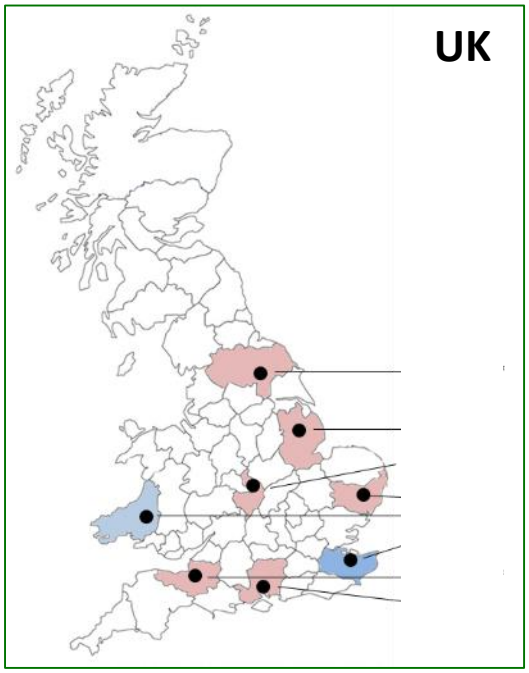
TuYV Monitoring surveys 2015-2017
(by DAS-ELISA)

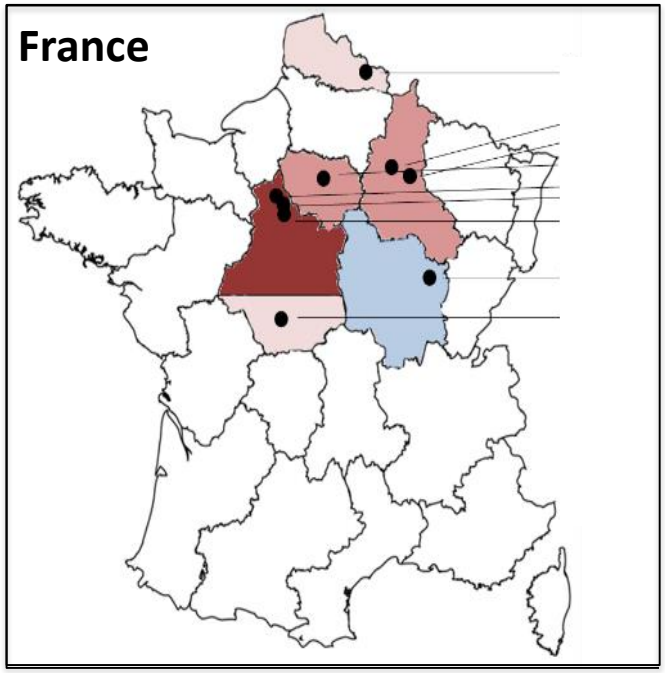
Year	Period	lab	Scope area	No. Of locations
2015	Spring	Warwick	Europe	28
2016	Spring	Warwick	Europe	21
2016	Spring	JKI	Europe	329
2016	Autumn	DSMZ	Germany	40
2017	Spring	Limagrain	Europe	177
2017	Spring	JKI	Germany	>700

Surveys initiated by Limagrain

TuYV Monitoring in spring 2015

(lab: University of Warwick, Wellesbourne, UK; J. Walsh)





TuYV Incidence %

40
50
60
70
80
90
100

● Sampling locations

Poland:

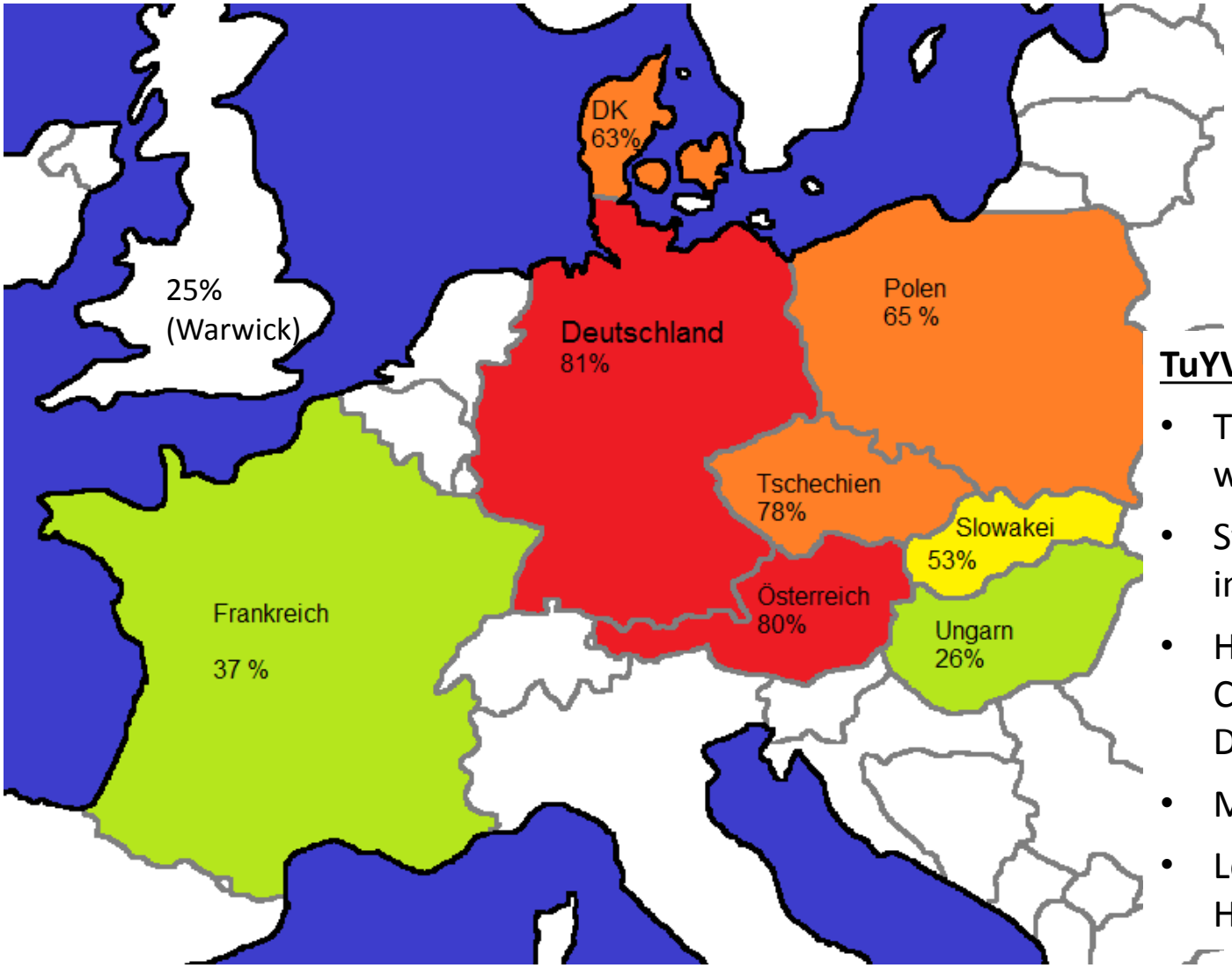
Czech:

