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Comparing impact of host species and environment on virulence in *Fusarium graminearum* and *F. culmorum*

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Fusarium ear blight resistance in wheat and maize

- FEB in maize and wheat causes yield losses, loss of grain quality (shrivelled kernels) and accumulation of mycotoxins in grains.
- Many different resistance factors are known able to prevent or slow down infection and accumulation of mycotoxins.
- These resistance factors are complex, difficult to select for and determined by manifold genes and gene-interactions.
- Resistant varieties are a key element for sustainable disease control.

➢ **Need for reliable and stable information on resistance level of varieties in breeding of resistance, variety tests and VAT tests (registration of new varieties).**

Resistance tests

- Wheat and maize resistance tests are infected artificially with *F. graminearum* and/or *F. culmorum.*
- Creation of conducive conditions (overhead irrigation).
- Symptom scoring - according to plant species and target trait – to appreciate level of resistance

(Source : Flickr and Agroscope IPS)

Disease severity and accumulation of DON on wheat in 2010 in Nyon and Cadenazzo

LP	no			année	10ww1260	10ww6594	DONww1260	DONww6594
40	1	111.11420	RUNAL	2010	19.07	41.77	16.45	97.00
40	2	194.10077	ZINAL	2010	23.74	55.27	16.69	78.54
40	3	111.11834	LEVIS	2010	36.37	52.59	60.09	99.33
40	4	194.10119	CAMBRENA	2010	15.37	48.95	20.75	74.75
40	5	111.12754	CH CLARO	2010	22.25	46.75	25.00	90.48
40	6	111.13248	SURETTA	2010	18.71	54.13	35.24	66.96
40	7	221.10002	SERTORI	2010	14.03	37.26	18.05	24.48
40	8	111.10010	ARINA	2010	6.98	30.08	12.62	23.69
40	9	111.13431	MOLINERA	2010	14.05	41.43	16.53	63.09
40	10	111.13726	(SIMANO)	2010	10.86	39.99	12.01	59.07
40	11	194.10134	ORZIVAL	2010	19.53	49.76	29.16	76.65
40	12	111.13805	(LORENZO)	2010	28.34	51.96	52.30	126.40
40	13	111.13866	(CAMPIONI)	2010	26.26	49.24	81.63	147.77
40	14	194.10518	(TANELIN)	2010	17.47	42.16	66.15	75.04
40	15	111.13940	(JAZZI)	2010	36.70	58.10	126.21	105.97
40	16	111.13563	(MAGNO)	2010	25.78	51.73	38.98	94.23
40	17	111.13784		2010	25.78	47.27	27.98	71.13
40	18	211.13058		2010	21.10	36.64	14.14	23.50
40	19	191.11080	AISC.3	2010	9.37	33.72	3.18	52.59
40	20	191.10922	VALODOR	2010	31.73	66.33	52.81	122.74
40	21	191.11047	EVENT	2010	19.07	33.62	14.34	83.72
40	22	191.11024	BATUTA	2010	17.13	46.75	38.60	112.39
40	23	191.11033	STRU 061879	2010	20.78	42.58	49.79	80.63
				010	38.42	69.44	100.30	107.80
				010	20.11	49.76	64.61	110.06

Examples of reactions:

