

Genetics for low correlation between FHB and DON in a bread wheat population

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Fusarium head blight (FHB) & deoxynivalenol (DON)

- FHB is a major fungal disease with global importance, causing more concern on food safety than yield reduction, due to its ability to produce mycotoxins represented by DON
- Due to technical and cost reasons, many studies on FHB did not measure DON, simply assuming varieties with low FHB have low DON, and vice versa
- Normally, FHB and DON show significantly positive correlation; but sometimes very low or even negative correlation could be found between the two traits, as reviewed by Paul et al. (2005)

36 published and 127 unpublished studies were selected for a meta-analysis

About 65% of all r values were >0.5

About 28% of all r values were between 0.5 and 0

About 7% of all r values were <0



Why low correlation between FHB and DON

- Temporal separation between FHB evaluation and DON assessment
 - Sampling for DON is usually 30-45 days later than FHB evaluation
 - Late infection usually doesn't cause obvious FHB but may lead to high level of DON
- Physical separation between the tissues for evaluation of FHB and DON
 - Chaff usually has higher level of DON than kernel, same applies to barley and oats
 - Active detoxification mechanism in kernel (Type III resistance)



Resistance Mechanisms for FHB and DON

- Several resistance mechanisms have been proposed, but the below ones are the most frequently researched:
 - Type I for initial infection of FHB
 - Type II for pathogen spread within the spike tissues
 - Type III for DON content on grains
 - Type IV for kernel infection rate

- In most studies, Types III and IV were associated with Type I or II, thus many researchers take the former simply as consequence of the latter



QTL for Type III Resistance in Published Studies

- QTL mapping for DON has been available in limited number of studies, due to the additional expense and the assumption that DON is dependent on FHB
- In a Meta-analysis, Liu et al. (2009) summarized QTL for different FHB resistance components and found that only 25 out of 209 QTL were associated with Type III, and none of them was independent from Type I and/or Type II
- A few studies showed QTL exclusively for DON; but mostly they were minor QTL and/or not repeatable



QTL Mapping in a CIMMYT line IAS20*5/H567.71

- IAS20 is a Brazilian FHB resistant cultivar, and its pedigree is COLONIAS//FRONTANA/KENYA-58
- A RIL population derived from NASMA and IAS20*5/H567.71 was used, containing 197 entries
- Field trials were performed in 2010, 2013, 2014 and 2017 in El Batan, Mexico
- Phenotyping was conducted for FHB index, FDK, DON, as well as PH and DH
- Genotyping was done with Illumina Infinium 15K SNP markers and some SSRs and SNPs



FHB screening nursery at El Batan, Mexico

- Move fields from Toluca to Batan (2006)
- Logistic efficiency
- Enhanced capacity (2 ha/10,000 plots)