TuYV in spring 2015

- TuYV was found in all OSR key areas across Europe
- Heavy infestations in Germany, France, Poland and Czech
- Medium infestations in UK

TuYV Monitoring in spring 2016

(lab: JKI Quedlinburg; S. Fischer, A. Habekuß)



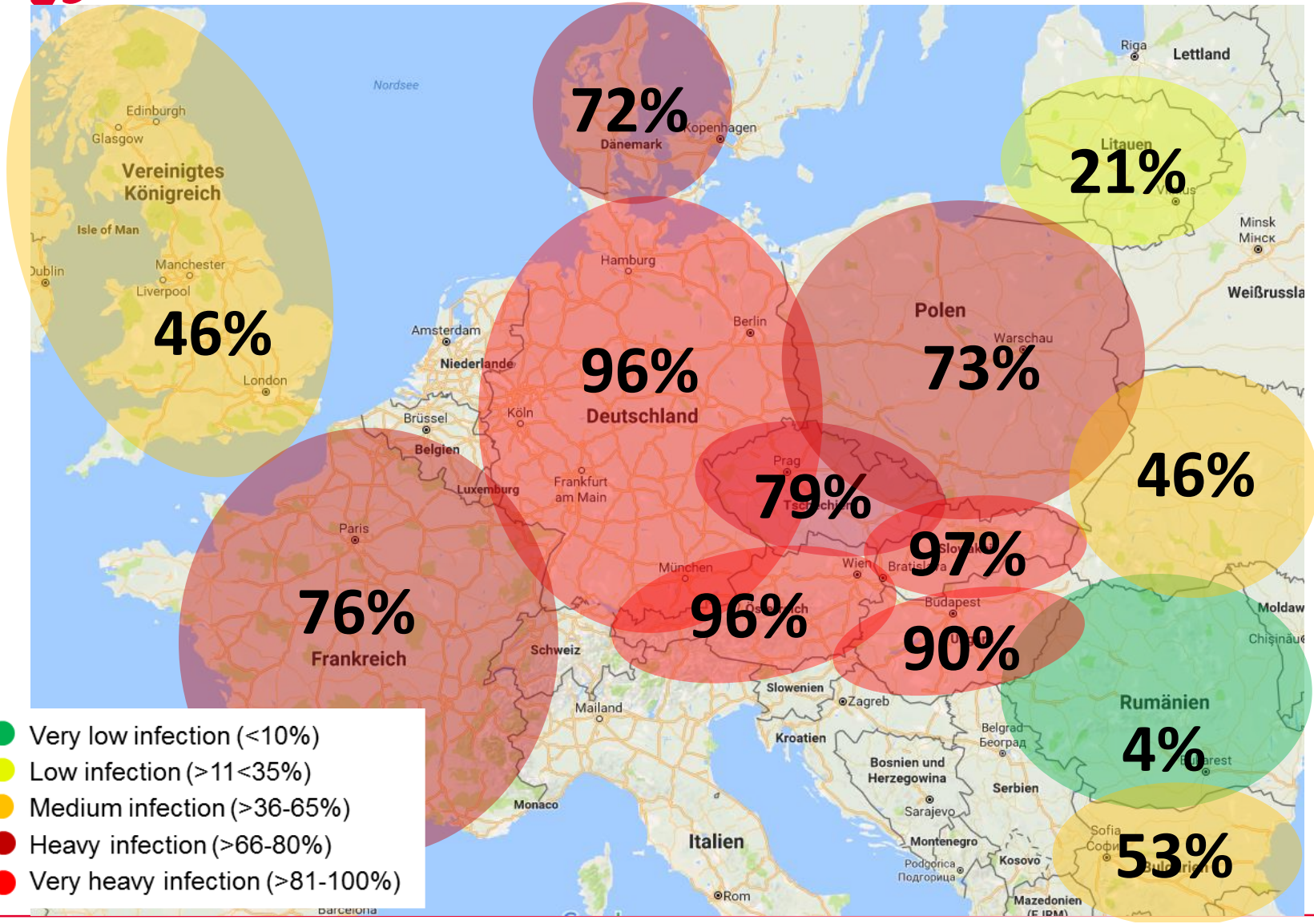
Incidence
0-20%
21-40%
41-60%
61-80%
81-100%