Arina: low severity and low DON

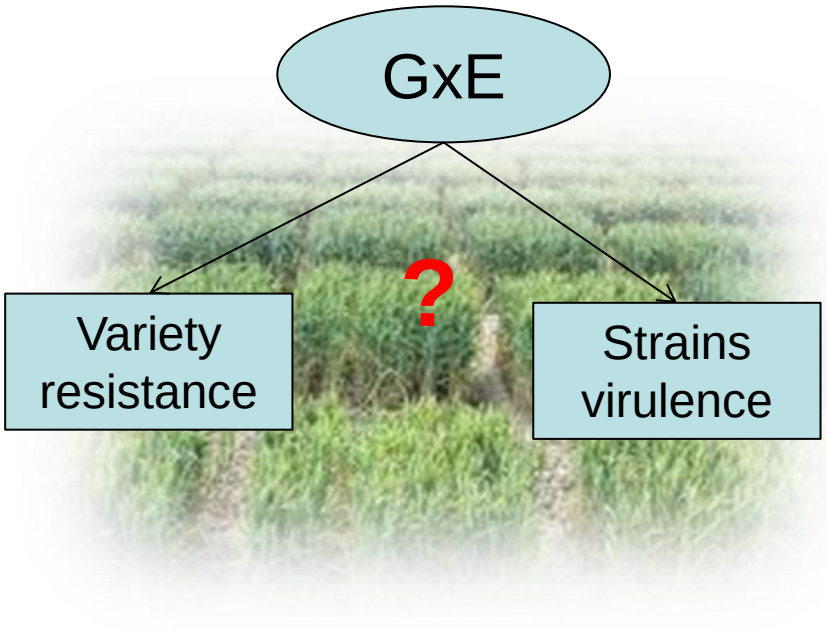
Campioni: high severity and high DON at both sites

AISC.3: low severity but sometimes elevated DON

Battuta: from intermediate to high severity and always high DON

Evaluation of the resistance

Significant differences in disease severity and DON accumulation between different locations (and years).



How to stabilize results of resistance tests in order to improve breeding for resistance ?

Here:
What is the influence of *Fusarium* strains' virulence on resistance tests ?

Which factors may impact strains' virulence ?

Environmental factors
Fusarium species and chemotype
Resistance of host
Host species

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1. Effects of environmental factors on strain virulence

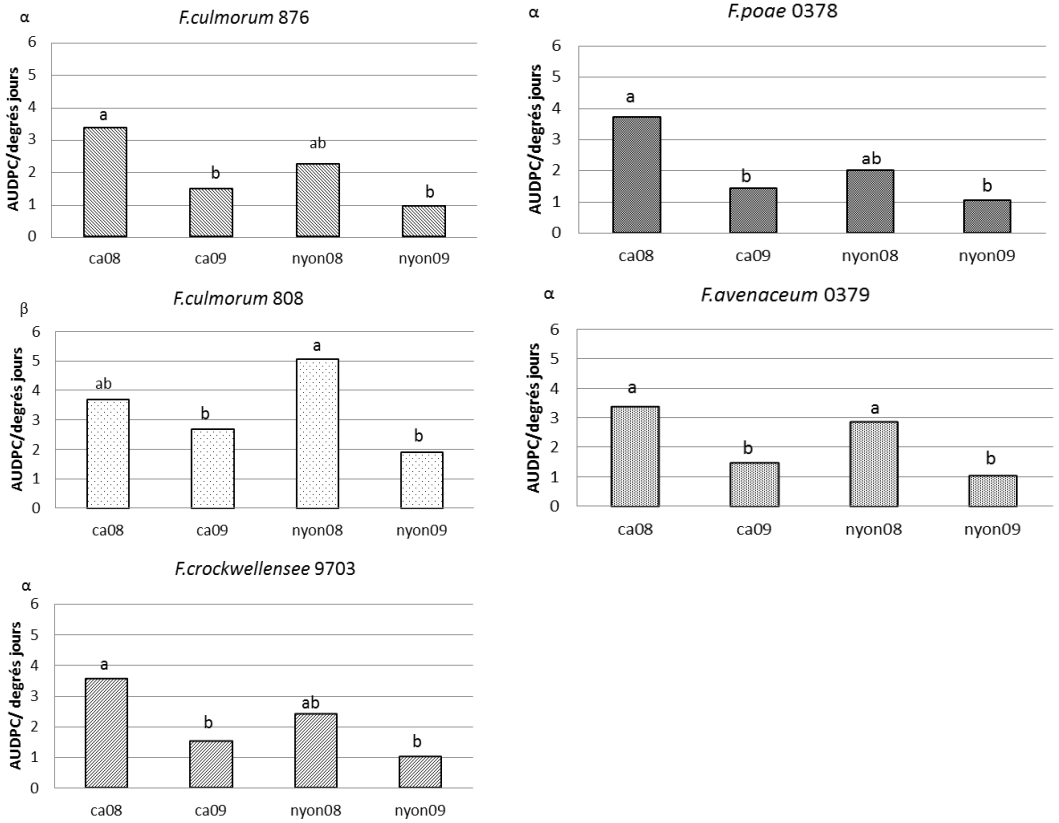
Field experiment:

- 6 WW varieties
- Infected with 6 Fusarium strains
  - *F. culmorum*
  - *F. poae*
  - *F. avenaceum*
  - *F. graminearum*

- Repeated in 4 environnements
  - Nyon (VD), Cadenazzo (TC)
  - 2008, 2009
  - Temperatures, humidity, wetting period are known

→ Analyse of disease severity

1. Effects of environmental factors on strain virulence



- «Cadenazzo 2008» conditions have fostered strain virulence.
- Humidity and wetting period were correlated with virulence (resp 0.78***, 0.71***) but not temperature.
- But one strain can be more virulent in one environment (ex : *F.culmorum* 808 in Nyon 2008) but not in another.

→ Strains virulence is dependant on environnment ($p<0.05$)

→ Varieties resistance was not linked with environmental factors.

2. Effect of strain properties on virulence

Is the virulence linked with strain properties?

- Species
- Chemotype

Field experiment:

- 3 SW varieties (Carasso, Nadro, Toronit)
- Infected with 18 *Fusarium* strains
  - Species determined *(F.culmorum, F. graminearum*)
  - Chemotype determined (NIV, 3A-DON, 15A-DON)
  - Wheat or Maize as pathogen source
  - Isolated in different places in Switzerland

Strain number	Species**	Plant origin	Chemotype
1073	*Fusarium culmorum*	Maize	3A-DON
1068 *	*Fusarium culmorum*	Maize	NIV
808 *	*Fusarium culmorum*	Wheat	3A-DON
376 *	*Fusarium culmorum*	Wheat	NIV
1153 *	*Fusarium graminearum*	Maize	15A-DON
1088 *	*Fusarium graminearum*	Maize	15A-DON
Fg13 *	*Fusarium graminearum*	Wheat	15A-DON
1149 *	*Fusarium graminearum*	Wheat	15A-DON
1069	*Fusarium culmorum*	Maize	NIV
97003	*Fusarium crookwellense*	Wheat	NIV
378	*Fusarium culmorum*	Maize	3A-DON
1879	*Fusarium culmorum*	Wheat	NIV
254	*Fusarium culmorum*	Wheat	3A-DON
1065	*Fusarium culmorum*	Maize	NIV
2113	*Fusarium graminearum*	Wheat	15A-DON
1151	*Fusarium graminearum*	Maize	15A-DON
1145	*Fusarium graminearum*	Wheat	15A-DON
876 h	*Fusarium culmorum*	Wheat	Not available
876 l	*Fusarium culmorum*	Wheat	Not available