Maize-wheat rotation with CA practices →

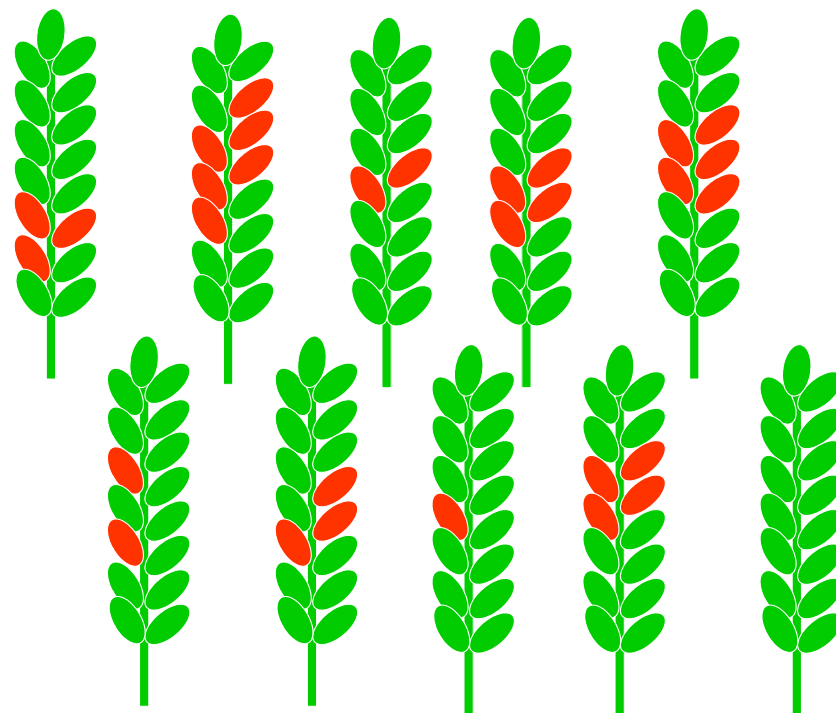


← Automated programmable misting system

Precision spray inoculation →
technique



FHB screening nursery at El Batan, Mexico



$$\text{FHB Index} = \text{Incidence} \times \text{Severity} / 100$$

Example: Incidence: 90.0%

Severity: 20.8%

FHB index: 18.7%



Correlation among FHB, FDK and DON

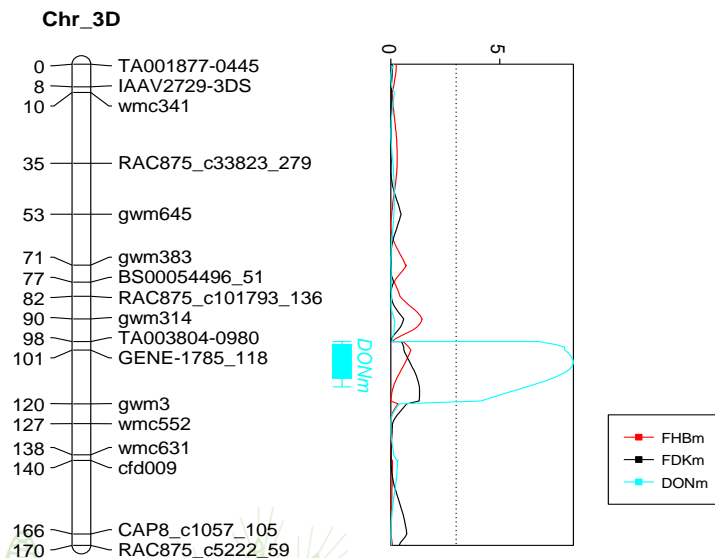
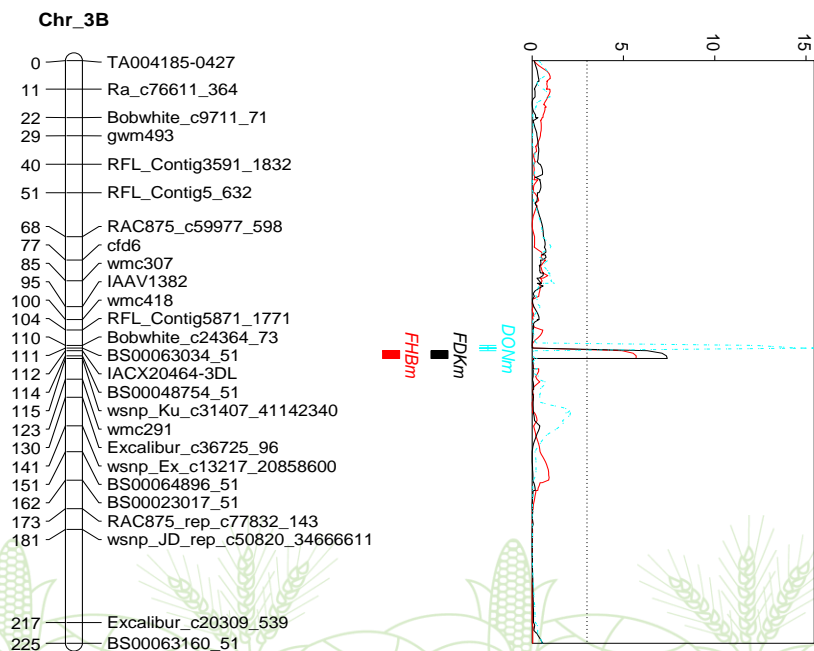
	FHB10	FHB13	FHB14	FHB17	FDK13	FDK14	FDK17	DON13	DON14	DON17
FHB10	1									
FHB13	0.63	1								
FHB14	0.66	0.85	1							
FHB17	0.52	0.52	0.53	1						
FDK13	0.42	0.3	0.31	0.22	1					
FDK14	0.42	0.2	0.28	0.32	0.61	1				
FDK17	0.42	0.37	0.4	0.29	0.59	0.56	1			
DON13	0.2	0.31	0.33	0.15	0.36	0.24	0.38	1		
DON14	0.21	0.23	0.29	0.12	0.34	0.35	0.41	0.71	1	
DON17	0.23	0.31	0.07	0.16	0.32	0.36	0.47	0.66	0.66	1