TuYV in Spring 2016

- TuYV was found widespread
- Strongest infestations in Germany + Austria
- High incidences in Czech, Poland, Denmark
- Medium in Slovakia
- Low in UK, France, Hungary

TuYV Monitoring in spring 2017

(lab: Limagrain, Chappes, FR)



indicated here: Ø TuYV infection rate of susceptible varieties per country

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TuYV occurence in OSR in Europe 2015-2017

Summary

- Since neonic seed treatmens were banned, Limagrain started to monitore TuYV presence year by year (DAS-ELISA)
- Within 3 years, 6 surveys have been initiated
- TUYV was found widespread in the main OSR cropping regions in Europe every year
- In 2017, the occurence of TuYV was extraordinary high (strong aphid presence in autumn 2016)
- Most severe attacked regions every year have been
  - Germany, Austria, Poland, Czech, (Denmark)
- Varying levels of TuYV were detected in
  - France, Hungary, Slovakia (variation maybe caused by heat)
- Medium infestation areas seem to be
  - United Kingdom, Bulgaria, Ukraine
- In the UK, the average levels found were medium to low; but, varying a lot location by location due to aphid presence (also highly infected locations found in the UK)
- Low levels of infestation were found in
  - Lithuania, Romania (one year only)
- In countries with Neonic ST use (derogations), the data maybe linked to that (RO, HU, UA, UK, DK, Baltics?)

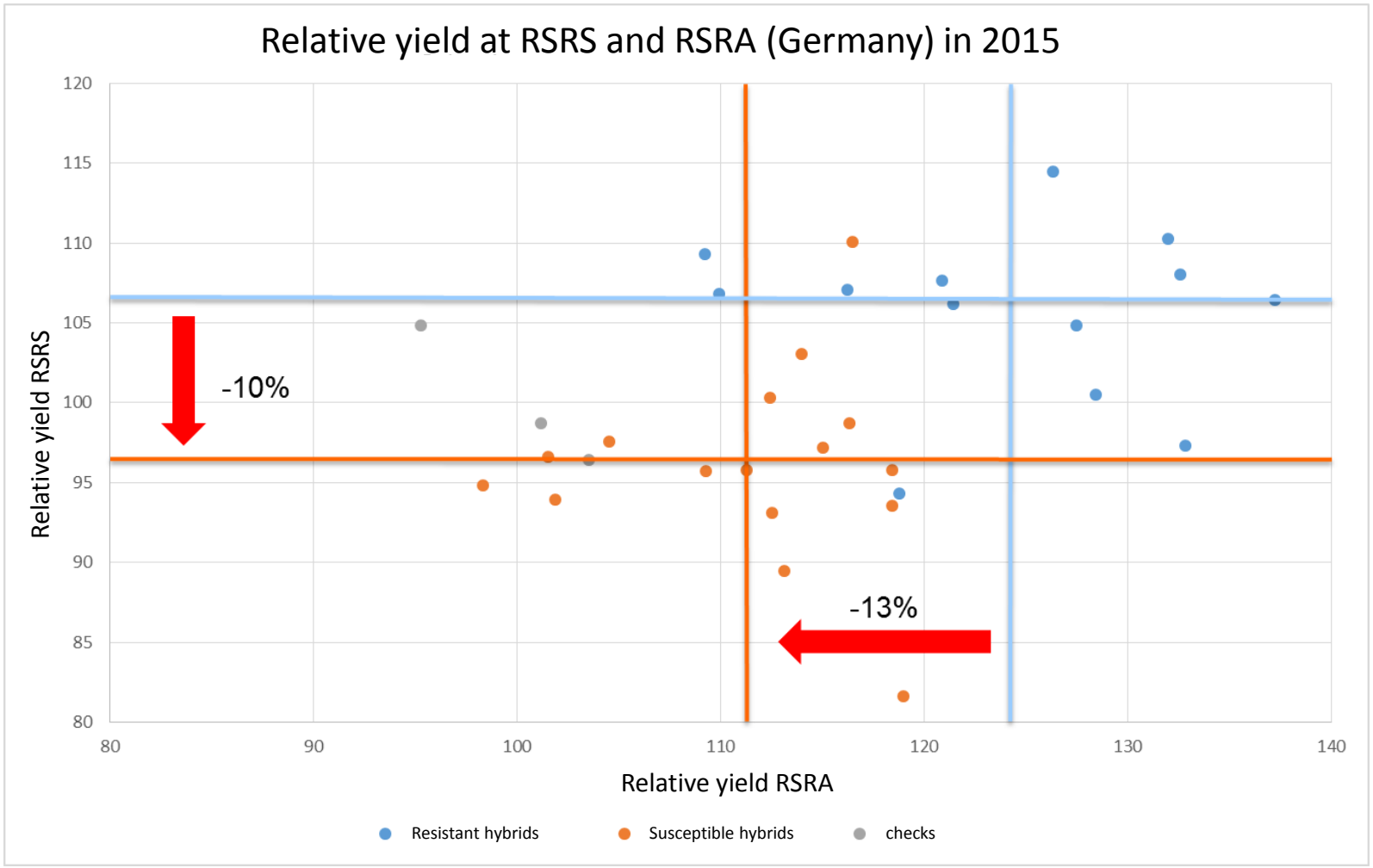
Yield impact caused by TuYV infections

Literature

- **Smith et al. (1985) UK decrease of 0.3t/ha**
- **Graichen et al. (1997) Germany 12 – 34%**
- **Jay et al. (1999) UK 11 – 26%**
- **Terres Inovia FR decrease 0.8-1t/ha**
- **Jones et al. (2007) Australia 37-46%**