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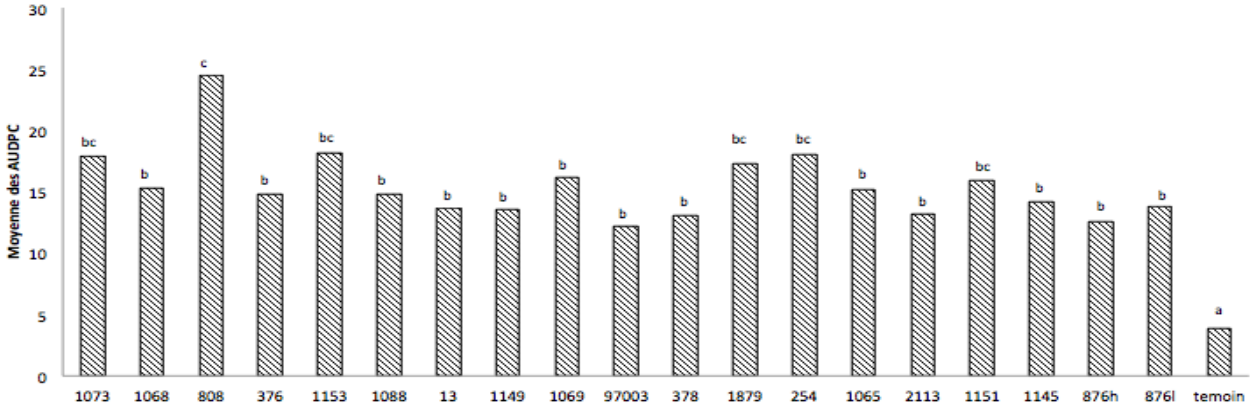
2. Effect of strain properties on virulence

(a) spike infected by the strain 2113, (b) spike infected by the strain 808 (source Agroscope IPS)



	Df	Sum Sq	Pr(>F)
chemotype	2	275.1	<0.001***
cultivar	2	474.9	<0.001***
Chemotype:strain	14	835.9	<0.001***
residue	123	3.508	--

	Df	Sum Sq	Pr(>F)
species	1	122.7	0.00827 **
cultivar	2	479.6	3.10e-06 ***
species : strain	15	983.6	1.31e-05 ***
residue	123	2093.6	

- Different levels of virulence between strains
- Strains chemotype and species has only a weak impact on virulence .
  - chemotype 7.5%, strain 23%
  - species 3.3%, strain 27.5%

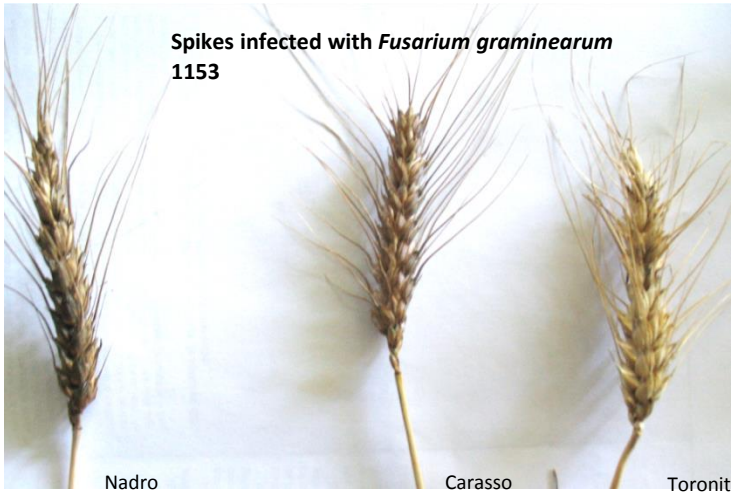
→ Strains virulence depends on other properties than species or chemotype.

3. Impact of wheat variety on virulence

Does the level of host resistance affect strains virulence ?

Field experiment

- 3 SW varieties (Nadro, Carasso, Toronit) with different levels of resistance
- Infected with the same 18 strains



Decomposition of variability depending on the pathotype and on the cultivar.

SOV	Df	SS	F value	Pr (>F)
pathotype	19	2143.1	8.712	<0.001 ***
cultivar	2	514.7	19.877	<0.001 ***
repetition	2	179.87	13.893	<0.001 ***
pathotype : cultivar	38	514.9	1.047	0.4139
residue	117	1514.8	---	

Both varieties resistance and strains virulence have impacted disease severity. But 44% of the variability was explained by strains effect.

No interaction was found between wheat genotype and pathotype.

