Resistance in lettuce to *Fusarium oxysporum* f. sp. *lactucae* race 4 (Fol: 4)

Disease resistance plays a key role in vegetable crop production and integrated pest management practices. It is a major goal for lettuce breeding.

Discovered for the first time in 1955 and described in 1967 as a novel forma specialis, *Fusarium oxysporum* f. sp. *lactucae* (Fol) is the pathogen causing "Fusarium wilt", a disease affecting lettuce. Fol: 1 (race 1) has been identified in 1967 in Japan and was then found in the USA, Iran, Taiwan, south of America and Europe. Fol: 2 (race 2) and Fol: 3 (race 3) have been identified in Japan in 2001 and since then have only been reported in Taiwan. The lettuce disease test for resistance to *Fusarium oxysporum* f. sp. *lactucae* can be used in DUS since 2013 with Fol: 1 and Fol: 2. This characteristic was initially described with two UPOV notes: 1 (susceptible) and 9 (resistant) (TG/13/10 Rev).

In 2016, Giraldi et al. described a new race of *Fusarium oxysporum* f. sp. *lactucae* race 4 (Fol: 4) and used several varieties to differentiate it from the previously identified races. A new differential set was proposed at the time to the ISF Disease Resistance Terminology Working Group (DRT WG). In 2018-2019, GEVES coordinated an interlaboratory project for ISF which included 14 partners to validate, the newly identified differentials and race for use in resistance claims. The conclusion was that the description of the Fol: 4 required further investigation.

As the new race of *Fusarium* creates a serious threat for growers and a challenge for breeders, a harmonisation action was needed on short term. That is why ISF DRT / IBEB members decided to engage a new project coordinated by GEVES and with expertise and participation of J. Clarkson from Warwick University.

GEVES and ISF organized a polling system to simplify the decisions to answer to the objectives of the project. The principle of the majority was applied for the selection of the decision rule and the reference material (isolate and controls).

Conclusion

The scenario with **three levels of resistance** (susceptible, intermediate resistance and high resistance) was favoured by the majority.

The **isolate I,** isolate 04750888 provided by G. Gilardi (AGROINNOVA) was unanimously selected as the type isolate for *Fusarium oxysporum* f. sp. *lactucae* race 4.

Reference controls:

- **Gisela** was selected as susceptible reference control. This variety is expected to be susceptible to the four races of *Fusarium* but it has to be validated still with races 2 and 3.
- **Ballerina** was selected as lower level of intermediate resistant control.
- **Patriot** was selected as higher level of intermediate resistant control
- **Lomeria and Palmos** were selected as highly resistant controls.

Figure: interpretation rule and controls for evaluation of resistance of lettuce to Fol: 4

This proposal for using three levels of resistance will be discussed at CPVO level by the examination offices at the time of the proposal to add the Fol: 4 characteristic in the Technical protocol for DUS.

Selected controls were added to the differentials table (as shown below), where the interpretations of Patriot and Romabella for race 4 were updated (from susceptible to intermediate resistant). It is noted that the resistant level observed during the project was identified as HR (highly resistant) in the differentials table to comply with the terminology.

Table of differentials selected and validated in the project

Differential host	**Fol: 1**	**Fol: 2**	**Fol: 3**	**Fol: 4**
Gisela	S	ND	ND	S
Patriot	S	S	S	IR
Costa Rica N°4	HR	S	S	S
Romabella	HR	HR	S	IR
Banchu Red Fire	S	HR	S	IR
Ballerina	S	ND	ND	IR
Lomeria	S	ND	ND	HR
Palmos	HR	ND	ND	HR

S: susceptible, IR: intermediate resistant, HR: highly resistant, ND: no data

The Differential set and the report can be found in the following link https://worldseed.org/document/differential-sets-fol-race-4/

Follow up

Complementary tests will be conducted by two partners and GEVES to complete the differentials table for missing results for races 2 and 3. If Gisela was found not to be susceptible to all races, a new search for a susceptible control to all races should be carried out. Moreover, a choice between the two varieties Lomeria and Palmos could be done depending on results on races 2 and 3 not yet known.

Reference material (differentials, controls and isolate I) can be used for DUS and will be integrated in MATREF.

Organisation of the project

The preparation, participation, and coordination of the project was done by GEVES. Participants on this project were: GEVES, Naktuinbouw, BASF, Bejo Zaden, Enza Zaden, Gautier, ISI Sementi, Ramiro Arnedo, Rijk Zwaan, Syngenta, Tozer, University of Warwick, and Vilmorin

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The ISF Disease Resistance Terminology (DRT) Expert Group (EG) operates internationally and aims the harmonization of terminology used on Disease resistance for vegetable crops. This EG consists of representatives from different initiatives (CPPSI, CPVO, Euroseeds WG HRT, INIA, IWGP/IBEB, MATREF, Plantum WG on Maintenance of Isolates, UPOV, UFS WG Genetic Resistances, APSA DRT, JASTA), organizations (GEVES, Naktuinbow) and seed companies (Enza, Semillas Fito, BASF, Bayer, Rijk Zwaan, Sakata and Chia Tai).

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