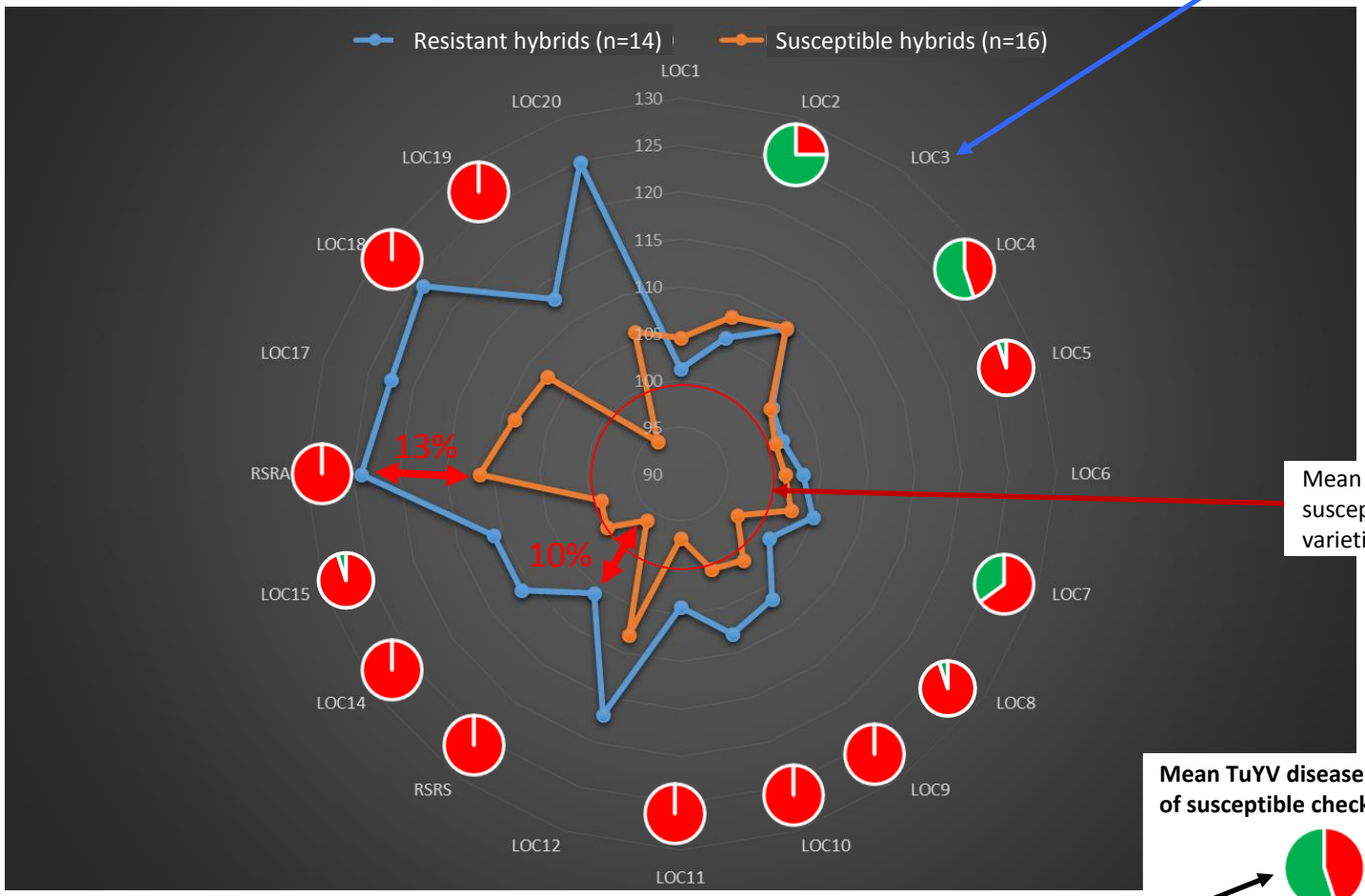
Edited by G. Lavillonniere, Limagrain Europe, 2015