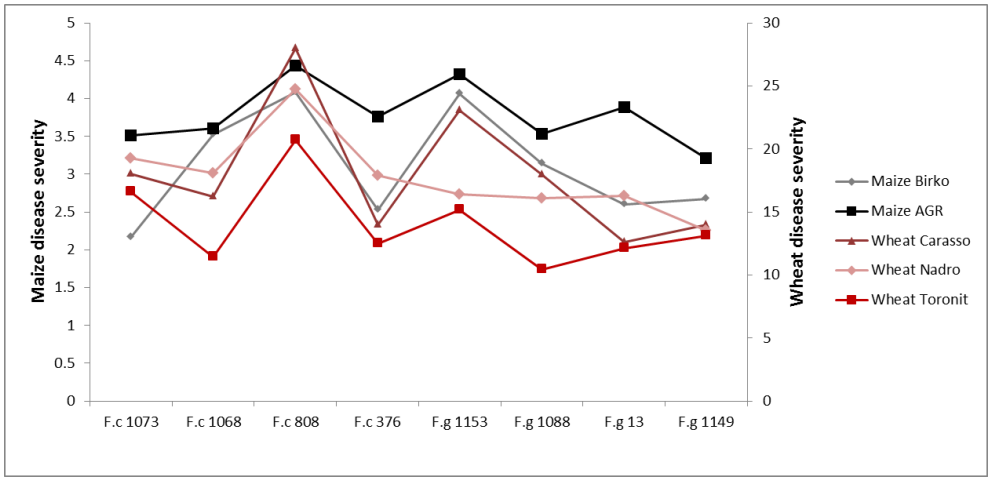
→ There was no interaction between strains virulence and genotype resistance

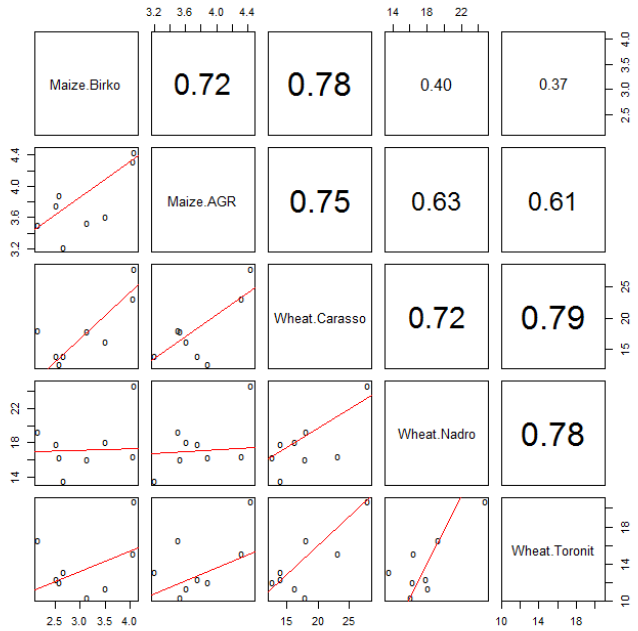
4. Impact of host plant on virulence

Does a *Fusarium* strain display the same virulence level on different hosts?

Field experiment

- 3 SW varieties (Nadro, Carasso, Toronit) with different levels of resistance
- 2 maize varieties with different levels of resistance
- Infected with 8 *F.culmorum* or *F.graminearum* strains with different levels of virulence





- The virulence of strains was correlated with different species and genotypes
- An highly virulent strain on wheat is also more virulent on maize whatever the resistance level of the variety.

→ Strains virulence is not linked with plant species and resistance.

Conclusion

- Virulence of *Fusarium* is similar on wheat and on maize.
- The virulence level but not the species of *Fusarium* determines the appreciation of the resistance in wheat and maize cultivars.
- Virulence is not influenced by the chemotype of the strain

  > influence of other endogenous factors.
- Virulence is influenced by environmental conditions (disease severity and synthesis of mycotoxins).
- Host resistance seems not to be influenced by the environment.

Approach to improve resistance tests:

→ Use of a mixture of carefully selected strains to compensate environmental effects.

Acknowledgements

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