- High correlation among FHB in different years, as well as among DON in different years
- Low correlation between FHB and DON
- FDK showed better correlation with DON than with FHB



QTL mapping results for FHB and DON

Chr.	Position	Left marker	Right marker	FHB index				FDK			DON content			R source	Traits associated
				2010	2013	2014	2017	2013	2014	2017	2013	2014	2017		
1BL	66.3-71.6	wmc419	BS00064032_51									4.4		I	
2AL	86.9-98.7	WEC_4379619	BS00039406_51					7.4						I	
2DL	15.7-18.9	tplb0021c10_951	GENE-0638_732								5.4			N	
3BL	109.6-119.0	BW_c24364_73	Ex_c27120_789	8.7	4.8	4.4	8.6	7.5	12.3	13.6	15.8	20	23.9	I	
3DL	89.4-119.7	TA003804-0980	gwm3								10.5	15.3	10.3	I	
4BS	44.1-46.3	Rht-B1	BS00021984_51		5.5									N	PH
4DS	0-10.7	Rht-D1	barc105	9.5	12.7	9.2	7.7	4.9		3.9				I	PH
5AL	147.6-147.9	WEC_5013188	Vrn-A1	3.9	21.2	21.7								I	DH, PH
5BL	92.1-92.4	BS00022673_51	R_c539_1789		4.8	3.4	3.9							N	DH
7AC	115.6-119.8	WERC_70021470	Ku_c97425_164						7.5					N	
Accumulated percentage of variation explained				22.1	49.0	38.7	22.0	19.8	19.8	22.9	26.3	39.7	34.2		



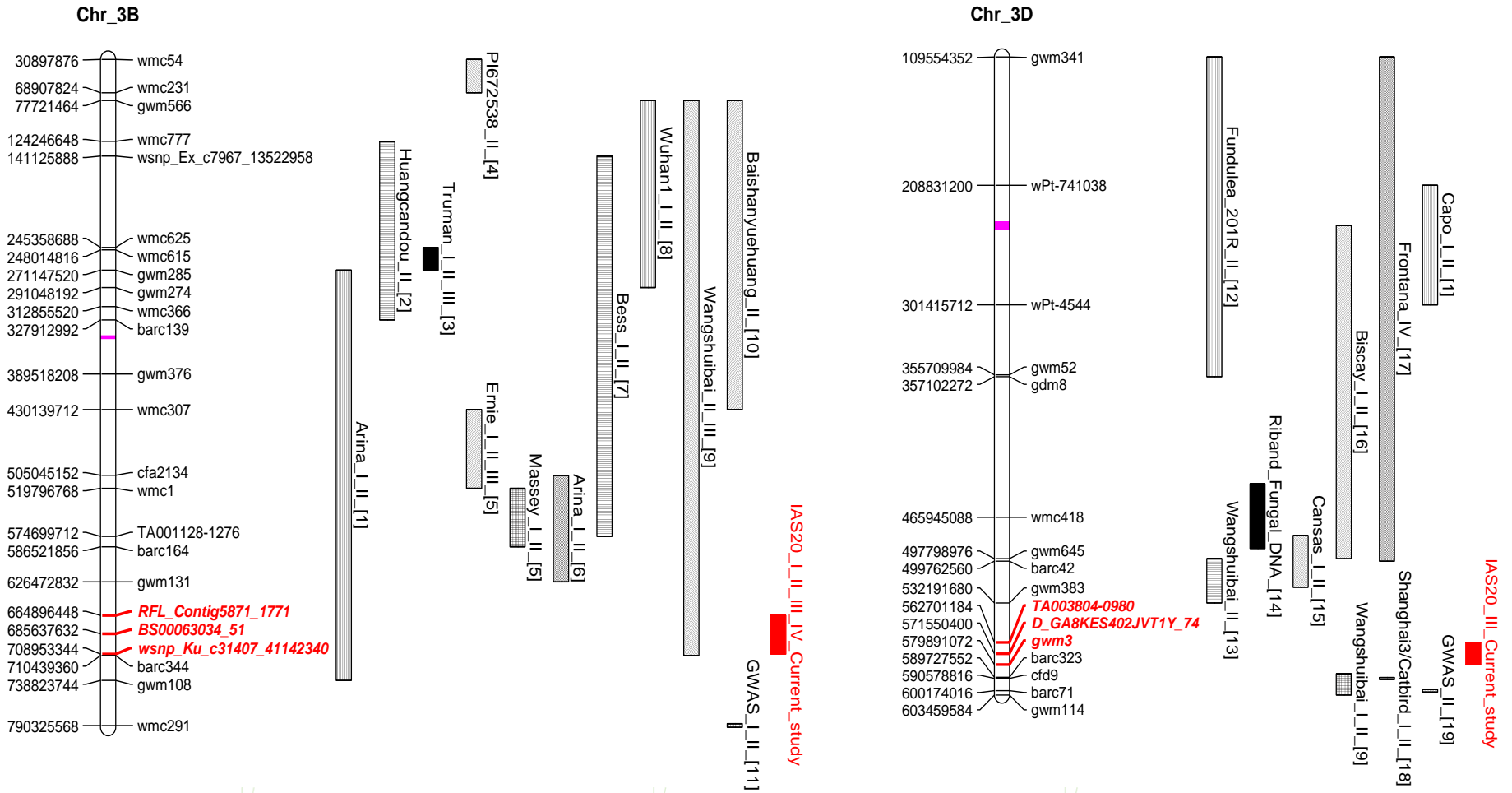
QTL mapping results for grain filling period (GFP) and grain filling rate (GFR)