TuYV resistant hybrids perform much stronger in higly infected locations

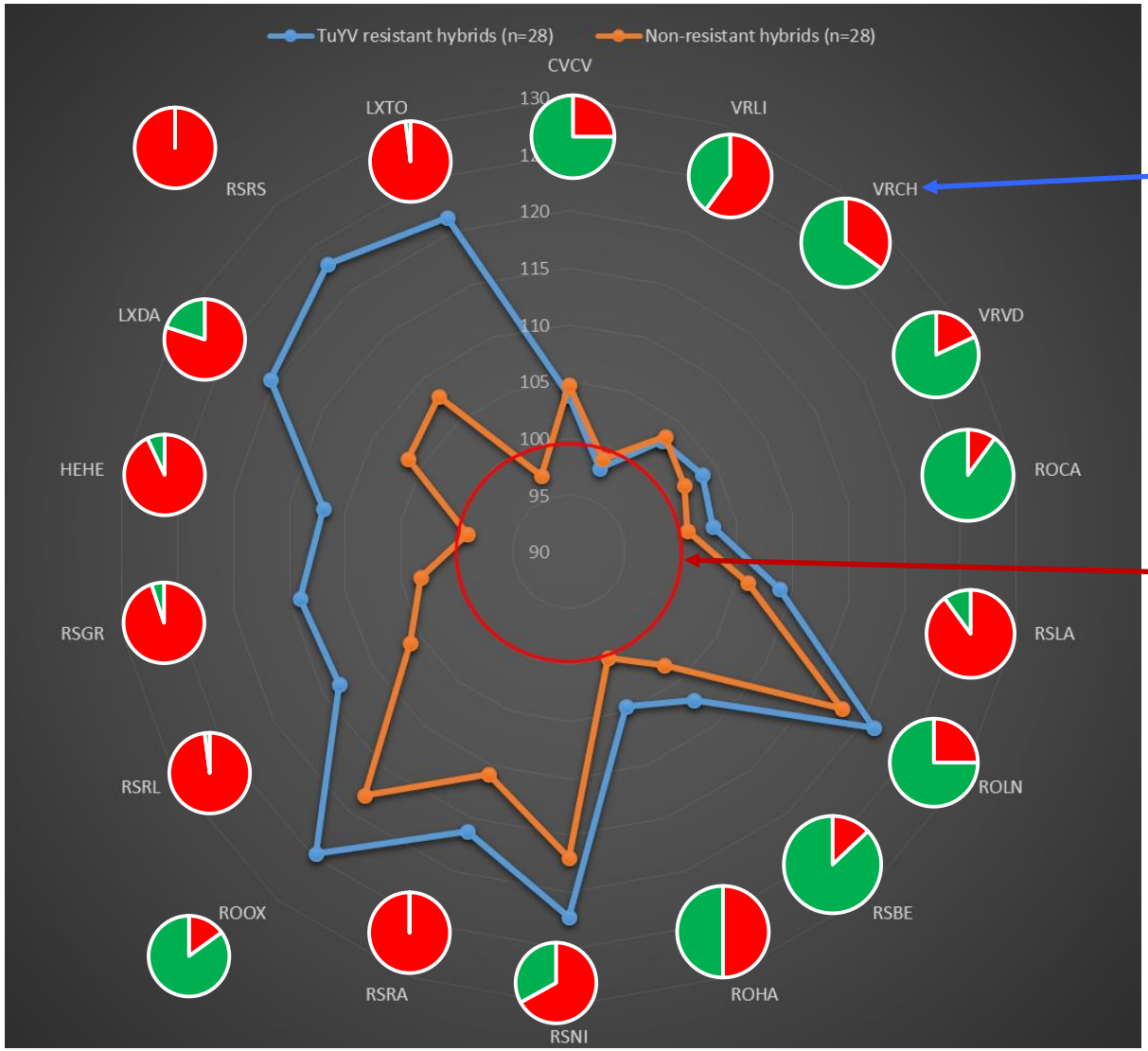


2015 - yield comparison under TuYV infection across Europe

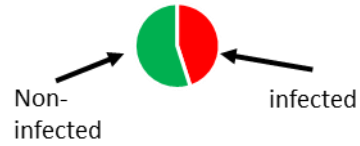
TuYV resistant vs. susceptible hybrids



2016 - yield comparison under TuYV infection across Europe



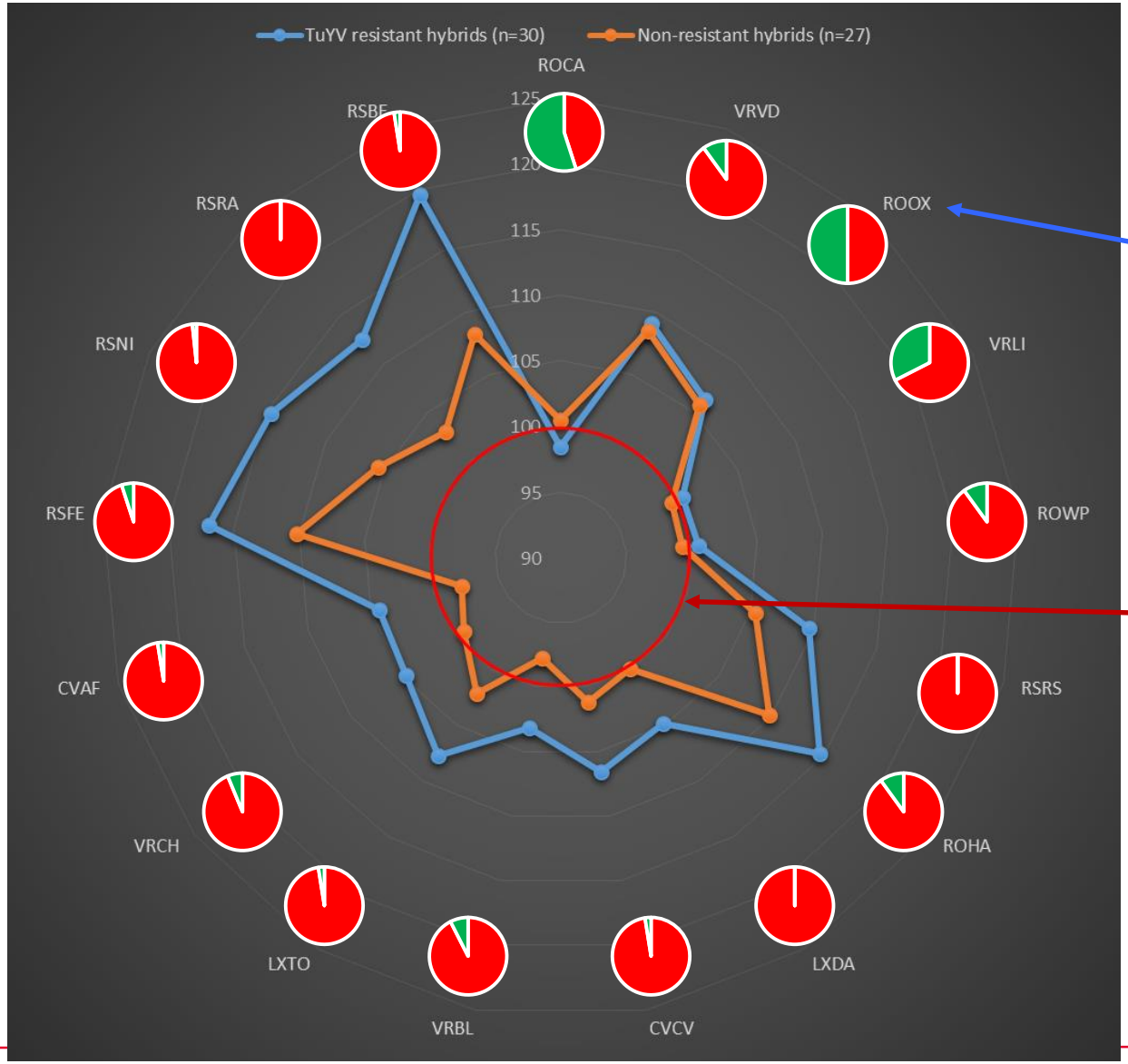
Mean TuYV disease incidence of susceptible checks



