Determination of virulence of European races of common bunt using a differential set of wheat cultivars

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Abstract

The development and increased use of wheat cultivars resistant against common bunt (*Tilletia caries/T. leavis*) could contribute to a reduction of fungicide seed treatment in conventional agriculture and reduce the impact of these pathogens in organic agriculture. In order to choose the optimal resistance genes for breeding programs, knowledge is needed about the occurrence of virulence of the pathogen against the different resistance genes of the host against common bunt in wheat. The purpose of the study was to determine the virulence patterns of common bunt present in Europe and Iran.

Part of the spores used in this study were collected in different places in Denmark about 20 years ago in the ORGSEED project, maintained on susceptible varieties and used for screening in variety trials. From 2010 onward, spores were collected and maintained on resistant varieties in the COBRA and LIVESEED project, and thereby a collection of races was established with specific virulence to the resistance of the varieties on which they were maintained (Borgen *et al* 2018).

At Julius Kühn Institute, another set of spores were collected mainly from different sources in Europe to develop identification tools for the differentiation of common and dwarf bunt (Sedaghatjoo *et al*. 2021; Forster *et al*. 2022). In 2019 these spores were provided to Agrologica and multiplied on the susceptible winter wheat variety Creator for two years. In 2021, spores from each spore sample were applied to seed of Creator and 24 resistant winter wheat varieties representing 14 different resistance genes. 50 seeds of each spore – seed combination were sown without replication. The trial was assessed by visual inspection in 2022.

Discussion

The wheat variety Creator is susceptible to almost all bunt races. Accordingly, all but one of the bunt strains sampled were able to infect this variety. The other varieties of the field trial displayed anything from high to medium (and lower) infection rates indicating that the respective bunt sample is virulent toward the resistance gene in the given variety, while other varieties are not infected at all by a given spore sample indicating that the variety has one or more functioning resistance genes against the respective bunt strain. Very low infections rates in some varieties could be caused by different factors: Either the variety is not 100% genetically homogeneous with respect to the resistance gene, or the spore sample is in fact a mixture of different races with different virulences, with some virulences only present in small amounts. Based on this study a definite conclusion of these two possible causes cannot be provided. In particular, Thule III(Bt13) and maybe also Rio(Bt6) and Pi554115(Bt4) seem to be infected at low levels by a range of common bunt samples, and it is therefore likely that the seed samples of the used varieties were to some degree heterogeneous.

Tabel 1: Wheat varieties with resistance to common bunt infected by 44 spore collections of common bunt from Europe and Iran. The spore samples can be grouped into 14 different races based on the differential lines reactions to infection.