Trait	<u>Chrom.</u>	Position	Left marker	Right marker	Phenotypic effects	Source
GFP	6AS	56.6-64.6	T_c10412_650	BW_c19647_159	4	N
	7AS	66.8-69.1	Ex_c34807_431	Ra_c9427_300	9.1	N
	Accumulated percentage of variation explained				13.1	
GFR	4BS	44.1-46.3	Rht-B1	BS00021984_51	10.6	N
	4DS	0.0-10.7	Rht-D1	barc105	5.8	I
	6BS	19.4-24.7	TA004132-0670	Ra_c26860_648	6.0	I
	6BL	70.4-70.7	IACX5699	Ku_c25725_1921	6.4	N
	Accumulated percentage of variation explained				28.8	

- Grain filling related traits were mapped considering its potential impact on DON content
- None of the identified QTL coincide with 3BL or 3DL QTL



Physical positions for the 3BL and 3DL QTL and previously reported ones



QTL Mapping in a CIMMYT line IAS20*5/H567.71

- SNP markers flanking the 3BL and 3DL QTL have been transformed into KASP markers for their utilization in MAS
- Additional KASPs on the 3BL and 3DL QTL regions are being tested in order to fill the gaps and identify closer markers
- Based on haplotyping results of the progenitor lines of IAS20*5/H567.71, resistant source of the 3BL QTL might be Frontana, and that of the 3DL could be Kenya58
- The concept of Type III resistance was initially proposed based on the fact that Frontana has an ability to detoxify DON (Miller et al. 1985), and the identification of the 3BL QTL may provide an evidence for the phenomenon



Future plan for research and breeding

- Both the 3BL and 3DL QTL showed major and stable effects on Type III resistance (detoxification), which may be of interest not only to breeders but also to grain industry
- Fine mapping of both QTL are being planned
- Developing diagnostic markers for the two Type III QTL and investigate their occurrence in CIMMYT germplasm.
- Combining Type I (2DLc from Soru#1, Mayoor etc.), Type II (*Fhb1/Sr2* recombinants) and Type III (3BL and 3DL from IAS20) in CIMMYT genetic background, and screen for lines with holistic resistance via markers, field evaluation, laboratory experiments (DON analysis)





Thank you
for your
interest!

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