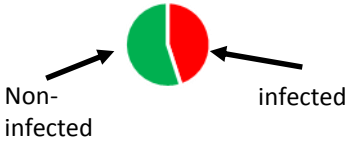
Trial location

Mean of susceptible check varieties (=100%)

2017 - yield comparison under TuYV infection across Europe



Mean TuYV disease incidence of susceptible checks



Trial location

Mean of susceptible check varieties (=100%)

Yield gap [%]* -> indicator for yield impact caused by TuYV

Year	Min	Max	Mean	No. Of locations
2015	-3%	19%	7%	20
2016	-1%	25%	7%	19
2017	-7%	11%	5%	20

* Yield gap between the mean of the TuYV resistant and the mean of the susceptible sub group within a well balanced group of new oilseed rape hybrids in annual trial series across Europe

Analysis of TuYV caused yield impact 2015-2017

Preliminary synthesis of the yield impact caused by TuYV infections, observed in 59 field trials from 2015 to 2017 in DE, FR, UK, PL & CZ

Yield impact	no impact (0% or below)	1% to 5%	6% to 10%	11% to 15%	16% to 20%	> 20%	Total observations
Absolute observations [n]	9	22	13	10	3	2	59
percentage	15%	37%	22%	17%	5%	3%	100%
not impacted/ impacted	15% not	85% impacted					
severely impacted	53% not		47% yes				
categories	**15%**	**37%**	**39%**		**8%**		
	not impacted	slightly impacted	severely impacted		heavily damaged		

Yield impact by TuYV

Summary

- Measurement of the exact yield impact caused by TuYV infection is difficult
- But, as the set of resistant and susceptible hybrids used in this study are genetically very close to each other, the applied testing method is a practical indicator
- It was shown: Yield gap and TuYV disease incidence are linked to each other
- In the majority of the trials (85%) the yield was impacted by TuYV
- Severe yield impacts (>5% loss) were found in half of the trials (47%)
- Very often (39% of observations), the actual measured yield loss was between 6 to 15%
- Yield impactation higher than 15% was observed rarely (8%); therefore, it is assumed that some older publications have overestimated the damaging potential of TuYV
- Without TuYV presence, the resistant varieties perform on the same level as the conventional hybrids → the TuYV resistance trait causes no yield penalty!

Insecticide-Resistance is a major challenge… As well, for plant breeders!

KNOWN RESISTANCE

- Carbamates (1A)
- Organophosphates (1B)
- Pyrethroids-Pyrethrins (3A)
- Neonicotinoids (4A)

Myzus persicae

PEST DISTRIBUTION

Source:

IRAC
Insecticide Resistance Action Committee

Plant breeding for TuYV resistance in oilseed rape

1992: first TUYV-resistance identified ("R54")

- Public funded collaborative GFP-screening project
- Initiated by Dr. Graichen at the Federal Institute for Breeding Research

1994-2006: GFP research projects in Germany (collaboration of breeding companies)

- Prebreeding activities
- Genetics and mapping of the resistance
- Resistant Genotypes for breeding activities