	Blizzard	Tilliko	Thule III	IFA-P106.30	NIL-12	PI-554-098	NIL-10	Tillexus	Pi-554-099	NIL-9	Magnifik	Pi554120	Pi554100	Rio	Hohenheimer	NIL-5	Pi554115	Nebred	pi554121	Ridit	Bussard	Pi554097	PG3540	NIL-1	Creator	
	Bt3 +Bt6 +7A	BtZ	Bt13	Bt12		Bt11	Bt10		Bt9		?	Bt8	Bt7	Bt6	Bt5 +1B	Bt5	Bt4		Bt3		BtH	Bt2	Bt1		Bt0	
Pan-35, Germany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	
Pan-9, Germany	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	3	0	0	0	83	
Vr-13, Denmark	2	0	2	0	0	0	0	0	4	0	0	6	0	0	0	0	2	0	0	0	0	0	0	0		
Hansa, Sweden	0	0	19	0	0	0	0	0	0	0	0	3	0	0	0	0	3	3	0	0	5	0	0	0	50	avirulent
Vr-0, Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	11	0	0	11	7	0	0	0		
Pan-34 Sweden	0	0	3	0	0	0	0	0	0	0	3	0	0	0	0	0	19	3	0	0	9	0	0	0	89	
Pan-19, Germany	0		9	0	0	0	0	0	0	0	0	0	0	3	0	0	33	31	17	0	12	14	0	0	33	Bt4
Pan-24, Schweiz	0	0	9	0	0	0	0	0	9	0	0	33	20	9	0	0	9	9	50	9	17	12	0	0	33	Bt8 Bt3
Pan-25, Italy	0	0	0	0	0	0	0	0	0	0	0	64	9	3	0	0	14	0	0	0	0	0	0	0	35	
Pan-26, Italy	0	0	3	0	0	0	0	0	0	0	0	23	27	0	0	0	0	9	0	0	11	0	0	0	67	
Pan-22, Germany	0	0	12	0	0	0	3	0	0	0	0	43	25	6		12	3	0	0	0	0	9	0	0	71	Bt7 Bt8
Pan-23, Germany	0	0	24	0	0	0	0	0	0	0	0	77	29	0	0	3	7	0	0	0	5	0	0	0	60	
Wiik-Emmer	0	3	0	0	0	0	0	0	0	0	0	25	14	0	0	0	0	0	9	0	3	12	0	0	50	
Vr10, Denmark	0	43	0	###	0	0	38	98	0	0	0	0	22	2	0	2	2	0	0	0	2	0	0	7		BtZ Bt10 Bt7
Pan-7, Germany	0	0	14	0	0	0	3	0	9	0	0	0	0	0	0	0	0	0	0	0	0	91	97	0	50	Bt2 Bt1???
Pan-17, Germany	0	0	12	0	0	0	0	0	12				6	3	0	0	12	3	0	0	0	0	88	94	57	Bt1
Vr-5, Denmark	0	0	2	2	0	0	0	0	0	0	0	0	2	2	17	83	20	0	0	0	75	2	4	4		Bt5 Bt2???
Pan-1, Austria	0	0	0	0	0		0	0	3	0	0	0	3	3	0	3	23	0	3	0	86	60	0	0	40	Bt2 Bt4?
Pan-6, Austria	0	0	0	6	0	0	0	0	9	0	0	23	0	0	0	0	6	0	0	0	50	14	0	0	50	
Vr-DOT, Denmark	0	0	0	0	0	0	0	0	0	0	0	0	2	4	0	11	6	0	0	2	94	26	7	7		
Pan-18, Germany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	60	50	0	0	75	
Pan-11, Germany	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	91	50	0	0	83	
Pan-21, Germany	0	5	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	88	33	0	0	50	
Pan-4, Austria	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	3	14	0	0	0	86	91	0	0	67	Bt2
Pan-10, Germany	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	0	100	86	0	0	75	
Pan-20, Germany	0	0	33	0	0	0	0	0	0	0	0	6	6	0	0	0	0	0	3	0	86	97	0	0	75	
Pan-8, Germany	0	0	19	11	0	0	0	0	0	0	0	0	0	3	0	0	6	0	0	9	94	87	0	0	67	
Pan-13, Germany	0	0	25	0	0	0	0	0	6	0	0	0	0	0	0	0	3	0	0	0	97	87	0	0	50	
pan-Veron, Tjeck Rep.	0	0	11	0	0	0	0	0	6	0	0	3	50	23	0	0	50	33	38	0	83	0	3	60	67	Bt7 Bt4 Bt3?? Bt2?? Bt1???
Pan-3, Austria	0	0	6	0	0	0	0	0	5	0	0	0	67	0	0	15	0	0	0	0	67	91	0	0	50	
Pan-Aros	0	0	12	0	0	0	0	0	0	0	0	2	57	0	0	6	14	3	0	3	86	86	0	24	57	
Pan-2, Austria	0	0	9	0	0	0	0	0	0	0	0	0	57	0	0	0	5	0	3	0	86	100	0	0	83	Bt7 Bt2
Pan 30, Iran	0	0	17	0	0	0	0	0	0	0	0	0	57	6	0	6	0	0	6	6	94	100	0	0	67	
Pan-16, Germany	0	0	0	0	0	0	0	0	14	0	3	17	50	3	0	0	14	3	13	11	86	100	0	0	86	
Pan-29, Iran	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	50	3	0	0	97	98	0	0	50	Bt4 Bt2
pan-31, Iran	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	30	2	0	7	95	100	0	0	94	
Pan-27, Latvia	0	6	0	0	0	0	0	0	0	0	0	0	14	12	0	0	6	###	0	0	83	67	50	44	0	
Vr-2, Denmark	0	0	0	0	0	0	0	0	0	0	0	0	14	2	0	0	8	0	0	0	94	91	60	75		Bt7 Bt2 Bt1
Pan-Stava, Sweden	0	0	3	0	0	0	0	0	0	0	0	0	26	3	0	0	0	3	0	0	91	97	83	75	86	
Vr-3, Denmark	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	75	80	100	89	0	0		Bt3 Bt2
VrZ, Denmark	0	57	6	0	0	0	38	50	0	0	0	0	0	33	0	0	75	26	0	0	4	0	0	0		BtZ Bt13
Pan-28, Iran	0	43	71	3	0	0	33	44	14	0	0	0	0	14	0	0	86	40	20	0	12	0	0	0	50	Bt10 Bt4 Bt6
Pan-32, Iran	0	0	86	0	0	0	0	0	0	0	0	0	0	50	0	0	94	81	67	89	88	50	0	0	26	Bt13 Bt6 Bt4
Pan-33, Iran	0	2	91	0	0	0	0	0	0	0	0	0	3	50	0	0	91	71	67	83	83	67	0	0	83	Bt3 Bt2

After assessment of the field trials, spores were collected from resistant varieties with low infections, and reinoculated on the same variety. The result of this reinoculation is not available yet. If this reinoculation leads to increased infection, it will indicate that virulence has been present in the spore sample, whereas if it leads to a similar low or lower infection, it will indicate that the infection was caused by impurity of the differential line.

Bunt samples that show a similar infection level to the distinct resistant varieties may be of the same race. Common bunt is caused by two closely related species, *Tilletia caries* (syn *T. tritici*) and *T. laevis* (syn *T. foetida*). Goates (2012) described 57 races of bunt by their reaction to a similar set of differential lines. Only few races from our study have the same combination of virulences and avirulences as the races described by Goates (2012).

Although the collection of spores does represent primarily Germany, Sweden and neighboring countries it provides a first impression of common virulences. Our study suggests that the virulence against Bt2 and Bt7 is most common in this region, whereas virulences against Bt1, Bt3, Bt5, Bt9, Bt10 and BtZ is more rare. As mentioned above, it is likely that the differential line of Bt13 is impure, and that virulence against this gene is more rare than the results indicate. There are no races with virulence against Bt11 and Bt12 and the variety Blizzard. Genetic studies have shown that these genes are not single genes but are combinations of multiple genes (Unpublished).

These conclusions are in line with previous surveys made by Mascher *et al* (2018), but represent a broader range of spore samples. Babayants et al (2006) found virulense in Ukraine to all Bt-genes Bt1-Bt7, but not to Bt8-Bt15.

Keywords

winter wheat, common bunt, organic agriculture, resistance breeding, virulence survey

Acknowledgments

Phenotyping was done in the BOOST projekt funded by Organic RDD, and the DIVERSILIENCE projekt funded by CoreOrganic Cofund. Collection of spores prior to the field trial was done By Bent Nielsen in the ORGSEED projekt (2001-5) funded by FØJO, and purification of the spores was done in the COBRA project (2013-16) funded by CoreOrganic. Multiplication and revitalisation of spores was done in the LIVESEED project (2017-21) funded by HORIZON2020. The spore collection at JKI was accumulated during a project funded by the Federal Ministry of Food and Agriculture of the Federal Republic of Germany based on a decision of the German parliament (Grant Numbers 2812NA128 and 2812NA017).

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