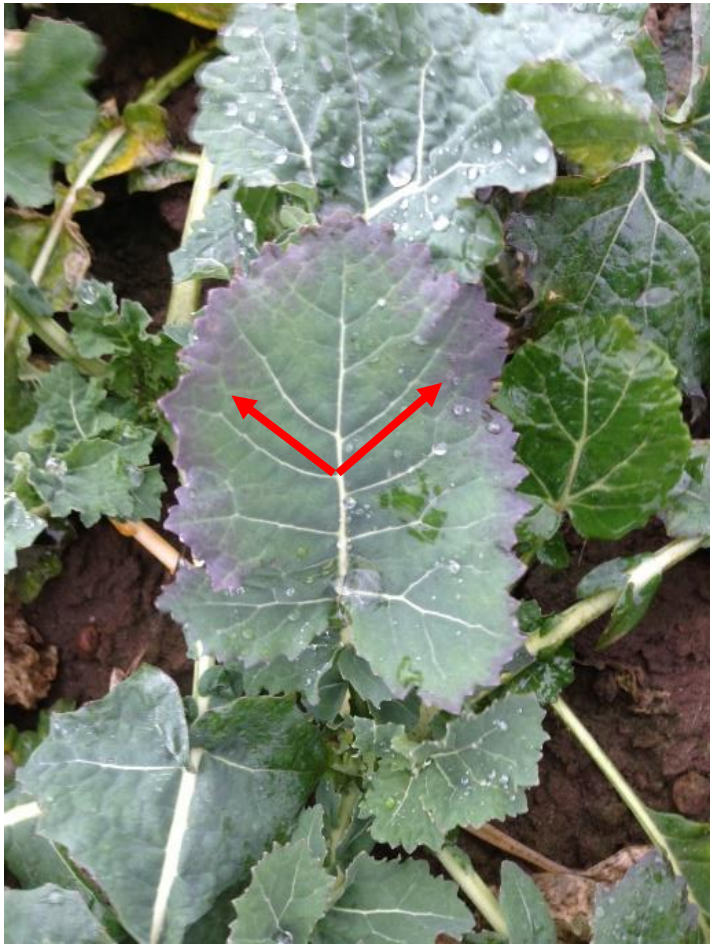
Breeding from several years on identified genetic resistance in Limagrain Europe

- Crossing and testing on parent lines
- Identified TuYV resistant parent lines with good agronomic features

First LG hybrids with TuYV resistance

- Limagrain is the 1st company with TuYV resistant hybrids
- Several hybrids in registration process since 2014
- 1st TuYV resistant hybrid cultivar registered in 2015
- Highly performing hybrids listed in several countries 2016 and 2017

Resistance is visible by lower leaf discolorations in autumn



Susceptible varieties show a violet/black frame

Resistant varieties without any violet or black discoloration

Pictures from Limagrain Deutschland (2014)

Differences in leaf discoloration are clearly visible
(autumn)

Foto: Rosenthal, Germany, 23.11.2016 (Limagrain)

TuYV resistant hybrid

Susceptible hybrid

Differences also in spring symptoms of TuYV

Purple leaves on the border

Green leaves on the border

Pictures from Limagrain Europe

Differences also in spring symptoms of TuYV

Purple leaves in TuYV affected plot

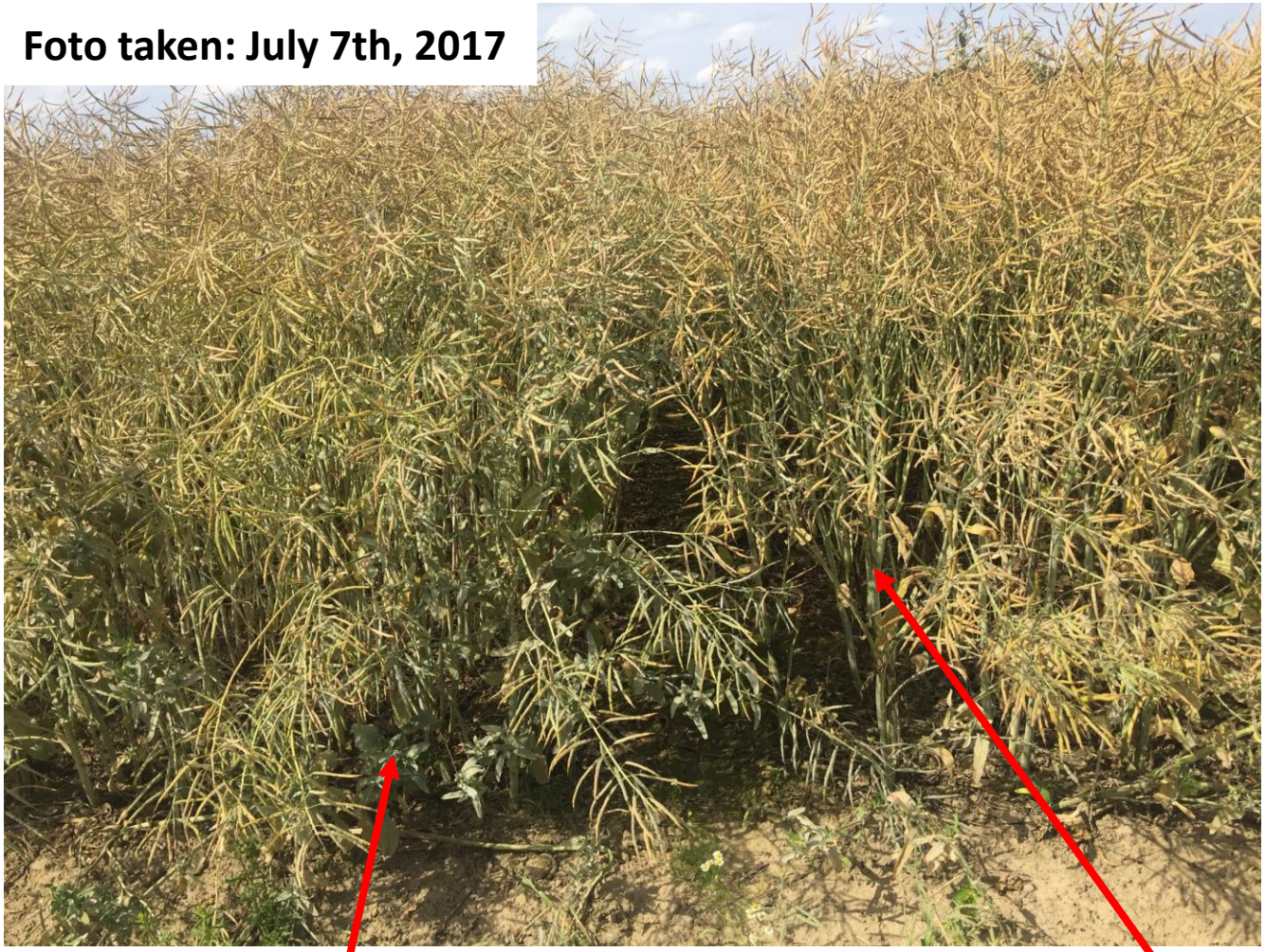
Green leaves in none/low TuYV affected plot

Pictures from Limagrain Europe

TuYV resistance influences senescence of plants

TuYV resistant hybrids keep their leaves longer than susceptibe varieties → longer period of phytosynthesis

Foto taken: July 7th, 2017



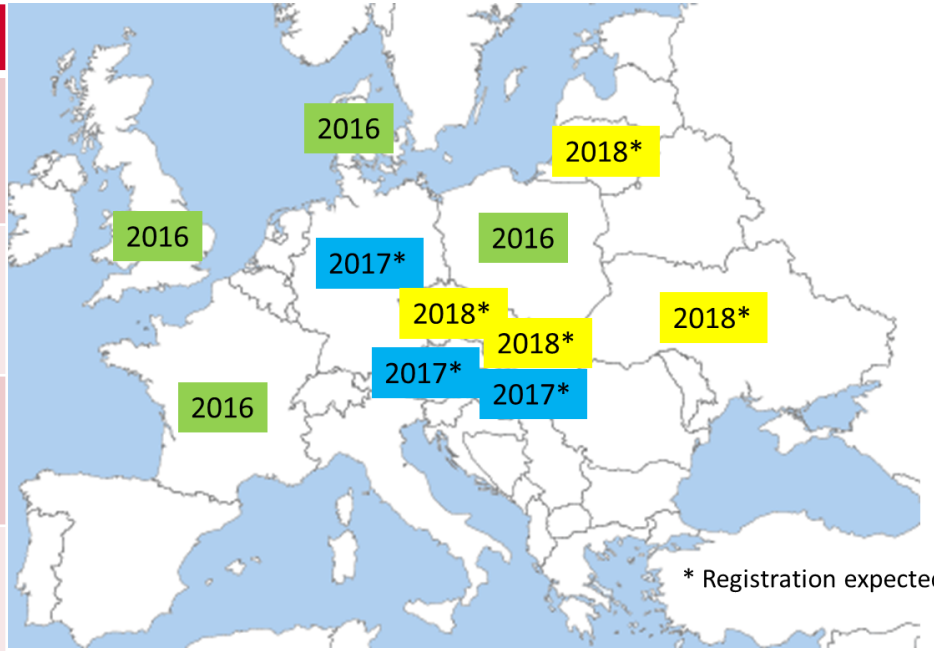
Rosenthal, Germany, July 7th, 2017 (Foto: Limagrain Europe)

Resistant: Some leaves remain

Susceptible: All leaves have disappeared

Milestones in the development of TUYV resistant OSR varieties

Year	Country	type	variety	breeder
2001	Italy	OP	Caletta	Semundo
2013	**UK**	**OP**	**Amalie**	**Limagrain**
2015	**CZ+AT**	**HR**	**Allison**	**Limagrain**
2016	**DE**	**HR**	**Asterion**	**Limagrain**
2016	**UK, FR, PL, DK**	**HR**	**ARCHITECT**	**Limagrain**
2017	FR	HR	Temptation	DSV
2017 (expected)	**DE**	**HR**	**ARCHITECT Albrecht Advocat**	**Limagrain**



Registration status of the TuYV resistant hybrid cultivar ARCHITECT in Europe

ARCHITECT is the most promising TuYV resistant hybrid for the European market

Limagrain

Synthesis: the current challenges in OSR cropping require for TuYV resistant hybrids

- No neonicotinoid seed treatment
- More aphid resistance to available chemistry
- Difficulty in correct spray timing
- TuYV is an important pathogen of oil seed rape
- High TuYV presence has been detected in EU
- Reduce yield and quality
- TuYV is mainly transmitted by Aphids (*Myzus persicae*)

TuYV resistant Hybrid is the best way to control the virus

TuYV resistant hybrids are not aphid resistant

Photo: Hahn, M, LALLF MV; October 2016

- **TuYV infections will be managed by genetic resistance**
- Normally, no insecticide application will be necessary
- But, like 2016, in case of massive aphid migration a potential insecticide would be helpful

3 Photos: Muskolus, A, IASP; October 2016

Conclusions

- TuYV became a relevant thread for OSR cropping across Europe
- The increase of TuYV occurence will go on
  (global warming, greening, seed treatment etc.)
- In case of severe infestation, the yield impact caused by TuYV varies between **5 and 15%**
- TuYV resistant hybrid cultivars compensate virus-caused yield losses
- The TuYV resistance trait shows no penalty on the yield
- TuYV resistant hybrids are already registered or currently in registration process in all relevant European countries
- TuYV resistant hybrids are the ideal tool for IPM strategies
- From Limagrain, **ARCHITECT** is the most promising hybrid
- We believe, in the future, the market will change completely to TuYV resistant cultivars
  (also other breeders have already started the transformation)
- In the future, the harm of TuYV infections in OSR will be banned by genetic resistance
- Nevertheless, for extraordinary aphid attacks, potential insecticides would be helpful

Current situation in the fields

TUYV symptoms in volunteer crops -> potential for new infections is present!

Mügeln/Saxonia (Eastern Germany), September 19th, 2017

Thanks for listening

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